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THE CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

1981 REPORT

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

Dear Dr. Whitham,

The theme of this year's meeting of the Canadian Advisory Committee on Remote Sensing (CACRS) was "The Future of the National Remote Sensing Program". The chairman of the organizing committee was Mr. Frank Hegyi, Director of the Inventory Branch of the B.C. Ministry of Forests. A total of 71 recommendations were presented of which 62 can be handled by the Canada Centre for Remote Sensing and 9 must be passed up to the Interagency Committee on Remote Sensing for action.

A major event at this year's meeting was the opening address given by Dr. A.E. Collin, Associate Deputy Minister, on behalf of Mrs. Judy Erola, Minister of State for Mines. This address set the stage for the meeting and contributed greatly to its success.

This year's meeting was important in that it allowed the full CACRS body to examine and discuss major issues such as RADARSAT, and also the impact on the regional programs of the quantum jump in price imposed by NOAA for satellite data reception which will occur on October 1, 1982. It would have been very difficult to deal with the full implications of the latter issue without the CACRS organization.

A new feature of this year's program was a panel composed of senior officials from the major remote sensing technology companies which presented the viewpoint of industry on the National Program and the direction it has taken. The panel discussion was a high point of the meeting and it is evident that industrial participation will be a regular feature of further CACRS' meetings.

Yours sincerely,

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

30 July 1982

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

The following is a summary of the discussions that occurred at the annual meeting of the Canadian Advisory Committee on Remote Sensing, which took place at Arnprior, Ontario, between March 29 and April 1, 1982.

Objectives of the Meeting

The overall theme of the meeting was "The Future of the National Remote Sensing Program". The major topics to be examined were:

1. What are the major challenges and opportunities in applications?
2. How does technology meet the challenges?

As well as this, recommendations emanating from the provinces and the working groups were to be tabled and discussed.

Organization

The participants in the meeting (see Section 10 for a detailed list) representing the provincial and federal governments, industry, and the universities, formed four teams in the following discipline areas:

1) Agriculture, Forestry and Wildlife
2) Arctic Navigation and Oceans
3) Cartography and Engineering
4) Geography, Geology, and Water Resources

Presentations were made to the plenary session by invited speakers on the state-of-the-art in Canada at present in all these applications areas. Each speaker gave a brief overview of the status of current activities in Canada, emphasizing the results of successful projects, highlighting potential challenges and opportunities, showing the economic impacts of the technology, and winding up with recommendations on future plans.

These papers formed the basis of discussion in each of the four workshop groups, which themselves developed more detailed recommendations which were then presented and discussed in plenary session.

There was also a panel discussion in which five of the major Canadian companies involved in the technology of remote sensing were represented, to present the ways in which Canadian industry can meet the technological needs of Canadian resource managers.

RESULTS

The **Agriculture/Forestry/Wildlife** workshop, led by Dr. Peter Kourtz, (see recommendations 3.1.1 to 3.1.9) focussed mainly on the Canadian radar satellite program, expressing their strong support for RADARSAT and emphasizing the need for a complementary VIR scanner as the secondary sensor on the satellite. They also highlighted the need for money to be spent on applications research while the satellite is still in the planning stages, and suggested the establishment of a national microwave spectrometer/radiometer laboratory. They were concerned about the present low level of funding in forestry remote sensing research at the federal level, and also recommended that the Technology Transfer Office assess the best means of making remote sensing training materials available.

The **Arctic Navigation/Oceans** workshop, led by Dr. Jim Gower (see recommendations 3.2.1 to 3.2.10) concentrated to a great degree on sensor development. They emphasized the value of an optical sensor for RADARSAT, as did other groups, and also recommended more coordination and planning between the various government agencies which presently fund sensor development in Canada. They recommended better integration between CCRS and AES in the reception and distribution of AVHRR and CZCS data, and the inclusion of such data in MOSAICS correction. They expressed concern about the lack of microwave-related training in Canada and suggested the initiation of a series of workshop/courses.

The **Cartography/Engineering** workshop, led by Dr. George Zarzycki, (see recommendations 3.3.1 to 3.3.3) looked in detail at the problem of assuring continuity of data in light of the increases in reception and royalty charges recently announced by NOAA for LANDSAT. They recommended that royalty payments for LANDSAT products be considered as a common good and therefore that they not be recoverable from the user. They also recommended that in making plans to assure continuity of data, the government ensure that the price of satellite data will remain competitive with alternative methods. They also made specific statements about the parameters needed in future satellite systems in order to meet cartographic requirements.

The **Geography/Geology/Mining/Water Resources** workshop, led by Ms. Diane Thompson, (see recommendations 3.4.1 to 3.4.8) emphasized their support for a Canadian domestic satellite in order to assure continuity of data as well as to provide a better bargaining stance with other nations; given the existence of the RADARSAT program, they recommended the inclusion of a VIR scanner as the secondary sensor, to provide continuity of visible data. They also emphasized the need for proper archival of LANDSAT data, to provide the primary base for continuity of data. Further, they pointed out the need for coordination of training courses and facilities, and they suggested a live demonstration of image analysis systems at the Eighth Canadian Symposium on Remote Sensing (May 1983, Montréal).

CACRS REORGANIZATION

The terms of reference of CACRS and of the CACRS Executive were tabled for approval. The terms of reference for CACRS had been tabled the previous year in much the same format, but had been changed slightly at the suggestion of IACRS. The new terms of reference are included in this report in Section 2, but are subject to final approval by IACRS. The terms of reference for the Executive were approved as tabled.

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 early in the calendar year to review programs and make recommendations.

Terms of Reference of CACRS

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

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

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

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

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

   - evaluating the results.

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

   - promoting research and development activity

   - exchanging scientific and technical information

   - organizing conferences, seminars and training courses.

Structure of CACRS

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

Chairman:	Director General, CCRS
Executive:	An executive committee was established in 1981 with terms of reference and structure described below.
IPTASC:	The Interprovincial/Territorial Advisory Subcommittee of CACRS is a body of representatives appointed to CACRS on the recommendation of the provinces and territories.
Working Groups:	CACRS establishes such working groups as it deems necessary to carry out its work. Some of the groups may operate on an 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 CCRS.

Terms of Reference of the CACRS Executive

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

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

2. To decide on realistic methods of

implementing these recommendations.

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

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

5. To oversee special studies.

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

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

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

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

Structure of the CACRS Executive

The representation on the CACRS Executive is as follows:

Chairman:	Director General, Canada Centre for Remote Sensing
Provinces:	Chairman, Vice-Chairman, and Past Chairman, IPTASC, (Interprovincial/Territorial Advisory Subcommittee of CACRS).
Working Groups:	Two representatives elected by the working group chairmen, to be appointed for a two-year term.
Industry:	A representative of Canadian industry may be invited on an as-required basis to address a particular agenda item at an Executive meeting.
Universities:	The Chairman, Education Working Group.

3.0 RECOMMENDATIONS

These recommendations have been extracted from the Working Group and Provincial reports and from the reports of the workshop groups which met at CACRS. They have been considered by the CACRS Executive, and the comments of the Executive have in some cases been expanded upon by CCRS.

3.1 Recommendations from the Workshop on Agriculture, Forestry and Wildlife:

3.1.1 That a steerable VIR Scanner, with a resolution of 25m, be the second sensor on the RADARSAT satellite.

Comments on 3.1.1:

The supporters of this recommendation should submit a technical brief to the RADARSAT Office.

3.1.2 Whereas a need exists for satellite SAR data in supplementing the VIR monitoring of land resource (agriculture, forestry, wildlife), we strongly support the RADARSAT program.

Comments on 3.1.2:

This statement will be forwarded to IACRS and to the RADARSAT Office.

3.1.3 That CCRS ensure that adequate manpower and financial resources are identified in the future SAR program to support the development of operational land applications of RADARSAT data; for example, that a combined SAR/VIR agricultural experiment in Melfort, Saskatchewan be supported by CCRS and Agriculture Canada in 1983 as a high priority project.

Comments on 3.1.3:

CCRS would welcome a formal project proposal on this subject through the regular channels.

3.1.4 That as part of a long term Canadian microwave program, the feasibility of establishing a flexible microwave spectrometer/radiometer laboratory be evaluated, as a national facility which would be funded and maintained for use by Canadian investigators.

Comments on 3.1.4:

This recommendation will be considered by CCRS Management, including the RADARSAT Office. Other government departments which might also be interested in pursuing it will be informed through IACRS.

3.1.5 That the RADARSAT test line (Ottawa to Petawawa) be used as a standard test line for all CCRS airborne sensors and that all useable data be archived for use by interested investigators, and that the existence of this line be made known to all organizations testing airborne sensors.

Comments on 3.1.5:

This test line has been selected as convenient and as providing a suitable variety of imagery from a microwave sensor point of view. It is certainly possible to use it for other airborne sensors as well, but it may not be equally appropriate for the wide variety of sensors presently flown. This will be investigated and recommendations provided to those involved in sensor and applications development.

3.1.6 That CCRS assess the best means of making remote sensing training materials available.

Comments on 3.1.6:

This recommendation will be forwarded to the Technology Transfer Office, CCRS.

3.1.7 That CACRS express concern about the current level of support for federal forestry remote sensing research, and that it request that the Canadian Forestry Service increase activities in this very important area.

Comments on 3.1.7:

This recommendation will be forwarded to IACRS.

3.1.8 That a Chairman be appointed to revitalize the Forestry Working Group.

Comments on 3.1.8:

The Chairmanship of the Forestry Working Group has been accepted by Dr. Peter Murtha, University of British Columbia.

3.1.9 Now that TOPAS is entering its initial design and development phase, that an ad hoc committee be formed to ensure that there is continuous interface with and review of the program by users, and that this committee report to the Chairman of CACRS every six months.

Comments on 3.1.9:

This recommendation will be forwarded to the CCRS Project Selection and Review Committee.

3.2 Recommendations from the Workshop on Arctic Navigation and Oceans:

3.2.1 Because of the vital importance of secondary sensor choice on RADARSAT, that prior to consideration by the RADARSAT Review Board and taking of a final decision, members of CACRS be informed of the basis for the choice and be given time to make comments and recommendations.

Comments on 3.2.1 (See 3.1.1 above)

Individuals or groups with strong feelings on this question should present technical briefs to the RADARSAT Office before a final decision is made.

3.2.2 Although other sensors might have higher total priority for all interests represented by this group, nonetheless the group agrees that an optical sensor has value for ocean/ice (water colour, wide coverage ice imaging, continuity with current analyses) as well as for land. The group also feels that more cost effective designs than the thematic mapper may well exist (flexible parameters, solid state optics could be more useful for all projected applications), and therefore recommends that RADARSAT actively investigate the options for a baseline optical sensor design.

Comments on 3.2.2:

See response to 3.2.1.

3.2.3 In order to improve availability of meteorological and ocean imagery (especially AVHRR and CZCS), that AES and CCRS hold meetings to plan to improve and coordinate reception, distribution and archival. (AES already operates facilities at Edmonton, Toronto, with plans for Halifax; Shoe Cove will be concentrating more on this in the future; facilities for CZCS are needed.)

Comments on 3.2.3:

This recommendation will be considered by the CCRS Management Committee. It is understood that AES is actively interested in pursuing this.

3.2.4 That a DCP reception facility be established for the east coast; data is presently received at Shoe Cove, but is currently discarded.

Comments on 3.2.4:

See response to 3.4.8 below.

3.2.5 Since it is possible that government funded sensor development in Canada has resulted in fragmentation of industrial effort into several parallel projects that are not well directed at commercial markets, it is recommended that a working group be established to investigate this problem, and to recommend future action to all concerned, especially to funding agencies such as PILP, DSS and NSERC. Membership should include representatives of these agencies, as well as of industry, universities and government agencies such as CCRS, AES and DFO that are involved in sensor development. (The group cited possible examples in optical spectroscopy and microwave sensor development, where the viability of Canadian industry in international markets could possibly be improved by increased coordination.)

Comments on 3.2.5:

This recommendation has been referred to the PILP Committee for their comments and action.

3.2.6 In view of RADARSAT and related developments, that a microwave remote sensing course be organized in Canada along the lines of the digital image workshop; such workshops have now been successfully held on several occasions around Canada by a variety of instructors.

Comments on 3.2.6:

This recommendation will be referred to the RADARSAT Office for its opinion and advice.

3.2.7 Since there is a need for courses in Canada lasting between 3 days and one month, (such courses are currently given in the U.S.), that Canadian education establishments be assisted to develop such courses, particularly focussing on oceans and ice; such courses need to be held regularly, and advertised internationally.

Comments on 3.2.7:

The issues raised in this recommendation will be included in the terms of reference of the consultant hired to do a study of remote sensing education in Canada. (See 3.4.2 below.)

3.2.8 Since there is concern that during development of new digital capabilities for handling satellite images, the quality and throughput of present hardcopy products might suffer, that sufficient emphasis be placed on maintaining quality of these hardcopy photographic products.

Comments on 3.2.8:

This concern will be placed before the CCRS Management Committee.

3.2.9 That meteorological and ocean image formats (AVHRR and CZCS) be included in the design of MOSAICS to allow geometric correction of this data.

Comments on 3.2.9:

At present, MOSAICS is funded only to produce LANDSAT and SPOT data. Its design has been made sufficiently flexible, however, to allow for other data sources to be included as options when funds become available.

3.2.10 That consideration be given to monitoring RADARSAT bus position and attitude to sufficient accuracy to allow precision processing of image data with minimal use of land marks.

Comments on 3.2.10:

This recommendation will be referred to the RADARSAT Office. As in 3.1.1 and 3.2.1 above, the most effective way to influence the planning and development of RADARSAT is to present briefs to the Project Office and become actively involved in the planning process.

3.3 Recommendations from the Workshop on Cartography and Engineering:

3.3.1 Whereas the current LANDSAT imagery has a useful application in topographic mapping, that in considering future satellite systems, cartographic requirements be kept in mind and the following minimum characteristics be met:

1) resolution equal to or better than LANDSAT MSS
2) detection of cultural change equivalent to MSS band 5
3) detection of water features equivalent to MSS band 7
4) coverage of prescribed areas (i.e. 100-200 1:250,000 map sheets) in a time frame not exceeding two years.

Comments on 3.3.1:

The Chairman of the Cartography Working Group has agreed to submit a technical brief on this subject to the RADARSAT Office.

3.3.2 Recognizing that two potential methods of acquiring remote sensing data are either a national satellite program or an international arrangement involving royalty payments, and accepting the fact that the former would be considered a common good and therefore not recoverable from the data user, it is recommended that any royalties payable in the latter case also be considered a common good and therefore not recoverable from the data user.

Comments on 3.3.2:

This recommendation will be referred to IACRS.

3.3.3 Whereas Canada has the task of mapping the second largest landmass in the world and whereas satellite imagery is now being used operationally in a cost effective way in certain cartographic applications, it is recommended that:

1) the continuity of satellite imagery of the Canadian land mass be assured in a time frame and format suitable for operational uses
2) the price for the satellite data be competitive with alternative methods.

Comments on 3.3.3:

This recommendation will be referred to IACRS.

3.4 Recommendations from the Workshop on Geography, Geology and Water Resources:

3.4.1 Given the need for continuity of data, to have the capability of bartering with other satellite operating countries, and to maintain a viable Canadian remote sensing industry, it is recommended that Canada strongly support the RADARSAT Project.

Comments on 3.4.1:

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

3.4.2 It is apparent that there is a variety of training needs, both national and international, in remote sensing and that there is no co-ordinated source or mechanism for providing information on existing training courses. It is therefore recommended that the Education Working Group be re-established to consider needs and availability of courses, the Chairman of the Working Group not to be a member of an educational institution.

Comments on 3.4.2:

It is noted that the Education Working Group has been disbanded, with Dr. Philip Howarth remaining as rapporteur, until the CACRS Executive has examined the final report on Education presently being compiled by Dr. Howarth. This recommendation would require the involvement of more time and effort than is normally given by volunteer working group members, and therefore it will be referred to the CCRS Management Committee to see if funds are available to hire a consultant for this purpose. (See 3.2.7 above.)

3.4.3 Since continuity of LANDSAT data availability is essential, that high quality archiving of both processed and unprocessed LANDSAT data be established for good quality Canadian data over the LANDSAT period of record.

Comments on 3.4.3:

This recommendation will be referred to the CCRS Management Committee. See comments on 3.8.1.

3.4.4 Given the importance of visible and infrared data to many satellite data users in Canada, that the continuity of such satellite data be ensured, if necessary through inclusion of VIR as the second RADARSAT sensor.

Comments on 3.4.4:

The RADARSAT Office has established a group to consider the merits of various secondary sensor options. The supporters of this recommendation are encouraged to submit a technical brief to the RADARSAT Office to help this group with its work.

3.4.5 The formation of an Image Analysis Working Group, as recommended by the Data Handling Working Group, is supported. This Group should arrange for a 'live' demonstration of image analysis systems by the systems companies at the next Canadian Remote Sensing Symposium, possibly supported financially by the CCRS or Symposium Committee. This Working Group should arrange for the preparation of a brief description of the programs and capabilities currently available on image analysis systems in Canada.

Comments on 3.4.5:

This recommendation has been forwarded to the Chairman of the Eighth Canadian Symposium on Remote Sensing (Montréal, May 1983).

3.4.6 That the Treasury Board guidelines for evaluation of economic benefits be distributed to CACRS members, in order to promote the realistic evaluation of remote sensing cost-benefits in individual programs.

Comments on 3.4.6:

This document, "Benefit-Cost Analysis Guide", published by the Department of Supply and Services, is now somewhat out of date (published 1976). The summary, 5 pages, has been circulated to CACRS members. Those wishing the full book may order it from the Canadian Government Publishing Centre, Hull, Québec, K1A 0S9, Catalogue No. BT 35-2-1976.

3.4.7 In order to improve communications between aircraft and ground crew, that all CCRS aircraft be provided with air-to-ground communication facilities, and that ground sets be made available to field parties.

Comments on 3.4.7:

This is an ongoing problem for which adequate solutions are continuously being sought. "Air-to-ground" communications means something completely different depending on the area, the aircraft involved and the facilities available to the ground crew. Also of importance is whether the activity is strictly data acquisition, where all that the ground truth team wants to confirm is the exact time of coverage, or whether the activity is an interactive one involving activities on the ground affecting the imagery to be collected. CCRS has recently added FM communication capability to its Dakotas in an attempt to see if this will provide an improvement over conventional aircraft communications systems. Should this prove useful, its use will be expanded to the other aircraft as appropriate.

3.4.8 Given that data retransmission via satellite is an important remote sensing tool in Canada, that Energy, Mines and Resources (CCRS), in conjunction with the Interdepartmental Committee on Space, assess the vaiability of (1) establishing and operating a Canadian receiving station for DCP data; and (2) providing facilities for data retransmission on appropriate Canadian satellites.

Comments on 3.4.8:

A joint Working Group meeting on this subject took place in May, 1982. The Chairmen of the Water Resources Working Group and the Working Group on Oceans are preparing a brief that can be sent to IACRS. A preliminary draft policy has been received and the appendices to it should be complete by September.

3.5 Recommendations from the Province of Ontario:

3.5.1 Professor R. Parent of the Royal Military College recommends that the Working Group of CACRS on Engineering Applications have lab-exercise material based on actual studies prepared for civil engineering students at various levels.

Comments on 3.5.1:

The CCRS User Assistance and Marketing Unit will contact Professor Parent to discuss his needs.

3.5.2 The Ontario Centre for Remote Sensing commends CCRS on the quality of LANDSAT data production - with special mention of the excellent quality of colour composites - and on the efficiency of service; on the establishment of a well-funded office for technology transfer; and on the program to upgrade Canadian receiving stations for the next generation of satellite data.

Comments on 3.5.2:

This statement will be forwarded to IACRS.

3.5.3 Air, Earth and Oceans Ltd. recommends an improvement in communication among users of remote sensing data, through, for example, a more up-to-date national newsletter.

Comments on 3.5.2:

CCRS is doing the best it can with limited staff to prepare, edit, translate, and send out a national newsletter several times a year. Contributions from other agencies, the provinces, industry, and universities are welcome.

3.5.4 Kenting Earth Sciences Ltd. wishes to participate more actively in the national remote sensing program and proposes two members of its staff for membership in the Working Group on Geography.

Comments on 3.5.4:

The Working Group on Geography is at present a task-oriented limited-life group. The interest of Kenting Earth Sciences is noted, however, and it is possible that other working groups could use the new members indicated.

3.6 Recommendations from the Province of Nova Scotia:

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

Comments on 3.6.1:

The needs of the Atlantic Provinces are well recognized by CCRS. Discussions have been held with Nova Scotia and the other Atlantic Provinces to discuss coverage in more detail. Talks are underway with NASA and NOAA to ensure that coverage comparable to that from PASS will be available.

3.6.2 That CCRS through whatever means necessary, including transfer of funds from other programs, provide the necessary financial, equipment, data, and technical manpower to support a full scale technology transfer program.

Comments on 3.6.2:

This recommendation is noted and will be forwarded to the CCRS Management Committee.

3.6.3 Due to the greatly increased number of installed or soon to be installed image analysis systems outside the Ottawa area and also due to the deleterious price increases proposed for CCT's and DICS tapes, it is recommended that CCRS set up a more formalized lending library for those tapes already in their possession. In addition, it is recommended that CCRS make available an up-to-date list of the owners of all such Canadian tapes with complete information regarding image location, date, quality, etc. that the owner is prepared to release.

Comments on 3.6.3:

CCRS will be announcing a policy shortly on the lending of CCT's and DICS tapes. It is worth noting, however, that Canada must not appear to be evading the royalty fees imposed by NOAA for the use of data, since a more stringent and higher cost charging system might well then be imposed.

CCRS further feel that it is not appropriate for them to make public a listing of tapes or products ordered by individuals, companies, or agencies.

3.7 Recommendations from the Working Group on Data Handling and Satellite Technology:

3.7.1 a) That the Working Group be split into three full Working Groups: a Satellite Technology Working Group; a Computer Compatible Tape Working Group and an Image Analysis System Working Group (IASSWG).

b) That the IASSWG become an Image Analysis Systems Working Group with the IASSWG forming the nucleus of the sub-group concerned with analysis science and technology and a second sub-group being completed by some users of analysis systems; the IASSWG also recommends that the Chairman of the IASSWG be the Chairman of the new Working Group for continuity.

Comments on 3.7.1:

This recommendation was referred to the Chairman of CACRS for decision, and after discussion with many people, he decided not to implement it at this time. However, a new group called "Image Analysis Systems Users Group" will be formed with cross membership between it and the IASSWG.

3.7.2 CCRS should fund a study to investigate the requirements for an image analysis system network in Canada with an immediate objective of identifying the functions such a network could perform.

Comments on 3.7.2:

Any CCRS action on this recommendation will be delayed until the completion of a study related to this subject presently being conducted by the University of Alberta under NSERC funding.

3.7.3 CCRS should fund research and development in university on very long range problems to achieve future objectives for the Terra Observation Pattern Analysis System (TOPAS).

Comments on 3.7.3:

This recommendation will be considered by the CCRS Management Committee. In the meantime, CCRS recommends that universities interested in conducting such studies apply for appropriate NSERC grants.

3.8 Recommendations from the Geography Working Group:

3.8.1 That the highest quality and most representative LANDSAT CCT's be selected over the period of record for Canada and preserved in an archive for future reference.

Comments on 3.8.1:

CCRS is in favour of this recommendation but recognizes that considerable help will be needed. CCRS has agreed to set up a library of approximately 30 CCT's, to be available for educational purposes. In general, LANDSAT data is archived as a matter of course. CCRS is considering a program of preservation of early LANDSAT data against gradual deterioration of the original storage medium (HDDT's) over the years.

3.8.2 That CCRS work with appropriate agencies (e.g. Lands Directorate) on the further development of land use/land cover mapping and monitoring in Canada using LANDSAT data.

Comments on 3.8.2:

Considerable work on developing methodologies in this area has been done by the Ontario Centre for Remote Sensing, and it is therefore suggested that the initiators of this recommendation contact OCRS.

3.8.3 That continued emphasis be placed on the production of geometrically corrected (e.g. DICS) LANDSAT data.

Comments on 3.8.3:

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

3.8.4 That CCRS prepare suitable educational packages for remote sensing applications in geography for distribution to universities and other teaching institutions.

Comments on 3.8.4:

Their recommendation will be forwarded to the User Assistance and Marketing Unit, recognizing that much work in this area has already been done.

3.8.5 That the cost implications of the new generation of satellites for image processing and analysis, and the availability of systems adequate to carry out such analysis, be evaluated by CCRS and reported upon to the user community.

Comments on 3.8.5:

(See response to 3.4.5). The Methodology Section, CCRS, will be asked to report on this at the next CACRS meeting.

3.9 Recommendations from the Education Working Group:

3.9.1 Given the comparatively small amount of research funds available to universities through federal granting agencies, the anticipated increases in data costs will have a considerable impact on university research. It is recommended that CCRS and the Working Group on Education determine methods to minimize the cost increases for bona fide research projects.

Comments on 3.9.1:

Dr. Philip Howarth will draft a letter to NSERC pointing out the increased charges for LANDSAT data and asking for increases in funding to account for this.

3.9.2 Given that university and college instructors are actively involved with teaching on a long term basis, that CCRS involve educational institutions in workshops and technology transfer activities as much as possible.

Comments on 3.9.2:

CCRS takes note of this recommendation and welcomes the help offered.

3.9.3 Given that education is a provincial responsibility, it is recommended that CACRS require IPTASC members to actively explore with educational institutions ways in which they can aid remote sensing teaching and research in their provinces.

Comments on 3.9.3:

This recommendation will be referred to IPTASC through Victor Zsilinszky, who will report back on answers received at the next Executive meetings. It is to be noted that OCRS already coordinates activities with Ontario universities.

Comments on 3.9.3:

3.10 Recommendations from the Water Resources Working Group:

3.10.1 Since it is recognized that funding and software development were generally inadequate for data analysis for the SURSAT project, it is recommended that there be sufficient effort and funding available for data analysis capabilities for new data sources such as SAR, LANDSAT-D, and SPOT, particularly as they apply to the field of water resources.

Comments on 3.10.1:

CCRS agrees to study the incorporation of SAR, LS-D, and SPOT data in its applications development program. The identification of choice water resources projects with a high economic or social value by the Water Resources Working Group would be appreciated by CCRS as an input.

3.10.2 That Canada acquire a ground based scatterometer and radiometer system to carry out basic microwave studies in support of applications and development work. The capital cost and annual operating expenses, including a support staff dedicated to the system, would best be funded by a central agency. The facility is viewed as having one-half of its time being available to agencies and groups other than the central agency (e.g. CCRS).

Comments on 3.10.2:

See response to 3.1.4.

3.10.3 That water be recognized as a separate element and not put into workshop groups with land and land resources - there are land, water and marine elements.

Comments on 3.10.3:

The Executive has taken note of this recommendation for future CACRS meetings.

3.10.4 That there be improved coordination on airborne missions between crew and ground personnel; the aircraft should respond to the needs of the user and to do this properly, an understanding of "coincident ground data" in terms of hydrological applications is required by CCRS personnel.

Comments on 3.10.4:

CCRS wholeheartedly agrees with this recommendation. CCRS personnel involved in airborne missions continuously strive to better understand user requirements, particularly as relates to ground truth operations coincident with airborne coverage. In particular response to hydrological applications, CCRS plans to meet with users to better understand their requirements and to agree on appropriate procedures to ensure validity of the data collected.

3.10.5 In a truly national remote sensing program that there be consideration on how users can get remote sensing data in image or digital form from any source - including weather satellites - in real or near-real time. Again in a truly national remote sensing program, that there be serious support of not only LANDSAT type data collection, but also of systems useful to other applications - e.g. SMMR, altimeter, scatterometer, SAR - many of these apply to oceans and ice.

Comments on 3.10.5:

This recommendation will be forwarded to the User Assistance and Marketing Unit.

3.10.6 That Water Resource agencies be encouraged to make clearer statements of their needs and identify the benefits. (The WRWG tries to do this, but water resources is a big field). At the same time, CCRS should broaden their perspective as to what constitutes "water resources".

Comments on 10.6:

The executive feels that the Working Group on Water Resources is the best group to undertake this task. It would also welcome a broader definition of "water resources" from the Working Group.

3.11 Recommendations from the Working Group on Ice:

3.11.1 That CCRS obtain historical NOAA data from the U.S. Archives, for all Canadian land areas, offshore areas and to the North Pole (before this data becomes irretrievably lost).

Comments on 3.11.1:

This idea is being investigated by a CCRS/AES/DFO team.

3.11.2 That the Applications Division, CCRS, perform or cooperate in research related to machine classification of digital SAR data of sea ice.

Comments on 3.11.2:

A project is being developed to investigate this problem.

3.11.3 That the CCRS Data Acquisition Division devote the necessary resources to continue the systematic evaluation of the current SAR system (Ice W.G. Recommendation No. 1, 1980) so that more meaningful study of quantitative radar signals can be undertaken.

Comments on 3.11.3:

This activity is presently underway and is considered one of the high priority objectives of the airborne program.

3.12 Recommendations from the Working Group on Agriculture:

3.12.1 That a Canadian satellite provide repetitively on a 10-day cycle (or less), sun synchronous, contiguous coverage of the Canadian agricultural area during the entire April 1 to October 1 growing season.

Comments on 3.12.1:

See comments on 3.4.4.

3.12.2 That an imaging system collecting reflected energy in the Visible and Reflected Infrared portions of the spectrum, with a minimum spatial resolution of 30m, along with a recording device to store foreign data be carried as part of the Canadian satellite payload.

Comments on 3.12.2:

See comments on 3.4.4.

3.12.3 That Canada participate with any foreign country or agency in terms of satellite data acquisition to ensure a continuous supply of domestic and foreign imagery.

Comments on 3.12.3:

This recommendation will be referred to the CCRS Management Committee and to IACRS.

3.12.4 That the Canadian effort in the area of sensor development, satellite systems and cooperation with foreign governments and/or agencies not neglect the necessary support required for data handling, processing and distribution to the user communities.

Comments on 3.12.4:

This recommendation will be referred to the CCRS Management Committee and to IACRS.

3.12.5 That as a standard product, LANDSAT 185mm black and white positive transparencies be produced, on request, using any user-specified look-up table values. The Agriculture Working Group also recommends that as a special product such transparencies be produced from DICS tapes.

Comments on 3.12.5:

The feasibility and costs of producing these products are being investigated.

3.13 Recommendations from the Working Group on Engineering Applications:

3.13.1 That geometrically-corrected imageries, similar to those produced by DICS for the present LANDSAT data, be available for high resolution satellite imageries from the national facility.

Comments on 3.13.1:

See comments on 3.2.9. The MOSAICS project, which will be operational in 1986, will provide this data.

3.13.2 That the potential of mapping using SPOT imagery be investigated.

Comments on 3.13.2:

CCRS has indeed undertaken SPOT simulation programs to evaluate its potential for mapping.

3.13.3 That pilot projects using simulated imageries be conducted to investigate systematically their application to engineering studies and to demonstrate and document the benefits of digital analysis systems to those who presently rely on airphotos alone.

Comments on 3.13.3:

With the imminent launch of LANDSAT-D, CCRS and the user community will be able to use the actual LS-D data for evaluation. As far as SPOT simulations and SAR data are concerned, CCRS is indeed interested in incorporating a selection of projects in its applications development portfolio, subject to resource limitations. The identification of choice engineering projects with a high economic or social value by the Working Group on Engineering Applications would be appreciated by CCRS as an input.

3.13.4 That pilot projects be organized by the Working Group, involving personnel having relevant experience, qualification and interest. Projects should be carried out in conjunction with various agencies such as government, industry and educational institutions.

Comments on 3.13.4:

This activity should indeed be undertaken by the Working Group.

3.13.5 That test areas for such projects:

a) be located in different physiographic regions of Canada,
b) already have sufficient airphoto coverage and ground truth.

Comments on 3.13.5:

CCRS is in agreement with this recommendation.

3.13.6 That for Thematic Mapper imageries, the rendition which assigns blue, green and red to Bands TM 3, 4 and 5 respectively be available for all future pilot projects.

Comments on 3.13.6:

Such products will be available to the extent possible with the planned production facilities and at a cost yet to be determined.

3.13.7 That the most useful colour composite for analysing thermal signatures, water quality and rock types from Thematic Mapper imageries be defined.

Comments on 3.13.7:

CCRS agrees to include in its 1983-84 program, the evaluation of the most useful colour composites of TM data for a number of applications, including water quality and geology.

3.13.8 That the Working Group investigate, at the earliest possible date, the feasibility of having programs established in colleges and universities to meet the manpower requirements in satisfying future demands in high resolution satellite imagery programs.

Comments on 3.13.8:

CCRS encourages the Working Group to undertake this activity.

3.13.9 That the National Workshop on Engineering Applications be an annual event, held in rotation across the country to foster national interest and awareness in engineering applications of remote sensing.

Comments on 3.13.9:

There is considerable expense involved in this workshop. Under present financial restraints, it is probably impossible to make it an annual event unless additional sponsors or sources of funding can be found.

4.0 **REPORTS OF THE CANADA CENTRE FOR REMOTE SENSING**

Historical Highlights

1968

MAY: Meeting of Interdepartmental Committee on Remote Sensing of Earth Resources from Aircraft Satellites convened by Dr. L.W. Morley to discuss advantages of joint programs in remote sensing.

1969

JULY: The Program Planning Office officially established with Dr. L.W. Morley as Director.

1970

FEB.: First Montebello meeting to form the working groups of the Program Planning Office.

MAY: Cabinet Committee on Science Policy and Technology gave approval for EMR to negotiate a Memorandum of Understanding between EMR and NASA.

1971

JAN. 16-20: Second Montebello meeting to review reports of the working groups.

APRIL 1: Canada Centre for Remote Sensing officially established.

MAY: Agreement with NASA signed.

1972

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

JULY 23: LANDSAT-1 launched.

1973

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

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

APRIL: Manitoba Remote Sensing Centre established in Winnipeg.

SEPTEMBER: Ontario Remote Sensing Centre established in Toronto.

1974

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

APRIL 2-May 1: Second Canadian Symposium on Remote Sensing (Guelph, Ontario).

JUNE: Alberta Remote Sensing Center established in Edmonton.

1975

JANUARY 23: Launch of LANDSAT-2.

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

SPETEMBER 22-24: Third Canadian Symposium on Remote Sensing (Edmonton).

1976

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

1977

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

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

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

1978

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

MARCH 5: Launch of LANDSAT-3.

APRIL: Launch of HCMM.

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

JUNE 27: Launch of SEASAT.

JULY: ERIM SAR installed and operational in the Convair 580 as part of the SURSAT Program.

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

OCTOBER 10: Failure of SEASAT.

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

1979

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

OCTOBER: Digital Image Correction System (DICS) became operational at CCRS.

DECEMBER: Cabinet approved Canada's participation in ESA's Preparatory Program for a Remote Sensing Satellite, expected to be launched with a radar in 1987.

1980

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

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

MAY: Cabinet approved the arrangement under which CCRS aircraft may be leased by private industry for blocks of time

AUGUST: Dr. L.W Morley, who had been Director General of CCRS from its earliest days, resigned to become Science Counsellor at the Canadian High Commission in London. Mr. E.A. Godby, formerly Associate Director General, was appointed Director General.

SEPTEMBER: Publication of the Executive Summary of the SURSAT Project Report, summarizing results received. Recommendation made to establish follow-on RADARSAT Project.

1981

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

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

DECEMBER: Cabinet approval received for programs to; a) continue actively in the Co-operative Program for the European Space Agency's ERS-1 Satellite Program; b) upgrade the Prince Albert Satellite Station to receive LANDSAT-D; c) develop the LANDSAT-D Image Analysis System (LDIAS); develop the MOSAICS System (Multi-Observation Satellite Image Correction System).

SATELLITE PROGRAM

In 1981, the Prince Albert Satellite Station, PASS, continued to track LANDSAT-2, LANDSAT-3 and the NOAA series of satellites, and recorded some 1400 orbits. PASS completed the changeover from the of cibachrome photo-graphic process to the new cibachrome products which are receiving wide acceptance and praise by the user community. A computer compatible tape (CCT) system upgrade was also completed this year and allowed PASS to support user near-real time monitoring projects.

A display system was added to the system to provide a moving window display capability during reception and a display of CCT scenes for quality control analysis.

The LANDSAT-D program was approved and the station upgrades for reception and recording of the LANDSAT-D MSS and Thematic Mapper (TM) sensors was initiated in the fall of 1981. The letter from NASA/NOAA establishing the new fees, $600,000 per station, for LANDSAT-D was received in January 1982 and required rethinking of Canada's LANDSAT-D program. The LANDSAT-D program was altered as follows:

1) Prince Albert will be upgraded to receive LANDSAT-D MSS and TM data;

2) The present processing system at PASS, MIPS, will be upgraded and modified to process MSS-D data.

3) No TM data will be processed at PASS for the first year and a half. CCRS Ottawa will develop a simple TM transcription system for generating TM CCTs from TM HDDTs. There will be no corrections applied using this transcription system.

4) MDA of Vancouver is being contracted to develop a TM bulk processing system. This system will be ready in October 1983 and will generate TM bulk (system) corrected imagery and CCTs for Canadian users.

In 1981, Shoe Cove Satellite Station, SCSS, continued to track and record LANDSAT-2 and the NOAA series of satellites and recorded some 360 LANDSAT orbits and over 700 NOAA orbits. The SCSS system was still undergoing troubleshooting to eliminate speckling or noise occurring in CCT products of both LANDSAT and NOAA data. Major elements of the original system were replaced. Software was being rewritten to bypass the DVTR which was the station's early archive recorder. CCTs have been made with the new configuration and are being evaluated.

It had been planned to upgrade SCSS for LANDSAT-D but, with the new fee structure from NASA/NOAA, it has been decided to:

1) Receive and record LANDSAT MSS only at Shoe Cove until 1 October 1982. There will be no upgrades to SCSS for X-band reception of MSS and TM data.

2) Discontinue tracking all LANDSAT satellites on 1 October 1982.

3) Continue to track, record and archive NOAA data and complete system upgrade for enhanced NOAA products in late 1982.

4) Continue to supply archive data from the station.

LANDSAT MSS CCTs are currently available in two formats: the old CCRS universal format and the standard international format developed in 1978 by the LANDSAT Ground Stations Operator Working Group to facilitate exchange of remote sensing data from various sources. After the launch of LANDSAT-D, MSS and TM CCTs will be offered in the standard format only. CCRS is also producing SEASAT SAR and airborne SAR-580 CCTs in the standard format. And, shortly NOAA AVHRR and airborne MEIS II imagery will be available in the same standard format.

The demand for geometrically corrected high precision LANDSAT MSS products has continued to increase in 1981-1982. To meet this growing demand for DICS products, a second image terminal was added to the system in order to correct in parallel two images. In 1982-1983 the DICS system will have the capacity of producing 800 CCT products with faster turnaround time.

To facilitate the utilization of data from multiple complementary sensors such as LANDSAT MSS or TM and SPOT High Resolution Visible (HRV) sensors, and their integration with geographic information systems, CCRS has received approval in principle from Cabinet for developing with industry an advanced precision processing facility named MOSAICS, (Multi-Observation Satellite Image Correction System). MOSAICS will offer resource managers platform- and sensor-independent digital and film geocoded products. These products will be in the UTM projection, will have a sub-pixel accuracy in multi-temporal registration and in absolute geodetic control. MOSAICS is planned to become operational in 1985-1986.

Data Processing Support Program

The CCRS Synthetic Aperture Radar Processing (C-SHARP) system has been phased into production. The C-SHARP system can presently describe SAR-580 video signal data from HDDTs into CCTs and can digitally process SAR image data in the form of CCT or film products. The sensor data supported are the SAR-580 X, L and C-band and SEASAT-1 L-band. The systems processing capability is designed to be expandable to other SAR sensors as they become available. The Time Sharing System (TSS) and the combined airborne/LANDSAT playback system have continued to provide efficient and effective computer services:

1) by performing transcription, processing and quality assessment of satellite and airborne remote sensing data and products;

2) by providing an R&D facility for developing new products and simulating data from future missions such as SPOT;

3) by maintaining databases and reporting facilities for the LANDSAT image inventory (IISS), airborne operations, bibliographical searches (RESORS), project and materiel management, and remote sensing users directory and profile.

In 1981, TSS has been available 99% of the time and eight percent of system utilization was attributable to IISS and RESORS (remote) access by external users. At present, IISS contains over 200,000 LANDSAT scenes and RESORS has 33,000 bibliographical citations.

The Colour Image Recorder (CIR) product has continued to be offered on a user demand basis. There were some 850 CIR images produced in 1981. Digital enhancement techniques for applications such as rangeland, forestry as well as a standard enhancement have been developed and are currently being tested on the CIR.

AIRBORNE PROGRAM

Microwave Sensors

Substantial progress has been made improving the radar systems on the CV-580 aircraft. The integration of a new C-band transmitter and receiver was successfully accomplished early in 1981 and the new channel was used in Europe and in some RADARSAT experiments. Under lower backscatter conditions the signal-to-noise ratio of the C-band channel is not very good and a plan is now in place to upgrade the C-band system, particularly by the addition of a new antenna and feed structure. It is anticipated that the C-band system upgrade will be complete by the end of 1982. Further improvements in motion compensation and antenna control are also planned.

Processing of digitally recorded SAR data can be carried out now by both CCRS and the Radar Group at the Communications Research Centre. Present data processing rates are relatively slow. Optical processing of signal film has been performed by the Defence Research Establishment Ottawa and production processing of SAR imagery is expected to commence shortly.

The K-band profiling radiometer, on loan from NASA, is available on the CV-580 together with the Ku-band scatterometer as research systems to support SAR and microwave application research. A contract has also been let, supported by the RADARSAT Project Office, for the development of a new C-band scatterometer which will also be mounted on the CV-580.

Continuing sea ice radar application research has been carried out with data acquisition missions to the Beaufort Sea under both freezing and melting conditions. The objectives of this work are to gather the data which is necessary to describe accurately the capabilities of radar and to help develop better operational, airborne and spaceborne ice reconnaissance sensors. Particular attention is being paid to the problems associated with the quantitative use of SAR imagery for ice classification.

The CV-580 was also, as in previous years, leased to support the end of season drilling in the Beaufort Sea.

Visible and IR Scanners

Although the lidar bathymeter was not flown in 1981, the Canadian Hydrographic Service has determined, on the basis of the 1980 flight trials of photogrammetric and lidar hydrography over the Bruce Peninsula, that the lidar system can achieve the depth accuracy demanded by the international charting standard. The photogrammetric technique has been abandoned because of its poor depth accuracy, low reliability and severe operational constraints. The use of inertial navigation systems for the measurement of aircraft position and attitude during these surveys will be replaced by a microwave range/range positioning system and a low cost attitude-heading reference system from which data can be obtained rather more simply and accurately. A study of techniques to improve the depth accuracy of the lidar bathymeter is underway and the Canadian Hydrographic Service is now planning the development of a scanning lidar bathymeter.

The water quality model developed to interpret airborne MSS and NIMBUS-7 CZCS data has been extended to produce images of coastal water depths and bottom type. A data set, collected over the Bruce Peninsula test site, has been processed and will be evaluated by the Canadian Hydrographic Service.

