THE CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

1975 REPORT

Dr. J. D. Keys
Chairman
Interagency Committee on Remote Sensing
Ottawa, Ontario

Dear Dr. Keys:

The fifth meeting of the Canadian Advisory Committee on Remote Sensing took place in an atmosphere of change and financial restraints which engendered pessimism amongst some but which for others provided stimulus and opportunity for innovation.

There is a general feeling amongst remote sensing specialists that the users are not exploiting the new technology fast enough, and at the same time there is a feeling amongst users that they are being asked to adapt to new technology before they have learned the old.

In particular the microwave technology, as exemplified by the SEASAT(A) satellite, was unfolded. Hopes and schemes were presented for bringing airborne synthetic aperture radar to Canada.

It has been necessary to put the Sensor Working Group in moth balls for a year because of cutbacks coupled with new responsibilities for CCRS and no new money.

Two perennial problems predictably reared their heads: what to do about post-secondary and post-graduate education in remote sensing in Canada, and how to find more money for users to fund applications. A committee was set up under Mr. Slaney of the Geological Survey of Canada to address the first, and again the ball was thrown to the users on the second. If remote sensing is important to the users, they should be willing to invest money in it. Nevertheless, there were a few outstanding examples of user effort and investment such as forest fire research, topographical mapping, ice reconnaissance, and thermal mapping of urban areas for heat loss.

A slight change in the CACRS structure was recommended - that the Oceanography, Atmospheric Sciences, and Ice Working Groups be joined into one group for ocean management purposes. The three groups will continue to meet separately for their separate scientific purposes.

As far as CCRS itself is concerned, there are three main thrusts to pursue. These are:

1. To continue to provide and improve remote sensing services in the visible and infra-red areas, as exemplified by the LANDSAT series and the thermal and multispectral methods in the airborne program.

2. To push towards the development of operational cost-effective management and information systems related to (1).

3. To make a new effort in promoting the development of microwave sensors and systems in Canada.

Yours sincerely,

L. W. Morley

L. W. Morley
Chairman
Canadian Advisory Committee
on Remote Sensing

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1.0 THE CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

1.1 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.

1.2 Terms of Reference

The purpose of the Canadian Advisory Committee on Remote Sensing is advising and assisting the Government of Canada, through the Minister of Energy, Mines and Resources, in meeting the objectives of the national program on remote sensing of the surface environment by assessing national needs, promoting research and development, by diffusing remote-sensing technology into Canada, and by assisting in the coordination and evaluation of programs to assure a high level of national benefits relative to the cost of remote sensing.

Its advisory duties shall include:

- coordination of existing and proposed new programs and recommending priorities
- advising on remote-sensing platforms:
  satellite systems
  aircraft systems
  balloon systems
- sensor development
- data processing
- cataloguing, reproduction and marketing of data
- regional involvement
- research grants and contracts

It will assist:

- by generating requests for airborne remote-sensing surveys
- by carrying out on-going evaluation of existing projects
- by organizing conferences, seminars and training courses for the diffusion of remote-sensing technology into Canada.

The Committee will establish such working groups as it may deem necessary to carry out this work.

2.0 Summary Minutes: Canadian Advisory Committee on Remote Sensing, Arnprior, Ontario March 29 - April 1, 1976

2.1 Introductory Session

Dr. L.W. Morley welcomed participants to the annual CACRS meeting, including a representative from the Netherlands. He reviewed the objectives of the CACRS working groups and noted the progress that had been made towards quasi-operational systems. He suggested possible changes that might be made in the organization of the working groups and pointed out that time was allotted later in the week for detailed discussion of such changes.

Mr. Jean-Claude Henein gave the CCRS status report, summarizing the reports of the three divisions (4.2, 4.3, and 4.4).

2.2. Presentation by the Representative from the Netherlands (see 8.1)

Mr. R.H.J. Morra, of the Rijkswaterstaat, Ministry of Transport and Water Control, gave a presentation on the status of remote sensing activities in the Netherlands.

2.3 Reports by the Provinces (see 6.0 - 6.10)

Reports were presented by a representative of each province with the exception of British Columbia, which had declined to submit a report for 1975. Only short 5-minute presentations were made, as the reports had been previously circulated. There was therefore some time available for questions on specific aspects of the reports.

2.4 Reports by the Specialty Groups (see 7.0 - 7.8)

Reports were presented by the chairmen of each of the specialty groups. As with the provinces, the reports had been previously circulated and so very brief presentations were made.

2.5 Report on the Transfer to Industry Plan

Mr. Ralph C. Baker, Chief, Data Acquisition Division, CCRS, informed the meeting about the progress that was being made on the implementation of the transfer of the airborne operations program from the Canadian Forces Airborne Sensing Unit to Innotech-Intera. Mr. Victor R. Bennett, President, Innotech Aviation Ltd., and Mr. Brian Bullock, President, Intera Environmental Consultants Ltd., were also present for the discussion which followed.

2.6 Options for a National Remote Sensing Association

A plenary discussion was held on possible options for a national remote sensing association. Points of view were presented by Mr. E. Scullion, President, Ontario Association for Remote Sensing; M. Guy Rochon, Vice-President, L'Association québécoise de télédétection; Mr. Cal D Bricker, representing the Remote Sensing Committee of the Canadian Institute of Surveying; and Professor Donald J. Clough, Vice-President, Canadian Remote Sensing Society. Considerable discussion ensued but no concensus was reached.

2.7 Future Technology

A discussion on future technology was led by Dr. Ed Shaw, Chief, Data Processing Division, CCRS, who presented recent news from NASA on future satellites and sensors, both optical and microwave. Mr. Ralph C. Baker spoke about the options offered by the Space Shuttle program.

2.8 Management Information Systems (see 8.2)

Presentations were made to the meeting on two complex systems. Mr. Arthur Bickerstaff, Director (retired), Forest Management Institute, Environment Canada, spoke on the existing forest management information system in Canada and its needs for the future. His paper appears as section 8.2. Dr. Roger A. Stacey, Ocean and Aquatic Sciences, Environment Canada, spoke on Canada's ocean management information systems, and described the work that is presently going on to re-think these systems.

2.9 Study Groups (see 3.4 - 3.5)

The meeting then broke into four study groups which each had as its task to discuss the redirection of the working groups in light of the foregoing presentations and discussions. The Conclusions of the study groups are presented in detail in section 3.5 and in concensus form in section 3.4. The conclusions of the study groups were presented to the plenary session the following morning by the study group chairmen.

2.10 Recommendations (see 3.0 - 3.5)

Based on the study group discussions, the meeting then moved on to detailed consideration of the recommendations made by the working groups, specialty groups, and provinces. As there was not enough time to finish this detailed discussion, the meeting delegated responsibility to a smaller group chaired by Dr. Morley to conclude the consideration of the recommendations at a later date. The recommendations appear in sections 3.0 to 3.3.

2.11 Closing Remarks

Dr. Morley closed the meeting, remarking on the amount that had been accomplished in three days, and looking forward to a successful year ahead.

3.0 RECOMMENDATIONS OF CACRS, 1975

3.1. Introduction

3.1.1. Reports from the provinces, the working groups, and the specialty groups were prepared in advance of the CACRS meetings and circulated to all members. The recommendations made in each of these reports were consolidated before the meeting by an ad-hoc group consisting of Dr. Ira C. Brown, Chairman, Working Group on Hydrology, Mr. Burtt Smith, Representative of the Province of New Brunswick, and Dr. Jaan Kruus, DOE Co-ordinator on Remote Sensing, with secretariat support from CCRS. The recommendations outlined in sections 3.2 and 3.3 are therefore a consolidated listing and do not correspond on one-to-one basis with the individual recommendations made in each group's report to CACRS (section 5 to 7).

3.1.2. The consolidated recommendations, having been circulated to the members of CACRS before the meeting, were discussed at CACRS in some detail until time ran out. The meeting then delegated to a smaller group the final responsibility of discussing the remaining recommendations. This group consisted of the chairman of the four CACRS study groups, Dr. J.R. Gower, Dr. P.A. Lapp, Mr. G. Morrissey, and Dr. A.F. Gregory, along with Dr. L.W. Morley. This group met at CCRS in June 1976 and prepared comments on these remaining recommendations (section 3.3).

3.1.3. The recommendations made by the four study groups to the final plenary session of CACRS are listed in section 3.4 as consolidated by Dr. J.R. Gower. The individual study group reports are found in section 3.5.

3.2 RECOMMENDATIONS DISCUSSED AND ACCEPTED AT ARNPRIOR

3.2.1 Future Program Planning and Development

3.2.1.1 Specific studies should be arranged to investigate the possibilites for bilateral programs between Canada and other nations for the development of components of remote sensing satellites, including the impact of the Space Shuttle as the future launch vehicle for remote sensing satellites. (Data Handling)

3.2.1.2 IACRS and CACRS should give priority to increased support for and emphasis on the development of practical applications of remote sensing. This could be done through demonstration projects leading to the development of operational programs such as:

a) implementation to a routine production stage of techniques and facilities for digital processing at CCRS;
b) promoting the use of computer-compatible tapes as the most effective means of analysing copious streams of information;
c) biophysical mapping from LANDSAT data for the Arctic;
d) extension of the Arctic ice reconnaissance season;
e) development of practical non-visual geological applications;
f) the 4 WMO projects now underway in Canada i.e. St. John River (AES), Columbia Basin,(BC Hydro and IWD), Souris River (AES), and Lake of the Woods (IWD).
(Geoscience, Geography, Ice Reconnaissance, Hydrology, Limnology)

3.2.1.3 IACRS should encourage the independent development of remote sensing expertise at specialty centres and support the obtaining of the necessary facilities. (CCIW)

3.2.2. The Airborne Program

3.2.2.1 In the terms of reference of the airborne transfer plan, provision should be made

a) to meet requirements for narrow time frames which frequently vary depending on weather and growing conditions;
b) to provide for close communication between air crew and the ground observers, using portable radio equipment;
c) to establish aircraft changes, in both line-mile and flying-hour terms, as long in advance as possible, and to publish them before the beginning of the new fiscal year, in order to facilitate program planning by users;
d) to enable the negotiation of longer-term R & D projects between CCRS and users;

(Agriculture, Oceanography, Geography)

e) to ensure no direct competition between government-owned aircraft and those in the private sector.

(CAAS)

3.2.2.2. The report to CACRS from the Data Acquisition Division should contain a consolidated listing of all projects.

(Geography)

3.2.2.3. The scatterometer and a SLAR should be installed on board the Convair 580 and CCRS should review the potential of LANDSAT - SLAR composite images.

(Ice Reconnaissance)

3.2.2.4 CCRS should be urged to acquire the capability of obtaining remotely-sensed data at altitudes not less than 20,000m./70,000 feet.

(Ontario, Agriculture, Forestry & Wildlife)

3.2.3 Sensors and Systems

3.2.3.1 CCRS should continue to provide support for a vigorous microwave program for all-weather remoe sensing as an essential prerequisite for the future Canadian airborne and satellite remote sensing systems. A step in this process might be that IACRS seek to make available SLAR capability in Canada.

(Data Handling, Ice Reconnaissance)

3.2.3.2 CCRS should examine the possibility of on-line digital data distribution systems and interchange of data with automated systems such as CGIS (Canadian Geographic Information System)

(Limnology, Forestry and Wildlife)

3.2.4 Quality of Imagery

3.2.4.1 Data from ADAS, including flight parameters, should be made available to investigators on a timely basis.

(Oceanography)

3.2.5 Training

3.2.5.1 CCRS should be receptive to requests from universities for help in various areas such as:

a) allowing scientists to serve on graduate student supervisory committees;

(University of Guelph)

b) consulting regarding teaching and methodologies of applications;

(University of Waterloo)

c) sponsoring research and development activities at universities;

(University of Toronto)

d) assisting universities in obtaining equipment.

(Lakehead University)

3.2.5.2 CACRS should establish an ad hoc interdisciplinary committee to investigate the need for a Canadian training centre or courses for the analysis of remotely-sensed data, versus the presently available training facilities. The committee would investigate the level of demand for such a centre and present the results of its work, including recommendations for implementation, to a future meeting of CACRS.

(Geoscience, Geography, provinces)

NOTE: This proposal was accepted in principle. Mr. R. Slaney is to call an initial meeting of an interdisciplinary committee including:

L. Sayn-Wittgenstein (Forestry)
I. Brown (Hydrology)
A. Mack (Agriculture)
A. Gregory (Geoscience)
H. Audet (pro-tem representative of the province of Quebec on this Committee)
L.W. Morley

3.2.6. Information

3.2.6.1 The Chairman of CACRS should advise the working groups that principal investigators should be encouraged to utilize the scientific and technical expertise available both at CCRS and at NAPL-RC in project of mutual interest.

(Photo Reproduction)

3.2.7. Appreciations

3.2.7.1 CACRS recommend that its Chairman express appreciation to:

a) Laurie Philpotts for his past service as secretary of the Agriculture W.G. and contributor to remote sensing in Canada;
b) The Research Branch, Canada Agriculture, Kamloops, for hosting the Agriculture W.G. in Kamloops, September 18, 19, 1975.

(Agriculture)

3.2.7.2. Barringer Research Ltd., CRESS (York University), and Remote Sensing Section, MTC, all commend the CCRS on its liaison and co-ordination efforts.

(Ontario)

3.2.8 Recommendations which do not require CACRS Action

3.2.8.1 CCRS should request AES to set up a specialty centre to report on AES activities.

(Atmospheric Sciences)

- This has been done.

3.2.8.2 AES should inform the Oceanography Working Group of any processing of VHRR data.

(Oceanography)

- This level of communication can be established directly without going through CACRS.

3.2.8.3 IACRS, CACRS, and CCRS should provide direction for the activities of working groups in the coming year.

(Geography)

- This will be done at CACRS

3.2.8.4 The Agriculture Working Group should set up a sub-group on the applications of remote sensing to rangeland studies.

(Agriculture)

- This is within the jurisdiction of the Working Group and does not require CACRS approval.

3.3 RECOMMENDATIONS DISCUSSED SUBSEQUENT TO ARNPRIOR (with comments from CCRS)

3.3.1 The Airborne Program

3.3.1.1 The Data Acquisition Division should institute procedures which would allow some acquisition of data over large project areas even when part of the area has unacceptable atmospheric conditions.

(Quebec)

CCRS comment: The user should specify in his project request how much cloud cover is acceptable.

3.3.1.2 Every effort should be made to utilize the extensive marketing and operational capabilities of Canada's aerial survey industry in achieving commercial benefit from the country's heavy expenditures in remote sensing research and development.

(CAAS)

CCRS Comment: The need for extensive marketing in remote sensing has long been recognized. For this reason, industry has been involved in the airborne program through the Innotech/Intera/Lavalin consortium. Technical information is available to other aerial survey companies to use freely under their own initiative.

3.3.2 Sensors and Systems

3.3.2.1 CCRS should ensure the development of a low-cost ($50,000) image analysis terminal for analysis of digital remotely-sensed data in order to encourage wider use of digital products and techniques in the user community.

(Data Handling)

CCRS comment: CCRS will endeavour to implement this recommendation subject to the availability of funds. Dr. W.M. Strome may be contacted for further details.

3.3.3 Quality of Imagery

3.3.3.1 NAPL-RC and CCRS should ensure that a high level of quality control and repeatibility is maintained consistently in the production of photographic products.

(Geoscience, Agriculture, Geography, provinces)

CCRS comment: Dr. E. Shaw has held detailed discussions with ISIS on the problem of quality control. Both CCRS and NAPL are giving advice and assistance to ISIS. The quality control groups in CCRS and NAPL are endeavouring to assure high quality of colour products.

3.3.3.2 CCRS should provide up-to-date information on the status of the backlog, and a special note should be added to the image catalogue reminding users that b/w prints are autododged and that undodged products may be obtained by special order.

(Geoscience)

CCRS comment: CCRS agrees to include a note in the catalogue explaining the details of the autododging process used.

3.3.3.3 Guidelines should be established to provide uniformity for reporting accuracy of classifications from digital and photographic imagery.

(Agriculture, FMI)

CCRS comment: Dr. W.M. Strome will convene an ad-hoc working group for this purpose and will present a draft policy at the next CACRS meeting.

3.3.3.4 CCRS should pursue an option of obtaining high resolution microfiche for LANDSAT images from Prince Albert and Shoe Cove.

(Ice Reconnaissance)

CCRS comment: Although the microfiche product was intended as an index only, CCRS has suggested to ISIS the possibility of producing a high-resolution product.

3.3.3.5 Methods should be developed and implemented to correct for atmospheric effects on LANDSAT data.

(Forestry)

CCRS comment: CCRS has undertaken a project to develop methods for improving the atmospheric correction on LANDSAT data.

3.3.3.6 In order to be useful in many disciplines, spaceborne imagery should be geometrically corrected to provide data that is readily related to existing maps.

(Cartography, Geography)

CCRS comment: Bulk processing is being done to include system corrections up to precision of 10 km or better. Precision correction will be available on request by August 1977.

3.3.4 Information

3.3.4.1 CCRS should increase its efforts at marketing and acquainting the public with remote sensing capabilities by:

a) staffing a full-time marketing position;
b) developing a special LANDSAT index listing excellent images for each frame centre and season, taking into account all imagery available of Canada;
c) producing a Technical Guide to Remote Sensing in the Canadian context to provide potential users with a concise easy entry to the technical field of remote sensing. Such a guide would be aimed at an audience at the community college level and up and might contain
    - a glossary
    - a summary of the capabilities of various sensors used in aircraft or satellites
    - examples of successfully demonstrated applications
    - information sources for those wishing to go further
d) preparing a manual of methodology for digital data manipulation;
e) encouraging the establishment of regional order offices;
f) continuing to improve the content, timing, and distribution of the newsletter;
g) clarifying policy and priority for LANDSAT images of Newfoundland.

(Photo Reproduction, Geoscience, Hydrology, Geography, CAAS, Oceanography, Limnology)

CCRS comment:

a) Plans exist to create a full-time marketing and user services section.
b) The World Bank has produced such an index which CCRS will investigate and endeavour to extend to Canada.
c) CCRS supported the publication of Eye in the Sky by Dorothy Harper. Users are also referred to the ISP manual on remote sensing.
d) CCRS has undertaken to provide such a manual by mid-1977.
e) This is being done by establishing and providing technical assistance to Provincial Centres which act as regional order offices.
f) The newsletter is now published quarterly and CCRS is constantly trying to improve its quality. We would appreciate specific feedback from users and we welcome user contributions.
g) Newfoundland data is at present received via data tapes from NASA. When the Shoe Cove Satellite Station is opened in late 1976 this problem will be solved.

3.3.4.2 CACRS working groups should identify to the Sensor Working Group their requirements for new data products and information about their research into new applications for sensors.

(Sensor)

CCRS comment: The recommendation made by last year's CACRS meeting, that the Sensor Working Group should actively solicit inputs from the discipline working groups, should stand.

3.3.5 Organization

3.3.5.1 CACRS should form a new working group on the use of remote sensing CCT data, concerned with data formats and exchange of analysis techniques.

(Data Handling)

CCRS comment: The Working Group on Data Handling will establish a sub-working group on the use of CCT data.

3.3.5.2 CACRS should support Canada's working toward a clear policy on its international position regarding remote sensing projects and urges the establishment of a working group or committee that will ensure the coordination.

(Forestry)

CCRS comment: It is the policy of CCRS to spend approximately 3% of its available manpower on foreign aid and United Nations participation. CCRS is also planning to assign a full-time scientist to co-ordinate information and planning on remote sensing undertakings in the international field.

3.3.5.3 The Ice Reconnaissance and Glaciology working group should be renamed "The Working Group on Ice".

(Ice Reconnaissance)

CCRS comment: Agreed

3.4 CONCENSUS RECOMMENDATIONS FROM THE FOUR STUDY GROUPS

3.4.1 Working Group Organization

The discipline oriented working groups should be continued for the next year, but they should consider the points below and report on them at the next CACRS meeting.

a) Members should normally retire after the stated term.
b) Scientific or technical competence is the most important criterion, but regional representation is also important.
c) Any other points made by any special task force created to consider working group reorganization should be considered.

Problem oriented short term ad-hoc working groups were strongly approved as a method of approaching problems (e.g. one to consider education and training, others for management systems and one for organization of working groups).

New working groups should be formed; one for the "Physics of Remote Sensing", reflection spectroscopy and microwaves, and another for considering general problems of resource management. This point should be further considered by a suitable task force.

3.4.2. Future CACRS Meetings

Future CACRS meetings should be made more stimulating and productive. To this end a small program group should be formed now to plan next year's meeting, and should include a IACRS representative (since the body being advised should be represented). While this program group should have the last word, we strongly recommend:

a) that meetings be held in small specialized groups which then report to plenary sessions;
b) that reports and recommendations coming from discipline working groups go to these smaller groups which then report to a plenary session;
c) that the specialized groups that are to advise CCRS on priorities should be given details of future plans (CCRS to note this);
d) that the final outpout of CACRS should be recommendations to IACRS and to CCRS;
e) that we leave the location of the next meeting to this program group.

We recommend that the program group be composed of:

Dr. L.W. Morley,	CCRS
K. Greenaway,	IACRS
J. Kruus,	DOE
P. Lapp	P. Lapp Associates

Other smaller points of concensus exist in the four study groups reports, but time did not permit inclusion in the above summary. The four individual reports are appended in 3.5.

3.5 INDIVIDUAL STUDY GROUP REPORTS

3.5.1 STUDY GROUP NO. 1
Chairman: Dr. Philip A. Lapp

3.5.1.1 Discipline Working Groups

The views expressed about the discipline working groups were that:

a) there has been a significant loss of enthusiasm and lowering of morale among members of many of the groups;
b) there is a need for more action and activity in the groups in order that they be revitalized;
c) there appears to be some stagnation resulting from prolonged periods of membership in certain cases;
d) some groups were inhomogeneous in their makeup, representing a variety of interests and backgrounds, not necessarily scientific or technical in nature.

It was concluded that:

a) the discipline group structure should be preserved;
b) discipline groups should be peer groups within which there is scientific and technical respect among all members of the group;
c) members should be selected for their scientific and technical competence only;
d) the Chairman should be free to operate his group as he sees fit, reflecting his own style of leadership, and not having to conform to some perceived structure of action;
e) the chairman's tenure of office should be restricted to 3 years, renewable after review by the Chairman of CACRS;
f) the groups should promote the publication of scientific and technical papers in the appropriate discipline-oriented refereed journals as opposed to the establishment of a scientific journal dedicated to remote sensing. (Technological journals, such as the Journal of the Canadian Remote Sensing Society, are more oriented to engineering articles on remote sensing technology);
g) the groups should push for the international scientific recognition of remote sensing and should secure a strong Canadian position in an international federation of remote sensing under the umbrella of ICSU.

3.5.1.2. CACRS

CACRS represents the forum for the national program of remote sensing, embodying as it does all of the principal actors. CCRS is not its godfather, but is its host. Thus, while CACRS might be viewed as an advisory body, it also playsa role in defining the national program. The annual CACRS meeting then provides the forum for the exchange of information, both informally as a social function and formally through the annual working group reports.

3.5.1.3. Users

While the scientists and engineers within the discipline working groups are users in their own right, there are a wide variety of users that probably would be exluded on the basis of the suggested membership criterion. They include:

a) resource managers not possessing current scientific or technical backgrounds, and thus not potential peer group members;
b) traffic and operations managers in transportation;
c) environmental forecasters - weather, ice pollution, etc.;
d) those who develop or enforce regulations and codes;
e) those who formulate and advise on policy both in government and industry.

3.5.1.4. New Working Group

In view of the proposed membership structure of the discipline working groups, there is a need to focus user applications of remote sensing through a group of persons capable of trnslating remote sensing science and technology into the language and needs of the user. Users such as those listed above would not generally be attracted to CACRS unless they happened to possess the appropriate science or engineering background.

It is proposed that:

a) a "Resource Management and Applications Group" be established within CACRS (a more appropriate name should be assigned);
b) the group consist of persons capable of influencing applications of the science and technology of remote sensing for specific requirements of users;
c) membership be based on fields of application such as oceans, agriculture, land use planning, etc;

d) the group identify and promote remote sensing applications through whatever influence its members can exert on the control of available resources, and on the formulation of policies and regulations.

3.5.2. STUDY GROUP NO. 2
Chairman: Dr. J.R. Gower

3.5.2.1. Summary of Recommendation Highlights

a) Working group organization should remain approximately as at present.
b) Short term working group should be formed for recommending solutions to problems or setting up management systems.
c) Working groups and CCRS should stress education of potential users, the working groups by organizing workshops and symposia in conjunction with some regular meetings, CCRS by providing teaching aids.
d) A science steering group should be formed to consider general scientific developments.
e) CACRS meetings should be reorganized to allow more stimulating discussions, in some cases in smaller groups.
f) CACRS meetings should be held in conjunction with the Canadian Remote Sensing Symposia.

3.5.2.2. Organization of Working Groups

The study felt that regional working groups would not be practicable, since these would tend to split back into specialty groups. Occasional joint meetings between specialty working groups and the appropriate provincial groups in a given area could accomplish much the same thing by concentrating on the problems within that region. The group favoured the formation of problem-oriented working groups which would report within a given time frame and then dissolve. Present examples of this organization are the soil moisture subgroup of the Hydrology Working Group and the aerial hydrography subgroup of the Oceanography Working Group. In future, study groups could also work on the setting up of management systems in various fields. The problems to be considered by these ad-hoc groups would be suggested by existing working groups or by CCRS.

Some amalagamation does appear possible between working groups, such as:
a) combining Hydrology and Limmology;
b) combining Oceanography and Ice;
c) redistributing of Geography among other groups.

This would be subject to the agreement of the working groups concerned and could be organized fairly informally by their holding joint meetings.

The need for a science steering group was also agreed on, to consider general scientific developments (see below).

3.5.2.3. Purpose of the Working Groups

Dr. Morley stated that his basic interest was in the dissemination of information upwards and downwards. The official terms of reference of the working groups also include technology transfer, fostering experiments and research, and making recommendations to CACRS. Mr. Morra, of the Netherlands, stressed the importance of providing education in simple language to reach new users.

Dr. Morley said he had hoped that the working groups would perform cost-benefit studies and help set up management systems, but he had found that the scientists or the groups were mostly not interested in this and therefore such work had gone on under contract and in CCRS. In general what the working groups do is set by their present membership.

3.5.2.4. Membership of Working Groups

Discussion centered around whether the working groups should contain 'managers' or 'scientists'. The groups were originally set up with more managers, but there has since been some replacement by scientists. Dr. Morley stated that he had trouble in choosing managers in setting up the groups, though the Hydrology Working Group, where management systems are now in operation, has several mid-level managers.

In the scientifically technical field of remote sensing the predominance of scientists seems both inevitable and acceptable at least until management systems are operating in a field. It can also be noted in passing that in the Oceanography Working Group the CACRS chairman was initially a manager who later replaced himself by a scientist.

The study group noted, as above, that management systems could be set up by special short term study groups involving members from outside the present groups. It was also suggested that professional societies might like to be represented on some of the present working groups.

3.5.2.5. Organization of Working Group Meetings

Given that working groups tend to have a scientific membership, they can still educate and reach managers and new users by holding workshops and symposia in conjunction with some regular meetings. Although the value of mutual education was mentioned in early working group meetings, later meetings seemed to lose interest if they remained closed to outsiders.

CCRS should also assist in providing liaison and education by providing suitable teaching aids such as books, viewgraphs and slides.

Observers from other working groups can be invited to meetings (CCRS should provide an updated mailing list) and for more open meetings regional mailing lists such as that provided by the Alberta Remote Sensing Center would be very useful. Cal Bricker has offered to contact local remote sensing users if any suitable meetings are held in Alberta. Copies of the minutes of such meetings should then be sent to all attendees.

3.5.2.6. Reorganization of CACRS Meetings

It was generally felt that the present meeting definition lacked interest. Any interesting discussion on the brief reports on the second day was prevented by the postponement of discussion on the recommendations to the last day. This also removed much discussion from the remainder of the second and third days.

Splitting into smaller groups for different problems was generally recommended, though the talks by Baker, Henein and Shaw on future data handling and satellite systems could have led to interesting discussions especially if the report on future developments from the science steering group proposed above could have been included. In general it was felt that a more flexible agenda would be useful.

There was a strong feeling that CACRS should be held in conjunction with the Canadian Remote Sensing Symposia. These together would fit into one week and would ensure a mutual boost in attendance as well as making experts available for CACRS discussions. It does not appear that the cost to CCRS would be much greater, certainly when compared to past Montebello meetings, and cost to other attendees would be reduced. Written CACRS reports could still, if necessary, be annual, though there was some feeling that an annual CACRS meeting was too frequent.

3.5.3 STUDY GROUP NO. 3
Chairman: Mr. Graeme Morrissey

3.5.3.1. The study group began its deliberations by examing the role of CACRS and its effectiveness as an advisory body. The major roles were identified as providing constructive criticisms of CCRS programs, providing advice for program planning, and disseminating information. Other roles include the responsibility to help develop a National Remote Sensing Program and to organize workshops.

Two questions were asked as to the effectiveness of these roles: did these meet the requirements of CCRS, and did these roles include the major concerns of the Working Groups, Provincial Groups and Specialty Groups. In general, it was considered that these major concerns could be satisified with a CACRS which fulfilled these roles, since alternative information/control routes such as IACRS and other federal/provincial channels are also available to most of the CACRS groups. However, there appeared to be two special interest groups who may not have an adequate voice, the universities and industry, both as clients and as suppliers. Industry has other routes but these are, for the most part, limited to sales to CCRS, and there are no client associations of this type.

3.5.3.2. The study group then turned to the question of how well the present CACRS functioned and what changes appear to be needed. The present quiet CACRS year was considered adequate proof that changes were needed since no bureaucracy could operate that well. (Some members suggested that this was especially applicable at the federal level). After discussion, several recommendations on how the effectiveness of CACRS could be improved were developed:

a) special working groups are needed to examine the training question. It was realized that CCRS cannot carry out this training function but a working group could serve as a focus for this problem area;
b) a working group on the physics of remote sensing appears to be needed to advise all working groups in this area. This could probably be realized by elevating the sensor sub-group on Reflection Spectroscopy to working group status and broadening its terms of reference ;
c) all discipline working groups should be directed to carry out a critical

examination of their contribution to CACRS and identify changes needed in terms of reference, or possible mergers or splits that are required. This examination should be completed and reported to the other CACRS groups by fall so that each group can comment on any proposed changes;

d) the policy of rotating membership has not been adhered to in many cases and must now be enforced in the case of discipline working groups. New blood must be introduced at regular intervals;

e) the selection of Chairmen of CACRS discipline working groups should include more consideration of regional/provincial distribution. Almost all the present chairmen are from the National Capital Region or Toronto;

f) if CACRS is to advise on future CCRS programs, then it should have access to five year plans or similar documents. Without these, CACRS cannot provide advice and thus ensure that the needs of remote sensing interests in government, universities and industry, are satisfied as far as the budget will permit.

3.5.4. STUDY GROUP NO. 4
Chairman: Dr. Allan F. Gregory

3.5.4.1. Introduction

In discussing the possible redirection of working groups, the study group reviewed current terms of reference, considered four relevant questions, drew conclusions, suggested improvements, and made specific recommendations as summarized below:

3.5.4.2. Relevant Questions

3.5.4.2.1. Is there a problem with the present system of working groups?

Although there was a wide range of opinion, there was general concensus that the present system had problems. It was apparent that each working group had different problems as opinions varied from one working group with minor problems to one which considered the wole CACRS structure to be wrong. There was concensus on the following points:

a) the system of working groups is not as effective as it should be in transferring either technology or applications through the remote sensing community;

b) there is unnecessary duplication in reports by closely associated working groups and specialty groups;

c) the development of data processing techniques has proceeded in some cases without adequate direction from scientists in the relevant discipline;

d) there is a need to improve cross-fertilization between technologists and users.

Some members expressed dissatisfaction with the the apparent emphasis at CCRS on satellite sensing relative to airborne sensing, with the apparent emphasis by CACRS on technology relative to practical applications and with the lack of "seed money" for initiating development of applications.

3.5.4.2.2. What are the responsibilities of the working groups?

It was agreed that the prime responsibility of the working groups was to advise IACRS on the development of the national program of remote sensing. Other responsibilities are either impractical or beyond the capabilities of the working groups. Thus, dissemination of information to users is best achieved through existing professional associations, although there is a need to keep CACRS and IACRS up-to-date. In the absence of funding, implementation of projects can be achieved only indirectly through sympathetic agencies, and not all working groups receive such support. The assessment of airborne projects can not be achieved on a timely basis by the working groups. Cost benefit analyses are at present the responsibility of a specialized section at CCRS.

Some members suggested that the working groups should have a budget of "seed money" for development of applications and that the working groups should be consulted in planning the annual CACRS meeting.

3.5.4.2.3. Do the working groups meet their current responsibilities?

The study group concluded that the working groups do not all have the same responsibilities but that overall the system operates satisfactorily. However, it was also agreed that the current system of working groups and meetings could be improved with only relatively minor changes in the system.

3.5.4.2.4. How can the current system be improved?

The following ways of improving the system were suggested:

a) that reporting procedures at the annual meeting of CACRS be improved by consolidating similar reports and by revitalizing the deadly 5-minute report cycle;

b) that interchange be increased between users and their respective working groups;

c) that the mechanism be strengthened for exchange of ideas between users and both the sensor technologists and the methodologists;

d) that a strong development of the education/training function be fostered;

e) that ad hoc task forces be made use of to study specific problems in depth;

f) that the exchange of ideas be improved between disciplines, provincial groups and specialty centres;

g) that CACRS members be involved in planning and organizing the annual meeting;

h) that "seed money" be provided for funding applications research.

3.5.4.3. Specific Recommendations

Relative priorities are not implied in the specific numbering although recommendations early in the listing are considered to be more important than those later in the listing:

a) CACRS should establish two ad hoc task forces to advise and recommend as warranted on:
   i) a means of improving education and training for remote sensing;
   ii) a means to improve the interchange between users and both the sensor and data processing technologists;

   these task forces should be established during this meeting and should report back to CACRS on or before the next annual meeting;

b) at the discretion of the current chairmen, the working groups should remain as presently constituted;

c) The working groups should be encouraged to organize multi-disciplinary workshops that alternate in time and location with the Canadian Symposia on Remote Sensing;

d) The Sensor Working Group should give priority to consideration of user requirements for sensor development;

e) All working groups should consider opening up their working group meetings to provincial representatives and users from outside the working group membership. Expenses of such participants would not be recoverable from CCRS;

f) the Chairman of CACRS should request the assistance of CACRS members in planning and organizing the annual CACRS meeting.

   COROLLARY: CACRS members who do not respond to the Chairman's request should not complain about content or structure;

g) oral reports from specialty groups should be incorporated in reports from relevant working groups and the latter reports should emphasize practical applications;

h) the chairman and membership of all working groups should be rotated on a 3-year cycle with minimal re-appointment to second terms.

4.0 REPORTS OF THE CANADA CENTRE FOR REMOTE SENSING

4.1 Historical Highlights

1967

May 27: Meeting of representatives from Energy Mines and Resources, National Research Council, Forestry, Defence Research Board, Agriculture, to discuss Canadian participation in the EROS project. Tentative costs over a 3-year period were estimated at $765,000.

1968

May 23: Meeting of Interdepartmental Committee on Remote Sensing of Earth Resources from Aircraft and Satellites convened by Dr. L. W. Morley to discuss advantages of joint programs in remote sensing. Sixteen representatives from 8 government agencies attended.

Nov. 20: Meeting of Interdepartmental Committee on Remote Sensing chaired by Dr. L. W. Morley to initiate planning for a Canadian program of remote sensing.

1969

June 20: Liaison meeting to hear and discuss briefs from representatives of government, industry and universities concerned with organizing a Canadian program of remote sensing. Fourteen briefs were received, comprising 6 from federal-government agencies, 7 from industries and consultants and 1 from university.

July 22: Cabinet Committee on Scientifc and Industrial Research recommended that EMR should be the agency responsible for coordination and funding of "Resource Satellites - Canadian Research Program" and should establish an ad hoc interdepartmental committee to steer the program. The Program Planning Office was officially established with Dr. L. W. Morley as director.

Oct. 8: First meeting of "Interdepartmental Committee on Resource Satellites and Remote Airborne Sensing", chaired by ADM, Science and Technology, EMR.

Oct. 28: Second meeting of the Interdepartmental Committee, at which it endorsed a program of participation with the U.S.A. in the NASA Earth Resources Technology Satellite (ERTS) Program.

Nov. 24: Memorandum to Cabinet from EMR re "Proposed Projects for Resource Satellites and Remote Airborne Sensing for 1970-71", requesting that the Cabinet Committee on Science and Technology consider four urgent projects: (1) hyper-altitude aircraft experimental Earth sensor operation; (2) research and development on remote sensors; (3) study of incidence of cloud-free areas; and (4) study of data reproduction system for resource satellite data. Total funding: $550,000.

Nov. 28 Cabinet Committee on Science Policy and Technology agreed that $550,000 funding be made available, as per memorandum of November 24, 1969.

Dec. 24: Third meeting of Interdepartmental Committee approved appointments of chairmen for 7 ad hoc working groups: (1) Forestry; (2) Hydrology, Oceanography, Limnology, Fisheries and Meteorology; (3) Data Reproduction and Distribution; (4) International Cooperation; (5) Sensor and Data Systems; (6) Remote Airborne Sensing; and (7) Geology.

1970

Feb. 14 First Montebello meeting to form the working groups of the Program Planning Office.

March 5: Fourth meeting of Interdepartmental Committee set (1) the functions of a Program Planning Office (PPO) to serve as its secretariat; (2) terms of reference for user groups; and (3) the membership of 14 groups (extending the 7 groups of the December 24, 1969 meeting). These working groups are subcommittees of what is now called the Canadian Advisory Committee on Remote Sensing (CACRS).

April 18: Memorandum to Cabinet from EMR re: "Resource Satellites and Remote Sensing: Collaborative Programs with the United States", proposing a 3-year experimental program of remote sensing from aircraft and satellites related to the ERTS-A satellite, to be launched on March 22, 1972. A proposed memorandum of agreement between EMR and NASA was appended to the memorandum. The proposed program included (a) ground receiving station at Churchill, Manitoba; (b) continuation of experimental airborne remote sensing program; (c) continuation of sensor development; (d) facilities in Ottawa for computer-correcting, reproducing and distributing data; and (e) partial financing of regional interpretation centres. A 3-year forecast of expenditures was included.

May 1: Cabinet Committee on Science Policy and Technology gave approval for EMR to negotiate a memorandum of understanding between EMR and NASA, as requested in the April 18 memorandum.

1971

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

Feb. 1: Beginning of systems integration contract with Computing Devices of Canada to produce a data processing facility to process the data from the LANDSAT-1 satellite.

Feb. 11: Treasury Board's memorandum re: "Change in Organization" authorizing the establishment of the Remote Sensing Centre as a new organizational element of EMR, as proposed in the paper "Organization for a Program in Remote Sensing of the Surface Environment", by a task force organized by Dr. L.W. Morley, October 16, 1970. (The Centre was subsequently renamed Canada Centre for Remote Sensing, with Dr. Morley appointed as its founding director).

March 31: Submission of working group Reports: (1) Agriculture and Geography; (2) Atmospheric Constituents; (3) Cartography and Photogrammetry; (4) Forestry and Wildlife; (5) Geology; (6) Ice Reconnaissance and Glaciology; (7) Water Resources; (8) Satellite and Ground Station Engineering; and (10) Sensors.

April 1: Canada Centre for Remote Sensing officially established.

April 21: Memorandum to Cabinet from EMR re "Earth Resources Survey (ERS) Agreement" reviewing international policy aspects of the proposed agreement with the U.S. (April 18, 1970). Included were drafts of a proposed exchange of diplomatic notes, with annexed arrangements between EMR and NASA.

May 14: Agreement with NASA signed.

June 23: Memorandum to Cabinet from EMR re "A Program for Remote Sensing of Earth Resources and the Surface Environment", seeking approval for (a) an increase of capacity for the Air Photo Production Unit (APPU) and the National Air Photo Library (NAPL) of the Surveys and Mapping Branch of EMR, to handle the additional load of the remote sensing centre; (b) an airborne remote sensing program; (c) conceptual studies of an internationally shared resource satellite system and other remote sensing systems. The memorandum recommended a supplementary budget to cover item (a) and a "B" budget for FY 1972-73 to cover the other items as "an integrated remote sensing program" to be undertaken in 1972-73. It also recommended the replacement of the ad hoc Interdepartmental Committee by a senior interagency committee to be chaired by the ADM, Science and Technology, EMR. It also contained forecasts of expenditures for three alternative optional programs.

July 1: CFASU formed and became operational.

July 29: Record of Cabinet decision, approving (a) the supplementary budget to increase the capacity of the APPU/NAPL; (b) the FY 1972-73 "B" Budget for the integrated remote sensing program (including an expansion of the airborne sensing part of the program); (c) the new Interagency Committee on Remote Sensing (IACRS); and suggesting (d) shifting the temporary Prince Albert Receiving Station (PASS) from Prince Albert to Churchill. (Subsequently, it was decided not to move the Station to Churchill.)

Nov. 30: Purchase of Falcon Fanjet aircraft.

1972

Jan. 4: Meeting of the Interagency Committee on Remote Sensing (IACRS) at which terms of reference for the Canadian Advisory Committee on Remote Sensing (CACRS) were approved, and at which the first partial "cost recovery" or "shared funding" formula was approved (whereby CCRS may charge federal Government user agencies for airborne remote sensing).

Jan. 17: Submission of an "A" budget for FY 1973-74, establishing the CCRS "A" budget activity level at about $6.5 million, and 104 man years, a minimal datum for on-going activities.

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

March: "A" level budget of $5,431,000 and 60 man years approved by Treasury Board.

July 6: Treasury Board Memorandum (1961) entitled "The Canada Centre for Remote Sensing" submitted, providing 3 options.

The option approved included $5.431 million and 84 man years. This option, though workable, does not include grants for regional centres. It is technology frozen and does not attain the objectives outlined in the Cabinet memorandum of June, 1971.

July 23: LANDSAT-1 launched.

July 26: First imagery of Canada received.

July 27: First LANDSAT image presented to Honourable Robert Stanbury, Ministry of Communications, at the International Society of Photogrammetry conference held in Ottawa.

1973

January: Establishment of Applications Division of CCRS, and initiation of a concentrated program of applications research and development.

February: Establishment of remote sensing imagery Browse Facility at CCRS.

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

February 19-22: (Fourth Montebello) second CACRS meeting.

April: Manitoba Remote Sensing Centre established in Winnipeg.

Distribution and sale of LANDSAT Quicklook imagery of Canada undertaken by Donald Fisher and Associates[1], Prince Albert, Saskatchewan.

July: Ontario Assocation for Remote Sensing established.

First stage of cost recovery implemented for CCRS airborne remote sensing program.

September 18: Ontario Remote Sensing Centre established in Toronto.

November: Program Planning and Evaluation Unit established at CCRS.

Manitoba Remote Sensing Data Bank established in Winnipeg.

Experimental tracking and reception of NOAA satellite data.

1974

January: Proposals for private enterprise involvement in the CCRS airborne remote sensing programs requested from industry.

February: LANDSATFICHE subscription became available from Donald Fisher and Associates.

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

April 2-May 1: Second Canadian Symposium on Remote Sensing, Guelph, Ontario.

April: Image 100 interactive image analysis system delivered to CCRS.

NOAA data of Canada recorded at Prince Albert Satellite Station.

June: Convair 580 long-range turbo-propellor remote sensing aircraft acquired by CCRS.

June 6: Alberta Remote Sensing Center established in Edmonton.