In collaboration with the Canadian Coast Guard, the Environmental Protection Service and several oil companies, a remote sensing mission was flown over an oil spill dispersant trial off the Newfoundland coast. A digital IR/UV line scanner with the newly developed real time display, the low light level television, the laser fluorosensor and annotated photographic cameras were carried on a DC-3. The principal outputs of the project were a series of images depicting the evolution of the spill; and a data catalogue which will allow other agencies to access the data is being prepared.

An attempt was made to fly the laser fluorosensor as an operational sensor on a number of external projects last year. None of the data acquired were completely satisfactory because the users were investigating targets other than hydrocarbons on water for which the CCRS system was optimized. Because of the lack of user support and resources in the Centre, the fluorosensor development project will be terminated in the summer of 1982 and the sensor withdrawn from service.

The OMA, MPPH and the single channel IR line scanner were not flown in the last year.

A special dual channel IR detector operating at 1.55-1.75 m and 2.08-2.35 m will be available for LANDSAT-D simulations on the MSS beginning this spring.

The single channel line scanner will be upgraded to acquire 3 or more channels of data as part of a gradual conversion of all systems to digital recording. The principal applications are expected to be those requiring an IR and UV or a multichannel IR capability.

The pushbroom imager will be delivered this spring and will undergo an extensive series of laboratory and airborne trials before being offered as a production sensor in the spring of 1983. The imager, which presently has 5 channels defined by filters in the visible part of the spectrum, will offer higher spatial resolution and radiometric sensitivity than existing rotating mirror scanners.

Aircraft Systems

The Mincom tape recorders in the aircraft are being replaced by Bell & Howell recorders. It is expected that this upgrade will alleviate many of the reliability problems which have been experienced over the past two years. A new data acquisition system, MAID, has been developed for recording precision navigation and other housekeeping data. To reduce the number of steps in the data reduction process, MAID will write directly on computer compatible tape. These tapes will be converted to standard disk files which are accessible to the existing software on the CCRS PDP-10 time sharing system. MAID will be available on the Falcon this spring and a special version capable of logging SAR parameters will replace ADAS on the CV-580 by early summer. MAID data will be used principally for aircraft track recovery and the geometric correction of MSS imagery.

A new camera annotation system has been developed for use with the RC-10's and specially modified Hasselblads. Each frame is annotated with aircraft number, date, time and position. The system is stand-alone, accepting data directly from the LTN-51 and the time code generator.

The Falcon has been reconfigured, limiting its operations to MSS data acquisition projects. The sensor complement can include the MSS, two annotated RC-10's and the MPPH. MAID and a Bell & Howell tape recorder complete the package. The great demand for MSS data during the summer months, the complexity of the installation and the limited resources at the Centre have necessitated the reduction in flexibility of the sensor package; an analogous situation is found on the CV-580 in which only microwave projects are now flown.

Software has been developed for photogrammetric bundle adjustments using inertial data. Although the software is not available for production use, the understanding developed in the course of its development has suggested a new method of processing aircraft navigation data for track recovery and a novel, highly cost-effective method for carrying out the geometric correction of airborne electro-optical imagery. A new track recovery software package will be available for production use early in 1983 and work will begin shortly on the geometric correction problem.

Airborne Operations

The attached list summarizes the utilization of CCRS aircraft during the last year. There are four classes of airborne task:

Internal: internal CCRS tasks for applications and sensor development.

External: usually applications development projects proposed by external users (industry, university and government) which were flown at the subsidized rate of $18.50/-line mile.

Lease: projects for which the aircraft are leased through Innotech Aviation. The two major projects in this class were the SAR-580 European Campaign (159 hours) and the SAR-580 support of drilling operations in the Beaufort Sea.

Co-op — tasks requested by other federal government agencies for which the full operating costs are recovered. There may be projects in which non-CCRS systems are flown (e.g. the DREO multi-channel IR line scanner, the DRES laser terrain profiler and the AES laser ice profiler) or very large projects which cannot be supported by CCRS without additional resources. Flying for the RADARSAT project falls in this category.

The 20% increase in aircraft utilization over the previous average may be attributed largely to the SAR-580 European Campaign.

The number of hours flown on external projects has been decreasing slowly over the past few years. There are a number of possible reasons for this: the service is no longer being marketed aggressively, there is a growing commercial capability, and the data reduction and interpretation has become very sophisticated and costly.

Aircraft operating costs have increased. Users should anticipate an increase of approximately 35% on the charges for services offered by the Airborne Program beginning April 1st, 1982.

CCRS Aircraft Utilization F/Y 1981/82:

Category	No. of Tasks Flown	A/C Hours Flown
Internal (CCRS)	17	257
External	22	119
Lease	7	276
Co-op (with other Gov't Dept.)	20	130
Total	66	782

Average yearly aircraft utilization over previous two years -- 657 hours.

The following is a breakdown of <u>External</u> projects flown:

Discipline	No. of Tasks Flown	A/C Hours Flown
Agriculture	2	21
Forestry, Wildlife	9	33
Geography	2	2
Geology	4	37
Limnology	1	13
Oceanography	1	5
Sensor Testing	1	1
Environmental Impact	1	6
Miscellaneous	1	1

Province	No. of Tasks Flown	A/C Hours Flown
British Columbia	2	8
Alberta	3	14
Saskatchewan	2	30
Ontario	8	24
Quebec	2	10
New Brunswick	1	9
Nova Scotia	2	9
Various Provinces	2	15

APPLICATIONS PROGRAM

LANDSAT-D Image Analysis System

A major initiative was begun in the past year to develop a state-of-the-art image analysis facility to handle Landsat-D Thematic Mapper data. Cabinet approval was received in May 1981 and Treasury Board authorization in February 1982 to develop this Landsat-D Image Analysis System (LDIAS). The system is being designed to effectively analyze the Thematic Mapper data which has seven spectral bands and an increased spatial and radiometric resolution over the multispectral scanner on the present Landsat satellites. Hardware acquisition and research on Landsat-D image analysis algorithms has begun. A VAX 11/780 will be the host computer for this system, supplemented by the necessary high speed processing equipment required to meet the functional specifications.

A second major project received cabinet approval in 1981. The objective of this project is to develop the methodology to integrate geographical and remotely sensed data. As remotely sensed data becomes more commonly used, in conjunction with other data sources in resource management systems, it will be necessary to effectively combine the various data types. In this manner it will be possible to make resource management decisions more efficiently, using all the available information. The program definition phase of the study has been funded for three years.

Applications Development

During 1981 the Applications Division continued to work in conjunction with other Canadian companies and agencies to find new and better ways to assess and monitor environmental change.

In 1980 CCRS reported on experiments carried out in cooperation with Alberta Energy and Natural Resources and Alberta Environment, to develop an enhanced Landsat colour image product to assess rangeland conditions. The success of this experiment led to a 1981 request for Landsat enhancements covering twenty-two range areas in Southern Alberta. These data were used operationally by the field staff of the Public Lands Division of Alberta Energy and Natural Resources.

This operational success in Alberta led to demonstrations of the use of rangeland enhancements to the PFRA (Prairie Farm Rehabilitation Association) in Saskatchewan. As a result of a demonstration project carried out under contract, in cooperation with CCRS and PFRA, Saskatchewan has requested data for fifteen large range areas for the 1982 grazing season.

On the research side of the project, an experiment was carried out to evaluate the application of LANDSAT enhancements to the fescue prairie. The work was carried out at the University of Calgary, with data and analysis support from CCRS, and funding by the Alberta Remote Sensing Center. Workshops are planned for 1982 to train the range management community in the use of the technology.

Research on potato area estimation in New Brunswick was continued in 1981. With CCRS assistance, Statistics Canada staff used LANDSAT data to generate a timely crop area estimate by early September. As in 1980, the estimate produced by means of digital analysis of Landsat data was closer to the published figure than any of the conventionally produced estimates. Plans are underway to extend coverage to a much larger area in the 1982 crop year.

Following on from earlier spectroscopic work on Canola-rapeseed, a joint CCRS-Statistics Canada project was aimed at developing and applying crop area estimation procedures for this major oilseed crop. Methods were developed which use either standard LANDSAT digital data or Digital Image Correction System data. A timely and accurate estimate was made in the B.C. Peace River District, while a much larger area was evaluated in the Alberta Peace and Crop District 4a. The project was co-sponsored by the Canola Council of Canada and both the Alberta and British Columbia Governments.

A joint project was undertaken with the Canadian Wheat Board, Statistics Canada and Agriculture Canada to assess whether, and to what extent, satellite remotely sensed data can be used to assess crop condition. Extensive work has been carried out during the past year using NOAA AVHRR (Advanced Very High Resolution Radiometer) (spatial resolution of 1.1 km at nadir). This sensor appears to be an excellent complement to the LANDSAT Multispectral Scanner (MSS) giving a synoptic overview that can be used to direct the analysis of the higher spatial resolution MSS data.

Work has continued in the past year on the assessment of the ability of microwave imagery to distinguish between vegetation cover types. This is being carried out as part of a joint venture between CCRS and DFVLR in Germany.

CCRS initiated a project with the Geological Survey of Canada (GSC) to assess the potential of Landsat data in producing maps of surficial geology. To evaluate the procedures a wide range of Canadian northern environments were selected. Preliminary results indicate that two methods will be useful. In environments where vegetation patterns reflect the surficial sediments, supervised classification is highly successful in discriminating most surficial units at a scale of 1:125-000. In other areas, such as the Boreal Forest and the High Arctic Islands, where sediment vegetation relations are not clear, enhanced Landsat imagery is useful in delimiting boundaries and discriminating units such as gravel. rock outcrop, turbid water and organic terrain (bogs).

In co-operation with the Nova Scotia Department of Lands and Forests (N.S.D.-L.F), CCRS commenced a project to monitor forest change in Nova Scotia and to use this information in updating a forest inventory. The change detection project was carried out in two areas of the province: Cape Breton Highlands, a region typifying softwood forests, and Guysborough County, a region typifying mixed and deciduous forests. The detection procedures made use of multi-temporal overlays (two and three summer dates) followed by supervised classification. Preliminary results indicate a high accuracy in clearcut detection, but estimates of selective cuts were not consistent.

In June 1980, CCRS contracted the planning and coordination of a project to demonstrate the application of remote sensing methods to meet the information needs of an industrial woodlands operation. An industrial partner was selected as the cooperator and participant in all stages of the project. A workshop was held in Fredericton in November 1981 to present the results of the project to other forestry companies in Eastern Canada. It is planned to present the results at other industrial association meetings in 1982.

CCRS has continued to support provincial agencies, companies and educational institutions interested in local sponsorship of digital image analysis workshops. During the past year workshops have been presented in Ontario, Nova Scotia, New Brunswick and Quebec. Additional workshops are being planned for 1982.

The operation and development of the Remote Sensing Online Retrieval System (RESORS) is continuing with the support of CCRS contracts. The document database has grown to 33,000 citations and the slide database to 4,000. During 1981, over 6000 searches were provided to users upon request. The system is now accessible on the DATAPAC network, and is being routinely searched from as far as Australia.

International Activities

During the past year Applications Division's involvement in various international activities has remained modest but very active. Numerous international delegations have been received and introduced to CCRS capabilities. Technical missions from several countries including Argentina, the Peoples Republic of China, Malaysia and the Philippines have been hosted for more extensive discussions concerning Canadian remote sensing capabilities.

Support of CIDA development projects has continued. Work continues toward the goal of a West African remote sensing centre. The long-standing cooperative project with Peru has been brought to a successful conclusion. It appears likely that CIDA will approve a Peruvian proposal to continue this close tie with Peru with the goal of increasing Peruvian technical independence in remote sensing over the next three years.

In support of Canadian industry, CCRS has provided intensive training opportunities to visiting experts from Argentina and Thailand. This type of international support contributes in a positive way to the image of Canada and our industrial capabilities in overseas markets.

Within the limits of mandate and resources, it is anticipated that CCRS Applications Division will respond to an ever increasing number of requests for international support and involvement. The benefits to Canada from such activities have been such that continuing involvement is highly desirable and likely.

Technology Transfer Program

An interdepartmental remote sensing technology transfer program was approved by Cabinet in March, 1981, and Treasury Board approval was granted in late September, 1981. The long-term goal of the technology transfer program is to contribute to a widespread, regular use of remote sensing data and methods for the inventory, monitoring and management of Canada's land and water resources. In a given region or province, the program will be organized as a joint effort of federal agencies and provincial/regional resource management agencies, but other agencies (industry, universities) will also be involved. A new section, the Technology Transfer Office (TTO) has been established in the Applications Division of CCRS. Although the initial work has been carried out by seconded personnel, the TTO will soon be staffed by newly hired personnel.

Since the approved resources permit the program to start initially in one province only, preliminary discussions with the provinces and territories took place to ascertain their relative interests and needs. As a result of this assessment, IPTASC and CCRS agreed that the Maritime provinces (New Brunswick, Nova Scotia, Prince Edward Island) as a region, and the Province of Manitoba are the two best candidates for the first technology transfer program. Subsequently, more detailed discussions took place between CCRS and these provinces to develop a preliminary plan for the technology transfer program in each region. This includes specification of demonstration projects, the involvement of end user agencies, and the contribution of resources to the joint program. It is expected that the final choice will be made on the basis of the preliminary plans by late April, 1982. The program will start in the first province or region in early 1983 and will last approximately three years. If the program is successful (and subject to the approval of additional resources) an expansion into two other provinces is anticipated in 1984.

CANADA'S RADAR SATELLITE PROGRAM

Introduction

Canada is pursuing a role in remote sensing satellites by developing the capability to build airborne and spaceborne synthetic aperture radars (SAR) and high speed digital SAR processors, cooperating in the European remote sensing satellite program (ERS-1), and performing the Phase A technical and economic studies for a radar satellite system, RADARSAT.

Since 1976 a serious effort has been made in Canada to concentrate on synthetic aperture radar (SAR) as the primary sensor to provide information over the frozen and open oceans bordering Canada, and in support of information needs in forestry, geology, hydrology and agriculture. During the period 1977 to 1979 through its SURSAT project, Canada participated in the NASA SEASAT program. Despite the early failure of SEASAT, 35 SAR orbits were recorded at Shoe Cove and 80 SAR orbits obtained over western Canada from U.S. recording stations.

In the same timeframe, CCRS acquired the ERIM multi-channel SAR, modified it, and installed it in their Convair 580 aircraft. The aircraft flew over 530 hours in fulfilling the data acquisition needs for approximately 100 experiments. The majority of the aircraft SAR data was optically processed by ERIM. Late in the project a real-time digital processor and digital recording capability provided a limited quantity of digitally processed data.

The experience of both aircraft and spacecraft SAR in serving Canadian needs as demonstrated in the SEASAT and SURSAT projects was sufficiently persuasive that both the airborne and the national satellite SAR interests of Canada are being extended. The SAR 580 was fitted with a third frequency - C-band (d = 5m) - in 1981, and there has been a commitment to Phase A of the RADARSAT Program (1981-1990), which is outlined below. These national activities are in parallel with and complementary to the participation of Canada in the ERS-1 microwave remote sensing satellite program.

Applications

Canada has diverse requirements for monitoring human activities and environmental phenomena in ocean and remote areas. Such requirements include location and identification of ocean traffic, data on the type and extent of ice coverage information for preparation of weather and sea-state reports and forecasts, and location and identification of ocean pollution. The increase in exploration and development activities offshore and in the Arctic and the extension of jurisdictional limits offshore created an increased need for regulatory data.

In general, regulatory data is required on a regular, frequent basis. Consequently for the Canadian North, only sensors which can penetrate cloud and operate in both darkness and daylight are applicable. The SURSAT Project thus considered only microwave sensors and gave particular emphasis to synthetic aperture radar (SAR) since this is the only microwave sensor capable of providing high resolution imagery from space.

The major effort of the SURSAT Program was directed toward performing a set of experiments to assess the feasibility of satisfying monitoring requirements via satellite and gaining experience in microwave satellite technology. The principal technical activities were participation in the NASA SEASAT satellite project by installation of reception and rewriting equipment at St. John's, Newfoundland and by developing a high quality digital image processor for the SAR data. Also the "SAR-580" facility was created - a Convair 580 aircraft equipped with a four channel X and L-band synthetic aperture radar, optical and digital recorders, and real-time X-band digital processor.

SURSAT Experiment Results

The following principal results were obtained:

Experiments dealing with surveillance of human activity were largely concerned with detection of ships on the ocean using SEASAT and airborne SAR data, detection of ocean pollution, detection of selected human activities on land and ice, and applications of SAR data to search and rescue tasks. For activities that involve objects on the surface, such as seismic lines or fishing vessels, experiments suggested that finer resolution, shallower incidence angle, and a shorter wavelength were required, as compared to the 25 meters resolution, 20° incidence, and 23 centimeters wavelength of SEASAT. Detection of oil spills was verified using radar, but subtle distinctions of petroleum slicks from natural phenomena resembling oil slicks required further work.

Normally not considered an accurate mapping tool, SAR, as flown on SEASAT and as processed digitally produces imagery that meets high standards for cartographic accuracy. For flood mapping, it was found from the Red River near Winnipeg that SAR imagery was superior to air photography because of its consistent tone contrast, its ability to show flooded wooded areas, and because wet soil had a similar appearance to standing water in aerial photographs. In surficial and structural geology, the results confirmed the usefulness of SAR and in particular led to the discovery in Nova Scotia of evidence of volcanic activity through structural features not previously known. Also, SAR data in combination with optical multispectral data could greatly increase the ability to discriminate between agricultural crops.

Ice and ice related applications are the most important information needs to be addressed by a SAR system for Canada. The project grouped 19 ice related proposals into 3 major experiment areas, located in the Beaufort Sea, the Baffin-Labrador Seas, and the Gulf of St. Lawrence.

Under summer melt conditions, SEASAT L-band SAR imagery of sea ice is relatively featureless while airborne X-band SLAR imagery over identical ice fields show topographical features clearly. The effect of the low SAR incidence angle combined with presence of surface melt water is presumed to be responsible for this difference.

During freeze-up conditions, information available from SEASAT SAR is much improved. Identificable ice types included old, first-year, and young ice. Smooth floes of second year, often not identifiable on SLAR because of high incidence angles involved, also showed a unique signature. Newly formed ice showed on open-water areas as regions of no sea clutter.

Open-water areas provided strong sea clutter returns, often more so than adjacent ice surfaces, resulting in a reverse image from that normally observed in SLAR. In the vicinity of ice floes, open water often showed a margin of low sea clutter along one side of the floes. This effect was confirmed in several cases to be associated with wind directions.

From the examination of other optically processed data, it is quite evident that the dynamic range of first-year and multi-year ice equals the dynamic range of new ice. This makes it virtually impossible to classify sea ice at L-band frequencies based on backscatter alone. Using shape and texture does, however, permit the interpretation of a large number of ice types and features.

Future of Canadian Programs

Canada is moving firmly ahead in its domestic airborne SAR development program, a domestic SAR satellite project, and on cooperative international activities such as ERS-1. These all are seen to be complementary, and beneficial to the long term needs in Canada.

The major project is RADARSAT, for which there are three elements: mission requirements definition supported by aircraft SAR experiments; a Phase A concept study which analyses spacecraft and ground system alternatives that respond to the user requirements; and research and development of radar technology.

The objectives of the RADARSAT Project are:

- To perform the Phase A technical and economic studies necessary to define a radar satellite implementation program that would provide a limited operational capability to supply timely ice information for selected Arctic or east coast operations, and provide research data and operational data to meet selected land and ocean requirements. The satellite payload consists of an imaging radar plus one or more of the following secondary sensors: scatterometer, optical imager, scanning microwave radiometer and altimeter.

- To develop Canadian industrial expertise in spaceborne radar technology through a research and development program, so that a radar satellite including radar systems and major sub-systems in space and ground processing can be built in Canada.

- To develop program options for the satellite radar and secondary sensors, including international cooperation with other space agencies or companies, and cost sharing arrangements with domestic and foreign data users.

The Canadian requirements for the mission have now been identified and reported. This work was performed in collaboration with NASA, who identified the U.S. requirements. Bilateral teams were established for the discipline areas: ice, oceans, renewable and non-renewable land resources. In general there was good agreement between the requirements of the U.S. and Canada in each individual discipline but greater disparity between the disciplines. The RADARSAT technical study is responsive to these requirements by adopting a multi-beam radar approach.

The overall concept for the Canadian radar satellite program is as follows. It is an end-to-end system that starts with a satellite in an inclined polar orbit transmitting signals from its wide swath SAR to ground receiving stations, where the data is converted into digital images. The image data is relayed via communications satellite (ANIK) to an ice-information centre, where other data such as from aircraft SAR or weather satellite is incorporated to provide a forecast of ice conditions. The forecast is again relayed by communications satellite to the tankers and other users in the form of annotated images.

The spacecraft will consist of a 3-axis stabilized platform with sufficient power and weight capacity to carry a C-band or L-band SAR and complementary microwave or optical sensor. In addition the transponder for search and rescue mission might be carried. Preliminary studies of existing spacecraft buses have shown that there are several which could be adapted for this mission. The spacecraft would be designed for a 3-5 year life, with further spacecraft launched depending on the user needs and success of the program. Three or four satellite would be needed to provide an operational service from 1990-2000. The baseline parameters for the radar payload are a swath of 150 Km. or greater with a resolution of 25 to 30 metres at 4 looks and an incidence angle of 30° to 45°. Preliminary orbit studies have shown that with this swath width it is possible to obtain twice-daily coverage over the primary Arctic transportation corridor, the North-West Passage. Coverage options may be extended through the use of a variable incidence angle antenna.

Direct telemetry will be sent to one or more Canadian ground stations. They will be equipped with hardware SAR processors, with sufficient throughput to maintain zero back-log for the areas requiring near real time response plus a reserve capacity to deal with back-up load-sharing between stations. The ice-information centre will house image analysis facilities that will enhance ice features in the images, and add annotation to show the location of ice-fields, the wind vectors and other information obtained from aircraft data. The total data handling time between acquisition of satellite data to delivery to ships must occur in 2 to 4 hours. A mission control facility will be used to monitor spacecraft performance, command orbit adjustments and schedule sensor coverage.

In order to develop Canadian industrial expertise in spaceborne SAR a substantial development program has been initiated. An assessment of the radar components needed and the difficulty of building a space-borne radar at either C-band or L-band has been undertaken. As a result of this work, digital processor studies and the preference of the mission requirements teams, a C-band space-borne radar was selected for RADARSAT.

Design studies are now underway on all major aspects of a space-borne SAR. Bread-board versions of several transmit-and-receive radar electronic subsystems are under development. Future work is planned in antenna structures and deployment, and high power amplifier tubes.

Development of high speed arithmetic elements for SAR processing is nearing completion. A high speed processor capable of ½ speed operation on C-band satellite radar will be designed and built.

A C-band scatterometer has been studied and will be built by late '83. The design and construction of advanced digital C-band dual-polarised aircraft SAR is planned by late '84. The aircraft SAR will be used to provide SAR system expertise, for use in a satellite support role, and for direct field use by industrial operators. The scatterometer will be used to determine radar backscatter coefficients of terrain, ice types, and open oceans for the satellite radar design.

The current project is planning for a RADARSAT launch in 1990 with an estimated cost on the order of $300 M This is an ambitious program and will probably require offsetting contributions from industry and other international partnerships. The project is actively talking to other nations, and the oil and gas industry in Canada to negotiate satisfactory cost sharing. The results of these negotiations will be incorporated in the Phase A documentation late in 1982, which will form the basis of Phase B development and final project definition in 1983 and following years.

Conclusions

Canada's interest in SAR has been increasing since 1976, and is now substantial, evidenced by national commitment to Phase A of a SAR satellite project in addition to domestic airborne and international SAR activities. The SEASAT experience was very positive, establishing a solid base of processing technology and informed users in Canada. There is a well recognized need for SAR information products, particularly in the Arctic, where reliable and routine weatherproof surveillance is essential.

MULTILATERAL MEETING

Canada hosted the first Multilateral Meeting in Ottawa -- May 8-9, 1980.

The purpose of that meeting which was attended by representatives from the U.S.A., Japan, France, ESA and Canada, was to explore how greater compatibility and complementarity could be achieved in spaceborne systems.

The participants agreed: (a) to sponsor 3 regional technical conferences (one in Africa, one in S.E. Asia and one in South America); (b) to exchange long-term planning information; (c) to have a follow-on meeting in a year's time. The follow-on meeting originally scheduled for Spring '81, is now scheduled to be held in Paris under ESA sponsorship on May 12-13, 1982.

The Canadian delegation will be led by Dr. K. Whitham, Assistant Deputy Minister Research and Technology Sector, EMR.

5.1 REPORT OF THE WORKING GROUP ON AGRICULTURE

AIRBORNE REMOTE SENSING

The successful application of 35-mm color IR prints in stereo for classi-tying botanical communities under rangeland conditions illustrates the feasibility of studying vegetation growth and management practices in field and for field plot experiments. The camera system is readily adaptable to aircraft which are found at most small airports. It enables the spectral data to be obtained at the right stage of vegetative growth or state of disease infestation. At low altitude (< 1000 ft AGL) excellent IR images may be an acquired even under dense cumulus cloud cover with automatic exposure system. Vertical and oblique VIR 35-mm photos were used in assessing range productivity in the north-eastern pasturelands of Saskatchewan, southern Alberta and interior range of B.C. Other small format camera systems (50 and 70-mm) were used in studying extent of leafy spurge in Manitoba, knap-weed in the B.C. interior range, grasshopper damage in Saskatchewan, and effort of soil erosion and changes from drainage. Detailed land-use studies were carried out in Eastern Ontario. Large scale format (280-mm) Color IR was acquired over the ground reference points in the three prairie provinces (42 sites) for the Crop Information System Landsat analyses program.

SPACEBORNE REMOTE SENSING

Landsat imagery was used for assessing potato acreage in New Brunswick and the results compared favorably on a pilot operational basis. Introducing modified radiation enhancement procedures in the non-red/IR portion the spectrum has increased the ability to interpret over-winter grazing conditions in the rangelands of the Brown Soil Zones of southern prairies. Overlaying Land Resource and Legal Survey information registered to Landsat imagery provides a capability of assessing crop management practices for specifically selected fields within identified municipalities. The high incidence of cloud cover continues to preclude widespread adoption until more frequent orbital passes are available or microwave imagery becomes available for current crop assessment.

TECHNICAL AND SCIENTIFIC DEVELOPMENT

Preliminary interpretation of the two visible infra-red bands from the NOAA meteorological polar orbiting satellite indicates it to be useful for determining changes in areal distribution of green vegeta-tion on a regional basis during the summer. The low resolution of the imagery provides a rapid analyses of the vegetative condition for a large area (eg. 600x600 miles) several times a week. The changing orbital paths, however, do not allow at present for rapid temporal registration (Cooperative Demonstration Cereal Crop Project - CCRS).

Special radiation enhance-ment procedures were developed for analyzing rangelands of the southern prairies. Assessing the potential productivity of these areas requires the determination of matured vegeta-tion. Thus, enhancement of bands other than the chlorophyl-sensitive bands are required (eg. blue, green).

Research on the correlation of the primary vegetation bands to Leaf Area Index (LAI) and associated vegetative growth conditions was carried out. Detailed studies were carried out on relation of the red band to crops using densiometric data from specially filtered black and white airborne photography.

No further airborne radar studies were acquired pending return of the Convair 580 (CCRS) to Canada and its availa-bility during the entire growing season.

USER LIAISON AND TRAINING

A number of cooperative demonstration projects between the CCRS and other agencies in Canada assisted in providing expertise and image analyses facilities for assessing acreage of potatoes in New Brunswick range productivity in southern Alberta and canola acreage in Peace River Region.

The tenth Agriculture Working Group was held in Fredericton, N.B., November 1981. Papers on Remote Sensing Application using 35-mm aerial photography were presented and Potentials and Limitations of Satellite data in crop identification was presented at the meeting along with review of work being carried out across Canada.

RECOMMENDATIONS

A. RADARSAT PROJECT

Whereas the entire growing season (April 1 to October 1) is the crucial time frame for agricultural applications of satellite remote sensing data and not just the relatively short period when crops are at their maximum photosynthetic activity, and

Whereas agricultural target calendars indicate relatively rapid, significant changes in the spectral character of crops, many of which are not manifested by changes in surface roughness or dielectric constant, and that the time-frames for image acquisition for various applications are relatively narrow (less than 14 days), and

Whereas LANDSAT-D may be the last of its series and other proposed satellite imaging system would not provide contiguous coverage, and

Whereas considerable funds and successful effort have been expended in the application of current LANDSAT data to crop inventory and monitoring based on continual contiguous coverage with VISIBLE/Reflected IR imaging systems,

The Agriculture Working Group gives its full endorsement to the recommendations of the Renewable Land Resource Study Team of the RADARSAT Project and further recommends that:

1) A Canadian satellite provide repetitively on a 10-day cycle (or less), sun synchronous, contiguous coverage of the Canadian agricultural area during the entire April 1 to October 1 growing season:

2) An imaging system collecting reflected energy in the VISIBLE and Reflected INFRARED portions of the spectrum, with a minimum spatial resolution of 30 m, along with a recording device to store foreign data be carried as part of the satellite payload: (The Agriculture Working Group recognizes that such a system could be de-activated during the winter, over oceans, or over clouded areas and that at such times a non-imaging system could be activated. In this regard the Agriculture Working Group support the recommendations presented to the SURSAT Project by hydrologists concerned with snow cover mapping.)

3) Canada participate with any foreign country or agency in terms of satellite data acquisition to ensure a continuous supply of domestic and foreign imagery.

4) The Canadian effort in the area of sensor development, satellite systems and cooperation with foreign governments and/or agencies not neglect the necessary support required for data handling, processing and distribution to the user communities.

B. IMAGE PROCESSING, C.C.R.S.

Whereas the Alberta Remote Sensing Center, the Faculty of Forestry, University of British Columbia, and International Range Remote Sensing Limited desire high quality black and white positive transparencies of LANDSAT data for color additive viewers, and

Whereas the above organizations have found that such transparencies in 185-mm format (and sometimes in 70-mm format) produced by C.C.R.S. are too dark for color additive viewing, and

Whereas the Alberta Remote Sensing Center has found that black and white positive transparencies (185-mm format) produced at 2X the normal look-up table values lead to suitable images for color additive viewers.

The Agriculture Working Group recommends that as a standard product LANDSAT 185-mm black and white positive transparencies be produced, on request, using any user-specified look-up table values. The Agriculture Working Group also recommends that as a special product such transparencies be produced from DICS tapes.

APPENDIX I. LITERATURE CITED

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2. Geib, P., P. Crown, and A.R. Mack. 1981. Bibliography on application of remote sensing and aerial photography to agricultural crops, soil resources and land use. Research Branch, Agriculture Canada, Ottawa.

3. Razdani, R. 1981. Potential and limitation of satellite data in crop identification in New Brunswick.

APPENDIX II. LIST OF GROUP MEMBERS (APRIL 1981)

1. Dr. A.R. Mack (Chairman), Land Resource Research Institute, Agriculture Canada, Arboretum Bldg. #74, Ottawa, Ontario K1A 0C6 (613-995-9039) April 81 - March 84.

2. Dr. P. Crown, (Secretary), Alberta Institute of Pedology, University of Alberta, Edmonton, Alberta T6G 2E3 (403-432-2886) April 81 - March 84.

3. Mr. E. Brach, Statistical and Engineering Research Institute, Agriculture Canada, Ottawa, Ontario K1A 0C6 (613-995-9671) April 81 - March 84.

4. Mr. Mervin Ross, Saskatchewan Crop Insurance Corp., 2240 Albert St., Regina, Saskatchewan S4P 2J3 (306-565-5081) April 81 - March 84.

5. Mr. R. Barry Proud, Crops Section, Agriculture Div., Main Bldg., Statistics Canada, Tunney's Pasture, Ottawa, Ontario K1A 0L7 (613-995-4877) April 81 - March 84.

6. Mr. R. Karamanos, Dept. of Soil Science, Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon, S7N 0W0 (306-343-5184) April 79 - March 82.

Honorary Life Member

Mr. L.E. Philpotts, 7 Philips Drive, Ottawa, Ontario K2E 6R6 (613-224-7157) September 75.

7. Dr. E. Derenyi, Department of Survey Engineering, University of New Brunswick Fredericton E3B 5A3 (503-453-4698) April 79 - March 82.

8. Mr. Kent Watson, International Range Remote Sensing Ltd., 1355 Nanaimo St., Kamloops, B.C. (604-578-8409) April 81 - March 84.

9. Dr. J.F. Benci, Canadian Wheat Board, 7th Floor N., 423 Main St., Winnipeg, Manitoba R3C 2P5 (204-949-2633) April 81 - March 84.

10.

11. Prof. Stewart Hilts, Dept. of Land Resource Science, Univ. of Guelph, Guelph, Ontario N1G 2W1 (519-824-4120) April 81 - March 82.

12. Ms. Janette MacAuley, P.O. Box 2000, Market Analyses Div. P.E.I. Dept. of Agriculture, Charlottetown, P.E.I. C1A 7N8 (902-892-4101) April 81 - March 84.

13. Mr. Nick Roller, Economics Branch, Crop Statistics, Ministry of Agriculture and Food, 801 Bay St., Toronto, Ontario M6A 1B6 (416-965-1064) April 81 - March 84.

14. Dr. D. Hedley, Commodity Analyses Division Economics and Marketing Branch, Agriculture Canada, Sir John Carling Bldg., Ottawa, Ontario K1A 0C5 (613-995-9554) April 81 - March 84.

15. Mr. Jim Hilton, Range Management Branch, B.C. Forestry Dept., 540 Borland St. William's Lake, B.C. V2G 1R8 (604-392-6261) April 79- March 82.

16. Dr. R. Ryerson, Canada Center for Remote Sensing, Energy, Mines and Resources 717 Belfast Road, Ottawa, Ontario K1A 0Y7 (613-995-1212) April 81 - March 84.

17. Mr. J. Wright, Palliser Wheat Growers Association, 219-3806 Albert St., Regina Saskatchewan S4S 3R2 (306-586-5866) April 80 - March 83.

18. Mr. J. McKinnon, Prairie Agri-Photo, P.O. Box 816, Carman, Manitoba R0G 0J0 (204-745-2479) April 81 - March 82.

19. Dr. C. Shaykewich, Dept. of Soil Science Univ. of Manitoba, Winnipeg R3T 2N2 (204-474-8153) April 81 - March 84.

20. Mr. Fred Boyce, Statistics Branch, Economic Services Division, Alberta Dept. of Agriculture, 9718 - 107th St. Agriculture Bldg., Edmonton, Alberta T5K 2C8 (403-427-4015) April 81 - March 84.

5.2 REPORT ON WORKING GROUP ON CARTOGRAPHY AND PHOTOGRAMMETRY

The National Landsat Collection

In 1980, the Cartography and Geology Working groups recommended that a project be set up to investigate the establishment of a visual image library of best quality Landsat images. At the 1981 CACRS meeting the proposal was presented for the creation of a 35-mm slide collection of Landsat scenes covering all of Canada. This proposal met with sufficient favourable response from the attendees to warrent action being taken.

After discussion with Topographical Survey, the National Air Photo Library and the Department of the Environment, a committment of manpower, funds and interagency cooperation was agreed upon which enabled the project to proceed. Work began in May 1981 and was completed February 1982.

The basis on which the collection has been built is the library of 1:1 000 000 Landsat colour transparencies acquired over a period of years by Clayton Rubec of the Lands Directorate, D.O.E. The objective of the DOE collection is the same as that of the National Collection - good quality, cloud-free, snow-free images at each image centre. When work commenced, the DOE collection was not complete, and contained many images which were desirable to up-grade.

Contrary to popular opinion, there are not an excess of good Landsat scenes, nor is it easy to find the ones that may exist. Catalogue listings can, at best, be used only as indicators of possibilities. These must be cross-checked with microfiche for cloud content and image quality. In the neighbourhood of 60 new colour images had to be created on the CIR to fill gaps or up-grade existing images.

Prior to copying to the 35-mm format, the images were provided with a legible annotation giving the WRS number and the date of acquisition of the image. Copying was done by the Canadian Government Photo Centre of the NFB. Subsequent reproduction of these master slides will also be done by this organization.

The collection numbers 889 slides, and it has been divided into eleven regional groupings. A slide of the mosaic of the region, if it exists, is included in each group. These regional collections are each assembled in 3-hole binders using transparent sleeves to hold the slides.

The price of the collection has been kept to its 1981 projected price of $500. It is hoped that at this price it will attain good distribution and provide an opportunity for many more people to examine satellite imagery.

The basic collection of 889 slides avoids the redundancy of coverage that exists between orbits above 60°N lat., by omitting selected image centres. Work was started on completing the collection to include <u>all</u> image centres, but unfortunately staffing restrictions resulted in the loss of the employee working on the project. Continuation of the porject is therefore temporarily suspended.

Revision of 1:250 000 and Assessment of 1:50 000 maps

The use of Landsat imagery to revise Topographic maps at 1:250 000 and to assess the revision requirements of 1:50 000 maps, which was reported at CACRS 1981, has moved into an operational phase, with proposals being solicited from the mapping community for the 1982 Topographic program.

Extraction of Water features from Landsat MSS

A project is underway to test the feasibility of extracting water features from digital MSS imagery processed in the DICS system. In map-making, cartographic restrictions present accurate representation of lakes on small scale maps (1:500 000 and smaller). This results in a distortion of the portrayal of the true character of the land in areas like the pre-Cambrian shield. If the drawing of lakes is replaced by Landsat-derived water bodies, many more lakes could be portrayed and they could retain their scale-correct dimensions, thus avoiding the generalization and exaggeration now present on these maps.

Positioning of Off-Shore Features

DICS products have continued to be a useful adjunct to positioning or confirming the position of off-shore features for new 1:50 000 mapping.

Appendix I
Current Bibliography

Fleming, E.A., "A National Landsat Collection and a Proposal for a Library of Landsat Images". Proceedings of the 7th Canadian Symposium on Remote Sensing, Winnipeg, Sept. 8-11, 1981.

Fleming, E.A., "Monitoring Revision Requirements for Canadian Maps". Proceedings of the 7th Canadian Symposium on Remote Sensing, Winnipeg, Sept. 8-11, 1981.

Fleming, E.A., "Topographic Map Revision Using Satellite Imagery". 2nd National Workshop on Engineering Applications of Remote Sensing, Feb. 11-12, Edmonton 1982.

Appendix II

Chairman of Working Group

Dr. J.M. Zarzycki
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5.3 DATA HANDLING AND SATELLITE TECHNOLOGY

The working group as a whole had a fairly inactive year, which has led to proposals for restructuring the group into three independent entities.

RECOMMENDATIONS

Re-organization

1. The Working Group be split into three full Working Groups: a Satellite Technology Working Group; a Computer Compatible Tape Working Group and an Image Analysis System Working Group (IASSWG).

2. The IASSWG should establish an Image Analysis Systems Working Group with the IASSWG forming the nucleus of the sub-group concerned with analysis science and technology and a second sub-group to be completed by some users of analysis systems. The IASSWG also recommends that the Chairman of the IASSWG be the Chairman of the new Working Group for continuity.

Technical

3. CCRS should fund a study to investigate the requirements for an image analysis system network in Canada with an immediate objective of identifying the functions such a network could perform.

4. CCRS should fund research and development in university on very long range problems to achieve future objectives for the Terra Observation Pattern Analysis System (TOPAS).

REPORT OF SUB-GROUPS

Satellite Technology

This group led by J. Taylor has not met this year. Its membership will be reviewed and brought up to date to include active respondents from the AIAC space committee. They will study and report on:

(a) The Canadian industrial strategy for collaboration in RADARSAT by other space agencies.

(b) An industrial assessment of the opportunties for participation in read-out and distribution of SPOT satellite data. (This topic may be taken up by a larger government/industry task force.)

Image Analysis

This group, led by D. Goodenough, has met twice this year. They have focused their attention on transportability of image analysis software, and the development plan for a new generation analysis system TOPAS. They concluded that it is not feasible to standarize on analysis software because of various equipment peculiarities. The TOPAS development will use an industrial team with guidance provided by government scientists. They have proposed recommendations 2, 3 and 4. A copy of terms of reference and list of members is appended.

Future plans for the working group include:

- A report on format for recording Landsat digital data on cassette tapes.

- A report on on-line remote sensing data bases.

- A review of specific satellite data production problems.

- A guide to CCT format documentation.

Computer Compatible Tapes

This recently appointed group, led by P. Pearl, has met once this year. The members are drawn from Industry, Government, and University across Canada and represent a broad cross section of capabilities, interests, and expertise. A list of members is attached. The terms of reference of the working group were reviewed and, after discussion, were accepted unmodified. A copy of these terms of reference is appended.

Future plans for the working group include:

A report on format for recording Landsat digital data on cassette tapes.

A review of specified satellite data production problems.

A guide to CCT format documentation.

5.5 REPORT OF THE WORKING GROUP ON EDUCATION

The Working Group on Education was a task-oriented working group established for the purpose of preparing a survey of remote sensing teaching and research in Canadian educational institutions. A questionnaire was distributed to educational institutions and the results are currently being compiled and analyzed. There have been delays in the completion of the survey, but it is anticipated that the report will be finalized in the summer of 1982.

5.6 REPORT OF THE WORKING GROUP ON ENGINEERING APPLICATIONS

INTRODUCTION

In 1981, the Working Group focussed its efforts in organizing the "Second National Workshop on Engineering Applications of Remote Sensing" and in coordinating the evaluation of simulated thematic mapper (LANDSAT D) and SPOT imageries.

SECOND NATIONAL WORKSHOP

The second national workshop, held in Edmonton, Alberta, February 11-12, 1982, was jointly sponsored by the Canada Centre for Remote Sensing and the Ontario Ministry of Transportation and Communications. The Alberta Remote Sensing Centre acted as host and was also an active participant.

The objectives of this workshop were to provide an update on engineering applications in general and to develop recommendations pertaining to the upcoming high resolution satellite imageries. Accordingly, the themes and program were designed to present the status of these two aspects before proceeding to the panel and group discussions from which recommendations were to be developed.

For the first time, speakers from the U.S. were invited in order to obtain an insight into developments outside Canada. As in the case of the first workshop, invitation to participate was extended to those involved in remote sensing at the management level.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations pertaining to the thematic mapper (LANDSAT D) and SPOT imageries were based on evaluation of simulated imageries by the Working Group prior to the workshop and by the participants during the workshop. It should be noted that the results of such evaluation depended, to a large extent, on the nature of simulated imageries used and resources and time available for analysis.

The 5 sets of conclusions and 4 major recommendations were developed during the panel and group discussion and are presented separately in two subsections following under specific headings.

Conclusions

Direct Applications

(1) The availability of high resolution thematic mapper and SPOT imagery will increase the general application of satellite imageries by the engineers.

(2) Ground resolution for both types of imagery is still insufficient for detailed terrain analysis. However, they are suitable for general operational planning for large scale engineering projects such as pipeline and hydro-electric developments.

(3) Compared to the thematic mapper imagery, SPOT imagery is more useful for visual interpretation since it provides a higher resolution and stereoscopic coverage.

(4) Considering the resolution and scale at which it will be available and its stereoscopic capability, SPOT imagery has the potential to be a substitute for high altitude aerial photography.

(5) Repetitive, up-to-date coverage provided by thematic mapper and SPOT imageries is important to engineering studies requiring change detection such as erosion, flooding and instabilities.