Summer: Experimental transmission of NOAA and ERTS imagery data of Canada to the Arctic for use in navigation in ice-infested waters.

September: 1974-75 authorized budgetary level of $6,251,000 and 86 man -years.

October: CF-100 jet aircraft retired.

December: Contract to develop a satellite tracking station to be located in St. John. Nfld., awarded to MacDonald-Dettwiler and Associates, Vancouver.

December: Hardware system installed at CCRS for processing of airborne remote-sensing data.

1975

January 23: Launch of LANDSAT-2.

March 31-April 3: Fourth CACRS meeting, Arnprior, Ontario.

May 7: Contract signed with Innotech Aviation Ltd., and Intera Environmental Consultants Ltd. for the transition of the airborne production system from government to industry.

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

September: 1975-76 authorized budgetary level of $7,757,000 and 97 man years.

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1. The name of this company was changed to Integrated Satellite Information Services Ltd. in January, 1975.

4.2 REPORT OF THE DATA ACQUISITION DIVISION

4.2.1 Introduction

1975 has seen the transfer of aircraft services from CFASU to Innotech Aviation Ltd., of Montreal. Each of the aircraft had to be out-of-service for a period of time for conversion to civilian status with a consequent reduction in projects and line miles which could be flown this past season.

Long term capability continues to be developed; first, the Convair 580 modifications are in hand, second, a greater emphasis has been made in the development of new sensor capabilities, particularly in the laser area.

The budget still does not permit a strong move into a viable program to develop new sensing capabilities in a timely fashion. The principal work is in the laser area, thanks to DSS bridge funding. More effort and funds are still needed, in order to move effectively into the areas of:

- microwave sensors for all-weather ice, water and related studies,
- imaging multispectral systems to complement resource satellite data,
- completion of the development of a viable laser bathymeter and to explore systems for positive species identification.

The following sections cover the activities of the past year in detail.

4.2.2 Airborne Operations

4.2.2.1 Operations Summary 1 April 1975 to 30 November 1975

a) Aircraft Utilized:

1 Falcon, 2 DC 3's

b) Projects Tasked:

Falcon	57	
C-GRSB	47	
C-GRSA	13	117

c) Projects Flown:

Falcon	48	
C-GRSB	35	
C-GRSA	12	95

d) Projects Cancelled: 16

e) Total Line Miles to Date:

Falcon	10,891
C-GRSB	2,582
C-GRSA	2,664
	16,137

f) Line Miles by Agency to Date:

Federal

Agriculture Canada	1203
Atomic Energy of Canada	16
Canadian Penitentiary Service	4
DOE Bedford Institute of Oceanography	550
DOE Canada Centre for Inland Waters	557
DOE Canadian Forestry Service	0
DOE Canadian Wildlife Service	88
DOE Environmental Protection Service	0
DOE Fisheries and Marine	142
DOE Forest Management Institute	723
DOE Inland Waters Directorate	90
DOE Laurentian Forest Research Centre	152
DOE Pacific Forest Research Centre	86
Dept. of Indian and Northern Affairs	2227
DOE/CCRS Joint Project	912
EMR Canada Centre for Remote Sensing	1627
EMR Geological Survey of Canada	0
EMR Topographical Survey Directorate	181
Parks Canada	1149

Provincial

Alberta Department of the Environment	58
Alberta Institute of Pedology	42
Alberta Sensing Centre	318
BC Environment and Land Use Committee	168
BC Hydro & Power Authority	61
Edmonton Regional Planning Commission	200
James Bay Development Corporation	868
Manitoba Department of Agriculture	415
Manitoba Department of MREM	491
Manitoba Dept. of Municipal Affairs	0

Provincial (Cont'd)

NB Department of Agriculture	219
Ontario Bean Producers Marketing Board	0
Ontario Horticultural Research Inst.	124
Ontario Ministry of Natural Resources	41
Ontario Ministry of the Environment	31
Ontario Ministry of Transportation and Communication	678
Quebec Ministry of Lands and Forests	566
Saskatchewan Research Council	592
Waterloo, Regional Municipality of	0
Yukon Lands and Forests Service	298

Industry

Bechtel Canada Limited	18
Canatom Limited	6
Dilworth,Secord,Meagher & Assoc. Ltd.	37
F.D. Patton Consulting Engr. Geologist	160
H.W. Barnhart and Associates Ltd.	2
Hydrological Consultants Limited	96
McKinnon Photo Studios	0
P.A.R.D. Associates	4

University

BC Institute of Technology	30
BC University	126
British Columbia University	127
Guelph University	3
McGill University	0
McMaster University	0
Quebec University (Montreal)	622
Windsor University	25
York University	4

4.2.2.2 Operational Sensors

a) Vinten Cameras

No major unserviceabilities were encountered. An in-camera annotation system is under test and evaluation. The results are encouraging.

b) Metric Camera

Sufficient cameras and filters are now available and calibrated, to ensure compliance with user requests.

c) Scanners

A new signal processor was acquired and placed in full operation approx. 1 June 1975. The system provides high quality imagery on 5" film in continuous tone or level sliced form. Imagery is S-bend corrected. One alternate presentation is bi-format in which continuous tone and level sliced data from the same channel are displayed side by side, or a two channel simultaneous presentation is made.

d) PRT 5

The PRT 5's were recorded throughout all flights on the Mincom tape recorders and could be overlayed on scanner imagery through the original signal processor, and, since December 1975, on the new processor as well.

4.2.2.3 Aircraft

a) Falcon

The interior of the Falcon was completely reconfigured last winter, providing improved operator efficiency. An installation for the LTN-51 was completed and for flights requiring this navigation system the unit can be installed. Standard 19" racks were constructed and installed in the aircraft with all the operator positions in a fore and aft configuration. Each operator position was optimized for operator efficiency taking into account the functional role, and grouping the appropriate controls. The aircraft is being converted to civilian status and registration (C-GRSD) this winter.

b) DC3 (Dakota)

Both aircraft performed well during the season. They have been purchased from DND and converted to civilian status and registration (C-GRSA - Sensor Test; C-GRSB - Operations).

c) Convair 580

A contract was awarded to Innotech Aviation to modify this aircraft to a remote sensing role. They will carry out most of the modifications initially planned. Budget restrictions have resulted in a deletion of several sensor holes and some of the rack space. The present plan will provide for two 21" glass ports and two 30" open holes with pressure domes. An upward looking port for a skylight reference will be provided along with several small downward looking ports for instruments such as the PRT 5. The rack configuration will consist of eight single 19" racks. Work is also proceeding in parallel on the engine, propellor and airframe overhauls and certification. Delivery of the modified aircraft will be in the summer.

4.2.3 Development of New Sensing Capabilities

4.2.3.1 Airborne Bathymetry

Work done by Optec Inc., under contract financed by DSS bridge funding, has

4.2.3.1 Airborne Bathymetry (Cont'd)

resulted in the design of an airborne scanning lidar bathymeter. The system would be expected to have a performance figure of at least $\alpha d=6$ under daylight conditions. (The optical attenuation co-efficient, α, varies between 0.5 and 1 m^{-1} for the wavelength which would be used by such a system in typical coastal waters. The depth, d, is the ultimate depth to which the bathymeter can be expected to map). Thus, it is expected one could measure water depths up to around 12 meters under favourable conditions.

Several areas of technical risk have been identified by this contract and these will be investigated in the coming year.

The existing CCRS Laser Bathymeter (a profiling sensor) now outputs its data and a wide angle television picture of the ground onto video tape. Data continues to be gathered with this system in an effort to determine the best means of analysing and reducing bathymeter data. Certain improvements are to be made to the system to increase the maximum depth of penetration which is, at present, limited to approximately 6 meters.

4.2.3.2 Identification of Oil Spills, Chlorophyll and Water Pollution

a) Laser Based Techniques

A contract financed by DSS bridge funding has been let for the design and construction of an advanced remote sensing laser fluorosensor. This new sensor, like the UTIAS laser fluorosensor, will use a pulsed laser emitting light in the UV to excite fluorescence. Because the instrument will have sixteen spectral channels as well as two channels in which fluorescence lifetimes can be measured, it is hoped that it will be possible to identify and classify oil. Chlorophyll concentrations and water pollution should also be identified by their fluorescence characteristics. It has been designed as a profiling sensor capable of both day and night operations. Extensive flight testing over a large variety of targets will begin in the fall of 1976.

A second contract has been let to measure fluorescence emission spectra and fluorescence lifetimes in the laboratory. A set of standard oil samples as well as various substances occurring naturally in the water are being studied (in water) to determine the classification potential of the new fluorosensor. Pollutants and chlorophyll will also be studied.

Flights of the UTIAS laser fluorosensor over oil spills, pollutants and chlorophyll will continue at least until the new fluorosensor is delivered.

b) Spectroscopic Based Techniques

A calibrated four channel photometer has been added to the CCRS operational sensors. This sensor was developed by York University as a direct development from the earlier Sensor Working Group activities to determine a method for remote chlorophyll concentration measurement.

The sensor features spectral flexibility through interchangeable filters which can be as narrow as 10nm. Calibration for spectral reflectance is maintained by referencing a skylight source to the input optics for each channel via fibre optic coupling. The sensor is non-imaging, however the field of view is selectable from ten to one hundred milliradians. The data is output digitally from each channel every forty milliseconds, including complete sensor status parameters, and is recorded through ADAS.

A number of projects have been flown with the photometer, six over the Great Lakes and one over the Atlantic off Yarmouth to evaluate the data from a variety of water masses, including turbid regions, and different weather conditions. The method for calculating chlorophyll concentration involves ratioing the measured upwelled radiation in the blue and green channels. Specular reflection measured in the near infrared channel is subtracted from the other channels. Preliminary results indicate that the method is valid for routine chlorophyll measurements.

Additional applications may be found in agriculture and forestry where there is an increasing demand for a sensor having fine spectral resolution and spectral flexibility to identify crop type and vigor. A secondary application for the photometer is the ability to test, evaluate and calibrate the data from imaging spectrometers or multispectral scanners.

4.2.3.3 Mapping the Distribution and Thickness of Ice

Sea ice type identification from the air has been investigated with the CCRS 13.3 GHz dual polarized scatterometer.

The scatterometer system has been improved by the addition of a "combiner" developed at the Communications Research Centre. The combiner is an analog device which removes, 4.2.3.3 Mapping the Distribution (Cont'd)

in real time, the fore-aft ambiguity which could otherwise exist in the power spectrum of the output of the scatterometer. The two combiner output signals, corresponding to the like and cross polarized components of the backscattered radiation, can be recorded and processed subsequent to the flight either by analog or digital techniques. Although the digital data processing which has been developed gives detailed results for a succession of relatively small ground elements, it is inefficient and at present requires a computer processing time twenty to sixty times slower than real time. Various ways of presenting the digital data have been developed. Analog processing represents a faster but less detailed alternative for longer flight lines. Consideration is being given both to ways of improving the data processing and ways in which the absolute accuracy of the results can be improved. At present the absolute accuracy of the results is limited by the lack of precise knowledge of the antenna patterns when the system is mounted on the DC-3 aircraft.

The scatterometer system has been used successfully in a number of missions. As well as the Aidjex project (reported separately under paragraph 4.2.4.2) data has been collected during flights over the Northumberland Straights in winter, over Lake Ontario and over known agricultural terrain in the Ottawa area. Already the sensor has shown an extremely promising ability to differentiate between different sea-ice types. Further work will be carried out this winter off the east coast to gather data from a variety of ice conditions and sea states.

4.2.3.4 Navigation Capabilities

In addition to the unique ADAS recorded Inertial Navigation Systems, both Doppler and Global VLF navigation systems were interfaced to ADAS, installed and tested in the experimental DC-3, C-GRSA. These systems not only give improved navigation and track recovery capabilities (when used together with Kalman filtering techniques) but greatly ease the navigation problems in the Arctic and over the ocean where the Convair will operate much of the time.

4.2.4 Major Projects

4.2.4.1 Aerial Hydrography Project

Further test flights were flown over the Sudbury test range and the data has been analysed. The position accuracies attained are sufficient for Aerial Hydrography, however, at the present time the accuracy of the attitude outputs is not acceptable. Further processing techniques (filtering, etc.) are being developed and it is hoped that the required improvements in accuracy will be obtained.

During the Sudbury flights, data was gathered for a preliminary study by MOT in the development of their airport navigation aids checkout system.

4.2.4.2 Arctic Sea-Ice Project

The experimental DC-3,C-GRSA, flew a remote sensing ice reconnaissance mission in the Arctic during the time period April 10th - April 20th, 1975. This project was in support of the AIDJEX experiment, the Beaufort Sea program and the CCRS evaluation of the scatterometer as a remote sensing tool for the study of Arctic Sea ice. Flight lines were flown at the site of the AIDJEX ice camp 300 miles NE of Point Barrow Alaska and along a series of lines in the Mackenzie Bay area. Ground truth was obtained by personnel at the AIDJEX camp and by Imperial Oil for selected lines in the off-shore Beaufort Sea program. The sensor complement included the 13.3 GHz dual polarized scatterometer, an Aerojet 37 GHz microwave radiometer (loaned by DOE), an RC-10 surveying camera, a Daedalus infra-red line scanner, and the LTN-51 Navigation System. All the data, (excepting photographic) was recorded on magnetic tape, much of it through ADAS, including all housekeeping information; the photographic data was annotated in flight by ADAS. Data comparison after the flight was therefore relatively easy.

Good quality results were obtained from all the sensors. The scatterometer data reduction completed to date has indicated that this data will be useful in helping to differentiate between different ice types, for comparative studies with the other visible, infra-red and microwave sensors and in providing scattering coefficient data as a function of angle for both modelling studies and the prediction of high depression angle SLAR (2-3 cm wavelength) performance. SLAR coverage was also obtained by the DND APS 94D for both study areas during the same time period.

4.2.4.3 Ocean Chlorophyll Measurement Experiment

An experiment to assess the feasibility of quantitatively measuring the ocean surface chlorophyll concentration, by different remote sensing techniques, was carried out by CCRS, in collaboration with DOE, in August 1975 off Yarmouth, Nova Scotia.

4.2.4.3 Ocean Chlorophyll (Cont'd)

The impetus for this experiment developed from the oceanographer's requirement to measure the areal distribution of surface chlorophyll concentration synoptically.

A number of sensors have been developed by several agencies to attempt quantitative remote sensing chlorophyll measurements. Three of these sensors, the DOE Spectrometer, developed by DOE Victoria, the CCRS Four Channel Photometer, developed by York University (described under 4.2.3.2b) and the DOE Laser Fluorosensor, developed by DOE Ottawa, were the primary sensors flown on this experiment. CCRS provided support sensors for thermal and flight track imaging including a Daedalus thermal scanner, a LLLTV and a PRT-5 I.R. radiation thermometer, together with the LTN-51 for navigation purposes.

Ground truth data was provided by DOE, Bedford Institute of Oceanography. Two ships, the Maxwell and the Harangus were equipped for measuring chlorophyll concentration profiles as well as physical oceanographic parameters.

Both daytime and nighttime missions were flown during a period of three days, over a preselected flight track, in order to experience changes in the ocean mixing and upwelling. The spectrometer, photometer and thermal sensors were used for the daytime flights and the laser fluorosensor, LLLTV and the thermal sensors were used for the nighttime flights. The two ships steamed the flight line providing continuous ground truth data during the flight periods.

Sensor and navigation data were interfaced and recorded digitally on the DC-3 aircraft using the CCRS ADAS system. Ground truth data were time and position coordinated with the aircraft data.

Data reduction and analysis is being performed by CCRS, by DOE (Victoria, Ottawa and BIO) and by York University. Data from each of the primary sensors is being evaluated with the ground truth data and compared to the other sensors in order to define the extent to which these different techniques can measure and map the concentration of chlorophyll.

4.2.5 Industrial Involvement in the Airborne Program

During the past year the industrial involvement program has moved from the planning to the implementation phase. As a result of the evaluation of proposals received in early 1975 a contract was let by DSS in April 1975 to Innotech Aviation Limited of Montreal and their primary sub-contractor, Intera Environmental Consultants of Calgary. This contract is for the provision of services covering two major areas.

Firstly, aircraft services will be provided for a period of three years, to essentially replace those services previously provided by the Airborne Sensing Unit of DND.

Secondly, and more directly related to the industrial involvement activity, a "Transfer Plan" report will be prepared, essentially proposing the step associated with the transfer of the Airborne Production System from CCRS to industry. This report, which will be delivered to CCRS in early 1976, will serve as a basis for discussion by CCRS in laying the framework for a transfer plan proposal which is planned to be submitted to IACRS in the Spring of 1976. Included in the plans for discussions on the Transfer Report are meetings with members of the Interdepartmental Task Force Committee as well as with members of CACRS.

Although initial Treasury Board approvals for the program were substantially reduced from that proposed in the Task Force Plan, CCRS has now received additional funding authorization effective April 1976. As a result of this, additional funding and personnel have been provided to operate the Convair 580 aircraft and to provide more comprehensive support to the airborne production system. This, coupled with the current Convair modification program which will be completed in late May 1976, should ensure that the airborne program service to users will be fully operational.

4.2.6 Airborne Experimental Facility available to other Laboratories

More and more the experimental capabilities of the Data Acquisition Division (DAD) are being used for projects initiated by other agencies.

CCRS would like to encourage other agencies in joint programs utilizing their own capabilities, married to those of CCRS/DAD. There is available one DC-3 (C-GRSA) and very soon the Convair 580 (C-GRSC) as experimental platforms equipped with exceptional data acquisition, recording and navigation systems. Both aircraft have camera ports, extra ports for special sensors and spare rack space for control and test electronics.

4.3 REPORT OF THE DATA PROCESSING DIVISION

4.3.1 Introduction

During the past year major support was given to the development of software for the Image 100 system and to the development of a viable ground support data processing system for data acquired by aircraft-borne sensors. With the successful launch of LANDSAT B changes were made to the satellite data processing software to accommodate data being received from both LANDSAT 1 and LANDSAT 2 satellites.

Work was continued on the Laser Beam Image Recorder until budget cuts and other considerations resulted in a decision to curtail the project. A colour quick look system, the continuous scanning film recorder, was attached to one of our two KA-10 computers and is now producing colour images of reasonable quality. Work is continuing on a suitable annotation system.

Additional equipment was ordered for Prince Albert and for the new receiving station to be located at Shoe Cove in Newfoundland.

4.3.2 Data Collection Platform Support

During the past year CCRS has continued to receive DCP data from NASA, converting this to engineering units and providing it to users through a teletype or telex link. The once-a-day update and direct request update procedure is being maintained.

NASA has installed a new receiving site in Alaska which has increased DCP messages received from Western and Northwestern Canadian regions. LANDSAT-II is being used for DCP retransmission.

The number of Canadian platforms in operation, supported by CCRS, is increasing to a total of 30 during the next year.

4.3.3 Prince Albert Satellite Station

During 1975, the Prince Albert Satellite Station recorded 2,302 orbits of LANDSAT data and 675 orbits of NOAA. The quicklook camera system produced 96,339 LANDSAT and 22,061 NOAA black and white images for distribution by ISIS, formerly Donald Fisher & Associates. In February last year, ISIS introduced the ISISFICHE (formerly known as ERTSFICHE) which is a microfilm card containing all the scenes recorded per day, with identifying annotation for band 6 of LANDSAT. A total of 22 fiche subscriptions are currently being filled by ISIS.

On 22 January 1975, LANDSAT II was launched and placed in an orbit such that nine day coverage, rather than eighteen day coverage, of land areas occurs. LANDSAT II provided both multispectral and return beam Vidicon data for about one month, after which the RBV cameras were turned off and the multispectral scanner became the prime sensor. Canada, by establishing cooperative projects with NASA scientists, has been receiving LANDSAT I and LANDSAT II data continuously since the LANDSAT II launch in all areas except that part of the Maritimes which is outside of Prince Albert coverage.

4.3.3.1 Quicklook System

The quicklook system was upgraded this year by adding a new high resolution CELCO monitor and camera system. The resultant imagery has a much improved resolution. This unit will be used until a laser beam recorder system (MIPS) becomes available.

4.3.3.2 Multi-Image Processing System - MIPS

A Multi-Image Processing System (MIPS) is presently in procurement for Prince Albert. The MIPS will contain a data formatter, radiometric and geometric correction capability, and a single laser beam image recorder which will produce all four bands simultaneously, black and white, on 9-inch film. The development of this system is being negotiated with a contractor in Vancouver. Installation and operation of the system at Prince Albert is scheduled to occur in the summer of 1977. At that time, Prince Albert will be capable of producing all of the black and white image products that NAPL Ottawa now produces.

4.3.3.3 Danish Agreement

Early in the spring of 1975, an agreement was negotiated with the Danish Government to provide data to Danish users on the coastal areas of Greenland and the Davis strait. ISISFICHE and black and white prints are being supplied from Prince Albert to the Danish users. When the East Coast Station at Shoe Cove, Newfoundland, goes into operation in the fall of 1976, it is expected that the expanded coverage of Greenland will be requested.

4.3.3.4. Imagery Transfer to PASS

In the last report, it was stated that CCRS would move the black and white imagery to Prince Albert by the summer of 1975. The transfer was delayed due to the facility not being ready and an inadequate data base being available at Prince Albert. Now, all is ready for transfer during February 1976. All black and white imagery products will be ordered, generated and distributed from Prince Albert through ISIS. All other imagery products, colour, mosaics and tape-to-film will be retained by CCRS at Ottawa. These are CCRS's first steps towards providing regional data distribution points and decentralization of the imagery processing and distribution function.

During the first year of operation until MIPS is delivered, data will be recorded at Prince Albert, the data tapes sent to Ottawa for processing to master negatives, quality inspection performed, and the negatives sent to ISIS for making imagery. The master negatives will be archived at Prince Albert for five years and then returned to Ottawa. When imagery is needed at Ottawa, it will be generated on demand only.

After the delivery of MIPS to Prince Albert, the data will be directly recorded on film and black and white products will be generated by ISIS: only master data tapes will be sent to Ottawa for archiving, storage and for use in generating special products.

4.3.3.5 Sea-Ice Fax

Because of the success of the demonstration project in 1974, in which LANDSAT and NOAA images were sent in real time from Prince Albert to ships in the arctic, the service was continued in 1975. Satellite imagery is sent by facsimile land lines to Ice Forecast Central in Ottawa. Facsimile images are also sent via the ANIK satellite to Arctic stations, where their content is relayed via H.F. links to ships navigating through the ice.

4.3.3.6 Prince Albert Blindspot

Since the launch of LANDSAT I, CCRS has been dependent on NASA to supply Canada with data on its spring wheat project areas situated around Saskatoon, Saskatchewan and in the PASS blindspot. In January 1976, a manually operated 12 foot antenna system was introduced to receive LANDSAT data from overhead passes. Preliminary data reception indicates i) sufficient signal can be received during the overhead pass to produce useful imagery; ii) sufficient signal can be received down to an elevation angle of 10-15 degrees to produce useful imagery; and iii) manual tracking of the overhead pass is difficult but can be accomplished to provide imagery. An auto track is being evaluated for use with the 12-foot antenna; if it proves feasible then effort will be expended to have it ready for the summer of 1976.

4.3.4. East Coast Station

The Portable Earth Resources Ground Station (PERGS) is under assembly and testing at Vancouver for delivery to the Shoe Cove Satellite Receiving Station near St. John's, Newfoundland in June 1976. The station and antenna systems will be operated for three months at Vancouver to verify that they are ready to assume a full operational and production role. The station when commissioned in October 1976 will be capable of providing black and white 70mm quicklook imagery and CCT's from bulk data tapes of the NOAA & LANDSAT spacecraft. A digital FAX interface to land lines is included so that digital images can be sent directly from the system to remote FAX terminals. The equipment may be easily expanded to handle satellites such as the HCMM.

The station site is being readied during this period by initiating contracts for the antenna base and pedestal, acquisition of appropriate contractors for maintenance and operations, and acquiring permanent station personnel.

4.3.5 Satellite Image Production

Of 5,717 orbits recorded to date at Prince Albert and 322 by Goddard, 3,478 orbits of LANDSAT 1 and 558 orbits of LANDSAT 2 have been converted to imagery in Ottawa. The backlog of 1,519 LANDSAT 1 and 484 LANDSAT 2 orbits is of priority two or lower.

The current inventory contains 47,578 scenes in black and white and 12,489 scenes in colour.

The completion of the EBR vacuum system rework was accomplished and is a major contributor to a higher production capability. The rework has resulted in better stability and reliability of the image production system and higher quality of output imagery. Work will continue on the electro-optical area to reduce some remaining noise and image distortion.

The success of the EBR work has also allowed the tightening up of quality inspection standards on the master positives and negatives to assure that better and consistent colour imagery can be generated. More detail on colour imagery generation appears in the NAPL-RC report.

Due to tape unit incompatibility with the NASA recording equipment, only 25 Canadian east coast tapes were received and duplicated for the year. This problem will disappear with the activation of the Shoe Cove Station.

The Image Production System had to respond this year to several load changes: increased throughput due to two satellites; full production status of mosaics and tape-to-film products; the use of ISISFICHE to do cloud evaluation prior to processing; the use of new software for selecting only the frame or frames desired on an orbit. The response was gratifying in that the overall image production rose 41% from last year with the quality remaining equal or improving on all products.

4.3.6 Image Inventory Services

In response to the launching of LANDSAT-B on January 22, 1975, a parallel database was created for inventory control and ordering of imagery. Consequently, users may like to place additional standing orders for this imagery. All new order forms now differentiate satellite missions and the search of the database via the IISS program has been modified to give an initial choice between LANDSAT I and II. Future issues of the imagery catalogue will have a section for each of the satellites.

4.3.7 Airborne Processing System

The Data Acquisition Division is recording analog and digital data from many of their airborne sensors. The sensor data and navigation data is annotated and collected in flight by the ADAS (Airborne Data Acquisition System) equipment. The airborne data processing system provides ground support facilities within the Data Processing Division. Software and hardware exist for processing analog and digital sensor data. The scatterometer, ERTS photometer and Miller photometer analog data are processed with CCT output. The low speed sensor data recorded digitally on the ADAS MUX track is provided on sensor disk files for user access on the DEC 10 time sharing system. It includes navigation data from three new systems, camera firing times, photometer and other low data rate sensors. The data can be provided on line printer listing, plotter output or CCT's.

During 1976, capability for processing multi-channel digital data will be added, in stages as required. A system has been designed to handle data recorded from the Daedalus 260 digitizer which Data Acquisition Division will be installing. The processor will initially be able to strip two channels simultaneously, with inherent capability for expansion to 11 channels by the addition of Channel Units. The imagery data will be reformatted and recorded on computer compatible tape for general use and may be supplied in pixel format to an imaging device as a quick-look facility.

A colour strip film recorder (CSFR) is under development for the airborne processing system and is already producing imagery from pixel formatted tapes. During 1976, it will be refined and annotation will be implemented. A second mode of operation will also be developed, whereby it produces a hard copy of an image already displayed on a monitor screen, e.g., IMAGE 100, Bendix MAD or other.

4.3.8 Computer Compatible Tapes

A new format for CCT's was introduced during the year to transmit system-corrected LANDSAT MSS data. A description of the format in its final form is now available as a Technical Memorandum (75-3), "Format Specifications for Canadian LANDSAT MSS System-Corrected Computer Compatible Tape". The first page of the report is devoted to the description of the spacecraft, its sensor subsystems, the MSS data products and the data processing methods employed to system correct scene data. The CCT format is discussed in the second part. More detailed accounts of the methods used to implement radiometric and geometric corrections are given in some of the appendices to the report. Although the same general format is adopted by NASA and the Eros Data Centre (EDC), there are several minor differences between the CCTs supplied by NASA or EDC and CCRS. Those differences are summarized in one of the appendices. Copies of the Memorandum can be obtained by writing to Brian McGurrin, TIS Library, CCRS, 717 Belfast Road, Ottawa. In 1975, there were 454 requests for CCTs of which 89 were for LANDSAT II. This represented a slight increase in production from the 430 generated in 1974.

4.3.9 Digital Image Correction System

This PDP11/70 based system will be implemented in 1977 and will perform radiometric and geometric corrections on satellite, aircraft or other imagery. It will not only relieve the general time sharing system at CCRS of a heavy load, but will provide correction and manipulation services hitherto unavailable. It will consist of:

(a) A display unit for coarse visual location of Ground Control Points. (GCP)

(b) A hardware correlator for accurate pinpointing of GCP's.

(c) A hardware correction unit, capable of complex radiometric correction, and accurate geometric correction, including image rotation.

4.3.10 User Peripherals

The Optronics Scanning Micro-Densitometer has been upgraded and filters for primary and complementary colours are available, as well as a slot for the user to add his own. A software package is available and transparencies or prints up to 22 cm square can be scanned, or black and white film can be exposed.

An Array Processor is being added in 1976, and a special interface to the CCRS time sharing system is to be built. This will be capable of accepting data in many formats from the computer and reformatting to and from the Array Processor as required. The Array Processor will operate as a TSS computer peripheral and will relieve the CPU of many time consuming number-crunching tasks.

4.3.11 Computer Operations

The Timesharing system functions as a general-purpose in-house service bureau and supports the following major uses:

- All pre-processing associated with the LANDSAT production system which the dedicated PDP-10 on the LANDSAT computer system has no time to accomplish;
- All LANDSAT post-processing such as inventory database update, invoicing, work ordering, inquiry systems;
- All in-house software and hardware development for all CCRS computers and other systems;
- On-line financial management information system;
- Technical Library data base management system;
- Production of LANDSAT imagery in digital form on computer compatible tapes, requested by outside users, which are used to perform complex digital analyses at the user's own computer facility;
- Increasing support for research and development of automated interpretation techniques;
- Support of special-purpose interpretation hardware such as the interactive colour video display which sees extremely heavy usage by outside agencies.

Since they are in a developing industrial area the several systems have been increasingly subject to severe power fluctuations, shortages and cuts, resulting in serious delays, from time to time, in production and research processing. In spite of these problems, production has generally been at a high level.

This past year has seen a very heavy increase in the usage of private disc packs for LANDSAT analysis and steps are being taken, budgets permitting, to add to the availability.

The Centre still has only 8 dial up telephone lines to the TSS, causing a user queue to build from time to time. Another 8 lines were planned for 76/77, but budget restrictions forced its postponement. We ask users patience until such time as more dial up lines can be provided. DATAROUTE access from remote areas will be available by March, 1976.

4.3.12 Future Satellite Programs

There has been a heavy involvement in planning and preparing for future U.S. satellites, especially the HCMM and SEASAT-A satellites. Current budget restrictions may reduce the scope of our activities, but we are planning to equip Prince Albert for reception of HCMM data in late 1977 and Shoe Cove to be a major centre for reception and processing of SEASAT-A data in 1978.

4.4 REPORT OF THE APPLICATIONS DIVISION

4.4.1 Introduction

The past year has been one of considerable physical growth and change in the Applications Division. The expansion witnessed during 1975 is permitting the Division to extend its contacts with users, both geographically and in terms of discipline interests. The new manpower is also being reflected in an increased research effort into new areas of airborne and satellite remote sensing technology. The division is confident that these positive trends will continue and will have even greater impact through 1976.

4.4.2 Personnel

This year has seen a number of additions and changes of personnel with appointments being made at all levels within the Division. Dr. Murray Strome is now chief of the Applications Division, and Dr. Keith Thomson has shifted from the Methodology Section to become the new Head of the Applications Development Section. In addition to these changes several new appointments have been made. Dr. Ray Lowry has joined the Methodology Section and, Dr. Josef Cihlar, Dr. Bill Bruce and Mr. Guy Rochon were recently appointed to the Applications Development Section.

The post-doctoral fellows in the Division have continued, as in past years, to make important contributions to various research activities in the Division. During 1975, the Division acquired the services of three post-doctoral fellows; Dr. Ade Abiodun, Dr. Morris Goldberg, and Dr. Ravindra Kumar.

The Technical Information Service has recently appointed Mr. Brian Silcoff to the new position of Assistant Head. Mr. Silcoff will be assisting Mr. Brian McGurrin in the continued development of the Reference Library and in the expansion of other user reference services.

The scientific staff welcomed the increased technical support provided for the Division during 1975. Five new research assistants have joined the Division; Dr. Jahagirdar, Mr. Mike Kirby, Mr. Kevin O'Neil, Miss Diane Robert and Mr. Raymond Vilbikaitis.

Throughout 1975 visiting scientists and secondees have again been accommodated at CCRS. A number of these representatives from federal agencies, universities and other countries, have spent various amounts of time at the Centre using its facilities.

4.4.3 Facilities

4.4.3.1 Digital Interpretation Equipment

Demand for time on the digital analysis systems developed by the Applications Division has increased steadily in 1975. This heavy utilization by outside investigators and CCRS scientists has necessitated a number of actions relating to the development and usage of the equipment.

The IMAGE 100, installed at CCRS in April of 1974, is now operating 140 hours a week in order to accommodate demand. These extended hours have necessitated the hiring of additional operators to assist users. There are now three well qualified operators with backgrounds in physics, computing science and electrical engineering. It has also been necessary to accelerate the development program for the digital systems by increasing the number of system programmers assigned to the IMAGE 100. In early 1975, the original complement of one programmer, half-time was increased to three programmers, full-time. Although the Applications Division retains the responsibility for research and development programs and system scheduling, the responsibility for maintenance and operation of the IMAGE 100 has passed to the Data Processing Division.

Numerous modifications have been made to the IMAGE 100 during the past year, reflecting both scheduled development and response to user recognized requirements. The IMAGE 100 hardware has been modified through the addition of 48 K words (16 bit) of core memory, bringing the total core memory to 120 K words. Further additions include a 44M word RPO4 disc drive, and a second 1.2M word RKO5 disc drive.

Substantial improvements have been made to the IMAGE 100 software as well, through the development of new programs, the elimination of errors and the significant modification of General Electric supplied software. The requirement for multi-tasking operation of the IMAGE 100 system has now been met through the recent installation of a new operating system (RSX - 11D).

The new programs developed for the IMAGE 100 include:

- maximum likelihood decision rule program for elimination of class confusion;
- histogram clustering;
- spatial filtering programs to produce classes with smoother spatial distributions;
- sophisticated refresh memory diagnostics;
- fast video tape program for quick saving and recalling of results;
- two-axis densitometer program;
- binary theme print program with output at map scales from 1:50,000 to 1:1,000,000;
- electron beam recorder output program with geometric scaling;
- universal CCRS-JSC input programs;
- programs to examine and dump header and/or video data in CCRS-JSC formats;
- temporal registration program with affine transformation;
- pattern generation diagnostic program;
- simulation programs for Fast Fourier Transforms and maximum likelihood classification;
- tape-to-disk and disk-to-IMAGE 100 programs.

A number of other programs have been enhanced for improved operation on the IMAGE 100:

- general purpose transform module;
- fast N-D vector file generation with annotation file capability;
- two-channel histogram cluster display program;
- migrating means clustering program (now allows user to add and/or subtract clusters and to save and restore cluster files);
- 1-D histogram display;
- window program;
- theme exchange;
- video exchange;
- theme/input/output;
- input/output programs augmented to handle EROS format;
- radiometric and scene correction program.

These are also but a few of the many programs currently being converted to run under the RSX-11D operating system which was implemented for users on January 12, 1976.

In January of 1975, the Division embarked upon a major hardware modification program for the IMAGE 100. At that time, a contract was awarded, (on the basis of competitive bids) to the Computing Devices Company (a division of Control Data Corporation of Canada Ltd.) for design of IMAGE 100 hardware modifications. The necessary modifications as identified by the Applications Division are:

- programmable IMAGE 100 switch control;
- flexible preprocessing control;
- programmable scale factors;
- increase to 18 the number of bits in the signature analyzer counters;
- improved system timing;
- design of a hardware Gaussian classifier;
- increased programmable control of the general purpose transform module;
- cursor modification;
- design of a bulk classifier;
- design of a hardware spatial filter;

- map overlay input capability;
- modification of the scanner logic module to utilize video channel 5.

Computing Devices and CCRS are in the process of implementing these modifications. Their effect will be to substantially increase the flexibility and effectiveness of the IMAGE 100 for bulk classification of entire LANDSAT frames.

The Division supports, in addition to the IMAGE 100 system, the Modular Interactive Classification Analyser (MICA) software system on the PDP - 10/KI time-sharing system. The MICA system, unlike the IMAGE 100, offers the programming ease of a large computer. The preliminary investigation of techniques are thus most commonly carried out using the MICA system, while the IMAGE 100 is used primarily in direct support of research activities.

This system has also undergone significant improvement in 1975, including implementation of the following new programs:

- modular assembler and FORTRAN routines for disk and colour display input and output;
- histogram clustering programs;
- spatial filtering programs;
- vector file generation program;
- table look-up classification program; *
- affine temporal registration and correlation programs;
- principal components enhancement** programs.

* The table look-up classification program has reduced classification time by a factor of ten.

** These enhancement programs were developed by Dr. M. Taylor (DND). They have been designed to provide optimum interaction with the human perception system.

There are certain digital image analysis applications in which the user may be more interested in enhancement than in classification. In recognition of this need, the Applications Division supports a software system called MADCON (formerly, MADUSE). The MADCON system permits the user to interactively pseudo-colour, density slice, ratio, enhance, any band or combination of bands, or carry out three dimensional classification. The results are immediately displayed on the Bendix Multispectral Analyser Display (MAD). Documentation for this, and other software system components is provided in the form of "HELP" files, which can be accessed by the user.

Anyone wishing to use the IMAGE 100, MADCON, or MICA system should submit a request in writing to the Chief, Applications Division. The request should include a brief description of the objectives to be achieved, the methods to be used, the quantity of data to be analysed, as well as the desired output products. Such requests have been necessitated by the heavy demand and high operating costs for use of these systems. There is at present no charge made to the individuals using these systems.

4.4.3.2 Visual Interpretation Equipment

A variety of visual interpretation devices are available for users and are located at the CCRS, Belfast Rd., facility. These include two precision light tables and magnifiers, an interpretoscope, a zoom stereoscope, light tables, a colour additive viewer, and a density slicer with an edge enhancer. The Centre recently acquired a Kargle Reflecting Projector as well as the capability of superimposing map and image information on the density slicer. Use of any of this equipment can be arranged through the Chief, Applications Division.

4.4.3.3 Mobile Visual Interpretation Equipment

Again this year CCRS has made a colour additive viewer and a density slicer available on a loan basis to provincial remote sensing agencies. During the past year, Manitoba and Newfoundland have made use of this CCRS service.

4.4.4 Applications Division Projects

Most of the projects carried out by the Division staff, are joint projects with other agencies. These projects may be initiated in-house or at the user agency's request. The following is a list of the projects in which the division participated during 1975.

Development of a remote sensing compatible land use activity classification comparable with the Canada Land Inventory present land use classification (in co-operation with the Lands Directorate, Environment Canada.)

A study of the applications of an airborne 4 channel photometer to water quality studies (with Service Qualité des Eaux du Québec).

Lake Classification studies in James Bay (with Société de développement de la baie James).

The application of LANDSAT data in the limnological study of Southern Indian Lake (with the Fresh Water Institute, Winnipeg, Manitoba).

Coastal resources inventory in the Atlantic provinces via satellite imagery (with DOE Lands Directorate, Atlantic Region).

Classification and inventory of Banff-Jasper National Park (in co-operation with the Northern Forest Research Centre, DOE).

Analysis of scatterometer data of agricultural targets.

Investigation of clustering methods and development of a rapid clustering procedure.

Investigation of methods for radiometrically correcting LANDSAT data.

A feasibility study for the measurement of potato acreage in New Brunswick using LANDSAT and high altitude airborne imagery (in co-operation with the New Brunswick Department of Agriculture).

A preliminary evaluation of remote sensing for white bean acreage measurement in Ontario (with Agriculture Canada and the Ontario Bean Producers Marketing Board).

An evaluation of remote sensing for land use and cropland mapping in P.E.I.

Colloque sur la télédétection (with Laval University).

Preparation for CCRS participation in the Heat Capacity Mapping Mission Satellite (HCMM) Programme.

Preparation for CCRS participation in the NIMBUS-G satellite programme.

Preparation for CCRS participation in the SEASAT programme.

The Saint John River Flood Project (in co-operation with the Canada-Japan research project).

Satellite studies of the aquatic vegetation and sediment distribution in Lake Kainji, Nigeria (post-doctoral studies).

Use of spectral signatures in classifying the vegetation of Western Sierra-Leone (post-doctoral studies).

Forest fire mapping in the North West Territories (with the Department of Indian and Northern Affairs).

Newfoundland Remote Sensing Facility (Federal Winter Works programme).

Evaluation of the utility of a multi-channel airborne scanner.

Quantitative analysis of suspended sediment concentration and distribution in the MINAS BASIN, Nova Scotia.

Development of a water quality index from LANDSAT data using chromaticity theory.

Analysis of water inflow characteristics into Kamloops Lake, B. C.

Analysis of archaeological sites in central Ontario.

Colour transformation optimized for human perception. (Co-operation with DND).

Infested forests (in co-operation with the Pacific Forest Research Centre, DOE).

Development of the IMAGE 100 system.

Development of the Modular Interactive Classification Analyzer (MICA).

Investigation of reflectances recorded by the SKYLAB spectrometer (S191).

Analysis of SKYLAB Multispectral Scanner Imagery (S192).

Methods of Feature Selection.

Implementation of a Colour Read/Write Microdensitometer System.

Proposed participation in the SEASAT programme.

Investigation of methods for optically analyzing synthetic aperture radar imagery.

Implementation of a black and white microdensitometer.

Design of a reflectance spectroscopy facility.

Management of a visiting scientist seminar series.

Design of a coherent optical processing facility.

Investigation of the geometric distortions in SEASAT L-band synthetic aperture radar imagery.

Design and implementation of a 64-channel software package for digital imagery in CCRS-JSC universal format.

Development of a simulator for fast Fourier transforms and maximum likelihood classification.

Investigation of methods for geometrically correcting LANDSAT data.

4.4.5 Technical Information Service

During the past year the Technical Information Service has improved its capacity to assist users by implementing a new and more flexible version of RESORS (Remote Sensing On-Line Retrieval System) and by an increased emphasis on preparation of reference aids for remote sensing.

RESORS is now being accessed directly from terminals in Alberta, Manitoba, Ontario, Québec, Nova Scotia and Newfoundland. During the past year RESORS performed 3945 information searches, supplied over 75,000 literature references, and answered 3225 requests for document photocopies. During the same period the RESORS staff acquired over 2000 technical papers, most of which have now been indexed and added to the data base.

In August, RESORS III was superseded by RESORS IV, a system having significant improvements over the former version. There are several new commands which encourage more flexible interaction during searches, a new data base including references to 35mm slides for use as visual aids in remote sensing lectures and presentations, and a current awareness feature which allows a user to search for relevant material added since his last search.

RESORS staff have also prepared a "Glossary of Remote Sensing" and a "Directory of Remote Sensing" which will soon be made available to users.

The Satellite Image Library (formerly called the Browse Facility) has continued to collect LANDSAT and NOAA Imagery, and has added a file of selected SKYLAB imagery. This library has prepared new panels for the CCRS display, and has begun to be involved in the preparation of information packages such as an annotated "Best of LANDSAT" on 35mm slides, and the "CCRS User Information Kit" as a source of general information on remote sensing.

During the past year this section has assisted over five hundred users with imagery-related questions and problems.

4.4.6 User Contacts

In response to the 1974 CACRS recommendations the Applications Division staff have endeavoured to strengthen liaison with the CACRS discipline working groups and the provincial centers or committees. A staff member has been assigned to each working group and a number of staff members serve as principal contacts for provincial centres or committees.

4.4.7 Publications and Presentations

Abiodun, A. "The Applications of Remote Sensing Technology in the Development of West Africa". Report prepared for the International Development Research Centre, Ottawa. June 1975.