(6) The availability and cost of these imageries will be determining factors in the extent of their use.

Products

Significant savings in mosaic construction will be realized if high resolution, geometrically- corrected imageries are available.

Image Analysis

(1) For the thematic mapper imagery, the colour composite which assigns blue, green and red to Bands TM 3, 4, 5 respectively appears to have great potential for engineering applications.

(2) The colour composite (multispectral mode) of the simulated SPOT imagery could approach the small scale colour infrared aerial photography in terms of level of detail and type of information.

Education and Training

The full benefits of high resolution satellite imageries can be realized only if sufficient qualified personnel in all related areas of operation is available.

Workshop

It is difficult to maintain interest, contact and momentum across the nation when the workshop is held at two-year intervals.

Recommendations

Products

(1) Geometrically-corrected imageries, similar to those produced by DICS for the present LANDSAT data, should be available for high resolution satellite imageries from the national facility.

(2) The potential of mapping using SPOT imagery should be investigated.

Image Analysis and Pilot Projects

(1) Pilot projects using simulated imageries should be conducted to investigate systematically their application to engineering studies and to demonstrate and document the benefits of digital analysis systems to those who presently rely on airphotos alone.

(2) Pilot projects should be organized by the Working Group, involving personnel having relevant experience, qualification and interest. Projects should be carried out in conjunction with various agencies such as government, industry and educational institutions.

(3) Test areas for such projects should

(a) be located in different physiographic regions of Canada,
(b) already have sufficient airphoto coverage and ground truth.

(4) For thematic mapper imageries, the rendition which assigns blue, green and red to Bands TM 3, 4 and 5 respectively should be available for all future pilot projects.

(5) The most useful colour composite for analyzing thermal signatures, water quality and rock types from thematic mapper imageries should be defined. Special equipment may be required and such needs and corresponding availability should be investigated.

Education and Training

The Working Group should investigate, at the earliest possible date, the feasibility of having programs established in colleges and universities to meet the manpower requirements in satisfying future demands in high resolution satellite imagery programs.

Workshop

The National Workshop on Engineering Applications should be an annual event, held in rotation across the country, to foster national interest and awareness in engineering applications of remote sensing.

APPENDIX I

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5.7 REPORT OF THE WORKING GROUP ON FORESTRY, WILDLANDS AND WILDLIFE

This Working Group was previously chaired by Dr. Peter Kourtz, Petawawa National Forestry Institute, DOE, but after he resigned his chairmanship there was a hiatus of about one year before a new chairman was appointed, and no activity took place in this period. Dr. Peter A. Murtha, Faculty of Forestry, University of British Columbia, has now been appointed chairman, and it is expected that activities will now recommence. A Five-Year Organization and Work Plan is under discussion.

5.8 REPORT OF THE WORKING GROUP ON GEOGRAPHY

Introduction

In June 1981, the Geography Working Group undertook the specific task of the preparation of a pre-symposium publication and three papers on the use of Landsat for mapping the changing geography of Canada, for presentation in June 1982 at the COSPAR (Committee on Space Research) Symposium XXIV in Ottawa.

Preparation of the publication and papers was still in progress at the end of 1981. During the year, meetings of the Working Group were held in June and in September to plan and carry out the work. The publication will consist of three major papers written by Working Group members Dr. R.A. Ryerson, Dr. P.J. Howarth, and Dr. F.J. Bonn, with an editorial introduction and summary by M.D. Thompson, Working Group Chairman. The papers will cover the use of Landsat in Canada over the past decade for monitoring hydrologic and coastal change, urban/agricultural change, and resource development. A number of Canadian case studies will be discussed and summarized, with the original authors included as co-authors in the appropriate paper. A limited amount of re-analysis of digital Landsat data will be carried out on the CIAS, to produce illustrative materials for the publication and for the paper presentations at the symposium.

Forecast

The specific task assigned to the Working Group during 1981 of preparation of a publication and presentation to COSPAR on the use of Landsat for mapping the changing geography of Canada over the past decade will be completed in June 1982. At this time, no additional work for the Working Group is planned beyond that date.

Recommendations

Due to the task-oriented and specific nature of the work carried out by the Geography Working Group during 1981, no general recommendations are made to CACRS at this time.

Appendix I

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5.9 REPORT OF THE WORKING GROUP ON GEOSCIENCE

Introduction

At each of the last two CACRS meetings, CCRS management has urged working groups to concentrate their efforts on research issues of topical interest. This new policy was first implemented by the GWG when it agreed to participate in RADARSAT through a sub-working group called the Non-Renewable Resources Study Team.

A second project of potential interest to GWG members, is a proposal to produce lineament maps of Canada using LANDSAT MSS images.

Spaceborne Remote Sensing - RADARSAT

Shortly after the establishment of the RADARSAT Project office (RPO) in Ottawa, the GWG was invited to support Project activities by forming the Non-Renewable Resources (NRR) Study Team. The NRR Team is one of four applications teams formed to carry out definition studies for a Canadian controlled satellite, carrying as prime sensor, a Synthetic Aperture Radar. The activities of the other teams and the Project itself, are described elsewhere in the CACRS report. The Team has participated in numerous activities, all of which are designed to provide information for a Phase A (satellite definition) report to be produced in the late fall of 1982.

During the summer, ten sites of geological interest were flown with the CCRS CV-580 aircraft carrying the modified ERIM 4 channel (XHH, XHV, CHH & CHV) SAR. C-band is the designated satellite SAR frequency. The SAR experiments are intended to provide a better understanding of stereo SAR imagery, rock structures, lineaments, rock units, surficial deposits and coastline morphology. A report describing the experiment sites and the aims of the airborne experiments, forms part of the RPO, Preliminary Mission Requirements Document.

The Team also carried out investigations to define desirable parameters for a satellite SAR to be used for geological investigations using published literature, and available airborne SAR and SEASAT-SAR imagery. This report forms part of the RPO Mission Requirements Document. The basic requirements were identified as:

- high resolution (20 to 25 meters)
- C-band (5.3 GHz, 6 centimeters)
- 2 incidence angles (30^{o} and 50^{o}) to provide stereo cover
  HH polarization
- high geometric accuracy to permit registration of different data sets
- radiometric range to provide images with grey tones comparable to an air photo
- a set policy for accumulating and archiving a world data set.

Early indications suggest that the antenna can be electronically switched within a modest range of incidence angles, and that acquisition of a world set of stereo images will be given a high priority.

Other activities included a meeting in April with the corresponding US NRR Team at NASA, where the Team received a briefing on US plans which included the Shuttle Imaging Radar (SIR-A flight). Examples of imagery produced by the SIR-A flight have confirmed the geological value of SAR imagery acquired at high incidence angles. The team was also instrumental in an RPO decision to acquire the University of Kansas software for computer modeling of SAR imagery.

A Lineament Map of Canada

The USGS recently asked for support from Canada to produce a lineament map of the North American Plate (Canada, USA, Greenland, Mexico, Central America) as a contribution to the centennial celebrations of the Geological Society of America to be held in 1989. The map would be produced using LANDSAT MSS images supplemented by published lineament data. The GSA publication would be at 1:5,000,000 scale and, ideally, would overlay an image mosaic, digitally compiled from MSS data. The basic mapping of the lineaments should be carried out at a much larger scale, probably at 1:500,000, so that a fairly detailed set of lineament maps of Canada might also be produced at 1:1,000,000 scale. Conceptually, the lineaments should be digitized to permit easy changes and updates to be made to the data, and to enable maps to be produced of any area at a range of scales. The Geological Survey of Canada does not have the funds or the manpower to carry out this project in-house. However, there is a reasonable possibility that GSC would support costs of drafting, editing and publication of lineament maps produced to an agreed format, by other groups in Canada.

A trial lineament map of the Sudbury-Timmins area (76°-82°W, 46°-50°N) at 1:1,000,000 scale, is being prepared to evaluate the problems associated with map production. If this trial map is favourably received, a second sub-group of GWG will be formed to help coordinate a national lineament mapping programme.

Appendix I - Current Bibliography

1981 Non-Renewable Land Resources Study Team in Appendix II, Preliminary Mission Requirements Document, RPO, 81-2 (32 pages)

1982 Non-Renewable Land Resources Study Team in Appendix III, RADARSAT Mission Requirements Document, RPO, 82-7 (30 pages)

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5.10 REPORT OF THE WORKING GROUP ON ICE

Airborne Remote Sensing

While en route to a European mission with the newly-installed C-Band SAR modification (see Technical Developments) the CCRS Convair-580 overflew Julianehaab Bay, S. Greenland. In a co-operative experiment with the Danes small multi-year ice floes in close pack conditions were imaged with the X/C SAR and a Hasselblad (CV-580), imaging radiometers (Danish Air Force C-130) SLAR and search radar (Greenland Ice Patrol Twin Otter). A surface-measurement party was deployed by Greenland Ice Patrol helicopter.

The CV-580 flew a second sea ice mission in 1981, freeze-up conditions in the Beaufort Sea, as part of the Radarsat project. Also in October and organized by the Radarsat project, the University of Kansas scatterometer system was installed on a helicopter and flown off the NW and SE coasts of Prince Patrick Island. The field areas were also imaged by the AES Ice Patrol SLAR and a US Navy P3 equipped with a multi-frequency radiometer but, unfortunately, were out of range for the Convair-580 based in Inuvik.

Airborne radio-echo sounding of Ellesmere Island glaciers and ice shelves and glaciers at Mt. Pattullo, B.C., was carried out in 1981 by University of British Columbia, Dept. of Geophysics.

Spaceborne Remote Sensing

The major news item concerning ice is the study initiated in 1981 for the proposed Canadian Radarsat project. Ongoing field programs and engineering studies are focussing on the use of a C-Band (5.3 GHz) frequency for the spaceborne SAR.

ESA is also proceeding with plans for the ERS-1 satellite which will include a combined SAR-scatterometer known as the active microwave instrument (AMI). In establishing the specification for the SAR component of the AMI Canadian requirements and desires for sea ice mapping have been considered.

Surface Remote Sensing

Marine radars have been used in ice detection studies at: Borden Peninsula, land based (O.S.S., Fisheries and Oceans), McKinley Bay, drill-ship bridge and derrick top (Dome Petroleum Ltd.) and Beaufort Sea, tethered balloon (Dome Petroleum Ltd.). Developments in this area were reviewed during the Ice Working Group meeting in St. John's, Newfoundland.

C-CORE is continuing to evaluate the potential for "over the horizon" radar for ice mapping and also the use of CODAR (a H.F. radar for coastal dynamics) for east coast operations.

Technical Developments

As previously mentioned, an additional frequency option was added to the X- and L-Band SAR onboard the CCRS CV-580. The C-Band modification was completed in June 1981, and is being used for on-going CCRS programs as well as the requirements study for Radarsat. Unfortunately, the signal-to-noise ratio of this channel is poor and the performance of this channel is being upgraded to match the X-Band performance.

Applications

During the operational season in the Beaufort Sea, Dome Petroleum utilized both SLAR and SAR imagery routinely. The SLAR was operated during the summer season by Mars Ltd., the CV-580 SAR was operated by Intera during the freeze-up period.

Benefits

A Radarsat study has been completed by A. McQuillan on the potential benefits of satellite radar data for Arctic activities, where the benefits derive mainly from ice hazard detection.

User Liaison

Extensive user input was solicited by Philip A. Lapp Ltd. for future operational ice parameters and data products required; whether these might be procured by Radarsat or aircraft missions.

The Working Group on Ice sponsored an Ice Remote Sensing Information Meeting in St. John's, Newfoundland in November 1981, attended by thirty persons from the province. Presentations by AES Ice Branch management and by oil and shipping company representatives covered current ice reconnaissance services, future developments and industry plans and requirements.

The second workshop on the Microwave Remote Sensing of Sea Ice and Icebergs was held at Langley Research Centre, Hampton, Virginia on 6-9 April 1981. Fifteen of the 60 attendees were from the Canadian ice community.

Recommendations

The Working Group on Ice recommends that:-

1. CCRS obtain historical NOAA data from the U.S. Archives, for all Canadian land areas, offshore areas and to the North Pole (before this data becomes irretrievably lost).

2. Applications Division CCRS perform or co-operate in research related to machine classification of digital SAR data of sea ice.

3. CCRS Data Acquisition Division devote the necessary resources to continue the systematic evaluation of the current SAR system (Ice W.G. Recommendation No. 1, 1980) so that more meaningful study of quantitative radar signals can be undertaken.

Appendices

Appendix I - Current Projects

For glacier, sea ice and ice physics studies in Canada see Ice, No. 65, 1981, the newsbulletin of the International Glaciological Society.

Appendix II - Current Bibliography

Information on snow and ice publications in Canada is available from Simon Ommanney, Snow and Ice Division, NHRI, who is preparing bibliographies up to 1981. These include special works on Ellesmere Island Glaciers and Ice Islands.

_____, 1982, "Ice Remote Sensing Information Meeting", St. John's, Newfoundland, 3 November 1981, Working Group on Ice, January 1982, Ottawa, 60 pp.

Lapp, P.A. and D.J. Lapp, 1981, "Preliminary Statement of User Requirements for Ice and Ocean Information", Radarsat Project Report 81-3, July 1981, Ottawa, 82 pp.

McQuillan, A., 1981, "Potential Benefits of Satellite Radar Data in Support of Arctic Activities", Radarsat Project Report, in draft December 1981, Ottawa, 95 pp.

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5.11 REPORT OF THE WORKING GROUP ON OCEANOGRAPHY

The working group has not met since the last CACRS meeting, but areas of interest to the group were covered at other meetings as discussed below.

Lack of satellite data is now strongly limiting activities in this field. New sensor programs have been delayed or cancelled and even data already collected is slow in being processed to easily usable form. Lower funding has also reduced the analysis effort, especially in the U.S.A., and new initiatives are shifting to Europe and Japan.

Satellite observations

Microwave data

Much U.S. Seasat data is now processed and available through NOAA's data distribution system (EDIS), but many of the more sophisticated analyses remain to be carried out for the following types of data.

Scatterometry provides measurements of surface winds in a form that would be extremely useful to ocean operators if used either by them directly or through AES, and processed to weather, wave, and ice drift forecasts. Removal of the directional ambiguities is still a problem and U.S. (NASA Goddard) and Canadian (AES, Toronto) studies continue on this.

Altimetry can provide mean sea surface height variations that show the magnitude and direction of ocean currents in geostrophic balance. Such results would be of great interest for ocean circulation and climate studies but the measurement accuracy is limited to satellite tracking errors, inadequate knowledge of the geoid as well as by limited measurement precision. Various techniques for extracting information from existing (Seasat and GEOS-3) data are being examined and a study on the much more precise, planned U.S. TOPEX mission is continuing, but on a delayed schedule.

Synthetic aperture radar (SAR) images show roughness patterns caused by wind, surface and internal waves, current boundaries and various types of ice cover. Analysis of Seasat data is far from complete. Early analyses relied on less precise optical processing and in many cases need to be repeated using digitally derived images. Delays in digital processing is currently frustrating the Radarsat project in its efforts to evaluate applications of a satellite SAR, in particular as discussed at the Radarsat meeting BIO, Nov. 3-4, 1981:

- setting precise limits on wave measurement accuracy under different conditions

- locating surface traces of internal wave patterns and bottom features

- mapping the radial component of surface currents over an image

Microwave radiometry provides multichannel data that is affected by, and can in principle measure, sea surface temperature, surface roughness, atmospheric water vapour and liquid water, fractional ice cover and various ice properties. Usefulness of the data depends on the accuracy that can be achieved in each case. Analyses to determine these are currently still complicated by sensor and calibration problems (polarization, beam width, sun glint, interference) as well as by inadequacy of comparison data sets.

Infrared data

This continues to be used as cloud cover and data collection and processing limitations allow. Availability of digital, or suitably enhanced data appropriate to ocean applications does not appear to have improved much recently. Most successful uses require repeated coverage implying arrangements for large volume data acquisition and processing. (See comments on data processing below.)

Optical (water color data)

Nimbus 7 CZCS data also suffers from availability problems, with data from the first year of operation 1978/9 now being available from NOAA/EDIS in raw form (Level 1 - CRTT) with very few fully processed (Level 2) scenes yet available. A west coast project using semi-qualitative analysis of water color images received at Scripps has demonstrated potential value to Canadian fisheries science, and a presentation of these and other results at the NAFO meeting (BIO, November 1981) has begun to show the potential importance of such data.

Airborne observations

The Convair 580 was involved in SAR data collection on a Hibernia overflight (August 1981) for wave studies related to Radarsat (Keeley, DFO).

The Convair 580 also took part in a European campaign during the summer consisting of experiments designed to assist in planning the ERS-1 satellite SAR program, among those of oceanographic interest:

North Sea Oil Slicks) Bottom Topography Effects) Directional Surface Waves) SAR Imaging Mechanism)	Germany
Directional Wave Spectra) Sandwave Experiment) Marine Traffic Survey)	U.K.
Oil versus Chlorophyll	Italy
Microwaves and Waterwaves	Holland
Oil Spills	Euratom

Aerial hydrography flights were carried out with the inertially monitored stereo camera system, and the bathymetric lidar mounted in a DC-3. Studies are being organized under contract to promote transfer of this technology to industry.

Flights off the west coast measuring water color with the IOS spectrometer from a chartered aircraft (Brittain Norman Islander) were carried out as part of the CZCS study referred to above.

Radar imaging of waves on the Columbia River bar with a real aperture X band radar on a U.S. National Guard OV-ID aircraft was carried out in a joint NOAA (PMEL)/IOS project to observe wave current interactions.

Sensor development

Design studies for a solid state (CCD) optical spectrometer scanner were completed, and a contract was let for its construction in March 1982. The basic design borrows from recent electro-optic designs for astronomy and space science. The sensor is designed specifically for chlorophyll mapping using natural fluorescent emission at 685 nm, but is flexible enough for many other uses in the optical region.

Brief specifications for the present configuration are:

Spectral coverage	430 to 800 nm
Number of pixels	1500
Field of view	70°
Number of bands	8

The bands are formed by selective addition of the 256 outputs that cover the observed spectral band with a resolution of about 2 nm.

The sensor will be delivered in mid-1983 for airborne testing. It is designed to be the prototype for a satellite sensor.

Data processing

A DFO study investigated the department's requirements for image processing equipment. A report is available from H. Edel and a more detailed internal report for BIO is in preparation. Systems supplied by Dipix and OVAAC-8 were found lacking in software and processing power, but recent developments in OVAAC-8 are toward the larger VAX scale systems. Availability of software developed for ocean applications on larger DEC systems, e.g. from the University of Miami, would also be a distinct advantage.

A sophisticated image processing system is being implemented at UBC for the computational vision project which includes satellite data processing as one segment. The system has a larger VAX (780), with image processing terminal and Optronix film recorder and digitizer. Hardware should be in place by mid-1982.

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5.12 RENEWABLE LAND RESOURCES

The Working Group on Renewable Land Resources was established in May, 1981 with the principal objective of preparing and documenting the renewable land resource mission requirements for a spaceborne synthetic aperture radar (SAR). The group is also a part of the RADARSAT project structure where it serves as a Study Team representing renewable land resources.

Approach

The work of the group to date has concentrated on identifying significant resource information needs that could be met with satellite SAR data, reviewing the present knowledge about the use of spaceborne SAR data for these applications, and defining mission requirements that a future satellite SAR mission would have to meet in order to satisfy the renewable land resources application requirements. The Working Group held four meetings in 1981 (6 February; 12 and 13 March; 21 and 22 April; 27 and 28 July) where the resource information requirements and their value, timeliness requirements, data processing constraints, and optimum SAR sensor parameters were discussed. In addition, specialty workshops on the state of the art of SAR applications in forestry (8 September), hydrology (16 October) and agriculture (26 November) were organized and attended by scientists involved in previous R&D projects employing microwave data. An additional analysis of airborne SAR data from several SURSAT projects was also conducted. An extensive liturature review was undertaken in support of the mission requirements study. Based on the identified gaps in the knowledge of SAR data applications, an experimental program for the collection and analysis of airborne SAR images was defined. This program encompasses three major experiments (one in each of forestry, hydrology, and agriculture) as well as several targets of opportunity.

Results

Results of the Working Group's activities have been compiled in two documents (References 1 and 2). The presentations and discussions at the specialty workshops have been summarized separately (Reference 3).

Thirteen agriculture, seven forestry, and nine hydrology information needs have been identified to which satellite SAR data can contribute. Each information requirement was assessed in terms of optimum SAR sensor parameters, probability of success with various baseline SAR parameters, ancillary data sources required, revisit period, available temporal window, and processing requirements (both type and timeliness). The benefits to land resource management applications in Canada were found to depend on the SAR parameters selected. While dual frequency, dual incidence angle SAR was identified as the optimum system, a single frequency (C-band), high incidence angle system would also provide valuable information for renewable land resource applications. The ability of SAR to obtain data at pre-specified days is a key advantage in monitoring land resources whose condition and behaviour are linked to the growth/seasonal cycle. While the primary focus of the WG's activities has been a SAR system, the high importance of VIR satellite data for land resources applications has been realized and brought to the attention of the RADARSAT project.

Recommendations

The Renewable Land Resource Working Group recommends that:

1. the second sensor onboard RADARSAT be a steerable VIR sensor;

2. CCRS ensure that adequate manpower and financial resources are identified in the future SAR program to support the development of operational land applications of RADARSAT data;

3. a combined SAR/VIR agricultural experiment in Melfort, Saskatchewan be supported by CCRS and Agriculture Canada in 1983 as a high priority project;

4. As part of a longterm Canadian microwave program, the feasibility of establishing a flexible microwave spectrometer/radiometer laboratory be evaluated. This national facility would be funded and maintained for use by Canadian investigators;

5. RADARSAT test line (Ottawa to Petawawa) be used as a standard test line for all CCRS airborne sensors and that all data be archived for use by interested investigators. The existence of this line should be made known to all organizations testing airborne sensors.

Appendices

Appendix I - References

1. RADARSAT, 1981, "Preliminary Mission Requirements Document/Renewable Land Resources", June, 40 pp.

2. RADARSAT, 1982, "SAR Mission Requirements for Renewable Land Resources", Draft Final, February, 56 pp.

3. Cihlar, J., T. Hirose and A. Rencz. "SAR Applications in Agriculture, Forestry and Hydrology: State of the Art Review". In preparation.

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5.13 REPORT OF THE WORKING GROUP ON WATER RESOURCES

Introduction

One meeting of the Working Group was held in 1981 in Edmonton on October 20-22. The Alberta Remote Sensing Centre and Alberta Environment were our local hosts. Plans were initiated for the 2nd Canadian Workshop on Data Collection Platform Networks to be held in Ottawa on May 25-26, 1982 in conjunction with the 16th Annual Congress of the Canadian Meteorological and Oceanographic Society. One day was devoted to scientific presentations, including invited presentations from Dr. Don Wiesnet of NOAA/ NESS and Dr. Jim Ormsby of NASA/Goddard. The annual business meeting was held on the third day. As in 1980, much of the Group's attention focused on problems related to data collection platforms and data retransmission via satellite.

Six new members were appointed to the Working Group during the year. The entire list of members is given in Appendix II.

Remote Sensing of Water Resource Elements

Highlights of reports presented at the business meeting are given below. More complete information is available in the Minutes of the 8th Meeting of the Working Group which are available from either the Secretary or Chairman. Appendix I lists the scientific topics to be discussed at Working Group meetings and the rapporteurs responsible for reviewing the field.

a) Precipitation

The Atmospheric Environment Service (AES) is continuing the development of the RAINSAT project designed to produce short term precipitation forecasts. It involves the use of GOES-IR and weather radar data. At the Pacific Weather Centre of AES, work by Diane Ingraham on the analysis of GOES-IR imagery for estimating precipitation is being studied in the hope of developing this method into a reliable quantitative precipitation forecasting tool. Recent research by Ingraham includes a project to refine rainfall depth-area-duration estimates made from GOES-IR imagery for incorporation into rainfall-runoff models and for river forecasting needs. This project was supported by the U.S. National Weather Service, Hydrologic Services Division. B.C. Hydro is particularly interested in this type of development. Installation of the Vancouver GOES receiving station and Meteorological Data Analysis System is to be completed by the spring of 1982.

The Alberta Research Council is to design and implement the systems required to transmit digital weather radar (precipitation) data from Penhold to Edmonton, and display the data in several useful formats in the offices of the River Forecast Centre. The systems are to be fully operational by the spring of 1984.

The Stormy Weather Group at McGill and INRS-Eau are continuing their research on the combination of radar and ground based rainfall measurements as improved inputs to the CEQUEAU hydrological model.

At the 4th Hydrometeorological Conference of the American Meteorological Society held in Reno, Nevada, several papers were presented which dealt with the remote sensing of precipitation using satellite imagery and radar, particularly as applied to warning services of severe floods.

b) Snowcover

Snowcover mapping from aircraft (snowline flights) was again conducted by B.C. Hydro twice during the freshet for all drainage basins operated by them. Snowcover data derived from NOAA satellite imagery was provided by NOAA/NESS for the Columbia River drainage above Mica dam. During 1981 four analyses were made and the results agreed well with data obtained by other means. Imagery derived snowcover data for late July seemed to over-estimate snowcover, probably due to the inclusion of bare rock areas in the snowcovered total.

Laval University and INRS-Eau are cooperating in a study using satellite data to improve the evaluation of the amount of snow on the ground throughout the winter and particularly during the snowmelt period. The investigation is being conducted for the James Bay Energy Corporation in basins of interest to them.

The Hydrometeorology Division of the Atmospheric Environment Service continued to provide analyses of snowcover extent in the Saint John Basin and its sub-basins. A digital based system of image interpretation of NOAA data is used.

The need for a country-wide snowcover mapping program capable of analysis of selected basins was discussed. The problems of access in real-time to digital data from weather satellites, of the resources required to implement such a system, and of who should be responsible for the provision of such analyses were discussed. The questions were basically left unresolved.

A snow experiment was being planned as one of the RADARSAT Renewable Land Resources experiments. The target area was the Animal Research Institute near Ottawa. Members were invited to participate if they were interested.

c) Ice

The possible use of SAR imagery for monitoring the period during which ice roads on lakes could be safely operated was discussed. This was suggested as a useful target of opportunity project within the RADARSAT program.

d) Soil Moisture and Groundwater

Research by the USDA and NASA Goddard on the use of active microwave data for estimating the average surface soil moisture for several watersheds in Oklahoma was noted. The best results were obtained using C band data at incidence angles of 10 and 15 degrees and a soil moisture depth of 0 to 15 cm. Surface soil moisture is not only an important variable in hydrological models, but it is an important element in global climatic models.

In Saskatchewan, airborne remote sensing was more active in 1981. One project by CCRS was to detect groundwater movement of chemically contaminated water in a uranium tailing pile near Uranium City. The Potash Corporation of Saskatchewan and Cominco Mines used Air Quest (of Winnipeg) to overfly their potash mines to detect if environmental degradation was occurring. This project was termed commercial in 1980 after eight successful years of flying by CCRS. The task failed to be completed in 1980 and has been dropped from a multi-spectral mission to a photographic mission in 1981.

The Ontario Centre for Remote Sensing used thermography (infrared line scanner) for ground-water spring detection with respect to establishing fish hatcheries for the Ministry of Natural Resources. Conventional photography and thermography are also being used as part of a feasibility study to delineate landfill leachate for the Ontario Ministry of Environment.

In Nova Scotia, A.B.P. Consultants Ltd., CCRS and the Nova Scotia Remote Sensing Centre were co-operating on the integration of ground and airborne MSS and colour IR data for the study of groundwater quality and saltwater intrusions in the lower Annapolis River Basin.

e) Hydro-Geomorphic Processes

Dr. Thomson reported on his work on drainage pattern analysis using X and L-band SAR data. Radar for this type of analysis is particularly suitable in areas for which adequate maps are not available and which are usually under cloud cover.

f) Coastal

CCRS initiated a joint project in 1980 with Environment Canada to investigate the potential roles of present and future high resolution satellites for monitoring wetland vegetation in the Fraser River Estuary, British Columbia. Landsat MSS data and simulated LANDSAT-D Thematic Mapper data were tested; maximum wetland classification accuracy was achieved during the spring. Future work is to refine the analysis techniques and develop an operational satellite-based monitoring program for the Fraser Estuary.

The groundwater/saltwater studies in the Annapolis Basin of Nova Scotia were noted in d) above.

g) Water Quality

A major remote sensing experiment on the Great Lakes was conducted by CCRS, Canada Centre for Inland Waters (CCIW) and Moniteq Ltd. using Coastal Zone Colour Scanner (CZCS) data and airborne MSS data. Correlation coefficients between CZCS derived estimates and in-situ measurements have been reported as high as 0.72 for chlorophyll and 0.89 for total suspended solids.

A chromaticity analysis package for obtaining measurements of suspended sediment concentration from Landsat MSS and airborne multispectral scanner data has been developed by CCRS.

Results of optical studies for water quality measurements based on in-situ measurements of solids and chlorophyll that have been undertaken by NWRI/CCIW were reported in the May 1981 issue of Applied Optics. The model is suitable for low-level aircraft data, but progress on an algorithm for atmospheric attenuation adaptable for satellite use is not encouraging.

York University (Prof. J. Miller) has initiated a two-year research program relating optical measurements to water quality parameters (dissolved organic content, chlorophyll, turbidity, zooplankton, etc.). Moniteq has developed an operational technique for lake bathymetry studies, using MSS data flown at 5,000 and 10,000 ft. with pixel resolution of 3.5 and 7 metres, respectively. The technique is applicable in depths of water up to 10 metres with a resolution of plus or minus 0.5 metre. Moniteq will also be investigating the correlation of lake acidity to lake water clarity from Landsat data.

A report on the "Development of an Operational Water Quality Monitoring System using Landsat Data" prepared for the Freshwater Institute of Environment Canada by the Sibbald Group was brought the attention of the WRWG. In particular, the study centred on estimating and mapping the sediment levels in Southern Indian Lake, Manitoba.

Satellite Data Retransmission

The most effective satellite application in the water resource sector, affecting every water agency in the country, continues to be data retransmission from data collection platforms (DCPs).

The number of DCPs known by WRWG members to be in operation as of October 1980 and using satellite retransmission is as follows:

British Columbia - 21
Alberta - 8
Saskatchewan - 13
Ontario - 11
Quebec - 58

AES - 10
IWD - 60

Rapid expansion of DCP networks is planned in the next few years by all agencies.

Problems in operating DCPs were discussed by members whose agencies were involved in such activities. These included DCP operation, sensor operations, data retrieval and archiving.

The Working Group has on file a list of hydrometeorological sensors used on DCPs and a list of companies and their representatives involved in the manufacture of DCPs, sensors, and receiving stations. These lists will be updated and made available to others upon request.

User Liaison

The WRWG sponsored a one-day scientific meeting in Edmonton prior to the annual business meeting. Over forty persons were in attendance. Dr. Don Wiesnet, Chief, Land Sciences Branch, NOAA/NESS discussed present and future U.S. satellite systems, particularly as they relate to water resource applications. He reviewed the status of the polar orbiting (NOAA) and geostationary (GOES) weather satellites. The importance of reducing their annual costs and extending their space life was pointed out. He noted that a potential user can influence the future of the system with the development of new applications and ideas. He discussed in detail plans for Landsat-D and the Thematic Mapper (TM). The availability of TM data over foreign areas, particularly during the evaluation period, was not known. The phased transfer of Landsat from NASA to NESS is to be completed by 1985, with privatization of the program being a real possibility.

Dr. Jim Ormsby of the Hydrologic Sciences Branch, NASA, Goddard Space Flight Center provided a review of their remote sensing research and technology transfer programs related to water resources. Their relative research effort is shifting from the visible and near-IR through the thermal-IR to the microwave and longer wavelengths. Of particular interest, was his discussion of their Application System Verification Tests (ASVTs) which are intended to test new systems in a quasi-operational mode to bridge the gap to fully operational implementation, if warranted. One major ASVT was the snowcover mapping by satellite and its application to both seasonal and real-time hydrologic modelling (i.e. SSARR Model). The benefit/cost ratio of this application in the eleven Western States was estimated to be 75:1 given that the satellite is in place. Another ASVT dealt with water management and control, and particularly the use of Landsat derived land use information in runoff models. Other studies included the measurement of surface soil moisture using passive microwave (21 cm), a cooperative snowmelt modelling study involving the percent snowcover by elevation zone, and a study of surface snowcover condition (depth, wetness, grain size, etc.) using 0.8 and 21 cm microwave emissions.

Other presentations at the meeting were from Dr. E. Langham on the RADARSAT program, Dr. K. Thomson on the SPOT satellite, and John Bullas and Bill Hume on the AES satellite receiving facilities in Edmonton for imagery and DCP's.

Through the initiative of Dr. Peter Jolly, the Working Group now has an initial list of consultants carrying out remote sensing activities in water resources. A summary of remote sensing activities of eight companies is available. The list will be updated and expanded as new information becomes available and it will be made available to interested parties. The Working Group would appreciate being informed of other consultants not known to it who are working in the water resource field.

Dr. B.E. Goodison and J. Whiting attended the first meeting of the International Association of Hydrologic Sciences (IAHS) Committee on Remote Sensing and Data Transmission for Hydrology. A review of remote sensing and water resources in Canada was given. B.E. Goodison was elected Secretary of the Committee. The President is A.I. Johnson (U.S.A.) and the Vice-Presidents are T. Andersen (Norway), G. Schultz (F.R.G.) and S. Pieyns (France).

Conclusion and Forecast

The value of the Working Group format, beyond advising CACRS, was vividly brought home at the meeting of the IAHS Committee on Remote Sensing and Data Transmission. Because of this reporting structure, we were able to give an overview of Canadian activities in the water resources field. Representatives from other countries spoke of their own or their agency's work, but they generally were not able to review national activities. We would have been in a similar situation if the Working Group did not exist and our contribution at the international level would have been diminished.

The Working Group aims to continue its activities in the development, promotion and application of remote sensing techniques in the field of water resources. As a follow-up to the Workshop on Data Collection Platform Networks held in Quebec City in 1980, the Working Group is co-sponsoring a second workshop on the subject with the Canadian Meteorological and Oceanographic Society's Special Interest Group in Hydrology. The Workshop will feature: presentations by manufacturers; a presentation on the Department of Environment's policy on standards for collection, communication and archiving of DCP data; a panel discussion of the need for a Canadian receiving station and DCP transmission facilities on Canadian satellites; and fourteen scientific/technical papers. The development of a DCP User Committee will be supported, hoping that it may be able to carry on some of the coordination role that the WRWG has been performing.

The WRWG realizes that considerable expertise in the application of remote sensing to water resource problems now exists in the private sector. In a review of consultants activities, however, there are areas where remote sensing applications exist and have reached "operational status", but the developed technologies do not appear to have been effectively transferred to the private sector. Such areas include: hydrological forecasting using snowline delineations as the main indicator; hydrological modelling using drainage basin land cover and physiographic characteristics as the independent variables; and, delineation of flooded area extents. The WRWG feels that it is necessary to foster closer ties with the private sector and to determine how it may improve technology transfer to this group. Canada is well ahead of other countries in the development of coordinated DCP networks. This expertise should be made known to Canadian consultants for their use on assignments in third world countries.

An area of concern expressed to the WRWG is the lack of accurate information on costs of remote sensing services which could be used by consultants. It is most important for a consultant to have accurate estimates for such services. Information on costs for remote sensing technology should be determined as to costs for hardware, software, installation, operation and maintenance as well as the in-field man hours required. Any assistance or direction on this concern that CCRS, particularly the Marketing Division, could provide to the WRWG and hence to consultants would be of great value in promoting technology transfer in water resources.

In the near future there must be increased research on the application of remote sensing data in hydrologic models. Some initial work on this has been done by the Hydex Corportion in the United States, but little has been done in Canada. Yet, this is particularly one of the most important areas of application.

Recommendations

Since it is recognized that funding and software development were generally inadequate for data analysis for the SURSAT project, it is a concern of the WRWG that there is sufficient effort and funding available for data analysis capabilities for new data sources such as SAR, Landsat-D, and SPOT, particularly as they apply to the field of water resources.

It is also recommended that Canada acquire a ground based scatterometer and radiometer system to carry out basic microwave studies in support of applications and development work. The capital cost and annual operating expenses, including a support staff dedicated to the system, would best be funded by a central agency. The facility is viewed as having one-half of its time being available to agencies and groups other than the central agency (eg. CCRS).

Appendix I - Review Topics and Rapporteurs

Precipitation: Schaefer, Fortin
Snow: Sporns, Langham, Goodison
Ice: Whiting, Sherstone
Soil Moisture and Groundwater: Ostry, Peters
Hydro-Geomorphic Processes: McCullough
Coastal: Thomson
Data Transmission: Lamb, Myslik, Whiting
Water Quality: Alfoldi, Ostry
Hydrologic Modelling: Jolly
Wetlands: Thomson

Provincial Activities: as appropriate

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6.1 REPORT OF THE INTERPROVINCIAL/TERRITORIAL ADVISORY SUBCOMMITTEE OF CACRS

TERMS OF REFERENCE

As an annual responsibility of IPTASC members at the CACRS meeting, the Terms of Reference of the Sub-Committee were reviewed, and were amended slightly. The current Terms of Reference are as follows:

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.*

*"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 co-operation 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 benefit 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 by CACRS on the recommendation of the respective 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 chairman on an issue with which they do not agree. If agreement between the chairman and objecting members is not reached, the issue shall be resolved by a mail-in-vote of the majority of members. If a quorum of four produces a tie vote, the issue shall be resolved by a mail-in-vote of all members.

Each representative may invite someone to attend 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 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.

Chairmanship

IPTASC elects both a chairman and vice-chairman to hold office for two years. At the end of that period, the vice-chairman becomes chairman automatically, and a new vice-chairman is elected. Elections are held only at an annual meeting or when a vacancy occurs.

NEW OFFICERS

Cal Bricker handed the chairmanship over to vice-chairman Victor Zsilinszky for a two-year term, effective April 16, 1981 at the 1981 Annual Conference of CACRS according to the IPTASC Terms of Reference. Frank Hegyi was elected vice-chairman for the same term.

As a result of a resolution at the 1981 Annual Conference, CACRS formed a seven-member executive including three IPTASC officers: the past chairman, current chairman and vice-chairman.

MEETINGS

The IPTASC representatives on the Executive Board participated in two meetings during June 9-10 and November 24-25, 1981, when CACRS recommendations, planning of the Arnprior '82 meeting and matters about the national remote sensing program were dealt with.

On September 3, 1981, the Interagency Committee on Remote Sensing met and received an IPTASC presentation by Frank Hegyi for the purpose of bringing the two organizations closer together. The presentation included the following subjects:

- provincial involvement in remote sensing;

- concerns of users: principally, continuity of data, the future cost of LANDSAT products, and the development of an operational capability at the provincial level, in part by technology transfer from CCRS;

- support from IPTASC for CCRS projects such as TOPAS and RADARSAT

The mid-term IPTASC meeting was held in Winnipeg on September 8, in conjunction with the 7th Canadian Symposium on Remote Sensing. The meeting included a report on the IPTASC presentation to IACRS, a briefing by CCRS personnel about TOPAS and RADARSAT, reports on provincial activities and discussion on the theme of CACRS '82.

On February 9, 1982, IPTASC members met at 2464 Sheffield Road, Ottawa, at the request of Ralph Baker, Acting Director-General of CCRS, to examine the implications of a major increase in the price of LANDSAT products and to assist the planning of the CCRS technology transfer program. To respond to CCRS proposals regarding the above matters, IPTASC formulated the following recommendations:

"1. It is recommended that CCRS ensure complete Canadian coverage of Landsat-D (MSS and TM) whether from Canadian or other sources, at uniform Canadian prices.

2. It is recommended that:
   a) international price of the Canadian-produced Landsat products meet the recommended price structure as of October 1, 1982;
   b) discussion take place with U.S. space agencies to determine probable price structure changes between now and 1986;
   c) domestic prices be gradually and uniformly phased in on an annual basis and designed to equal international price by October 1, 1984 starting on October 1, 1982.

3. IPTASC agrees with the presented Technology Transfer scenario and recommends that the final question regarding priority provinces be resolved by mutual agreement between the competing provinces and CCRS."

These recommendations were submitted to IACRS on February 9, 1982 by Ralph Baker and were received with the following reaction: IACRS accepted recommendations 1, 2(b) and 3, while 2(a) and 2(c) will be treated according to the results of negotiations with the responsible U.S. organizations.

Finally, the Sub-Committee will hold its last meeting of the 1981/82 term on March 29, 1982 in Ottawa, to prepare for the Annual Conference at Arnprior.

MEMBERSHIP

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6.2 THE MARITIME REMOTE SENSING COMMITTEE

On December 10, 1981, the Maritime Council of Premiers signed into being the Maritime Remote Sensing Committee. This was done on the recommendation of the participating provincial governments.

The committee is comprised of two representatives from each of the three provinces and two members representing the Council of Maritime Premiers, with the Maritime Resource Management Service designated to provide administrative and technical support to the committee.

The mandate of the committee is to investigate a remote sensing technology transfer and development program for the Maritimes.

It should be noted that this concept was passed and supported at the CACRS meeting 1981 at Arnprior.

The committee has recently engaged the services of Intera, Ottawa, to assist in the design of an appropriate technology transfer program. In fact, at a February 9, 1982 meeting of IPTASC it was announced by CCRS staff that the Maritimes and Manitoba had been selected as number one and number two respectively to be placed in semi-finalist positions for the technology transfer program to be finalized later this year.

The committee is comprised of Mr. Don Gillis and Mr. Bob Nicholson, from Prince Edward Island, Mr. John Wightman and Mr. Ed MacAuly from Nova Scotia Mr. W.R. Trenholm and Mr. Lawrence Peters from New Brunswick and Mr. Jim Stanley and Mr. Ron Johnston from the Council of Maritime Premiers. The committee executive is Mr. W.R. Trenholm, Chairman, Mr. Ed MacAuly, Vice Chairman, Mr. Don Gillis, 2nd Vice Chairman, and Mr. Jim Stanley , Secretary. Also, with full observer status, Mr. Ivan Ford from Newfoundland has been attending the majority of the committee meetings.

The committee has agreed to establish a Maritime Support Center, which will be located at the same location as the Maritime Resource Management Service in Amherst, Nova Scotia, but will be an entity unto itself to serve the Maritime Committee and provide support to the Provinces involved.

Any joint venture of this nature and magnitude requires time and patience to develop but the Committee members and others associated with this undertaking are very much encouraged by the fact the bureaucracy involving three provinces and a regional body have been able to proceed together and develop this committee in a little as ten months or less.

The Maritime Region has determined that Remote Sensing does have a place within the region; however, local technological capabilities per se are lacking. A number of private sector organizations have expressed strong support for the activities of the Maritime Committee and are ready to respond appropriately. In fact, the structure is in place to very effectively ingrain the technology of remote sensing into the everyday operational activities of the public and private sector bodies provided an effective program of technology transfer with the necessary support and sustenance is developed and put into place. Now that the Maritime Committee is in place, timing is of the essence. Delays in implementing a technology transfer program with appropriate support will undoubtedly result in lessened impact on both the federal and maritime sector

6.3 REPORT OF THE ALBERTA REPRESENTATIVE

Airborne Remote Sensing

The Alberta Remote Sensing Center coordinated requests for airborne flights between Alberta requestors and the Canada Centre for Remote Sensing (CCRS). Liaison was maintained with requestors and Airborne Operations, CCRS, throughout the flying program.