Abiodun, A. "Remote Sensing Technology in the Development of Nigeria". Report prepared for the National Council for Science and Technology, Lagos, Nigeria. August 1975.

Ahern, F. J. and R. Vilbikaitis, 1975: "Modulation Transfer Function Analysis of the Quick-Look Imaging System". CCRS Technical Report.

Ahern, F. J., 1975: "Remote Sensing: A Practical Application of Classical Physics". Presentation to the Physics Department, University of Waterloo, Waterloo, Ontario.

Alfoldi, T. T. and G. E. Beanlands. "Towards an Operational Inventory of Coastal Regions". Presented at the 3rd. Canadian Symposium on Remote Sensing, Edmonton, Alberta (in press)

Alfoldi, T. T. and R. A. Ryerson. "Satellite Imagery Interpretation - Suggestions for Laboratory Design". CCRS Technical Report . 73-4 Revised May 1975.

Alfoldi, T. T. "Remote Sensing of Natural Hazards for Environmental Impact Assessment". E. P. S. Remote Sensing Seminar. March 1975.

Alfoldi, T. T. "Photo Enhancement by Electro/Optical Techniques for Remote Sensing Applications". Presented at the Snow/Ice Workshop. January 1975.

Alfoldi, T. T. and N. A. Prout. "Geometric Adjustments of IMAGE-100 Outputs for Ground Truth Compatibility". April 1975.

Alfoldi, T. T. "Utility Analysis of the Bendix II-Channel Multispectral Scanner". Presented at the CASI-Aerospace Electronics Symposium. Halifax, February 1975.

Brochu, C. J. and R. T. Lowry. "Logiciel Graphique Interactis ecrit en APL pour le traitement des données". DREO Technical Note No. 75-14, Ottawa, Ontario.

Cihlar, J. 1975. "Image Analysis Equipment in Use at the Canada Centre for Remote Sensing". Presented at the workshop on Remote Sensing of Wildlife, Québec City, Québec, November 1975.

Gloerson, P. and W. M. Strome, 1975: "Ice Reconnaissance by Satellite". Presented at the 3rd Canadian Symposium on Remote Sensing, Edmonton, Alberta. (in press)

Godby, E. and D. Goodenough, 1975: "The Canadian Remote Sensing Program". Lecture to Alberta Remote Sensing Course, Edmonton, Alberta.

Goldberg, M. and S. Shlien, 1975: "A Four-Dimensional Histogram Approach to the Clustering of ERTS-1 Data". Aerospace Electronics Symposium, Canadian Aeronautics and Space Institute, Halifax, N. S.

Goldberg, M., D. Goodenough and S. Shlien, 1975: "Classification Methods and Error Estimation for Multispectral Scanner Data". Proc. Third Canadian Symposium on Remote Sensing, Sept. 22-24, Edmonton, Alberta (in press)

Goodenough, D., 1975: "IMAGE 100 Classification Methods". Aerospace Electronics Symposium Canadian Aeronautics and Space Institute, Halifax, N. S.

Goodenough, D., 1975: "Automated Forestry Classification with LANDSAT Data". Presentation to the Pacific Forest Research Centre, Victoria, B. C.

Goodenough, D., 1975: "Rapid Inventories for Park Management". Presentation to Parks Canada, Western Region, Calgary, Alberta.

Goodenough, D., 1975: "Applications of Image Processing and Pattern Recognition to Remote Sensing". Presentation to the Department of Electrical Engineering, McGill University, Montreal, Québec.

Goodenough, D., 1975: Lectures to United Nations/UNESCO Seminar on Remote Sensing Applications, Ottawa, Ontario (Topics: "Reflectance Spectroscopy", "Hardware Implementation of Selected Pattern Recognition Procedures").

Goodenough, D., 1975: "Methods of Clustering and Spatially Filtering LANDSAT Imagery on the CCRS IMAGE 100". Presentation to the IMAGE 100 Users' Group, Jet Propulsion Laboratories, Pasadena, California.

Kirby, C., D. Goodenough, D. Day, and P. van Ecyk, 1975: "LANDSAT Imagery for Banff and Jasper National Parks Inventory and Management". Proc. of the Third Canadian Symposium on Remote Sensing, Sept. 22-24, Edmonton, Alberta. (in press)

Lowry, R. T. and C. J. Brochu, 1975: "A System for the Treatment of Airborne Laser Profilometer Data of Ice", DREO Report No. 725, Ottawa, Ontario.

McNeil, W. R., K. P. B. Thomson and J. Jerome. 1975: "The Application of Remote Sensing Spectral Measurements to Water Quality Monitoring". Canadian Aerospace Electronics Symposium, Halifax, N. S.

Rochon, G., E. J. Langham. Sur la transformation des radiances en réflectances pour l'étude de la qualité de l'eau. Troisième Symposium canadien de télédétection. Edmonton, 1975. (in press)

Rochon, G., E.J. Langham. Télédétection par satellite dans l'évaluation de la qualité de l'eau. Verein. Limnol. Stuttgart, Oct. 1975. 19: 189-196.

Ryerson, Robert A. and David M. Gierman. "A Remote Sensing Compatible Land Use Classification". First presented to the Canadian Association of Geographers, Vancouver, May 1975. Published as Canada Centre for Remote Sensing Technical Note 75-1, Energy, Mines and Resources, Ottawa. May, 1975.

Ryerson, Robert A. "An Investigation of Agricultural Data Collection Using Aerial Photographs". Ph.D. Dissertation, Faculty of Environmental Studies, University of Waterloo, Waterloo, Ontario. Canada. October 1975. 350 p.

Ryerson, Robert A. "Remote Sensing and Geographical Topics in Canada" RSEMS. October 1975. 27 p.

Ryerson, Robert A. and David M. Gierman. Land Use Information in the Great Lakes Basin. Final Report for the Pollution from Land Use Activities Reference Group Task B1, International Joint Commission, Windsor, Ontario, 1975.

Ryerson, Robert A. "Urban Remote Sensing: Status of Research and Applications". Canada Centre for Remote Sensing, Energy, Mines and Resources, Ottawa. February 1975.

Ryerson, Robert A. "Urban Land Use Mapping Activities at CCRS, EMR and Lands Directorate, Environment Canada". Symposium on Urban Remote Sensing, University of Alberta, Edmonton, Alberta, May 1975.

Shaw, E., P. Gloersen, W.M. Strome, Near Real-Time Transmission of Satellite Imagery, 3rd. Canadian Symposium on Remote Sensing, Edmonton, Alberta.

Shlien, S. and A. Smith, 1975: "A Rapid Method to Generate Spectral Theme Classification of LANDSAT Imagery". Journal of Remote Sensing of the Environment.

Strome, W.M. 1975. "Remote Sensing - the Future". 3rd. Canadian Symposium on Remote Sensing, Edmonton, Alberta.

Strome, W.M., P. Fishman and G. Bressanin. "Options for Prospective Users of Earth Resources Satellite System Data", International Astronautical Federation XXVth Congress, Amsterdam, Sept. 30-Oct. 5, 1974.

Strome, W.M., S.S. Vishnubhatla, and F.E. Guertin, 1975. Format Specifications for Canadian Landsat MSS System Corrected Computer Compatible Tapes. CCRS Research Report 75-3.

Thomson, K.P.B. "Spectroscopy from Space". Presented to the Ottawa Chapter, Canadian Chemical Society, October 1975.

Thomson, K.P.B. "The Application of Satellites to Wildlife Studies". Presented at the Workshop on the Remote Sensing of Wildlife in Québec City, November 1975.

Thomson, K. P. B. "Les applications de la télédétection à l'université de Laval", Québec, November 1975.

Thomson, K. P. B. , Pare, C. , Roy, M. D. 1975. "Digital Analysis of Multispectral Satellite Data Applied to Lake Surveillance problems in large hydro-electric Developments". Proceedings of the 3rd. Canadian Symposium on Remote Sensing, Edmonton, Alberta. (in press)

Thomson, K. P. B. 1975. "Problems Associated with the Remote Sensing of Water Colour" Hydrography Committee of the 63rd. Statutory Meeting of the International Council for the Exploration of the Sea, Montreal, Canada.

Thomson, K. P. B. "Water Quality Monitoring and Remote Sensing of Oil Spills". Presented at the EPS Seminar on Remote Sensing, March 1975.

5.1 REPORT OF THE WORKING GROUP ON AGRICULTURE

5.1.1 AIRBORNE REMOTE SENSING

Nineteen projects involving 3161 nautical miles of airborne imagery were completed for studies involving crop indentification and acreage measurements, rangeland management, and detection of crop damage by winter kill, insects, disease, and salinity. Other studies involved water-balance and sediment loads in the Spring Creek (Alta) drainage basin related to agricultural development, mapping of soil climatic units, (Sask.), applications to soil and resource inventories (Man.), assessment of flooding damage (Red River Valley) land-use management of Agricultural Crown Lands (Inter-lake region Manitoba), changes in native vegetation for monitoring land-use intensity for grazing (4 sites proposed in Manitoba but later cancelled), and thermal IR for mapping forest pockets (Ontario).

A further 18 requests covering 5347 nm were requested by other disciplines (forestry, geography) for imagery of interest in land-use studies of non-cultivated or unimproved areas adjacent to urban and forested areas or in northern agriculture fringe areas.

Much of the imagery obtained was 9x9-inch infra red false color aerial photography, thermal Line Scan, and PRT5 radiometry taken at altitudes varying from 3,250 to 36,000 feet involving multi-stage sampling and seasonal changes. Turn-around time and film processing and reproduction was generally reliable and within the 3-week period as requested. Acquisition of imagery at the optimum growth stage was still made difficult by the cloud and atmospheric conditions. For three years in a row no imagery of one particular area has been obtained due to weather and cloud conditions within the time frame requested.

Use of airborne photography supplemented by field observation was widely used for calibrating and verifying results of Landsat I and II imagery in several of the studies.

5.1.2 SPACEBORNE REMOTE SENSING

The Canadian-U.S. Spring Wheat Program (LACIE) remained the main agriculture user of resource satellite imagery during the year for coverage of some 15 sites in Canada and 6 in the U.S. The 9-day coverage provided by LANDSAT I and II during the summer greatly increased the opportunity for repetitive coverage and enabled classification analyses for different growth stages or allowed, in some cases, at lease one coverage during the summer. A study on sampling requirements is being conducted under contract with the Sibbald Group, Calgary, involving the establishment of 14 supplementary test sites. The intention is to perform statistical analyses of differences in spectral signatures of crops and to determine the feasibility of extrapolating signatures from one area to another. Evaluation of satellite imagery for a rangeland management program was begun in 1975 with a feasibility study conducted by Intera Consultants, and the establishment of two test areas in the interior range area of B.C. and the subalpine area near Kananaskis, involving the University of B.C., Agriculture Canada, Kamloops, and the Wildlife Service.

A study on computer-aided classification of land use in the Mackenzie River area and in the northern Manitoba was continued in a cooperative study with LARS.

5.1.3 Technical Developments

Development in use of unsupervised and supervised classifiers of LANDSAT data using Image-100 continues under the Canada-U.S. Spring Wheat Program. Several serious limitations continue to restrict ready application of the classifiers: (1) accuracy of geometric registration for site location; and (2) ready input of ground data for verification of classification accuracy. Temporal registration for use on automatic classifiers is not readily practical at the present time. Research continues on determining laser fluorometric response from various crops and soils.

The use of black and white optical separations of the three sensitive layers of color aerial photographs with Black and White infra-red photographs were demonstrated for color-image constructions in agriculture and other areas of study. Selected 2-image combinations usually enhanced feature descrimination better than 3-image combinations. (Studies on crop diseases-Ottawa)

5.1.4. Applications and Benefit Analysis

An assessment of various types of remote sensors at different scales and times for application to rangeland management in Western Canadian range country was conducted by Intera Consultants, Calgary. They concluded that false-color IR photography, in general, provided the most information for rangeland management. At a scale of 1:10,000. distribution of species' associations, ground-cover and conditions of vegetation, variables related to soil (moisture, erosion, salinity) and variables related to management (forage utilization, trails), were well distinguished. Color photographs were more useful for cattle censusing and some vegetation assessment. Thermal imagery showed some differences due to soil moisture and ground cover when taken at noon, and the presence of cattle in open areas when taken in early morning. Analyses of Landsat data (Bands 5 and/or 7) enlarged to around 1:200,000 provided information for vegetation and hydrological features when combined in color, green and red respectively, Airborne false color IR at a scale of 1:100,000 is satisfactory for transect coverage of typical range areas, with larger scale (1:20,000) used as a check on detail. Around mid-May appeared to be the best time to assess forage development in the foothills areas. Cost of coverage of various sized sample areas and scales is given in their report. Ability to detect selected parameters of vegetation and soils for range management is presented for a range of scales of aerial and Landsat imagery.

A marketing study on potential benefits from remote sensing of grain crops was completed by the Sibbald Group in their report on "Surveillance of Crops from Space".

5.1.5. User Liaison

Several programs involved close liaison between CCRS and various researchers across Canada. The cover-crop acreage study conducted by Dr. Atkinson, Lethbridge Research Station, involved staff and facilities of CCRS, particularly those associated with the Image-100 Multi-spectral Analyser. The potato crop acreage study with the N.B. Dept. of Agriculture utilized the data processing facilities of CCRS. Close liaison was maintained between Agriculture Canada research staff and CCRS on the Spring Wheat Program in processing the data and in discussion with the U.S. on the Large Area Crop Inventory Experiment. (LACIE)

5.1.6 Training

Several agriculture experts assisted in the training programs at the Alberta Remote Sensing Center, Edmonton, the Manitoba Remote Sensing Centre, Winnipeg, and the CIDA International Training School conducted at Guelph University. In addition, talks and presentations were made to various groups (Alberta, Saskatchewan).

5.1.7 Conclusions and Forecast

Airborne and resource satellite programs involved crop identification and acreage measurements in five of the provinces, and rangeland studies in two. Crop loss detection was concentrated in two provinces with assessment underway in four provinces using mainly aircraft imagery. Development of land units for stratifying crop regions continued to be of assistance in improving classification where there is interference of background reflection from soil surface. Determination of narrow-band reflection and fluorescence spectra of crops was continued in order to assist in separating similar types of crops. Improved supervised and unsupervised classifiers were developed by CCRS and used by several researchers. Lack of available Landsat imagery over the centre of the Canadian spring wheat region continued to prevent studies from being carried out on crop indentification in most of Saskatchewan by the Univeristy of Saskatchewan during 1975. The greater repetitive coverage by the operation of the two Landsats considerably increased the chances of acquiring cloud-free imagery during the critical viewing time of late June and July.

5.1.8 Recommendations of the Agriculture Working Group

It was recommended that:

1. In the terms of reference of the transfer of aircraft program to industry provision be made:

   (a) to meet requirements for narrow time frames which frequently vary depending on weather and growing conditions;
   (b) for close communications between the air crew and the ground observers;
   (c) that aircraft charges be established before the beginning of the new year to facilitate planning by users.

2. Continued effort be made to improve the quality of color photography.

3. Guidelines be established to provide uniformity for reporting accuracy of classification from digital and photographic imagery.

4. Consideration be given to the acquisition of aerial photography at higher altitudes than is presently within the capability of Canadian aircraft.

5. Full support be given to the Heat Capacity Mapping Mission (HCMM)

6. The Agriculture Working Group set up a subgroup on the applications of remote sensing to rangeland studies.

7. Appreciation be expressed to Laurie Philpotts for his past service as secretary of the Agriculture Working Group and contributor to remote sensing in Canada.

8. Appreciation be expressed to the Research Branch, Canada Agriculture, Kamloops for hosting the Agriculture Working Group in Kamloops, September 18 and 19, 1975.

5.1.9.3 List of Membership in Agriculture Working Group -1975

Dr. A.R. Mack (Chairman), Soil Research Institute, Canada Department of Agriculture, Room 3010, K. W. Neatby Building, Ottawa, Ontario K1A 0C6 (613-994-9657).

Mr. P. Crown,(Secretary), Alberta Institute of Pedology, University of Alberta, Edmonton, Alberta, T6G 2E3 (403-432-5877) Sept.75-Mar.78

Mr. E. Brach, Engineering Research Service, Canada Department of Agriculture, Ottawa, Ontario K1A 0C5 (613-994-9561)Sept.76-Mar.78

Mr. Jack Chevalier, General Manager, The Canadian Agricultural Chemical Association 116 Albert Street, Suite 716, Ottawa, Ontario K1P 5G3 (613-232-6802) Sept. 73

Mr. O. Code, Agricultural Statistics, Statistics Canada, #5 Temporary Bldg., Ottawa, Ont. K1A 0L7 (613-994-9814) Sept.72-Aug.75.

Dr. L. Crosson, Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon, Sask. S7N 0W0 (306-343-5186) Sept. 75-Mar. 78.

Mr. V.A. Hodgson, Plant Pathology Section, Research Station, Canada Department of Agriculture, Fredericton, N.B. (506-475-9931) Sept 73-Aug. 76.

Mr. A. Johnston, Research Station, Agriculture Canada, Lethbridge Alta. T1J 4B1 (403-327-4561) Sept 75-Mar 78.

Mr. T.V. Martin, Canadian Wheat Board, 7th Floor N. 423 Main Street, Winnipeg, Manitoba R3C 2P5 (204-985-3435)Sept 75-Mar 78.

Dr. R. Paquin, Chercheur Scientifique, Station de Recherchers 2560, Chemin Gomin, Ste-Foy, Quebec, G1V 2JC (418-694-4020)Mar.74-Mar.77.

Dr. R. Protz, Department of Land Resources Science, University of Guelph, Guelph, Ont. (519-824-4120)Ext 2481. Sept 73- Aug 76.

Mr. M. Riach, Agriculture Division, Statistics Canada, Room 1141,#5 Temporary Bldg.Ottawa K1A 0L7 (613-994-9956) Mar 74-Mar.77

Dr. R.S. Rust, Economics Branch, Canada Department of Agriculture, Sir John Carling Bldg., Ottawa, Ontario K1A 0C5 (613-994-5504) Mar.74-Mar.77.

Dr. A.L. van Ryswyk, Research Station, Canada Department of Agriculture, Box 940, Kamloops, B.C. (604-376-5565) Sept.76-Aug.76.

Dr. R. Ryerson, Canada Centre for Remote Sensing, Dept. of Energy, Mines and Resources 717 Belfast Road, Ottawa, K1A 0E4 (613-995-9916) Mar.75-Mar.78.

Mr. C. Sibbald, 720 Bow Valley One, 202-6th Ave.S.W. Calgary T2P 2W6 (403-261-9673) Sept.72-Aug.75.

Mr. J.W. Strath, Kenting Limited, 600 6th Avenue, S.W., Calgary, Alberta (403-263-2980) Sept. 73-Sept. 76

Mr. C. Tarnocai, Department of Soil Science, University of Manitoba, Winnipeg, Manitoba (204-474-9354)Mar.74-Mar.77.

Dr. V.Wallen, Chief, Crop Disease Loss Section Ottawa Research Station, Canada Agrculture Ottawa, Ontario K1A 0C6 (613-994-5555) Mar 74-Mar.77.

Dr. Awni Raad, Director, Soil & Crops Division Dept. of Agriculture and Forestry, Charlottetown, P.E.I., (902-892-1267) Mar.75-Mar.78.

Honary Life-time Member

Mr. L.E. Philpotts, 7 Philips Drive, Ottawa, Ontario (613-224-7175) Sept. 75.

5.1.9.1 1975 Projects in Relation to Agriculture Crops and Land Use

Projects Flown by CCRS-1975

Project No.	Requesting Agency	Principal Investigator	General Geographic area	Altitude ASL feet	Camera Format (inches)	Lens (inch)	Film no.	Date Flown	Date Imagery Shipped	Nautical Miles Flown
75-6	Agric.Can.Res. Br.,Ste.Foy	R. Paquin	test sites Montreal to Quebec City	3250	9x9	6.0	2443 IRLS	May 29 Aug 7		42
-7	Agr.Can.,Res. Br.,Ottawa	D. Harcourt	Belleville, Ont.	3900	9x9	6.0	2443 IRLS	June 10	July 4	60
-8	Agr.Can. Res. Br., Ottawa	P.K. Basu	Picton,Wellington Ont.	6600	9x9	6.0	2443 IRLS	July 4	July 30	24
-9	Agr.Can.Res. Br.,Saskatoon	L.S. Crosson	Spring Wheat Test sites, Man,Sask, Alta.	33,000	9x9	6.0	2443 IRLS	July 27	Aug 8	141
-10	Agr.Can.Res. Br.Saskatoon	L.S. Crosson	Outlook, Sask.	33,000	9x9	6.0	2443 IRLS	July 27	Aug 20	28
-13	Agr.Can.Res. Br.Kamloops	A.L.Van Ryswyk	Kananaskis Living- Stone Ranges, B.C. Alta.	36,000	9x9 9x9	6.0 6.0	2443 2448 IRLS PRT5	May 28 July 3 Sept 8	Jun 26 Aug 14 Sept 24	294
-14	Agr.Can.Res. Br.Kamloops,	A.L.Van Ryswyk	Lac du Bois Range, Kamloops,	35,000 12,000 7,000 6,000	9x9 9x9	6.0 6.0	2443 2445 IRLS PRT5	May 26 Jun 9 July 23 Sept 6	Jun 18 July 8 Aug 12 Sept 26	198
-16	B.C. Environ and Land Use B.C.	J.R. Marshall	Kelowna, B.C.	3,000 9,800 25,800	9x9	6.0	2445 IRLS PRT5	May 21	Jun 24	104
-21	Ont.Hart.Res. Inst. Vineland	J.Wiebe	Wellandport, Ont.	.2,000 6,000 IRLS	9x9 9x9	6.0 6.0	2445 2445	July 3 May 16		67
-23	Forestry Wild- life,Edmonton	C.L.Kirby	Banff/Jasper Parks	35,000	9x9 9x9 IRLS PRT5	6.0 6.0	2445 2443	July 3		1332

-25	P.A.R.D. Associates	P.A.R.D. Assoc.	Red Deer,Alta.	9000	9x9 70 70 70 70	6 3 3 3 3	2445 2443 2402 2424	May 28	June 27	4
-28	Agr.Can.Res. Br.,Lethbridge	T.G.Atkinson	Vulcan/Clair-holm,Alta.	32000	9x9 70 70	6 3 3	2443 2424 2405	May 22	June 18	183
-29	Agr.Can.Res., Br.Lethbridge	T.G.Atkinson	Blood Indian Reserve,Alta.	5700	9x9 70 70 70	6.0 3 3 3	2443 2445 2405 2443	May 2	June 16	35
-30	Agr.Can.Res. Br.,Lethbridge	T.B.Sommer-feldt	Clausholm/ Raymond Alta	12,200	9x9	6.0	2443	May 22 July 24 Sept 8	June 20 Aug 8 Sept 24	246
-33	Quebec Univ. (Montreal)	D.Robert	St.Hyacinth	5000	9x9 9x9 IRLS PRT5	6 6	2443 2445	Apr 30	June 2	37
-35	Quebec Univ. (Montreal) (Geography)	Jean Carriere	Montreal	11,100	9x9 9x9 IRLS PRT5	6 6	2443 2445	Apr 30 Aug 5	May 26 Sept 17	148
-41	Ont.Min.Trans and Comm. Toronto	S.Mathur	Strathroy	3,300	9x9 9x9 70 70 IRLS	6 6 3 3 3	2443 2445 2402 2402 2424	May 9 May 10 Jul 30 Jul 31 Oct 22	June 9 June 9 Aug 29 Aug 29	600
-45	B.C. Univ. Vancouver	R.P. Wellington	North Van-couver	6,000 31,000	9x9 9x9 9x9	6 6 6	2443 2445 2405	Sept 5/6		1237
-47	Man.Dept of REM	B.Banntyne	South-. eastern Manitoba	36,000	9x9 70 70 70 70	35 3 3 3 3	2443 2445 2405 2424 2445	Jul 28	Aug. 4	491

75-52	Sask.Res. Council Saskatoon	S.H.Whitaker	Estevan,Rockglen Cypress Hills	33,000	9x9	3½	2443	Jul 11	Aug 22	80
-58	Alta.Inst. of Pedology Edmon.Alta.	T.W.Peters	Fort Saskat- chen	7250 19,250 36,000	9x9 70mm 70mm 70mm 70mm IRLS PRT5	3½ 3 3 3 3	2443 2405 2405 2424 2425	Jul 8	Aug 1	758
-59	Waterloo Regional Mcply	J.D.Pawlivy	Grand River, Kitchener Waterloo	4,000	9x9 9x9 IRLS PRT5	6 6	2443 2445	Incomplete		80
-63	Sask. Res. Council	W.A.Meneley	Sask.Potash sites	23,000	9x9 9x9	6 3.5 IRLS PRT5	2445 2443	Jul8-11 Jul 26	Aug 12 Aug 12	162
74-64	Sask.Res. Council	W.A.Meneley	Little Red River Reserve	22,750	9x9 9x9 IRLS PRT5	6 3.5	2445 2443	Jul 8 Jul 26	Aug 12 Aug 12	60
-65	Sask.Res. Council	E.A.Christ- ianson	Fort Qu'Appelle		9x9 9x9 IRLS PRT5	6.0 3.5	2445 2443	Jul 11 Aug 26	Aug 12 Aug 12	21
-68	Dept. of Ind. & Northern Affairs	D.J.Lenning	Wood Buffalo National Park	30,000	9x9 9x9 IRLS PRT5	3,5 6.0	2443 Jul 9	Jul 2 Aug 21	Jul 31	1912
-75	Guelph Univ.	E.E. Mackin- tosh	Rushing River Prov. Park	2300	9x9 9x9	6.0 6.0	2443 2445	Aug 8	Sept 18	3

- 77	Man.Dept. of Agric.	L.Cotton	Caberry/ St.Laurent	6000 36,000	9x9 9x9 70 70 70 70	3.5 6.0 3 3 3 3	2445 2445 2405 2405 2424 2443 IRLS	Sept 25	Oct.14	76
-90	N.B.Dept. of Agric.	P.N.Mosher	St.John River Valley	34,000	9x9 9x9 IRLS	6.0 3.5	2443 2445	Sept 1	Sept 24	219
-101	Yukon Lands & Forests	R. Desroches	Yukon settle- ments, NWT	10,000 10,500 11,000	9x9 9x9 IRLS	6 6	2443 2445	Sept 22	Oct 8	988
-105	DOE Canadian Wildlife Ser- vice	J.B.Kemper	Peace River Alberta	14,000	9x9 9x9 IRLS	6 6	2443 2445	Sept 21	Oct 8	88
-110	Agr.Can.Res. Br. Ste.Foy Quebec	R.Paquin	Montreal/ Quebec test sites	20,500	9x9 9x9 IRLS	6 6	2443 2445	Oct3		36
-111	Edmon.Region- al Planning Commission	L.E.Milton	Edmonton area	33,300	9x9 9x9 IRLS	6 6		Sept 24	Oct 9	406

5.2 REPORT OF THE WORKING GROUP ON ATMOSPHERIC SCIENCES

5.2.1 Airborne Sensing Program

Once again there appeared to be an increase in the use of airborne facilities by the atmospheric sciences community in Canada during the past year although the increase involved aircraft facilities outside CCRS. Although none of these activities was coordinated via the Working Group, information and encouragement provided by the members has continued to stimulate interest in the use of aircraft to support Atmospheric Research. The Working Group received a briefing from INTERA/INNOTECH on the new arrangements for the CCRS Aircraft Facilities and although it was decided that no formal action by the Working Group was required, representatives of the companies agreed to visit AES headquarters to obtain information on possible involvement in immersion sensing of the atmosphere.

5.2.2 Spaceborne Remote Sensing

There has been a marked increase in the use of operational meteorological satellite data by the Canadian Atmospheric Services. This has resulted from an improvement in the direct read-out facilities operated by universities and the Federal Government and an increase in the resources available to exploit this information. This increased interest in spaceborne observing systems is expected to continue and grow with the development and deployment of more advanced sensor systems scheduled for future operational meteorological satellites in the TIROS-N Series.

There is continued interest in the U.S. atmospheric research satellites of the NIMBUS and Explorer series. Dr. Carl Mateer, AES, has been selected as a member of the Solar Backscattered Ultraviolet and Total Ozone Mapping System (SBUV/TOMS) NIMBUS-G Experiment Team and Dr. Gordon Sheperd of York University is a co-investigator in the Atmospheric Explorer program. In addition, several Canadian scientists are involved in development of techniques to integrate aerological information obtained from NIMBUS sounding systems in operational objective analysis programs in preparation for the operational deployment of similar sounding systems on TIROS-N.

There has also been a marked increase in activities related to the effects of the atmosphere on remote sensing of the earth's surface from space. Several groups, both within government and universities, have initiated or proposed research programs in this important area. The Working Group considers that this is a very important area and has decided to support the type of research by actively supporting these programs. At the time of going to press, the CACRS Working Group on Atmospheric Sciences, and the AES Panel on Remote Sensing are planning a joint Workshop on the Effects of the Atmosphere on Remote Sensing of the Earth's Surface. It is hoped that the workshop will provide a forum where a wide spectrum of atmospheric scientists will be able to discuss the problems of atmospheric effects on spaceborne remote sensing with a group of scientists from other disciplines who employ remote sensing techniques in their research. Although final details are not available at this time, CACRS Working Group Chairmen will be advised of the arrangements for participation in the Workshop as soon as possible.

5.2.3 Technical Developments

At the present time most of the Canadian technical development programs in remote sensing for atmospheric sciences are in the areas of ground-based and balloon-borne systems, although significant progress has been made in the development of real-time digital image processing system for meteorological satellite data. Several Canadian Universities, Toronto, York, Western and others, are actively engaged in surface-based atmospheric sounding programs using both electromagnetic and acoustic systems. Much of this effort is being directed towards interpretation of the data as well as developing hardware. The AES, in cooperation with Canadian Universities and industry and the National Center for Atmospheric Research (USA) released a series of stratospheric balloons during the summer of 1975. These balloons carried both immersion and remote sensing devices to measure trace atmospheric constituents involved in the chemistry of the ozone layer. Both the AES and the University of Alberta introduced real-time digital processing systems for scanning radiometer data from NOAA I-TOS satellites. The AES system was designed for the HRPT service and the University of Alberta system for the APT service. Although both are primarily designed to support weather prediction systems for both operations and research, the ability to provide tailored processing for a wide range of applications has increased interest from other scientific disciplines.

5.2.4 Applications and Benefit Analysis

There are no cost-benefit analyses under way at the present time that involve the Working Group on Atmospheric Sciences. The CCRS study on remote sensing applications for hydrology is concerned with precipitation measurement and prediction but the members consider that meteorological input to this study should be obtained directly from the AES.

5.2.5 User Liaison

The Atmospheric Sciences Working Group has not attempted to take an active role in this area during the past year.

5.2.6 Training

No special training programs were carried out in the past year.

5.2.7 Conclusions and Forecasts

The Working Group has continued to feel that it is sometimes confused with a specialty centre for AES. It is to be hoped that the meeting between senior management of CCRS and AES held in 1975 will clarify the position of the Working Group and allow it to concentrate on encouraging the development of remote sensing applications in Atmospheric Sciences.

5.2.8 Recommendation

The Working Group recommend that CCRS request AES to set up a specialty centre or equivalent for AES to report on AES activities in remote sensing in support of its programs and thus leave the Working Group free to concentrate on remote sensing in the Atmospheric Sciences.

5.2.9 Appendix I

MEMBERS OF WORKING GROUP ON ATMOSPHERIC SCIENCES

Dr. C.L. Mateer, Atmospheric Processes Research Branch, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4

Mr. E.G. Morrissey, Meteorological Services Research Branch, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4.

Prof. A.I. Carswell, Department of Physics, York University, 4700 Keele Street, Downsview, Ontario.

Mr. W.L. Clink, Atmospheric Instruments Branch, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4.

Mr. John H. Davies, Manager, Barringer Research Ltd., 304 Carlingview Drive, Rexdale, Ontario.

M. Michel Ferland, Service de la Météorologie, Direction générale des Eaux, Ministère des Richesses Naturelles, 1640 Boulevard de l'Entente, Québec 6, P.Q.

Prof. K.D. Hage, Department of Geography, University of Alberta, Edmonton, Alta.

Mr. L. Shenfeld, Air Management Branch, Ontario Dept. of Energy & Resources Management, 880 Bay Street, Toronto, Ontario.

Dr. H.E. Turner, Air Quality & Inter Environmental Research Branch, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4.

Prof. Charles Young, Dept. of Physics, University of New Brunswick, Fredericton, N.B.

Dr. W.F.J. Evans, Atmospheric Processes Research Branch, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4.

5.3 REPORT OF THE WORKING GROUP ON CARTOGRAPHY AND PHOTOGRAMMETRY

5.3.1 Airborne Remote Sensing

Super Wide-Angle Photography

Super wide-angle photography is used routinely in the production of 1:50,000 mapping at photo scales of 1:50,000 since this permits the use of piston driven aircraft, however, small scale (1:150,000) super wide-angle photography has not been available for mapping purposes in Canada (prior to 1976). Sample photography over the test range in Arizona provided by the Lear Jet Corporation, and over an Ottawa range by CCRS, has shown that such photography can be used for 1:50,000 map compilation although limitations exist in the contouring of "flat" terrain and in the interpretation of some urban detail.

5.3.2. Spaceborne Remote Sensing

5.3.2.1 SKYLAB

SKYLAB-EREP provided an experimental, short-term, multisensor series of earth images that afforded hard-copy photographic products with a wide range of ground resolutions. The S190A and S190B imagery was tested for cartographic applications in the Canadian national mapping program, particularly for planimetric mapping at scales of 1:50,000 and 1:25,000. Because earth sensing passes were limited in number, the samples acquired over Canada were relatively small and fragmented. However, sufficient imagery was obtained to permit a comprehensive study involving six separate investigations.

Planimetric Accuracy

The position of forty-seven photo-identifiable road intersections were measured on two successive photographs of the 190A camera system in a Wild STK-1 stereo comparator. These were compared with UTM coordinates derived from 1:50,000 maps for the same points. A 2-dimensional transformation resulted in RMS residuals of 35-40. The lowest residuals (25 m RMS) were obtained as a result of a 3-dimensional transformation.

Horizontal Control Extension

Four strips of 4 models each were studied; two black and white and one colour strip from the 190A camera and one colour strip from the 190B camera. The internal accuracy of the strips was very good and compared favourably with conventional aerial photography. The RMSE at check points ranged from 35 m for the 190A black and white to 86 m for the 190A colour. The RMSE at image scale was about the same for both colour strips, but, because of the larger scale of the 190B coverage the RMSE at ground points in that strip was in the range of 16 m - 32 m.

The Potential of Employing S190 Imagery as Control for High Altitude Aerial Photography

It was found that the combination of SKYLAB photography with up to 24 high altitude photographs did not significantly improve accuracies in X, Y, and Z when using polynomial transformation adjustments. However, an improvement of 20-25% in results was obtained from one test that utilized a more comprehensive "ray bundles" adjustment.

Qualitative Evaluation

Examination of the six film types used in the 190A camera system established that for recording mapping detail from this altitude, Pan-X aerial black and white (SO-022) in the band width 0.6 to 0.7 μm was the most reliable. The aerial colour (SO-356) was good, but no better than the black and white for mapping purposes.

Revision Potential

Map revision for new major roads and powerlines in non-urban areas was found to be possible with both 190A and 190B photographs for 1:250,000 maps. The resolution of the 190B camera was not sufficient for the photographs to be used for 1:50,000 map revision but they proved good indicators of where revision was required.

Photomapping Potential

The 190B camera system of SKYLAB provided excellent photographic products for the production of 1:250,000 photomaps although coverage was so limited that no standard sheet could be prepared.

5.3.3 Technical Developments

5.3.3.1 Wide-Angle Aerial Photography

The use of a 600 nm filter for small scale mapping photography in low-contrast terrain areas was instituted in 1975. Although there are apparent contrast improvements in these areas, some difficulties were encountered in that single flight missions often contained both high contrast mountainous terrain as well as low contrast forest or tundra areas and airborne filter changes were not practical. The resulting photography in mountainous areas with the 600 nm filter did not show any apparent loss of shadow detail due to the filter, but no controlled tests were available.

5.3.4 Applications

Positioning Offshore Features With LANDSAT Imagery

In the compilation of new 1:50,000 maps in the Ungava region of Quebec LANDSAT imagery provided the best available information for the position of a group of offshore shoals. Based on residuals at control points it is considered that the positions derived in this manner have an RMSE of 40 to 50 m. Four LANDSAT images were used in the determination of the position of the shoals.

Revision

LANDSAT images are used as a routine source of information for map revision information in the production of topographic maps.

5.3.5 Conclusions

Cartography and photogrammetry depend on the use of metric cameras and these to date have been restricted to airborne missions. Refinements in photogrammetry are therefore based on airborne systems at present. SKYLAB and LANDSAT have provided a new source of information for map revision but neither would totally replace traditional methods, even in their optimum operation.

Photogrammetric applications for LANDSAT and SKYLAB products that have been tested to date all reflect the same shortcomings - that of poor identification of control points which limits their use to 1:250,000 mapping or smaller if normal map accuracy standards are to be met.

5.3.6 Recommendations

To make a spaceborne imagery useful to photogrammetry, methods of targeting and transferring ground positions with a higher degree of accuracy than is currently being achieved is required.

5.1.9 Appendices

I Current Bibliography

Stewart, R.A., "Mapping From Satellite Photography", Presented to the Commonwealth Survey Officers Conference 1975.

Stewart, R.A., "Investigation of Selected Imagery From SKYLAB/EREP S190 System For Medium and Small Scale Mapping", Presented to the ASP-ACSM Convention, Phoenix, October 1975.

Fleming, E.A., "Canadian Mapping Use of LANDSAT Imagery", Presented to the 10th International Symposium on Remote Sensing

of Environment, Ann Arbor, October 1975.

II List of Members

Chairman, Dr. J.M. Zarzycki, Surveys and Mapping Branch, 615 Booth Street, Ottawa, Ontario, K1A 0E9.

Secretary, Mrs. E.A. Fleming, Surveys and Mapping Branch, 615 Booth Street, Ottawa, Ontario, K1A 0E9.

5.4 REPORT OF THE WORKING GROUP ON DATA HANDLING AND SATELLITE TECHNOLOGY

5.4.1 Introduction

Three meetings of the full working group have been held since the last CACRS meeting. Only the sub-working group on Data Handling, Recording and Image Enhancement Techniques held separate meetings throughout the year. The working group has taken on the responsibility of monitoring developments in the high density digital recording field, for long term archiving of the vast volumes of data acquired using remote sensing technology. The working group, in conjunction with the sub-working group on Microwave Sensors, of the Sensor Working Group, hopes to sponsor a workshop on Synthetic Aperture Radar in the fall of 1976.

5.4.2 Canadian Participation in Remote Sensing Satellite Programs

In 1976, the sub-working group on Canadian Participation in Remote Sensing Satellite Programs plans to consider the impact of the Space Shuttle as a potential launch vehicle for future Canadian Remote Sensing Satellites. No separate meetings were held during 1975.

5.4.3 Data Handling, Recording and Image Enhancement Techniques

The sub-group held a number of meetings throughout the year. Considerable effort was expended in gathering and presenting data on new recording technology to the group. The general conclusion is that while there are some very interesting experiments being conducted in industrial and university laboratories throughout the world, it will likely be at least three years before any of the techniques are sufficiently developed in a commercial sense to permit replacement of the high density magnetic recorders now used universally for collection of image type remote sensing data. The sub-group intends to keep abreast of advanced recording technology in order to alert CCRS to take an active roll in its development for remote sensing applications, bearing in mind that action must be taken by 1978 in order to implement a system suitable for EOS in 1980.

The sub-working group has discussed the needs for a low-cost digital interactive analysis system. It was agreed that a colour interactive display is the key to such a system, that a standard television display is adequate for the purpose, and that the system cost must be in the order of $50,000 to gain wide acceptance.

5.4.4 Data Retransmission

The Department of Communications has conducted studies on user requirements for data collection using a proposed UHF satellite. TELESAT has countered with a proposal using its communication satellites to meet these user needs. To date, no decision has been made. Users in Canada are experimenting with data transmission facilities of SMS/GOES. The units supplied by Bristol for the Beaufort Sea Project have been certified by U.S. authorities and no problems have been reported. The convertible units produced by Ball Bros. have not communicated data successfully via SMS/GOES although they do operate satisfactorily with LANDSAT.

5.4.5 Synthetic Aperture Radar Workshop

Together with the Microwave Sensors sub-working group of the Sensors Working Group, the Working Group on Data Handling and Satellite Technology plans to hold a three day workshop to familiarize Canadian scientists with the technology, data processing problems and applications of SAR systems. The tentative workshop outline is as follows:

Day 1	Principles of SAR and technical problems
	Digital and Optical Processing Fundamentals
Day 2	Detailed Examination of Digital Processing
	Panel discussion

Day 3 Applications of SAR data

Panel discussion and tours of CCRS facilities.

The workshop was originally scheduled for the fall of 1975. However, it was postponed for one year until the issue of Canada's participation in the SEASAT program is clarified.

5.4.6 EOS/LANDSAT-D

At present, EOS/LANDSAT-D is being planned by NASA as the follow-on program to the present LANDSAT series. As presently envisaged, this satellite will have more spectral bands, higher resolution, and much higher data rates. In order to assist in Canada's planning for participation in this program, the Working Group intends to focus on the technical problems which must be solved in order to record, process, disseminate and analyze the data from this satellite. The group hopes to develop a preliminary systems specification for the ground element of this satellite program.

5.4.7 Recommendations

The first of the following recommendations is viewed by the Working Group as being of the highest priority. No priority was assigned to the others.

5.4.7.1 CCRS should actively support proposals to Cabinet and/or Treasury Board for a microwave sensor systems development program as an essential prerequisite for the future Canadian airborne and satellite remote sensing systems.

5.4.7.2 Specific funded studies should be undertaken to examine the impact of the Space Shuttle as the future launch vehicle for remote sensing satellites.

5.4.7.3 Studies should be funded to investigate the possibilities for bilateral programs between Canada and other nations for the development of remote sensing satellites.

5.4.7.4 CCRS should take steps to ensure that a low-cost ($50,000) image analysis terminal is developed for analysis of digital remote sensing data in order to encourage wider use of digital products and techniques in the user community.

5.4.7.5 A new technology CACRS working group should be formed: "Working Group on the Use of Remote Sensing CCT Data". This group would be concerned with data formats and exchange of analysis techniques. In the interest of coordinating the software and hardware developments projected for the future, close liaison should be maintained between this new group and the Working Group on Data Handling and Satellite Technology.