Spaceborne Remote Sensing

The Alberta Center continued to provide through its Landsat program, advice and assistance in the acquisition and application of Landsat to requestors not only in Alberta, but British Columbia, Saskatchewan, Yukon and the Northwest Territories.

Alberta Remote Sensing Center

The Center assisted Alberta and out-of-province users in the acquisition, application and analysis of remotely sensed data. An ARIES II Image Analysis System was installed in the Center to provide an additional method of producing analysed data.

Training

In cooperation with the Faculty of Extension, University of Alberta, the Center conducted the "Tenth Alberta Remote Sensing Course". Participants were from government, education, private industry and the public from across Canada.

The Center conducted tours for educational institutions. Short courses and briefings were presented to government agencies, educational institutions and the private sector throughout the province. A Remote Sensing Course was conducted in Whitehorse, Yukon, for the Federal Government.

There was an increased number of remote sensing undergraduate courses and graduate studies at Alberta universities. Colleges, technical schools, high schools and elementary schools have also increased their remote sensing programs.

The Center hosted the annual meeting of the CACRS Water Resources Working Group. The Second National Workshop on Engineering Applications of Remote Sensing was also held at the Center.

Landsat Rangeland Project

In 1981, the Public Lands Division of Alberta Energy & Natural Resources, the Canada Centre for Remote Sensing of Energy, Mines & Resources, and the Alberta Remote Sensing Center of Alberta Environment completed a two year joint project to evaluate Landsat data in monitoring range conditions in Southern Alberta. The project developed a useful and easily interpreted Landsat product for practical on-the-range use.

Southern Alberta Public Lands staff evaluation of the use of the enhanced color composite Landsat images, produced by the Canada Centre for Remote Sensing, was extremely positive - all field staff found the imagery useful and informative. September imagery proved the most useful in determining the past season's cattle distribution on the short grass prairie. Areas that received the greatest grazing pressure and those lightly grazed are easily identified on the north-south oriented images by color differences. Attention is immediately drawn to problem areas, which considerably reduces range reconnaissance. Spring images are good indicators of the past year's use and range types can be more easily mapped. Previously drawn range management plans were found to correspond to the image of that area. Images and slides of images proved to be a good visual presentation for Grazing Association meetings when discussing management problems and solutions.

The Canada Centre for Remote Sensing will publish a detailed report on the Project. As well, the Alberta Remote Sensing Center will publish an abridged version for distribution to range managers and others interested in the practical applications of the Landsat imagery to range management.

The project sponsors conducted Landsat Rangeland Workshops in Lethbridge. The response of government and private range managers from Alberta, British Columbia and Saskatchewan required three workshops. These were oriented to the practical needs of the range managers and utilized hands-on study of the project developed Landsat images. The participants were so unanimous in their approval of this new product and methodology that production and distribution of images is underway. The production of hard-copy enhanced color composite Landsat images of Alberta rangelands will be carried out at the Alberta Remote Sensing Center. Distribution will be made through the Alberta Bureau of Surveying and Mapping's Distribution Services' offices in Southern Alberta.

The Center financially supported a number of Remote Sensing Demonstration Projects.

Appendix I - Alberta Advisory Committee on Remote Sensing

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6.4 Report of the British Columbia Government Representative

Airborne Remote Sensing

The acquisition of air photography, covering a considerable portion of British Columbia, was coordinated by Surveys and Mapping Branch of the Ministry of Environment, in cooperation with the Provincial Inter-agency Mapping Program Steering Committee. The highlights of the 1981 air photography program are as follows: high-level (1:40 000) black-and-white photography covering N.T.S. 82 J and K, plus partial coverage of N.T.S. 92 J and N, N.T.S. 93 C,H,L,M and P, N.T.S. 94 L and M, and N.T.S. 104 I and P; high-level (1:40 000) colour infrared partial coverage of N.T.S. 92 H and I; mid-scale (1:20 000) black-and-white photography covering N.T.S. 93 I, L and P, N.T.S. 94 A,B,E, and F, plus partial coverage of N.T.S. 92 E,F,J,K and N; normal colour photography (1:15 000) covering N.T.S. 92 P which will be utilized in mapping the mountain pine beetle infestation in the Chilko public sustained yield unit.

The operational use of 70 mm photography has continued as an integral part of the provincial multi-phase forest and range inventory system. In addition, the following trials and projects were undertaken: debris movement in Carnation Creek, logging waste studies at the University of British Columbia Research Forest, detection and mapping of root rot infection centres at Cowichan Lake, range productivity estimation and the joint Ministry of Forests - Pacific Forest Research Centre multi-stage sampling project in Kamloops for the detection, mapping and assessment of damage caused by mountain pine beetle.

In addition, Timberline Ltd., a forestry consulting company based in Vancouver, has acquired a helicopter boom and camera system and is using it among other things for Tree Farm Licence inventory, for spruce and balsam bark beetle and mountain pine beetle reconnaissance and inventory, and for timber reconnaissance and inventory.

B.C. Research initiated research into the potential roles of small-format aerial photography from remotely-controlled aircraft platforms. Both fixed-wing and rotary-wing platforms are under evaluation. Development to date has centred upon appropriate control systems.

Spaceborne Remote Sensing

The number of spaceborne remote sensing activities continued to increase during 1981. Agencies involved in these activities include AES, B.C. Hydro, B.C. Research, Institute of Ocean Sciences, MacDonald, Dettwiler and Associates Ltd., Ministry of Environment, Ministry of Forests, Pegasus Earth Sensing Corp., University of British Columbia, Canada Centre for Remote Sensing and others.

Significant progress has been made in the operational use of spaceborne data both in the public and private sectors. For example, the Ministry of Forests is using R.B.V. imagery to monitor and map depletions due to harvesting, fire and other causes. This program has been highly successful and cost effective. Pegasus Earth Sensing Corp. has undertaken over ten contracts applying LANDSAT MSS data to such activities as geological exploration, vegetation classification and critical wildlife habitat mapping. The MacDonald, Dettwiler and Associates Ltd. image analysis system is being used both internally and through contracts for such activities as ice studies, directing tanker traffic in the Arctic, road and highways planning and other resource applications. The Institute of Ocean Sciences is applying spaceborne data to ocean studies with emphasis on NOAA and NIMBUS 7 imagery.

Through contracts supported by provincial agencies and private industry, B.C. Research has evaluated LANDSAT MSS data for land-cover mapping, rangeland and turbidity monitoring and wildlife habitat inventories. Thematic Mapper (TM) simulation studies for interior wetland inventories and for monitoring the impacts of port construction have also been undertaken.

A significant amount of work is being done in the development of image analysis systems, hardware and software, and of applications of spaceborne data to resource management. Examples include MacDonald, Dettwiter and Associates development of a number of products for commercialization and exploitation such as:

1) Geocoded image correction system hosted on a VAX computer,
2) Rehosting of the CCRS-CIAS software on a VAX computer,
3) Development of an airborne synthetic aperture radar system,
4) Development of a TM bulk processing

system hosted on a VAX computer for CCRS,

5) Recently completed development of an airborne multiple-detector electro-optical imaging scanner II (solid state),
6) Finalization of the development of a meteorological (geostationary) satellite receiving station and data acquisition system for the Atmospheric Environmental Service,
7) Mid-range systems designed for user specific applications, and
8) Development of procedures and applications for resource management.

The U.B.C. Remote Sensing Council, faculty, graduates and undergraduates are actively involved in remote sensing research and its applications in the Departments of Computer Science, Forestry, Georgraphy, Oceanography, and Soil Science. Research projects are many and inter-disciplinary. They include: monitoring reindeer rangeland conditions; assessment of pre-visual symptoms of bark beetle attack; software development of navigation systems for polar orbiting space craft of the TIROS and NOAA variety; monitoring changes in arctic wetland due to pipe-line construction; automatic verification and update of forest cover maps, use of GEOS data in climatology studies, use of digital terrain models in radiometric calibaration and interpretation of LANDSAT MSS imagery, including removal of sun illumination effects and atmospheric and topographic effects; use of digital terrain models in the precision rectification of remotely sensed imagery; analysis of air pollution effects on vegetaion via MSS data and air photography; air photo studies of "healthy trees" as well as arctic terrain analysis for terrain mobility studies.

Research facilities for digital image analysis at U.B.C. include Comptal Vision I colour image processing display system, connected via a megabit per/sec network communication link, to U.B.C.'s main frame AMDAHL 470 V/8 computer system running MTS. Recently through major NSERC funding, the laboratory for computational vision has acquired a DEC VAX 11/780 system running UNIX and an OPTRONICS Colormation C-4500 model D colour film scanner/writer. This latter facility is dedicated to digital image analysis with communications link to both Comtal and AMDAHL.

Through NSERC funding in cooperation with MDA, other efforts principally in oceanography, are underway to put together a tracking antenna facility to study space craft navigation.

Some of the problems centred around data acquisition. Satellite data must flow more easily from the receiving stations and archived data source. The U.B.C. community is a user-community, and improvement in remote sensing will only occur once the data distribution network has been improved. Users should be contacted with respect to their requirements and every effort should be made to meet these requirements. Airborne data are almost as difficult to obtain as satellite data. Much of the aerial photography has been acquired through private contractors, but the presence of only one MSS scanner makes the acquisition of simultaneous data a very speculative project.

In conclusion, U.B.C. has a thriving remote sensing community doing a large number of tasks which ultimately will play an important part in Canada's national remote sensing program. Because they are primarily training both future users and scientists, cooperation with other elements of the Remote Sensing Community is very important. For further details, please contact Dr. Peter Murtha.

The B.C. Hydromet Networks Coordinating Committee, representing AES, Air Services Branch of the B.C. Ministry of Transportation and Highways, B.C. Hydro, Water Management Branch of the B.C. Ministry of Environment and Water Resources Branch of Environment Canada, are actively engaged in using both spaceborne and airborne remote sensing techniques for applications in water resources management, in the optimum uses of water resources for hydroelectric generation, and in flood control. Applications include snow-cover mapping based on snow-line flights and GOES and TYROS-N satellite imagery. In addition, an operational real time Data Collection Platform (DCP) network using Labarge and Bristol systems to monitor water levels, temperature and precipitation, and water content of snowpacks is in place. This system, which transmits data via communication satellites and GOES and TYROS satellites to ground receiving stations such as PASS and to a telecommunications network, has had the greatest impact of the current remote sensing applications. The Handar DCP will be evaluated owing to some difficulties being experienced with the existing systems. Storm precipitation estimates from IR imagery show promise in providing an operational storm warning system, which is urgently needed in Western Canada.

The Pacific Forest Research Centre increased the number of staff involved in remote sensing, enhanced its digital image processing capability, established an agreement with the B.C. Research Council for the use of the PFRC image processing facility, and worked on the following remote sensing projects: ecological mapping of the Yukon Territory, mapping of root-rot centres in cooperation with the Greater Victoria Water District, monitoring of wetland changes in the Queen Charlotte Islands in cooperation with the B.C. Ministry of the Environment, monitoring the Comox harbour estuary in cooperation with the Canadian Wildlife Service, examination of SEASAT data over Southern Vancouver Island, investigation of slope stability and landslides in the Queen Charlotte Islands as part of the fish and forestry interaction program, development of a multistage sampling procedure in the interior of British Columbia in cooperation with the B.C. Ministry of Forests, and examination of airborne MSS data in the interior of British Columbia.

Conclusions and Forecasts

The use of remotely sensed data has increased greatly owing to technological developments, successful demonstrations of applications, and cost effectiveness. Applications of both conventional and spaceborne remotely sensed data are expected to become more attractive as new systems become operational. The integration of image analysis with geo-data base systems will further increase the attractiveness of satellite data and is expected to provide a major impetus to the application of spaceborne data.

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6.5 REPORT OF THE PROVINCE OF MANITOBA

AIRBORNE REMOTE SENSING:

During 1981, the Interdepartmental Committee on Aerial Photography (I.C.A.P.) processed requests and served as a clearing house for aerial photography requirements of Provincial Government Departments and Crown Corporations. After completion of the 1981 flying season, a total of 29,269 line kilometers of aerial photography were flown in the Province of Manitoba with prints deposited in the Air Photo Library for general use.

The purpose of this photography is as follows:

(a) Federal Government Mapping programs - 3,324 line km.
(b) General use reconnaissance photography (70 mm) - 9,815 line km.
(c) Community base mapping - 281 line km.
(d) Forest inventory programs - 14,888 line km.
(e) Highways construction programs - 961 line km.

The Provincial Air Photo Library has now completed its update of missing, archival photography. In addition, over 3,700 hard copy, colour, remote sensing photographs were acquired for the library.

A 16 mm. microfilm system for the perusal of all aerial photography contained in the Provincial Library will be operational by the end of April, 1982. This quick look method of viewing photos on microfilm will greatly reduce the time required to conduct photo searches and make selections.

7TH CANADIAN SYMPOSIUM ON REMOTE SENSING:

Manitoba played host to the 7th Canadian Symposium on Remote Sensing. The Symposium was sponsored by the Canadian Remote Sensing Society of the Canadian Aeronautics and Space Institute. The event was organized by the Manitoba Branch of the Canadian Institute of Surveying and chaired by Mr. W.G. Best.

The theme for this Symposium was "Down to Earth Management". Poster and plenary sessions were broken up into four categories: land use applications, ecological applications, earth science applications and data management and acquisition.

The symposium attracted 250 delegates and 13 commercial exhibitors from Canada, the United States and abroad. Approximately 80 papers will be published in the proceedings.

SPACEBORNE REMOTE SENSING

The Manitoba Remote Sensing Centre (M.R.S.C.) conducted an investigative study on satellite image analysis equipment for the Province. At the present time this type of service is not available in Manitoba. Project work becomes difficult when the service is external and at a considerable distance. Several options were suggested in the report and these are being actively persued.

APPLICATIONS

Many major remote sensing projects were carried out by the M.R.S.C. over the past year. A project to map barren land caribou habitat using LANDSAT data was completed for the Wildlife Branch, Department of Natural Resources. Various computer classification techniques were used to provide the necessary data to produce vegetation cover maps for six 1:250,000 map sheets in North Western Manitoba.

A project was completed which provided a photo base map of Spruce Woods Provincial Park showing the distribution of leafy spurge (Euphorbia esula). A total of 162 square kilometers were mapped. Colour infrared photography, supported by ground sampling was used for the interpretation. A similar project was conducted in C.F.B. Shilo area where the five main battle runs and fire guard were mapped. Both these areas are considered a source from which leafy spurge may spread to surrounding agricultural land.

Colour infrared aerial photography was also used by the Agricultural Crown Lands Branch as a means of monitoring the effectiveness of aerial spraying on 100 parcels of wooded land which were to be cleared.

The Provincial Wildlife Branch also used colour infrared photography to count muskrat huts in three marsh areas for purposes of obtaining census figures. This is an operational management technique used for establishing trapping quotas.

A pilot study was conducted for the Wildlife Branch on the application of LANDSAT data in measuring white-tailed deer habitat in Southern Manitoba. The Wildlife Branch is concerned about the amount of bush land being cleared in favour of agricultural use. The mapping project was to define the accuracy of LANDSAT data in a test area for area calculations of wooded cover. Statistical analysis was conducted to compare area calculations obtained by LANDSAT as compared to area calculations obtained from large scale 1:15,840 aerial photographs. With a maximum discrepancy error of approximately 10% between the two measuring techniques, the results are very encouraging. With a few refinements this development will be used as an on going monitoring function.

Two other remote sensing projects were initiated during the past year. One was to compare LANDSAT data to conventional photography for mapping wood salvage operations after a large forest fire devastated the Porcupine Mountain Forest Reserve. The second project is designed to evaluate the use of LANDSAT data for the mapping and monitoring of wood cutting operations in South East Manitoba.

Ducks Unlimited has undertaken a project to map wetlands in designated areas in the three prairie provinces. Digital analysis of LANDSAT imagery was used as the primary data source.

The Remote Sensing Centre provides a service to the Forestry Branch in mapping wild fire areas from LANDSAT data. Over the past year, 16 areas were mapped, in various parts of the Province, covering 206,181 hectares.

A wood bison habitat mapping project was carried out for the Wildlife Branch, Department of Natural Resources to evaluate the potential of re-establishing a herd in Manitoba. The Canadian Wildlife Service is providing 50 animals as a breeding herd from Elk Island, Alberta. A 2800 square kilometer block of the Interlake west of Waterhen Lake and east of Provincial Highway No. 6 was assessed. Reconnaissance fixed-wing flights and forest inventory maps provided an overview to select sites for detailed ground truthing, accessible only by helicopter. High level black and white aerial photography was interpreted to produce the habitat map. Critical wintering habitat types for wood bison are wet meadow and fen vegetation comprised mainly of sedges (Carex spp) and reedgrass (Calamagrostis spp). Wetland vegetation types were classified high, moderate and low for habitat suitability. Upland sites were broadly categorized, into coniferous, deciduous, and mixed wood, regeneration, immature and mature forest types. A more detailed vegetation analysis and mapping project was also completed for a 25 square kilometer proposed enclosure area where the initial herd will be intensively managed. The future progeny will be released to range freely in the larger unrestricted block. Digital analysis and enhancement techniques of LANDSAT scenes covering the broad study area may be employed in the future to further refine the habitat map.

A pilot, soil erosion-crop yield study covering two quarter sections of agricultural land near Austin was initiated for the Land and Water Division, Department of Agriculture. Low level colour infrared supplementary aerial photography missions were flown by the Manitoba Remote Sensing Centre staff during crop emergence and prior to harvest. Eroded and non-eroded areas were delineated on the near I.R. photos. Soil samples were obtained from several of each of the site types and analysed for nutrient status. The objective was to determine crop yields for the sunflower and barley crops on both eroded and non-eroded sites. Due to insect infestation and crop disease both crops failed to produce normal yields. Consequently the study was terminated.

An ecological land classification of the Nejanilini Lake, 64P N.T.S. map sheet was initiated by the Manitoba Remote Sensing Centre with advisory and technical support from the Lands Directorate, Environment, Canada. The Lands Directorate has developed a methodology that has potential for national application to the Provinces and Territories. This pilot study will test the feasibility of the classification system. Field data relating to landform, soils, vegetation and perma frost were collected in conjunction with a major caribou habitat mapping project covering six map sheets in the northwest part of the Province. Terrain analysis was carried out using high level black and white photography. A geometrically corrected enlarged LANDSAT scene will be used for the final mapping base at a scale of 1:250,000. The new approach to land classification includes an expanded ecosection data table that lists environmental factors relating to terrain, vegetation and water. In addition, resource management interpretations describe in detail, terrain trafficability and sensitivity, vegetation, hydrology, wildlife, fisheries, landscape aesthetics and special features. In the event of future development schemes in northern Manitoba this resource data base will provide resource planners and managers with an invaluable source document to make judicious environmental impact decisions.

TRAINING

A certificate program of studies in remote sensing is now being offered at the University of Winnipeg. The majority of the required courses are offered regularly through their evening program. This allows those that are already employed to expand their level of knowledge. The University of Manitoba and Brandon University are also offering courses in the field of remote sensing.

A lecture series on boreal ecology and remote sensing techniques was presented to the zoology graduate studies class at the University of Manitoba. Introductory sessions included basic photo interpretation of black and white, true colour and near infrared aerial photography using a mirror stereoscope, Examples of digital analysis of LANDSAT scenes, thermal scanner and radar imagery were exhibited and discussed. The ecological land classification methodology of mapping landforms, soils, vegetation and perma frost was explained in detail. Several classified maps and interpreted, sets of photos were examined covering the low, mid and high boreal ecoregions and the low and high sub-arctic ecoregions. During the final sessions the students carried out an ecological land classification project on part of an unmapped portion of the Province.

A specially tailored mini-course was conducted through the Manitoba Centre for the Water Resources Branch. With assistance of staff from the Centre, Dr. J.D. Mollard presided over the sessions. Remote sensing and photo interpretation related to hydrology applications was the theme of the course.

Staff of the Manitoba Remote Sensing Centre also conducted 10 seminars on remote sensing at Brandon University and the University of Winnipeg. Seminars were also presented for high-school teachers during their in-service days with the aim of exposing them to remote sensing with respect to its use as a teaching aid in geography courses. As well two staff were invited as guests of the Geography Department of the University of North Dakota located at Grand Forks, North Dakota. The purpose of the trip was to tour the facilities in the Geography Department and to become aware of the post graduate remote sensing program being offered.

CONCLUSION AND FORECAST

The success of co-operative projects between the Department of Natural Resources, resource managers and the Remote Sensing Centre have had considerable impact on integrating remote sensing techniques into operational monitoring and data gathering needs. New projects are now being considered which were previously not feasible because of cost restraints. The future looks good for establishing more demonstration projects.

6.6 REPORT OF THE PROVINCE OF NEW BRUNSWICK

Since last year's report the concept of Remote Sensing in New Brunswick has continued to develop as an operational means of information determination for a number of areas. Remote Sensing is beginning to be seen as a tool to be used as an operational management device.

The Provincial Remote Sensing Committee has met regularly and dealt with issues such as a Provincial Remote Sensing Centre, the development of a Maritime Remote Sensing Committee, a continuing education Remote Sensing Program, an Image Analysis Workshop, a Provincial Remote Sensing brochure, membership on CACRS working groups, the development of a list of present and potential remote sensing areas within the Province, and a strong attempt to cooperatively, with the Maritime Remote Sensing Committee, develop a technology transfer program that is appropriate to the Province.

The Remote Sensing Committee in New Brunswick has now taken its proper place within the bureaucratic structure in that it is now properly associated with the provincial policy body dealing with documentation, mapping, surveying and land related data collection and has a reporting structure to the Official Committee on Land Use.

In support of the Maritime Remote Sensing Committee, a motion was put by the New Brunswick Committee to the N.B. Cabinet Committee on Economic Development that a Maritime Remote Sensing Committee be established under the Council of Maritime Premiers. This was passed and forwarded to the Council where it was formally established on the 10th of December, 1981.

The concept of a Provincial Remote Sensing Centre has been dealt with and at this writing it has been established that the Province will open a Remote Sensing Office as an extension to the present photograph and mapping library.

In September 1981 at the University of New Brunswick a continuing education program on the introduction to Remote Sensing was commenced. The course was a direct result of the New Brunswick Committee's efforts and the cooperation of the Survey Engineering Faculty of the University. The program which lasted for ten weeks was well attended and indicated a strong interest in this field.

An Image Analysis Workshop jointly sponsored by CCRS, the N.B. Committee and the University of New Brunswick was held on February 22-24, 1982, with an unexpected registration for the three day workshop. In excess of 30 applicants were accepted for the program. As a result of this interest it is now expected that another workshop will be necessary in the fall of 1982.

The New Brunswick Committee now has a color brochure which is being used to assist in the promotion of the use of remote sensing tools. This brochure is available in both English and French and is intended merely to indicate the existence of remote sensing and its possible applications within New Brunswick.

The New Brunswick Remote Sensing Committee has a number of Sub Committees, one of which has the responsibility of membership on CACRS working groups.

Any information or communication concerning working group activities should be addressed to Mr. David MacFarlane, Director of Forest Inventory, Department of Natural Resources, P.O. Box 6000, Fredericton, N.B., E3B 5H1.

The N.B. Committee is looking forward to the acquisition of a Dipix image analysis system by the University of New Brunswick. This should influence greatly the continued interest in the use of remote sensing by people within the Province and at the same time provide people trained in the use of this equipment locally.

Equipment with Remote Sensing application is gradually increasing.

Presently one company offers a small aircraft single camera 70mm format photography in a vertical mode. An angency of the Council of Maritime Premiers offers a twin engine aircraft with a variety of sensing equipment, including 70mm, 9X9 and video imaging formats. A number of government departments are using light aircraft with handheld 35mm sensing capability. Also available within the Province are three Linear Measurement Set Video Analysis Machines.

It should also be noted that the Provincial Committee is aware of the use being made of remote sensing techniques by STATS Canada in the enumeration of the areas of potato production within New Brunswick and is looking forward to the future developments related to this activity.

The use of remote sensing, other than normal aerial photography, but incorporating this normal aerial photography, is just beginning to germinate. One might refer to this as the neo-natal period of New Brunswick Remote Sensing.

6.9 REPORT OF THE PROVINCE OF NOVA SCOTIA

The afterglow of the most successful 6th Canadian Symposium on Remote Sensing held in Halifax in 1980 has resulted in continued growth in remote sensing activities and interest. The anticipation of the benefits to the user community which will flow from the technology transfer program scheduled for 1982 has promoted co-operative activity in the Maritime region of an unprecedented magnitude. The importance of a fully funded and supported program by CCRS cannot be overemphasized at this time when hopes have been raised so high.

Airborne Remote Sensing

The majority of operational remote sensing in the province was carried out using airborne data. The Department of Lands and Forests has awarded a contract to prepare a Biophysical Land Inventory from normal color photography. High altitude CIR photography has been acquired to monitor spruce budworm damage in Cape Breton Island.

The Environmental Protection Service with regional offices in Dartmouth carried out a number of image acquisitions and analysis projects on data collected mainly in Newfoundland. Lands Directorate has employed a number of airborne products such as: CIR, small-scale B & W, as well as video coverage to conduct studies in the province and the region.

A number of Provincial Departments including Mines and Energy, Transportation, Agriculture and Municipal Affairs make use of existing airborne data in their operational and planning functions.

The Nova Scotia Remote Sensing Centre in co-operation with CCRS acquired considerable TIR, CIR, MSS, and other photographic data on projects relating to research in geological mapping to agricultural and environmental monitoring. The Centre also continued its acquisition of small format photographic data from light aircraft for a wide variety of projects including construction monitoring of the site of the power house for the Annapolis River Tidal Power Project. Remote sensing data in the files of the Centre were used by staff researchers, staff and students at the Nova Scotia Land Survey Institute and Acadia University, government agencies at all levels, consulting firms, and private individuals, including farmers and woodlot owners.

Spaceborne Remote Sensing

Three agencies reported significant work on spaceborne imagery, while several others started preliminary work in 1981 but plan to expand this phase in 1982. Dr. Duncan Keppie of the Nova Scotia Department of Mines has completed a geological lineament map for the entire Province from Landsat. This will be published in 1982. The Nova Scotia Department of Lands and Forests in conjunction with CCRS is assessing the application of Landsat imagery for cutover and gross-feature mapping. The regional offices of Environment Canada are using a variety of spaceborne data in such sections as Lands Directorate, Marine Environment Branch and Inland Waters. The Bedford Institute of Oceanography and the Nova Scotia Land Survey Institute are both increasing staff in anticipation that either one or both will have a full-fledged image analysis system during 1982. It is understood that a number of mining exploration firms active in the province have made extensive use of digital image analysis of Landsat; however, detailed information is not available.

Technical Developments

The most significant technical development in 1981 was the establishment of Atlantic Canada Airborne Sensing as a joint venture by Maritime Resource Management Service and a private flying concern. This organization operates a modern, twin-engine aircraft equipped with a 250-mm mapping camera; two 70-mm cameras, as well as 3/4 inch color and B & W video systems. This provides local, quick response service so necessary in this area of quickly changing weather conditions.

The Nova Scotia Land Survey Institute announces that a team of three of their graduate computer programming students have developed an image analysis software package for use on a general purpose computer system. A standard monochrome video terminal is used in conjunction with a dot matrix line printer for hard copy maps. The Institute plans to install the first fully operational Geographic Information System in Atlantic Canada early in 1982. Future work is expected which will combine the results of image analysis as one or more data sets in the G.I.S. data base.

User Liaison

The Nova Scotia Remote Sensing Committee held a number of meetings throughout the year to provide liaison between major users. The loss of Tom Alföldi as our regular contact with CCRS was deeply felt by all. CCRS was unable to supply a full-time replacement so that at many meetings no CCRS person was in attendance or a variety of individuals came. This has been interesting and each person has tried their utmost to provide assistance, however, it would be desirable if CCRS would appoint a full-time contact person and ensure that attendance at our meetings is a priority.

Training

The Nova Scotia Land Survey Institute in co-operation with the Canada Centre for Remote Sensing, the Nova Scotia Remote Sensing Centre, and the Nova Scotia Remote Sensing Committee conducted a Digital Image Analysis Workshop at the Nova Scotia Land Survey Institute on November 23-25. Dr. Andy Rentz of CCRS and Dr. R. V. Maher of Nova Scotia Land Survey Institute conducted the technical sessions for the 21 participants. The sessions featured a great deal of "hands-on" image analysis using the newly developed "image analysis software package" at NSLSI. Response from participants was very favourable and discipline specific workshops are planned at NSLSI when they receive their "stand-alone" image analysis system in 1982.

The two year, four semester, remote sensing training program at NSLSI is being revised effective September 1982 into a very intensive, three semester, 48 week program. This training is aimed at recent graduates in the natural resources and environmental disciplines. Sixteen students are expected to enroll. For those who qualify, financial assistance may be available ranging from $3,000. to $10,000., depending upon circumstances.

Conclusions and Forecast

1981 was a year of reflection on the success of the 6th Symposium and considerable planning for major projects in 1982. The increased level of activity indicated at MRMS, BIO, and NSLSI indicate that even with hard economic times, remote sensing in Nova Scotia has an expanding future.

The level of anticipation generated in the region by the CCRS Technology Transfer program must be nurtured by CCRS into an operational reality. To falter now would have a serious negative impact on the development of remote sensing technology in Atlantic Canada.

Recommendations

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

(2) That CCRS through whatever means necessary, including transfer of funds from other programs, provide the necessary financial, equipment, data, and technical manpower to support a full-scale technology transfer program.

(3) That due to the greatly increased number of installed or soon to be installed image analysis systems outside the Ottawa area and also due to the deleterious price increases proposed for CCT's and DICS tapes, it is recommended that CCRS set up a more formalized lending library for these tapes already in their possession. In addition it is recommended that CCRS make available an up-to-date list of the owners of all such Canadian tapes with complete information regarding image location, date, quality, etc. that the owner is prepared to release.

APPENDIX I - List of Group Members

Dr. Andrew Rentz (613) 995-1210
Canada Centre for Remote Sensing

Mr. Bob Feindel (902) 469-7901
Atlantic Air Survey Limited

Mr. Dave Wilson (902) 426-4196
Lands Directorate

Mr. Andrew Patton (902) 424-4091
Community Planning Division
N. S. Department of Municipal Affairs

Mr. Graham Doyle (902) 455-7241
Canadian British Consultants

Mr. Don Hirtle (902) 424-5300
N. S. Department of Environment

Dr. Duncan Keppie (902) 424-8598
N. S. Department of Mines

Mr. Herb Ripley (902) 667-7231
Maritime Resource Management Service

Mr. Ed MacAulay (902) 895-1591
(902) 424-7594
N. S. Department of Lands & Forests

Mrs. Mary Dwyer Rigby (902) 463-7226
Consultant
Dartmouth, N. S.

Mr. Roger Percy (902) 426-8301
Environmental Protection Service

Prof. P. Rangaswamy (902) 429-8300
Nova Scotia Technical College

Mr. David Rice Smith (902) 424-7769
N. S. Department of Transportation

Mr. Dave Smith (902) 424-3266
Inland Waters Directorate

Mr. John Wightman, Chairman (902) 584-2226
Nova Scotia Land Survey Institute

Airborne SAR data was used together with LANDSAT data in a land cover mapping project.

Professor R. Parent of the Department of Civil Engineering, Royal Military College, used one series of 32 black and white stereograms for each student, and a set of 20 black and white stereopairs and stereotriplets per student which were purchased from the National Air Photo Library (NAPL).

6.10 REPORT FROM THE PROVINCE OF ONTARIO

The following report is based on replies to a questionnaire distributed by the Ontario Centre for Remote Sensing.

No. of agencies contacted: 58

No. of replies:

Government	-	6
Private Sector	-	9
Universities	-	11
Total		26

Airborne Remote Sensing

Professor G.O. Tapper of the Department of Geography, Laurentian University, reports the use of approximately 200 panchromatic, 9" x 9" aerial photographs, as well as approximately 100 colour and 100 colour infrared photographs of the same format. Some 10 thermal images of various Ontario cities and the same number of SAR images of Ontario and Eastern Canada were also employed.

Professor P.J. Howarth of the Depart- of Geography, McMaster University, employed 35 copies of 10 panchromatic stereotriplets for teaching purposes, and approximately 30 photographs (panchromatic, colour and colour infrared) for an advanced course. Approximately 1400 panchromatic photos were employed in three research projects, as well as 144 colour infrared photos; not all of these photos were purchased by the university for these projects. Hand-held 35mm colour aerial photography was acquired for one of the studies. In addition, imagery from an 11-channel MSS was requested from CCRS for a LANDSAT-D simulation study of land cover/land use mapping in Southern Ontario. CCRS also obtained colour infrared aerial photography in support of this project. Both thermal and radar data were used in teaching and labs.

Mr. I. Hale, Program Director of Survey Engineering Technology at Ryerson Polytechnical Institute, reports the use of approximately 1,000 black and white, 20 colour and 20 colour infrared photographs. Samples of both thermal and radar data were used to demonstrate image characteristics.

Dr. S.H. Watts, Teaching Master in Geology at Sir Sandford Fleming College, employed approximately 100 black and white photos for teaching purposes, and 30 black and white photos from NAPL for research. Thermal and radar data were used to a limited extent for lab demonstration.

Professor F. Salvatori of the Department of Landscape Architecture, University of Toronto, reports the use of 50 1:10,000-scale black and white aerial photographs.

Professors of the Department of Geography of Trent University employed several dozen panchromatic aerial photographs for teaching purposes. They made very limited use of thermal and radar data.

Professor A.B. Kesik of the Department of Geography, University of Waterloo, used approximately 600 black and white photographs, 500 reproduced by offset printing and 100 by photographic printing, and 40 colour photographs. Approximately 50 thermal images and 50 SLAR images were used for teaching purposes. Thermal imagery formed the basis of a study of lake surface temperature patterns. Professor E. LeDrew of the Department of Geography reports using approximately 60 large-scale black and white aerial photographs. Hand-held supplementary aerial photography was acquired from a helicopter. Video thermal imagery was requested from AGAtronics Ltd. Professor S.I. Solomon of the Department of Civil Engineering employed 10 aerial photographs.

The Land Use Coordination and

Special Studies Unit, Environmental Approvals Branch, Ministry of the Environment, acquired approximately 200 35mm and 70mm oblique colour aerial photographs internally, for the monitoring of liquid industrial waste disposal sites and for land use plan monitoring. Approximately 25 9" x 9" black and white aerial photographs were also used. Aerial photography was also obtained through a private company, Airborne Applications Group, for pollution monitoring. Aerial thermography acquired through a joint project with the Ontario Centre for Remote Sensing was used in environmental monitoring.

The Technical Support Unit of the Hydrology and Monitoring Section of the Ministry of the Environment employed approximately 100 1:15,840-scale aerial photographs.

The Surveys and Mapping Department of Ontario Hydro, which has the responsibility to provide remote sensing data to Ontario Hydro as a whole, reports the use of approximately 25,000 black and white photograph, as well as 250 colour and 50 colour infrared photographs. Approximately 3,300 miles of aerial photography at various scales were obtained through the private sector, producing over 5,000 near-vertical negatives. The Land Use and Environmental Planning Department employed 3,100 9" x 9" aerial photographs in scales from 1:10,000 to 1:50,000, and approximately 30 colour photographs.

The Remote Sensing Section, Maintenance Operations Branch, Ministry of Transportation and Communications, reports the use of a large number of aerial photographs of various types for a range of purposes. Aerial photographic flights were obtained through the federal government and private companies.

The Ontario Centre for Remote Sensing employed large quantities of aerial photography of all types, from provincial and national sources, in research programs and training seminars. The Centre conducted an extensive and varied program of multi-camera airborne sensing, obtaining black and white, colour and colour infrared photography, principally in the 70mm format, in support of research and trial-application projects. Under the Centre's coordination, a large volume of colour infrared coverage was obtained by Capital Air Surveys within three administrative districts of the Ministry of Natural Resources, for the assessment of forest regeneration. The OCRS obtained aerial thermography with its Daedalus line-scanner for a number of projects, including a study to determine the usefulness of this imagery in the location of potential areas of roof instability over mine sites. In conjunction with the HEAT SAVE program of the Ministry of Energy, the OCRS coordinated, largely through Intertech Remote Sensing, the acquisition of aerial thermography for 8 Ontario cities. Radar imagery was used in 1981 principally in training seminars.

Air, Earth and Oceans Ltd. reports the use of 50 9" x 9" colour infrared and 10 9" x 9" black and white aerial photographs. Aerial missions were requested to obtain 1:2,000-scale colour infrared photography. Thermal imagery was extensively used in a search and rescue study. Ground-based thermal imagery was acquired. Experiments were performed on applications of the low-light-level viewer. SAR and SLAR imagery were used in sea ice studies and in radar image interpretation seminars conducted in cooperation with the Ontario Centre for Remote Sensing.

Airphoto Analysis Associates Consultants Ltd. employed approximately 2,000 black and white and colour aerial photographs.

Beak Consultants Ltd. used 800 black and white aerial photographs at scales of 1:15,840 to 1:5,000, and commissioned low-altitude black and white photography of a site in southwestern Saskatchewan from the North West Survey Corporation.

Dendron Resources Surveys Ltd. reports the use of several thousands of aerial photographs of the following types: standard black and white photos at scales of 1:15,840 and 1:10,000; 1:15,840-scale colour infrared photos; and black and white and colour photos at scales of 1:1,000 to 1:1,600. One photographic mission was requested from a private company. Dendron itself obtained approximately 7,000 70mm large-scale black and white and 500 colour photographs for purposes of forest inventory and forest type map checking.

Ecologistics Ltd. employed 100 conventional black and white aerial photographs, and acquired low-level colour and colour infrared photography through a private company.

Gregory Geoscience employed approximately 25 1:50,000 panchromatic photographs, as well as 16 photomosaics at the same scale. The company itself acquired nearly 800 frames of small-format, low-altitude, oblique photography for field verification of topographic map revision. Very limited use was made of airborne thermal and radar data for teaching purposes.

Marshall Macklin Monaghan Ltd. reports using approximately 2,000 9" x 9" black and white photographs. The company acquired 9" x 9" black and white coverage for mapping purposes through Capital Air Surveys, Global Remote Sensing, Western Remote Sensing, Northway-Gestalt and Kenting Earth Sciences.

Scintrex Ltd. reports the use of approximately 1,000 black and white photographs in 1981.

Spaceborne Remote Sensing

Professor G.O. Tapper of Laurentian University employed nearly 200 LANDSAT scenes, on 35mm slides, for teaching purposes.

Professor P.J. Howarth of McMaster University employed LANDSAT imagery, as well as digital classifications and enhancements, in lectures and labs. Weather satellite imagery was also used. For three research projects, the following data were used: 10 DICS tapes, 15 MSS colour transparencies, 17 RBV transparencies, 10 EBIR outputs, phtographs and electronic and line-printer outputs. SEASAT radar imagery in both 70mm format and enlargements was used in two projects.

Both Professor R. Parent of the Royal Military College and Professor I. Hale of Ryerson Polytechnical Institute report using slides of LANDSAT images for teaching purposes.

Professor S.H. Watts of Sir Sandford Fleming College reports the limited use of LANDSAT imagery, in print and transparency formats, for lab demonstration and term projects.

At the Department of Geography of Trent University, a small number of LANDSAT images were used in one course.

Professor A.B. Kesik of the Department of Geography, University of Waterloo, reports the use of 40 black and white LANDSAT prints and CCT's of two scenes in the preparation of a master's thesis. Professor E. LeDrew of the same department reports the extensive use of LANDSAT imagery transparencies and CCT's in teaching and research. Professor S.I. Solomon of the Department of Civil Engineering reports the extensive use of LANDSAT and GOES imagery and CCT's, particularly in four research projects.

The Land Use and Environmental Planning Department of Ontario Hydro reports the use of digitally-analyzed LANDSAT data for a land-cover mapping trial, in a joint project with the Ontario Centre for Remote Sensing.

The Ontario Centre for Remote Sensing purchased approximately 500 LANDSAT images for use in research and trial-application projects, in training seminars, and to update the OCRS imagery library. Approximately 75 LANDSAT CCT's were purchased as the primary data source for land use, wetland and forest mapping. The OCRS continued to receive GOES and NOAA weather satellite imagery daily, for particular use in the scheduling of airborne operations.

Air, Earth and Oceans Ltd. employed LANDSAT imagery for engineering site selection.

Dendron Resource Surveys Ltd. demonstrated the potential contribution of LANDSAT data to forest management, to representatives of the forest industry.

The emphasis of the 1981 activities of Geostudio Consultants Ltd. was on the development of methodologies for the application of digitally-analyzed LANDSAT data, using DICS tapes.

Gregory Geoscience Ltd. used approximately 2,000 LANDSAT frames (48% were black and white MSS frames, 40% RBV imagery and 12% colour imagery), as well as 8 CCT's, of which 5 were DICS tapes.

Kenting Earth Sciences Ltd. reports the use of black and white and colour LANDSAT imagery in the initial preparation of project estimates and during the preliminary phase of projects in areas for which no maps were available.

Marshall Macklin Monaghan Ltd. employed approximately 10 LANDSAT images at scales of 1:1,000,000 and 1:250,000.

Applications and Developments

Professor P.J. Howarth reports that remote sensing was applied by investigators in the Department of Geography, McMaster University, to the following projects:

- change detection in the Peace-Athabasca Delta using LANDSAT digital data

- LANDSAT-D simulation study of land cover/land use mapping in southern Ontario

- geologic mapping in the Grenville Province of Ontario, using LANDSAT MSS and RBV data, and SEASAT radar data

- land use/land cover mapping in the Hamilton-Wentworth region of Ontario using LANDSAT MSS and RBV data and SAR airborne data

Professor Howarth also reports the development of a recommended procedure for determining hydrologic and vegetation changes using LANDSAT DICS data.

Professor I. Hale of Ryerson Polytechnical Institute reports the development of a method of multi-parameter analysis for route and site selection, in conjunction with Bird and Hale Ltd. Computerization of the method is underway.

Professor S.H. Watts of Sir Sandford Fleming College reports the use of remote sensing imagery for the examination of structural control of fiord development in an Arctic field study area.

Professor F. Salvatori of the Department of Landscape Architecture, University of Toronto, employed aerial photography in resource and environmental analysis.

The Department of Geography of Trent University employed remote sensing imagery in hydrological research on small basins and in the study of ice cover on lakes.

Professor A.B. Kesik of the Department of Geography, University of Waterloo, reports the interpretation of LANDSAT imagery and aerial photography for geological and geomorphological information. Professor E. LeDrew used aerial thermography and small-format aerial photography to determine surface thermal gradients and current trajectories in a small lake. He also reports the development of computer programs for edge detection of thermal patterns from CCT's. Professor S.I. Solomon of the Department of Civil Engineering reports the following applications of satellite data:

- LANDSAT-based land use/land cover mapping in Columbia

- a flood prediction study in Pakistan using LANDSAT data

- estimation of solar radiation at the earth surface using GOES data

- rough land use/land cover mapping using GOES data

Professor Solomon also reports the development of software with which microcomputers (with disc, tape drive and line-printer) can be used to perform the digital analysis of LANDSAT and GOES CCT's.