5.4.8 Working Group Members (1975)

Dr. W.M. Strome (Chairman)
Chief, Applications Division,
Canada Centre for Remote Sensing,
Dept. of Energy, Mines & Resources,
717 Belfast Road,
Ottawa, Ontario, K1A 0E4.
Tel. (613)-995-9916

Dr. R. E. Barrington,
Communications Research Centre,
Communications Department,
P.O. Box 490, Terminal "A",
Shirley Bay,
Ottawa, Ontario, K1N 8T5.
Tel. (613)-996-7051 (ext. 395)

Mr. M.N. Cobb,
CASD,
Environment Canada,
Place Vincent Massey,
Ottawa, Ontario, K1A 0E7.
Tel. (819)-997-3946

Dr. J.N. de Villiers,
Data Acquisition Division,
Canada Centre for Remote Sensing,
Dept. of Energy, Mines & Resources,
2464 Sheffield Road,
Ottawa, Ontario, K1A 0E4.
Tel. (613)-998-9060

Dr. Martin Fournier,
Department de Genie Electrique,
Faculte des Sciences,
Universite Laval,
Ste-Foy, Québec, G1K 7P4.
Tel. (418)-656-3556

Dr. D.G. Goodenough,
Applications Division,
Canada Centre for Remote Sensing,
Dept. of Energy, Mines & Resources,
717 Belfast Road,
Ottawa, Ontario, K1A 0E4.
Tel. (613)-995-9916

Dr. John Graham,
Program Manager,
SPAR Aerospace Products Ltd.,
825 Caledonia Road,
Toronto, Ontario, M6B 3X8.
Tel. (416)-781-1571

Dr. J.W. Locke,
Institute for Aerospace Studies,
University of Toronto,
4925 Dufferin Street,
Downsview, Ontario, M3H 5T6.
Tel. (416)-667-7716

Dr. A. Kavadas,
Space Engineering Division,
University of Saskatchewan,
Saskatoon, Sask., S7N 0W0.
Tel. (306)-244-0976

Dr. Jaan Kruus,
Coordinator, Satellite & Airborne Sensing,
Science Policy Branch,
Environment Canada,
Ottawa, Ontario, K1A 0H3.
Tel. (819)-997-3766

Dr. J.S. MacDonald,
MacDonald, Dettwiler & Associates,
2812 West 12th Avenue,
Vancouver, B.C., V6K 2N4.
Tel. (604)-732-8823

Dr. F.J.F. Osborne,
RCA Montreal Limited,
Ste. Anne de Bellevue, P.Q.,
H9X 3L9.
Tel. (514)-457-9000

Dr. E. Shaw,
Chief, Data Processing Division,
Canada Centre for Remote Sensing,
Dept. of Energy, Mines & Resources,
2464 Sheffield Road,
Ottawa, Ontario, K1A 0E4.
Tel. (613)-993-3350

Mr. C.I. Taggart,
Atmospheric Environment Service,
Environment Canada,
4950 Dufferin Street,
Toronto, Ontario, M3H 5T4.
Tel. (416)-667-4813

Mr. J.D. Taylor,
Canadian Astronautics,
39 Bellmews Plaza,
Highway 7,
Bells Corners,
Ottawa, Ontario.
Tel. (613)-722-9571

Mr. S. Washkurak,
Geological Survey of Canada,
Dept. of Energy, Mines & Resources,
601 Booth Street,
Ottawa, Ontario, K1A 0E8.
Tel. (613)-994-9367

Mr. Fred Potts,
Computing Devices of Canada Ltd.,
P.O. Box 8508,
Ottawa, Ontario, K1G 3M9.
Tel. (613)-596-4862

5.5 REPORT ON DATA RETRANSMISSION

This working group was disbanded in 1971, but in view of the continuing and, indeed, developing interests expressed by the Hydrology Working Group, there is a requirement for some committee to serve as a focus for such activities. CACRS assigned the responsibility for technical developments to the Working Group on Data Handling and Satellite Technology.

5.6 REPORT OF THE FORESTRY, WILDLIFE AND WILDLANDS WORKING GROUP

5.6.1 Airborne Remote Sensing

Aerial photography still prevails as a remote sensing tool for forestry, wildlife and wildland management. The emphasis is on applications, including the use of radar altimetry and large-scale airphoto sampling in provincial forest inventories, biophysical or integrated resource surveys (including urban forestry projects) based on airphoto interpretation combined with ground investigations, and animal enumerations and breeding habitat assessments of snow geese and Beluga whales.

5.6.2 Landsat and other Satellites

A comprehensive summary of Canadian Landsat related endeavours in forestry and wildland inventory and management, was provided at the Tenth International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, 1975. In wildlife applications there are some promising experiments in the use of sequential satellite imagery as an aid in assessing the snow geese breeding potential of inaccessible northern areas.

5.6.3.1 Technical Developments in Interpretation

The trend towards more research into interpretation of digital Landsat data continued, and was broadened by the inclusion of field spectroradiometry of trees. A summary of present achievements in these endeavours was presented and discussed at the last annual meeting of the Working Group.

Canadian activities in the orthophoto and stereo-orthophoto research and applications parallel increased interest in these mapping techniques by developing countries for resource exploration and management. This situation is a welcome catalyst to further progress.

Details on the above matters are in the Forest Management Institute report (7.3).

5.6.3.2 Sensor Development

Tests with a laser profilometer, which gave good results in early trials, will be continued.

5.6.4

5.6.5 User Liaison and Training

The Third Canadian Symposium on Remote Sensing in Edmonton, and particularly the (first Canadian) Workshop on Remote Sensing of Wildlife in Quebec City, were well attended highlights of the year, to which members of the Working Group contributed as organizers and by delivering papers. In addition, several papers on forestry, wildlife and wildlands were presented at remote sensing conferences and meetings in North America and Europe.

Under CIDA auspices, contacts in resource mapping and remote sensing with Indonesia were strengthened by the presentation of lectures and demonstrations at the UN/FAO Regional Training Seminar on Remote Sensing Applications held in Jarkarta during November 1975. Similar contributions were also made in Canada, where several remote sensing training sessions were held for audiences with interests in integrated surveys, e.g. in Whitehorse, Halifax, Joho National Park H.Q., Lawrencetown, Edmonton, Calgary and other places.

The Canadian Forestry Service film "The Forest Watchers", on remote sensing applications in forest management, was completed by the National Film Board. It has been shown in a number of places, and can be obtained on loan from the Canadian Forestry Service Information Services in Ottawa.

5.6.6 Conclusions and Recommendations

The annual meeting of the Working Group, held in Ottawa October last, showed clearly that the Group is alive and keenly interested in continuing its integrated approach to remote sensing research and applications to the benefit of forestry, wildlife and wildland management.

There exists a notable awareness that electronic image processing has reached a stage where it can usefully assist in broad resource inventories of less explored regions of developing countries. This situation has led to further research in interpretation methods and in the supporting basic studies of reflectance characteristics. Progress in automated mapping and orthophoto developments also are followed by practitioners in various fields and results will be applied as soon as possible. These considerations are reflected in the recommendations submitted by the Forestry, Wildlife and Wildlands Working Group to the 1976 CACRS meeting.

5.6.6.1 Information Program

Information on new developments in space programs, readout stations, NASA activities, data on new sensors and the results of experiments carried out with such sensors by CCRS and other collaborators, should be given wider distribution in the remote sensing community. It is further recommended that the CCRS newsletter be strengthened to promote the dissemination of such information.

5.6.6.2 International Program

Canada should continue to work towards a clear policy on its international position regarding remote sensing with a focus on the problems associated with the acquisition and dissemination of satellite imagery.

The Canadian remote sensing community should encourage:

a) the training in developing countries to improve the ability to use new technology;

b) participation in studies to determine the feasibility of establishing data receiving facilities, storage and distribution centres;

c) development, manufacture and marketing of internationally competitive equipment for receiving and processing imagery.

The Canadian Advisory Committee on Remote Sensing should create a working group to report on international developments in remote sensing. The working group should be concerned with assembling information on data needs of various disciplines, the provision of data to meet these needs, the dissemination of such information among the remote sensing community, the transfer of technology to developing countries, training and international regulations concerning the use of satellite data.

5.6.6.3 Technical Program

The CCRS should provide an expanded digital image interpretation service to meet a rapidly increasing demand which in a year or two is likely to be four or five times what it is today. An expanded service should not only include a greater accessibility to equipment at the CCRS but also the establishment of regional distribution of facilities through terminals or regional centres.

A remote sensing aircraft capable of reaching altitudes of 70,000 feet, should be available under operational auspices of the CCRS. This vehicle should carry:

a) a highly calibrated photogrammetric camera;

b) multispectral cameras for interpretation purposes;

c) multispectral scanners;

d) thermal and radiometric sensors;

e) flight data logging capability including navigation data.

The CCRS continue to encourage initiatives in the development of direct links between digital equipment and resource data banks such as the CGIS to improve the effective and timely use of the large quantity of information generated by automated interpretation systems.

Methods should be developed and implemented to correct Landsat data for atmospheric effects in order to facilitate single-date and multi-date digital image analysis.

5.6.7.1

5.6.7.2 Appendix I - Selected 1975 Canadian Publications: Forestry, Wildlife and Wildlands

Alföldi, T.T. and Beanlands, G.E. 1975. Towards an operational resource inventory of coastal regions. (1)

Bajzak, D. 1975. Interpretation of flooding damage to trees in the main reservoirs Churchill Falls, Labrador. (1)

Beaubien, J. and Jobin, L. 1975. High-altitude colour-IR photographs for evaluating spruce budworm damage in Quebec. (1)

Blokpoel, H. 1975. Radar studies of air-borne bird movements. (2)

Boissonneau, A.N. and Jeglum. J.K. 1975. A regional level of wetlands classification suitable for interpreters using LANDSAT-1 Imagery. (1)

Chilar, J. 1975. CCRS image analysis equipment with special reference to wildlife counts and habitat mapping. (2)

Gierman, D., Switzer, W., Moran, G. and Ryerson, R. 1975. Remote sensing and the Canada geographic information system for impact studies. (1)

Heyland, J.D. 1975. Increase the accuracy of your airborne censuses by means of aerial photographs. (2)

Heyland, J.D. 1975. Monitoring arctic-nesting goose productivity by means of satellite imagery. (1)

Kalensky, Z. and Scherk, L.R. 1975. Accuracy of forest mapping from Landsat computer compatible tapes. (3)

Kalensky, Z. and Wilson, D.A. 1975. Spectral signatures of forest trees. (1)

Kerbes, R.H. 1975. Use of current satellite imagery to predict the nesting success of lesser snow geese. (2)

Kirby, C.L., Day, D., van Eck, P. and Goodenough, D. 1975. LANDSAT imagery for Banff and Jasper National Parks inventory and management. (1)

Lavigne, D.M. and Falconer, A. 1975. A role for Landsat Data in the ecological mapping of the Canadian Arctic. (2)

Lavigne, D.M. 1975. Use of ultraviolet photography in remote sensing pagophilic seals. (2)

Lee, P.G. and Hocking, D.F. 1975. Remote sensing and the Syncrude development. (1)

Lee, Y.J. 1975. How reliable is LANDSAT imagery in estimating clear-cut areas? (1)

Mollard, J.D. 1975. The integrated use of different aerial remote sensors and available map data in making engineering and environmental studies of terrain. (1)

Murtha, P.A., MacDonald, R. and Watson, K. 1975. Mapping of forest clear-cutting, South Vancouver Island from LANDSAT-1 Imagery. (1)

Peet, F.G. 1975. Digital image processing at the Forest Management Institute. (2)

Peet, F.G. 1975. A technique for locating ground calibration data on Image 100 output. Forest Management Institute, Ottawa. Information Report FMR-X-84.

Reimchen, T.H.F. 1975. Physical geology using aerial photographs, Banff and Jasper National Parks. (1)

Sayn-Wittgenstein, L. and Wightman, J.M. 1975. Landsat applications in Canadian Forestry. (3)

Thompson, K.P.B. 1975. Balloon remote sensing. (2)

Valentine, K.W.G. and Hawkins, J. 1975. A quantitive comparison of colour photography and LANDSAT imagery for a small scale land resource map of northern British Columbia. (1)

Williams, P. 1975. Small format airborne camera system and associated studies. (2)

Winquist, E. and Jackson, C. 1975. The monitoring of timber harvesting and forest fires in Alberta. (1)

(1) To be published in the Proceedings of the Third Canadian Symposium on Remote Sensing, Edmonton, Alberta, 1975.

(2) To be published in the Proceedings of the Workshop on Remote Sensing of Wildlife, Quebec City, P.Q., 1975.

(3) To be published in the Proceedings of the Tenth International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, 1975.

5.6.7.3 APPENDIX III

FORESTRY, WILDLIFE & WILDLANDS WORKING GROUP

Chairman:
Dr. L. Sayn-Wittgenstein
Forest Management Institute
Canadian Forestry Service
Department of the Environment
396 Cooper Street
Ottawa, Ontario K1A 0H3

Secretary:
Mr. A.A. Buys
Forest Management Institute
Canadian Forestry Service
Department of the Environment
396 Cooper Street
Ottawa, Ontario K1A 0H3

Mr. J.D. Heyland
Quebec Wildlife Service
Edifice de la Faune
P.O. Box 7276
Quebec 7, P.Q.

Mr. J.B. Bruce
Inventory Division, Forest Service
Department of Lands, Forests and
Water Resources
Victoria, B.C. V8V 1X5

Dr. A.H. Aldred
Forest Management Institute
Canadian Forestry Service
Department of the Environment
396 Cooper Street
Ottawa, Ontario K1A 0H3

Mr. V. Zsilinszky
Ontario Centre for Remote Sensing
4th Floor, 801 Bay Street
Toronto, Ontario

Mr. B.M. Smith
Forest Branch
Department of Natural Resources
Room 549, Centennial Building
Fredericton, N.B.

Dr. J. Cihlar
Canada Centre for Remote Sensing
717 Belfast Road
Ottawa, Ontario K1A 0E4

Professor G. Ladouceur
Faculté de Foresterie
Université Laval
Quebec 10, P.Q.

Mr. Jean Thie
Lands Directorate
Department of the Environment
20th Floor, Place Vincent Massey
Hull, Quebec K1A 0H3

Mr. R.W. Roberts
Canadian International Development Agency
Jackson Building
122 Bank Street
Ottawa, Ontario K1A 0G4

Mr. Parker Williams
Integrated Resources Photography Ltd.
P.O. Box 2278
Vancouver, B.C.

Professor J. Vlcek
Department of Civil Engineering
University of Toronto
35 St. George Street
Toronto, Ontario M5S 1A4

5.7 REPORT OF THE GEOGRAPHY WORKING GROUP

5.7.1. Airborne Remote Sensing

Once again the group is pleased to report its satisfaction with the airborne operations of C.C.R.S. No adverse reports of performance by the contractor nor complaints about products were received by any group members and it seems that another successful year of operations must be recorded. After considerable debate the group decided that the list of projects designated as geography should be omitted from this annual report and included in a consolidated listing of projects flown during the year. A major reason for this decision was the difficulty of defining projects which were solely geographical and the growing feeling that all projects are in part geographical.

There was unanimous agreement that the information bulletin produced by the airborne section was excellent and should be the model for similar bulletins by all sections of C.C.R.S. so that the real value of C.C.R.S. efforts can be assessed. The group wishes to commend this particular publication and underline its usefulness, comprehensive nature and attractive format. It is an effective document for communication with users at all levels of sophistication and is therefore unique in the range of materials produced by C.C.R.S.

The group is favourably impressed with the provision of 5" format scanner imagery density sliced for different thermal levels and welcomes this new option for users. The position corrections which have been incorporated are equally welcomed. Congratulations are due to Maj. McLaren for his excellent and practical approach to utilisation of the airborne sensors and the work done in detecting heat loss and insulation problems for several demonstration areas. This work also provides a model which other C.C.R.S. units would be well advised to emulate.

Experiments with the use of balloons as platforms for sensor work appear to be practical and a great advantage for certain types of study. The working group is impressed by the speed with which this new technique has been evaluated and looks forward to its implementation as a user service in the near future.

The lack of any appropriate communication about pricing policy has caused the working group great concern. It remains clear that remote sensing needs a great deal of applications development. This cannot be achieved unless funded research in this area is permitted. Only a policy of research time dedicated to applications development seems consistent with the aims of C.C.R.S. Whilst the group supports the ultimate aim of cost recovery in the airborne programme it wishes to stress the importance of a balanced development to this end and stresses the importance of funded research and development so that real progress in introducing this technology to end users can be made. Too rapid an introduction of cost recovery may damage the current achievements of the airborne remote sensing unit and cause major problems for C.C.R.S. in the implementation of its mandate. There appears to be an obvious and regrettable gap between the excellent work performed by the airborne division and the indifferent bureaucracy which surrounds it. This requires urgent attention.

The provision of low cost structures for first time users requires careful re-evaluation. The aim of this policy is commendable. It seems logical that a first time user who utilises the time lapse property of remote sensing requiring a small amount of imagery in each of three successive years can be a valuable contributor whereas a first time user who does not fully understand what is being done may also gather imagery over a large area at low cost, and produce no worthwhile results. In such a situation the former investigator may incur greater costs than the latter although he will produce greater return and involve C.C.R.S. in less work and cost. In effect this penalises the more effective user and encourages the inappropriate or wasteful use of resources. The policy could be revised so that approved projects (rather than simply first time users) qualify for the reduced rates. Approved projects would then be those judged to be effective contributions to the development of remote sensing in Canada and could extend over three or four seasons until the project was completed, rather then be subject to the uncertainties of pricing policy on a random annual basis which can seriously affect projects with a budget which has been established to span a number of years. Such a careful evaluation is needed and an effective communication with user groups and working groups might even prove to be advantageous in this evaluation as these groups include investigators who are not necessarily able to generate their budgets at the whim of federal bureaucrats but who often require real knowledge, insight and demonstrated cost effectiveness in order to implement their projects.

5.7.2. Spaceborne Remote Sensing

The double name for LANDSAT/ERTS is something of an unnecessary irritation in dealing with a user community which was slowly becoming interested in remote sensing through a growing knowledge of the ERTS programme. The ultimate irony now is that to introduce users to the LANDSAT programme the most effective document in the ERTS data users handbook! Confusion abounds in the failure of C.C.R.S. to inform users of its policy on the renumbering of all recorded images to a system which does not conform to the numbering system used in the U.S. thus compounding the difficulties of ordering scenes from both systems.

User services remain of low quality. Experiences during the past year include the provision of an outdated catalogue and a "do-it-yourself" reply to an enquiry about imagery for a given area. This enquiry was preliminary to a major order. Requests for colour-matched imagery for mosaicing purposes resulted in the provision of images which included frames on which clouds were pink, other frames on which clouds were blue and others on which clouds were green. Enlargements continue to include scratches, hairs and dust. Orders for images carefully selected from ISISFISCHE are met with the response that the images are not in the system, or "not yet processed" or "available soon" and no further action for several months. One series of orders for a major study was processed during a malfunction of the inventory computer and images ordered from the catalogue listing as being of high quality were referred back because they were said to be unavailable. The cost of this in real dollars spend on inferior and substitute imagery was great. No attempt was made to rectify this situation or to provide the appropriate imagery in place of that which had been substituted.

C.C.R.S. still does not provide a simple statement of the LANDSAT programme nor of the value and use of the image products. Requests from potential users to working group members still require a great deal of personal effort and there is no effective way of referring such inquiries to an appropriate information officer or of providing literature comparable to the information bulletin of the Airborne Operations unit. This situation was recently summarised well by a response from the user service who referred a request to the browse file. After becoming somewhat confused in attempting to answer the question the respondent stated that the best solution was for the enquirer to stop by at 717 Belfast Road and see the available imagery. This is a delightful response if one considers that the enquirer was some 400 miles from Ottawa. Such a situation after several years of operation and the expenditure of several millions of dollars is lamentable. Effective communication with users remains a first priority (see previous reports of the Geography Working Group.)

Quality control in image processing has caused many problems. Careful measurement of density levels in images processed in Canada and in the U.S.A. containing the same data for the same area on the same date show great discrepancies between the two products. The greater consistency of grey levels and the more detailed processing that is possible with the data obtained from Sioux Falls provides a standard which should be matched by Canadian processing of the same data. This situation represents a reversal of that noted by working group members in the past when the group expressed its appreciation of the superior quality of the best C.C.R.S. imagery. Some members also report major differences in quality between different orders of the same images and the catalogue identifiers of image quality are not a particularly lucid guide to the product.

C.C.R.S. acting as lead agency and presumably sole interlocutor with N.A.S.A. in the HCMM project produces a situation where Canadian investigators, who are not employed by C.C.R.S. cannot now produce a project proposal which is approved for funds before its evaluation by N.A.S.A. The limited lead time for such proposals, the dealing through intermediaries and the excessive amount of paperwork required to also seek funds for such a project through other agencies has resulted in an unfortunate apathy in the user community. This once again appears to indicate the need for C.C.R.S. to operate like other branches of government with funds for research projects which are of value to Canadian remote sensing.

The production of the mosaics of Canada from LANDSAT data is welcomed by the group which feels that a supporting document in the form of a brief booklet on the LANDSAT project would be a useful item to accompany each mosiac. There is still great concern about the dissemination of ERTS data and some form of microfische index and ordering system should be made available in centres other than Ottawa and the seats of provincial governments. In the opinion of the geography working group it is still difficult for the potential user to find out what the LANDSAT programme produces and how these products may be effectively used.

Again the working group feels that effectively illustrated publications which provide potential users with examples of applications should be produced as a matter of priority. This suggestion is in no way met by the type of summary of existing literature on land use published recently by the applications division. Such summaries are more widely available to the user community through the Goegraphical Abstracts series E (remote sensing).

5.7.3. Technical Developments

Maximising the content of images for a given purpose is now possible at low cost. It would be greatly to the advantage of C.C.R.S. to offer a custom processing service so that images which directly meet the needs of individual investigators can be produced with a minimum of difficulty. Unless such a service is implemented it becomes difficult to understand the purpose of the continued work of the data processing and applications divisions. The availability of the Image 100 system has not apparently led to innovation during the past year and in the opinion of the working group efforts based on the known physical properties of earth surface materials would be more valuable than the. endless pursuit of statistically based grouping algorithms which have no demonstrable link with the items in the scene.

The most important development in image manipulation would be map correction so that positions conform to some standard distortion of position on the earth's surface such as the universal transverse mercator projection or similar rather than the LANDSAT projection currently presented. This would be a major step in promoting the use of LANDSAT data.

5.7.4. Applications and Benefit Analysis

Applications of remote sensing continue to be numerous but not clearly presented to potential users. The working group held a workshop for urban planners and managers in Edmonton in May and a common response from participants was that they did not know such data were available and where could further information be obtained. The workshop presented both aircraft and spacecraft data for urban areas. The results indicate that the proposal presented last year for packs of data relating to a given region should be prepared and marketed. A selection of appropriate images for each major city region could be assembled from the existing data and made available to urban planners in those regions.

Conducting benefit analyses is beyond the scope of the groups activities and no benefit analyses of remote sensing in geography are known to the members of the working group.

The following extract from last years report remains true: "Benefit analyses in geographical studies are difficult to conduct. Above all the value of geographic studies is in the integrated information about specific places and the relationships between these places. At this level remote sensing data are primarily geographical data. There is, however, no government agency concerned with an integrated view of the nation, and, consequently, no single place for a geographical applications office which would study regions of Canada per se and utilise the wealth of remote sensing data made available annually through C.C.R.S.

The geography working group continues to suggest biophysical mapping projects, geomorphological mapping, monitoring of seasonal change, monitoring of sediment concentrations in rivers and lakes, and the applications of remote sensing in urban mapping and regional planning. After two years of operation the group concludes that administrative inertia will continue to be the greatest obstacle to effective progress. The federal government and the provincial governments are the only agencies directly concerned with the administration and planning of regions. Consequently there are few other markets for ERTS and regional scale data which can so effectively utilize its major properties. Thus, industrial and commercial activities will not be able to precipitate government action by exploiting the imagery for such regional administrative purposes. The group reluctuantly concludes that until the administrators finally realise that a ministry of Canada could be a realistic and useful agency in the government of Canada we shall continue to see fragmentation of environmental information amongst departments. This situation clearly exists at the moment and appears to be the most significant reason why much of the integrated regional component of remote sensing data is apparently ignored.

Interdisciplinary and multidisciplineary research teams utilising remote sensing from space vehicles, aircraft, helicopters and ground surveys can clearly contribute a great deal to studies of resource areas, areas of urban expansion, pipeline corridors etc. In some of these areas there is commercial activity and thus one may hope for a government response parallel to this. The use of ERTS and other remote sensing data in the work in progress on pipeline corridors is already producing positive results. Studies in the eastern Arctic and the McKenzie corridor which have utilised such data have shown it to be an effective component in the work.

It is also apparent that remote sensing has developed for itself the image of a sophisticated technology requiring millions of dollars worth of hardware for its full implementation. This is unfortunate because many applications of remote sensing follow directly from the low cost photographic materials which are readily available. In many respects remote sensing can be considered to be our "regional eyes" and thus provide the overview from which problems can be identified and further investigated. Identification is often the most effective single step in problem solving and there is no a priori requirement that identification should initially be complex. Familiarity with a region is often the most effective qualification for the individuals charged with the definition and solution of regional problems. Such familiarity can be improved by the appropriate application of remote sensing data.

The group discussed the problems of applications developments and the difficulties experienced by C.C.R.S. in its role as a purveyor of remote sensing services. Members of the working group are anxious to assist in these activities but it is not clear how this can be most effectively implemented. This leads to a certain degree of frustration amongst the members of the working group who were recently informed that C.C.R.S. must be requested to provide information if this is required. Because this seems to recast the role of the working group as an independent organ which must seek information from C.C.R.S. there will be a period of readjustment. Thus far members of the group had generally believed that their role was to respond to C.C.R.S. requests for advice, evaluation of program and projects and to report annually on the operation of the C.C.R.S. program from the geographic viewpoint.

In general the working group feels that it has invested a great deal of time in the discussion of appropriate applications of remote sensing data. The development of guidelines for the use of such data for biophysical mapping (see Appendix IV) and the work in progress on similar statements with respect to urban applications cannot be directly implemented by C.C.R.S. The working group thus requests a clear statement from C.C.R.S. about the appropriateness and usefulness of these endeavours."

5.7.5. User Liaison

The following extracts from last years report convey the sentiments of the group once again: "This topic has two significant components. The first being liaison between C.C.R.S. units and users and the second between the working group and users. Clearly both can be improved if liaison between C.C.R.S. Division is improved and this results in improvements in liaison between C.C.R.S. and the working groups. Users need to be presented with a coherent view of the structure of remote sensing agencies in Canada and directed to the appropriate units without overloading these units with public relations work.

The working group feels that a series of leaflets, one for each working group (discipline and provincial groups), should be produced and these together with a C.C.R.S. leaflet should then be distributed as appropriate."

During the year the working group held an urban applications workshop in Edmonton in May attended by 47 participants from 23 organisations in 10 different cities. The general response indicated that this venture was a success and a report on this workship is included as Appendix III.

As in previous years the working group feels that there is still a large amount of information which must be conveyed to the user community. There is still no concise statement of the remote sensing programs of C.C.R.S. Users still cannot easily obtain a simple description of the satellite remote sensing data types and their uses, similar comments apply to the catalogues of LANDSAT Data. The implementation of a microfische index of

N.A.P.L. airborne remote sensing data and the colour ERTS imagery is urgently required.

It is a matter of priority for C.C.R.S. to implement a visual library of LANDSAT data and the results of projects based on them. Similar urgency attaches to the need for dissemination of the information contained in the airborne division's visual library. Dissemination of this information in a suitably refereed and edited form is essential if a worthwhile teaching program is to be mounted by Canadian universities. Without such a program the dissemination of remote sensing data will remain sporadic and distorted by the discipline bias and administrative convenience which is currently evident.

The rapid development of C.C.R.S. has been accompanied by the development of the working groups. During this period of growth some problems have become apparent, one of these is the lack of funding for full demonstration projects. Consequently C.C.R.S. cannot demonstrate the versatility and power of remote sensing data. It is therefore extremely difficult to demonstrate this versatility and power to prospective users of remote sensing data. The national interest would be well served by funding C.C.R.S. to produce a series of monographs which clearly demonstrate the applications of remote sensing data. This may require the funding of suitably chosen demonstration projects.

5.7.6. Training

The situation with respect to training is becoming absurd. C.C.R.S. holds the clearly stated position that training is the function of the universities. At the same time C.C.R.S. has the only advanced remote sensing equipment in Canada for image analysis and this is in support of its research and development role. No university has a suffiently large group of staff to man a research and teaching unit devoted solely to remote sensing and thus there is no group which is likely to attract an N.R.C. negotiated development grant of sufficient size to purchase an appropriate range of remote sensing equipment. The demand for training courses visible in the success of the Alberta short course and the U.N. short course held in Ottawa and Guelph reveals the need for a teaching unit properly equipped to introduce sophisticated image analysis to participants in training courses. Because of the high cost of such a unit and its potential international significance the group concludes that the only viable answer is for C.C.R.S. to support the concept of a national training facility for remote sensing.

Such a facility might be created by direct government action to form a remote sensing facility as a unit directly funded by, and part of, N.R.C. It may be appropriate for the department of Energy, Mines and Resources to contract to a university for this purpose or it might be advisable for C.I.D.A. and/or I.D.R.C. to participate in the funding of such a unit. However the funding is arranged it is becoming clear that some such facility is necessary in Canada. It is the view of the geography group that such a facility will be increasingly required in the next ten years and unless it is funded and established soon the U.S. will continue to be the major supplier of training for Canadians who wish to study remote sensing.

A report reviewing the teaching of remote sensing in Canada prepared by J.T. Parry for the Association of Universities and Colleges of Canada and circulated 4 years ago indicated a number of departments of geography offered some training in remote sensing but not as a major emphasis. No university is equipped with sophisticated image analysis systems dedicated to remote sensing data and unless such a complete analysis system is made available for training purposes it seems unlikely that a major remote sensing school will develop in Canada. Without such a school it is doubtful if Canada can play a major international role in remote sensing. It is the opinion of the working group that there has been little significant change since Parry's report was presented.

5.7.7. Conclusions and Forecast

After reviewing the national programme in remote sensing the working group concludes that a clearer definition of the role of working groups is necessary. Either the group should be given an expanded role in communicating with users or in developing plans for the future of remote sensing in Canada including both the role of C.C.R.S. and the ancillary training research and industrial development which should accompany the growth of C.C.R.S.

The airborne programme of C.C.R.S. continues to be successful. The dissemination of data from space platforms requires much more attention and the development of practical applications and appropriate products for end users should receive priority. Unless this is done the position which Canada occupies as a major user of LANDSAT data will be taken over by others. The existence of the quicklook system is not itself sufficient to give the Canadian system credibility; this system must be supported by clear demonstration of its practical uses. Data processing must support the acquisition system so that the products are of an appropriate quality which can be fully analysed and the development of practical low cost systems of image interpretation and enhancement is a priority. Without this type of development the value of the C.C.R.S. hardware is difficult to asses in terms other than its unique availability in Canada. Custom processed images at low cost and supplied through a rapid and efficient system are priority need for the national programme.

The items discussed above are vital if user agencies are to expand the role of remote sensing in their activities. Liaison with users is still a prime need and the creation of user products, as recommended by this group for several years is still a necessity. Slowly the items which this group recommended to C.C.R.S. as appropriate items for production in Canada are emerging through the U.S. agencies for the U.S. leaving our programme notably lacking in the production of innovative (or any) user products.

Unless funds are made available for the development of user oriented products the C.C.R.S. programme dealing with spaceborne data will continue to either stagnate or decline. The group concludes that little significant progress was made in this area during 1975. Apart from the airborne programme which is a clearly established and vigorous unit of C.C.R.S., user liaison is poor. The following conclusion from last years report remains true.

"To gain maximum benefit from the remote sensing program C.C.R.S. must be funded and staffed to provide a greater range of user services and a range of technical documents and demonstration materials. If this is done there can be no doubt that the program will increase in vitality and efficiency. If this is not done potential users will be lost. These remarks also apply in the context of Canadian participation in international projects."

The group also concludes that the national programme in remote sensing is losing vitality, appeal and effectiveness. Members of federal government agencies invited to join the working group for the past year either declined the invitation or, having accepted failed to attend a single meeting. The working group had been under the illusion that the efforts of C.C.R.S. were directed to the prime user groups in government which had funded missions to which remote sensing was pertinent. On the basis of our experience the effectiveness of these efforts appears limited. Unless some clear goals for the working groups are developed it seems that apathy will continue to spread and bring about their demise.

5.7.8. Recommendations

5.7.8.1. Very careful consideration must be given to the implications of the cost recovery programme as the airborne remote sensing activity becomes fully commercial. The working group recommends that appropriate research and development projects should be approved for the lower cost rate rather than a simplistic approach permitting lower cost to first time users only. Research and development projects which will extend over more than one year should be operated at an agreed cost over the whole period to prevent unreasonable cost changes from destroying their budgets. Costs should be established on a 3 year basis and published in advance so that planning can be effectively undertaken by potential investigators.

5.7.8.2. As a matter of priority I.A.C.R.S. should seek to establish a national training facility for remote sensing. This should be an interdisciplinary institute funded directly by the federal government and should have a major international role in the training of remote sensing data analysis techniques, in the design, installation and maintenance of remote sensing equipment, from receiving stations to instruments for analysis. The centre should be fully equipped with these devices and should provide a rigorous and sophisticated training at a post graduate level including applications in specialist areas. It is of little consequence whether the institute is independent, a direct arm of government or contracted to an existing university but the need for such an institute is great and is growing.

5.7.8.3. The format of the working group annual reports to C.A.C.R.S. should be amended so that the report of the airborne operations unit contains a consolidated listing of all projects and these are no longer included within the reports of individual groups.

5.7.8.4. C.C.R.S. should exercise closer control over the quality of imagery produced from LANDSAT data tapes and sold to the user community. Specifically the density levels of images should not change dramatically in successive orders, and the range of density levels in the step wedges should be within reasonable limits on all black and white imagery. Colour images should be processed with reasonable colour consistency for all frames and at all times.

5.7.8.5. An improved newsletter which provides news (not historic comment) on a frequent and regular basis and keeps users informed of on going projects, availability of facilities and activity of C.C.R.S. sections and divisions should be produced. The working group recommends that such a newsletter be sent to all university and college geography departments in Canada. Publication of the results of major tasks undertaken by C.C.R.S. and technical reports on user products and systems available to users should be implemented immediately. Announcements of these items in the newsletter should be followed by the publication of properly illustrated fully edited reports.

5.7.8.6. Dissemination of information about the LANDSAT data available should include some form of regional depository and order office. This aspect of image distribution is badly reglected.

5.7.8.7. A LANDSAT information list consisting of explanatory brochures, sample images, interpretations and catalogues should be made available immediately. In view of the costs of the LANDSAT programme and the time elapsed since its inception such information is badly overdue.

5.7.8.8. Biophysical mapping from LANDSAT data for the Arctic should become a priority matter. The geography working group provides in Appendix IV the document it produced two years ago as a basis for defining such a project.

5.7.8.9. I.A.C.R.S. and C.A.C.R.S. and C.C.R.S. are each respectfully requested to communicate to geography working group some comment on this report and to provide some direction for the activities of this group during the coming year.

5.7.8.10. Map correction of imagery from all satellite systems should be a prime objective for the data processing division so that users are provided with data which can readily be related to existing maps.

5.7.9.1. Appendix I
Current Bibliography
(compiled by J.J. Klawe as directed by the working group)

Allard, M., Photo interpretation and applied geomorphology: Gatineau-Lievre area. Ph.D. thesis in progress.

Golding, D.L. (1973) Satellites and snowpack Forestry report Vol. 3, No. 3 p. 10. Snow cover and melting snow from ERTS imagery Canadian Surveyor Vol. 18, No. 2, (1974) pp. 128-134.

Kirby, C.L. (1973) Remote sensing: Earth Resources Technology Satellite, Forestry Report, Vol. 3, No. 3, pp. 1-2.

Forest and land inventory using ERTS imagery and aerial photography in the boreal forest region of Alberta, Canada, Third ERTS Symposium, Washington, D.C., Goddard Space Flight Center, December 1973, Vol. 1, paper A8, pp. 127-136.

Temporal analysis of ERTS imagery in Boreal forest region, The Canadian Surveyor, Vol. 28, No. 2, (1974), pp. 142-146.

P. Van Eck, A.H. Legge, D.R. Jaques and C.E. Poulton, Development and Application of an Ecologically Based Remote Sensing Legend System for the Kananaskis, Alberta, Remote Sensing Test Corridor, University of Calgary, Environmental Sciences Centre, 1974, 28 pp.

Parry, J.T. (1974) Current and anticipated use of remote sensing in the geosciences, Canadian Advisory Committee on Remote Sensing 1973 Report, pp. 81-83.

X-Band radar in terrain analysis under summer and winter conditions, Proceedings, Second Canadian Symposium on Remote Sensing, (1974), pp. 471-487.

The use of composite minimum brightness charts in the mapping and intrepretation of snow in Quebec-Labrador, Proceedings, pp. 165-185.

The Role of Panchromatic, Color and Color Infrared Airphotos in the Analysis of Road Conditions (Ottawa: Defence Research Board of Canada, Contract Report SP2.7090163, Serial 2SP3.0024, 1975), 70 pp.

Snow conditions in Quebec-Labrador interpreted from ESSA 9 satellite imagery, Photogrammetria, Vol. 30 (1975), pp. 41-66.

The Mapping and Interpretation of Snow Conditions in Quebec-Labrador using ESSA 9 Composite Minimum Brightness Charts (Ottawa: Defence Research Board of Canada, Contract Report SP2.7090153, Serial 2SP2-0076, 1974), 36 pp.

Bhyat, M., The Application of the ERTS Imagery in Terrain Analysis using Direct Visual Interpretation and Colour Enhancement Techniques. (Masters thesis)

Tighe, D., Remote sensing in hydrological studies. (Thesis in progress).

Gagnon, H., (1974(, Remote sensing of areas subject to landslides in eastern Canada, Proceedings of the Second Canadian Symposium on Remote Sensing, Vol. 2, pp. 347-365.

Kesik, A.B., ERTS-1 data and thematic cartography in Canada, in Proceedings of the 5th International Conference on Cartography (Madrid: 1974).

Thompson, M., Study of Two Remote Sensing Techniques for the Detection of Sulphur Dioxide Stress in Forest Vegetation. (Masters thesis).

Wong, P., Landuse mapping from ERTS-1 data. (Thesis in progress).

Momsen, R.P., El uso de la Fotografia Aerea para Interpretaciones Socio-Economicos (Caracas: Ministerio de Planificacion, 1974), 29 pp.

Adams, F. and A. Falconer, ERTS data as a cartographic base, in Proceedings, Second Canadian Symposium on Remote Sensing (1974), pp. 639-641.

Bhyat, M.F.H. and A. Falconer, Remote sensing imagery for the Lake Ontario test site, in Proceedings, Second Canadian Symposium on Remote Sensing (1974), pp. 609-611.

Falconer, A., Remote sensing for the Lake Ontario hydrology test site. Symposium Proceedings, Management and Utilization of Remote Sensing Data (Falls Church, Virginia, American Society of Photogrammetry, 1973), pp. 177-190.

Regional ecology and environmental impact using ERTS data, in Proceedings, Second Canadian Symposium on Remote Sensing (1974), pp. 41-45.

Bruce, W.D. (1974(High Altitude Photography: An Improved Data Source for Drainage System Analysis. Proceedings of the Second Canadian Symposium on Remote Sensing, pp. 613-625.

Howarth, P.J. (1974) Summary: Session on the Lake Ontario Basin Test Site. Proceedings of the Second Canadian Symposium on Remote Sensing, pp. 635-637.

Howarth, P.J. (1974) Remote Sensing in Hydrological Studies: Two Examples from Southern Ontario. Paper presented at the Annual Meeting of the Canadian Association of Geographers, May 1974.

Paul, L.A. (1974) Aspects of the Coastal Geomorphology of Les Iles de la Madeleine Using Remote Sensing Techniques. Unpublished B.A. Thesis, McMaster University, 101 pp.

Salisbury, N.J. (1974) High Altitude Aerial Photography for the Interpretation of Agricultural Land Use. Unpublished B.A. Thesis, McMaster University, 109 pp.

Edwards, P. (1975) The use of high altitude photography as an improved data source for drainage system analysis. Unpubl. M.A. Research Report, McMaster University, 58 pp.

Howarth, P.J. and M.K. Woo, (1975) The influence of scale in the remote sensing of snow cover. Proc. of the 32nd Annual Meeting of the Eastern Snow Conference, 18 pp. (In press).

Kinnard, D.A., (1975) Remote sensing techniques for conducting off-street and terminal parking studies from helicopter and light aircraft. Unpubl. M.A. Research Report, McMaster University, 54 pp.

5.7.9.2. Appendix II
Geography Working Group Membership (Dec. 1975)

Dr. Allan Falconer (Chairman)
Department of Geography
University of Guelph
Guelph, Ontario NOB 1CO

Mr. G. Falconer
Chief, Geog. Division
Surveys and Mapping Branch
580 Booth St.
Ottawa, Ontario K1A OE4.

Dr. F.K. Hare
Department of Geography,
University of Toronto
Toronto, Ontario M5S 1A1.

Dr. Philip Howarth (Secretary)
Department of Geography
McMaster University
1280 Main St. West
Hamilton, Ontario L8S 4K1

Prof. Janusz Klawe
Department of Geography
University of Alberta
Edmonton, Alberta, T6G 2H4.

Prof. Gerald McGrath
Dept. of Geography
Queen's University
Kingston, Ontario K7L 3N6

Dr. John Parry
Department of Geography
McGill University
Box 6070, Station A
Montreal, P.Q. H3C 3G1.

Dr. Tom Peucker
Department of Geography
Simon Fraser University
Burnaby, B.C. V5A 1S6.

Dr. Barry Wellar
Asst. Dir. Inf. Systems Group
Ministry of State, Urban Aff.
355 River Rd.
Ottawa, Ontario K1A OP6.

Mr. S. Witiuk
Census Processing
Census Field
Stats. Can. Ottawa, Ontario.

5.7.9.3. Appendix III
Geography Working Group Report on the Urban Applications Workshop
(Edmonton May 22nd 1975)
by P.J. Howarth.

During 1975, the Geography Working Group and the University of Alberta sponsored a one day symposium on Remote Sensing and Urban Studies. This was held in Edmonton on May 22 and was attended by 47 participants from 23 organizations in 10 different cities.

The morning was devoted to presentations by members of the Geography Working Group. J. Klawe welcomed the participants to the University of Alberta and A. Falconer, who chaired the meeting, outlined the role of the Geography Working Group and its relationship to C.C.R.S. and C.A.C.R.S. P. Howarth discussed the conclusions reached by a subcommittee of the Geography Working Group charged with considering possible applications of remote sensing in urban studies. With the exception of a number of land use studies, little attention has been given to the applications of remote sensing in urban studies in Canada. It was suggested that a market study be undertaken to determine the data and information needs of urban and regional planners that might be fulfilled by remote sensing methods.

For a number of the participants, this meeting was their first introduction to remote sensing. On behalf of E. McLaren, who was unable to attend, P. Howarth outlined the capabilities of CCRS to acquire airborne data for urban areas. Examples of photography and thermal imagery that have been obtained by CCRS over urban and urban/rural fringe areas in Canada were presented. A small display of Albertan photography and imagery was also organized by the Working Group and participants from Alberta.

B. Wellar considered the state-of-the-art in remote sensing for urban studies. He provided a conceptual framework to illustrate where remote sensing has provided or could provide an input to urban studies. With a lack of studies in Canada, he drew a number of samples from work undertaken in the United States. He emphasized that governments in Canada at various levels have been using conventional photography for a number of their planning operations. Although there is a willingness to experiment with new types of remotely sensed data, the question of cost/benefit is an important factor which tends to restrict this activity.

Examples of the types of information that can be extracted from remotely sensed data were given in two presentations. R. Ryerson described studies in urban land use mapping that are being carried out by CCRS and DOE. He concentrated on a study in the Great Lakes Basin undertaken by CCRS and the Lands Directorate, Environment Canada, with the support of Ecolcon Canada Ltd. The study was produced for the International Joint Commission, and land use maps were compiled at 1:50,000 scale from high altitude photography for the major urban areas to update existing Canada land inventory maps. In the northern regions of the basin, 1:250,000 scale maps were produced from LANDSAT data.

P. Howarth described a second study in which maps of land use and land use change were produced at a scale of 1:12,000 from 1:60,000 scale colour infrared photography for part of the city of Burlington, southern Ontario. Details of the times and costs to undertake the mapping, as well as the procedures involved, were discussed.

In the afternoon, it was the turn of the urban and regional planners from Alberta to present their views on remote sensing and urban studies. A. Grey of the City of Calgary described the approach that his city uses to information management. With an operational information system, the city is able to obtain updated land use information maps as and when required. In such a situation, remote sensing is not able to compete. For smaller cities and towns, however, and in rural areas, he felt that remote sensing had a valuable role to play.

W. McCoy of the Alberta Department of the Environment described his involvement with remote sensing. Working at a regional level, particularly in northern Alberta, LANDSAT data provides a regional overview and assists in planning field work. Conventional panchromatic photography is used in the office and in the field, and for particular areas of interest low altitude 35 mm hand-held photography can provide valuable information. The presentation was illustrated with examples of the data that have been used.

F. Marlyn, Director of Special Projects and Policy Planning in the Alberta government commented on the presentations given during the symposium. He agreed with Mr. Grey's comments on land use and urban information systems. He felt that if used wisely, remote sensing has a definite role to play in data collection. Examples he quoted included growth studies in rural areas and the planning and layout of subdivisions. He felt that it would be valuable to assess conventional methods and remote sensing procedures for obtaining information on various aspects of the environment that are of concern to the numerous agencies in Alberta.

K. Campbell of the Alberta Centre for Remote Sensing described the work of his agency and invited participants to make use of their facilities. A wide-ranging discussion session ended the symposium and J. Klawe thanked the participants for their contributions.

5.7.9.4. Appendix IV Geography Working Group Guidelines for the Identification of Biophysical Land Units, Land use Categories, and Phenological events from LANDSAT Imagery.

by J.T. Parry

Land classification has been a traditional concern of the earth scientist, either at the regional scale in terms of physiographic provinces and forest regions, or at the local scale in terms of landscape facets and land use categories. The basic methodology is similar at all levels of generalisation and involves the identification of the surface and near-surface attributes which are significant for the study, and the categorisation of the land surface into discrete areal units on the basis of particular dominant attributes or sets of attributes. In general, one is concerned with attributes which are clearly visible both in the field and in an aerial view, and many systems of land classification have come to rely on remote sensing, particularly aerial photography, to provide a planimetric view of the surface attributes of the area of interest. The photo or image records these as spatial structures, and thus provides a data base for their evaluation. In the ideal situation, the sensor records parameters which are directly related to the surface attributes, and so the image displays spatial groupings which correspond to specific terrain types or land use categories. More frequently, however, the sensor parameters do not correspond directly with the terrain parameters and it is necessary to interpret the terrain conditions from associated features.

Spacecraft imagery has several advantages compared with aerial photography in this respect. Firstly, there is the broad synoptic view which allows examination of the area of interest in the context of its surroundings. Secondly, there is the advantage of essentially uniform illumination, since the solar altitude is constant for the whole area covered by a particular spacecraft image. Thirdly, because of the spacecraft altitude there is a relatively small field of view which means that luminance or total diffuse reflectance values are not affected to any appreciable extent by variation in the viewing angle. Thus, the application of densitometric techniques for discrimination among terrain types is more appropriate to spacecraft imagery than conventional aircraft imagery. Fourthly, there is the advantage of repetitive coverage, which provides a basis for monitoring changes in the landscape and permits sequential studies of bio-physical processes and economic activities. Finally, there is the advantage of being able to examine small scale landscape patterns as imaged in different spectral bands under identical conditions, and of having the opportunity to assess the way in which patterns at a particular level of generalisation collapse to give patterns of successively higher order. For these reasons, spacecraft imagery provides a unique approach to land classification and regional differentiation at the macro scale, and it also provides a basis for assessing the validity of existing first and second order land classification schemes.

Imagery from ERTS 1 is prepared for users at a scale of approximately 1:1 million. At this ratio, one centimetre represents ten kilometres ground distance and one inch is equal to 16 miles. The nominal spatial resolution is 150 metres (500 feet), although in good contrast situations this may be surpassed, and so moderate sized features are detectable. The ERTS sensor parameters have been taken into account in preparing these guidelines which contain brief reviews of three land classification systems - a physiographic system containing first and second order components, a bio-physical system which offers a hierarchy of first, second, and third order subdivisions, and a land use system which can be used at either the first, second, or third order level. The guidelines also contain a listing of phenological and other events that can be detected on spacecraft imagery and a review of the factors which are significant in preparing a phenological calendar.

Guidelines

1. Familiarisation with the ERTS system and check for existing coverage of areas of interest.

Refs. i ERTS Data User's Handbook, NASA 1972 plus revisions.
ii Canadian ERTS Data User's Handbook, C.C.R.S., May 1973.
iii NASA ERTS 1 Satellite Coverage of Canada (map), C.C.R.S., Nov. 1972.
iv Remote Sensing in Canada, Nos. 1-3, C.C.R.S., July 1972-April 1973.

2. Delimitation of physiographic regions (Bostock system)

Refs. i H.S. Bostock, A provisional physiographic map of Canada, Paper 64-35, Geol. Surv. of Canada, 1964.
ii Physiographic regions of Canada, Map 1254 A, Geol. Surv. of Canada, 1970.
iii S.S. Holland, Landforms of British Columbia, a physiographic outline, Bull. 48, B.C. Dept. of Mines and Petroleum Resources, 1964.

Bostock's physiographic regions of Canada provides a first order land classification system based on geology and physiography which is applicable at scales of 1:1 million and smaller. The physiographic regions and provinces proposed by Bostock are naturalistic subdivisions within each of which there are similarities of surface configuration which are the result of a similar orogenic history, a similar response of the bedrock to erosion, and a similar geomorphological evolution. In general, the boundaries of the physiographic regions and provinces correspond to a geological or a physical feature, such as a lithological contact, a structural alignment, a river

System of Physiographic Subdivision

Level	Major Region	System (cordillera only)	Region	Division
	Shield	-	James	Nipigon Plain
Examples	Borderland	-	Arctic Coastal plain	Mackenzie Delta
	Borderland	Coastal Mountains	Coastal trough	Fraser Lowland
Scale of mapping	1:1 million and smaller	1:500,000 1:1 million	1:500,000 1:1 million	1:125,000 1:500,000

Bio-physical Land Classification System

	1	2	3	4
Level	Land Region	Land District	Land System	Land Type
	Boreal B12	-	* Epinette	-
Examples	Boreal B18A	-	* ML 40	-
	Montane M5	-	* Gregoire	-
Scale of mapping	1:1 million 1:3 million	1:500,000 1:1 million	1:125,000 1:500,000	1:10,000 1:20,000

* Examples from D.S. Lacate (1969)

I.A.S.C. Land Use Classification System

Level	1	2	3*
	Urban	Extractive	Limestone
Examples	Agriculture	Cropland	Row crops
	Urban	Transportation	Rail yard
Scale of mapping	1:1 million and smaller	1:100,000 1:500,000	1:15,000 1:50,000

*Level 3 categories from R.H. Alexander, 1973

or a hypsometric level.

The system presented by Bostock is a hierarchy consisting of major regions of approximately 1.5×10^6 square miles in area within which are progressively smaller units down to divisions with areas of approximately 5×10^3 square miles.

ERTS imagery provides a unique opportunity for determining the extent to which these subdivisions are visible from space, their dominant attributes, and the boundary characteristics.

In evaluating the ERTS images the following aspects should be considered -
(a) whether or not Bostock's physiographic subdivisions can be recognised, and the

degree of correspondence between boundaries recognised on the image and those appearing in the literature;

(b) the image attributes associated with each subdivision - for example, image density or color value, pattern, texture, shadowing effects, etc;

(c) the terrain attributes responsible for the image appearance - for example, surface composition, cover type, drainage texture, etc.,

(d) the boundary characteristics - for example, continuity and sharpness;

(e) the spectral band or color composite in which the subdivisions and their boundaries are most readily interpreted.

3. Delimitation of Bio-physical land units (Canada Land Inventory System for forest lands and wildlands)

Refs. i D.S. Lacate (ed.), Guidelines for Bio-physical Land Classification, Canada Land Inventory, Dept. of Regional Economic Expansion, Ottawa, 1969.
ii J.S. Rowe, Forest Regions of Canada, Bull. 123, Can. Dept. of Northern Affairs and Natural Resources, 1959.
iii G.A. Hills, A ready reference to the description of the land of Ontario and its productivity, Ont. Dept. of Lands and Forests, Prelim. Rept. 1959.
iv U. Nielsen and J.M. Wightman, A new approach to the forest regions of Canada using 1:160,000 colour infrared aerial photography, Information Report FMR-X-35, Canadian Forestry Service, Aug. 1971.

The Canada Land Inventory system is a bio-physical classification of a reconnaissance type which provides a basis for land classification in forestry, agriculture, recreation, and wildlife studies. The system is designed to differentiate and classify ecologically significant segments of the land surface rapidly and at a relatively small scale. Emphasis is placed on the classification and mapping of patterns of soil, landforms, vegetation, and water as delimited on air photos with supporting field checks. The system relies to a considerable extent on air photo interpretation techniques, and so it is well suited to application with spacecraft imagery.

Land Regions are defined as areas characterized by a distinctive regional climate; however, the climatic information necessary to classify such regions is not currently available throughout much of Canada and so natural vegetation must be used as the index. The Land Region is of large areal extent. It is heterogeneous and often consists of several distinct contiguous landscapes. At the present time, Halliday's forest regions of Canada, as revised by Rowe (1959), provide the only framework for identifying first order ecological and climatic subdivisions of this type.

Land Districts are comparable to the Site Districts of Hills (1959). They are subdivisions of the Land Region based primarily on the differentiation of physiographic and geomorphic patterns. Land Districts are defined as areas characterized by distinctive patterns of relief, geology, and associated regional vegetation. Second order subdivisions of this type have so far received very little attention and with a few exceptions have not been mapped.

Land Systems are defined as areas characterised by a recurring pattern of landforms, soils, and vegetation. They are identifiable and mappable from air photos by discrimination of textures and patterns. Within Land Systems the soil and vegetation are heterogeneous, but distinctive, repetitive patterns can be recognised and related to landform assemblages. A detailed procedure for the classification of landforms, water bodies, vegetation, and soils at the Land System level is provided in Lacate (1969) and will not be duplicated here.

Land Types are areas with a fairly homogeneous combination of soil and vegetation, the former considered at the soil series level, and the latter treated as a chronosequence. However, since it is doubtful whether fourth order units of this type can be identified on ERTS 1 imagery, they will not be discussed further.

There is good reason to believe that first, second, and third order bio-physical land units can be effectively identified on ERTS 1 imagery, and that the imagery will provide a relatively consistent source of information for applying the Bio-physical Land Classification system to the country as a whole. In evaluating the ERTS 1 images for the study areas the following aspects should be considered:

(a) whether or not the Forest Regions of Rowe (considered as surrogates for Land Regions) and the Site Districts of Hills (considered as surrogates for Land Districts) can be recognised;

(b) the degree of correspondence between the boundaries recognised on the image and those appearing in published sources;

(c) the image attributes associated with each subdivision - for example, image density or color value, pattern, texture, shadowing effects, etc.;

(d) the terrain attributes responsible for the image appearance - for example, landform assemblage, drainage texture, soil type, cover type, state of the group, etc.

(e) whether or not Land Systems can be identified on ERTS images, and the significant image and terrain attributes;

(f) the boundary characteristics of first, second, and third order land subdivisions - for example, continuity and sharpness;

(g) the spectral band or color composite on which the subdivisions and their boundaries are most readily interpreted.

4. Delimitation of Land Use categories (I.A.S.C. system)

Refs.
- i J.R. Anderson et al., A Land Use Classification System for use with Remote Sensor Data, USGS Circular 671, 1972.
- ii R.N. Colwell et al., Monitoring Earth Resources from Aircraft and Spacecraft, NASA SP-275, 1971.
- iii R.H. Alexander, Central Atlantic Regional Ecological Test Site: a prototype regional environmental information system, Progress Report, Geography Applications Program, U.S.G.S., January 1973.

The Land Use Classification System prepared by Anderson et al for the U.S. Inter-Agency Steering Committee on Land Use Information and Classification (the I.A.S.C. system) was specifically designed for application using spacecraft imagery. The system can be used with imagery taken at different times of year and the categorization allows vegetation and other types of land cover to be used as surrogates for activity. In addition, the system is hierarchical so that the categories can be expanded to include progressively finer detail obtained from sources other than satellite imagery.

At Level 1, a general classification based on nine categories of land use is provided - urban and built-up land, agricultural land, rangeland, forest land, water, non-forested wetland, barren land, tundra and permanent snow. At Level 2, the complexity of the inventory is increased and 34 specific land use types are recognised; however, it is noted by Anderson that some types are extremely difficult to interpret from spacecraft imagery alone and it may be necessary to check other information sources to achieve a satisfactory interpretation. At Level 3 supplementary information is generally required and only in ideal circumstances can the specific type of land use or activity be interpreted from the imagery.

In evaluating the ERTS images the following aspects should be considered:

(a) the relative ease and completeness of the interpretation at each level in the system;

(b) the image attributes associated with each land use type - for example, image density or color value, pattern, texture, associative features, etc.;

(c) the specific features of the different land use types and activities which are most useful in their interpretation;

(d) the spectral band or color composite in which the land use categories and their boundaries are most readily interpreted.

5. Preparation of a Phenological Calendar

ERTS imagery affords an excellent opportunity for monitoring temporal change in various environmental phenomena and thus provides the basis for the preparation of a phenological calendar in which other events can also be recorded. For convenience, phenological changes and other events can be grouped under four headings and the more common items in each category are listed below. Both the date of the event and its pattern of occurrence are important, since the former provides the basic data for such a calendar and the latter often furnishes significant discriminant clues in delineating bio-physical land units.

Natural Vegetation

Passage of the 'green wave' (leaf on)
Flowering
Maturation
Senescence and leaf fall
Disease or infestation
Drought

Crops and Orchards

Foliation
Flowering
Ripening and maturity
Harvest
Disease or infestation
Wilting and drought

State of the Ground

Snow cover
Snow melt
Saturated conditions
Flooding

Local Climate and Hydrology

Snow and rain storm tracks
Freeze-up and break-up
Floording and drought

When interpreting the ERTS 1 image with respect to phenological events the following aspects should be considered:

(a) the image attributes associated with different phenological changes and other events - for example, changes in image density or color value, changes in size and shape, changes in texture, etc.

(b) the spectral band or color composite in which the phenological change is most apparent;

(c) the season or date at which the various types of land units are best disciminated;

(d) the rate of change of the image attributes associated with each phenological event.

6. Sample interpretation of an ERTS image

It is very probable that considerable variation will be found from one area to another with regard to the kind of information that can be interpreted from the ERTS image and the level of terrain classification that can be accomplished. It is also probable that some aspects of these guidelines will prove inapplicable and some items will require modification in view of the differences in regional character from one part of Canada to another. The ERTS image of the Montreal area with its overlay and accompanying text which would be appended to these guidelines intended as an illustrative sample of the procedures that can be followed rather than a blueprint for other interpreters.

5.8 REPORT OF WORKING GROUP ON GEOSCIENCE

5.8.1 Remote Sensing from Aircraft

During 1975, there was a marked decrease in the number of CCRS airborne projects of interest to geoscientists. Of the 117 projects that were scheduled, only three projects of direct geological interest were completed: 75-165 for surficial geology in Saskatchewan, 75-98 for analysis of landslides in British Columbia and 75-114 for Precambrian studies in Ontario. This continuing decrease in geological use of airborne sensing is attributed to a decline in user interest, particularly in view of increasing costs and the current small number of clearly-defined geological applications.

Appreciation to the aircraft crews and CCRS planning staff was expressed for excellent targeting and liaison in the completed projects. Good imagery was provided by NAPL. Service was also good with the exception of several misdirected packages of photos. A new handbook has been prepared by CCRS detailing available sensors and aircraft.

No airborne sensing by other agencies was reported to the Working Group.

5.8.2 Remote Sensing from Space

5.8.2.1 LANDSAT: No major or continuing problems with availability or quality of LANDSAT data were reported to the Working Group. However, a need was expressed for more rapid processing of images in the backlog, especially for areas that have relatively few images. Several specific cases of poor quality control in production of images were reported, including blurred black and white transparencies and misregistered colour composites. In general, quality was reported to be excellent. Delivery in most cases was good although the production of enlargements was considered to be slow.

Considerable concern was expressed about the uncertainty as to which images are autododged and which have correction for earth rotation. A general statement or specific classification in the image catalogue would help to clarify this situation, especially for those scientists who wish to order images for tonal or spectral analyses. A listing of the best seasonal images for each centre would also assist purchasers although, in large part, this information can be obtained from the general catalogue backed up by an Image Inventory Search and Summary (IISS) for recent data.

5.8.2.2 Other Spacecraft in Orbit: No other acquisition of data for geological purposes was reported to the Working Group. Gregory Geoscience outlined a 1975 trial contract for the Department of Indian and Northern Affairs with the objective of monitoring and forecasting snow and ice conditions in northern Canada using NOAA and LANDSAT images.

5.8.2.3 Future Spacecraft: U.S. agencies are considering the feasibility and role of a manned spacecraft mission (GEOSAT) for earth observations. Further details may be obtained from F.B. Henderson, Energy and Environment Division, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720, U.S.A.

SEASAT and the HCMM satellite will have experiments of interest to geologists. The imaging radar on SEASAT, with a proposed resolution of 25 m, may have applications in coastal geology. Other sensors will be limited by relatively poor resolution or wide line spacing. The Heat Capacity Mapping Mission satellite will measure thermal infrared radiation at the warmest and coolest times of each day. In addition to locating geological materials with contrasting thermal properties, the two daily measurements will make it possible to study the thermal inertia of surficial materials. Such studies may aid in classifying rocks and soils. Further details may be obtained from Dr. E. Shaw, C.C.R.S.

5.8.3 Technical Developments

No new technical developments specifically related to geological applications of remote sensing were brought to the attention of the Working Group. As revealed by the results of a questionnaire (see 5.8.4.3), visual interpretation of black-and-white LANDSAT prints is the major technique currently used by Canadian geoscientists, excluding conventional photogeology.

However, the development of digital terrain classification techniques is being continued by the Terrain Sciences Division of the Geological Survey of Canada. J. Netterville reported on his extension of A.N. Boydell's work (reported last year). He noted that such automated classifications of LANDSAT data comprise a potentially rapid and relatively accurate alternative to the conventional methods of preparing preliminary Arctic terrain maps by airphoto analysis. The technique is being assessed in terms of cost and a broader range of terrain classes. R. Steffensen of Geostudio Consultants reported on his digital studies of terrain classes in the forested Mackenzie Valley. He noted that in such terrain the spectral classes correlate more closely with vegetational units than with geomorphic units.

Automated classification of alteration zones, gossans and other compositional phenomena is being assessed in the U.S.A. (see proceedings of the First Annual William T. Pecora Memorial Symposium on "Applications of Remote Sensing to Mineral and Mineral Fuel Exploration", American Mining Congress, Sioux Falls, S.D., Oct. 1975). No applications relevant to vegetated terrain, such as central Canada, were reported. No similar Canadian research was reported to the Working Group.

At the institute of Sedimentary & Petroleum Geology in Calgary, N.E. Haimila has initiated studies on the use of false colour images to predict lithologic changes within mapped formations and on the use of edge enhancement techniques for tectonic trend analysis. P. Chagarlamudi (Univ. of Manitoba and CCRS) is continuing his Fourier analyses to elicit spectral information and calculate coherence between comparable LANDSAT and aeromagnetic data.

5.8.4 Applications and Benefit Analysis

The number of Canadian geoscientists using remote sensing continued to grow gradually during 1975 but the involvement of the geoscientific community is still low, with certain major exceptions. Most applications utilized LANDSAT data rather than airborne sensing. Few specific geological applications were brought to the attention of the Working Group although a significant number of companies, consultants and government agencies are known to be using LANDSAT data routinely and occasionally for research. The scale of involvement of geoscientists in remote sensing is indicated in the summary of results from a relevant questionnaire (see 5.8.4.3).

5.8.4.1 Aerial Sensing: Preliminary results were reported for one project by the Manitoba Ministry of Resources and Environmental Management. B. Bannatyne (Industrial Minerals) reports encouraging results in locating sphagnum moss. The same imagery was used successfully to delineate small outcrop areas by C. Lamb (Geol. Survey). A full range of sensors was used in the project but the most useful type of data was not specified.

5.8.4.2 LANDSAT: A number of consultants and mineral exploration companies are known to be using LANDSAT data routinely as an adjunct to their exploration programs. Commonly, the data are visually integrated with other information to complete an initial reconnaissance of a selected area. Particular emphasis is placed on structure, continuity of formations and surficial cover. Specific examples were not reported to the Working Group although a diverse variety of exploration targets were sought, e.g. fault zones, placer deposits, kimberlite pipes, alteration zones and domical fuel traps. Other reported areas of study included mapping of mine dumps (at 1:50,000 scale) classification of linears and correlation with geophysical data (see also 5.8.4.3).

Government agencies reported a variety of examples of on-going studies e.g. search for gravel (S. Ringrose & V. Singhroy), structural and tectonic analyses of Precambrian areas (C. Lamb; T. Frohlinger; G. Southard), all for the Manitoba Ministry of Resources and Environmental Management. At the Institute of Petroleum Geology, N.E. Haimila has studied domal structures in the Northern Interior Plains. B. Pelletier (G.S.C.) reported an interesting application to the problems of dynamic processes in the coastal areas, particularly estuaries, deltas, beaches, etc. e.g. Mackenzie River delta. With oceanographic control and complementary data, there is a possibility of producing a new and different series of maps.

Geological applications of LANDSAT data are being investigated at the Department of Earth Sciences, University of Manitoba (fabric analyses and correlation of LANDSAT data with other geological and geophysical data, under direction of D.T. Anderson and H.D.B. Wilson). At the University of New Brunswick, Win Naing (Geology Dept) is completing an analysis of the Caledonia area using LANDSAT and other data.

Black-and-white LANDSAT mosaics for all of Canada and for the primary NTS quadrangles are available from the National Air Photo Library. Scales range appropriately from 1:2,500,000 to 1:500,000.

5.8.4.3 <u>Results of Questionnaire on Geological Applications of LANDSAT Data</u>: During the summer of 1975, CCRS circulated a questionnaire to purchasers of Canadian LANDSAT data. The questionnaire was designed to assess the current level of application of LANDSAT data by geoscientists. The results of the questionnaire were presented to the 1st W.T. Pecora Memorial Symposium in Sioux Falls, S.D. by A.F. Gregory and L.W. Morley. A summary follows:

Canadian interest in LANDSAT data is widely spread and more-or-less equally divided among companies, educational institutions and government agencies. Geoscientists have had a long, continuing and major involvement with the Canadian LANDSAT program. However, at present only a small fraction(10%?) of the geoscientists have a strong commitment to the activity. Current information defining sales and use of LANDSAT data shows that identifiable geoscience organizations are major, if not the principal, users of LANDSAT data. Excluding reference collections, mineral and fuel exploration companies and consultants are the prime users.

About three quarters of the Canadian geological users have been using LANDSAT data since they became widely available in late 1972; the remainder started use more recently, primarily in 1974. Nearly one quarter of the Canadian users also have experience with LANDSAT data for other parts of the world.

Visual photogeologic interpretation of black-and-white prints comprises the principal method of analysis currently in use. Digital processing and machine assistance have not really been assessed for geological applications in Canada and little relevant research has been reported. However, there has been a major advance in the digital classification of Arctic terrain (see 5.8.3).

Few practical applications have been documented in Canadian literature. However, the results of the questionnaire show that LANDSAT images are being extensively and systematically used by exploration companies and geological consultants in all parts of the country. The practical objectives of such applications are relatively simple e.g. a regional overview of the geology was the prime requisite. Linears and selection of exploration target areas were also considered to be important uses. Secondary objectives include spectral discrimination of rock types and alterations, environmental studies and classification of materials. The principal information derived from LANDSAT data comprises: geological structures (including linears), broad classification and continuity of rock formations and surficial geology. Other uses included: terrain classification, land use, location of construction aggregate, waste disposal, mapping of subsidence and correlation with aeromagnetic data.

Over half of the geological users of LANDSAT data claimed a modest to large benefit from such use but could not identify a specific dollar benefit. The major benefits reported were: (1) acquisition of geological information that is not readily available otherwise; (2) acquisition of supplementary information to be integrated with other data; and, (3) a saving in time in assessing the regional geology.

5.8.5 User Liaison and Training

5.8.5.1 Action: Activities related to liaison and training were similar to those reported in 1974. Relevant Canadian papers submitted to this Working Group are listed in Appendix I.

At a meeting of the Working Group on November 5th, 1975, members and observers participated in a one-day workshop illustrating analogue and digital methods of analyzing remotely-sensed data. On the next day, the following invited reports were presented: CCRS Airborne Program - E.J. McLaren, CCRS; Future Satellite Programs - J. Cihlar, CCRS; Microwave Measurement of Soil Moisture - L.S. Collett, GSC; Automated Mapping of Terrain Classes from LANDSAT Data - for tundra, J. Netterville, GSC; for forested areas, R. Steffensen, Geo-studio Consultants.

LANDSAT data are receiving increasing use as a conceptual base for planning mineral exploration and for analyzing regional structure. The utilization of LANDSAT data will continue to follow the typical use curve that describes the temporal development of new technology. With respect to visual photogeologic interpretation, the use of LANDSAT data has risen rapidly to "Panacea Peak", fallen into "Sanity Slump" and is now beginning to climb "Reality Rise" toward the "Plateau of Practicality". However, for such uses as spectral discrimination and machine processing, the geological goals have yet to be defined and regular, low-cost production has not been achieved.

Further research in these fields will be hindered by the fundamental limitations of surficial obscuration (lichens, vegetation and overburden), resolution and the lack of the third dimension, depth. Such limitations suggest that major support for this research must be obtained from organizations concerned with surficial mapping (e.g. governments and universities) rather than from mineral exploration companies which have equal or greater concerns with depth and detail. Nevertheless, there are compositional contrasts of geologic interest (e.g. gossans, alteration zones, vegetational anomalies) that can serve to focus further research by means of spectral and automated analyses. The subsequent development of practical applications will be guided by the fact that these techniques, like all other methods of exploration, will not be specific but, rather, will undoubtedly present a multiplicity of anomalies for field checking.

Visual interpretation of LANDSAT images will continue to receive increasing acceptance as a tool, in conjunction with others, for developing concepts to guide mineral exploration and geological mapping, both in Canada and abroad. LANDSAT images will soon become a prime tool for regional geological reconnaissance, especially for poorly-explored, arid and semi-arid areas. This will probably become true even if the satellite system were to fail in the near future. However, much additional experience must be accumulated before geologists can confidently associate mineral deposits with features of LANDSAT images. In particular, the ubiquitous linears will require classification and analysis before their geological significance can be fully understood.

Spectral discrimination and automated processing will evolve very slowly until substantial funding and dedicated programs are developed in support of geological applications. A major and practical advance in terrain classification by automated methods appears imminent. However, because of complex interrelationships between bedrock, soil, water and vegetation, automated pattern recognition will remain unattainable for all but the simplest geological goals and even there may be too expensive for practical application. While LANDSAT data have the advantage of uniform raked illumination, minimum geometric distortion, synoptic view and world-wide coverage, it is primarily the related low cost of purchase and analysis that has led to their wide-spread adoption for regional reconnaissance. Spectral discrimination and automated processing will not be adopted for regular use until their current high costs are reduced. Indeed, it remains to be shown that such methods will be significant for mineral exploration and geological mapping.

During the year, members of the Working Group presented lectures to: Seminar on Geological Applications of Remote Sensing, University of New Brunswick; the Third Alberta Remote Sensing Training Course; and the Manitoba Familiarization Program in Remote Sensing.

The G.S.C. is continuing acquisition of high quality images for its reference collection (0-5% cloud; 0% snow).

5.8.5.2 Planning: At the November 6th meeting of the Working Group, discussion confirmed the continuing lack of specialized training and an increasing need for such training, especially in support of geological applications. It was the consensus of the members and observers present at the meeting that a concerted effort should be made to assess the need for training. Subsequent work by R. Slaney developed the following concepts and relevant recommendation (see 5.8.8.1) for establishing a multidisciplinary training centre for the analysis of remotely-sensed data:

1. As presently conceived, the centre should be based on the I.T.C. model, modified to accommodate areas of expertise that are specifically Canadian.
2. The centre should have facilities for teaching, consultation and research.
3. Some form of association with a university is highly desirable.
4. It is designed primarily for postgraduate students, i.e. for scientists with some years of experience wanting to extend their expertise so that they can tackle problems recognized through their work.
5. The centre is conceived as an international training facility i.e. its interests are world-wide.
6. Once established, the centre should be self-financing.
7. Courses should be available in several languages.
8. Emphasis should be placed on short courses - 3 months and 6 months in length.
9. The curriculum should place equal emphasis on practical tasks and on lecture material. Emphasis should also be placed on integration of studies not only within disciplines-but between disciplines.
10. Suggested core studies for all students: Physics of remote sensing; Data acquisition systems; Airborne and space platforms; Data quality; Methods and techniques of image analysis; Basic photogrammetry.
11. A need for special studies is recognized in 4 areas: forestry, geoscience, hydrology, soil science.

Geoscience studies should be based on both imaging and non-imaging systems, in conjunction with standard geophysical surveys.

5.8.6 Role of the Working Group

As in previous years, the role of the Working Group on Geoscience was reviewed. While there was no concensus among members, there was a strong feeling that the role and membership of all working groups should be reconsidered by CACRS with a view to reconstituting and consolidating them into fewer groups with emphasis on practical applications rather than scientific disciplines.

5.8.7 Conclusions and Forecast

Aerial photography continues to be the most widely used type of remote sensing excluding, by definition, geophysics. Other airborne methods of remote sensing are useful for specialized purposes but, from a geological viewpoint, have not yet proven to be widely practical.

5.8.8 Recommendations

HIGHEST PRIORITY

5.8.8.1 IACRS and CACRS should increase the support for and emphasis on the development of practical applications of remote sensing even, if necessary, at the expense of technical developments.

5.8.8.2 CACRS should establish an ad hoc interdisciplinary committee to investigate the need for a Canadian training centre for the analysis of remotely-sensed data (see 5.8.5.2). The committee should determine the level of demand for such a multidisciplinary centre and the most desirable curriculum. The results of the committee's work should be presented to a special meeting of CACRS in the fall of 1976 and be published by CCRS.

5.8.8.3. Specific airborne simulations should be completed at appropriate scales, altitudes and test sites before deciding the extent of Canadian participation in future satellites such as HCMM and SEASAT. In particular, the concept of heat capacitance mapping should be tested.

5.8.8.4 Techniques and facilities for digital processing at CCRS should be implemented to the stage where they can be applied in a routine production sense by knowledgeable persons outside CCRS.

5.8.8.5 In view of the fact that geoscientists are major users of LANDSAT data in Canada, IACRS should advance research and development of practical non-visual geological applications. While there are geological constraints, the major limitations appear to be low-level commitment and inadequate funding by major geological organizations.

LESSER PRIORITY

5.8.8.6 A special note should be added to the image catalogue, search lists and relevant publications noting that the black-and-white products are autododged and hence should not be used for quantitative tonal or spectral interpretation. The notice should emphasize that undodged products may be obtained by special order.

5.8.8.7 NAPL-RC and CCRS should ensure that a high level of quality control is maintained consistently in the production of photographic products.

5.8.8.8 CCRS should give increased priority to the production of LANDSAT images in backlog, particularly where there is minimal coverage, and should advise users of the current status of such backlog through the CCRS newsletter.

5.8.8.9 A special LANDSAT index and/or map should be developed to assist users in ordering the best image for each centre and season.

5.8.8.10 CCRS and EROS catalogues of LANDSAT data should be compared and good images of Canada, which are not in the Canadian catalogue, should be acquired and integrated into the Canadian system.

5.8.9 Appendix I: Canadian papers and reports submitted to the Working Group

Gregory, A.F. and Moore, H.D. "The Role of Remote Sensing in Mineral Exploration with Special Reference to ERTS-1", Bull. C.I.M.M. vol. 68, #757 (May), pp. 67-72, 1975

Haimila, N.E. "Possible Large Domal Structures along a Regional Arch in the Northern Interior Plains", in G.S.C. Report of Activities, Part C, paper 75-1C, 1975.

5.8.10 Appendix II - List of Members, 1975

Working Group on Geoscience

Member	Term of Membership
Dr. A.F. Gregory, Chairman President, Gregory Geoscience Limited, 1750 Courtwood Crescent, Ottawa, Ontario K2C 2B5	72-75
Dr. A.N. Boydell, Chief, Surficial Geology and Soils Division, E.L.U.C. Secretariat, Parliament Buildings, Victoria, B.C.	75-77
Mr. W. Bruce Applications Division, Canada Centre for Remote Sensing, 2464 Sheffield Road, Ottawa, Ontario K1A 0E4	75-77
Dr. G.L. Colgrove, Executive Assistant-Exploration, International Nickel Co. of Canada, Box 44, Toronto Dominion Centre, Toronto, Ontario M5K 1E3	73-76
Dr. D.G. Cook, Institute of Sedimentary & Petroleum Geology, 3303-33rd St., N.W., Calgary, Alta. T2L 2A7	73-76
Dr. A. Darnley, Chief, Resource Geophysics & Geochemistry Division, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8	72-75
Dr. D.H. Hall, Dept. of Earth Sciences, University of Manitoba, Winnipeg, Man. R3T 2N2	73-76
Mr. A. Nadeau, Department of Natural Resources, 1640 Boulevard de l'Entente, Quebec, P.Q.	75-77
Dr. K.E. Northcote, Dept. of Mines and Petroleum Resources, Parliament Bldgs., Victoria, B.C.	73-76
Dr. W.A. Padgham, Resident Geologist's Office, Dept. of Indian & Northern Affairs, P.O. Box 1500, Yellowknife, N.W.T. X0E 1H0	75-77

Appendix II (Con't)

Member	Term of Membership
Dr. J.T. Parry, Dept. of Geography, Burnside Hall, McGill University, Box 6070, Station "A", Montreal, Que.	72-75
Dr. B.R. Pelletier, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8	72-75
Mr. V.R. Slaney, Resource Geophysics & Geochemistry Division, Geological Survey of Canada 601 Booth Street Ottawa, Ontario K1A 0E8	75-77
Dr. M.G. Tanguay, Dept. of Genie Mineral, Ecole Polytechnique 2500 Ave. Marie-Guyard, Montreal, P.Q. H3C 3A7	75-77
Mr. N.H. Ursel, N.H. Ursel Associates Ltd., Suite 210, 2399 Cawthra Road, Mississauga, Ontario	73-76
Dr. H.W. van de Poll, Department of Geology, The University of New Brunswick, Fredericton, N.B.	75-77
Mr. D.G. Vanderveer, Department of Mines & Energy, St. John's, Newfoundland	75-77
Dr. S.H. Whitaker, Geology Division, Saskatchewan Research Council, Saskatoon, Sask.	75-77
Dr. D.F. Woolnough, Head, Land Survey Section, Alberta Environment, 10040 - 104 Street, Edmonton, Alberta T5J 0Z6	Resigned October, 1975

Ex officio

Mr. H.D. Moore, Recording Secretary,
Gregory Geoscience Limited,
1750 Courtwood Crescent,
Ottawa, Ontario K2C 2B5

5.9 REPORT OF THE WORKING GROUP ON HYDROLOGY

5.9.1 Airborne Remote Sensing

The Atmospheric Environment Service of Environment Canada has continued the Airborne Radiation Thermometry (ARTS) Surveys of the Great Lakes and the St. Lawrence River.

B.C. Hydro's Hydrology Section continued its snowline flights observing the snow covered area of 17 drainage basins once in May and once in July. These flights also provided ground truth for the WMO Case Study in the Columbia River Basin.

The airborne natural gamma spectrometer survey was carried out over the Souris Basin (North Dakota and Saskatchewan) by the U.S. National Weather Service in February and March, 1975, to measure the water equivalent of the snow cover. Canada cooperated in the collection of ground data. The survey proved to be a success especially in providing the operational agencies with near real-time (within 24 hours).

The Manitoba Water Resources Branch conducted flying for surveillance of river levels in southwest Manitoba particularly of the Assiniboine and Souris Rivers. The multispectral imagery was used to determine the extent of flooded areas, track the movement of runoff water, assess damage claims, and determine bank-full flow to aid in reservoir regulation.

5.9.2 Spaceborne Remote Sensing

Canada is participating in an international project on snow studies by satellites sponsored by the World Meteorological Organization. Four international basins were selected for joint Canada - U.S. study: the Saint John, Lake-of-the-Woods, Souris and Columbia. The Atmospheric Environment Service is responsible for overall coordination of Canadian contributions to the project. Many other federal and provincial agencies are involved in the analysis of VHRR and LANDSAT imagery and the collection of ground truth information. Much of the coordination of this work has been handled through the Working Group's Task Force on Snow and Ice. These basin studies are considered to be principal "demonstration projects" for developing practical methods of using satellite data for analyzing the extent of snow cover. In addition, efforts are being made to obtain from the remotely sensed data information on snow melt and snow depth. This project will continue through the 1975-76 snow season. It is expected that additional efforts will be made to analyze digital data to supplement the imagery analysis, to develop improved turnaround time for the provision of imagery and to conduct a limited program of airborne remote sensing in support of the project. The Task Force on Snow and Ice has invited the cooperation of CCRS on these aspects of the study.

In the Columbia River Basin Study there are considerable discrepancies between the snow cover values from the B.C. Hydro snowline flights, the Glaciology Division studies and NOAA's studies. The main problem seems to be the difficulty in detecting snow under heavy conifer-type tree cover and distinguishing between rock and snow. More sophisticated analysis procedures are required to detect snow under these conditions.

By analyzing LANDSAT-1 digital data for the different degrees of reflectance in the near infrared, CCIW personnel identified watershed boundaries during snow-melt conditions and distinguished between areas of recharge and discharge of groundwater. The study focused on two watersheds in Southern Ontario namely, the Big Creek and the Big Otter Creek; in total this is an area of about 1466 km^2. The drainage pattern obtained agreed well with the available ground observations and will aid in improving basin management models.

There is an interest in using cloud climatology to better define the distribution of precipitation on a mean monthly basis and possibly using it for estimating precipitation on a daily basis in remote areas. Such methods are being studied in the U.S.

5.9.3 Technical Developments

The AES studies at Woodridge, related to WMO projects, are a test of various international methods for measuring precipitation, soil moisture and evaporation and include gamma techniques particularly for improving ground truth for snowpack water equivalent and soil moisture. Work at the beginning of 1975 on the enhancement of satellite snow imagery showed many interesting features that were previously not apparent. At that time the procedure was manual and subjective. During the year programmes have been developed that automatically compute the enhancement matrix for a particular subject of study. Many other improvements have been made including automatic brightness/colour ranging and adding the capability for contouring vector levels in the synthetic image. The result is a much more powerful technique which is suitable for user applications. In view of this, the study of snow imagery is being resumed in cooperation with the Snow and Ice Task Force.

A portable gamma ray spectometer was acquired by the Water Resources Branch IWD and tested in the Souris River Basin. Experiments with this equipment continue at the Central Experimental Farm in Ottawa and in the Bad Lake research basin in Saskatchewan.

5.9.4 Applications and Benefit Analysis

Retransmission of hydrological data via satellites has been operationally proven as practical and is in use in remote areas but has not been expanded because funds are not available at the present time for more ground platforms.

Gregory Geoscience Limited under contract to DINA, is providing weekly snow and ice cover watch reports which pin point the location of the receeding snow line, indicate ice conditions on northern lakes and rivers, and forecast snow and ice cover until freeze-up. These are available to the public through the DINA regional geologists at Yellowknife and Whitehorse and efforts are underway to make this service available to as many users as possible.

The WMO demonstration projects of Remote Sensing of hydrometeorological elements for water management in 4 large drainage basins, the Columbia River, St. John River, Lake of the Woods and Souris River are a move toward practical application of remote sensing. At present the only element being looked at is the percent area covered by snow but it is planned to expand these studies to try to identify snow depth or water equivalent and to identify metamorphosed snowpack versus dry snowpack and thus give some indication of melt conditions.

The Saint John River and Columbia River Studies are well underway. These studies are expected to cover a two year period. Remote sensing for the Columbia River Study will concentrate on snow cover mapping and its application for practical water management. Recent snow cover for specific sub-drainages is required as input for short-term runoff forecasting models which are of particular operational importance during the freshet. The Columbia River Treaty Hydrometeorological Committee is cooperating in these studies and ground truth observations by means of snowline flights are provided by B.C. Hydro. Abstractions of snow cover data from Satellite Imagery is being provided by the NOAA Satellite Service Office in Washington, D.C., using NOAA-VHRR Imagery. Snow cover mapping from LANDSAT Imagery is provided by the Snow Hydrology and Instrument Section, IWD, for the following six bains; Kootenay River above Canal Flats, Columbia River above Donald, Duncan drainage above Duncan Dam, Illecillewaet River above Greely Creek, Blueberry River above Willow-Bank Creek and North Saskatchewan River at Whirlpool Point. It is hoped that operational methodology for remote sensing of hydrometeorological parameters will evolve from the WMO projects and that such methodology will then be documented in operational manuals and practical handbooks.

As a result of the Workshop on Remote Sensing of Snowcover a letter was sent to CCRS, AES and IWD, suggesting that they consider the value of coordinating their efforts to develop demonstration projects and assess their costs relative to conventional methods. The hope was that once such a demonstration project was shown to be operationally feasible and economical that it might then be picked up on an operational basis by appropriate management agencies. A project was proposed to map snow cover and snow water equivalent in the Lake Superior basin and though it received approval in principle there is no funding or man year allotment available at present.

5.9.5 User Liaison

In an effort to increase liaison with users the Hydrology Working Group has started holding every second meeting in different centres across Canada and inviting people in the regions to attend and contribute to the meetings. The agenda is planned to try to minimize administrative business and encourage maximum exchange of information. The first of these meetings was held in Victoria, B.C. on June 2-3, 1975, and 12 regional people attended.

5.9.6 Training

There is still a need for workshops or training sessions to increase awareness of the potential of remote sensing and to increase expertise in interpretation and application of remote sensing. Both of these activities are required to help move the use of remote sensing from the area of studies to that of application.

The major effort in this direction was the holding of a workshop on Remote Sensing of Snowcover at CCRS January 13-15, 1957. This workshop was considered very successful by the approximately 35 people who attended. It provided detailed information on current methodology and technology in this field which indicated that remote sensing of snow cover is one of the most advanced practical applications of remote sensing to hydrology and is being used on an operational basis in the United States. In Canada it is very close to moving from study to operational basis. Satellite Imagery can define the areal extent of snowcover and its changes on a daily basis from NOAA Satellites and on a 9 to 18 day basis from LANDSAT Imagery, cloud cover permitting. Satellite Images indicate thickness of snow to a limited extent and can differentiate new snow from metamorphosed snowpack but cannot yet give quantitative figures of water content. To provide quantitative areal snow water content data on a research basis, satellite imagery has been used in combination with other remote sensing systems and ground measurements and has provided promising results. One of the most promising has been the combination of snowcover from satellite data with measurement of the attenuation of natural gamma radiation from aircraft and ground truth by measurement to provide a technique for giving water equivalent of moderate snow cover. Future methods using micro-radiometry may allow measurements through clouds and at night.

The workshop concluded that there is an abundance of information available in the research and experimental field of remote sensing but little has been done to apply this in the operational field and future activities should concentrate on the application of the remote sensing tools to practical operations and particularly to demonstration projects, operational manuals and practical handbooks and seminars. The workshop also prepared the following list of seven distinct requirements:

1) Water storage in and under the snowpack
2) Demonstration projects
3) Better ground truth systems (local and remote sites)
4) Area of snowcover, its depth and density
5) 12 hour basin precipitation, 5 day quantitative precipitation forecasts
6) Imagery in near real-time.
7) Spectral and physical properties of snow.