The Land Use Coordination and Special Studies Unit, Environmental Approvals Branch, Ministry of the Environment, applied aerial thermography supported by colour photography for the detection of leachate seepage from landfill sites.

The Technical Support Unit of the Hydrology and Monitoring Section of the Ministry of the Environment interpreted aerial photography to obtain geological and hydrogeological information for the siting of landfills.

The Surveys and Mapping Department of Ontario Hydro employed colour infrared aerial photography for the detection of sub-surface field drainage tiles in southwestern Ontario, both in order to minimize damage during hydro line construction and to provide a historical record. The Land Use and Environmental Planning Department reported that it interprets conventional black and white aerial photographs for all route and site selection projects, extracting information on land use, agriculture, vegetation, pits and quarries, mines, topography, soil/slope conditions, wildlife habitat and surficial hydrology. Data identified on the photographs is checked in the field, then transferred to mosaics or topographic maps, or encoded for computer mapping and analysis.

The Ontario Centre for Remote Sensing put into full operation a system for computerized map production from digitally-analyzed LANDSAT data, based on the Applicon Colour Plotter. The Centre developed software to produce maps with a UTM grid, latitude and longitude references, legend, delineation of the boundaries of colour-coded themes in black or white, and annotation of features by characters or graphic symbols. Programs have also been written to permit users of the system to effect outlining, shading and annotation of features on the final Applicon-printed map through manipulation of a cursor on the display monitor of the image analysis system. A technique has been devised to integrate the analysis results from two or more images within a single map, for the complementary use of different seasons of imagery and for change detection from a comparison of data from different years. Work is presently underway on the development of software for the integration into a single Applicon-produced map of data from existing thematic maps and other forms of remote sensing imagery, with data derived from the digital analysis of LANDSAT data.

The OCRS digital analysis/computerized map production system was employed in numerous LANDSAT-based programs in 1981. The following are some examples:

- classification and mapping of wetlands of the Ontario portion of the Hudson Bay-James Bay Lowland

- land use/land cover mapping of Ontario

- trial application of digitally-analyzed LANDSAT data to agricultural land use mapping for the province

- synthesis of vegetation change over a period of years, related to changes in the emission of industrial pollutants

- forest mapping north of latitude 52°N (the northern limit of the standard provincial forest inventory program)

The following are examples of OCRS programs based on other forms of remote sensing data:

- coordination of an extensive operational application of the OCRS-developed method for the assessment of forest regeneration success

- development of a technique using aerial thermography, photography and LANDSAT imagery for the location of potential areas of roof instability over mine sites

- continued development of an aerial photographic method for the quantitative evaluation of forest damage from spruce budworm infestation

- coordination of thermal and photographic data acquisition for 8 towns and cities; direction of thermography presentations to homeowners at 2 residential energy conservation clinics of the Ministry of Energy

- test of digitized thermography for the analysis of thermal plumes in waterbodies

Beak Consultants Ltd. interpreted 1:25,000-scale aerial photography for forest cover and surficial geology mapping, as part of a reservoir preparation study conducted in northwestern Ontario. Black and white photographs at a scale of 1:5,000 provided data on vegetation types and the distribution of wetlands.

Dendron Resource Surveys Ltd. performed forest stand typing and the measurement of height and crown area on black and white, colour and colour infrared photography, to produce volume estimates for forest and biomass inventories. The company reports development of the use of inertial navigation systems for obtaining orientation parameters for photogrammetric restitution; and the refinement of photogrammetric tree volume estimation techniques.

Ecologistics Ltd. employed black and white, colour and colour infrared photography to establish baseline environmental conditions surrounding a proposed landfill site.

Geostudio Consultants Ltd. reports further progress in the development of methodologies for the digital analysis of LANDSAT data. The GEOTHEME analysis technique was successfully applied to the mapping of waterbodies in Western Canada. A project was completed for Agriculture Canada demonstrating the ability to retrieve automatically portions of DICS data on the basis of Land Survey System geographical land parcel descriptions.

Gregory Geoscience Ltd. applied the interpretation of LANDSAT imagery using the Procom projection compositor to the revision of 35 1:250,000-scale Canadian topographic maps, and to change detection on 500 1:50,000-scale topographic maps for planning of revision photography. Interpretative geological mapping was performed for projects in Ethiopia and Canada, using the Procom system to integrate gamma-ray, aeromagnetic, gravity and LANDSAT data and existing geological maps. The company is aiming at automation of the Procom system.

Kenting Earth Sciences Ltd. applied satellite data to small agriculture and land use mapping projects; employed it in initial project assessment and as basic data where no maps were available; and used repetitive coverage to supplement other information sources on large projects.

Philip A. Lapp Ltd. is conducting a study of the suitability and viability of a range of satellite sensors for Canadian ice and oceanographic data requirements. The final reports of the study will be available in mid-1982.

Marshall Macklin Monaghan Ltd. employed a large volume of aerial photography and a limited amount of LANDSAT data in the historical review of landfill sites, the location of specific geological features, terrain evaluation and mapping.

Training

Professor G.O. Tapper reports that two undergraduate courses of the Department of Geography of Laurentian University include training in the interpretation of remote sensing imagery.

Professor P.J. Howarth of McMaster University reports that remote sensing courses given at the third and fourth-year levels were attended by 83 students, that a graduate remote sensing class was conducted, and that three students completed master's degrees in geography with specialization in remote sensing.

Professor R. Parent of the Royal Military College reports that a terrain analysis course includes training in the interpretation of aerial photography.

Professor I. Hale reports that two courses on airphoto interpretation, one of an introductory nature and one with emphasis on engineering studies, were conducted twice in 1981.

Professor S.H. Watts of Sir Sandford Fleming College teaches an introductory course in remote sensing to third-year geology students.

Professor F. Salvatori of the Department of Landscape Architecture, University of Toronto, includes applications of remote sensing within a Landscape Architectural Design Program.

Professors of the Department of Geography of Trent University offer training in airphoto interpretation as part of several courses. It was reported that LANDSAT thermal and radar imagery were used, to a limited extent, in one course only.

Professor A.B. Kesik of the Department of Geography, University of Waterloo, taught undergraduate and graduate courses in remote sensing, and supervised honours essays and master's and doctoral theses based on remote sensing applications. Professor E. LeDrew taught fourth-year and graduate remote sensing courses, and directed remote sensing-related graduate research. Professor S.I. Solomon of the Department of Civil Engineering, University of Waterloo, taught one graduate course on the use of remote sensing in hydrology, and supervised two graduate and one doctoral student in the performance of remote sensing research.

In 1981, the Ontario Centre for Remote Sensing acted as catalyst in the formation of the Committee on Advanced Remote Sensing Education and Research (COARSER), which consists at present of 24 professors from 12 universities and colleges, as well as a representative of the Ontario Centre for Remote Sensing. A Steering Committee made up of 5 professors and the Chief Scientist of the OCRS was established. The following are some of the objectives of COARSER:

- to maintain, on behalf of the universities and colleges of Ontario, an inventory of courses offered in remote sensing in the province, instructors, curricula, written teaching materials, and equipment on hand and proposed for acquisition;

- to provide, on request, advice to a post-secondary institution or an individual instructor on curricula, methods of instruction and teaching materials in remote sensing;

- to identify and request specialists to teach specific courses, as required;

- to act, on request, as a source of informed comment on programs in remote sensing at the graduate level;

- to identify topics for which teaching materials are needed, to be prepared by the OCRS and other members of the Committee, with the cooperation of the Steering Committee;

- to identify the types of workshops to be organized at OCRS for remote sensing instructors;

- to advise government ministries and departments of the need for research and development of sensors, techniques of remote sensing data analysis and applications of remote sensing technology, as necessary.

Under its technology transfer program, the Ontario Centre for Remote Sensing conducted the following remote sensing training seminars in 1981:

General Remote Sensing Seminar for Professionals (5 days)

General Remote Sensing Seminar for Managers (3 days)

Remote Sensing Seminar on Forestry Applications (3 days)

Remote Sensing Seminar on Land Use Applications (3 days)

Remote Sensing Seminar on Geological Applications (3 days)

Photo Interpretation for Boreal Forest Conditions (5 days; conducted twice in 1981)

Photo Interpretation for Great Lakes-St. Lawrence Forest Conditions (5 days; conducted twice in 1981)

All courses emphasized hands-on experience in the practical application of remote sensing data. Staff members from government organizations, private companies and universities participated. Attendance was limited to 10 for each course, to ensure individual attention.

Under the Canada-Germany Scientific and Technical Exchange Program, the Chief Scientist of the OCRS conducted a series of advanced seminars on applications of LANDSAT and radar data to forestry, land use and geology for teaching staff of the Faculties of Geography and Forestry of the University of Freiburg, West Germany.

Other aspects of the OCRS technology transfer program included the following:

- A wide variety of remote sensing consultation and/or assistance was provided to 47 organizations of the Ontario Government;

- A wide variety of remote sensing consultation was provided to 27 private companies;

- Consultation and assistance were provided to staff, graduate and senior undergraduate students from 15 university departments;

- Eight workshops were given for students, at the OCRS, at the request of teaching staff;

- Eight guest lectures were presented at universities by OCRS staff, at the request of professors;

- Graduate or doctoral thesis supervision and guidance were provided to 10 students. In some cases, the OCRS digital image analysis facility was made available for use in studies toward thesis preparation.

Air, Earth and Oceans Ltd. conducted a radar image interpretation seminar in conjunction with the Ontario Centre for

Remote Sensing, and gave lectures on the same subject at the University of Toronto and Ryerson Polytechnical Institute.

Dendron Resource Surveys Ltd. demonstrated to representatives of the forest industry applications of large-scale and conventional photography and LANDSAT imagery to forest management. Staff of the company provided instruction at a remote sensing workshop.

Dr. A.F. Gregory, President of Gregory Geoscience Ltd. taught one course involving remote sensing application in 1981.

Kenting Earth Sciences Ltd. conducted an in-house information program on spaceborne remote sensing.

Assessment of Benefits

The general consensus among the university and community-college professors who reported using remote sensing imagery to any significant extent, was that it was extremely valuable in teaching and indispensable in their research projects.

Mr. R.C. Ostry of the Technical Support Unit, Hydrology and Monitoring Section, Ministry of the Environment, reported that, although the total commitment of his Unit to remote sensing remains low, it has become an integral part of the work program.

Mr. L.E. Milton, Manager of the Land Use and Environmental Planning Department of Ontario Hydro, commented that information derived from photo interpretation provides a major component of both site-specific and regional environmental assessment studies.

The Ontario Centre for Remote Sensing believes that the computerized map production system it has established in tandem with its image analysis system has overcome an important obstacle to the operational application of LANDSAT data to thematic mapping over large areas.

The general consensus among the private companies which replied to the OCRS questionnaire was that the use of remote sensing was an essential part of their business. Kenting Earth Sciences Ltd. expressed a growing interest in the application of LANDSAT to topographic and thematic mapping.

Conclusions and Forecast

The consensus of university and college professors who replied to the questionnaire was that the Committee on Advanced Remote Sensing Education and Research would be useful in advancing training in the use of remote sensing, and that the OCRS technology transfer program was a valuable source of assistance. Several professors stated that more funds were required for the purchase of equipment and imagery for remote sensing instruction.

The Ontario Centre for Remote Sensing is encouraged by evidence of a growing interest in the use of remote sensing techniques on the part of private companies in the province, and by the high level of interest in advancing remote sensing education shown by university and college professors.

Air, Earth and Oceans Ltd. recommended that OCRS conduct a comprehensive study into the status of remote sensing in Ontario, and that province-wide standards in remote sensing education be developed.

Dendron Resource Surveys Ltd. commented that both CCRS and OCRS are succeeding in efforts to extend the use of remote sensing beyond the scientific community in that several companies are now prepared to carry out operational projects using sophisticated remote sensing technology.

Recommendations

Professor R. Parent of the Royal Military College recommends that the Working Group of CACRS on Engineering Applications have lab-exercise material based on actual studies prepared for civil engineering students at various levels.

The Ontario Centre for Remote Sensing commends CCRS on the quality of LANDSAT data production - with special mention of the excellent quality of colour composites - and on the efficiency of service; on the establishment of a well-funded office for technology transfer; and on the program to upgrade Canadian receiving stations for the next generation of satellite data.

Air, Earth and Oceans Ltd. recommends an improvement in communication among users of remote sensing data, through, for example, a more up-to-date national newsletter.

Kenting Earth Sciences Ltd. wishes to participate more actively in the national remote sensing program and proposes two members of its staff for membership in the Working Group on Geography.

1981 Publications and Papers

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Dalman, D.W. and R. Johnson. Operation Skywatch: the Ontario Ministry of the Environment Program of Aerial Surveillance for Environmental Monitoring. Proceedings, Remote Sensing for Resource Management Conference, Soil Conservation Society of America, Kansas City, Missouri (in press).

Feldman, U., P.J. Howarth and J.A. Davies. Estimating Surface Wind Direction over Drifting Pack Ice. Journal of Geophysical Resarch, Vol. 86, No. C9, pp. 8117-8120.

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6.11 REPORT OF THE PRINCE EDWARD ISLAND REMOTE SENSING COMMITTEE

The Prince Edward Island Remote Sensing Committee has not been active during the past year. Interest has been shown by several users in resource departments to apply remote sensing techniques to particular problems. Of late, discussions among these potential users and their counterparts in Nova Scotia and New Brunswick have proceeded. Recently, the Council of Maritime Premiers has approved the formation of a Maritime Remote Sensing Committee.

During the second week of January, representatives of government, industry and the university met and agreed to re-activate the provincial committee. From that meeting two representatives, who coincidentally are the new Chairman and Secretary of the Provincial Committee, were chosen to represent P.E.I. on this Maritime Remote Sensing Committee. The new Chairman is Don Gillis of the Engineering Department at U.P.E.I., and the new Secretary is Robert Nicholson of the P.E.I. Department of Agriculture & Forestry.

The general consensus of the meeting was that new efforts through the Maritime Committee would be forthcoming in the new year. There appeared to be a real desire among meeting attendees to get some projects going and successes achieved in Prince Edward Island.

General economic conditions, financial restraint, and staff reductions are the background against which this new interest should be tempered. However, the need and desire still exist and with co-operation of all and new approaches perhaps good progress can be made.

6.14 REPORT OF THE REPRESENTATIVE OF THE YUKON TERRITORY

An integrated multidiscipline resource inventory was conducted in the MacMillan Pass area of Yukon during the summer of 1981. The study area is equivalent to one 1:250,000 NTS mapsheep in area. Mapping was done at a scale of 1:100,000 and included aquatic, vegetation, soil/surficial geology and archaeology components. Individual discipline maps will be published, in addition to ecosection-ecodistrict maps.

A landsat image, bands 5, 6, 7, was enlarged to the 1:100,000 scale and contours were superimposed. This product was used to facilitate the stratifying of vegetation ground truth sites.

Vegetation community maps of the Demspter Highway Corridor will be available prior to March 31, 1982. The mapping technique involved unsupervised classification of landsat imagery on the image 100 system and ground surveys. Scale of mapping is 1:100,000.

The Forestry Section, DIAND will be employing visual interpretation of color landsat transparencies (bands 4, 5, and 7) to prepare a general map of vegetation types for the entire Yukon Territory. Scale 1:250,000. The Forestry Section will also be testing 1:250,000 landsat color prints for use as a supplement to standard maps and air photo for fire detection work from fire towers during the 1982 summer season.

7.1 SPECIALTY CENTRE REPORT:

PETAWAWA NATIONAL FORESTRY INSTITUTE

Introduction

Remote sensing research is being undertaken by the digital remote sensing and fire management systems groups at the Petawawa National Forestry Institute. PNFI operates, maintains and upgrades the ARIES image analysis system and supports current research programs covering a wide range of sensors and applications (e.g., Landsat MSS, airborne MSS, airborne synthetic aperture radar and laser fluorosensor; insect defoliation, regrowth monitoring, forest classification and databases, and forest change detection).

Assessment of Spruce Budworm Defoliation with Digital Airborne MSS Data

Two approaches are being investigated. 1) The assessment of the total amount of defoliation (loss of foliage of current year and previous years). This approach will be useful for monitoring stand condition, predicting mortality and planning salvage logging operations. 2) Assessment of current defoliation (loss of current year's foliage; assessed by detecting the red-brown colour of affected trees caused by partially consumed needles adhering to a web-like feeding tunnel produced by the budworm). The approach will aid in determining the current distribution of the budworm, detecting new outbreaks and in managing control programs.

Total Amount of Defoliation Eleven channel airborne MSS data were acquired at 19 m and 4.5 m resolutions over two predominantly fir/spruce, mixedwood forest on Cape Breton Island, N.S. Supervised and unsupervised classification techniques were examined. Variations in the signatures of stands due to differing hardwood component or crown closure make classification of defoliation level in stands of different composition or density difficult. Supervised classification of the 19 m data was unsuccessful due to the small size of the forest stands. The 4.5 m data was successfully classified although due to the effects of varying crown closure and hardwood component only dense fir/spruce stands were classified. Four levels of defoliation 0-33%, 33-66%, 66-90% and >90% plus a class of wind blowdown were identified. Misclassification was approximately 25%. A good classification was obtained using only channel 9 (0.77-0.90 µm), channel 3(0.45-0.50 µm) and channel 7(0.63-0.70 µm). Channel 9 and 3 were the most useful for separating defoliation level. Unsupervised classification gave two broad levels of defoliation for both the 19 m and 4.5 m data and may be particularly applicable for areas in which forest stands are small and supervised techniques are difficult. Results of this study are reported in "Assessment of Spruce Budworm Defoliation Using Digital Airborne MSS Data, D.G. Leckie and F.G. Gougeon, Proceedings 7th Canadian Symposium on Remote Sensing, Winnipeg, September 1981 (in press).

Current Defoliation Two test areas in northern New Brunswick were flown in early July 1981 during the period when trees affected by the budworm had a red-brown colour. Eleven channel MSS data at approximately 8.5 m, 4.0 m and 1.0 m resolution as well as normal colour and colour infrared photography was acquired. Preliminary results show potential for both principle component enhancement and classification procedures for assessing current defoliation.

Conifer Regrowth Monitoring with Landsat

There is an increased demand for monitoring forest regrowth. PNFI is investigating methods for monitoring conifer regrowth based on winter Landsat imagery from successive years or intervals of years. Winter snow cover will eliminate interference due to hardwood regrowth and differing ground cover types. Landsat DICS tapes (1973, 76, 78, 80 and 81) and aerial photography of a test area (Lake Traverse, Algonquin Park, Ont.) have been acquired. Clearcut logging and planting have taken place between 1972 and 1978. Jack pine regrowth predominates. A regrowth survey of selected sites has been completed.

RADARSAT

The remote sensing group at PNFI is conducting a forestry experiment as part of the renewable resources project of the RADARSAT program. The purpose of the study is to determine the potential of C band radar and the proposed RADARSAT satellite for forestry applications. Clearcut mapping and regrowth monitoring are of particular importance in light of forestry needs and radar capabilities. Airborne C and X band synthetic aperture radar was obtained (Aug. 1981 and March 1982) over three test areas in the Petawawa region. Area 1 (Lake Traverse study area) is primarily for the assessment of conifer regrowth. Area 2 (PNFI research forest) will be used to investigate regrowth, clearcuts and species discrimination. Area 3 (Canadian Forces Base Petawawa) was flown for the Terrain Evaluation Group at McGill University (Dr. J.T. Parry) and will be used by PNFI for evaluating C band's potential for mapping clearcuts. Initial optical-visual analysis of the photographic radar image product indicates some ability of C band for regrowth assessment, some difficulties in clearcut mapping (cuts occasionally confused with other open areas), and possibilities for conifer species discrimination. Digital data will be processed, corrections applied and the imagery registered with the aid of digital terrain models. Spectral and textural analysis will be applied to the data. Airborne MSS was obtained over the same areas concurrent with the summer radar data. Combinations of radar and MSS data will be investigated.

Landsat Forest Database and Change Detection

The remote sensing group is scientific authority for an unsolicited proposal by Scientific Consulting Services of Ottawa (Dr. Mayer Alvo and Dr. Morris Goldberg primary investigators). The objectives are to use an unsupervised classifier developed by CCRS and Dr. Goldberg in order to construct a multi-temporal forest classification and reliability database, to improve the classification by comparing results from images of successive years, and to automatically detect and identify changes in forest cover. The system will be tested on a DICS frame in central Newfoundland and implemented as a pilot project for the rest of Newfoundland. PNFI staff are involved in monitoring the contract, and testing and implementing the results.

The forest fire management systems group is using the same classifier to help build a 50 meter resolution forest cover type and terrain database for the 7.9 million hectare area of the Société de Conservation de l'Outaouais. Other databases already existing include weather, fire and lightning location. These databases are and will be used for forest fire management purposes.

Other Activities

The remote sensing group is also assisting DOE and CCRS in monitoring a large PILP contract to DIPIX Systems Ltd. for conversion of the ARIES software to operate on a 32 bit Digital VAX computer system.

Laser fluorosensor data were acquired over test areas of the PNFI forest as part of an initial examination of the usefulness of fluorosensor data for detecting vegetation stress and tree species. An oblique colour video camera system was tested as an aid to sketch mapping of spruce budworm defoliation during the red-brown stage.

The staff also gives numerous demonstrations of the ARIES system and assists outside users of ARIES. The ARIES facilities are available to outside users and visitors are welcome.

Appendix I: Project Staff

Digital Remote Sensing

Dr. P.H. Kourtz (A/Project Leader)
Dr. D.G. Leckie
F.G. Gougeon

Fire Management Systems

Dr. P.H. Kourtz (Project Leader)
B. Todd
B.E. Mroske
B. Roosen

8.1 REMOTE SENSING APPLICATIONS IN AGRICULTURE

R.B. Proud, Chief, Crops Section
Statistics Canada

Introduction

This presentation might be described as a two-part paper or perhaps more accurately, two separate mini-papers. I intend to show in very general terms how remote sensing has affected the work of the Agriculture Division of Statistics Canada and where I see it proceeding in the future.

The Main Crop Area Estimating System

First, by way of background, and because I believe it is impossible to explain how remote sensing fits into our program of agricultural statistics without saying a little about the program itself, I want to say a few words about what we do.

The Crops Section is responsible for making estimates of area, yield and production for all crops in Canada on a provincial and to some extent, sub-provincial basis. Until we began working with remote sensing data, almost all of this information was obtained from surveys of one kind or another. Limiting the description entirely to the estimation of crop area, two main procedures have dominated our methodology. For all major crops, one of the most reliable indications of the area has come from probability sample surveys using area segments as the sampling unit. In other words, throughout Canada we select area segments measuring about 1 by 3 miles and by visiting all farms with land inside each segment, we obtain information as to the area of crops grown within the boundaries of that particular segment. In various ways that are irrelevant to this description, we then expand those segment values into provincial estimates of crop area. This survey is supplemented by mail surveys of a panel of farmers from whom somewhat similar information is received. The mail survey involves a questionnaire which asks farmers for their area of each crop for the current and the previous year. This obviously provides a change of area indication which is chained back to the previous census estimate and then corrected to the current census when it becomes available. These then are the two main indications of crop area, one provided by enumeration, the other via a mail panel. Other indications may become available from supply-disposition analysis etc. Ultimately the commodity statistician analyses all the indicators and using past experience and any additional knowledge available, arrives at an official estimate of area for the particular crop in question.

The Application of Remote Sensing to Crop Area Estimates

The Agriculture Division first examined remote sensing techniques in 1974. Unfortunately, few resources were devoted to the project and the person involved soon left Statistics Canada. In early 1979, it was decided to make a fresh appraisal of the possibilities of using remote sensing data from the LANDSAT satellite series. Very early in our endeavours we contacted CCRS and were fortunate enough to make the acquaintance of Bob Ryerson who, along with several colleagues, has made a major contribution to the success of our work. In those early days (early that is for us in Statistics Canada) I was convinced that such a procedure could be very useful. However, as Statistics Canada has few if any resources for research projects, it was very important to develop a project that could show success and become operational almost immediately. The decision was made to estimate potato area in New Brunswick. The high probability of success was indicated by the considerable work previously completed for this crop in this province. In addition, compared to some other provinces, New Brunswick's agricultural area is of "manageable size". A third important point was that we had considerable faith in our existing system, thereby providing check data for the indications that could be developed from LANDSAT imagery.

There is no time to go into the details of the system we developed, but in layman's terms, and I do not consider myself an expert in remote sensing, we digitally analyzed the LANDSAT images for the three potato growing counties and we obtained crop information for all the segments within these counties. This procedure involved identifying fields of potatoes as well as possible confusion crops on air photographs of each segment. Certain segments were used during the classification of the LANDSAT scene with all segments being used for correction purposes. By correction I mean that by using various regression techniques, it is possible to correct the LANDSAT image estimate for confusion crops and other problems. This I believe is the key to the success of the system.

Success of the System

In 1980 we came up with what we considered to be very acceptable results and continued the project with minor alterations in New Brunswick in 1981. This was a crucial year as ultimately we will have Census of Agriculture information providing very accurate information of crop and therefore potato area. The project went well in 1981 and although the Agriculture Census results are not yet finalized, it appears that the LANDSAT, ground data, regression indication will be within one per cent of the agriculture census estimate.

Last year, 1981, we initiated a project to estimate rapeseed area in the Peace River District of British Columbia and Alberta. Of secondary importance was an examination of the possibility of estimating total grains and summerfallow First indications are that the rapeseed estimate for British Columbia is extremely good when compared with other survey information. In Alberta, where we had additional problems with cloud-cover, I am not sure that we yet know how good an indication was developed. One point which is worth noting is that the indication in the Peace River of British Columbia was developed using only 16 area segments yet the coefficient of variation was less than the CV for the survey estimate using over 50 segments.

Future Plans for Use of Remote Sensing

Where do we go from here? In 1982, providing that LANDSAT imagery is available, it is intended to continue the New Brunswick project and to expand the estimation of potato area into Prince Edward Island and Ontario. At the same time, the project in Alberta and British Columbia will be expanded to include additional crop districts in southern Alberta.

My philosophy in using remote sensing techniques is quite simple. I consider it to be one of a number of tools available to the agricultural statistician. I am completely pragmatic in the use or otherwise of such techniques. In other words, compared with other methods and techniques that we use, remote sensing must be cost effective, time effective and quality effective or at least in combination of these criteria superior to other methodologies. The techniques we have used with considerable success have involved the marriage of satellite imagery and ground truthing through regression techniques.

This has convinced me that while remote sensing itself may be a useful tool, it becomes more powerful when integrated into a wider system of estimation. In the Agriculture Division, we have every intention of expanding our use of this technique. However, in expanding we must reduce our input elsewhere. Obviously as an economist, I make this change until marginal cost equals marginal revenue, or in other words, remote sensing systems no longer compete with other methodologies.

My concerns for the future are the possible loss of LANDSAT data this year and the somewhat uncertain future in the near term. A further concern is that Reaganomics may effectively destroy all the developments by pricing tapes out of our reach. For future crop estimation I need at most a nine-day interval in satellite passes with little escalation in cost of tapes. The present resolution seems to be adequate for our purposes and I would be worried that finer resolutions may escalate processing data to an unacceptable level.

Organization in the Future

From an operational and organizational point of view, I favour the continued close liaison between ourselves in Statistics Canada and the Canada Centre for Remote Sensing. The remote sensing part of our system is an area of rapidly developing technology for which we are not and do not intend to become experts. In future too, for budget and other reasons, we would like to transfer much of the work we do to the provinces. In this regard I believe the ideal type of collaboration would be one of equal partners: Statistics Canada, the provincial agricultural statistics departments or offices, CCRS, and the provincial remote sensing centres.

8.2 CONCERNS AND OPPORTUNITIES IN FORESTRY APPLICATIONS IN REMOTE SENSING

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Forestry and the Canadian Economy

To begin, I would like to briefly review the importance of forestry to the Canadian economy and at the same time point out the meagre resources going into forestry remote sensing research. One million jobs, or the equivalent of one job in ten, is connected directly or indirectly with forestry. In 1980 the value of Canadian forest products totalled 22 billion dollars or about $1000 per Canadian. If one were to add the export incomes from agriculture, fisheries and mining, they would not total the income received from forestry exports. Governments annually receive $3 billion from the taxation of forest industries; the federal government's share is $1.3 billion.

The Federal government, through the Canadian Forestry Service (CFS), carries out the most of the forestry research for the country. The CFS has an annual budget of $44 million or about 3.4% of the Federal government's annual income from forestry. The CFS currently spends about $200,000 on remote sensing research which is less than 0.5% of its research budget.

An outsider might conclude from these figures that all must be going well in the forestry business and that there is no serious need for forestry research, especially in remote sensing. But all evidence points to the contrary. In some provinces we are cutting the forest significantly faster than it is growing. Local wood shortages are already apparent and, in the near future, things are predicted to get much worse. We have an age gap in the next generation of trees that could bring the forestry business to an abrupt halt. This gap in raw material flow is the result of years of neglect and mismanagement. Fifteen percent of our forest land remains idle. Even today, for every five acres harvested one will remain in a non-productive state. In 1980, fires destroyed five times the average annual harvest area.

A vigorous research program is necessary to help ease the difficulties we are bound to encounter. Modern remote sensing will have an important role to play in clarifying the present forest state and how it is responding to our management efforts.

Summary of Current Landsat Applications in Canadian Forestry

Currently, most remote sensing applications in forestry involve the use of conventional and near-infrared medium-scale photography. Improved inventory methods based on large-scale photo sampling, developed during the last decade, are just now being applied. A few commercial companies and provinces have played a leading role in applying this technology for regeneration assessment and the updating of existing inventories.

Applications of LANDSAT are slowly beginning to appear. In Ontario, a LANDSAT-based survey of forest and tundra lands north of the 52nd parallel is in progress. In Québec, Jean Beaubien has been working on a LANDSAT survey of a huge area for Quebec Hydro. In British Columbia, the Ministry of Forests has just completed a province-wide forest change survey based on the use of LANDSAT's vidicon imagery. Enhancements of a 30 DICS frame area of the Lac St. Jean forest-fire region in Québec were completed this year and are available for use for forest fire fuel assessment. The Forestry Statistics and Systems Branch of the Canadian Forestry Service has just completed an initial inventory of the forest resources of the Northwest Territories. CCRS LANDSAT products were used for areas where no suitable aerial photography existed. Updates of this inventory are currently being carried out using LANDSAT to include forest fires up to the end of the 1981 season.

Summary of Forestry Remote Sensing Research

Research in forestry applications of remote sensing is carried out by the Canadian Forestry Service, provincial remote sensing centres, provincial forestry departments, and a few universities. During the past ten years this research has identified the role of LANDSAT in forestry and has developed and demonstrated application methods. Initially, the research efforts centered around LANDSAT's ability to map broad forest cover types. The ideas and methods derived from this work form the foundation of the current applications.

Research work of the past few years has concentrated on extracting additional information from the data. Geometric correction of the data enabled temporal overlays. These, it was quickly learned, provided more reliable and detailed information on forest types and provided us with the ability to monitor changes in these cover types. Current research efforts are aimed at developing database management systems to permit the easy use and presentation of the data. An important goal of this work is to be able to automatically monitor major forest changes over huge areas on a regular basis. Applications during the next decade will be based on these concepts and methods that are now nearing completion in our research computer centres.

Forestry Remote Sensing Concerns

I have two major concerns related to the state of forestry remote sensing. The first one deals with the level of Canadian Forestry Service support. The CFS remote sensing research and applications activities reached a peak in 1978. At that time a strong national research and development program was proceeding to integrate advanced statistical methods, large-scale photo sampling, and LANDSAT data with the aim or improving forest inventory procedures. During the past three years, the human resources associated with this work have been reduced to a level well below a viable threshold. Today this program does not exist and only four widely dispersed researchers remain. The program cannot be rebuilt because positions are not available. The productivity of the remaining group is so low as to bring into question the continued operation of the main research tools: the image processing computers. If remote sensing research is to continue in the Canadian Forestry Service a renewed national program must be defined and quickly staffed.

My second concern is related to a long term approach to technology transfer in forestry. Canadian forestry has played an active role in supporting the national remote sensing program in the creation and use of regional image processing systems. Forestry, with the assistance of CCRS, has sponsored numerous publications, demonstration projects, and seminars aimed at transferring the technology to the users. Probably all potential users have had some opportunity to read our literature, examine the standard products, attend our seminars, or work with our image processing equipment.

It is certain that more exposure to the technology will bring about more transfer. The interdepartmental Technology Transfer Office must develop and implement a plan involving more demonstration type activities. Where we lack initiative is in a longer term approach to the problem We must expose all forestry technical and university students to the concepts and methods of modern remote sensing. These are the people who will demand that modern remote sensing methods be integrated into future forestry operations.

With a few notable exceptions, the current course curriculums of forestry education programs include mainly conventional air photography topics. Few forestry remote sensing teachers have been exposed to modern image processing concepts or methods and some are not even aware of the standard products available from CCRS.

There are many approaches that might be used to assist the forestry educators. A remote sensing teacher's package could be assembled and distributed. A 'travelling road show' could visit each school and assist in teaching and demonstrating the technology. This road show could include the use of a portable image display system. A special course, funded by government, could be set up to teach the teachers. A Canadian remote sensing textbook aimed at technical and university forestry school instruction might be commissioned.

Opportunities in Forestry Applications

I would like to briefly mention three important activities that are taking place that could have important consequences for remote sensing in forestry. Canada is currently planning and developing an imaging radar satellite that will have the potential to image general forest cover in all weather conditions. Preliminary tests of the CCRS airborne radar system, designed to simulate the future satellite performance, indicate that major forest changes will be able to be monitored. In addition, it may be possible to add to the satellite a visual-infrared imaging system. This secondary sensor package could consist of a steerable push-broom type, 25-meter resolution system. Such a system could provide Canadian forestry with a secure source of affordable operational data for the 1990s.

A second opportunity in forestry remote sensing is associated with the development by provincial government inventory groups of geographic timber inventory database systems. The data stored in such systems will be essential for future forest management activities. Modern remote sensing has an important role in updating these databases. Information from existing inventories, high and low resolution satellite imagery, and large-scale photo-sampling methods could be used for automated change detection, Bayesian approaches to updating, and dollar-saving multi-stage sampling procedures. These future timber inventory requirements provide a more applications-orientated framework for our remote sensing research. A new initiative by the CFS in this direction would probably be very productive. Forest mensurationists, statisticians, and remote sensing specialists could combine talents to develop new procedures that take advantage of the latest remote sensing developments to economically meet the demands of the new inventory systems.

A third opportunity relates to the important developments that are underway in the remote sensing hardware and software fields. Powerful image processing and display systems are being planned and developed to economically connect to the next generation of mini-computers. These systems should make image processing and display available to most major forestry users in the next five to ten years. This 'in house' image processing capability combined with low-cost colour displays, huge bulk memories, and efficient database management systems, will encourage the proliferation of small provincial and industry forestry information centres. The lack of affordable solutions to data communications problems will probably delay the implementation of large centralized information centres designed to support field users by remote displays.

RECOMMENDATIONS

To conclude, I would like to put forth three recommendations.

1) That the direction of the technology transfer program be modified to include a long term approach; a program is required to ensure that students of post-secondary forestry remote sensing courses receive an adequate exposure to modern remote sensing concepts, equipment, and methods.

2) That the necessary action be taken to include a visual-infrared sensor system on the Canadian RADARSAT satellite.

3) That concern be expressed about the current level of support for forestry remote sensing research, especially in the CFS.

8.3 Concerns and Opportunities in the Application of Remote Sensing to Water Resource Management

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Introduction

Next to air, water is the most vital natural resource. Yet, both water and air are so basic to Canada's economic and social activities that their importance is all too often overlooked. Although water plays an integral role in the management and development of other economic sectors, such as agriculture, energy, forestry and transportation, the needs for the application of remote sensing to water resource management may be quite different from these sectors. In particular, the temporal and spatial requirements for remote sensing data and the timeliness of receipt of these data by the user agency are often more stringent than for other land resource sectors. These differences are one reason why when we refer to data requirements that we should speak of "land and water resources" and not of "land and land resources."

This paper will provide an overview of some of the current activities in Canada where remote sensing and data transmission are used in water resources management. It will touch on some of the associated challenges and problems and conclude with recommendations appropriate to the water resource sector.

Economic Value of Water

The contribution of water resources to the Canadian economy can be demonstrated by citing a few examples of the value of water based on the cost of the next best alternative for providing similar services and goods. To illustrate, 68 per cent of Canada's electricity was supplied from hydro-electric power in 1977. For 1980, the replacement value of hydro-electric generation in Canada using thermal plants, would be 5.4 billion dollars using the domestic price for oil or 11.7 billion dollars using the world price. Similarly, the five largest windrawal uses of water in Canada, consisting of thermal power, manufacturing, municipal services, agriculture and mining, have an estimated value of 926 million dollars for 1980 on the basis of the next best alternative cost.

Further it is estimated that over two billion dollars was spent in 1980 for the design and construction of hydraulic structures (such as bridges, culverts, dams and irrigation projects and water control structures for hydro-electric power). Flood damage and relief assistance have amounted to some 200 million dollars annually. In contrast are the problems associated with the lack of water. In relation to agriculture, the Manitoba Crop Insurance Corporation has estimated that if a full scale drought developed in Manitoba and crops failed throughout the province, claims amounting to more than 150 million dollars could be made. Severe water shortages could have even greater implications for other economic sectors: power generation suffers decreased production because of low water levels and reduced water availability for cooling at thermal stations; industries, such as pulp and paper which are heavily water dependent, suffer through production cutbacks due to the lack of processed cooling water and curtailed water-borne transportation; low water levels tend to lower water quality, increasing industrial and municipal water treatment costs; and, deteriorating water quality economically damages the tourism and recreation industry.

The above noted dollar values refer to the estimated worth of water to the economy. The economic value of remote sensing to the Canadian water sector is an area which needs further assessment. In the United States, NASA has carried out Applications Systems Verification and Transfer (ASVT) projects, one of which was on the Operational Applications of Satellite Snow Cover Observations. Rango (1981) reported that the benefit/cost analysis run in conjunction with this project showed that for hydropower and irrigation the benefit/cost ratio was 72:1. The potential benefits from improved satellite (NOAA and Landsat) snowcover-based predictions across the eleven western U.S. states were 10 million dollars for hydropower and 26.5 million dollars for irrigation while the costs were about $505,000. These types of projects are needed in Canada to demonstrate the importance of remote sensing to water resources management.

Current Activities in Canada

The report of the CACRS Water Resources Working Group, included later in this document, provides an overview of many of the current remote sensing activities related to water resources. The scientific specialities which are reviewed include:

precipitation, snowcover, ice, soil moisture and groundwater, hydro-geomorphic processes, coastal processes, water quality, wetlands, hydrologic modelling, and satellite data retransmission. Areas of most activity both for research and applications include data retransmission, snowcover, precipitation, water quality and surface water temperature measurement.

The most effective satellite application in the water resource sector, affecting every water agency in the country, continues to be data retransmission from data collection platforms (DCPs). For B.C. Hydro, for example, the establishment of DCP networks has had the greatest impact in leading to improved short term flow forecasts, and DCPs are considered by them to be the only operational tool in the remote sensing field. DCP networks operated by federal, provincial and private agencies are expanding rapidly for the collection of data in remote regions. To improve short term flow forecasts, agencies need timely data (eg. hourly, 3-hourly) and DCPs offer this capability.

In the near future, data retransmission via satellite and the operation of DCPs in remote regions will form both the major challenge and the opportunity for potential benefit in water resource applications of remote sensing and data transmission. This is not to say that other applications will not continue to be developed and applied, but most operational water agencies will be focusing their attention on the use of satellite data retransmission. This will present problems which must be addressed. Standards for sensors, communication and archiving of data will be desired. Is there a need for Canadian DCP receiving stations for data retransmission via GOES? Is there a need for data retransmission facilities on Canadian satellites such as M-SAT and RADARSAT? Many feel the answer to these questions is yes. These questions and others will be discussed more fully at the 2nd Canadian DCP Workshop to be held in Ottawa in May, 1982.

The first application of satellite data in the water sector was the observation of snowcover. The Canadian contribution to the World Meteorological Organization's Snow Studies by Satellite Project was initiated in 1974. Snowcover analyses for four international basins - Columbia, Souris, Lake-of-the-Woods and Saint John - were carried out by different agencies using NOAA and Landsat imagery. In most cases, the basic technique was optical - electrical imagery analysis, but some analysis was conducted with digital satellite data. Satellite snowcover analysis has been continued by the Atmospheric Environment Service (Hydrometeorology Division) for the Saint John Basin. A digital processing system using NOAA/TIROS multi-channel data has been developed to determine the areal extent of snowcover in this forested basin (Waterman et al., 1980). The snowcover map is forwarded via telecopier to the Fredericton Flood Forecasting Centre within one day of data acquisition for use in their operational flood forecasting system. The timely acquisition, analysis and transmission of results to the user is critical if the satellite data are to be used effectively in operational water resource management.

From these studies the limitations of satellite data for snowcover studies were identified. In Canada, Landsat data cannot be used effectively on an operational basis because the 18-day temporal coverage is inadequate. The probability of cloud free coverage every 18 days is low and during that time interval the snowpack could disappear entirely. For large basins, the increased spatial resolution of Landsat means that passes on 4 or 5 successive days are required for coverage of the entire basin and this limits operational application to many snowcover problems. Cloud cover is a real problem in snowcover mapping both in obtaining coverage of the basin and in distinguishing between cloud and snow. Daily coverage of target areas by the weather satellites is an advantage in obtaining usable and timely data.

At this time we are still only able to determine the areal extent of snowcover, and there is no centralized system for mapping every basin which might be required by user agencies. For each user to implement their own analysis system would require their receipt of satellite data in near real-time and the development of an objective interpretation system which is affordable and transferable to "non-specialists".

A major challenge in the remote sensing of snowcover is to develop algorithms for determiing areal snow depth, water equivalent, areal extent and liquid water content for sensors having all-weather capabilities. The most immediate promise in this area is the use of passive and active microwave. As part of the RADARSAT program, there is an experiment to assess the feasibility of using X and C band SAR data for the determination of snow depth, state of the ground and snowmelt and to determine the effect of land cover, terrain roughness and diurnal and seasonal variations on the measurement capabilities. In addition, a major Canada/U.S. cooperative multi-stage remote sensing snowcover experiment was conducted during February 1982 over the Canadian Prairies. Ten agencies were involved. The study's objectives are: to assess the utility of passive microwave data for the mapping of Prairie snowcover, particularly in relation to areal extent, depth and water equivalent; to develop the capability of mapping areal snowcover (areal extent, depth, water equivalent) on the Canadian Prairies, integrating ground based, airborne and satellite data; and, to provide a direct intercomparison of Canadian and American airborne gamma-ray systems for the measurement of snow water equivalent. In addition to the two gamma aircraft, a U.S. Air Force Hercules flew the NASA airborne multifrequency microwave radiometer over the target areas. Data were recorded for appropriate NOAA (visible and IR) and NIMBUS-7 (SMMR) passes. A major success was in obtaining coincident ground, airborne and satellite data on the 700 miles of target lines over Saskatchewan. This occurred because the aircraft responded to meet appropriate snowpack and weather conditions as determined in consultation with the coordinator, aircrew, and ground personnel.

The use of surface water temperatures derived from satellite data is another important operational application for water resources management. From 1966 to 1980 the Hydrometeorology Division of AES monitored temperatures of the Great Lakes (excluding Lakes Michigan and St. Clair) using airborne radiation thermometry (ART). Until 1978 surveys were conducted approximately monthly on each of the lakes during the ice-free season. From 1978 onward, as the capability was perfected to determine water temperatures from NOAA infrared data, the ART program was gradually reduced. It was terminated in 1980.

Retrieval of Great Lakes temperatures from satellite digital infrared data began in 1977. Analyses are based on data from the NOAA polar orbiting environmental satellites. Comparisons with meteorological buoy measurements to date indicate that the RMS error is about 0.6°C. SRT temperatures are averages of, at best, 1 km square surfaces at the satellite sub-point, and represent progressively larger areas outward to the edge of scan. At present most analyses are derived using data from the 9.5-11.5 μ channel and an atmospheric correction routine that requires real-time radiosonde data as input.

The Hydrometeorology Division is analyzing Great Lakes and Bay of Fundy temperatures once every two weeks. To date, analyses of surface water temperature from SRT have been performed for the Great Lakes, Lake Winnipeg, Bay of Fundy and other Maritime coastal areas, and occasionally for smaller lakes in Ontario and on the St. Lawrence Seaway.

Uses of the temperature data include local weather forecasting, forecasting lake effect snowstorms, radiation budget calculations, forecasting freeze-up on the St. Lawrence Seaway, coastal climate studies, studies of fish reproduction and fish population movements and the assessment of Great Lakes nearshore water quality.

For smaller lakes where satellite resolution is insufficient for accurate temperature mapping, an airborne thermal line scanner has been used to acquire the data. These data have been used in energy budget calculations and the estimation of lake evaporation.

In the field of water quality there has been considerable research conducted toward the utilization of multispectral radiance responses recorded by satellite as a means of water quality monitoring over inland lakes. Initially Landsat digital data were used to estimate sediment levels in the lakes. Chagarlamudi and Schubert (1979) reported correlations greater than 90% between estimated and measured sediment levels, expressed as upwelling irradiance. Not all investigators, however, are as positive about the use of satellite data for water quality measurement.

Bukata et al. (1981) concluded that "the remote sensing of water quality parameters from aircraft altitudes presents distinct difficulties to thematic mapping of both chlorophyll-a and suspended minerals to much better accuracy than $\pm$ (50-100)% for inland water masses as optically complex as those found in Lake Ontario". They go on to state that "further complexities introduced by atmospheric scattering and absorption would only serve to render such water quality mapping from satellite altitudes even more tenuous." Earlier Bukata et al. (1980) had cautioned about the use of operational atmospheric correction algorithms which had been developed for water quality work, particularly those based on the CZCS 670 nm and the 700-800 nm-bands.

In discussions with some in the water quality field, it was pointed out that remote sensing had not yet made inroads into quantitative water quality measurement from satellites. As noted above, considerable research is being done on chlorophyll and suspended sediment measurement, but before a lot of the informaton gained is applicable to satellite monitoring more clarification is needed. It was also pointed out that as in the case of snowcover mapping the 18-day cycle of Landsat is not that good for water quality studies. It appears that there is still much to be done to meet operational water quality needs.

Finally, one application which will be very useful in Canadian water resource operations when developed and implemented is the determination of rainfall from satellites. Many studies are currently in progress to develop these techniques for Canadian situations. At McGill University, the "Stormy Weather Group" is working on precipitation estimation using weather radar and the integration of satellite and radar data. INRS-Eau with assistance from McGill are conducting a study in the Yamaska River basin combining weather radar and ground based rainfall measurements to provide improved rainfall data to the CEQEAU hydrological model in an effort to increase the accuracy of the model's runoff prediction and to assess its sensitivity to remotely sensed precipitation information. Weather radar, although not an airborne or satellite remote sensor, has great potential application for improving flow forecasting operations and for this reason provincial water agencies and the CACRS Water Resources Working Group have tried to keep up-to-date on developments. Ultimately, one can foresee the integration of radar, satellite and ground based data.

Currently the Atmospheric Environment Service, through outside contractors, is developing a program to produce short range (2-4 hours) forecasts of precipitation areas. These forecasts will initially identify areas of occurrence or non-occurrence. The system uses radar data to develop statistical signatures of rain areas in the satellite data base. A rain map is produced using radar data, where available, and otherwise just GOES satellite data. Predictions of areal precipitation will be provided by automatic extrapolation using pattern correlation.

On the west coast, Ingraham (1980) has developed a technique for estimating depth, area of coverage and duration of rainfall from GOES infrared images, based on a simple physical-conceptual model of the atmospheric physics of clouds. The technique has had initial testing on several large frontal systems occurring over British Columbia. Efforts are now focusing on the estimation of the depth-area-duration of rainfall from several storms over a well gauged area, comparing these estimates with those from the ground station networks and then updating the satellite estimates with the observed rainfall data so that the updated satellite rainfall estimates can be used reliably for river flow forecasting. Again timely receipt and processing of the data will be critical for ultimate operational application.

Implementation of a system using integrated ground based and remotely sensed data for rainfall determination is certainly a challenge for the future.

Problems, Challenges and Needs

Some of the problems and challenges facing those working in the water resource field have been summarized above. Again, the limitations of Landsat data must be remembered: repeat coverage only every 18 days; cloud cover (in combination with the 18-day cycle) limiting operational applications; passes on consecutive days may be necessary to cover the target area; and, acquisition of the data (digital, transparencies) by the user in a near real-time mode. Timely receipt of satellite data in a format directly useable by an agency is also a problem for satellites other than Landsat, particularly for near real-time applications. Implementation of a "delivery system" for satellite data to "outside users" to meet their operational requirements is a need and a challenge for current and future satellite systems. This need has been stressed by the RADARSAT Renewable Land Resources Study Team for consideration in the planning of the RADARSAT mission.

The development of new satellite applications for water resources management often requires airborne missions to be carried out first. One successful example of such a program was the Prairie snow cover experiment noted above. In a few cases there have been problems, particularly with CCRS aircraft, in coordinating airborne and coincident ground surveys. It cannot be overemphasized that for most water resource investigations, the elements being investigated are extremely dynamic in terms of their temporal and spatial variability.

In a recent SAR snow experiment near Ottawa, the mission was delayed because of aircraft malfunctions and was ultimately flown after most of the snow had melted. The principal investigator who had to arrange for coincident ground data, was not notified of the flight until three days later. Needless to say, the data were of limited use. In another instance, where coincident ground data were necessary, the principal investigator was not aware that the flight had occurred until one month after the thermal imagery mission was flown. The mission had to be repeated. There needs to be a greater awareness among the airborne personnel on the spatial and temporal constraints in the water resource sector. Airborne data should be collected when the principal investigator indicates that the target conditions are within those specified for the experiment. Close cooperation between ground and air crews is mandatory.

Finally, there is what one might refer to as a mandate problem. The CACRS Water Resources Working Group reports to and is responsible to CACRS and thus CCRS. Yet, CCRS is not necessarily involved in, nor totally aware of, the types of operational problems faced by Canadian water agencies. Since water resource applications often require NOAA data, water agencies have looked to the Atmospheric Environment Service to meet their needs. But, AES is taxed to meet its own requirements. Close consultation between CCRS and AES on the receipt, archiving and distribution of NOAA data to other user groups might help clarify this problem.

One of the problems and one of the challenges for the water resource community is to define its needs for remote sensing data, to outline the potential applications for remotely sensed data, and to begin looking at the associated cost/benefit statistics. During the last year, there has been considerable discussion on hydrology priorities and associated justifications for remote sensing data. Table 1 summarizes the needs for hydrology as determined by the RADARSAT Renewable Resources Study Team. The need for snow cover data rated as the top priority and satellite data are a major potential source of the temporal and spatial detail required for water resource applications. Further discussion of the elements in this Table is provided in the RADARSAT Mission Requirements Document 82-7.

An independent study within the Inland Waters Directorate identified their needs for remote sensing data in support of water quantity and water quality studies. Table 2 outlines the needs and gives the applications for which the data would be used. Priorities have not yet been attached to this list. However, snowpack information again appears as an important need.

The challenge for those of us working in hydrology and hydrometeorology is to develop and assess techniques to meet these needs. This is a broad and virtually a motherhood statement. To meet this objective, there are several more specific challenges facing us. Specifically, they include the need to:

a) Make CCRS more fully aware of the economic importance of hydrological components. When the Wheat Board says that snow depth is important in their work, everyone listens; when hydrologists say the same thing, we are asked for more justification.

b) Develop and assess techniques which use sensors with all-weather capabilities, i.e. passive and active microwave, and to gain continued support for our research on these applications.

c) Conduct research into the application and integration of remote sensing data into hydrologic models and of the integration of ground, airborne and satellite data for the determination of components of the hydrological cycle.

d) Institute a data base management system (including, quality control, archiving and delivery) for the timely dissemination to users of data that will increasingly flow from new sources, such as RADARSAT.

e) Improve the transfer of technology to hydrology consultants.

Recommendations

To help meet the remote sensing needs in the field of water resources, it is recommended that:

(1) Water be recognized as a separate component and that it not be lumped with land and land resources. In fact there are three distinct fields: land, water and marine.

(2) As best possible within the mandate of this meeting, data retransmission should be recognized as a viable remote sensing tool and serious consideration

TABLE 1

HYDROLOGY PRIORITIES AND JUSTIFICATON FOR SATELLITE INFORMATION
(based on RADARSAT Renewable Land Resources Study Team)

Information Need (Satellite Only)	Economic Importance	Geographical Significance	Value of Satellite Data vs. other Data Sets	Timeliness: Available Window	Timeliness: Freq. of Sensing
A - SNOW, ICE, RUNOFF					
A1 AREAL EXTENT OF SNOW COVER	H	N	H	Oct-June	2/week
A2 SNOW COVER WATER EQUIVALENT	H	N	H	Oct-June	2/week
A3 SNOW DEPTH	H	N	H	Oct-June	2/week
A4 FLOOD MAPPING-INNUNDATED AREAS	M	R	M	Jan-Dec	on demand
A5 SNOW: MELTING/NON-MELTING	M	N	H	Feb-June	3/week
A6 LAKE ICE COVERAGE	M	N	M	Oct-June	1/week
A7 GLACIER MELTING	L	R	L	June-Oct	1/week
B - SOIL/GROUND					
B1 SOIL MOISTURE-DISTRIBUTION AND PERCENTAGE	M	N	H	Mar-Dec	2/week
B2 SOIL MOISTURE-SALINITY	L	R	M	Apr-Oct	1/month
B3 IRRIGATION	L	R	L	May-Oct	1/day
B4 SOIL MOISTURE-PRECIPITATES	L	R	M	June-Dec	1/month
B5 STATE OF GROUND (FROZEN/ UNFROZEN, INCLUDING PERMAFROST)	M	N	H	Feb-June	2/week
B6 WETLAND CLASSIFICATION	M	N	M	Apr-Sept	1/month
B7 TERRAIN ROUGHNESS	M	N	M	seasonal	seasonal
B8 PEAT RESERVE FIBRE CONTENT	L	N	M	fall	once
C - PRECIPITATION	H	N	H	all year	continuous
C1 PRECIPITATION DETERMINATION (GOES IR)					
C2 INTEGRATION OF SATELLITE AND WEATHER RADAR INFORMATION					
C3 MEASUREMENT OF SOURCES AND EFFECTS OF ACID PRECIPITATION					

Notes:

1. Economic Importance: H-high, M-medium, L-low
2. Geographic Significance: N-national, R-regional
3. Potential Importance of Satellite Data in Relation to Other Data Sets: H-high, M-medium, L-low

TABLE 2

REMOTE SENSING OF HYDROLOGIC PARAMETERS:
NEEDS AND APPLICATIONS IDENTIFIED BY INLAND WATERS DIRECTORATE, ENVIRONMENT CANADA

A. QUANTITY - FLOW, WATER LEVELS, ETC.

1. SNOW PACK MONITORING FOR WATER EQUIVALENT, EXTENT AND DEPTH OF SNOW COVERED AREAS, AND/OR AREAS OF ACTIVE MELT	- improved operational forecasting of lake levels in Great Lakes basin - increasing accuracy of flood forecasting in small watersheds prone to spring runoff flooding - improved flood forecasting in prairie and mountain regions
2. OBSERVATION OF ICE CONDITIONS	- freeze-up, melt and break-up dates for rivers, presence or absence of ice and ice jams, tracking of ice floes to provide velocity estimates - freeze-up, melt and break-up dates for lakes
3. OBSERVATIONS OF HYDROLOGIC PARAMETERS AND PROCESSES IN WATERSHEDS	- timing of runoff - estimation of size of contributing areas - improved estimates of soil moisture conditions for input into flood forecasting models, development of better physically based evapotranspiration models - identification of vegetation types and estimation of their areal extent for development of better physically based evapotranspiration models - identificaton of major changes in river channels in remote areas - observations of formation, growth and release of glacier-dammed lakes
4. ESTIMATION OF WATER LEVELS AND FLOWS	- direct estimation of the areal extent of water-covered areas under flood conditions - indirect estimation of the extent of recent flooding based on inferences on soil misture conditions as evidence of recent submersion - estimation of lake level fluctuation, particularly for those in remote areas, as a function of observed changes in lake area - estimation of changes in river level for large rivers as a function of changes in river width - estimation of discharge

B. QUALITY - PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER BODIES

1. ESTIMATION OF CONTAMINANT TYPES	- particularly the observation of oil spills on water to determine, e.g. oil type, oil thickness or concentration, spill volume, interactions with new and old ice
2. ESTIMATION OF BIOMASS OR PRODUCTIVITY	
3. ESTIMATION OF CHEMICAL PROPERTIES	- pH, especially for evaluating effects of the long range transport of air polluants; salinity or conductivity); chloride; dissolved phosphorus; dissolved oxygen
4. ESTIMATION OF PHYSICAL PROPERTIES	- sediment loading, including sediment tracing and studies of sediment plumes, determination of areas contributing to sedimentation to provide background information for planning of sediment station network - temperature

should be given to: 1) establishment of a Canadian receiving station for DCP data; and, 2) provision of facilities for data retransmission on appropriate Canadian satellites to support this remote sensing activity.

(3) There is improved coordination on airborne missions between aircrew and ground personnel. The aircraft should respond to the needs of the user and to do this properly, an understanding of "coincident ground data" in terms of hydrological applications is required by CCRS personnel.

(4) There is consideration of how users can get remote sensing data in image or digital form from any source - including weather satellites - in real or near-real time. For example, for snow cover mapping, data are needed in a time frame when they are most useful and this will vary throughout the country depending on the rate of melt. Delivery of the data is crucial if there is to be an effective transfer of technology to the users themselves so they can perform their own analyses.

(5) If there is to be a truly national remote sensing program, there must be serious support of not only Landsat type data collection, but also support for systems useful to other applications - e.g. SMMR, altimeter, scatterometer, SAR. Many of these apply to oceans and ice research. In this regard, there is a need for a ground based radiometer/scatterometer system to support basic remote sensing research.

(6) Water Resource agencies should be encouraged, if not pushed, to make a clearer statement of their needs and to identify the potential benefits. The Water Resources Working Group tries to do this, but water resources is a large field. At the same time, CCRS should broaden their perspective as to what is "water resources". It is more than water quality.

(7) The remote sensing agencies should give more consideration to the needs and problems in hydrology.

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8.4 FUTURE OF THE NATIONAL REMOTE SENSING PROGRAM: MAJOR CHALLENGES AND OPPORTUNITIES IN APPLICATIONS IN GEOGRAPHY

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OVERVIEW OF CURRENT ACTIVITIES IN CANADA

Although the discipline of geography tends to overlap relatively extensively with other disciplines (in particular, geology, cartography, forestry, water resources, agriculture and wildlife management), three major areas of interest are considered to be the particular mandate of geographers. These are: (1) land use/land cover mapping and monitoring; (2) environmental monitoring; and (3) biophysical (ecological) mapping. The following overview of geography applications thus concentrates exclusively on these areas. It is interesting to note that some uses of remote sensing in geography are now so well-established as part of information systems that one is not sure whether to include them in this list.

The tables included in the following sections list a number of representative projects in each area of interest; information for each on location, remote sensor(s) used, the agency conducting the work, objective(s), and status are included. The definition of status is not rigorous, but divides the studies into three groups: research studies, pilot projects (also termed demonstration projects), and operational (or routine) work. It is assumed that studies on the application of remote sensing fall somewhere on a continuum from research to operational application (Figure 1), and that the general "push" is towards the operations end.

LAND USE/LAND COVER MAPPING AND MONITORING

Within the land use/land cover inventory and monitoring group, there appears to be a marked dichotomy between the traditional black and white aerial photography interpretation methods, and the use of satellite data. No particular need to use the "in-between" technology of airborne remote sensors (e.g. colour and colour infrared (CIR) photography, thermal data, radar data) has been identified. The use of radar data may be an exception to this generalization, as a number of studies have been carried out in recent years to evaluate the use of radar data for land use mapping; however, this does not appear to be as important as satellite data for future use in this field.

A number of Canadian projects using various remote sensing techniques are being carried out in this category, ranging in scope from large-area, land cover inventory mapping programs to thematic mapper simulation research projects over small, urban areas. Table 1 provides a summary of representative projects.

The majority of the projects are located in eastern Canada, are conducted by government agencies or universities, use LANDSAT data for mapping, and are research-oriented; 50% are thematic mapper (TM) and/or SPOT simulation land use research projects using the airborne multispectral scanner (MSS). The concentration of the less-traditional land use mapping tools like LANDSAT and the airborne MSS has contributed to the research-orientation of this group (Figure 1).

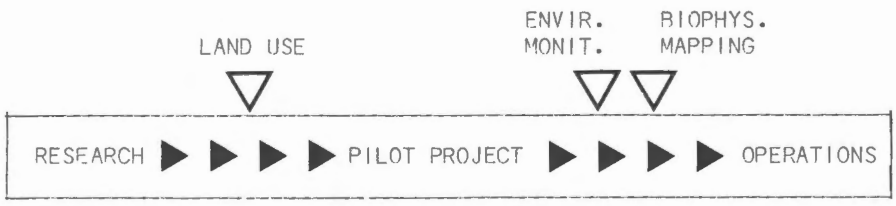

FIGURE 1. AVERAGE STATUS OF PROJECTS IN THREE GEOGRAPHY AREAS OF INTEREST BASED ON CURRENT ACTIVITIES 1981-82

Table 1. Land use/land cover inventory and monitoring remote sensing projects.

Location	Remote Sensor	Agency	Objective	Status
1. All Ontario	Landsat	Ont. R.S. Centre for Land Use Co-ordination Branch	To map land cover at 1:100 000 scale	Operational
2. Southern Ontario	Landsat	Ont. R.S. Centre for Ministry of Agriculture	To map agricultural land use at 1:50 000 scale	Pilot Project
3. Stratford, Ontario	Landsat, Airborne MSS	P.J. Howarth for Lands Directorate	To simulate thematic mapper in urban area	Research
4. Granby, P.Q.	Landsat, Airborne MSS	University of Sherbrooke (F.J. Bonn)	To simulate TM & SPOT in urban area	Research
5. Bridgetown, N.S.	Airborne MSS	CCRS	To simulate TM & SPOT for mapping land use	Research
6. Southern Ontario	Landsat, Airborne sensors	McMaster University (E. Boasson)	To determine accuracy of land cover use mapping, change detection	Research
7. New Brunswick	Landsat	U.N.B. (R. Yazdani)	To monitor crop rotations and other field changes	Research
8. Calgary, Alberta. Kitchener, Ontario. Stratford, Ontario.	Landsat, Airborne Photography and MSS	Lands Directorate	To test new CLI land use/cover mapping and monitoring	Research
9. Flathead Valley, B.C.	Landsat	B.C. Research for mining industry	To evaluate Landsat for land cover/use mapping	Research
10. James Bay Area, Quebec	Landsat	S.D.B.J.	To monitor effects of reservoir development	Operations

ENVIRONMENTAL MONITORING

Compared to work in the land use field, the emphasis in environmental monitoring projects is quite different. Project objectives, and thus the remote sensing devices utilized, vary much more widely; remote sensors used effectively include thermal linescanners, colour and CIR photography, LANDSAT, and radar. Some of these have been used routinely for over 10 years of environmental monitoring (e.g. monitoring of vegetation condition with CIR photography), so that on the average the environmental monitoring studies appear to be farther along the continuum toward operational use than do the land use studies (Figure 1).

The seven remote sensing projects involving environmental monitoring described in Table 2 use a variety of remote sensing techniques, including CIR and colour photography, and thermal and LANDSAT data. The majority of these projects are based in Alberta and Ontario and are conducted by government agencies; many more of these have reached the pilot project or operational stage than have those for land use/land cover mapping.

Similarly, the objectives of these environmental monitoring studies using remote sensing data vary quite widely, from assessment of sulphur dioxide (SO_2) damage over large areas (with LANDSAT) and small areas (with CIR photography), monitoring of mine reclamation success, and evaluation of highway construction impacts, to a number of hydrology-related environmental monitoring studies. The latter include monitoring environmental impact of a tidal power project and of water level changes in a large delta environment and thermal evaluation of a lake for nuclear waste disposal.

BIOPHYSICAL MAPPING PROJECTS

The biophysical mapping projects discussed herein include, but are not restricted to, Ecological Land Classification. The emphasis in biophysical mapping is divided between standard photo interpretation procedures using black and white aerial photography, and the use of LANDSAT data (although colour and CIR photography do also play a role in some projects). The frequent use of airborne photography in biophysical mapping projects has allowed the group to appear relatively far along the continuum toward operational status (Figure 1); however, the integration of LANDSAT data is seen as important and many studies using LANDSAT are still at the pilot project stage. One of the areas in which the efficient multistage approach to the use of remote sensing data is utilized is in Ecological Land Classification; the multistage approach dovetails very well with the hierarchical nature of this mapping system.

The projects described in Table 3 are relatively few, but again are representative of projects being carried out in Canada in other areas and for similar purposes. As with environmental monitoring, most biophysical mapping projects listed have reached a pilot-project or operational stage. The majority are concentrated in the north and west of Canada, and make extensive use of LANDSAT data. They are being carried out by both government agencies and private industry.

Two of the projects, conducted by provincial remote sensing centres, are testing the mapping methodology for the Northern Ecological Land Survey Map Series developed by the Lands Directorate for northern areas, and will probably produce maps at a scale of about 1:100 000. A third, industry-conducted, smaller-area project produced ecological land classification maps at 1:50 000 scale for recreation planning in a provincial park. Similar work has been carried out previously in several other locations.

The Lands Directorate is preparing a document regarding the diverse uses of remote sensing for ecological land survey, for use by resource managers. Finally, industry has prepared 1:50 000 scale maps of environmentally sensitive lands around major urban centres using LANDSAT and standard aerial photographs.

SUCCESSFUL PROJECTS IN GEOGRAPHY IN CANADA

"Successful" projects are here defined as those with positive conclusions regarding the use of remote sensing and with implications for upward change in status (i.e. toward routine or operational use). Most of the projects listed in Section 1, Current Activities, are still in progress; hence, their "success" cannot yet be determined. However, a selection of previous successful projects in the three subject areas is described below.

With regard to land use/land cover mapping, LANDSAT data have been successfully used for regional scale land use/land cover mapping and monitoring, and for assessment of the areal extent of change. Identification of the type of change in land use/land cover has been less successful, due mainly to the spectral and spatial resolution of current LANDSAT data. However, as seen in the number of research projects currently being conducted into simulation of thematic mapper and SPOT data,

Table 2. Environmental monitoring projects using remote sensing.

Location	Remote Sensor	Agency	Objective	Status
1. Annapolis Valley, N.S.	Airborne MSS, thermal, CIR and colour photography	N.S.L.S.I.	To gather base-line data prior to construction of Annapolis Tidal Power Projects, future monitoring using R/S.	Pilot project
2. Sudbury, Ontario	Landsat	O.R.S.C. for INCO.	To evaluate environmental damage in area 1973 to present.	Operational
3. Peace-Athabasca Delta, Alberta.	Landsat	McMaster University (Howarth and Wickware)	To monitor effects of hydrologic change in delta.	Research
4. Alberta	Airborne MSS, Thermal, Colour & CIR Photography	Alberta Environment	To monitor mine soil reclamation at Alberta coal mining sites.	Pilot Project
5. Ontario	Thermal	Univ. of Waterloo (E. Ledrew)	To model surface lake currents for nuclear waste disposal.	Research
6. Alberta	CIR Photography	INTERA	To monitor environment around sour gas plants.	Operational
7. Ontario	CIR & Colour Photography, thermal	Ont. MOT	To monitor environmental impact of highway construction.	Pilot Project
8. Manitoba	CIR Photography	Agric. Crown Lands Branch, Man. Agric.	To monitor effects of aerial spraying of wooded land.	Pilot Project
9. Roberts Bank Port, B.C.	Landsat, Airborne MSS	B.C. Research for Port of Vancouver	To assess areal extent and distribution of emergent vegetation	Research

a marked, future improvement in this field is anticipated.

Several remote sensing techniques are now being used routinely for environmental monitoring. Airborne remote sensing techniques have been employed to monitor reclamation of mine wastes and for assessing vegetation damage around sour gas plants, gas or oil well blowouts or other industrial accidents, and nuclear power plants. Pollutant effects on vegetation have also been successfully identified using LANDSAT data, although these are large-area, regional effects of a relatively severe nature. Such effects may be found in regions like Sudbury, Ontario or the Alberta Oil Sands and, as such, are somewhat atypical. Thermal data are currently being used for monitoring thermal effluent and its dispersal in lakes and rivers.

Recent work by Howarth and Wickware in the Peace-Athabasca Delta has identified a successful analysis technique for change detection in environmental monitoring using LANDSAT DICS data. This has important implications for other change detection studies.

A number of operational-status projects have been carried out in the field of biophysical mapping using different remote sensing techniques. It is, however, more common to find biophysical mapping using LANDSAT data and some airborne techniques at the pilot project or demonstration stage. Extensive testing of biophysical mapping systems (specifically, Ecological Land Classification) is currently underway, and the methodology identified for use of LANDSAT data in a multistage approach appears to be successful.

The notably successful use of LANDSAT data in the field of cartography, traditionally within the realm of geographers, will be reported by the Cartography Group and is only mentioned briefly here.

CHALLENGES AND OPPORTUNITIES

The challenges in the field of geographical applications for remote sensing appear to lie in the upgrading of the numerous research and pilot-project status studies to routine status. The same situation exists in all other fields, of course, but in several geographical applications, it appears that routine use is close to achievement. Land use/land cover mapping and change detection may now be carried out using LANDSAT data for assessment of areal change and for mapping of regional scale land use. It will require the increased spectral and spatial resolution of a new generation of satellites to permit assessment and monitoring of the type of change something to be expected of LANDSAT and SPOT. A marked "push" in this direction by CCRS should be considered.

Change detection in the land use field, as well as in environmental monitoring, will continue to increase in importance, making significant use of LANDSAT data. Some concern has been expressed for the present and the near future, in which LANDSAT data are not available as in the past, or are not available at all. Frequent coverage by LANDSAT is required on several of the projects mentioned (e.g. the southern Ontario agricultural land use mapping project) and this may not be forthcoming for another year or two. Additional concern is centred on the deteriorating quality of older LANDSAT data. Several workers have experienced problems with acquisition of historical CCT's or data products required in a number of projects, particularly those involving change detection. A program to preserve LANDSAT coverage of Canada over the LANDSAT period of record should be implemented at once.

Some have expressed concern that too much information will be available from these new satellites to be handled using current methodology, and that full machine interpretation will be a requirement for handling such information efficiently. This may mean a modification of the successful interpretation procedures established to date; it will also have important implications for use of image analysis systems now proliferating across the country.

Surprisingly, the much increased cost of LANDSAT CCT's is not expected to cause many problems for geographical projects. Most workers have stated that budgets will simply be increased to accommodate the LANDSAT cost, possibly a statement on the non-substitutability status which has now been assigned to LANDSAT data in many projects. After a decade of LANDSAT availability, use of such data has become a standard part of many projects, and users are prepared to pay to get the data.

Individual data acquisition problems surface in the airborne remote sensing program. Inadequate response of the CCRS to thermal survey research work with stringent time requirements is frequently cited.

In the educational field, treated separately by the Education Working Group in full, geographers have identified a lack of educational materials in the application of remote sensing to geographical studies. This

Table 3. Biophysical mapping projects using remote sensing.

Location	Remote Sensor	Agency	Objective	Status
1. Hudson Bay - James Bay Lowlands	Landsat	O.R.S.C.	To test biophysical mapping methodology and produce maps at 1:100 000 scale.	Pilot Project
2. Northern Manitoba	Landsat, B/W Air Photos	Manitoba Remote Sensing Centre	To test biophysical mapping methodology	Pilot Project
3. Central Saskatchewan	Landsat, B/W Air Photos	INTERA	To map biophysical resources of provincial park for recreation planning.	Operational
4. Canada	All types	Lands Directorate	To prepare manual on remote sensing use for ecological land survey for managers.	Research
5. Saskatchewan	Landsat, B/W Air Photos	INTERA	To inventory environmentally sensitive lands around urban centres and map at 1:50 000 scale.	Operational
6. British Columbia	Landsat, B/W Air Photos	Lands Directorate	To prepare biophysical maps of B.C. coastline	Operational

could be solved by preparation of such materials at CCRS from the wealth of materials and experience in that agency.

ECONOMIC IMPACTS OF REMOTE SENSING TECHNOLOGY

The economic impacts of remote sensing are difficult to properly assess on a casual basis; most workers have not evaluated the effects of remote sensing use in "dollars and cents" terms and thus cannot make accurate judgements or comments. As a result, only generalizations can be made herein. (Reference should be made to the CCRS Research Report No. 81-1, by R.A. Ryerson, regarding the cost benefits of the CCRS Airborne Program. More detailed information on geography-oriented projects is contained therein.)

It may be noted, however, that cost saving has a significant influence on the use of LANDSAT data over other data acquisition techniques in geography projects in land use mapping, environmental monitoring, and biophysical mapping. In fact, the majority of the research and demonstration projects do assess the quality and resolution of the LANDSAT analysis results compared with results from other data sources. Such comparisons result in a conscious or unconscious evaluation of the tradeoff in the increase in quality or generalization of the data available with the cost savings from use of LANDSAT. Of course, the monitoring capability of LANDSAT through its frequent overpasses, less easily available using other remote sensors, is figured into the cost-saving evaluation.

This is the case for land use mapping, for environmental monitoring, and for biophysical mapping--in each of these areas, it has been shown that ground and airborne methods provide certainly more detailed, but much more costly, information than does LANDSAT. Particularly in biophysical mapping, methodologies have been devised using a multistage approach to make the most efficient use of both aspects, i.e. to save time and money using LANDSAT, and still to obtain some detailed information from airborne and ground surveys where required.

The implications of the new-generation satellite data should be considered. More complex data sets will require more machine handling of data, not really a necessity up to this point when visual interpretation or minimal digital manipulation of LANDSAT data could often suffice. More image analysis systems are being purchased by industry, universities and government agencies across the country: although the CCRS TOPAS and MOSAICS systems are being designed to handle the new data, questions arise as to the ability of other current systems to handle the new data, to the increased costs of more complex analysis on the future use of LANDSAT data, and to the avilability of adequate analysis systems to the user community across Canada.

RECOMMENDATIONS

It is recommended that:

(1) The highest quality and most representative LANDSAT CCT's be selected over the period of record for Canada and preserved in an archive for future reference;

(2) CCRS work with appropriate agencies (e.g. Lands Directorate) on the further development of land use/land cover mapping and monitoring in Canada using LANDSAT data;

(3) Continued emphasis be placed on the production of geometrically corrected (e.g. DICS) LANDSAT data;

(4) CCRS prepare suitable educational packages for remote sensing applications in geography for distribution to universities and other teaching institutions; and

(5) The cost implications of the new generation of satellites for image processing and analysis, and the availability of systems adequate to carry out such analysis, be evaluated by CCRS and reported upon to the user community.

8.5 APPLICATIONS OF SPACE IMAGERY IN CARTOGRAPHY

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Surveys and Mapping Branch
Department of Energy, Mines and Resources

In terms of space imagery, only Landsat images are available at this time for photogrammetric and cartographic applications. Their use is described in numerous papers by Betty Fleming of Topographical Survey and in reports of the Working Group on Photogrammetry and Cartography. I am therefore not planning to repeat these papers as I am sure that at one time or another you have read them and are aware of the use of Landsat imagery in cartography. Briefly, it is now a standard production practice at Topographical Survey to make use of Landsat imagery for map revision at 1:250 000 and for the assessment of revision requirements for 1:50 000 scale maps. DICS products are used to help position offshore features on 1:50 000 maps. As you can see from the reports of our Working Group, a research project is underway to extract water features from Landsat MSS imagery produced in the DICS system. Experiments were also carried out with SAR imagery obtained from the now dead SEASAT. Landsat was not designed to meet cartographic applications, and any use we make of Landsat imagery to topographical mapping is an additional side benefit. The next remote sensing satellite in the U.S., the Landsat-D, will carry an MSS similar to that on Landsat-1, -2, and -3, and also the Thematic Mapper which will provide 30 metre pixel resolution and 7 spectral bands. However, so far as cartography is concerned, Landsat-D will suffer from the same problems as the other Landsats, i.e. limited ground resolution, no useful stereo, distorted image records, inadequate spacecraft position and attitude data. The potential for an expanded application of satellite imagery to cartography lies in new systems which are at different stages of development or planning.

I would like to devote some remarks to the characteristics which satellite systems should have in order to be of maximum use for mapping applications, and I will also discuss the potential applications of satellite systems which will be orbiting the earth in the next few years, or which are now in the planning stages.

There are five major requirements which must be fulfilled in order for a satellite system to be useful for cartographic applications (on a global scale).

1. high resolution
2. geometric fidelity
3. stereo coverage
4. weather independence
5. accurate determination of position and attitude of exposure stations

There seems to be a lot of confusion with regard to the definition of resolution of satellite systems. When remote sensors and photogrammetrists speak about resolution they don't mean the same thing. The remote sensors equate resolution with Instantaneous Field of View (IFOV) or the pixel size at the ground level, whereas to photogrammetrists, resolution means the resolving power expressed in terms of lines per millemetre of a low contrast target. The ratio of IFOV to resolving power is 1.0 to 2.5, that is, a 10 m IFOV is equivalent to a 25 m resolution in photogrammetric terms.

One of the limiting factors of non-photogrammetric camera systems in achieving the desired resolution suitable for topographic mapping is the data transmission rate. In the present Landsat the rate of data transmission is 15 megabits per second. For Landsat D a data rate of 85 megabits per second will be necessary. The present technological limit is 200 megabits per second, disregarding cost considerations. However, in order to reach the resolution of current photography achievable with photogrammetric cameras, a data rate of 900 megabits per second will be required. During the next decade it does not appear to be feasible to reach this rate. It would therefore appear that, for the foreseeable future, electronic sensors could not replace space photography to provide data required for cartographic applications at medium and small scales.

The Space Shuttle promises to be a suitable vehicle to provide space photography using photogrammetric-type cameras. The major advantage of the Shuttle is that its principal component, the orbiter vehicle, can be returned to earth with the exposed film. However, at present, when the Shuttle is launched from Cape Canaveral the permitting coverage is from latitude 30^{o}N to latitude 30^{o}S. The maximum inclination available from Cape Canaveral is 57^{o} which provides coverage of most of the world's populated areas. However, to be useful to Canada, we would require polar orbit which will not be available until after 1984, when the Western Test Range will become operational for Shuttle launches. Naturally, weather will also limit the usefulness of the system in Canada.

Another possibility of using metric cameras is the Multimission Modular Spacecraft (MMS). It consists of a central core to which a power supply module can be attached, as well as an attitude control module and a command and data handling module. There is a propulsion module to provide in-orbit maneuvering and an adapter between the spacecraft and its payload. The assembled spacecraft might be fitted with solar panels and various antenna for communication and might also be fitted with an adapter for launching expendable vehicles. The Multimission Spacecraft is especially designed for launch and retrieval by Shuttle. Photogrammetric cameras could be placed in the MMS and then retrieved by the Shuttle.

One Shuttle payload sensor system which has been built by Itek Corporation is the Large Format Camera (LFC). The essential parameters of the camera are focal length of 30.5 cm with 23 x 46 cm format. The camera has an automatic exposure sensor and forward motion compensation, permitting the use of high resolution, fine grain films. The magazine has a capacity of 4000 frames. The camera will be mounted on a pallet installed in the cargo bay of the Shuttle. Whenever the Shuttle is in the earth-viewing mode and illumination conditions are suitable, photography can be acquired.

A ground resolution (in photogrammetric terms) of 10 to 15 m can be obtained from nominal Shuttle altitudes. To date, this camera has not been assigned to a shuttle mission and will probably not fly until 1984. It is hoped that eventually the large format camera will be mounted on a free flying satellite like the Multimission Modular Spacecraft to be launched and serviced by the Shuttle.

Accurate determination of the position and attitude of the exposure station is important for cartographic application and NASA is proposing to develop an attitude reference package for use with the LFC. This will consist of two stellar cameras looking towards the horizon and directed 45° fore and aft of the normal to the ground track. From measurement of the identified stellar pattern after each flight, it will be possible to determine the attitude of each LFC frame with an accuracy of $\pm$ 0.5 arc seconds about each of the three rotation axes.

Modern technology would use stellar attitude reference systems employing electro-optical focal planes and on-board attitude reduction. Such systems are capable of obtaining 2 arc seconds attitude accuracy with an attitude update every 1 to 2 seconds. The choice of the film camera attitude system is based upon the availability of lenses left over from the S-190A camera system on Skylab, and the desire to have the attitude reference system available for an early Shuttle flight.

Accurate position in space of the exposure station can be provided by the Global Positioning System included in the payload package.

A major approved payload for the Shuttle is Spacelab, which is a joint venture between the European Space Agency and NASA and which is presently scheduled for launch in May 1983. Topographical Survey is participating in this experiment. The payload will consist of both manned experimental modules and pallets for other instruments. Of major interest to the cartographer is the Spacelab camera system. This is essentially a standard size Zeiss camera with 30 cm focal length and 23 x 23 cm format. From the anticipated altitude, these pictures will cover an area of 190 x 190 km with a ground resolution of approximately 20 m. This camera is phase A of ESA's camera development program called ATLAS. In phase B, consideration will be given to -

(a) adding image motion compensation to this camera and mounting it on an exterior pallet, and

(b) using a similar camera but with 60 cm focal length and image motion compensation,

(c) developing a new high resolution camera with image motion compensation for mounting in the manned module.

Under phase C, consideration will be given to mounting a camera system on free flying satellites which will operate independently of the Spacelab.

Although we would like to have photogrammetric cameras in space, we are not disregarding electro-optical sensors. One of the most promising imaging sensors is the linear array of charge-coupled devices. These arrays consist of several thousand detector elements and they can be butt-joined to provide more than 10,000 detectors per line. An optical system images a line from the ground scene to the line of the detectors. Ground resolution in the cross track detection depends upon the ratio of the optical system focal length to flying altitude, and the along-track detection depends upon the time in which the signals can be recorded as the vehicle moves along the orbit. NASA has undertaken studies on possible sensor configurations using linear arrays.

The National Mapping Division of U.S. Geological Survey has awarded a study contract for a system called MAPSAT which will provide both multi-spectral data and stereo data adequate for compilation of 1:50 000 scale maps with 20 m contour interval. The orbit will be the same as Landsat 1, 2 and 3. The Multispectral Linear Arrays will have a minimum of 10 m IFOV but the information could be clustered by onboard processing to provide lower resolution at multiples of the 10 m IFOV. On-board processing and selective acquisition will reduce the average data rate to 15 megabits per second which is compatible with the existing worldwide network of Landsat ground receiving stations. A highly stable spacecraft will permit a simple algorithm to be employed for the ground data reduction. MAPSAT is not an approved program and has no funding beyond the feasibility study.

The requirement that the MAPSAT system provide stereo coverage on a demand basis is accommodated by multiple imaging systems, one looking vertically to provide the basic multispectral capability, and two looking forward and aft of vertical by 23°. The fore and aft pair provide a base height ratio of 1 that gives strong heighting capability. For moderate to rough terrain where obstruction effects could occur, a base height ratio of 0.5 is available through use of the vertical with either of the fore or aft sensors.

A high degree of automation for the extraction of topographic information is achieved by control of the spacecraft to satisfy the epi-polar condition in which a ground point images at the same relative field location in both of the stereo sensors, and by exploitation of the resulting uni-dimensional aspect of the data in the identification of conjugate imagery and calculation of point elevations.

The reduction of the stereo data is essentially the determination of conjugate image points within the fore and aft data sets that is traditionally done via the human stereoscopic facility. In existing instruments that replace the human observer by an automated correlation process, the search for image conjugates takes place in both the along-track and cross-track dimensions. The epi-polar condition reduces this search to a single dimension, thereby improving the computational efficiency of the process. Dynamically the condition requires control of the spacecraft's absolute pitch, yaw and roll to within 10 arc-seconds to maintain fractional IFOV errors in epi-polarity.

A somewhat similar concept called STEREOSAT has its origin in the requirements of the geological community for stereo data. The vertical, fore-, and aft-looking linear arrays would be panchromatic, with multi-spectral data to come from the Landsat series.

STEREOSAT would use the Multimission Modular Spacecraft and would be launched from the Western Test Range by the Shuttle into the same orbit as Landsat. It would have a 15 m IFOV and a 61.4 km swath. Like MAPSAT, STEREOSAT has not been approved or funded beyond the study phase.

We are also looking forward to evaluating the images from the French SPOT satellite. The spacecraft will be launched into a sun-synchronous orbit at 822 km altitude. Mission control and data processing will be in Toulouse, France. The payload will consist of two high resolution optical systems which can operate in multispectral mode with 20 m IFOV or in panchromatic mode with 10 m IFOV. A rotating mirror will permit the scan to be acquired from areas left or right of the spacecraft as well as in the vertical, thus permitting stereo data acquisition. However, one of the practical disadvantages of the system is that the stereo coverage will be obtained from two adjacent orbits and it must be hoped that weather conditions will permit the obtaining of suitable stereo photography. We are anxiously awaiting this data so that the usefulness of the system to cartographic applications can be explored.

It is somewhat disheartening that Canada, the second largest country in the world, must depend on other smaller countries' satellite systems for remote sensing data of our land-mass. We should seriously consider a Canadian satellite designed to satisfy our requirements for remote sensing and cartographic data from space.

Reference:
1. A. P. Colvocoresses: An Automated Satellite System (MAPSAT)
2. F. J. Doyle: Status of Satellite Sensing Program

8.6 MAJOR CHALLENGES AND OPPORTUNITIES IN OCEANOGRAPHY

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Capabilities of satellite-mounted sensors to map ocean temperature, colour, surface waves, wind and currents have now been demonstrated, but no operational ocean monitoring satellite has yet been launched. Experimental satellites are planned by Japan and Europe, but the U.S. plan for the National Oceanic Satellite System (NOSS) has been discontinued. The Canadian RADARSAT would have ocean mapping capabilities and U.S. satellites will continue to carry infrared scanners, and possibly water colour mapping sensors.