Planning is well underway for a workshop on remote sensing of soil moisture and groundwater. This planning is being done in cooperation with the Canadian Remote Sensing Society who will be sponsoring the workshop which will take place in August 1976.

5.9.7 Conclusion and Forecast

The use of satellite remote sensing and some of the newer airborne remote sensing methods continue to be chiefly for descriptive studies though there is a continuing slow move towards the use for quantitative operational applications. The tight funding situation has probably contributed to this. The greatest advances toward operational use have been in the field of snow and ice.

Users still express a need for faster availability of images and data since the most valuable use of remote sensing is for near real-time operational work. Some studies cannot be moved to an operational basis until the data are available on this basis. For example experience related to WMO projects was that NOAA imagery from the U.S. took 2-3 weeks and LANDSAT imagery up to 6 months. This now comes through CCRS in about 2 weeks which is still too long for operational purposes where results are needed in 3-4 days or less.

The general outlook seems to be that to get more information from remote sensing on an operational basis there will have to be more use of interpretation directly from digital data rather than from images.

The working group concluded that the topics of main interest at present in the field of hydrology continue to be snowcover, groundwater and soil moisture.

5.9.8 Recommendations

The Hydrology Working Group recommends that:

5.9.8.1 CCRS support demonstration projects which can lead to development of operational programs. In the field of hydrology CCRS should give priority to support of demonstration projects for measuring the water equivalent of snowpack for use in forecasting. Four WMO projects in this field are now underway in Canada and should be supported for the use they will be to Canadians as well as Internationally. These projects in order of priority are:

i) St. John River -lead agency AES
ii) Columbia Basin in Canada - lead agency BC Hydro and IWD
iii) Souris River - lead agency AES
iv) Lake of the Woods - lead agency IWD

The type of support that is required is timely provision of imagery (not more than 2-3 weeks), provision of over-flights at times of LANDSAT imagery, digital abstraction of snowcover data and cooperation with the lead agency in analyzing the digital snowcover data.

It is expected that the program which at present concentrates on percentage snow cover will be expanded to attempt to provide some quantitative figures on snow depths and water equivalent and that the eventual outcome will be guides and manuals on the use of remote sensing for measurement of specific hydrological parameters.

5.9.8.2 CCRS consider the production of a Technical Guide to Remote Sensing in the Canadian context to provide potential users with a concise easy entry to the technical field of remote sensing. Such a guide would be aimed at an audience at the community college level and up who are interested in learning about remote sensing but do not know where to get information, are not familiar with the technical language and are not familiar with the capabilities.

Such a guide should contain:

- a glossary of abbreviations commonly used
- a summary of satellites and of sensors carried
- a summary of the sensors used in aircraft
- information sources for those wishing to go further
- the capabilities of sensors should be described in simple terms i.e. multi-spectral scanning could be described in terms of colours to introduce the user to the idea of wavelengths and similarly for the rest of the electro-magnetic spectrum.

5.9.9 <u>Appendices</u>

5.9.9.1 <u>Appendix I - List of Group Members</u>

Dr. I.C. Brown (Chairman)
Secretariat & Liaison
Inland Waters Directorate
Department of the Environment
Ottawa, Ontario. K1A 0E7

Mr. R.C. Ostry (Secretary)
Ministry of the Environment
Hydrology & Monitoring Section
Water Resources Branch
135 St. Clair West
Toronto, Ontario. M4V 1P5

Mr. R. Beauchemin
Chief, Water Planning & Management Branch
Environment Canada
2nd Floor, Provincial Building
135 St. Clair Avenue West
Toronto, Ontario. M4V 1P5

Mr. W.D. Bruce
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario. K1A 0E4

Dr. K.S. Davar
Department of Civil Engineering
University of New Brunswick
Fredericton, New Brunswick. E3B 5A3

Mr. R.K. Deeprose
Director, Technical Services Division
Environmental Engineering Support Services
Alberta Dept. of the Environment
4th Floor, Milner Building
10040-104 Street
Edmonton, Alberta. T5J 0Z6

Dr. B. Dousse
Water Resources Branch
Dept. of the Environment
P.O. Box 2000
Charlottetown, P.E.I. C1A 7N8

Mr. H.L. Ferguson
Atmospheric Environment Service
Department of the Environment
4905 Dufferin Street
Downsview, Ontario. M3H 5T4

Dr. R. Gillham
Department of Earth Sciences
University of Waterloo
Waterloo, Ontario. N2L 3G1

Dr. A.F. Gregory
President, Gregory Geoscience Limited
1750 Courtwood Crescent
Ottawa, Ontario. N2L 3G1

Dr. J. Kruus
Dept. of the Environment
Ottawa, Ontario. K1A 0H3

Dr. E. Langham
Dept. of the Environment
Ottawa, Ontario. K1A 0E7

Dr. D.W. Lawson
Dept. of the Environment
Ottawa, Ontario. K1A 0E7

Dr. M.G. Paulin
Ministère des richesses naturelles
1640 Boul. de l'Entente
Québec, P.Q. G1S 2T9

Dr. F. Prantl
Dept. of the Environment
P.O. Box 5050
867 Lakeshore Road,
Burlington, Ontario. L7R 4A6

Mr. Vladimir Schilder
Dept. of Indian & Northern Affairs
Ottawa, Ontario. K1A 0H4

Mr. U. Sporns
B.C. Hydro and Power Authority
c/o 970 Burrard Street
Vancouver, B.C. V6Z 1Y3

Mr. R.G. Tress
Airphoto Analysis Associates
366 Adelaide Street East
Toronto, Ontario. M5A 3W6

Mr. A. Warkentin
Dept. of Mines, Resources & Environmental
Management,
Winnipeg, Manitoba. R3M 2K2

Mr. J. Whiting
Saskatchewan Research Council
30 Campus Drive
Saskatoon, Saskatchewan. S7N 0X1

5.10 REPORT OF THE WORKING GROUP ON ICE RECONNAISSANCE AND GLACIOLOGY

5.10.1 Airborne Remote Sensing

5.10.1.1 Passive Microwave Radiometer

During the main AIDJEX experiment a joint program with Aerojet Electrosystems used three passive microwave radiometers, at 4.99, 13.4, 37 GHz, mounted on a Flextrack vehicle. These instruments provided ground truth at the Big Bear site during over flights by the NASA Convair 990 carrying a 19.4 GHz radiometer and CCRS C-47 carrying a 37 GHz radiometer and the scatterometer. The same aircraft flew missions over the AIDJEX triangle in August and October and will be in the area again in April 1976 with the Aerojet radiometers on the ground.

5.10.1.2 Scatterometer

Check-out flights with the scatterometer on board the CCRS C-47 were performed in February off Prince Edward Island. The scatterometer was used again on the same aircraft during April 1975 in the Beaufort Sea area, flying a mosaic parallel to the coast and legs perpendicular to the Mackenzie Delta coast. The results correlated very well with those obtained by the SLAR and ground truth information.

5.10.1.3 Radar

The DND SLAR has been used for ice studies in the PEI area and in the eastern arctic. Sequential imagery off Greenland showed numerous icebergs in fast ice and close pack and movement was detectable even with an elapsed time of 11 minutes.

5.10.1.4 Aerial Photography

Imperial Oil Ltd. used photography for ice-growth, extent and break-up in the Beaufort Sea offshore area during winter and spring 1975.

Low level metric aerial photography have been compared for studying ice break-up and jamming on the Mackenzie River (Glaciology Division, IWD/DOE). Glaciology Division has also used the wild RC-10 aerial camera to acquire metric photography in the eastern high arctic.

5.10.2 Spaceborne Remote Sensing

Scanning microwave radiometer data from NIMBUS-5 has been used to analyze the ice canopy of the north polar area, particularly in the Beaufort Sea area. This gives an all-weather capability to map the extent of open water, first-year and multiyear ice.

5.10.3 Technical Developments

Ongoing combined programs of DOC/CRC and DOE/OAA:

The UHF impulse radar underwent testing in the Ottawa area, spring 1975. Unfortunately the antenna suffered damage in transit to the Beaufort Sea and could not be used at the AIDJEX site.

This radar, now repaired, will be tested again over freshwater ice to determine its capability for detecting frazil ice and ice dams, January 1976, then at the Big Bear AIDJEX site in April.

The FM radar is undergoing modifications to its recording system and will be operational in 1976. Further testing of the X-band radar will be done on the CCRS C-47.

Ongoing program of University of British Columbia:

The UBC 840 MHz pulsed radar glacier sounder was successfully field tested in summer 1975. Airborne depth soundings of several cold glaciers in the St. Elias Mountains, Yukon Territory, gave depths up to 550 m; experiments to remotely sense bed surface roughness and ice birefringence were also attempted.

5.10.4 Applications and Benefit Analysis

AES-Ice Forecasting Central, has continued to use NOAA and LANDSAT data for operational preparation of its ice situation charts. The Airborne Radiometric Thermometer and laser profilometer data from the ice reconnaissance aircraft are now used operationally in tactical support of shipping and the preparation of daily ice forecasts.

A study on methods of archiving remotely sensed ice data in a data bank for rapid retrieval is progressing at the Ice Climatology and Applications Division, AES/DOE.

5.10.5 User Liaison

A workshop on SEASAT-A was held at

the Seventh Meeting of this Working Group, 19-22 January 1976; attended by three members of the US SEASAT-A team.

5.10.6 Training

A Specialist Workshop on Remote Sensing of Ice is being planned for late 1976.

5.10.7 Conclusions and Forecast

The Working Group again says, with even stronger emphasis than in its last report, that SEASAT-A has the potential of being an optimum ice remote sensing satellite. Indeed, present NASA justification for the satellite stresses ice applications as of equal importance as sea-state applications. Furthermore, recent decisions to turn the satellite on over land opens the door for numerous terrestrial applications.

5.10.8 Recommendations *

The Working Group on Ice Reconnaissance and Glaciology recommends that:

1. CACRS stress the urgency of committing Canada to participate actively with NASA in the SEASAT-A program.

2. since SEASAT-A will acquire data over land and ice, as well as the oceans, all other working groups should investigate the potential applications of SEASAT-A. They should consider the implications of the NASA report on its Active Microwave Workshop (NASA SP 376, ed. Richard E. Matthews, 1975) and the Symposium on Remote Sensing in Glaciology (Journal of Glaciology, Vol. 15, No. 73, 1975).

3. CACRS encourage extension of the Arctic ice reconnaissance season in view of industry presence in the Beaufort Sea and Arctic islands.

4. CCRS should continue to provide support for a vigorous microwave program for all-weather remote sensing.

5. CCRS pursue acquisition of a SLAR (since AES will not have SLAR capability until at least 1980) and CCRS should seek rental of SLAR for the Canadian user.

6. the scatterometer and a SLAR be installed as soon as possible on board the CCRS Convair 580.

7. CCRS review the potential of LANDSAT-SLAR composite images.

8. CCRS should pursue an option of obtaining high resolution microfiche for LANDSAT from Prince Albert and Shoe Cove.

9. the name of this group be changed to "The Working Group on Ice". (To consider floating and perennial ice.)

5.10.9 Appendix Group Membership

Dr. R.O. Ramseier, Chairman,
Head, Floating Ice Section,
Research Directorate,
Ocean and Aquatic Sciences,
Department of the Environment,
7th Floor,
580 Booth Street,
Ottawa, Ontario,
K1A OH3. 613 995-2014

Ms. L. Drapier Arsenault, Secretary,
Terrain and Ice Interpretation,
Box 772,
Stittsville, Ontario,
KOA 3GO. 613 836-4003

Mr. A.P. Beaton,
Atmospheric Environment Service,
Department of the Environment,
4905 Dufferin Street,
Downsview, Ontario,
M3H 5T4. 416 667-4712

Mr. R.F. Brown,
Norcor Engineering and Research Limited,
Box 277,
Yellowknife, N.W.T.,
XOE 1HO. 403 873-3707

Dr. W.J. Campbell,
Ice Dynamics Project,
US Geophysical Survey,
113 Thompson Hall,
University of Puget Sound,
Tacoma, Washington 98416,
USA. 206 593-6517

Dr. G.K. Clarke,
Department of Geophysics and Astronomy,
University of British Columbia,
Vancouver, British Columbia. 604 228-3602

Prof. R.J. Dempster,
Dean of Engineering,
Memorial University,
St. John's, Newfoundland. 709 753-1200
Ext. 2570

Ms. I.M. Dunbar,
Earth Sciences Division,
Defence Research Establishment,
Department of National Defence,
Ottawa, Ontario,
K1A 0Z4. 613 996-7051

Major C. Holmes,
National Defence Headquarters,
Department of National Defence,
DAASE 4-4,
Ottawa, Ontario. 613 993-2109

Mr. G. Legge,
Chief Operations Officer,
Canadian Coast Guard,
Tower C, Place de Ville,
Ottawa, Ontario,
K1A 0N5. 613 996-9705

Prof. V. Makios,
Department of Electronics & Materials,
Carleton University,
Ottawa, Ontario. 613 231-2727

Dr. A.R. Milne,
Ocean and Aquatic Sciences,
Department of the Environment,
512 Federal Building,
Victoria, British Columbia,
V8W 1Y4. 604 388-3331

Mr. C.S.L. Ommanney,
Glaciology Division,
Inland Waters Directorate,
Department of the Environment,
Ottawa, Ontario,
K1A 0H3. 819 997-2476

Dr. D.F. Page,
Radar Systems Engineering,
Communications Research Centre,
P.O. Box 490, Station A,
Ottawa, Ontario,
K1N 8T5. 613 996-7051
Ext. 412

Mr. J. Sowden,
Chief, Ice Forecasting Central,
Department of the Environment,
473 Albert Street, Room 527,
Ottawa, Ontario,
K1A 0H3. 613 996-5236

Mr. L.G. Spedding,
Imperial Oil Limited,
339 50th Avenue, SE,
Calgary, Alberta,
T2G 2B3. 403 259-0335

Dr. K. Thomson,
Canada Centre for Remote Sensing,
717 Belfast Road,
Ottawa, Ontario. 613 995-9916

Capt. J.P. Turcotte,
Marine Administration,
Transport Canada,
Transport Canada Building,
Place de Ville, 19th Floor,
Ottawa, Ontario,
K1A 0N7. 613 992-3878

* Additional recommendation

That SAR receiving component of the LANDSAT Station for Shoe Cove be designed as a portable unit, and the LANDSAT Station at Prince Albert be modified for plug-in of the portable SAR receiving unit.

5.11 REPORT TO CACRS FROM WORKING GROUP ON LIMNOLOGY

5.11.1. Airborne Remote Sensing

While members still report active involvement in the analysis of airborne data, a general decline in the usage of the airborne program for limnological applications is noted. This, however, is taken by the Working Group as a positive rather than a negative sign since more specific in-depth analyses are being performed in lieu of some of the more random and haphazard approaches that have tended to plague the development of remote sensing in the past.

5.11.2. Spaceborne Remote Sensing

LANDSAT-1 continues to be a much-used source of data for limnological studies. So much so, that concern is expressed at the backlog of available data from the two LANDSAT vehicles. The Working Group feels quite strongly that additional effort must be put forth into the serious evaluation of this backlog. This type of approach (analyzing already existing data) would logically merge with the current "tight money" configurations experienced by most research programs.

Analysis of SKYLAB data is being pursued at the Canada Centre for Inland Waters. However, the interpretation of these data are being hampered by such problems as:

a) the failure of the SKYLAB astronauts to obtain data on the requested test-site; data from a non-requested site are being processed;

b) the late arrival of data to CCIW;

c) the very poor quality of digital data from the multispectral scanner system; and,

d) extensive cloud cover throughout the scene.

5.11.3. Technical Developments

Software development has proceeded at a number of locations, particularly in regard to the interpretation of LANDSAT-1 data in water quality studies.

The development of such technological sensors as laser devices to measure oil remotely and fluorosensors and scanning photometers to determine inorganic and organic turbidities has been discussed at length in the reports of previous years. Data from such devices have yet to demonstrate reproducibility in their applications to limnological study. However, work in this area is being pursued at a number of institutions.

5.11.4. Recommendations

It is the general concensus of this Working Group that both the existing volume of remotely-sensed data and the expertise for collecting more data exceeds the present interpretative capabilities of the users. The emphasis of future programs must be addressed to reducing the lag between data collection and data interpretation. Interpretive techniques should be directed towards the understanding of limnological processes and the dissemination of that information to the appropriate management levels. We therefore recommend:

1) The use of digital multispectral data in computer compatible tape (CCT) format, together with the appropriate methodology, must be promoted as the most effective means of analyzing and interpreting the copious streams of spatial and spectral information synoptically collected over bodies of water. This could be accomplished through such measures as:

a) when requests for satellite imagery are processed by CCRS, an information sheet be included reminding the user that the data exists in digital form;

b) a brochure be prepared by CCRS explaining how to obtain CCT's and extract the data, services available at CCRS, and potential advantages of their use;

c) CCRS should examine the possibility of establishing a nationwide on-line data storage, retrieval, and manipulation system for handling digital remotely-sensed data.

2) A manual be prepared which would describe the methodology of digital data manipulation and the applications of such data to limnological problems.

The Working Group acknowledges the action taken by CCRS on our recommendation that it be informed of limnological projects initiated in remote sensing. It also notes that action has now been taken on its recommendation that CACRS inform the Working Group Chairmen of action taken on such recommendations.

5.11.5. Appendices

5.11.5.1. Appendix I - Current Reports

5.11.5.1.1. Saskatchewan

Airborne Program

In 1975, the number of agencies using CCRS decreased to 2. The Saskatchewan Research Council was again the highest user with 7 tasks. Crosson of the Institute of Pedology was the other user. The Canada Wildlife Service again flew their own program.

The SRC program dealt with geohydrology and its connection with surface water. The major part of the work centred on the 10 potash mines and the possibility of tailing pond seepage. In addition, as part of the SRC tasks, the following lakes were overflown: Wascana (in Regina), the Qu'Appelle chain of Echo, Mission and Katepwa and the Spruce River area of Christopher, Emma, Belle Lakes.

Liaison with CCRS

Cooperation between CCRS and the users has been excellent. The accuracy of the coverage has been very good. Only one mission was scrubbed and that because there were not enough jobs in Western Canada for the laser fluorosensor. One mission produced imagery which could not be photo reproduced. The major problem is still with NAPL and its scheduling or priority system.

One user has expressed the doubt that the private enterprise likely to take over the airborne work will be able to match the target accuracy required for his work.

ERTS

J. Whiting of SRC finished a CCIW contract on the use of airborne photography, and electromagnetics, and satellite multi-spectral techniques of finding groundwater seepage into shallow prairie lakes. Dr. A. Wacker has also been using ERTS tapes for clustering and sample classification. His problem has been to obtain data in the area of interest southwest of Saskatoon which is 120 miles down range from the antenna site. Until another antenna is online, this problem will persist.

Canada Wildlife Service

This is the only group this year actively using remote sensing solely for limnology purposes in Saskatchewan. The agency has tested medium level aerial photogrammetry and ERTS computer tapes to quantify wetland regimes as to changes in surface area, perimeter and peripheral vegetation. A study is also underway to develop a structural classification between open water and vegetation. They will be purchasing an optical densitometer to further their work. G. Adams' group has been able to identify aquatic plants in the Prairie wetlands with 87 to 90 percent accuracy. The major difficulty has been the resolution and scale limiting the identification to 3 metres of plant zone.

5.11.5.1.2 Freshwater Institute, Winnipeg

The Freshwater Institute, jointly with the Canada Centre for Remote Sensing, Applications Division, has undertaken a study to determine if information received from LANDSAT-1 and LANDSAT-2 is of detailed enough nature to be used to facilitate monitoring of the environmental impact created by the flooding and diversion of the Churchill River at Southern Indian Lake in northern Manitoba. This is a large lake (120 miles long) and it is expected that with increased water levels over old permafrost shoreline, extensive slumping and erosion will create major problems by increasing sedimentation within the lake.

The Freshwater Institute has extensive data from the past three years which establishes the baseline of turbidity in the various areas of the lake and they will continue to collect this information in some areas of the lake as the changes occur. If it is possible to correlate the available information with the data from the LANDSAT images consistently, future ground monitoring can be greatly enhanced by future LANDSAT-2 images. A report from CCRS is expected by early 1976.

5.11.5.1.3. Canada Centre for Inland Waters

As per Specialty Centre Report.

5.11.5.2. Appendix II - Current Bibliography

Wacker, A. and L.R. Custead. Classification of MSS data using clustering and sample classification. IEEE Geoscience Electronics, (in press).

Whiting, J.M. (1975). Evaluation and interpretation of ERTS images for Big Quill Lake. Contract from CCIW (DSS Contract KW-2-1077) Saskatchewan Research Council, Report E75-3.

____________ (1975). Determination of groundwater inflow to Prairie Lakes using remote sensing. Proc. Symp. Machine Processing of Remotely-Sensed Data, 3-5 June 1975, LARS, West Lafayette, Indiana. IEEE cat. No. 75 CH 1009-0-C. Reprinted IEEE Trans. Geoscience Electronics, Dec., 1975.

Whiting, J.M. (1975). Estimation of the effects of drainage and flood control works on the water levels of Little and Big Quill Lakes, Sask. Research Council Report E75-4.

Zoltai, S., F. Pollett, J. Jeglum and G. Adams. Development of a wetlands classification for Canada. Proc. 4th North American Forest Soils Conf., Quebec City, 1973, Pub. 1975 Univ. Laval, pp 497-511.

5.11.5.3. Appendix III - List of Group Members

Dr. R.P. Bukata (Chairman from July, 1975)
Head, Remote Sensing Section, ARD
Canada Centre for Inland Waters
867 Lakeshore Road
Burlington, Ontario L7R 4A6

Dr. R.K. Lane (Chairman until July, 1975)
Regional Policy, Planning & Evaluation Officer
Western & Northern Region
Department of the Environment, EMS
10025 Jasper Avenue
Edmonton, Alberta T5J 1S6

Dr. G. Adams (to June, 1975)
115 Perimeter Road
Canadian Wildlife Service
Migratory Bird Sanctuary
Saskatoon, Saskatchewan S7N 0X4

Mrs. H. Ayles
Biologist, Reservoir Ecology Project
Limnology-Eutrophication Section
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba R3T 2N6

Dr. E.B. Bennett, Observer
Basin Investigation & Modeling Section
Canada Centre for Inland Waters
867 Lakeshore Road
Burlington, Ontario L7R 4A6

Dr. J. Connor (to August, 1975)
Economics Department
Acadia University
Wolfville, Nova Scotia

Mr. P.J. Denison
Acres Consulting Services Limited
5259 Dorchester Road, P.O. Box 1001
Niagara Falls, Ontario L2E 6W1

M. J.P. Gauthier
Service Qualite des Eaux
Module E. Ch. 81-A
Complexe Scientifique
555 Boul. Henri IV, Parc Colbert
Ste. Foy, Quebec

Dr. G. Harris, Observer
Department of Biology
McMaster University
1280 Main Street West
Hamilton, Ontario L8S 4M1

Dr. E.J. Langham (to August, 1975)
Centre Quebecois des Sciences de l'eau
Universite Quebec
2525 Blvd. Laurier
Quebec, Quebec

Dr. T. Northcote
Institute of Animal Resource Ecology
University of British Columbia
Vancouver, British Columbia

Dr. G. Rochon
Canada Centre for Remote Sensing
717 Belfast Road
Ottawa, Ontario K1A 0E4

Dr. R.A. Vollenweider, Observer
Senior Scientist
Canada Centre for Inland Waters
867 Lakeshore Road
Burlington, Ontario L7R 4A6

Mr. J.M. Whiting
Engineering Division
Saskatchewan Research Council
Saskatoon, Saskatchewan S7N 0X1

Professor R. Winter (from August, 1975)
Economics Department
Acadia University
Wolfville, Nova Scotia

Mrs. I. Wile
Water Quality Branch
Ontario Ministry of the Environment
P.O. Box 213
Rexdale, Ontario M9W 5L1

Mr. J.E. Bruton (Acting Secretary from August, 1975)
Remote Sensing Section, ARD
Canada Centre for Inland Waters
867 Lakeshore Road
Burlington, Ontario L7R 4A6

5.12 REPORT OF THE OCEANOGRAPHY WORKING GROUP

In 1975 the working group held two meetings, the first at U.B.C., Vancouver on May 27, the second at Laval University on November 13. The May meeting was held on the day before the Canadian Meteorological Society's Annual Congress at U.B.C. which, for the first time, included an extensive oceanographic programme.

During the year, N. Anderson moved to Ottawa and has resigned from the working group. J. Allen left Memorial University and joined Maclaren Atlantic Ltd., but continues in the working group. R. Peters from Memorial University joined the working group and took on the role of secretary at the November meeting. K. Thomson is the C.C.R.S. representative.

The proceedings of the workshop on "Priorities for Oceanographic Remote Sensing", organized by the working group in Ottawa on November 14, are now available through C.C.R.S.

The working group heard briefings on the work of Hermes Electronics for the C.O.D.S. ocean data system, of Bristol Aerospace on rockets for remote sensing, and on the possibility of Canada/Japan cooperation in oceanographic remote sensing.

The next meeting of the working group will be at Memorial University, Newfoundland on June 15, 1976 when it is planned to visit the new satellite receiving station at Shoe Cove.

5.12.1 Airborne Remote Sensing

5.12.1.1 Joint Chlorophyll Sensing Exercise off Yarmouth, N.S.

A joint chlorophyll sensing exercise took place in August 1975 in a test area off Yarmouth, Nova Scotia. Two ships from the Bedford Institute of Oceanography were employed in a chlorophyll survey of the Bay of Fundy and measured chlorophyll concentrations, their variation with depth and water temperatures at first over the whole Bay and then at fixed locations of relatively high and low concentrations on the designated flight line during aircraft over flights. This data was collected by P. Vandall and K. Denman, B.I.O., who also coordinated the operation.

A C.C.R.S. D.C. 3 flew water colour, fluorescence and thermal sensors. The York University 4-channel scanning interference filter photometer was used to measure the blue/green colour ratio of the water (J. Miller) and the O.A.S. (Pacific) 256-channel spectrometer gave the full visible and near infrared spectrum of back scattered sunlight (R. Neville and J. Wallace). A C.W. laser fluorosensor was flown at night over the same flight lines (H. Gross). A PRT-5 thermal radiometer was used to monitor water temperature variations and a thermal scanner was also used for short sections of the flight. A low level TV camera was available for the night flights.

The exercise was a success in that sufficient good weather occurred in the scheduled time period and data was recorded successfully from all sensors. Delays in processing data from the Airborne Data Acquisition System (A.D.A.S.), primarily to provide a log of aircraft position, are so far preventing comparisons being made between ship and aircraft data. The VLF and INS systems themselves appeared to work well. Problems were also experienced with air/ship communications and with agreement on the basis for flight costing.

5.12.1.2 C.C.R.S. Falcon Flight over Vancouver

At the request of O.A.S., Pacific, the C.C.R.S. Falcon flew high level visible and thermal imagery over Vancouver and the area of the Fraser River plume during both flooding and ebbing tides on June 11, 1975. Surface current data was being collected at this time in Burrard Inlet and details of the flow shown up by Fraser River silt in the photos and by thermal patterns in the thermal imagery could be compared with this data. Surface water temperatures were collected during the day by a number of different agencies to calibrate the thermal imagery and a low level flight with a PRT-5 radiation thermometer was also used to check atmospheric attenuation in the infrared. Examples of the imagery were shown and discussed at the 63rd Statutory Congress of the International Commission for the Exploration of the Sea in Montreal in October 1975.

5.12.1.3 Balloon Photography

A 1600 cubic foot tethered balloon was used to photograph sequences of pictures of mine tailings upwelling to the surface in Rupert Inlet on Vancouver Island in April 1975 at different stages of the tide. The balloon was flown from a launch using a motorized winch. 35 mm colour photographs were taken from heights up to 1200 ft. The streamlined shape of the balloon allowed it to remain near the zenith under most wind conditions, and the complete system could be conveniently handled by a crew of two. The balloon was eventually damaged during an overnight storm, but not before useful sequences of pictures were obtained. A good holding facility for the inflated balloon is clearly needed.

The balloon was flown by Dr. Miyake's group at U.B.C. under contract to J. Gower (O.A.S., Pacific)

5.12.1.4 Target Tracking in the Beaufort Sea

In the second and final year of the Beaufort Sea Project, Dr. Garrett's group at O.A.S. (Pacific) used approximately 200 hours of aircraft time in August and September 1975 tracking drifting drogues marked with radio beacons in a 200 by 100 km area of the Beaufort Sea. Sea surface current data was successfully collected, although problems were experienced with weather and aircraft scheduling. About 70 targets were used; these were deployed from the air and had a useful life of one week on average before being washed ashore or caught in ice.

5.12.2 Spaceborne Remote Sensing

5.12.2.1 Landsat Imagery

Landsat images continue to be used in studies of coastal areas to show silt patterns in the water. Colour variations due to different chlorophyll concentrations have also been reported. The largest use of these images is now for ice studies. J. Marko (O.A.S., Pacific) has collected imagery for the Beaufort Sea Project and R. Ramseier (O.A.S., Headquarters) has used the imagery in Ottawa. A Landsat microfiche library is held at O.A.S. (Pacific).

5.12.2.2 N.O.A.A. Satellite V.H.R.R. Imagery

This imagery with its low resolution, but wider coverage and thermal channel, is more suitable for larger-scale oceanographic studies. An image can give ice cover information with resolution to 1 km for the Arctic Islands or the Beaufort Sea and is being used for this purpose in the Beaufort Sea Project. J. Marko and R. Thomson have recently published an interpretation of a trellis-like pattern in Beaufort Sea ice with a repeat scale of 120 km as being planetary waves in the water (Geophys. Res. Lett. Vol. 2, p. 431, October 1975).

Thermal V.H.R.R. imagery has been used to show surface temperature patterns off both east and west coasts. Some enhancements are available from N.O.A.A., but not as a standard product. Software for enhancing and displaying the images has been developed at O.A.S. (Pacific) and a report on the comparison of such images with standard oceanographic data taken off the West Coast was reported at the oceanographic session of the Canadian Meteorological Society at U.B.C. in May (J. Gower, D. Truax and S. Tabata).

5.12.2.3 Buoy Position Measurements for Surface Current Mapping

If buoy positions can be measured and reported by a satellite then the logistic problems of airborne buoy tracking are avoided. The electronic package becomes considerably more expensive, but costs are rapidly coming down. A set of five buoys were deployed by J. Garrett (O.A.S., Pacific) off the West Coast in December 1975 to be tracked by Nimbus 6. Accuracy appears to be about 1 mile and each buoy costs $5000. Future U.S. positioning systems on the TIROS satellites will be operated by France with cost of the service being recovered from users.

5.12.2.4 GEOS-3 Radar Altimetry

After the limited instrument tests on Skylab, GEOS-3 has been designed to show how a radar altimeter can measure world-wide sea levels and wave heights from space. The sensor penetrates cloud and works day or night, but is limited to the immediate track of the satellite. Release of data has been slowed down by the U.S. military and it now appears that all further results may be classified. Four test tapes have been released to investigators and show that the radar is capable of sea level measurements to about ± 20 cm. Further analysis will show how well wave heights can be determined.

Canadian investigations consist of a water level comparison with tide gauges on sea mounts off the West Coast (L.F. Ku, Tides and Water Levels, O.A.S., Ottawa) and comparison of satellite derived wave heights with measurements from Station PAPA (J. Gower, O.A.S., Pacific). Tide gauges have been lowered to the sea mounts in N.O.A.A. and O.A.S. cruises and some of this data has now been recovered.

5.12.2.5 Nimbus-G

C.C.R.S. has submitted two proposals for Canadian participation in the Nimbus-G satellite. These are:

a) a proposal on experimental airborne flights in conjunction with Coastal Zone Colour Scanner;

b) experimental airborne flights in conjunction with the 5 channel microwave radiometer.

The Oceanography Working Group has been briefed on these proposals and copies were presented to the secretary at the Quebec meeting.

5.12.3 Technical Developments

5.12.3.1 SEASAT

The coming U.S. SEASAT program (all-weather sensing of global wave patterns and winds over the ocean) has aroused considerable interest in Canada, though our degree of participation depends on the additional funding that can be made available. SEASAT data will allow Canada to extend oceanographic studies over the continental shelves and into the Arctic, but will not immediately result in a saving of effort or manpower on existing programs. SEASAT planning groups now exist both in O.A.S. and on a broader interdepartmental government level. The working group can provide contact with government, universities and industry on the working level. J.F.R. Gower has attended a meeting of the SEASAT user working group and is a member of the SEASAT Ocean Dynamics Advisory Subcommittee. Reports on Canadian and U.S. plans for SEASAT have also been presented to the working group by representatives of C.C.R.S. and D.O.E.

The present plan for Canadian participation includes upgrading the East Coast satellite receiving station to receive SEASAT data, production of a digital radar image processor and funding of research and development projects aimed at using the data and understanding their relationships to other oceanographic measurements.

5.12.3.2 Aerial Hydrography

Analysis of stereophotos and the aircraft position and altitude measurements from ADAS continue with the eventual aim of measuring shallow water depths with reduced ground control. There have been delays in ADAS data analysis and in collection of suitable data. N. Anderson has moved to Ottawa, leaving J.V. Watt as representative of O.A.S. (Pacific).

Optech has submitted a design for a laser bathymeter based on a survey of available equipment and of U.S. military and oceanographic experience. Funds are now needed to procure this system. Meanwhile, tests with the existing pulsed laser system continue so that design and processing of the data for the new system can be further improved.

5.12.3.3 Aerial Spectroscopy: 4 Channel Scanning Interference Filter Photometer

This photometer has been flown on several occasions on a C.C.R.S. D.C. 3 and has been shown to be a reliable system for measuring water colour ratios. Minor problems remain under humid conditions. The data processing has been automated and improved.

5.12.3.4 Aerial Spectroscopy: 256 Channel Silicon Diode Spectrometer

The spectrometer has been flown from a Beaver float plane on the West Coast and on a C.C.R.S. D.C. 3 in the exercise off Yarmouth, N.S. The *in situ* fluorescence line from chlorophyll has been observed and may well prove a useful indicator of chlorophyll concentration. Water colour measurements have also been made from a research ship, from a dock and over a CEPEX enclosed environment bag. Spectra have been obtained of soil colours in the Fraser Valley and a joint exercise with the Geological Survey of Canada is being organised.

5.12.3.5 Laser Fluorosensor

A contract has been given to Barringer Research Ltd. by C.C.R.S. to design and construct a new laser fluorosensor.

The new design is to be a significant improvement over the present research instrument now being used. An improved N_2 laser will provide exitation at 337 nm. The receiver will contain 16 spectral channels - the first centered on the water raman line at 381 nm and the sixteenth centered on the chlorophyll fluoroscence at 685 nm. In addition, there will be two spectral channels in which the fluoroscence lifetime can be measured. A real-time operator display and a computer compatible tape recorder complete the hardware.

Oil pollution detection has been emphasized in the design of the instrument and it is hoped that the spectral and temporal information should enable the oil in the slicks to be classified. Daylight operation of the sensor should be possible. This sensor should also be capable of monitoring chlorophyll concentrations as well as the concentration of other fluorescing materials in water.

Experiments will be continuing with the present research system until the improved fluorosensor is delivered in late 1976.

5.12.3.6 MIDAS - Marine Inertial Data Acquisition System (O.A.S., Pacific)

The system is similar to the ADAS units operated by C.C.R.S. It has the same inertial platform but has less data collection capacity and is more compact. Airborne and ground tests have concentrated on defining INS drift errors and track recovery is now accurate to about ± 30 ft. A gun sight system mounted on the aircraft is used to point out landmark directions to the system at intervals during the flight (see O.A.S., Pacific report).

5.12.4 Recommendations

5.12.4.1 Aircraft Costing

Translation of the standard line mile rate into cost per flying hour is a question that has been discussed before. It arose again during the joint chlorophyll experiment when extra flying hours could have been flown with little extra expense, but would have been charged at a rate of $1500 to $2000 per hour, equivalent to $14 per line mile. C.C.R.S. should define their policy here, noting that this was a "technique development" flight.

5.12.4.2 Aircraft to Ground Communications

In this same exercise, co-ordination of ground truth with the aircraft measurements was hampered by lack of communications. The working group recommends that C.C.R.S. makes portable radio equipment available for such exercises.

5.12.4.3 Delays in Processing of ADAS Data

The inertial system is capable of providing accurate track recovery from which track maps could be compiled and related to other flight parameters by regular time marks along track. No such data has yet been produced, processing must be speeded up.

5.12.4.4 Landsat Imagery of Newfoundland

Very little of this seems to exist. C.C.R.S. policy and priority for this should be clearly stated.

5.12.4.5 VHRR Data Received by A.E.S.

The working group would like to hear of any planned cooperation between C.C.R.S. and A.E.S. in processing or using this data. Enhanced thermal imagery is particularly interesting oceanographically and consideration should be given to producing it at Downsview.

5.12.5 Appendix - Membership as of November 1975

Dr. J.F.R. Gower (Chairman)
Ocean and Aquatic Sciences, Pacific Region
Environment Canada
512 - 1230 Government Street
Victoria, B.C.
(604) 656-2612

Dr. Ross Peters (Secretary)
Group Leader, Ocean Engineering
Faculty of Engineering and Applied Science
Memorial University
St. John's, Newfoundland
(709) 753-1200

Dr. André Cardinal
Faculté des Sciences
Université Laval
Québec 10, Québec
(418) 656-5001

Dr. K.L. Denman
Marine Ecology Lab.
Bedford Institute of Oceanography
Dartmouth, N.S.
(902) 426-3255

Mr. A.W. Fia
Vice President
Rocket and Space Division
Bristol Aerospace Ltd.
International Airport
Winnipeg, Manitoba
(204) 775-8331

Dr. Michel Khalil
University of Quebec
Rimouski, Quebec
(418) 724-1614

Dr. K.P.B. Thomson
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario
(613) 993-3350

Dr. Mikio Miyake
Institute of Oceanography
University of British Columbia
Vancouver 8, B.C.
(604) 228-3632

Dr. Trevor Platt
Marine Ecology Laboratory
Bedford Institute of Oceanography
Dartmouth, N.S.
(902) 426-3793

Dr. John H. Allen
Manager
Oceans and Ocean Engineering Division
Maclaren Atlantic Ltd.
Suite 616 Cogswell Tower
2000 Barrington Street
Halifax, N.S.
(902) 422-1304

5.13 REPORT OF THE WORKING GROUP ON REPRODUCTION AND MARKETING

5.13.1 Airborne Remote Sensing

Total line miles and imagery reproduction is lower at writing of report than that at this time last year. There are still a considerable number of projects to be flown and processed by the end of the 1975-76 operations year which will bring program output to 1974-75 levels as projected.

The 1976-77 program is estimated to equal the proceeding two years as the total output in both periods is the result of maximum utilization of aircraft and sensor capabilities.

Project line miles flown - 1973
46,023

1974
20,541

1975 to date
16,406

5.13.1.1 As of 22 Jan 76, 169 flights had been flown on 97 projects. Average number of calendar days for task turnaround was:

	1974-75	1975-76
ASU	2.09	2.49
NAPL/RC Processing	2.26	1.98
CCRS Annotation	16.81	10.22
Awaiting Order	0.06	0.16
NAPL/RC Reproduction	8.97	9.65
CCRS Quality Control	7.75	2.65

Turnaround for the 169 flights, by task priority, was:

Priority	FLIGHTS 1974-75	FLIGHTS 1975-76
1	59	65
2	7	0
3	14	12
4	108	92

Priority	CALENDAR DAYS 1974-75	CALENDAR DAYS 1975-76
1	3.35	3.15
2	15.80	0.00
3	34.50	26.33
4	37.54	27.88

Priorities for airborne remote sensing projects will remain as they were for the 1975-76 program although prime investigators will be advised to utilize Priority One for justifiable urgent requirements and Priority Four for the more routine project. Imagery reproduction will be:

Priority One - No indexing or annotation - imagery to user in 3 working days.

Priority Two - No indexing or annotation - continuous roll printing to user in 5 working days.

Priority Three - Indexed and annotated - continuous roll printing of B&W imagery and stereo pairs, beginning, middle and end of each colour roll to user in 15 working days.

Priority Four - Indexed and annotated - requested reproductions to user in 25 working days.

5.13.1.2 The 1975-76 airborne remote sensing program represent 7.7% on the NAPL Reproduction Centre's output. Full annual production comparison statistics to dates indicated in 1974-75 and 1975-76 are included as Appendices "I" to "V".

5.13.1.3 Innotech Aviation has replaced DND/ASU as the prime contactor responsible for aircraft maintenance and project flying. This change of responsibility and current line mile charges will be presented in detail by E. MacLaren of CCRS Airborne Operations.

5.13.2 Spaceborne Remote Sensing

To January 31, 1976, 52 computer generated Batch Orders, requesting 33,720 photographic items, have been processed, representing a total revenue of $99,536 (Colour - $35,467, B&W - $64,069). This represents a decrease in this year's demand for Landsat imagery through the Data Request and Standing Order route of 31.7%. The production statistics of Appendix "II", which includes film processing, Image Library and master negative production, indicate that the Landsat program is 23.1% of the total NAPL Reproduction Centre workload.

An accurate assessment of customer demand would be to delete initial production statistics which are absorbed by CCRS as operational costs. This would place customer orders for Landsat imagery at approximately 4.4% of the Reproduction Centre's workload.

5.13.2.1 Effective 2 Feb 76 Integrated Satellite Information Service Ltd. (ISIS) of Prince Albert, Saskatchewan assumed responsibility for the reproduction of B&W Landsat imagery. CCRS and ISIS have notified clients on their respective mailing lists of the change. Orders for B&W imagery are now to be forwarded direct to ISIS, and colour, to CCRS for reproduction at NAPL Reproduction Centre.

5.13.2.2 Canada Mosaic

The NAPL Reproduction Centre has compiled mosaics and is producing photomaps of Canada from imagery obtained from NASA's Landsat earth resources satellite. Considering Canada's land mass of 3.85 million square miles, this has to be the largest undertaking of its type in the world.

The country was divided into twelve segments following major geographic or political boundries. From approximately 40,000 Multispectral Scanner scenes available, a total of 1004, Band 6, and in some portions, Band 5, images were mosaicked using 1:1 million line maps on the Lambert Conformal Conic projection as the base control. The mosaics have an accuracy relative to these bases of approximately 1 to 1.5 kilometers. Continuous tone prints with a basic border but no photo image enhancement are available of each segment at a scale of 1:2.5 million.

The mosaic images were chosen on the basis of snow, ice and cloud-free conditions, except in the case of the Arctic Islands where imagery for the months of July and August, 1972 to 1974 inclusive, was selected. This selection did not provide complete coverage and for some areas of the Arctic it was necessary to use imagery with frozen lakes or some snow cover to complete the mosaic. In general, band 6, cloud-free imagery with earth rotation correction was utilized. However, in many areas, in order to obtain cloud-free coverage, segments of several images of the same scene were used. If earth rotation correction was not available, as is the case with earlier imagery, then several prints were made of the image and successive segments used to position detail within the required tolerances. Band 5 imagery was used in mosaicking Southern Ontario as it provides a more detailed presentation than Band 6 of the cities and transportation routes in this area of high development.

In addition to the twelve area sheets composed of summer imagery, there are also a 1:2.5 million Manitoba sheet prepared from winter imagery, a 1:1 million sheet of both Newfoundland and the Maritimes from summer coverage and 1:10 million prints of the entire nation and Canada, north of 60°N.