Lack of satellite data is now strongly limiting activities in this field. New sensor programs have been delayed or cancelled; moreover, data already collected is slow in being processed to easily usable form. Lower funding has also reduced the analysis effort, especially in the U.S.A., and new initiatives are shifting to Europe and Japan.

Canadian work is concentrating on evaluation of U.S. satellite data, and of airborne data collected by CCRS and other facilities, in order to plan the ocean data gathering sector of RADARSAT and to design future airborne and satellite instruments. Spacelab and other shuttle payloads, as well as cooperative projects on other satellites, provide opportunities for putting such instruments in space.

As examples of this evaluation work, we show two types of satellite imagery.

SEASAT SAR Example (Figure 1)

Radar imagery is an important new data source for satellite oceanography. Figure 1 shows a SEASAT SAR image digitally processed by the Communications Research Centre, Ottawa. The processor is slow, but can produce very precise, full revolution (1 look) images retaining the phase information needed to compute signal frequency spectra for different areas of the scene.

SEASAT was moving to the northwest, at 850 km altitude and 300 km offshore of Vancouver Island, when the radar, looking out to the right, made Figure 1, which shows mountains on Vancouver Island (top right) and the Olympic Peninsula (bottom left) and the water at the mouth of Juan de Fuca Strait. Water roughness and surface wave slope patterns show up strongly. Surface waves moving in from the Pacific show as parallel crest lines with a wavelength of about 1 mm on the image (164 m at this scale). Internal waves generated by the ebb tide, just ending at the time of the image, are made visible by modulation of water surface roughness. This causes the pattern of alternating dark and light bands across the mouth of the Strait. The bands show a wavelength of 650 m at the landward side (front) of the wave packet, decreasing to 300 m at the rear. The internal waves are oriented across the Juan de Fuca canyon which extends to the left of the image. They are being refracted by the shallower water on Swiftsure Bank at the top of the image, and advected by the tide, which has already turned to flood on the south side of the Strait near Cape Flattery. A second smaller and fainter pattern is visible in the lower right corner of the image. If this had also been generated near Cape Flattery, but 12 hours earlier on the previous ebb tide, it would have had to travel at about 0.5 m/sec to reach this position, a plausible speed for a combination of group and tide velocities. Larger scale brightness variations over the water are due to wind patterns affected by the complicated mountain topography.

Since all elements of the image are located in azimuth (the vertical coordinate here) by the apparent doppler shift of the radar returns received by the satellite, images of moving ships are displaced from their true positions at the end of the wake lines. This effect is clearly seen in the ship return near the centre of the image. The displacement of 1.5 mm (250 m) indicates a velocity towards the satellite of 2.1 m/s, or 11 m/sec (21 kt) on the sea surface at the heading indicated by the wake.

Measurements of the mean doppler spectrum from areas of the image can also give the range component of the apparent surface velocity of the water. Estimated precision is about $\pm$ 0.2 m/sec for averages over 1 km^2 areas, but systematic error sources may be larger than this. A cut across the internal wave packet off Cape Flattery shows a surface velocity modulation of $\pm$2 m/sec, a measurement which may be affected by the strong associated signal amplitude variations.

Design of the Canadian RADARSAT concentrates on mapping sea ice when the satellite is over the Arctic. Studies are now under way, using SEASAT and airborne radar (SAR 580) data, to make use of RADARSAT data when the satellite is imaging open water further south.

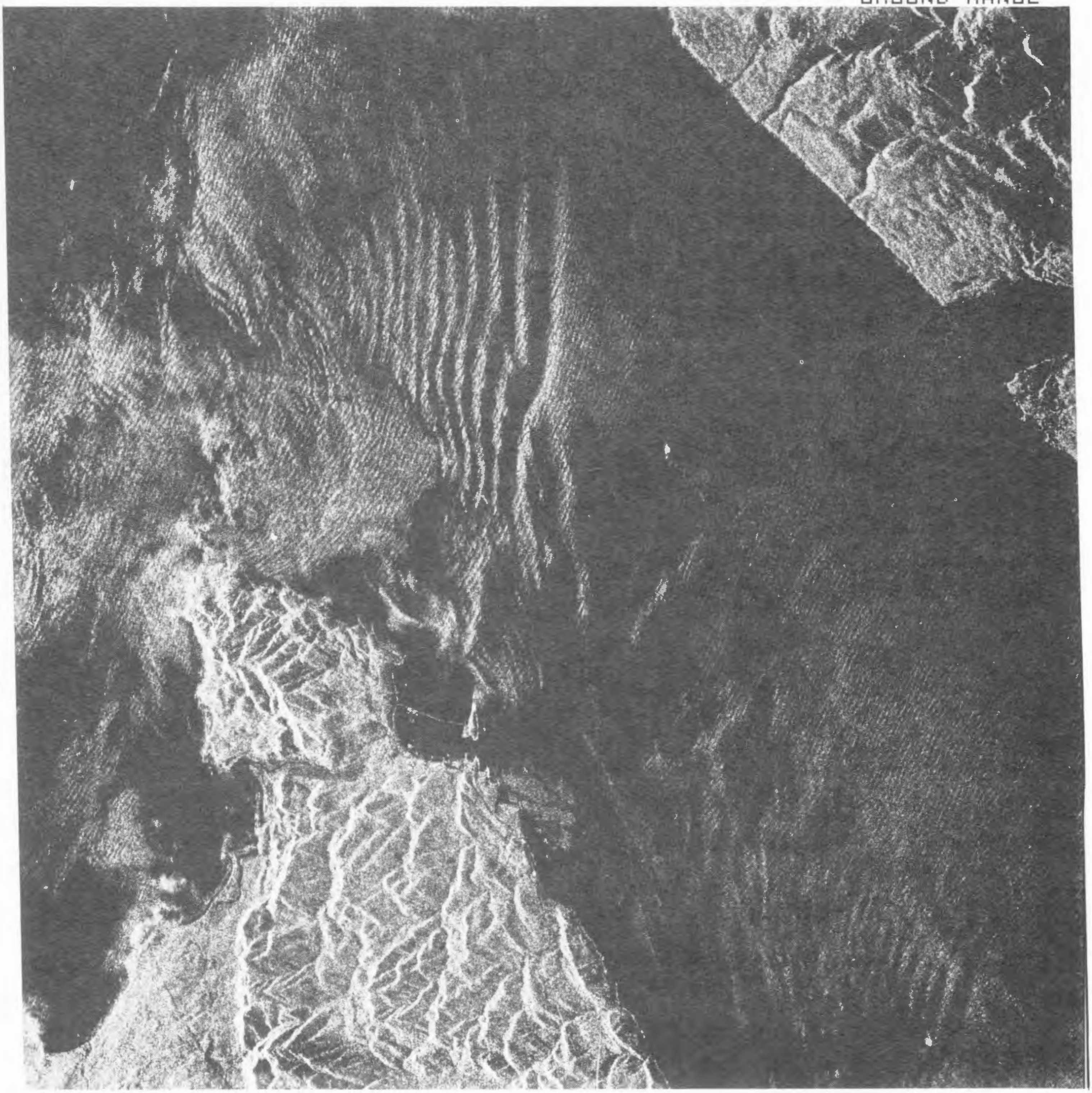

Figure 1 Digitally processed SEASAT SAR scene showing a variety of dynamic surface and internal wave phenomena as described in the text.

Figure 2 Chlorophyll pigment concentration image derived from Coastal Zone Color Scanner data as described in the text.

In order to supplement RADARSAT's SAR data, a scatterometer may be included to measure surface wind, or an altimeter to map sea level changes due to currents and eddies. An optical sensor is also possible.

Coastal Zone Color Scanner (CZCS) Example (Figure 2)

Quantitative mapping of water colour from space has now been demonstrated by the CZCS on Nimbus 7. The data can be used to map chlorophyll concentrations showing the changing patterns of primary productivity in the water, and to track movements in these patterns indicating the ocean dynamic that moves and mixes the water. Figure 2 shows an example of a processed image from this sensor which is formed from the ratio of signal levels in the green and blue bands of light received by the sensor. Land and cloud areas have been masked as white. The grey shades of this ratio image have been shown to relate directly to chlorophyll pigment concentrations in the water. The circular eddy in the centre of the image and the hammerhead feature further south contain about 2 mg m^{-3}, while values near shore are higher ($>$5 mg.m^{-3}) and offshore diminish to $<$ .5 mg.m^{-3}. In addition the features suggest a variety of water movements including flow out of Hecate and Juan de Fuca Straits and an along-shore current near the coast.

This data is relatively new, and it will clearly have important applications in biological and physical oceanography. In Canada the data is currently being used off the east and west coasts, and an improved water colour sensor is being built to explore the future potential of this type of sensing. This sensor is the DFO Fluorescence Line Imager (FLI), which will make use of solid state imaging detectors to allow measurement of the natural fluorescence signal from chlorophyll-*a* in phytoplankton, and to improve sensitivity for measurements of chlorophyll absorption effects such as that illustrated above. Mapping two properties of the chlorophyll-*a* simultaneously should lead to increased accuracy in the mapping of chlorophyll concentrations and may also allow changing properties of the phytoplankton to be studied as they grow and decay. The imager is currently being designed for high altitude flights, but the eventual goal is for improved measurements from space.

The question of which additional sensors to launch on RADARSAT is still open, and an optical imager may be included. Water colour (chlorophyll concentration) mapping is one important application that such an instrument should be capable of.

Conclusions

The above examples illustrate the types of satellite information available. Use of this data is limited by the current restricted availability of high quality data, by a lack of image processing facilities even at major research institutes, and by lack of education and training in this field at universities.

The working group has discussed these problems and identifies them as limiting factors for growth in this application of remote sensing.

8.7 MAJOR CHALLENGES AND OPPORTUNITIES IN ENGINEERING APPLICATIONS

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Overview of Current Activities in Canada

a) List of Applicable Papers Presented at the 2nd National Work-Shop on the Engineering Applications of Remote Sensing, Edmonton, 1982.

b) Available Abstracts Below.

Theme: Development and Applications of Remote Sensing

From Interpretation to Image Analysis - A Transition

G. Spafford (Abstract follows)

Thermal Sensing of Soil Moisture

J. Vlcek (Abstract follows)

Development of Airborne and Satellite Remote Sensing Applications

J.D. Mollard (Abstract follows)

Recent Developments in Engineering Applications of Remote Sensing

S.J.G. Bird (No Abstract)

Route Location Using LANDSAT Imagery

T. Reimchen (No Abstract)

Theme: High Resolution Satellite Imageries

High Resolution Visible and Infrared Observations from Space

W M. Strome & J.P. Hession (Abstract follows)

Canada's Radar Satellite Program

R.K. Raney (No Abstract)

Topographic Map Revision with Satellite Imagery

E. Fleming (Abstract follows)

ABSTRACT
G. Spafford: From Interpretation To Image Analysis - A Transition

Air photo interpretation has been a valuable tool to the civil engineer for many decades. The introduction of satellite imagery has enhanced the ability of the interpreter to define the pattern and composition of the earth's surface. The paper briefly presents several examples in some of which the satellite imagery alone was used. A variety of devices are used for image analysis, not all of which are of general use to the interpreter. Some of these devices are available through remote sensing centres established by the provincial governments. The quality of service provided at these centres varies and in most cases, the interpretive and analytic devices are limited. Methods of obtaining satellite imagery are summarized and problems in delivery discussed. The authors express the opinion that improvement of remote sensing centre facilities and services is justified.

ABSTRACT
J. Vlcek: Thermal Sensing for Subsurface soil Moisture

Soil water content affects physical properties of soil related to engineering applications as well as being a crucial factor in plant life. Survey of soil moisture over large areas by point measurement can be tedious, inaccurate and impractical. It is, therefore, not surprising that attention has been directed toward remote sensing methods as means of obtaining such data. Three remote sensing methods can be used for soil moisture detection: air photography, thermography and microwave imaging. Each of these methods has certain advantages and limitations. In this paper the application of thermal sensing will be discussed. In the first part basic thermal properties and behaviour of soils will be reviewed to establish a basis for understanding of thermal image patterns. In the second part, will be a presented experimental results with the emphasis on those obtained at the University of Toronto.

ABSTRACT
J.D. Mollard: Development of Airborne and Satellite Remote Sensing Applications

I plan to use about 30 slides to illustrate this talk, which deals with my experiences in developing remote sensing applications. The projects discussed date back to the 1940s. Remote sensing case history examples

begin with searches for sand and gravel construction materials, and with the location and mapping of dense concentrations of boulders and frost-shattered rock. Studies involving the selection of different types of engineering sites and routes, and with terrain mapping along them, are discussed next. An example of surficial geology and lineament mapping for oil and gas prospecting is followed by one carried out for base metal exploration. Slides of airphotos interpreted for groundwater location and development, and others illustrating shoreline erosion and bank stability mapping around recreational lakes and man-made reservoirs are then presented. The next slide shows one facet of a study showing historical (50-year) changes in erosion and sedimentation affecting wildlife habitat at a large modern delta in northern Canada. My final series of slides present examples of terrain data base mapping and eight derived land suitability maps for use in guiding regional planning and resource management. Each of the case history examples is illustrated by a slide showing a portion of an interpreted black and white panchromatic airphoto, an airphoto mosaic, or a LANDSAT data product.

ABSTRACT
W.M. Strome & J.P. Hession
High Resolution Visible and Infrared Observations from Space

The National Aeronautics and Space Administration series of Earth Observation Satellites, LANDSAT's-1, -2 and -3, have provided frequent, reliable high quality global observations using a high quality Multispectral Scanner (MSS) operating in the visible and near infrared region of the spectrum. The use of these data to provide information to improve the effectiveness of resource management is increasing. For some applications, the resolution of the data provided by the current LANDSAT series, 80 metres, is a limiting factor. In 1982, LANDSAT-D will be launched by the United States. In addition to the familiar MSS, this satellite will carry a new sensor, the Thematic Mapper (TM) which will have 30 metre spatial resolution and several new spectral bands. The data from this instrument will not be widely available until 1983 or later. In 1984, France is planning to launch the first SPOT satellite, which will contain two scanners which have 20 metre resolution in the multispectral (three channel) mode and 10 metre resolution in a panchromatic mode. Canada is developing plans to read out and process data from both of these satellites, as well as those from several other remote sensing satellites whose launches are being planned by the European Space Agency and Japan later this decade.

ABSTRACT
E.A. Fleming: Topographic Map Revision Using Satellite Imagery

LANDSAT imagery is being used effectively to provide revision information for 1:250,000 maps and change detection for 1:50,000 maps in the National Topographic Series of mapping. Off-shore features such as islands and shoals have been positioned using the CCRS DICS products and this type of digital imagery has been used for the automatic extraction of lake information for small scale maps on an experimental basis.

Conclusions Resulting from the 2nd National Workshop

Direct Applications

1. The availability of high resolution Thematic Mapper and SPOT imagery will increase the general application of satellite imageries by the Engineers.

2. Ground resolution for both types of imagery is still insufficient for detailed terrain analysis. However, they are suitable for general operational planning for large scale engineering products such as pipeline and hydro-electric developments.

3. Compared to the Thematic Mapper Imagery, SPOT imagery is more useful for visual interpretation since it provides a higher resolution and stereoscopic coverage.

4. Considering the resolution and scale at which it will be available and its stereoscopic capability, SPOT imagery has the potential to be a substitute for high altitude aerial photography.

5. Repetitive, up-to-date coverage provided by Thematic mapper and SPOT imageries is important to engineering studies requiring change detection such as erosion, flooding and instabilities.

6. The availability and cost of these imageries will be determining factors in the extent of their use.

Products

7. Significant savings in mosaic construction will be realized if high resolution, geometrically-corrected imageries are available.

Image Analysis

8. For the Thematic Mapper Imagery the colour composite which assigns blue, green and red to bands TM 3, 4, 5 respectively appears to have great potential for engineering applications.

9. The colour composite (multispectral mode) of the simulated SPOT imagery could approach the small scale colour infrared aerial photography in terms of level of detail and type of information.

Education and Training

10. The full benefits of high resolution satellite imageries can be realized only if sufficient qualified personnel in all related areas of operation are available.

Workshop

11. It is difficult to maintain interest, contact and momentum across the nation when the workshop is held at two-year intervals.

Miscellaneous

12. Because of diverse activities by various agencies throughout the country, there exists a need to establish and to maintain a record of the state-of-the-art in many areas.

Solution: As an example, MTC has been commissioning state-of-the-art reports on new investigations.

3. Maintaining a realistic balance between visual interpretation and digital techniques since conventional visual interpretation remains to be the only feasible method for many agencies and will be so for some time.

Recommendations

Recommendations originating from the 2nd National Workshop

A. Products

1. Geometrically-corrected imageries, similar to those produced by DICS for the present LANDSAT data, should be available for high resolution satellite imageries from the national facility.

2. The potential of mapping using SPOT imagery should be investigated.

B. Image Analysis and Pilot Projects

3. Pilot projects using simulated imageries should be conducted to investigate systematically their application to engineering studies and to demonstrate and document the benefits of digital analysis systems to those who presently rely on airphotos alone.

4. Pilot projects should be organized by the Working Group, involving personnel having relevant experience, qualification and interest. Projects should be carried out in conjunction with various agencies such as government, industry and educational institutions.

5. Test areas for such projects should:

   (a) be located in different physiographic regions of Canada;

   (b) Already have sufficient airphoto coverage and ground truth.

6. For Thematic Mapper imageries, the rendition which assigns blue, green and red to bands TM 3, 4 and 5 respectively should be available for all future pilot projects.

7. The most useful colour composite for analyzing thermal signatures, water quality and rock types from Thematic Mapper imageries should be defined. Special equipment may be required and such needs and corresponding availability should be investigated.

C. Education and Training

8. The Working Group should investigate, at the earliest possible date; the feasibility of having programs established in colleges and universities to meet the manpower requirements in satisfying future demands in high resolution satellite imagery programs.

D. Workshop

9. The National Workshop on Engineering Applications should be an annual event, held in rotation across the country, to foster national interest and awareness in engineering applications of remote sensing.

8.8 HOW DOES REMOTE SENSING TECHNOLOGY MEET THE APPLICATION CHALLENGE?

A PROVINCIAL PERSPECTIVE ON THE USE OF REMOTE SENSING TECHNOLOGY

Victor G. Zsilinszky
Ontario Representative

My job is to provide an overall view of the provincial remote sensing situation from coast to coast, in answering the question of how remote sensing technology stands up to the challenges of actual or proposed applications. I thought to reduce this job to a more manageable size by focusing on one specific provincial program - one which I am admirably familiar with, and which has been challenging the capabilities of remote sensing with some rigour for nearly a decade now. I speak of the Ontario Centre for Remote Sensing. I do think, however, that the overall assessment of the experience of users will be accurate - even though I may inadvertently miss important highlights of the programs of other provinces (for which I offer my apologies in advance). I believe that the problems and successes which the OCRS has encountered would be common to all users. If you do not agree, there will be ample opportunity at the workshop to present the unique concerns of your own province. Therefore, I shall deal with the following topics predominantly from the viewpoint of Ontario.

AVAILABILITY OF A CONTINUOUS SUPPLY OF DATA

With regard to data production, the present turnaround time provided by CCRS satisfies OCRS needs. We update our library at approximately three-month intervals, and place frequent special orders for particular projects. We generally receive hard-copy data within 2-3 weeks, at the most, and CCT's within 3 to 4 weeks of placing the order. Continuity of data supply in this sense, therefore, is not a problem.

With regard to weather-caused interruptions in the flow of satellite data for a particular purpose, back-up systems must be developed. These systems may not offer the same efficiency and economy as satellite data-based methods, but they should at least improve upon conventional methods which probably depend primarily upon ground surveys, and should, naturally, offer information compatible with that derived from satellite data. For example, for the OCRS program to map agricultural land use from the digital analysis of LANDSAT data, aerial photography is being considered and an airborne video recording system is being tested, for use as back-up. When a LANDSAT-based agricultural land use inventory program becomes operational, the procedure will be to determine whether usable imagery has been acquired on a scheduled image date, from the microfiche imagery, and to put the back-up system into use at once.

In some cases, changes in landscape conditions occur so gradually that up-to-date imagery is not required. One example is the biophysical classification of the Hudson Bay-James Bay Lowland. For the northern forest typing program, however, the recent occurrence of large, unfought fires would outdate the information until new imagery became available.

If a satellite had a serious malfunction and there were no other operating satellites which could make up the loss, the resulting data interruption would, of course, be fatal to programs based on continuous, near-real-time coverage. Naturally, operational users of this data need reassurance that, insofar as the matter lies within its power and not within that of NASA or NOAA, the federal government will not let the data flow dry up. We have encouraging signs that the federal government is aware of this responsibility. The Minister of State, Science and Technology has granted CCRS some $14 million to upgrade the receiving capability for LANDSAT D. A grant of $4 million was allocated to continue collaboration with the European Space Agency, so that Canadian users may benefit as much as possible from the data produced by ESA satellites. Developments toward RADARSAT have also been funded with $17 million.

One might worry that in the meantime, the real problem lies with the American cutback in funding for the space program. There are two facts to be borne in mind here:

a) The planned cutback in NASA's budget is $357 million in 1982 and $1 billion in 1983. The diverse requirements of the Space Shuttle represent about half of NASA's remaining budget, but, in view of its value in defense, it may be relatively safe from cutbacks. The U.S. Office of Budget and Management apparently believes that, rather than constrain all the other programs, including earth-resources satellites, it would be better just to lop off the space exploration program. (This information is drawn from an article entitled, "The NASA Budget, Planetary Panic", in Volume 120 of Science News.) However indignant we may feel about this approach, it would leave operational satellite-based programs on relatively firm ground.

b) NOAA is directed to run LANDSAT data distribution as something closer to a commercial enterprise. Therefore, we hear of a charge of $600,000 per receiving station, and of significantly higher data costs in Canada. For the research and education centres, such increases will be difficult to bear. For a full-fledged operational program, however, I would venture to say that the cost of LANDSAT data will always represent considerably less than half the cost of the program. Furthermore, the cost-effectiveness of an operational LANDSAT-based methodology would justify a large data cost: although the cost of using satellite remote sensing operationally may rise, it will still undercut the cost of traditional ground surveys. To cite an example from OCRS experience, it is projected from work done to date that LANDSAT-based operational land use mapping for Ontario will cost in the order of $1.50 per square kilometer (from purchase of CCT at $230 to finished map).

In short, I believe that concern and money are both available to keep earth-resources satellite data flowing without major interruption, but that it will be necessary for users to provide their own insurance, as far as possible, by developing airborne back-up systems.

STATE-OF-THE-ART OF IMAGE ANALYSIS SYSTEMS (AT PROVINCIAL CENTRES)

Practical, relatively small image analysis systems are permitting increasingly wider use of digital LANDSAT analysis. This is a necessary development on the eve of LANDSAT D. Central remote sensing organizations in Ontario and Québec have systems well established in operation. Nova Scotia is in the process of establishing a system; Alberta has acquired one; and Manitoba has similar plans. All systems are expected to be compatible, for the great advantage of easily-transferred software and shared experience.

a) System Costs:

The OCRS system consists of a PDP 11/34 computer and two sets of image display hardware (a Norpak 3050 Image Display System and a Dipix LCT-11). In total, the system has cost approximately $300,000 to purchase. Yearly maintenance costs $24,000. Staff scientists operate the system for their own projects; however, the services of a system manager are required ($25,000). The only supply costs are $16 per blank tape. At this time, however, a sum of $36,000 per year is paid for the development of new software.

OCRS has established an Applicon Colour Plotting System in tandem with its digital analysis system. The purchase price of this instrument was $100,000 in 1980. Software maintenance cost $2,400 per year. The training of an OCRS staff member for hardware maintenance and software problem diagnosis cost $1,000. The major component of the cost of hardware maintenance is the ink-application nozzles, which sell for $725 for a set of three. Supply costs are $265 for a 5-bottle carton of ink and less than $1 per 56cm x 86cm sheet of paper for printing maps.

The development of software to convert digital analysis results to an Applicon-acceptable format and of software to increase the annotation capability, has to date cost $30,000 per year.

In summary, it is estimated that the total yearly operating cost of both the image analysis systems is $63,400, not including the cost of developing new software.

b) System Output:

Output cannot be precisely evaluated, as it depends upon area size and complexity. It could take from 1/2 day to over a week for a scientist to complete a single classification satisfactorily. Similarly, it may take from 1 hour to over one working day to convert the classified data to an Applicon-acceptable format. Printing of the final map, however, takes only 15 minutes. (A sample is appended to this paper.) Production of colour separation masters of the map takes approximately 1 hour.

The OCRS digital analysis and computerized map production facilities operate 24 hours a day, 7 days a week, in order to meet the demand of research and application projects, and of access to the system granted under the OCRS technology transfer program to private companies and universities.

c) Conclusion:

Without undue boastfulness, I think I can predict that the type of classification and map production facility established at the OCRS is probably the way of the future in the operational application of LANDSAT and of similar satellite data, as it makes the information derived from the data available in a readily-usable format, rapidly and relatively inexpensively.

RESEARCH AND DEVELOPMENT PROGRAMS

Here, a short list of selected highlights will have to suffice. No attempt has been made at a comprehensive survey, in view of the time restrictions of this paper. You will, of course, all have an opportunity later to augment or correct what I have said.

The Alberta Center is conducting a demonstration project, together with CCRS, the Alberta Department of Energy and Natural Resources and the University of Calgary, to establish a LANDSAT-based technique for determining the capacity of rangelands for cattle grazing.

Manitoba is testing the feasibility of using the digital analysis of LANDSAT data to maintain an ongoing inventory of wooded cover in the southwest of the province, for the determination of white-tailed deer habitat.

The OCRS is conducting the following programs based on the digital analysis of LANDSAT data:
- general land use/land cover mapping for the province
- agricultural land use mapping
- forest type mapping north of latitude 52°N
- forest fuel mapping
- mapping wetlands of the Hudson-James Bay Lowland
- vegetation change analysis for environmental impact assessment

The following are some examples of programs based on airborne sensing:
- forest regeneration assessment by colour infrared photography
- detection of mine roof instability aerial photography and thermography
- completion of the surficial geology mapping of Northern Ontario

In Québec, the following programs are underway:
- cooperative program of the Laurentian Forest Research Centre and Hydro Québec to map forest conditions over a 200,000 km^2 region of the province
- a joint project of the federal Forest Fire Research Institute and the Ottawa Valley Conservation Society in the use of digitally-analyzed LANDSAT data in the planning of forest fire fighting strategy
- initial environmental impact assessment of the James Bay project of Hydro Québec; subsequent monitoring of reservoir flooding

In New Brunswick, both LANDSAT data and aerial photography have been employed in the development of a technique for the mapping of forests susceptible to damage from spruce budworm infestation.

In Newfoundland, LANDSAT imagery was used together with aerial photography for the mapping of structural and surficial geology by the Department of Mines and Energy.

TECHNOLOGY TRANSFER

One form of technology transfer is actively practised by the provincial remote sensing centres of Alberta, Manitoba and Québec, which give users access to a remote sensing laboratory and remote sensing data, and provide assistance in the performance of projects. Another form of technology transfer, that of cooperative projects, practised in at least 5 provinces, is exemplified by the Alberta joint project with CCRS to establish a LANDSAT-based rangelands capacity assessment technique. I understand that rangeland managers are active participants in this program, thereby accomplishing a transfer to the user community of a spaceborne sensing technique.

In 1981, the OCRS continued its program of technology transfer to government, the private sector and universities, through the following activities:

a) OCRS gave formal general and project-related consultation in remote sensing use to 25 different Ontario government agencies, some on several different occasions and topics. Consultation was also provided to 5 federal bodies and 4 organizations from other provinces. The Centre performed 31 research and trial-application projects with Ontario government organizations, both on a charge-back basis and on the basis of mutual financial contribution.

b) Approximately 25 Ontario companies received formal consultation (that is, lengthy, face-to-face discussion and advice, as distinguished from the providing of specific information by phone or letter). In certain cases, scientists from companies were granted the supervised use of OCRS facilities, including the digital analysis system, for purposes of specific, small-scale research. OCRS worked with 4 companies on joint research and development projects.

c) Fifteen different university departments took part in the OCRS technology transfer program in 1981. OCRS provides guest lectures, assistance in curriculum planning, workshops at the Centre for senior undergraduates, special training and access to lab and digital analysis facilities for graduate studies and assistance in thesis preparation. OCRS also performed 4 cooperative R&D projects with universities.

TRAINING

At the Alberta Center this past February, the tenth multidisciplinary remote sensing course was given. The Manitoba Remote Sensing Centre provides discipline-oriented remote sensing training, in cooperation with the University of Manitoba. The Québec Centre is also an active participant in remote sensing training in that province. The Land Survey Institute of Nova Scotia, which now houses the remote sensing centre of Nova Scotia, provides a unique national training centre for remote sensing technologists.

In Ontario, 8 training seminars were given in 1981, each emphasizing hands-on experience in data interpretation and analysis, and based primarily on actual remote sensing applications developed at the OCRS. The courses were as follows:

- General Remote Sensing Seminar for Professionals (5 days)
- General Remote Sensing Seminar for Managers (3 days)
- Seminar in Land Use Applications (3 days)
- Seminar in Forestry Applications (3 days)
- Seminar in Geological Applications (3 days)
- Photo Interpretation Course for Great Lakes-St. Lawrence Forest Conditions (5 days)
- Photo Interpretation Course for Boreal Forest Conditions (5 days)

Government employees, the staff of private companies and, in some instances, university professors, attended these courses.

ECONOMIC IMPACT

This is a question on which I prefer to speak of Ontario's experience alone, simply for the advantage of a basis in firm knowledge.

First, some cost-benefit data on the new OCRS computerized mapping technology. The economic benefit can only be estimated at this point, but early OCRS results have furnished the following figure: to use this technology for general land use or forest type mapping will cost between \$1.00 and \$2.50 per km^2. In the case of forest typing, this is approximately one-tenth of the cost of the traditional aerial photography-based technique. The levels of detail differ greatly, of course, but for northern regions of relatively simple forest conditions, the results from LANDSAT technology are more than adequate. A very important aspect of the new technology is its efficiency. For the OCRS land use mapping program, for example, it is estimated to take approximately 40 man-days to produce one 1:250,000-scale and 16 1:50,000-scale map sheets, for one 1:250,000-scale NTS map sheet area. (The calculation assumes that the digital system could be dedicated full-time to this one task.) At this rate, mapping over extensive areas which may otherwise have proceeded very slowly, or have been cut off before completion, can now be finished within a few years. Within the limits of satellite data continuity, this also implies more up-to-date information.

Permitted a personal observation on the future financial prospects of satellite remote sensing technology in Canada, I would say that they are reasonably bright, despite inflation, recession and increased data costs. I have three main reasons for this view:

a) Cutbacks in traditional programs may force managers to seek new methods;

b) New areas of resource exploration and development, particularly in the remote north, will create a demand for quick information on regions for which satellite data is the only existing coverage; and,

c) Initiatives are being taken toward the establishment of geographically-indexed digital data bases, for which digital satellite data will provide the foundation. The OCRS is itself taking such an initiative through the current development of software to integrate existing mapped data or data from other remote sensing data types with digitally-analyzed LANDSAT data, in a single Applicon-produced map.

RECOMMENDATIONS

First, OCRS would like to commend CCRS for the excellent quality of its product and service in LANDSAT data production; for the establishment of a technology transfer office; for the program to update Canadian receiving capability; and for its understanding and consultative approach to LANDSAT price increases.

Secondly, on the basis of the foregoing discussion, I would put forward the following general recommendations:

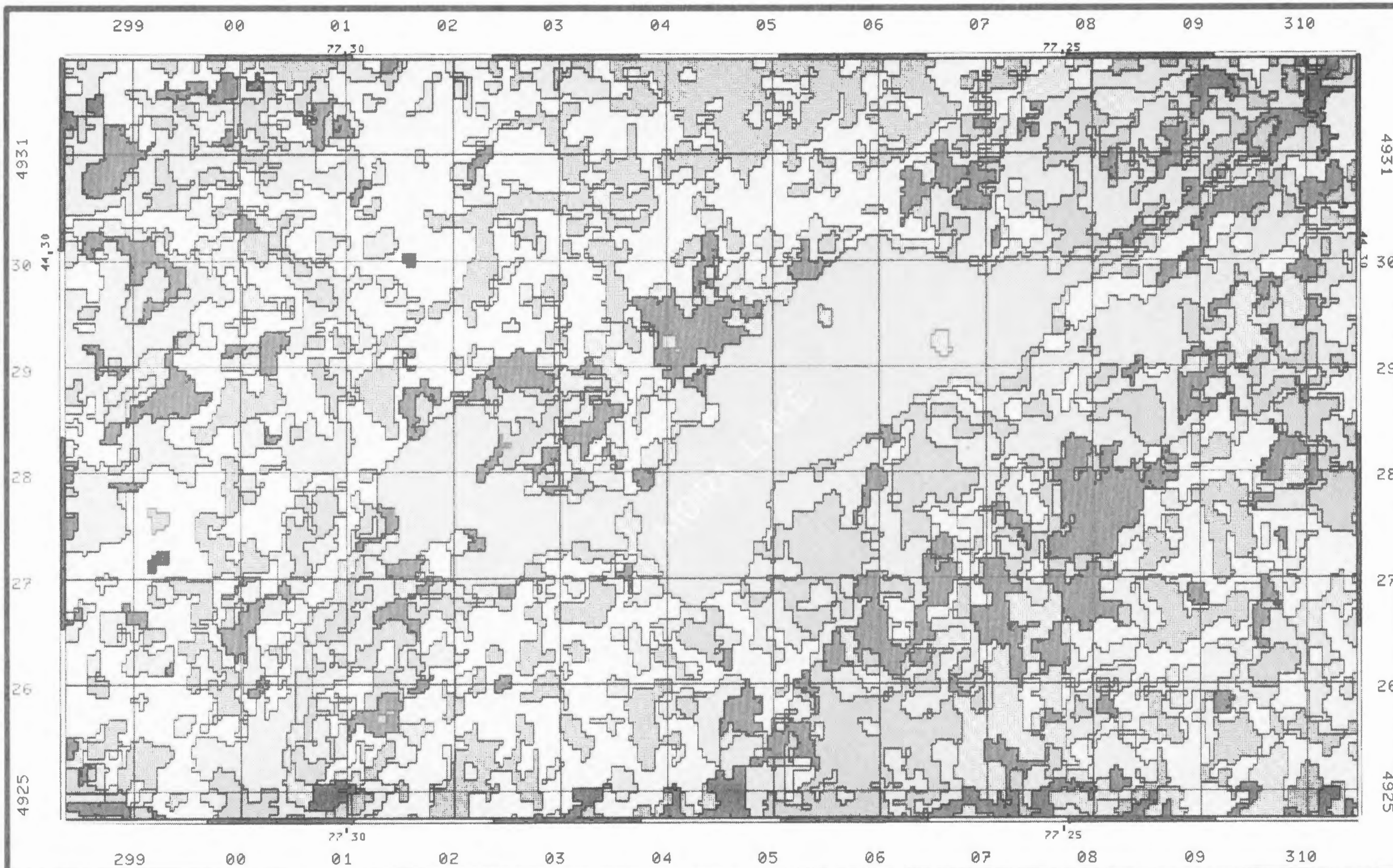
1. That CCRS manage the Canadian subscription to international satellite programs so as to minimize the possibility of a long-term interruption of data.

2. That the Technology Transfer Office equip itself with cost-benefit data from programs across the country, and with complete data on existing provincial programs, in order to support provincial or territorial organizations in efforts toward the establishment of remote sensing centres.

3. That successful provincial applications of remote sensing and their economic implications be publicized promptly through such channels as the CCRS newsletter. The onus is on the organizations who develop these applications to report their results.

4. That all provincial centres actively conduct technology transfer with or without the collaboration of CCRS.

5. Finally, and most importantly, that all provincial remote sensing centres take as their function the actual performance of remote sensing research and trial-application projects. I believe only in this way will true centres of expertise develop, grow and exchange the benefit of their experience. It is not that the coordinating and assisting roles which provincial centres have adopted are unimportant: in fact, they are vital. However, we at the OCRS have had the experience many, many times, that what one believes will work, from theory and previous related studies, may well fail to work as expected in practice. There is, therefore, no substitute for "the horse's mouth" at the centre of a provincial remote sensing community.



MOIRA LAKE AREA

GENERALIZED LAND COVER TYPES

BASED ON LANDSAT DATA OF JULY 2,1978. PREPARED AT O.C.R.S. (MNR)

SCALE 1:50000

- WATER
- DENSE DECIDUOUS FOREST
- CONIFEROUS FOREST
- PASTURE, FORAGE CROPS AND GRASSLAND
- CROPLAND (INC. SOME BEDROCK OUTCROPS)
- BARREN & EXTRACTIVE
- WETLANDS-SWAMP, BOG, MARSH (SOME CONIF.)
- EXPOSED SOIL AND BEDROCK OUTCROP
- MIXED FOREST (MAINLY DECIDUOUS)

MULTICLASSIFIED UNCLASSIFIED

8.9 REPORT ON THE PLAN FOR THE STUDY ON THE NATIONAL REMOTE SENSING PROGRAM

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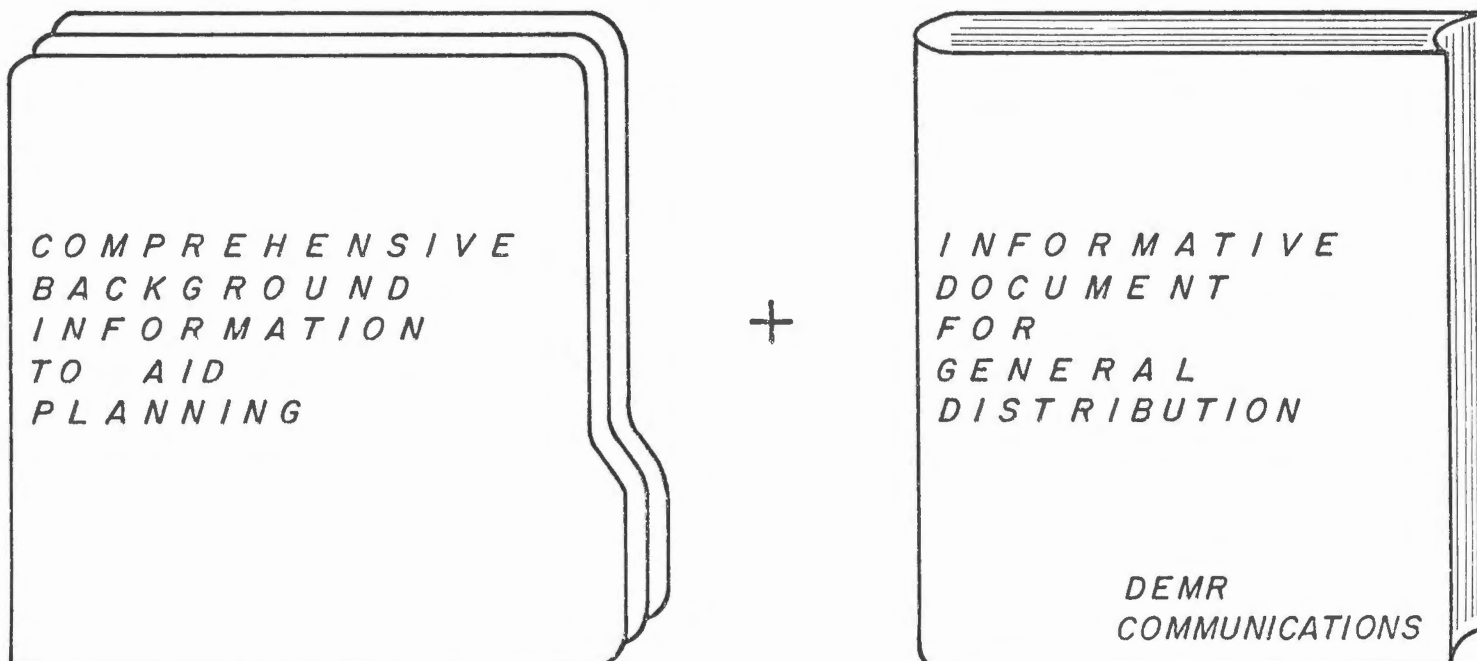
(U. of Waterloo 519-885-1211, X3280)