An extension of these area sheets will be to produce a series of 1:1 million photomaps of approximately 70 NTS primary quadrangles. Approximately half of this series is available as continuous tone prints with borders defined by the NTS grid and containing an overlay of map information to provide certain name, elevation and geographic detail. Project completion date is targeted for June 1976. Appendices VI and VII indicate the mosaics and photomaps available through the National Air Photo Library.

It is expected that there will be sufficient demand for the twelve area sheets and the Canada mosaic from educational institutes, provincial government and planning groups to warrant producing a half-toned lithographic product of each with the added enhancement of names, geographic and border notes. One such litho sheet, Manitoba, has been produced by the Directorate of Map Production and is available from the Canada Map Office as map sheet SIM 10S. The demand for the NTS photomaps is expected to be considerably less than that of the area sheets. These sheets will therefore not proceed immediately to lithographic reproduction but wait until the series is complete and some feel for the possible market has been obtained.

Photographic reproductions of all area sheets, the Canada mosaic and available photomaps are approximately 30 x 36" and can be obtained from the National Air Photo Library. Enlargements are also available to persons interested in images of larger scale. Appendix VIII lists the scales available and charges involved for paper prints and film transparencies and indicate the number of mosaics sold of each area during the present fiscal year.

5.13.3 Catalogues and Retrieval Systems

The Airborne Remote Sensing Catalogue was published in January 1976. It was the final catalogue in a series of twelve publications that comprise the NAPL Photo Coverage Catalogue. These catalogues list all Federal imagery acquired from 1966 to 1974 and beyond 1966 if older imagery is required to provide complete air photo coverage of Canada. Annual updates are planned and the 1975 imagery is being added to the system at this time. Appendix IX shows the quantity of catalogues sold of each area this year.

5.13.3.1 The complete package of Coverage Catalogues, 35mm col. microfiche of indexes and 16 mm B&W imagery in cartridges is now available from NAPL. Appendix X lists the number of fiche and cartridges applicable to each provincial or area catalogue and the prices per package. In the past year four regional centres have been equipped with viewers and a coverage catalogue package of their area of interest. Calgary has complete nation-wide coverage at the Institute of Sedimentary and Petroleum Geology, Edmonton has Alberta coverage at the Department of Lands and Forests, Winnipeg has Manitoba coverage at the Department of Mines and Natural Resources, and coverage of the Maritime Provinces is held at the Maritime Resource Management Service centre in Amherst, N.S. Plans are being made to have British Columbia coverage available in 1976 at the Geological Survey of Canada in Vancouver and at the B.C. Department of Lands, Forests and Water Resources in Victoria.

5.13.4 Research & Development

The most significant advance in 1975 was the change of imagery reproduction procedures that were introduced to ensure standardization and repeatability of Landsat products. The 70mm EBR films dynamic range was purposely lowered from the original 2.0 to 1.5 (Dmin - 0.3, Dmax - 1.8) to produce grey scale linearity on the 9½ inch B&W and colour master negatives. This linearity is necessary to reproduce the closest possible radiometric reference density values so that the band-to-band densities control the proper ratios of yellow, magenta and cyan dyes among the three represented bands in the colour composite negative.

The grey scale that accompanies each 70mm frame is related to the image density and to sensor exposure, therefore the second generation B&W master negative must be exposed and processed to produce the same 1.5 density range. In colour master negative production, the same 1.5 density range is maintained and the colour balance for each negative is achieved by exposing the colour film so that a densitometric neutral grey is formed at the 1.0 (± 0.1) density on the grey scale of each image.

This procedure produces the maximum amount of data in reproduced imagery and ensures repeatability of colour images.

5.13.4.1 CCRS is now producing 70mm EBIR negatives which are to be used as production masters at ISIS. NAPL/RC and CCRS are conducting tests to determine if colour imagery from EBIR negatives is of equal quality and repeatability as that from the present EBIR positive. There will be no change in production procedures until tests have been proven and specifications established.

5.13.5 Recommendations

5.13.5.1 The demand for Landsat products has declined for the second consecutive year. It is recommended that CCRS staff a full time marketing position in the Applications Division to promote the sale and use of satellite and airborne imagery to potential users and to raise their level of confidence in the interpreted data.

5.13.5.2 It is recommended that prime investigators be encouraged to utilize the scientific and technical expertise available at CCRS Applications and Data Acquisition Divisions and the NAPL Reproduction Centre in research and development projects of mutual interest.

5.13.6 Appendices

5.13.6.1 Appendix I - NAPL/RC Production Records - 2 Apr 74 to 2 Feb 75

5.13.6.2 Appendix II - NAPL/RC Production Records - 1 Apr 75 to 1 Feb 76

5.13.6.3 Appendix III - NAPL/RC Production Comparisons by Program

5.13.6.4 Appendix IV - Landsat Batch Order Revenue by Product to 31 Jan 76

5.13.6.5 Appendix V - Landsat Batch Order Revenue to 30 Dec 75

5.13.6.6 Appendix VI - Landsat Mosaic Area Sheet

5.13.6.7 Appendix VII - Landsat NTS Quadrangles Photo Map

5.13.6.8 Appendix VIII - Landsat Mosaic Scales, Prices and Sales by Area.

5.13.6.9 Appendix IX - NAPL General Coverage Systems Catalogue Sales

5.13.6.10 Appendix X - Prices of NAPL Catalogue and Microfiche System

Appendix I

NAPL REPRODUCTION CENTRE

Production Report for APS Period 1 APR. 74 to 2 FEB 75

PRODUCT	Aerial Survey	Airborne Remote Sensing	ERTS	Total
Contact Prints - B & W	412,410	3,310	39,225	454,945
- Colour	65,015	3,732	7,038	75,785
Continuous Printing - B & W	24,634	20,398	25,216	70,248
- Colour	23,030	13,597	505	37,132
Contact Transparencies - B & W	598	757	9,734	11,089
- Colour	1,426	1,123	3,666	6,215
Duplicate Negatives - B & W	5,528	71	430	6,029
- Colour	57	1	83	141
Diapositives	36,637	Nil	Nil	36,637
Enlargements - B & W	6,804	26	767	7,597
- Colour	1,771	75	309	2,155
Film Processing - B & W	61,378	17,549	43,353	122,280
- Colour	61,061	20,932	1,721	83,714
Mosaics - B & W	885	Nil	55	940
- Colour	150	Nil	8	158
NAPL - Index Maps	2,153	Nil	38	2,191
ERTS Master Negs. - B&W	2,153	Nil	68,328	68,328
ERTS Master Negs - Colour	•	•	13,335	13,335
Total Items Produced	703,537	81,571	213,811	998,919
Percentage of NAPL/RC Workload	70%	8.2%	21.4%	100%

Appendix II

NAPL REPRODUCTION CENTRE

Production Report for CPC Period 1 APR 75 to 1 FEB 76

PRODUCT	Aerial Survey	Airborne Remote Sensing	ERTS	Total
Contact Prints - B & W	324,871	1,549	20,485	346,905
- Colour	49,697	1,769	5,308	56,774
Continuous Printing - B & W	49,341	16,746	39,372	105,459
- Colour	28,480	14,218	95	42,793
Contact Transparencies - B & W	141	179	8,213	8,533
- Colour	2,050	340	3,128	5,518
Duplicate Negatives - B & W	8,920	2	303	9,225
- Colour	53	NIL	60	113
Diapositives	26,860	NIL	2	26,862
Enlargements - B & W	8,798	142	883	9,823
- Colour	771	105	255	1,131
Film Processing - B & W	34,198	15,524	65,793	115,515
- Colour	79,897	18,744	65	98,706
Mosaics - B & W	1,606	NIL	2	1,608
- Colour	230	NIL	4	234
Coverage Catalogues	783	NIL	16	799
NAPL - Index Maps	4,433	118	23	4,574
Master Negatives - B & W	NIL	NIL	51,828	51,828
- Colour	NIL	NIL	11,841	11,841
Landsat Mosaic Cont P.	NIL	NIL	1,061	1,061
MICROFICHE INDEXES	3,565	NIL	NIL	3,565
Total Items Produced	624,694	69,436	208,737	902,867
Percentage of NAPL/RC Workload	69.2%	7.7%	23.1%	100%

Appendix III

NAPL REPRODUCTION CENTRE

PRODUCTION COMPARISONS

Items Produced	1 Apr 74 5 Jan 75	1 Apr 75 4 Jan 76	% Difference
Aerial Survey	638,989	574,579	- 10
Airborne Remote Sensing	80,615	67,867	- 15.8
Landsat	200,173	170,719	- 14.7
Total Items	919,777	813,165	- 11.5
Aerial Survey			
B&W	419,995	359,939	- 14.3
Colour	69,736	73,873	+ 5.9
Film Processing B&W	55,683	31,473	- 43.4
Film Processing Colour	59,379	78,737	+ 32.6
Diapositives	32,202	22,855	29
Airborne Remote Sensing			
B&W	24,564	17,780	- 27.6
Colour	17,607	16,324	- 7.3
Film Processing B&W	17,514	14,924	- 14.8
Film Processing - Colour	20,932	18,709	- 10.6
Landsat			
B&W	67,880	45,346	- 33.2
Colour	10,114	7,726	- 23.6
Master Negs - B&W	66,227	45,558	- 31.2
Master Negs - Colour	12,774	10,845	- 15.1
Film Processing	43,158	60,613	+ 14.9
Mosaic Contact Prints		590	
Mosaic Enlargements		38	
Batch Order Revenue	$93,117	$92,114	- 1
Revenue			
Total Product $ Value	$1,183,506	$1,310,660	+ 10.7
Minus S&M	$ 257,180	$ 270,770	+ 5.3
Total Net Revenue	$ 926,326	$1,039.890	+ 12.2

LANDSAT BATCH ORDER REVENUE

1 APRIL 75 TO 31 JAN 76

B&W Product	Unit Cost	Quantity	$ Value
Contact Print	1.75	18,899	33,073.25
15 x 15" Enlargement	6.00	18	108.00
20 x 20" Enlargement	7.00	111	770.00
30 x 30" Enlargement	10.00	58	580.00
40 x 40" Enlargement	12.00	208	2,496.00
40 x 60" Enlargement	15.00	26	390.00
Strip Transparency	3.00	564	1,692.00
Strip Negatives	3.00	264	792.00
Strip Prints	1.75	6	10.50
Contact Transparency	3.00	7,607	22,821.00
20 x 20" Transparency	10.00	22	220.00
40 x 40" Transparency	20.00	32	640.00
40 x 60" Transparency	25.00	1	25.00
Duplicate Negatives	3.00	144	432.00
Total Revenue from B&W			$64,049.75

Colour	Unit Cost	Quantity	$ Value
Contact Print	4.00	3,281	13,124.00
15 x 15" Enlargement	20.00	17	340.00
20 x 20" Enlargement	25.00	70	1,750.00
30 x 30" Enlargement	40.00	9	360.00
40 x 40" Enlargement	50.00	76	3,800.00
Contact Transparency	7.00	2,251	15,757.00
Duplicate Negatives	6.00	56	336.00
Total Revenue from Colour			35,467.00

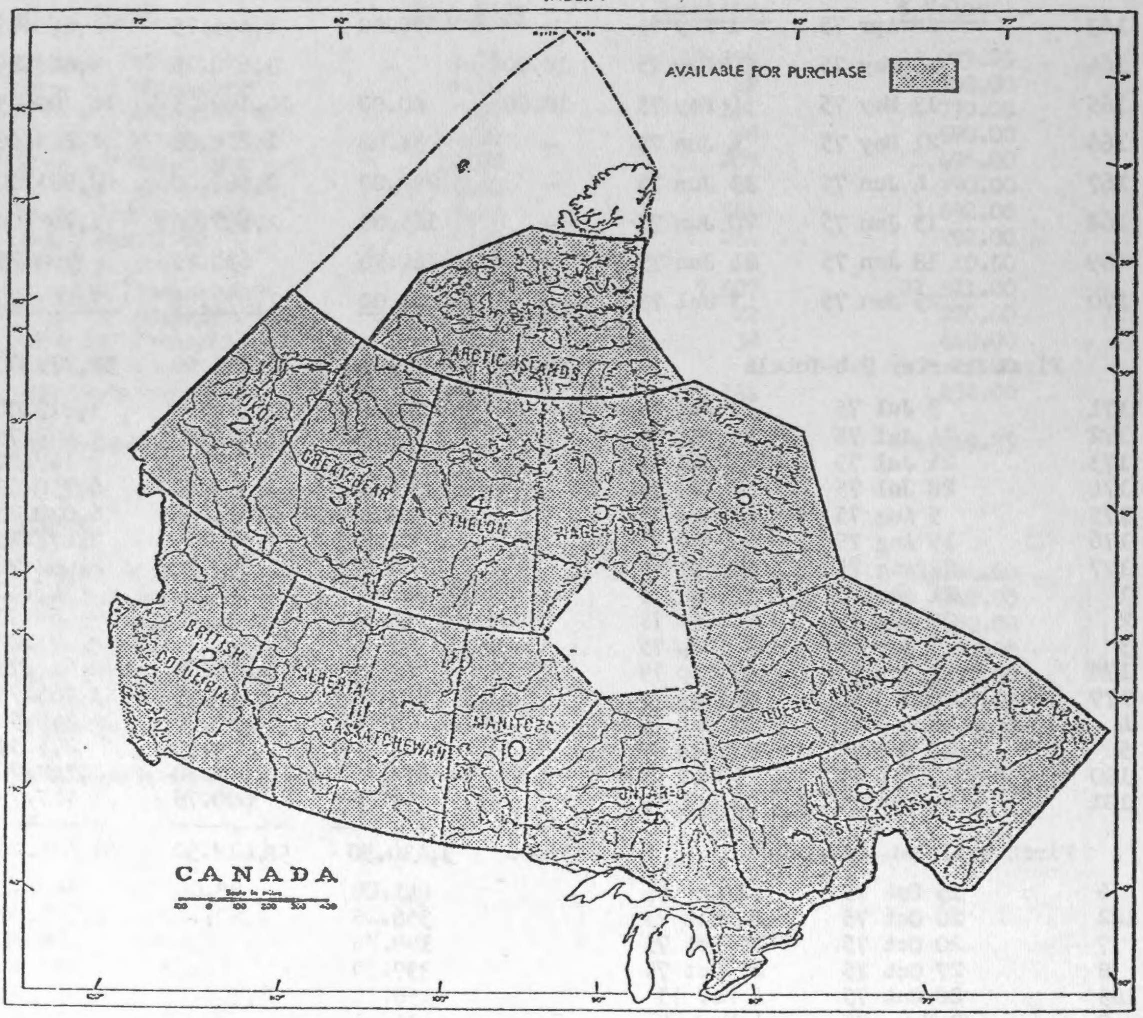
Appendix V

BATCH ORDER DOLLAR VALUE

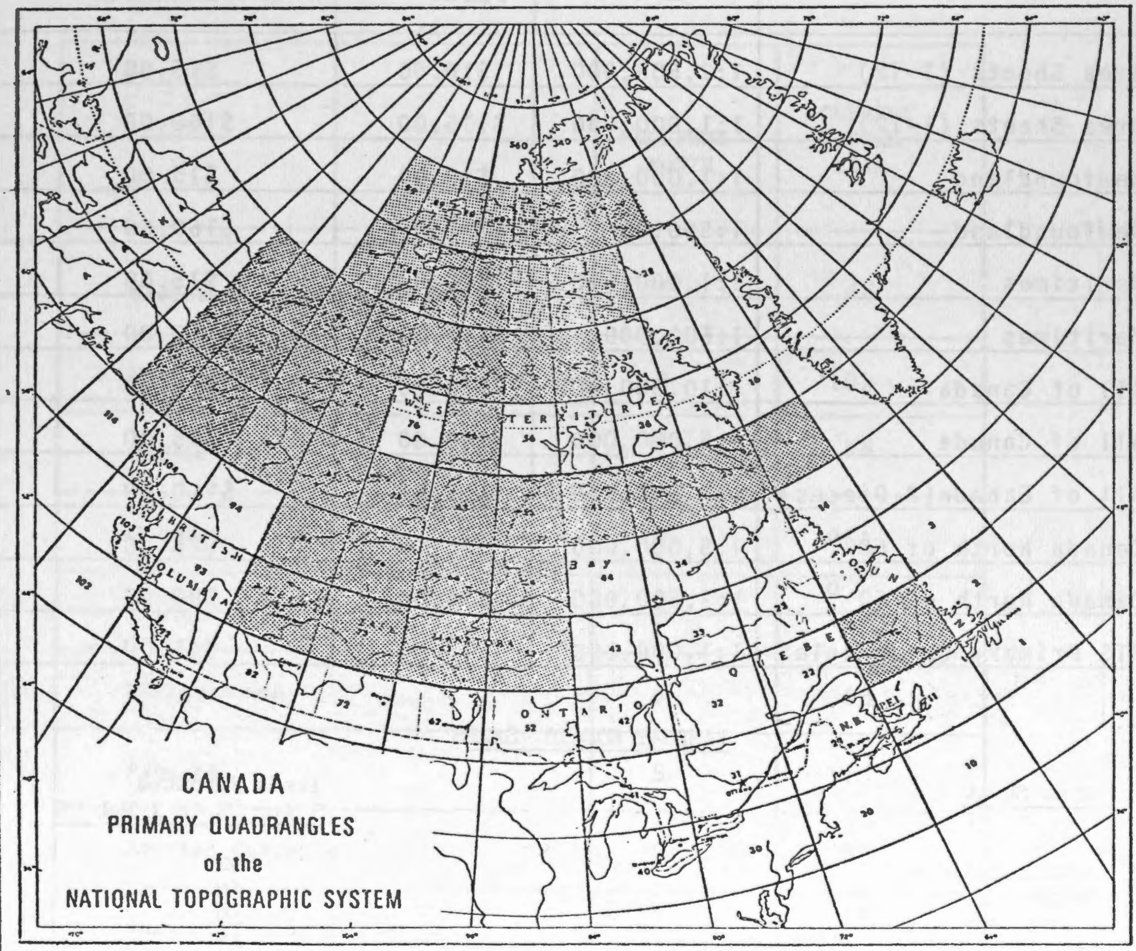
Batch Order #	Date In	Date Out	NAPL	CCRS	Other	Total
160	27 Mar 75	10 Apr 75	–	14.00	4,887.25	4,901.25
161	4 Apr 75	10 Apr 75	–	73.00	939.00	1,012.00
162	15 Apr 75	24 Apr 75	–	7.00	3,091.50	3,098.50
163	28 Apr 75	1 May 75	–	235.00	1,405.75	1,640.75
164	7 May 75	30 May 75	18.00	–	3,630.25	3,648.25
165	13 May 75	30 May 75	18.00	80.00	10,102.25	10,200.25
166	21 May 75	4 Jun 75	–	31.00	1,216.00	1,247.00
167	4 Jun 75	13 Jun 75	–	292.00	2,689.00	2,981.00
168	13 Jun 75	20 Jun 75	–	165.00	1,597.00	1,762.00
169	18 Jun 75	24 Jun 75	–	164.50	634.25	798.75
170	25 Jun 75	3 Jul 75	–	12.00	1,473.25	1,485.25
First Quarter Sub-Totals			36.00	1,073.50	31,665.50	32,775.00
171	3 Jul 75	10 Jul 75		166.50	1,146.50	1,313.00
172	14 Jul 75	21 Jul 75		347.00	1,515.75	1,862.75
173	21 Jul 75	23 Jul 75			147.00	147.00
174	28 Jul 75	6 Aug 75		367.00	6,383.00	6,750.00
175	5 Aug 75	13 Aug 75		395.50	5,634.75	6,030.25
176	15 Aug 75	25 Aug 75		24.50	2,652.75	2,677.25
177	22 Aug 75	28 Aug 75		82.25	1.970.50	2,052.75
1	21 Aug 75	29 Aug 75		342.00		342.00
2	28 Aug 75	3 Sep 75		63.00		63.00
3	3 Sep 75	5 Sep 75		71,00		71.00
178	11 Sep 75	19 Sep 75		14.00	2,602.75	2,616.75
179	18 Sep 75	23 Sep 75		182.00	1,583.75	1,765.75
4	16 Sep 75	18 Sep 75		9.00	239.50	248.50
5	23 Sep 75	25 Sep 75		-	274.50	274.50
180	1 Oct 75	9 Oct 75		236.25	1,911.50	2,147.75
181	6 Oct 75	10 Oct 75		57.00	690.75	747.75
First half Sub-Total			36.00	3,430.50	58,418.50	61,885.00
6	15 Oct 75	22 Oct 75		641.00	58.00	699.00
182	20 Oct 75	24 Oct 75		358.25	2,807.25	3,165.50
7	20 Oct 75	20 Oct 75		109.25	19.00	128.25
8	27 Oct 75	27 Oct 75		339.50	24.00	363.50
183	28 Oct 75	4 Nov 75		150.25	2,768.75	2,919.00
9	3 Nov 75	4 Nov 75		111.75	12.00	123.75
184	4 Nov 75	7 Nov 75		106.25	1,833.75	1,940.00
10	7 Nov 75	14 Nov 75		938.00	93.00	1,031.00
185	12 Nov 75	19 Nov 75		1,064.00	2,314.00	3,378.00
11	18 Nov 75	20 Nov 75		83.75	75.50	159.25
186	20 Nov 75	25 Nov 75		298.00	1,066.50	1,364.50
187	26 Nov 75	28 Nov 75			1,221.25	1,221.25
12	1 Dec 75	10 Dec 75		71.75	3,212.00	3,283.75
188	3 Dec 75	10 Dec 75		344.00	2,870.00	3,214.00
13	8 Dec 75	10 Dec 75		227.25	164.00	391.25
189	11 Dec 75	31 Dec 75		855.50	2,795.25	3,650.75
190	18 Dec 75	9 Jan 75		105.50	1,199.25	1,304.75
14	23 Dec 75	6 Jan 75		368.00	195.00	563.00
191	30 Dec 75	9 Jan 76		82.25	1,246.25	1,328.50
Third Quarter Sub-Totals			36.00	9,684.75	82,393.25	92,114.00

Appendix VI

INDEX 1



INDEX 2


CANADA
PRIMARY QUADRANGLES
of the
NATIONAL TOPOGRAPHIC SYSTEM
ONTARIO
MANITOBA
BRITISH COLUMBIA
TERRITORIES
Bay

Appendix VIII

CANADA BLACK & WHITE LANDSAT MOSAICS

DESCRIPTION	SCALE	PRICE PER PRINT	PRICE PER TRANSPARENCY
Area Sheets (1-12)	1:2,500,000	$10.00	$15.00
Area Sheets (1-12)	1:1,000,000	$115.00	$160.00
Newfoundland	1:1,000,000	$10.00	$15.00
Newfoundland	1:500,000	$115.00	$160.00
Maritimes	1:1,000,000	$10.00	$15.00
Maritimes	1:500,000	$115.00	$160.00
All of Canada	1:10,000,000	$10.00	$15.00
All of Canada	1:5,000,000	$40.00	$45.00
All of Canada(2 Pieces)	1:2,500,000	$115.00	$160.00
Canada North of 60 °	1:5,000,000	$20.00	$25.00
Canada North of 60 °	1:2,500,000	$75.00	$90.00
NTS Primary Quadrangles	1:1,000,000	$10.00	$15.00

LANDSAT MOSAIC SALES

Area Sheet	Items Produced 1 Apr 75 to 1 Feb 76
Arctic Islands	92
Yukon	60
Great Bear	49
Thelon	41
Wager Bay	24
Baffin Island	13
Quebec North	22
St. Lawrence	70
Ontario	112
Manitoba (Winter)	20
Manitoba (Summer)	51
Alta & Sask	57
British Columbia	70
Newfoundland	8
Maritimes Provinces	16
Canada	22
Canada, North of 60°	2
NTS Primary Quadrangles	65
Total	794

GENERAL COVERAGE SYSTEM CATALOGUES SOLD

	CURRENT MONTH	CURRENT FISCAL YEAR
Newfoundland and Labrador	7	48
Maritimes	3	103
Quebec	7	68
Ontario	10	61
Manitoba	3	79
Saskatchewan	6	43
Alberta	5	110
British Columbia	8	63
Yukon Territories	5	49
Northwest Territories	6	110
Remote Sensing	0	0
TOTAL	60	734

NATIONAL AIR PHOTO LIBRARY

Appendix X

CATALOGUE AND MICROFILM SYSTEM

CATALOGUE	COST $	NO.OF FICHE	COST @ $3.00 ea.	NO.OF CART-RIDGES	COST @ $25.00 each	TOTAL COST * $
Newfoundland & Labrador	2.50	45	135.00	120	3000.00	3149.50
Maritime Provinces (P.E.I., N.B. & N.S.)	2.50	50	150.00	170	4250.00	4414.50
Quebec	4.25	91	273.00	288	7200.00	7489.25
Ontario	4.00	103	309.00	305	7625.00	7950.00
Manitoba	3.00	58	174.00	291	7275.00	7464.00
Saskatchewan	2.50	56	168.00	229	5725.00	5907.50
Alberta	2.50	63	189.00	234	5850.00	6053.50
British Columbia	4.00	90	270.00	215	5375.00	5661.00
Yukon Territories	2.50	54	162.00	134	3350.00	3526.50
Northwest Territories	8.50	230	690.00	303	7575.00	8285.50
All of Canada (Mapping Photography)	36.25	505	1515.00	631	15775.00	17338.25
Airborne Remote Sensing Photo (All of Canada)	8.00	215	645.00			
Roll Number Catalogue	12.00					

* Roll Number Catalogue is included in Total Cost Figures.

5.14 REPORT OF THE WORKING GROUP ON SENSORS

5.14.1 General

During 1975-76, the Sensor Working Group met on four occasions to review programs in progress, establish a new method of operation and consider new proposals for sensor development. The 23rd meeting of the group takes place in Banff in early February, 1976. Out of a budget of $100,000, approximately $95,501.90 has been committed by CCRS in the current fiscal year as a result of recommendations by the Working Group.

A total of eight projects are being funded, five of them new this year. For the first time in its history, the Working Group recommended two federal government groups to conduct measurement programs supporting new sensor development. This followed competitive proposals and careful comparative studies, and was consistent with the policy that the most competent source to conduct the work would be sought, whether it be in industry, university or government.

Early in 1975, a decision was made to alter the structure of the Group to reflect more directly the specialized technologies associated with modern sensors. Accordingly, the following Committees were established:

Committee	Chairman
1. Reflection Spectroscopy	Dr. R. W. Nicholls
2. Microwave Sensing	Dr. D. F. Page
3. Laser Techniques and Applications	Dr. C. Cumming
4. Spectroscopic Techniques and Applications	Dr. A. R. Davis

Committees 1 and 2 had been established during the previous year, and have developed some momentum prior to the adoption of the new structure. While the latter three Committees represent the technologies associated with remote sensing, the Reflection Spectroscopy Committee is concerned with the "scientific underpinnings".

The Working Group on Sensors now consists of the four Committee Chairmen, the Chairman and Secretary of the Group and representatives from CCRS. They are listed in Appendix I, and members of the Committees in Appendix II. During the year, Mr. J. MacDowall, Vice-Chairman and Secretary since the beginning of the Group in 1970, left Canada to take up a post in Washington. He served the Group faithfully and with vigour, and will be missed by all. The Secretary now is Dr. J. N. de Villiers who also has been assuming increasing duties in the technical monitoring of sensor contracts.

Existing contracts and future proposals will be screened and judged by the appropriate technology Committee. Recommendations will be passed on to and debated by the Working Group and, as in the past, the Group will continue to transmit its composite recommendations to CCRS. Thus, while the Committees will focus their specialist expertise where required, they form part of and report to the Working Group as a whole.

Many of the currently-funded programs will be completed during 1975-76. For this reason, it was decided that the time had come for a repeat of the original solicitation for sensor proposals conducted in 1970. A list of current requirements for remotely sensed parameters or observables and related studies was prepared and inserted in the January, 1976, issue of the DSS Bulletin calling for expressions of interest by mid-February. From the response, shortlisted bidders will be requested to submit more detailed proposals. They will be evaluated by the appropriate Committee, and the Working Group will arrive at a set of program recommendations for 1976-77. The budget again has been set at $100,000, and as will be seen in Table 1, already $21,000 has been committed.

During the past year, there have been a number of significant Canadian sensor programs that do not fall within the direct influence of the Sensor Working Group. They include aerial hydrography, lidar bathymetry, a laser fluorosensor and a multispectral electro-optical imaging system.

Linked developments in inertially-controlled stereo-photography and lidar bathymetry are continuing in a joint CCRS/OAS program.

Problems exist in processing inertial data through ADAS and in vibrational stability of the LTN-51 platform, but they should be solved shortly. INS data from flights with the rigidly attached LTN-51/RC-10 camera (using the mount designed by NRC) over the Sudbury photogrammetric test range has been combined with photo derived positions (by S. Masry, UNB) using Kalman filtering techniques developed for MOT. Results confirm that the needed accuracy can be achieved.

Reports of phases I and II of Optech's proposals for the lidar bathymeter have been received by CCRS. A lidar bathymeter is definitely feasible, and sufficient support is now needed from the Hydrographic Service. Technical uncertainties remain in determining the greatest depth penetration and Optech have proposed a small project to investigate this.

The UTIAS laser fluorosensor development funded in the past by CCRS through Sensor Working Group initiatives has led to the industrial development of a sophisticated second generation airborne system by Barringer Research Limited of Toronto through DSS bridge funding. The system will measure both the fluorescence spectral signatures of targets in 16 parts of the spectrum and the fluorescent decay times in two parts of the spectrum. The system will be delivered to CCRS in the fall of 1976 for aircraft integration and ongoing evaluation. This is complemented by the NRC laboratory work, described later, to measure the fluorescent properties of real targets.

A push-broom multispectral electro-optical imaging system originally proposed by MDA Limited to the Sensor Working Group has now received support from DSS bridge funding. A two-channel prototype is being developed and will be delivered to CCRS later this year for aircraft integration and concept evaluation.

5.14.2 Recommendations

The Sensor Working Group recommends that:

5.14.2.1 CACRS Working Groups address their requirements for data products not presently attainable through remote sensing from which would flow substantial benefits, and convey such needs to the Sensor Working Group.

5.14.2.2 CACRS Working Groups conduct periodic reviews of the applicability of sensors already developed in Canada as have been listed in Sensor Working Group reports, and convey to the Group opportunities for existing sensors in new Canadian applications.

5.14.3 Project Status Reports

Table 1 is a summary of the sensor development programs to 1976. A summary of programs supported in earlier years appears on p. 130 of the CACRS 1974 Report. The eight programs funded in 1975-76 are described briefly in the following sections.

5.14.3.1 Semiconductor Infrared Photography (SCIRP)

The year 1975-76 marks the termination of the project after three years of intensive experimentation. In the final year, the objectives were to complete current investigations of electron injection photoconductographic system sensitive in the 1 to 3 micron IR spectral region.

It did not prove possible to extend the long wavelength limit of electron injection photography beyond 1.1 microns through substitution of germanium and lead sulfide substrates which had been used successfully earlier.

The infrared photoconductographic system consisting of a silicon lead sulfide hetero-junction image transducer, cellophane-polyvinyl alcohol (PVA) film and cadmium iodide electrolite produced blue images in 10 to 30 seconds when exposed to 10^2 watts per $cm.^2$ of near-infrared radiation. Substitution of amylose for the PVA in recent work increased film speed by 5 times, but was accompanied by new technical difficulties.

The technology developed over the past few years on the SCIRP project has made possible the evolution of more efficient semiconductors for use in solar energy conversion. NRC now is supporting Dr. Pinson in this work.

5.14.3.2 OMA - Spectrometer

The optical multichannel analyser - spectrometer instrument developed by Dr. Jeffers last year was flown in a CCRS aircraft in October, 1975. The flight line was over Lake Ontario from Toronto to Rochester. Spectra of the downwelling and upwelling radiation in two spectral regions (4600-6100A) and (5700-7100A) were obtained. They have been reduced to spectral albedoes and compared to albedo measurements made by Dr. Miller with the York/CRESS interference filter photometer. Agreement was to within a factor of two. It is believed that a lack of more precise agreement is due to the inability of the present spectrometer to record simultaneously the downwelling and upwelling radiation - a situation that is easily remedied by suitably redesigning the input optics.

Such modifications should result in a compact, versatile spectrometer system for passive reflection spectroscopic studies which could be installed in an aircraft, and be directly interfaced with the ADAS system for future operational use.

5.14.3.3 Michelson Scanning Interferometer

Developed through CCRS funding over the past few years, the Michelson interferometer design has emphasized compactness, ruggedness and ease of operation. During the past year, refinements were added to increase the efficiency and versatility of the instrument, and the software was written for transportation of the raw interferograms into conventional spectra suitable for interpretation.

In the current year, the objective has been to gain experience in the collection, processing and presentation of large amounts of spectral data. One flight was made over Lake Erie and approximately 700 interferograms were recorded. Analysis is proceeding using the software that has been developed.

The Fairchild CCD 201 self-scanning image sensor was purchased and tested last year. The 100 x 100 matrix of separate silicon sensor elements (0.4 to 1.1 microns) ultimately will be applied to the Michelson interferometer, but in the present year, the plan is to design and build the necessary circuitry for reading the signal from the sensor elements. Its use offers high spatial and high spectral resolution simultaneously, and therefore requires a high data rate. By integrating signals from a block of detectors, the resolution can be sacrificed in favour of lower data rates. Thus the instrument can be adapted for space or aircraft use and made compatible with whatever telemetry or recording bandwidth is available.

5.14.3.4 Laser Fluorescent Decay Time Measurements

Within the NRC Division of Biological Sciences, Dr. Arthur Szabo is conducting measurements of fluorescence lifetimes and spectra using a high-intensity monochromator and related instrumentation with a time resolution of 0.1 nanoseconds. The equipment is capable of reproducing the spectral conditions of typical fluorosensors using fixed frequency or tunable lasers. The decay time measurements take into account instrument dynamics and computer-introduced anomalies, and identify the dynamic components making up the fluorescent decay time characteristic. Variations of decay time with excitation wavelength and with the physical condition of the contaminent are being measured. The measurements provide essential scientific data in support of on-going fluorosensor development and field programs sponsored by CCRS.

Measurements are being made on the fluorescent properties of oils found in Canadain waters under a wide range of physical conditions. Similar measurements are planned on the background fluorescence of fresh and ocean waters in Canada, the fluorescence properties of noxious effluents such as lignin sulphonate, phosphates, reactor coolants and feed lot runoffs. Fluorescence spectra and decay times will be examined for various algae and their chlorophyll constituents.

The project began in October, 1975, and is expected to run for one year at the end of which it should be possible to estimate the ability of remote fluorosensors to discriminate between pollutant types, and perform an identification.

5.14.3.5 Satellite Laser Applications Study

Optech Inc., through its principal Dr. A. I. Carswell, is conducting a study on the use of lasers on spacecraft. It will examine the present status of space-qualified laser hardware and the achievements of lasers in satellites. More specifically, the study will focus on the use of spacecraft lasers for topside remote atmospheric diagnostics. One technique shows particular promise - Differential Absorption Lidar (DIAL)- which measures the difference between the response of two lidars tuned to slightly different wavelengths, one precisely on an absorption line, the other slightly off. The method should be useful in identifying such species as N_2O, CO, O_3, and SO_2.

5.14.3.6 Radar Remote Sensing Studies

The importance of microwave remote sensing to Canadian requirements is reflected in the award of a CCRS contract to perform "Studies of Radar Remote Sensors for Ice Thickness, Oil Spill and Soil Moisture Applications" to the newly-formed Applied Instrumentation Laboratory in the Department of Electronics at Carleton University, under Prof. Vasilios Makios in association with Profs. W. J. Chudobiak and A. R. Boothroyd. This work was initiated and carried out at CRC until this past year when it transferred to Carleton. Support for the work by the Working Group follows the Working Group's long term but elusive goal to develop an ice thickness radar for sea ice, and also supports another objective of determining a method for the remote measurement of soil moisture.

The program involves the investigation of impulse and homodyne radar techniques. A second generation wide band non-dispersive antenna has been developed which will be retrofitted to the existing prototype UHF impulse radar. Tests have been conducted successfuly on freshwater ice locally near Ottawa, and seawater ice tests are planned for late February in the Arctic. The antenna problem has been to eliminate end reflections. A solution has been attempted using lossy material at the ends of the ultra broad-band horns. Reflection reductions of -26 db are being achieved.

In connection with the feasibility of using the improved UHF instrument for soil moisture determinations, tests and studies using time-delay reflectometer techniques do not look promising. Thus there is a strong case for avoiding further proposals for developing active radar systems for measuring soil moisture until more information has been gathered about the EM properties of moist soils.

Experimental hardware for the existing VHF homodyne radar system has been prepared for the measurement of seawater ice thickness. Operating at 58 and 116 MHz., it is now ready for testing. A second sys- time operating at 4 and 8 GHz is being prepared for the measurement of oilspill thicknesses.

5.14.3.7 Measurement of Electrical Properties of Moist Soils

In furthering the soil moisture measurement objective of the Working Group, Mr. L. S. Collett of the Electrical Systems Section of the Geological Survey of Canada is conducting a series of laboratory and field measurements. The purpose is to establish the basic relationship between dielectric constant and moisture content in soils over the frequency range from 1 MHz to 1 GHz. Parameters to be taken into consideration are soil type, density, temperature, ion type and ionic concentration with soil moisture variation. The work is to be divided equally between the 1975-76 and 1976-77 fiscal years.

Laboratory measurements involve the use of electrode contact methods for small samples, and a coaxial tube with weighing and temperature control devices for 1000 cm^3 samples using TDR techniques. Field measurements will be conducted on the Experimental Farm using TDR, followed by the specification, design, construction and testing of a suitable system for airborne determination of bulk soil moisture. Work was initiated early in December, 1975.

5.14.3.8 Bibliographic Studies in Reflection Spectroscopy

The Committee on Reflection Spectroscopy set as an early goal the production of "an authoritative bibliography on the state of knowledge in the journals and other literature on all aspects of reflectance spectroscopy". Using online bibliographic search techniques, Dr. Frank Bunn of PhD Associates prepared listings of 1431 pertinent references from a total of nearly 6000 citations. Two listings were assembled: a complete reference (title-author-source) listing; and a subject claffified title (only) listing. All 1431 citations were key punched and computer printed.

Currently, software is being adapted for use with the York University computer to reassemble the 1431 citations into a Key Word in Context (KWIC) title listing and an Author listing for each author and his paper(s). A research note will be prepared and published describing the bibliography.

5.14.4 Appendix I - Members of the Working Group on Sensors

Dr. P. A. Lapp - Chairman
Philip A. Lapp Lapp Ltd.
14A Hazelton Avenue
Toronto M5R 2E2, Ontario

Dr. J. N. de Villiers - Secretary
Data Acquisition Division
Canada Centre for Remote Sensing
Ottawa, Ontario
K1A OE4

Dr. R. W. Nicholls, Chairman
Committee on Reflection Spectroscopy
Centre for Research in Experimental Space Sciences
York University
4700 Keele Street
Downsview, Ontario
M3J 1P3

Dr. D. F. Page, Chairman
Committee on Microwave Sensing
Head, Radar Section
Communications Research Centre
Department of Communications
P.O. Box 490, Station "A"
Shirley Bay
Ottawa, Ontario
K1N 8T5

Dr. C. Cumming, Chairman
Committee on Laser Techniques and Applications
Plans Staff, D.R.B.
Department of National Defence
101 Colonel By Drive
Ottawa, Ontario

Dr. A. R. Davis, Chairman
Committee on Spectroscopic Techniques and Applications
Head, CCIW Detachment
7th Floor, St. Joseph Boulevard
Place Vincent Massey
Hull, Quebec

Mr. J. R. B. Murphy
Science Procurement
Department of Supply and Services
88 Metcalfe Street
Ottawa, Ontario

Dr. L. W. Morley
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario

Mr. E. A. Godby
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario

Mr. J. C. Henein
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario

Mr. R. C. Baker
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario

Dr. E. Shaw
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario

Dr. D. Goodenough
Canada Centre for Remote Sensing
2464 Sheffield Road
Ottawa, Ontario

5.14.5 Appendix II - Members of Sensor Working Committees

5.14.5.1 Committee on Reflection Spectroscopy

Dr. R. W. Nicholls, Chairman
Committee on Reflection Spectroscopy
Centre for Research and Experimental Space Sciences
York University
4700 Keele Street
Downsview, Ontario
M3J 1P3

Mr. E. J. Brach
Engineering Research Service
Research Branch
Agriculture Canada
Ottawa K1A OC6

Dr. A. R. Robertson
Radiation Optics Section
Division of Physics
National Research Council
Ottawa K1A OR6

Dr. R. Measures
Institute of Aerospace Studies
University of Toronto
4925 Dufferin Street
Downsview M3H 5T6

Dr. W. W. Duley
Centre for Research and Experimental Space Sciences
York University
4700 Keele Street
Downsview, Ontario

Dr. E. J. Fjarlie
RCA Limited
Research Laboratories
Ste. Anne de Bellevue, Quebec

Mr. J. H. Davies
General Manager
Research & Instrumentation
Barringer Research
304 Carlingview Drive
Rexdale, Ontario

Dr. R. Quiney
Spar Aerospace Products Limited
825 Caledonia Road
Downsview, Ontario

5.14.5.2 Committee on Laser Techniques and Applications

Dr. C. Cumming, Chairman
Committee on Laser Techniques & Applications
Plans Staff, D.R.B.
Department of National Defence
101 Colonel By Drive
Ottawa, Ontario K1A OK2

Professor H. H. Arsenault
Department de Physique
Université Laval
Cite Universitaire
Quebec, P.Q. G1K 7P4

Dr. K. M. Baird
Division of Physics
National Research Council
Montreal Road Laboratories
Ottawa K1A OS1

Dr. W. Duley
Centre for Research
in Experimental Space Science
York University
4700 Keele Street
Downsview, M3J 1P3

Dr. R. A. O'Neil
Canada Centre for Remote Sensing
Department of Energy, Mines and
Resources
2464 Sheffield Road
Ottawa K1A OE4

5.14.5.3 Committee on Microwave Sensing

Dr. D. F. Page, Chairman
Committee on Microwave Sensing
Head, Radar Section
Communications Research Centre
Department of Communications
P.O. Box 490, Station "A"
Shirley Bay
Ottawa, Ontario
K1N 8T5

Mr. E. J. Langham
Department of the Environment
Environment Canada Headquarters
Fontaine Building
Hull, Quebec K1A OH3

Dr. Alex Kavadas
SED Systems Ltd.
P.O. Box 1464
Saskatoon, Saskatchewan
S7K 3P7

Dr. R. O. Ramseier
Head, Floating Ice Section
Ocean Technology Branch
Environment Canada
580 Booth Street, 7th Floor
Ottawa, Ontario

Mr. E. A. Godby
Canada Centre for Remote Sensing
Department of Energy, Mines
& Resources
2464 Sheffield Road
Ottawa K1A OE4

Dr. E. Shaw
Canada Centre for Remote Sensing
Department of Energy, Mines &
Resources
2464 Sheffield Road
Ottawa K1A OE4

Dr. Neil de Villiers
Canada Centre for Remote Sensing
Department of Energy, Mines &
Resources
2464 Sheffield Road
Ottawa K1A OE4

Dr. L. W. Morley
Canada Centre for Remote Sensing
Department of Energy, Mines &
Resources
2464 Sheffield Road
Ottawa K1A OE4

Mr. J. C. Henein
Canada Centre for Remote Sensing
Department of Energy, Mines &
Resources
2464 Sheffield Road
Ottawa, K1A OE4

Dr. K. Greenaway
Department of Indian and
Northern Affairs
Centennial Towers
400 Laurier Avenue West
Ottawa K1A OH4

Dr. Jim Gower
Ocean and Aquatic Sciences
Department of the Environment
Victoria, British Columbia

Dr. I. Henderson
Earth Science Division
D.R.E. Ottawa
Shirley Bay
P.O. Box 11490
Station "H"
Ottawa, Ontario K2H 8S2

Dr. T. J. Katsube
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A OE8

Mr. G. E. Haslam
Department of Communications
Communications Research Centre
Shirley Bay
P.O. Box 11490
Station "H"
Ottawa, Ontario K2HS2

Mr. H. G. Hengeveld
Ice Division
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario

Dr. A. R. Mack
Soil Research Institute
Research Branch, Agriculture Canada
Room 3010
K. W. Neatby Building
Central Experimental Farm
Ottawa, Ontario K1A OC6

Mr. E. F. Cornford
Tower C, 9th Floor
Area "C"
Place de Ville
Ottawa, Ontario K1A ON8

5.14.5.14 Committee on Spectroscopic Techniques & Applications

Dr. A. R. Davis, Chairman
Committee on Spectroscopic
  Techniques and Applications
Head, CCIW Detachment
Place Vincent Massey
7th Floor, St. Joseph Boulevard
Hull, Quebec

Dr. J. Gower
Ocean and Aquatic Sciences
Department of the Environment
1230 Government Street
Victoria, British Columbia

Dr. M. Milan
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario M3H 5T4

Dr. R. A. O'Neil
Canada Centre for Remote Sensing
Department of Energy, Mines &
  Resources
2464 Sheffield Road
Ottawa, Ontario

Dr. K. Thomson
Canada Centre for Remote Sensing
Applications Division
717 Belfast Road
Ottawa, Ontario

TABLE 1 (page 1 of 2)

SENSOR DEVELOPMENT

PROGRAMS SUPPORTED BY CCRS - 1974-76

PROGRAM	CONTRACTOR & PRINCIPAL INVESTIGATOR	FUNDING TO MARCH 31/75	FUNDING 1975-76	TOTAL	STATUS
LASER FLUOROSENSOR	UNIVERSITY OF TORONTO (DR. R. M. MEASURES)	123,234.17	-	123,234.17	COMPLETED (1974-75)
LIDAR	YORK UNIVERSITY (DR. A. CARSWELL)	50,900.00	-	50,900.00	COMPLETED (1973-74)
MULTIPLEX INTERFERENCE PHOTOMETER AND SCANNING INTERFEROMETER	YORK UNIVERSITY (DR. G. G. SHEPHERD)	98,250.00	-	98,250.00	COMPLETED (1973-74)
SEMICONDUCTOR INFRARED PHOTOGRAPHY	INFRARED PHOTOGRAPHIC LTD. (DR. WM. PINSON)	61,015.18	9,000.00	70,015.18	TERMINATED (1975-76)
GASPEC III	BARRINGER RESEARCH	75,530.50	-	75,530.50	COMPLETED (1975-76)
SOIL MOISTURE STUDY	BARRINGER RESEARCH	36,000.00	-	36,000.00	TERMINATED (1975-76)
OMA-SPECTRO-METER	YORK UNIVERSITY (DR. S. JEFFERS)	15,000.00	9,727.00	24,727.00	
MICHELSON SCANNING INTERFERO-METER	YORK UNIVERSITY (DR. J. R. MILLER)	14,400.00	13,356.90	27,756.90	
LASER FLUORES-CENT DECAY TIME MEASURE-MENTS	NRC (DR. A. SZABO)	-	11,000.00	11,000.00	A FURTHER $11,000 IS COMMITTED FOR 1976-77.