ASSESSMENT OF THE NATIONAL REMOTE SENSING PROGRAM

TIME FRAME

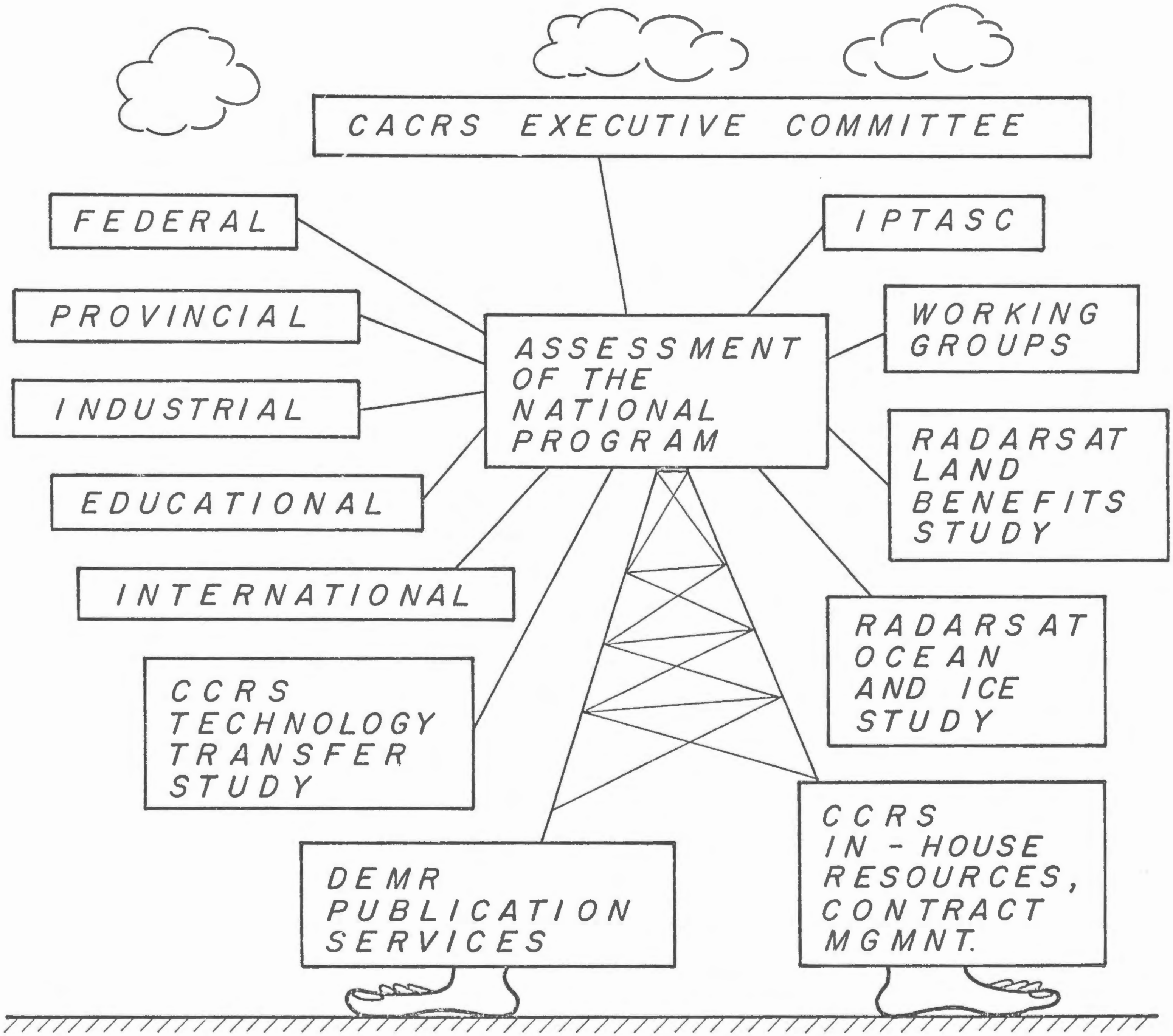
APRIL 1982 — MARCH 1983

OBJECTIVE: TO DOCUMENT CURRENT STATUS AND DIRECTIONS OF THE CANADIAN REMOTE SENSING PROGRAM



WORKFORCE

1.	CONTRACT AUTHORITY	— J. C. HENEIN CANADA CENTRE FOR REMOTE SENSING
2.	ADVICE & DIRECTION	— CACRS EXECUTIVE COMMITTEE (with CCRS Secretariat)
3.	CONTRACTOR RESPONSIBILITY	— DONALD J. CLOUGH SYSTEMS ENGINEERING ASSOCIATES LIMITED R.R. 2, BADEN, ONT., NOB 1GO Business office : 519 - 634 - 5371 University office : 519 - 885 - 1211 (x 3280)
4.	PUBLICATION TECHNICAL & EDITORIAL SERVICES	— COMMUNICATIONS BRANCH (PUBLISHING) ENERGY, MINES AND RESOURCES — BRIAN Mc GURRIN CCRS TECHNICAL INFORMATION SERVICE
5.	CONTRIBUTORS	— FEDERAL AGENCIES — PROVINCIAL AGENCIES — INDUSTRIAL PRODUCERS & CONSUMERS — INTERNATIONAL PLAYERS — EDUCATIONAL INSTITUTIONS — VARIOUS WORKING GROUPS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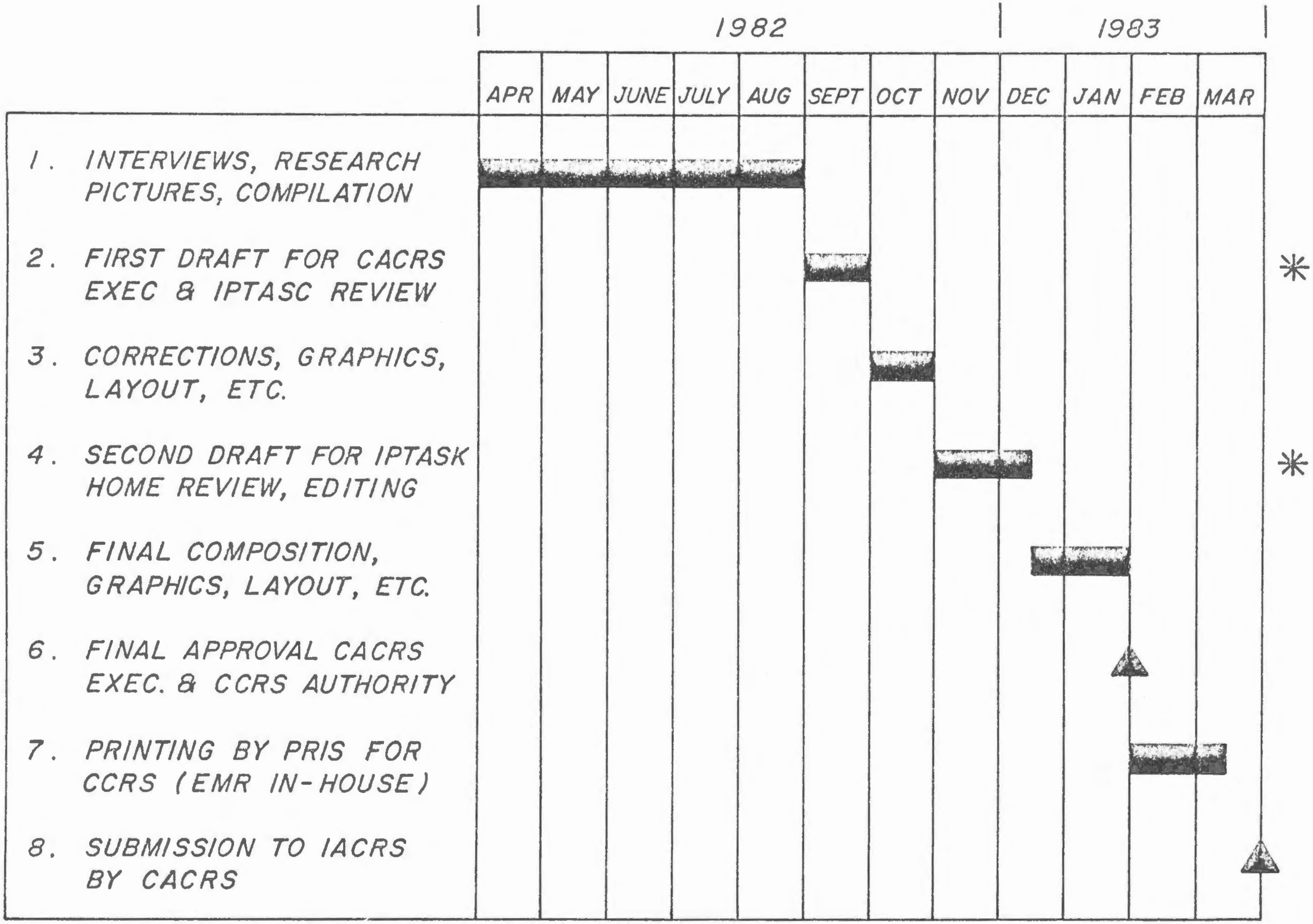
WORKING GROUPS
RADARSAT LAND BENEFITS STUDY
RADARSAT OCEAN AND ICE STUDY
CCRS IN - HOUSE RESOURCES, CONTRACT MGMNT.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1. INTERVIEWS, RESEARCH PICTURES, COMPILATION
2. FIRST DRAFT FOR CACRS EXEC & IPTASC REVIEW
3. CORRECTIONS, GRAPHICS, LAYOUT, ETC.
4. SECOND DRAFT FOR IPTASK HOME REVIEW, EDITING
5. FINAL COMPOSITION, GRAPHICS, LAYOUT, ETC.
6. FINAL APPROVAL CACRS EXEC. & CCRS AUTHORITY
7. PRINTING BY PRIS FOR CCRS (EMR IN-HOUSE)
8. SUBMISSION TO IACRS BY CACRS
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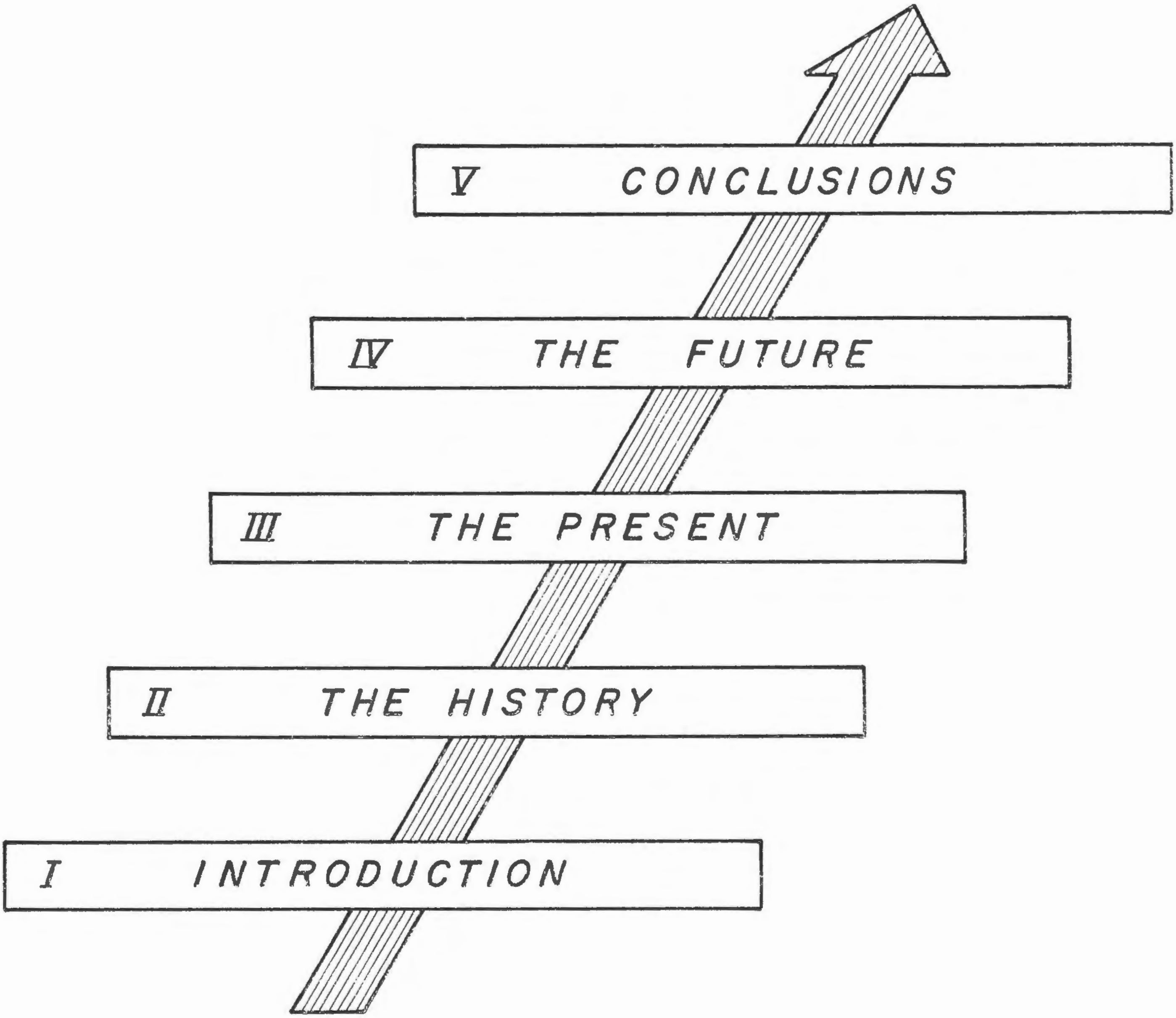
V CONCLUSIONS
IV THE FUTURE
III THE PRESENT
II THE HISTORY
I INTRODUCTION

8.10 FUTURE OF THE NATIONAL REMOTE SENSING PROGRAM: HOW ARE EDUCATIONAL INSTITUTIONS MEETING THE CHALLENGE?

Philip Howarth
McMaster University

In May 1980, John Roberts, Minister of State for Science and Technology stated:

> "Our universities are an essential element in the total national R & D effort. Without a strong, viable university research community, we will not have access to the latest technology; we will not develop the bright, creative minds that are so crucial to healthy science; and we will not be able to tackle the increasingly complex and urgent problems which concern us as a nation" (Source: CAUT Bulletin, Special Edition, 1982, p. 7).

These are worthy challenges for our educational institutions, but to what extent are these ideals being met?

The aim of this paper is to identify, with respect to remote sensing, the overall research and teaching capabilities of the universities and colleges of Canada. Strengths and weaknesses will be identified and the present capacity of educational institutions to meet the upcoming challenges of the National Remote Sensing Program will be assessed.

Week Of National Concern

It was appropriate that this year the Annual Meeting of the Canadian Advisory Committee on Remote Sensing (CACRS) should take place at the end of March, rather than at the usual time of mid-April. The CACRS meeting coincided with the "Week of National Concern" (March 24 - 31) declared by the Canadian Association of University Teachers (CAUT) to draw attention to "the underfunding of universities and the decline of quality education" (CAUT Bulletin, Special Edition, 1982, p. 1).

Some of the major concerns have been identified in an article in the Bulletin by the Executive Secretary of the CAUT (Savage, 1982):

- in most provinces, the percentage of provincial budget spent on education increased from 1960 to 1970. It then declined during the 1970s, so that it is once again at the 1960 level.
- although the percentage of federal support to universities has increased, there is concern that through the fiscal arrangements with the provinces, not all the support will reach the universities and colleges.
- scientific equipment is becoming outmoded and funds are not available for replacements. Buildings, especially in older universities, are falling into disrepair.
- universities are finding it increasingly difficult to provide adequate support for libraries, technical staff and secretarial services.

The basic problem facing all universities in Canada today is one of underfunding which in turn leads to non-productive pressures on the educational system.

University Funding

Funding of teaching and research at universities is a complex procedure, as illustrated in Figure 1. In essence, a university has four sources of financing. First, operating grants originate with the federal government, but are channelled to the universities through the provincial governments. Operating grants are usually calculated on a *per capita* basis. A second source of income is tuition fees, which vary depending on the province and the program of study being undertaken by the student. Third is research funding. Funding from federal sources is awarded to faculty or groups of faculty to support the direct costs of research. Funding for remote sensing specialists comes primarily from the Natural Sciences and Engineering Research Council (NSERC). Provincial funding for research is often available, but sources and amounts of money can vary greatly. The fourth and final source of funding would include research foundations and other private sources.

Teaching

There are several aspects to teaching that should be emphasized:

Enrolment As already pointed out, in most cases student enrolment directly influences the amount of finance received by a university from operating grants. If the increase in the *per capita* grant keeps pace with inflation (rarely the case during the

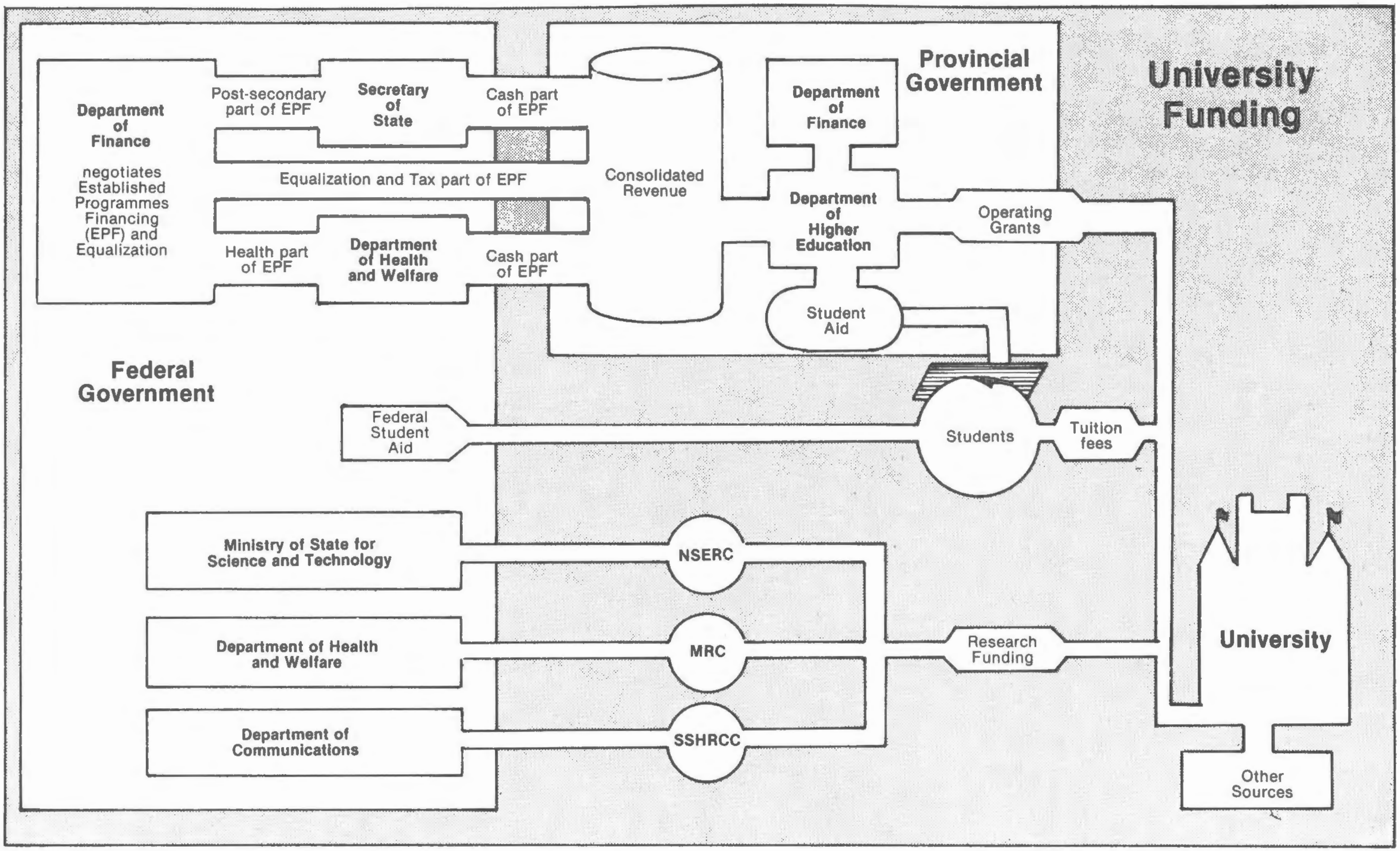

Figure 1: Diagrammatic representation of the system of financial support for Canadian universities (Source: CAUT Bulletin, Special Edition, 1982, p.3).

last decade), but student enrolment declines, the real income of the university also declines. With many fixed costs, it is difficult to absorb this decline.

It is also difficult to predict enrolment. There are several factors that can influence it:

- the size of the post-secondary age cohort (18 to 24 years).

- the participation rate, which in turn is influenced by the state of the economy, the amount of student aid, tuition costs and the availability of summer employment.

- the size of the non-traditional university group (e.g. mature students).

- the size of part-time enrolment.

Projected enrolment patterns quoted in the CAUT Bulletin, indicate a peak in university enrolment in Canada by 1983-84, followed by a decline. Depending on which of the factors that influence enrolment are emphasized, the decline in undergraduate numbers is predicted as being anywhere from 3.2% to 17% over the subsequent 20 years.

Graduate enrolment in the sciences, based on figures from NSERC quoted by Willes (1982), showed a decrease of 36% from 1970 to 1979. An encouraging trend is that in 1980-81, "applications for the support of first year graduate students increased by 12%, according to NSERC President McNabb" (Willes, 1982, p. 7). A similar increase occured in 1981-82 and is also predicted for 1982-83.

A world-wide trend experienced over the last few years has been an increase in tuition fees for foreign graduate students. In the spring of this year (1982) for example, Ontario announced that graduate tuition fees for foreign students would increase to $6,500 in 1982-83 and to $9,000 for the 1983-84 academic year. Discussion of the pros and cons of this move are beyond the scope of this paper. However, there will be a major effect on graduate programs where it has been difficult to attract good Canadian students (i.e. programs where students obtain good employment after a bachelor's degree, such as engineering). In such cases, numbers in graduate programs will be drastically reduced, making it difficult to maintain good undergraduate instruction and placing further pressures on the faculty.

<u>Course Instruction</u> It is important that members of CACRS appreciate the limited amount of instruction in remote sensing that undergraduate students are able to receive. Remote sensing is usually included as one of the topics in a degree program in an environmental science. In most universities, there are rarely more than two half courses in remote sensing. Each half course would usually consist of two hours of lectures and a two-hour lab per week for 13 weeks. In a total of 26 hours of lectures and 26 hours of laboratory classes, it is difficult to achieve more than a basic understanding of the concepts and achievements in the subject.

In the few colleges specializing in remote sensing, there are usually many more hours devoted to the subject. There is much more emphasis on the practical aspects of remote sensing and the technicians that are produced will form a vital element in the remote sensing community.

A much greater depth of understanding in remote sensing is achieved by students who specialize in the subject at the graduate level. With a two-year Master's program or a four-year Ph.D. program, a student not only receives in-depth instruction in remote sensing, but also carries out a great deal of reading and writing on the topic and is involved in the design, execution and writing of a specific research study.

<u>Education versus Training</u> It is important to emphasize the differences between education and training. Universities are primarily concerned with providing an all-round education for their students. As pointed out earlier, remote sensing is usually just one of the areas of instruction for students working in the environmental sciences.

The need for short-term training courses in remote sensing is often stressed at CACRS meetings. This need is realized, but it is not the prime function of universities to meet this demand. The faculty member has to contribute to the education of both undergraduate and graduate students, has to supervise the research of graduate students and at the same time pursue his own research activities. Rarely does he escape undertaking some administration as well! Given the range of activities required of the university faculty member, the provision of training courses has to take a secondary role.

During the present academic year, discussion of education and training has drawn some attention in the media as provincial education authorities have called for increased training for jobs in the whole educational system. The university viewpoint has been expressed by several educators, among them the President of McMaster University, Dr. Alvin Lee, who in a university newsletter (Contact, Jan. 15, 1982) "questioned what he called a federal and provincial government obsession with making schools, colleges and universities increasingly job- and training-related at the expense of fundamental education. The consequences (of such re-structuring) will harm this country for a long time to come". Dr. Lee also said that "he is concerned that if the system is re-shaped to emphasize training to fit jobs as they are currently defined at the expense of the arts and sciences, massive human obsolescence a few years down the road on a scale that makes our current concerns about employment look like a parlour game will be the result". A further point emphasized in the article is that "one of the functions of the schools and universities is to educate people who are capable of adapting their talents to new circumstances". Satellite remote sensing is an excellent example of this in that all of us who were employed prior to the 1970s have had to adapt and develop our skills to this new area of study.

Short Courses In addition to the provision of education in universities and colleges, there is also a definite need for shorter-term specialist training programs or courses. However, the expertise and/or equipment to instruct in such courses is not always located in the educational institutions. In the long term, however, it will be valuable to transfer some of this expertise to the permanent educational sector. This would aid in the overall transfer of remote sensing technology.

A variety of courses is currently being given in Canada, some by CCRS personnel, others by provincial centres. There is a need to identify types of programs and courses offered, and more importantly, to identify possible gaps that need to be filled. Involving universities and colleges in these programs would almost certainly be beneficial for long-term technology transfer.

Research

It is expected by universities that faculty members will maintain an active research program and publish the results of their work in research journals. For faculty in science and engineering, financial support of research is essential. For the majority, the NSERC operating grant is the major source of funding and it is important that members of CACRS appreciate the mechanism of reviewing proposals and the amounts of funding that are available.

In brief, faculty members submit research applications to NSERC which are assessed by peer review committees. Proposals are also sent to external reviewers. Several of us working in remote sensing have our applications considered by the Earth Sciences Grant Selection Committee (ESGSC). Barnes (1981) has provided a detailed description of the procedures involved and has also indicated the size of awards that are granted. Data from 1980 are shown in Figure 2, simplified from a histogram produced by Barnes (1981). Grants (both one year and three year) totalled approximately 500 of which about 330 were new applications. No award was made for 38 of the applications. Of the remainder, the range was from \$2 - 3,000 to \$38 - 39,000. The average operating grant in 1980 was \$14,600, with the modal class being \$7 - 8,000. Thirty-six researchers received \$20,000 or more, while only seven received over \$30,000.

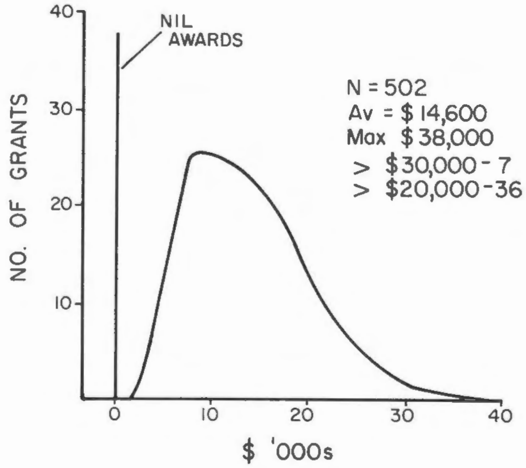

Figure 2: Distribution of 1980 NSERC Operating Grants in the earth sciences (from Barnes, 1981).

Equipment requests in the range of \$5 - 75,000 are also considered by the ESGSC Committee and in 1980 27 awards were made costing a total of \$510,000 (Barnes, 1981). Grants for equipment costing in excess of \$75,000 are considered by another committee and in 1980, four grants were made. However, as Barnes (1981, p. 24) points out "in earlier years, earth scientists generally received one, rarely two, awards each year".

Out of the grant, the faculty member has to provide some graduate student support and to cover costs of all materials, travel for field work, etc., not only for his own work, but also for his graduate student's research. Given the impending increase in the cost of LANDSAT tapes, the situation could easily arise where two LANDSAT tapes will cost 10% of the faculty member's operating grant.

The suggestion is occasionally made that a remote sensing specialist be included as one of the NSERC committee members to cover our area of specialty. In practice, however, the number of university faculty specializing in remote sensing is small. It is estimated that of the approximately 300 applications reviewed each year by the ESGSC, only three applications (i.e. 1%) will be directly concerned with remote sensing. Similar or smaller numbers of applicants will be found in the other grant selection committees.

The members of a committee cover a wide range of expertise and, from experience of site visits by the ESGSC committee, will have among their number persons with a good appreciation of remote sensing. In addition, they have specialist external reviews available to them, often provided by government research scientists.

As pointed out by Barnes (1981, p. 21) "the main criterion for awards is the excellence of the individual as judged by his recent work, and the merit of his proposal". Thus, the "publish or perish" syndrome comes into force. One must publish, not just anywhere, but in the refereed journals (i.e. this report does not count!), and one must publish more than one's colleagues to receive more support from the limited funds available.

In this section, the emphasis has been on Operating Grants. NSERC does have other granting schemes, the most relevant of which is the Strategic Grant. Special support is given to studies on selected aspects of oceans, energy, environmental toxicology, food and communications. Further details are available in the NSERC Awards Booklet.

Questionnaire

Background Two years ago, a questionnaire was prepared by the CACRS Education Working Group and circulated through the university and college system. The purpose was to determine the state of remote sensing teaching and research in Canadian educational institutions. There have been delays in analyzing the results, but a report is currently being prepared and should be completed and updated this summer. It was felt useful to present some summary results to give an idea of what is happening across the country.

Problems In compiling and analyzing the results, several problems were encountered. The first was the problem of defining the operational boundaries of remote sensing, a task that may not in reality be possible. There are obviously close connections between remote sensing, aerial photo-interpretation and photogrammetry. Some workers consider all three areas of study to be linked under the umbrella of remote sensing; others consider them separate disciplines. Moving further from remote sensing, where do the boundaries occur with astronomy, cartography, computer science, electrical engineering, geophysics and physics, to mention but a few related fields? A second problem can be referred to as the "bandwagon syndrome" or, if in doubt, call it remote sensing so as not to miss out on any possible benefits. For example, many environmental scientists will use aerial photographs in their studies for basic location and to give more spatial detail and information than can be obtained from topographic maps. Simply because the researcher looks at or uses aerial photographs does not mean that he is undertaking a remote sensing study.

Results With some judicious editing of questionnaires to circumvent the problems referred to above, the following initial results can be presented. In all cases, the educational institutions have been placed in five locational groups.

Table 1 shows the number of educational institutions with interests in remote sensing. No reply indicates that an institution is known to have some interest in remote sensing but did not respond to the questionnaire.

Table 2 shows the number of university departments offering courses in remote sensing. As can be seen, 31 university departments were offering introductory and/or advanced undergraduate courses, with only 20 departments offering graduate courses.

Table 3 shows the number of theses produced or in progress since 1974. Although the numbers are increasing, totals are smaller than one would anticipate and represent output from relatively few institutions.

TABLE 1: Number of Canadian Educational Institutions with Interests in Remote Sensing

Institution	British Columbia	Prairie Provinces	Ontario	Quebec	Atlantic Canada
Colleges					
- Number	2	4	3	1	1
- Departments	2	4	3	1	3
- No Reply	2	-	-	-	-
Universities					
- Number	1	6	9	6	3
- Departments	8	8	14	12	5
- No Reply	2	-	2	-	-

TABLE 2: Number of University Departments Offering Courses in Remote Sensing

Level	British Columbia	Prairie Provinces	Ontario	Quebec	Atlantic Canada*	Total
Undergraduate						
- Introductory	3	6	11	6	5	31
- Advanced	5	5	11	6	4	31
Graduate	3	2	7	5	3	20
Number of Universities	1	5	9	6	4	25

TABLE 3: Number of Theses Completed or in Progress Since 1974 (Based on 1980 Data)

Level	British Columbia	Prairie Provinces	Ontario	Quebec	Atlantic Canada*	Total
Remote Sensing Main Emphasis						
- Bachelor's	9	-	-	1	10	20
- Master's	11	4	30	14	3	62
- Ph.D.	4	1	3	4	1	13
Remote Sensing Used						
- Bachelor's	-	-	-	-	-	-
- Master's	2	-	8	20	1	31
- Ph.D.	2	-	3	7	-	12

* Includes Nova Scotia Land Survey Institute.

TABLE 4: Analysis of Canadian Remote Sensing Symposia Publications

	Symposium 4th	5th	6th
Number of papers	53	90	98
Number of foreign papers	10	24	21
Number of Canadian papers	43	66	77
Number with CCRS input	11	15	22
Percentage of CCRS papers	26%	23%	29%
Number with University/College input	18	17	15
Percentage of University papers	42%	27%	19%
Total number University Personnel (Faculty and Graduate Students)	23	33	29
Number of Educational Institutions	15	15	11

Symposia Contributions

Analysis of the questionnaire results provides an indication of how educational institutions have contributed to the National Remote Sensing Program in the recent past. It is difficult, however, to provide a comparative viewpoint with other sectors of the national program.

One forum where universities, government and industries come together, however, is at the Canadian Symposia on Remote Sensing. Given that research is an important element of university activities, it was felt that an analysis of university contributions to the Symposia would provide an objective assessment of the level of research activity in universities. Numbers and percentages of papers emanating from university sources were calculated for the Fourth, Fifth and Sixth Canadian Symposia on Remote Sensing held in May 1977, August 1978 and May 1980, respectively. The Third Symposium was not included as many of the papers were invited presentations. An air strike partially disrupted attendance at the Fifth Symposium so all papers accepted were included in the calculations. As a result, one or two errors in identifying affiliations as university or non-university may have occurred. Data for the Seventh Symposium were not available to the author.

The results of the compilation are shown in Table 4. The total number of Canadian papers increased over time. Using CCRS as a control group, it was found that the percentage of CCRS papers stayed fairly constant within the range of 23 - 29%. Submission of CCRS papers to the Fifth Symposium was down slightly, perhaps due to the problem of obtaining travel funds to visit Victoria.

The disturbing observation is that the total number of university and college papers to the Symposia declined over time and, as a percentage of the total number submitted, declined from 42% in 1977 to 19% in 1980. The total number of university personnel involved has remained fairly constant, the figure for the Fifth Symposium being inflated by a paper from one institution with six authors.

If one accepts that the number of Canadian contributions to the Canadian Symposia on Remote Sensing is an objective measure of the level of research activity in the country, then university activity remained static during the second half of the 1970s. This is not unexpected. As pointed out in a previous CACRS contribution (Howarth, 1979), remote sensing arrived a decade too late. The decline in financial support for universities in the 1970s has meant that faculty appointments in remote sensing have not been made and the establishment of viable remote sensing programs has not taken place. The outlook for the first half of the 1980s would suggest little change in this situation.

Highlights

In spite of some of the difficulties described above, progress has been made in the universities and colleges which will have a positive effect on the National Remote

Sensing Program. Some of the highlights can be identified as follows:

- using existing university faculty and facilities and aided by provincial funding, the University of British Columbia has established an interdisciplinary program in remote sensing involving eight university departments.
- in the Prairie Provinces, the University of Alberta has made a strong commitment to remote sensing by purchasing an image analysis system.
- the Ontario Centre for Remote Sensing is attempting to encourage remote sensing in universities by establishing a Committee on Advanced Remote Sensing Education and Research.
- in Quebec, strong remote sensing programs are being developed at Laval, McGill and Sherbrooke.
- in Atlantic Canada, the University of New Brunswick has purchased an image analysis system and the Nova Scotia Land Survey Institute is leading the way for Canadian colleges with a specialized remote sensing program.

Conclusions

On the basis of the above observations and analysis, the following conclusions may be drawn:

1. Underfunding of universities and colleges is likely to continue for at least the first half of this decade. As a result, there will be limited growth of remote sensing programs in Canadian educational institutions.
2. If the Canadian programs such as LANDSAT-D, TOPAS and RADARSAT develop as planned, the educational institutions will not be able to meet the demand for remote sensing specialists.

In other words, as far as remote sensing is concerned, we are not able to fully meet the challenges outlined by John Roberts and reported in the opening paragraph of this paper.

Recommendations

From this report, there are quite a number of recommendations that could be made. As requested, the number has been limited to three. These are all recommendations that can be acted upon by CACRS and CCRS:

1. Given the comparatively small amount of research funds available to universities through federal granting agencies, the anticipated increases in data costs will have a considerable impact on university research. It is recommended that CCRS and the Working Group on Education determine methods to minimize the cost increases for bona fide research projects.
2. Given that university and college instructors are actively involved with teaching on a long-term basis, CCRS should involve educational institutions in workshops and technology transfer activities as much as possible.
3. Given that education is a provincial responsibility, it is recommended that CACRS require IPTASC members to actively explore with educational institutions ways in which they can aid remote sensing teaching and research in their provinces.

Acknowledgements

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9.0 UPDATE TO THE REPORT ON THE ACTION TAKEN BY CCRS AS A RESULT OF THE 1980 CACRS RECOMMENDATIONS

In the 1980 Annual Report, all the recommendations made were compiled in Section 3, and comments by the CACRS Executive and by CCRS followed each recommendation. Most of the comments made at that time are still valid, but the following additional comments are published now, based on new facts and actions. The numbers below cross-reference to the 1980 CACRS Report.

3.3 Both Dr. Robert O'Neil, Head, Sensor Section, CCRS, and Dr. Keith Raney, Head, Microwave Studies Section, CCRS, are members of the Working Group on Oceans. Since Dr. Raney is presently seconded to the RADARSAT Project, it is hoped that this meets the intent of the recommendation.

9.1 The CCRS Technology Transfer Office has worked closely with the Maritime Remote Sensing Committee in discussing technology transfer possibilities in the Maritimes Region, and a formal agreement on technology transfer is now on the point of being signed.

9.5 The members of IPTASC have been involved at various stages in the Technology Transfer Program, and were in fact invited to decide the priority between the two provinces/regions which were contending for the first stage of the TTP. On the advice of IPTASC, negotiations were successfully made to begin trial projects in both provinces/regions (Manitoba and the Maritimes).

9.6 Though this recommendation was specifically concerned with the transportability of software among image analysis systems, CCRS wishes to point out that the establishment of a new Working Group for users of image analysis systems should provide a means for users to meet and discuss problems and solutions they have encountered.

9.7 As mentioned in 9.1 above, a pilot project for Technology Transfer in the Maritimes Region has now been agreed on. It is hoped that Newfoundland, in its capacity as an observer on the Maritime Remote Sensing Committee, will be involved in this program.

10.2 At present, CCRS continues to receive NOAA imagery at Prince Albert and Shoe Cove, and this will continue for the rest of 1982-83. Moreover, by the end of June 1982, NOAA imagery will be acquired and archived in Prince Albert in LGSOWG format and CCT's may be ordered in this new format. Imagery continues to be received at Shoe Cove in JSC format. The overall question of reception of NOAA data beyond March 1983 is under active discussion between CCRS and AES.

11.7 After much discussion, it was decided that the information which would have become available through a special CACRS questionnaire will become available during 1982 as a result of studies being carried on both in support of the RADARSAT program and in connection with the cost-benefit analysis of the current status of the Canadian remote sensing program. The directory proposed in this recommendation can then be prepared from the acquired data.

11.8 The originator of this recommendation has been informed that steps have been taken to meet the general aim of his recommendation, in the formation of the CACRS Executive and the creation of the Technology Transfer Program.

12.2 CCRS has corresponded with NSERC about the amount of grant money being made available for research into remote sensing applications. The reply from NSERC listed several significant project grants in this area and also indicated that a good deal of support is additionally included in project grants which may not be specifically identified as affecting remote sensing. It appears that NSERC made between \$400K - \$700K worth of grants for remote sensing applications research in 1981-82, which certainly approximates the 5% figure mentioned in this recommendation.

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11.0 TABLE OF ACRONYMS USED IN THIS REPORT

ADAS	Airborne Data Acquisition System (CCRS)
AES	Atmospheric Environment Service, DOE
AGL	Above ground level
AIAC	Air Industries Association of Canada
AMI	Active Microwave Instrument (a sensor to be flown on ERS-1)
ANIK	DOC communications satellites
ARIES	Interactive remote sensing interpretation system (first installed in CFS, and now in the Alberta Remote Sensing Centre)
ART	Airborne Radiation Thermometry
ASVT	Application System Verification Test (a NASA Program)
(A)VHRR	(Airborne) Very High Resolution Radiometer (AES instrument)
BIO	Bedford Institute of Oceanography DFO
CACRS	The Canadian Advisory Committee on Remote Sensing
CAUT	Canadian Association of University Teachers
CCIW	Canada Centre for Inland Waters, DFO
CCRS	Canada Centre for Remote Sensing
CCT	Computer-Compatible Tape
CFS	Canadian Forestry Service, DOE
CIAS	CCRS Image Analysis System
CIDA	Canadian International Development Agency
CIR	Colour Image Recorder (a CCRS instrument) Also Colour Infrared
COARSER	Committee on Advanced Remote Sensing Education and Research (an Ontario community representing 12 universities)
COSPAR	Committee on Space Research (International)
CZCS	Coastal Zone Colour Scanner, a sensor on NIMBUS-6
DCP	Data Collection Platform
DFO	Department of Fisheries and Oceans
DICS	Digital Image Correction System (CCRS)
DOE	Department of the Environment
DREO	Defence Research Establishment Organization, DND
DFVLR	Deutsche Forschungs-und Versuch-sanstalt Fur Luft-und Raumfahrt (the West German Space Research Agency)
EB(I)R	Electron beam (image) recorder
EDIS	NOAA'S data distribution system
EMR	Department of Energy, Mines and Resources
ERIM	Environmental Research Institute of Michigan
ERS	European Remote Sensing Satellite Program
ESA	European Space Agency
ESGSC	Earth Sciences Grant Selection Committee (an NSERC committee)
FLI	Fluorescence Line Imager (a DFO instrument)
GEOS	Geodetic Satellite (NASA)
GOES	Geostationary Operational Environmental Satellites (2/5) SMS - Synchronous Meteorological Satellite
GSC	Geological Survey of Canada, EMR
GWG	CACRS Working Group on Geoscience
HCMM	Heat Capacity Mapping Mission (a US satellite)
HDDT	High density digital tape

IACRS	Inter-Agency Committee on Remote Sensing, an executive-level committee representing many federal departments
IASSWG	Image Analysis System Sub-working Group, a sub-group of the Working Group on Data Handling and Satellite Technology
IOS	Institute of Ocean Sciences, Victoria, (DFO)
IPTASC	Interprovincial Territorial Advisory Subcommittee (of CACRS)
LANDSAT	US Remote Sensing Satellite series (Formerly ERTS)
LDIAS	LANDSAT-D Image Analysis System, CCRS
LGSOWG	LANDSAT Ground Station Operators' Working Group, an association of countries which operate LANDSAT receiving stations.
MAID	Maid-housekeeping data acquisition system (a CCRS airborne system)
MDA	Macdonald, Dettwiler and Associates Ltd., Vancouver
MIPS	Multi-Image Processing System (a CCRS system installed at Prince Albert)
MOSAICS	Multi-Observation Satellite Image Correction System (CCRS)
MPPH	Miller Pieau Photometer (a CCRS Airborne Sensor)
MRMS	Maritime Resource Management Service
MRSC	Manitoba Remote Sensing Centre
MSS	Multispectral Scanner
NAPL(RC)	National Air Photo Library (Reproduction Centre), EMR
NASA	National Aeronautics and Space Administration (US)
NFB	National Film Board
NHRI	National Hydrographic Research Institute, DOE
NIMBUS	Weather and Earth Atmosphere Satellites (US)
NOAA	National Oceanographic and Atmospheric Administration (US). Also a series of environmental satellites operated for that Administration.
NOSS	National Oceanic Satellite System (a joint program of NASA and NOAA)
NSERC	Natural Sciences and Engineering Research Council
NSLSI	Nova Scotia Land Survey Institute
NWRI	National Water Research Institute (DOE)
OCRS	Ontario Centre for Remote Sensing
OMA	Optical Multi-Channel Analyzer (a CCRS airborne sensor)
PASS	Prince Albert Satellite Station, CCRS
PFRC	Pacific Forest Research Centre, DOE
PNFI	Petawawa National Forestry Institute, DOE
RADARSAT	Canadian radar satellite program
RBV	Return Beam Vidicon, a camera system on LANDSAT
RESORS	Remote Sensing On-Line Retrieval System, a document retrieval system at CCRS.
SAR	Synthetic Aperture Radar
SEASAT	Ocean parameter observing satellite (USA) (1978)
SLAR	Side-Looking Airborne Radar
SMMR	Scanning Multifrequency Microwave Radiometer
SPOT	Satellite pour l'observation de la terre (a satellite proposed for launch in 1985 by CNES, France)
SURSAT	Surveillance Satellite Program (Canada)
TM	Thematic mapper, a sensor to be carried on LANDSAT-D
TOPAS	Terra Observation Pattern Analysis System (next generation CCRS analysis system)

TTO	Technology Transfer Office
USDA	United States Department of Agriculture
UTM	Universal Transverse Mercator System
VIR	Visible-Infrared
WRS	World Reference System

WALTZING MAT-RADAR

(written late one night during the meeting)

Once a Director General said to his underlings,
"I have a way to achieve lasting fame;
It may break the bank or rupture the economy,
But let's put a radar in space just the same."

"Sensing remotely, sensing remotely,
You'll come a-sensing remotely with me,"
And he sang as he sat and argued with the Cabinet,
"You'll come a-launching a satellite with me."

Questions remain in this project so magnificent;
Who will the Deity or Great God be?
Will the image processor be anywhere near good enough?
Can we transfer Joe and keep the technology?

Sensing remotely, sensing remotely,
Who'll come a-sensing remotely with us?
Will our eye in the sky be an all-Canadian RADARSAT,
Or must we mount our sensors on a multi-nation bus?

Many of the users, especially in the provinces,
Want CCT's from LANDSAT-1, -2, and -3;
Waiting for images they ordered several years ago,
Plaintively echo this question and plea:

"Why launch a radar, who wants a radar?
We'd rather have a scanner in the visible/IR,
For you can't see the colour of the wheat fields
with a microwave,
You'll cook all the salmon in the sea with a SAR."

How can Lee justify spending half a billion?
This bionic man and his old banjo,
If the price of gas is high, all the money goes to Calgary,
And who needs the Arctic if the price of gas is low?

Sensing remotely, sensing remotely,
Sense all the ice in the Great White North;
RADARSAT gets three tries to do it economically,
We'll launch Ed Shaw into space on the fourth!

Sensing remotely, sensing remotely,
Watch Ed Shaw as he a-sensing goes.
We'll map all the world in the microwave and optical,
You may like the data, but you'll pay through the nose.

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