TABLE 1 (page 2 of 2)

SENSOR DEVELOPMENT

PROGRAMS SUPPORTED BY CCRS - 1974-76

PROGRAM	CONTRACTOR & PRINCIPAL INVESTIGATOR	TO MARCH 31/75	FUNDING 1975-76	TOTAL	STATUS
SATELLITE LASER APPLICATIONS STUDY	OPTECH INC. (DR. A. CARSWELL)	-	8,000.00	8,000.00	
RADAR REMOTE SENSING STUDIES	CARLETON UNIVERSITY (DR. W. J. CHUDOBIAK)	-	25,843.00	25,843.00	
MEASUREMENT OF ELECTRICAL PROPERTIES OF MOIST SOILS	GEOLOGICAL SURVEY OF CANADA (MR. L. S. COLLETT)	-	10,000.00	10,000.00	A FURTHER $10,000.00 IS COMMITTED FOR 1976-77.
BIBLIOGRAPHIC STUDIES IN REFLECTION SPECTROSCOPY	PhD ASSOCIATES (DR. F. E. BUNN)	-	8,575.00	8,575.00	
SPENT ON PRIOR PROJECTS TO MARCH 31, 1974	SEE TABLE 1, p. 130 IN CACRS 1974 REPORT	324,272.80		324,272.80	
TOTALS		$798,602.65	$95,501.90	$894,104.55	

6.1 REPORT OF THE ALBERTA REPRESENTATIVE

6.1.1 Airborne Remote Sensing

Seventeen flight requests were submitted to the Canada Centre for Remote Sensing (C.C.R.S.) for projects; fourteen were completed, one partially completed and two not flown.

6.1.2 Spaceborne Remote Sensing

There was an increase in the use of spaceborne imagery, particularly in combination with airborne imagery. The number of orders for LANDSAT imagery compiled in the center and forwarded to the National Air Photo Library was greater than in past years.

This increase is attributed to the Center's LANDSAT Order Service, utilizing ISISFICHE and the compilation of orders for requestors.

6.1.3 Alberta Remote Sensing Center

The Alberta Remote Sensing Center, Alberta Environment, has facilities available free of charge to anyone in the province - provincial government, federal government, educational institutions, private industry, and the interested private citizen.

The Center's role is to assist all provincial users in the acquisition, application and analysis of remote sensing in the survey and management of the Alberta environment. Aircraft projects are flight planned and coordinated into a provincial program to eliminate duplication. The Center has specialized interpretation equipment and offers staff assistance in its operation. A library of aircraft and satellite imagery is maintained and a LANDSAT ISISFICHE Facility allows the viewing of scenes shortly after reception. A technical library and document retrieval system is available.

Facilities of the Center routinely travel the province. The Center sponsors symposia and conducts courses and lecture series.

To date 2,200 persons have visited the Center.

The establishment of the Center was an advantageous step in the development of the provincial remote sensing program.

6.1.4 Training

The Alberta Task Force on Remote Sensing conducted the Third Alberta Remote Sensing Training Course, sponsored by the Alberta Remote Sensing Center. It is planned as an annual event.

The Faculty of Extension, University of Alberta, conducted two remote sensing courses for Agriculture and Forestry.

The Third Canadian Symposium on Remote Sensing was held in Edmonton in September, 1975.

6.1.5 Conclusions

As the length of reports are usually in inverse proportion to the activities reported upon, this report is brief.

For detailed information concerning Remote Sensing in Alberta, contact the Alberta Center.

6.1.6 Appendix I

Alberta Task Force on Remote Sensing

Cal D Bricker
Alberta Remote Sensing Center
Alberta Environment
205, 100th Avenue Building
10405 - 100th Avenue,
Edmonton, Alberta
T5J 0Z6

M.C. Brown
Department of Geography
Tory Building
University of Alberta
Edmonton, Alberta

P.H. Crown
Alberta Institute of Pedology
Agriculture Building
University of Alberta
Edmonton, Alberta

E.G. Hammond
Operational Planning
Alberta Transportation
379 Transportation Building
9630 - 106th Street,
Edmonton, Alberta

G.L. Kirby
Northern Forestry Research
Center
Canadian Forestry Service
5320 - 122nd Street,
Edmonton, Alberta

J.J. Lowe
Timber Management Branch
Alberta Energy & Natural
Resources
109th Street, & 99th Avenue,
Edmonton, Alberta

W. McCoy
Southern Alberta Institute
of Technology
1301 - 16 Avenue, N.W.,
Calgary, Alberta

D.B. Patterson
Land Conservation & Reclam-
ation Division
Alberta Environemnt
10040 - 104th Street,
Edmonton, Alberta

W.D. Wishart
Fish & Wildlife Division
Alberta Recreation, Parks,
and Wildlife
O.S. Longman Building
6909 - 106th Street,
Edmonton, Alberta

G.I. Howell Jones
(Miss)C.M. Redmond
Resource Analysis Unit
Data Services Division
Environment and Land Use Committee

6.2 REMOTE SENSING IN BRITISH COLUMBIA, 1975

A SUMMARY REPORT

6.2.1 Background

Since March, 1975, the Map and Air Photo Sales Office, Map Production Division, Lands Service, has maintained remote sensing files for the province and has answered user requests. Some assistance in answering user requests and in submitting airborne requests has also been provided by the Resource Analysis Unit, Environment and Land Use Committee Secretariat. Since April 1976 this assistance has been provided by C.M. Redmond, Remote Sensing Co-ordinator, Data Services Division, ELUC Secretariat, Dept. of the Environment, 839 Academy Close, Victoria.

6.2.2 Airborne Remote Sensing

Thirteen flight requests were submitted to CCRS for the 1975 flying season; of these, eleven were virtually completed, one was cancelled, and one was not flown. The Resource Analysis Unit contacted all principal investigators upon receipt of a copy of the request, and provided minimal co-ordination.

6.2.3 Spaceborne Remote Sensing

Within the ELUC Secretariat, there has been a great increase in the demand for LANDSAT Imagery in the latter half of 1975. Use within other Government Departments and the private section is unknown.

6.2.4 User Liaison

LANDSAT Catalogues are available for view at both the Map and Air Photo Sales Office (553 Superior Street, Victoria, B.C.) and the Data Services Division (839 Academy Close, Victoria, B.C.). In addition, the Ocean Aquatic Sciences Offices at Pat Bay receive ISISFICHE. All 1975 CCRS Airborne Indices and most of the earlier indices for B.C. are available for view in the Resource Analysis Unit and the Map and Air Photo Sales Office.

6.2.5. Conclusion and Forecast

The use of Remote Sensing techniques in British Columbia continues to grow, but promotion is limited to individual contacts.

6.3 REPORT FROM THE MANITOBA PROVINCIAL REPRESENTATIVE

6.3.1 Airborne Remote Sensing

During 1975 there were 11 requests submitted through the Manitoba Remote Sensing Centre for airborne remote sensing projects. The total estimated line miles for these projects was 3,870. Coverage for three of the requests were completed and approximately 35% of a fourth request for a total of 840 line miles. Manitoba had unusually bad weather for aerial photography work during 1975. With a combination of bad weather and the aircraft not being available when conditions were suitable, there was a very low success rate on airborne remote sensing requests. However, this did not dampen the enthusiasm of the principal investigators. Those who were unsuccessful in acquiring data plan to resubmit their requests for next year.

Work is presently underway on the three projects that imagery was acquired for. The objectives of these are as follows:

a) to investigate the use of multispectral imagery for the detection of radiation damage;

b) to investigate the possibility of identifying peat deposit suitable for commercial development;

c) to determine the potential of remote sensing techniques for measuring and monitoring the intensity of land use on natural grazing and hay land.

The Centre, as of April 1, 1975, incorporated the provincial 70 mm camera system into its structure. This system includes two Hasselblaad 500 EL cameras with 70, 80 and 150 mm lenses. A variety of aerographic film types are available ranging from 2402 through to colour infrared and true colour. At present the system is only capable of operating one camera at a time, however, dual and tri-camera systems are presently being investigated and may be implemented next year. Aircraft are supplied from the Manitoba Government Air Division. Hatch plates and mounts have been designed to fit either a modified Cessna 337 or a standard Dehavilland Beaver. Altitudes of 10,000 feet can be obtained by either of these aircraft. The Centre has access to black and white photo laboratory facilities which have greatly improved turnaround times for processing and printing. Colour films must be processed in Ottawa. This year some 4,000 line miles of imagery were acquired at an average cost of $2.47 per line mile. A wide variety of users have been involved with this program. Flights were done for such areas as winter road location, river monitoring, flood damage, municipal planning, survey target identification, wilderness park planning, lakeshore monitoring, tourist park facility mapping, field water crop damage, habitat studies for deer management, habitat studies for water fowl, high water mark establishment, urban expansion studies, forest tent caterpillar studies, marsh boundary and habitat studies, road construction design, gravel pit monitoring, establishment of forest harvest patterns and muskrat hut counts.

6.3.2 Spaceborne Remote Sensing

The Centre maintained a subscription to Isisfiche during the year. This has proven to be an excellent means of keeping up-to-date records on available Landsat I imagery. The number of occasions where this facility is used is quite low, but nevertheless should be available at a regional centre.

Manitoba Data Services, a division of The Manitoba Telephone System, at the request of the Manitoba Remote Sensing Centre, is investigating the possibilities of using computer compatible tapes for operational use. Considerable difficulty has been experienced in sorting out the programs that were obtained from C.C.R.S. on a listing distributed during 1974. The Department of Soil Service, University of Manitoba has obtained a copy of the Larsys Program from the University of Saskatchewan. They have offered to co-operate in this project and exchange information. It is hoped that worthwhile results will be forthcoming in the near future.

The number of requests for Landsat imagery processed through the Centre increased during 1975. It is being purchased and used mainly by government departments for practical use in regional planning, mapping forest fire boundaries, producing surficial geology maps and updating existing maps. It is also used for monitoring forest cutover areas and hydro-electric developments.

The 1:1,000,000 Landsat I mosaic of Manitoba, produced in co-operation with the Canada Centre for Remote Sensing and the National Air Photo Library has proven to be very popular with Manitobans. The mosaic has been enhanced by putting on provincial boundaries, the names of larger lakes and rivers and the place names of some of the larger centres. This was done for ease in orientation for the individual user yet not take away from the natural detail. Prints are available on paper for $1.00 or photographic material for $15.00.

6.3.3 Technical Developments and New Equipment

The Canada Centre for Remote Sensing's policy of loaning equipment to regional centres for assessment purposes has been of considerable value to Manitoba. There was sufficient interest displayed in the density slicer loaned for a period of time during 1974 and 1975 to justify purchasing a Spatial Data System Model 703-32.

During 1975 a Spectral Data Color Additive Viewer was loaned for the same purpose. Several projects were undertaken to establish the usefulness and value of the instrument for operational needs. The Mineral Resources Division of the Department of Mines presently has a program underway to provide a sand and gravel inventory for the entire province. The Color Additive Viewer has shown enough promise that serious consideration is being given to acquiring one on a permanent basis.

6.3.4 User Liaison

The Surveys and Mapping Branch underwent a reorganization during 1975 which brought the Remote Sensing Centre and the Photogrammetric Section together as one unit. It was felt the work in these two areas was quite compatible and personnel can now be employed to better advantage in the overall work load to provide a better service. In the photogrammetric area the responsibility is to provide supplementary control from established ground surveys by aerotriangulation methods and to carry out the compilation of topographic and other specialized maps for programs undertaken by the Branch. In remote sensing the function remains the same, that of monitoring and co-ordinating activities in the technology for possible operational use. One additional responsibility is to maintain up-to-date records on all available aerial photography coverage of the province. This includes conventional 9 x 9 photography which is generally used for mapping, remote sensing imagery and 70 mm supplementary aerial photography. Presently there is a staff of ten to provide information on aerial photography coverage, assist with interpretation and remote sensing needs or fulfill mapping requirements.

For the purpose of developing remote sensing, the Centre maintains interpretation equipment for the use of Manitobans. User time is booked in advance and arrangements can be made for after hours work if desired. Equipment available is as follows:

Zeiss/Jena Interpretoscope-this is an excellent instrument for training and consulting because of its dual viewing feature. It also has an enlargement feature of up to 15 times.

Spatial Data System Model 703-32 density slicer which provides a quick method of analysis of many types of remote sensing imagery.

Numonics electronic calculator for determining area and linear measurements from maps and photographs.

K & E reflector projector for transferring detail from photograph to map.

GAF 240 for producing colour diazo transparencies as a colour enhancing technique.

Zeiss/Jena reader-projector with 17.5 enlargement for working with microfiche or 70 mm format Landsat and airborne imagery.

Lab facilities for developing, printing and enlarging 35 and 70 mm black and white film or enlarging portions of Landsat imagery.

6.3.5 Special Projects

The Department of Mines, Mineral Resources Division has a continuing program to provide a sand and gravel inventory for the province. The Aggregate Resources Unit is actively involved in the development of remote sensing techniques for this purpose. Apart from using conventional black and white aerial photos, they are investigating the use of infra-red and multi-spectral imagery for surficial mapping, terrain classification and to monitor the extraction of aggregates from pits. They are also investigating more sophisticated digital techniques - Interactive Multispectral Image Analysis System (Image 100) - provided by the Canada Centre for Remote Sensing.

Remote sensing has improved the observation of large geological features and significantly shortened the time required for aggregate exploration, thus making the task more efficient. Concentrated efforts are now being placed on the Brandon region, The Pas-Flin Flon region, highways in the north and the east side of Lake Winnipeg.

6.3.6 Training

During the year two courses were conducted by the Remote Sensing Centre in co-operation with the Continuing Education Division, Department of Professional Studies, University of Manitoba. The first was a five-day course held during the latter part of February. It was attended by 47 people who represented most disciplines that would benefit from remote sensing. This was primarily an introductory type course with a large number of presentations. The intent was to get the message across that remote sensing is useful in many ways. Approximately six weeks after the course, evaluation forms were sent out to each participant. The feedback was that future efforts should be discipline-oriented with lots of class participation dealing with local problems. Using these guidelines, a three-day course was set up and held December 10, 11 and 12. For this course, specific emphasis was given to forestry, geology, urban and regional planning. The first day was devoted to discussion of the physical basis of remote sensing, sensors, platforms, etc. The second and third days were designed for specific presentation on the application of remote sensing for the three disciplines. The afternoon of the third day was set aside for small group discussions and participatory exercises related to each of the fields. There were 43 participants for this course. Course evaluation requests will be sent out about the end of January, 1976. From the information received, future programs will be considered.

6.3.7 Conclusion and Forecast

The services and facilities of the Manitoba Remote Sensing Centre continue to be used at an ever-increasing rate. There are many people interested in remote sensing for operational use. Only a few can devote time to working out techniques for specific use. Through monitoring, suggestions can be made about techniques and methods that have been developed in other areas. These do not always apply to local conditions. Often modifications are required, or in some cases, new techniques worked out. Much effort is needed to develop remote sensing for everyday use, especially on a regional basis. Judging from the number of requests received at the Centre to do project work, there is a definite existing need for application, development and training. It is unlikely that response to these requests will be possible in the near future due to the shortage of staff.

6.3.8 Recommendation

Included with Provincial Representatives consolidated recommendations.

6.3.9 Appendices

National Working Group members from Manitoba:

Agriculture - Mr. C. Tarnocai, Department of Soil Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2 (204-474-9354)

Cartography and Photogrammetry - Mr. D. W. Crandall, Deputy Director, Surveys and Mapping Branch, Manitoba Department of Renewable Resources and Transportation Services, 1007 Century Street, Winnipeg, Manitoba R3H 0W4

Geoscience - Dr. D. H. Hall, Department of Earth Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2

Hydrology - Mr. A. Warkentin, Water Resources Division, Manitoba Department of Mines, Resources and Environmental Management, 1577 Dublin Avenue, Winnipeg, Manitoba R3C 3J5

Limnology - Mrs. Helen Ayles, Biologist, Reservoir Ecology Project, Limnology-Eutrophication Section, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba R3T 2N6

Provincial Representative - Mr. W. G. Best, Chief, Remote Sensing and Photogrammetry, Manitoba Department of Renewable Resources and Transportation Services, 1007 Century Street, Winnipeg, Manitoba R3H 0W4

6.4 REPORT OF THE NEW BRUNSWICK REPRESENTATIVE

6.4.1 Airborne Remote Sensing

The four requests for airborne remote sensing missions in New Brunswick were submitted directly to CCRS by individuals; two projects were forestry oriented, one dealt with agricultural crops and the last concerned a coastline study.

The Maritime Resource Management Services located in Amherst, N. S., were able to provide a limited service of conventional black and white, color, and color infra-red imagery for some local projects. It is hoped to improve and expand this service over the next year.

6.4.2 Spaceborne Remote Sensing

The LANDSAT I images from the provinces standing order have not been used extensively although several people have examined the copies on file and presumably ordered specific images.

The study of snow cover mentioned in last years report was continued and expanded this year. During the coming snow melt period it is hoped to correlate ground truth, high level photography, LANDSAT and NOAA imagery in order to predict more accurately the snow melt and run-off conditions that lead to flooding in the lower river basins.

The co-operative study with the Forest Management Institute to identify areas with high tree mortality due to the spruce budworm has not been completely successful. Some LANDSAT images have been processed in the Image 100 but it was found that so much variation exists in the forest condition being studied that the ground truth supplied was not satisfactory. The variation is caused by the "salt and pepper" effect of a mixture of tree species combined with varying degrees of mortality in spruce and balsam fir. Further work is planned as soon as better ground truth is obtained.

6.4.3 Technical Developments

Several projects are under study in different faculties at the University of New Brunswick. Laboratory measurements are being conducted by the Physics Department in preparation for the identification and interpretation of air pollutants that will be measured by the proposed NIMBUS - G satellite. An evaluation of some SKYLAB imagery is being done by the Survey Engineering Department. The Forestry Department has completed the study on the evaluation of wetlands started two years ago and is now involved in developing a system of recording data interpreted from aerial photographs so that it can be processed and presented in map form by computer.

6.4.5 User Liaison

User liaison continues on a low key informal basis. The committee members assist users where they can, whenever contacted. During the past year liaison between users and CCRS has been on a direct basis. The appointment of a liaison contact between CCRS and the provinces will serve a useful purpose.

6.4.6 Training

Members of the New Brunswick committee participated in two workshops for high school teachers, one at the local level was on the use of remote sensing as a teaching tool in geography courses. The second workshop held in Toronto was sponsored by the National Council for Geographic Education.

6.4.7 Conclusion and Forecast

Advances in the use of remote sensing have been made by individuals but no concerted effort has been undertaken to promote a more sophisticated use of the techniques available.

A proposal to establish a remote sensing centre for the Maritime Provinces was presented to the Committee of Environmental Ministers, set up under the Council of Maritime Premiers. No action has been taken on the recommendation and present indications are that money will not be available in the near future for this project. It is probable that the three provinces will continue as they are until the benefit of a common centre can be demonstrated in a tangible way.

6.4.9.1 Appendix I - Current Projects

A project of crop identification and acreage determination is being done to find out if remote sensing techniques are a reliable tool to (1) identify agricultural crops, and (2) determine acreage of agricultural crops grown in the New Brunswick Potato Belt.

Crops are being identified and acreages determined from surveys, low altitude photographs (3,000 feet), high altitude photographs (33,000 feet) and LANDSAT imagery. Comparisons of the results will be made to determine the accuracy and usefulness of these remote sensing techniques.

6.4.9.3 Appendix III - List of Group Members

Professor K. B. S. Burke
Department of Geology
University of New Brunswick
Fredericton, N. B.

Dr. K. S. Davar
Department of Civil Engineering
University of New Brunswick
Fredericton, N. B.

Professor Angus Hamilton
Survey Engineering Department
University of New Brunswick
Fredericton, N. B.

Mr. Phillip L. Hansen
Water Resources Branch
Department of Environment
Fredericton, N. B.

Mr. John M. Henderson
31 Forest Acres Court
Fredericton, N. B.

Professor W. H. Hilborn
Faculty of Forestry
University of New Brunswick
Fredericton, N. B.

Mr. William Hodgson
Research Station
Canada Department of Agriculture
Fredericton, N. B.

Dr. Peter Mosher
Plant Industry Branch
Department of Agriculture & Rural Development
Fredericton, N. B.

Mr. Burtt M. Smith
Forests Branch
Department of Natural Resources
Fredericton, N. B.

Dr. T. E. Sterner
Maritime Forest Research Centre
Canadian Forestry Service
P. O. Box 4000
Fredericton, N. B.

Professor Charles Young
Department of Physics
University of New Brunswick
Fredericton, N. B.

6.5 REPORT OF THE PROVINCE OF NEWFOUNDLAND, 1975

6.5.1 Airborne Remote Sensing

The 1975 airborne remote sensing mainly consisted of aerial photography. To support the provincial forest inventory program the Goose Bay area (Labrador) was covered with 1:12,500 scale black and white photography (Appendix IV). The above scale and color negative film were used to photograph two areas in the north-east section of the island of Newfoundland (Appendix IV) for the same purpose. A topographic mapping program is being conducted by the Crown Lands Office using 1:30,000 scale black and white aerial photography (Appendix IV).

In connection with a sea ice mapping project of the Engineering Faculty, Memorial University of Newfoundland test lines north of Prince Edward Island were covered using the following sensors:

(1) 70 mm. vertical and oblique aerial photography with black and white, normal color, and false color (color infrared) films and scales of 1:5,000; 1:15,000; and 1:30,000.

(2) thermal infrared line scanner

(3) laser profilometer

This sensing was carried out from an Electra aircraft contracted by the Ice Central, A.E.S., Ottawa.

An attempt was made by the provincial wildlife service to carry out caribou census in a section of Labrador and Newfoundland. Base lines were photographed using a 70 mm. Hasselblad camera and color infrared film.

6.5.2 Spaceborne Remote Sensing

The use of satellite imagery in Newfoundland was very restricted in 1975. ERTS and NOAA imagery and computer compatible magnetic NOAA tapes were applied in the sea ice mapping project. ERTS mosaics were also used in geological surveys by the provincial Mines, Energy and Resources Department. No agency has a standing order for ERTS imagery in Newfoundland. However, within the framework of a CCRS winter work project considerable ERTS imagery is being compiled covering Newfoundland and Labrador. Some enlargements of the imagery are exhibited for public view. The objective is eventually to compile coverage for each of the seasons.

The Memorial University has a continuous subscription of ISISFICHE.

6.5.3 Technical Developments

In connection with the ice mapping project a FORTRAN program was developed to map out equal density or intensity levels using magnetic tapes of scanning micro densitometers or computer compatible magnetic tapes of satellites. The program package consists of a main program and four subroutines. One of the subroutines is a modified version of a library program (called "CNTOUR") distributed by the University of Waterloo Computing Center. With this method ice distribution maps can be prepared from NOAA satellite tapes.

6.5.4 Applications and Benefit Analysis

Actual cost-benefit analyses were not carried out in 1975. However, quite a few projects were conducted which were considered feasible, such as the Newfoundland forest inventory, sea ice mapping using satellite imagery, etc. A brief summary of the 1975 activities of various agencies is included.

(a) Agriculture

The Canada Land Inventory is still going on. In 1975 the Sandy Lake area was mapped at 1:50,000 scale.

(b) Federal Forestry

A vegetation type mapping was carried out covering the area of the Terra Nova National Park. For this interpretation, 1:15,840 scale color photographs were used. The map was prepared for Parks Canada as part of a biophysical land classification inventory. Some pollution studies were also conducted by this center. Damage to vegetation from the Long Harbour phosphorus plant was determined and mapped using 70 mm. color infrared aerial photographs.[7]

(c) Provincial Forestry

The Provincial Intensive Forest Inventory was continued in 1975 using

1:12,000 scale, color aerial photographs. In addition, new cut over areas and new roads were mapped.

(d) Provincial Geology

As routine work the Mineral Development Division of the Mines and Energy Department is conducting surficial material and bedrock mapping using black and white aerial photographs and ERTS mosaics. Some of their work was published in 1975.[5,6,8]

(e) Provincial Lands Branch

The Canada Centre for Remote Sensing in cooperation with the above branch conducted a biophysical terrain evaluation of the St. George's Bay area using ERTS imagery. This study was carried out in conjunction with the Coastal Resources Inventory and Mapping Program.

(f) Provincial Wildlife

Three trials were carried out in caribou census. Base lines were flown with a Beaver aircraft over caribou populated areas and 70 mm. vertical color photographs were taken using a Hasselblad EM 500 camera.

(g) Memorial University of Newfoundland

Two major projects were completed in 1975. The effect of flooding on vegetation was studied through ground truthing and various aerial photographs in the Churchill Falls reservoir area.[2, 3] An investigation was carried out to evaluate the usefulness of remote sensed imagery in sea ice identification and mapping.[4] An experimental area near Prince Edward Island was ground truthed and covered with the following imagery:

aerial photographs, thermal and radar maps, ERTS and NOAA photos. Ice distribution maps were prepared on all imagery by visual interpretation, together with a computer drawn map using NOAA magnetic tapes.

6.5.5 User Liaison

The "Users Group" met twice. The topic of the first meeting was the discussion of the remote sensing winter work project. The second meeting dealt with the 1975 activities and with future needs. Personnel of the winter work project kept contact with approximately 90 individuals and firms through correspondence. Quite a few people visited their office. An even better liaison is expected in 1976. The supervisor of the above project was named as remote sensing coordinator until the end of May, 1976.

6.5.6 Training

Formal photo interpretation and remote sensing courses are offered by the Memorial University of Newfoundland. Some two to three hours seminars are also conducted for various groups in St. John's.

6.5.7 Conclusions and Forecast

In 1975 a few significant developments occurred which will influence greatly the remote sensing activities in Newfoundland. First of all a satellite receiving station is being built in Shoe Cove which should be operational by the end of June, 1976. Two large organizations were established (NORDCO and C-CORE) which make extensive use of remote sensing in their work. Both the provincial Crown Lands Office and the Faculty of Engineering moved into a new building with new remote sensing facilities. The former has an extensive remote sensing library, including that of the remote sensing winter work project. This unit is also capable of carrying out extensive topographic mapping. The new Engineering building houses a well equipped remote sensing lab. The following major equipment is available for image interpretation:

VP8 image analyser with graphic display monitor; scanning micro densitometer with magnetic tape unit; Baush and Lomb 240 zoom stereoscope; Baush and Lomb zoom transfer device; Kodak Magnaprint reader printer; Kelsh plotter. Besides these, four motorized Hasselblad 70 mm. cameras (two of these are MK-70) and a PRT-5 radiation thermometer are available for experimental data gathering.

The "Ocean Engineering Group" of the Engineering faculty is also involved in remote sensing projects. A great deal of literature concerning remote sensing was accumulated by this group.

In 1975 and early 1976 quite a few programs were initiated by NORDCO, C-CORE, and the "Ocean Engineering" of MUN using remote sensing concerning sea and ice state in the Atlantic. This work will be expanded greatly with the operation of the Shoe Cove station and with the launch of new satellites such as the SEASAT.

Considerable interest in remote sensing was generated by a special

NATO meeting on "Arctic Systems" which was held in St. John's, Newfoundland, in 1975. Within the framework of this meeting the use of various remote sensing systems was discussed and their importance was emphasized in connection with operation under arctic and subarctic conditions.

In evaluating the importance of remote sensing, it was the concensus of the users group that the Provincial Government should look after this matter officially in Newfoundland. A permanent position of a remote sensing coordinator should be created in the Provincial Civil Service. However, it was felt that this will not happen because of the tight money policy and because of the negligible interest in remote sensing (very low priority) by provincial politicians and deputy ministers.

6.5.8 Recommendations

The Newfoundland users group did not forward any recommendations this year. We were pleased with the action taken by CCRS on most of last year's recommendations and have decided that it is appropriate that we pursue current developments in our Province before submitting further recommendations.

6.5.9 Appendices

6.5.9.1 Appendix I - Current Projects

Several units of the Provincial Government are carrying out routine work involving remote sensing, i.e. forest inventory, geological mapping, evaluation applications for Crown Lands, topographic mapping, etc. In addition, some research projects are conducted by various agencies, the most significant of these being the multi-faceted sea ice research program being carried out by the Engineering Faculty of the Memorial University, by C-CORE and NORDCO. Plans were already made for the continuation of this research in 1976.

The CCRS has established an information centre (winter work project) which will be in operation until May 31, 1976. This facility has been set up to provide regional information on remote sensing, and particularly on ERTS imagery. There is a VUCOM terminal linked to three computerized data bases. A density slicer (model 703) is also available for use in the centre. At the present this facility is engaging in a variety of projects. The present staff consists of a supervisor, secretary, and three technicians.

6.5.9.2 Appendix II - Current Bibliography

(1) Bajzak, D. 1975. Interpretation of Vegetation and Surficial Deposits in the North. Paper presented at the 68th Annual Meeting of the Canadian Institute of Surveying, June 23-27, 1975, Fredericton, N.B.

(2) Bajzak, D. 1975. Interpretation of Flooding Damage to Vegetation in the Smallwood Reservoir, Churchill Falls, Labrador. Paper presented at the Third Canadian Symposium on Remote Sensing, Sept. 21-24, 1975, Edmonton, Alberta.

(3) Bruneau, A.A. and D. Bajzak, 1975. Effect of Flooding on Vegetation in the Main Reservoir, Churchill Falls, Labrador. Report submitted to the Churchill Falls (Labrador) Corporation. Memorial University of Newfoundland, St. John's, Newfoundland.

(4) Greene,B.A. 1975. Report of Activities, 1975 Mineral Development Division Department of Mines and Energy, Province of Newfoundland, St. John's, Newfoundland.

(5) Fogwill, W.D., and V. Hawkins, 1975. Bibliography of the Geology of Newfoundland and Labrador 1969 to 1974. Open file report, Mineral Development Division, Department of Mines and Energy, Province of Newfoundland.

(7) Sidhu, S.S., and B.A. Roberts, 1975. Damage to Vegetation in the Vicinity of a Phosphorus Plant, Long Harbour, Newfoundland. Bi-monthly Research Notes. Forestry Services Environment Canada. Vol. 31. No. 6, Nov-Dec 1975.

(8) Vanderveer, D. 1975. The Surficial Geology of the St. John's Area, with Special Emphasis on the Gravel Resources. Mineral Development Division, Department of Mines and Energy, Province of Newfoundland

6.5.9.3 Appendix III - List of Group Members

Dr. D. Bajzak, Faculty of Engineering, Memorial University

Mr. W.A. Ball, Price (NFLD) Pulp & Paper Ltd.

Mr. E.C. Banfield, Geography Department, Memorial University

Mr. D. Barbour, American Smelting & Refining Co.

Mr. K. J. Beanlands, Division of Crown Lands, Government of Newfoundland

Dr. P. Benedict, Faculty of Engineering, Memorial University

Mr. J.P. Bouzane, Nfld. Forest Research Centre, Environment Canada

Mr. J.A. Brennan, Newfoundland Forest Service

Maj. R.G. Bridgeman, Dept. of National Defence

Dr. A.A. Bruneau, Vice-President, Memorial University

Mr. J. Byrne, Newfoundland & Labrador Power Commission

Mr. H.W. Chancey, Research Station, Agriculture Canada

Dr. K.D. Collerson, Geology Department, Memorial University

Mr. M.P. Crane, Geography Department, Memorial University

Mr. B. Delaney, Nfld. Forest Service

Dr. R. Dempster, Faculty of Engineering, Memorial University

Mr. W.A. Dickson, Bowaters Newfoundland Ltd.

Mr. F.M. Earle, Nfld. Forest Service

Mr. A.M. Flemming, Fisheries Research Board of Canada

Mr. Dave Fong, Provincial Wildlife

Mr. B.A. Greene, Dept. of Mines and Resources

Mr. Stuart Gulliver, Newfoundland Remote Sensing Facility

Mr. S.E. Holmes, College of Trades and Technology

Mr. P.K. Heringa, Research Station, Agriculture Canada

Mr. S. James, Price (NFLD) Pulp & Paper Ltd.

Mr. M.J. Kennedy, Geology Department, Memorial University

Mr. Colin Langford, Newfoundland Oceans Research & Development Corp. (NORDCO)

Mr. R.V. Maher, Geography Department, Memorial University

Dr. J.B. MacPherson, Geography Department, Memorial University

Dr. A.W. May, Biological Station, Environment Canada

Mr. E. Mercer, Nfld. Wildlife Service

Mr. W. Nurr, Aero Tech. Services

Mr. J.B. Nuss, Churchill Falls Corp. Ltd.

Mr. N. Parsons, Nfld. & Labrador Power Commission

Dr. G. Ross Peters, Ocean Engineering, Memorial University

Dr. F.C. Pollett, Canadian Forestry Service, Environment Canada

Mr. B. Roberts, Nfld. Forest Research Centre

Mr. R.J. Rogerson, Geography Department, Memorial University

Dr. W.G. Smitheringale, Consultant, Geology

Mr. R. Smyth, Dept. of Mines & Energy

Mr. M.D. Suudom, Research Station, Canadian Dept. of Agriculture

Mr. D.G. Vanderveer, Mineral Development Division, Dept. of Mines & Energy

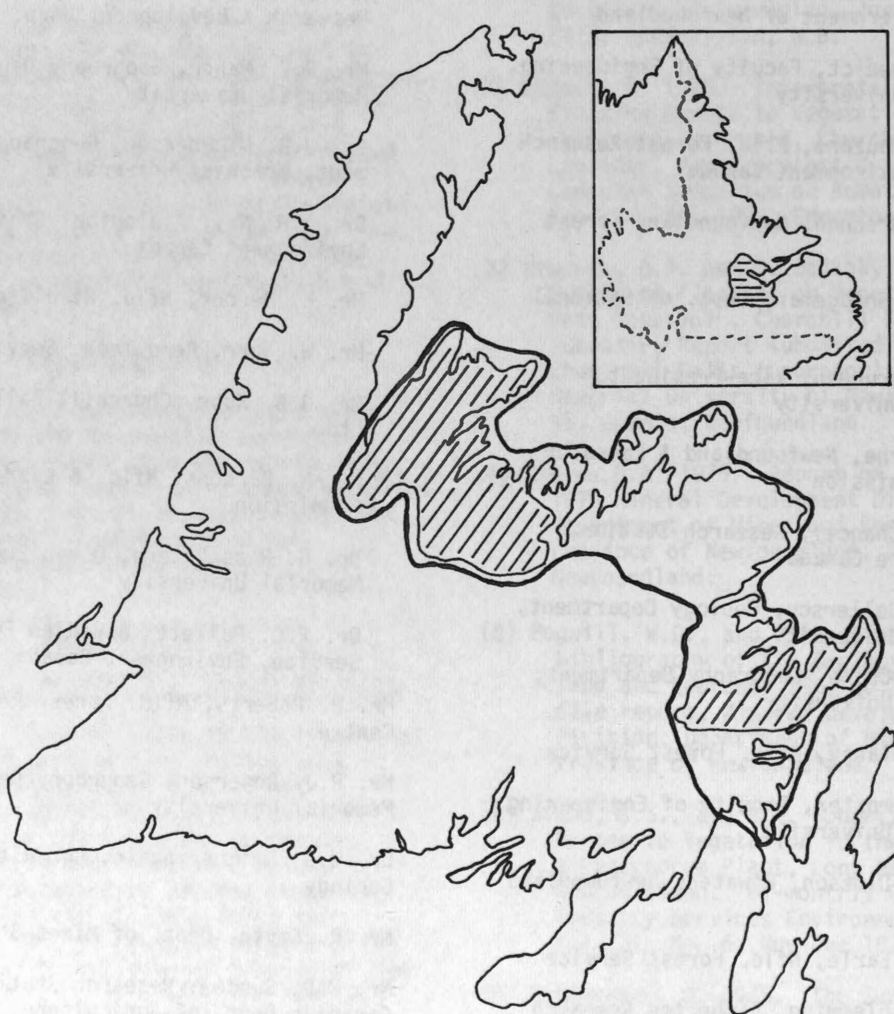
Mr. H. Whelan, Newfoundland Forest Service

Mr. J.W. Williams, Department of Agriculture

Mr. Robert Warren, Crown Lands Division, Government of Newfoundland

Mr. Rick Worsfold, Centre for Cold Ocean Resources Engineering (C-CORE), Memorial University

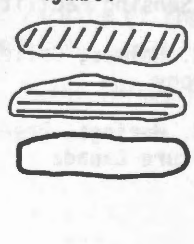
6.5.9.4 **Appendix IV - Airborne Imagery, 1975**



LEGEND

Type of Photography	Scale
Color negative	1:12,500
Black and white	1:12,500
Black and white	1:30,000

Symbol



6.6 REPORT OF THE NOVA SCOTIA COMMITTEE ON REMOTE SENSING

6.6.1 General Activities

During this past year, the Nova Scotia Committee has been primarily concerned with the Regional Center concept with a proposal being submitted to Government for consideration.

Quite apart from education being an integral part of the Regional Center proposal, this need has been recognized and to some extent, acted upon.

The use of conventional air photos appears to be fairly extensive. This is reflected in the fact that approximately 80,000 contact prints, both B & W and color were produced by MRMS for Nova Scotia customers.

The most recent meeting of the N.S. Committee was attended by Mr. Brian Bullock of INTERA Environmental Consultants Ltd., Calgary, Alberta. Mr. Bullock brought the Committee up to date on the transfer of the airborne program to a civilian company and the, then current, study being undertaken to establish remote sensing needs in Canada.

6.6.2 Regional Remote Sensing Center

According to the terms of reference established for the N.S. Remote Sensing Committee a proposal for a regional center was to be drafted and submitted to the Committee of Environmental Ministers, under the Council of Maritime Premiers, for consideration.

In July of this past summer, the proposal was presented to this committee with Dr. Morley of CCRS also addressing the committee on the subject of remote sensing centers.

The results of the presentation were far from conclusive, leaving the future of such a center, as proposed, still in doubt. There has been no further action taken by the N.S. Committee since that time.

6.6.3 Photo Interpretation and Remote Sensing Workshop

A workshop was held at the Nova Scotia Land Survey Institute, Lawrencetown, N.S. on October 2, 3 and 4 with registered attendance reaching 92 persons.

As an introductory seminar — short course, the object was to provide an initial exposure of both theory and technique to a wide range of users and potential users.

Any inquiries in regard to follow up courses should be directed to Mr. John Wightman, Vice-Principal, N.S. Land Survey Institute, Lawrencetown, Annapolis County, N.S.

6.6.4 Sensor Development & Use

Recent work within Nova Scotia has included: A project by the Bedford Institute of Oceanography, designed to obtain absolute measurements of sea surface chlorophyl using remote sensing instrumentation. The airborne sensors were: (1) a filter photometer to monitor visible radiation; (2) spectrometer which recorded light intensity measurements in several bands; (3) layer fluorosensor which measured light reflected from the fluorosense of chlorophyl. Preliminary evaluation of the results show a good correlation between ship and air sensor measurements.

Another B.I.O. activity was the work on a piece of equipment with the potential of night time monitoring of oil spills. This was to be tested using Argus aircraft over the Strait of Canso area.

The Environmental Protection Service will have a cluster of 70mm cameras, capable of being monitored in a Beaver aircraft, for use within the region.

6.6.5 1975 - Airborne Photography

The following provides a general breakdown of the 1975 photo coverage for the province of Nova Scotia as well as the contracting agency.

(1) Land Registration and Information Service, Summerside, P.E.I.

- B & W scale 1:10,000 portions of Colchester, Halifax, Hants, Kings, Guysborough, Richmond and Inverness.
- B & W, scale 1:33,000 of Cumberland, Annapolis, Kings and portions of Digby, Lunenburg, Queens and Colchester counties as well as all of Cape Breton Island with the exception of the area around the Strait of Canso.

(2) Nova Scotia Forest Industries, Port Hawkesbury, N.S.

- B & W scale 1:10,000 of Cape Breton Island with the exception of the portion including the National Park and to the north.

(3) Nova Scotia Dept. of Lands & Forests, Halifax, N.S.

- Colour infrared, scale 1 inch = 1 mile of Kings, Lunenburg, Annapolis, Queens, Digby, Yarmouth and Shelburne counties.

- Colour, scale 1:10,000 of a small portion of Halifax County.

- Colour, 1:10,000 Cumberland County and the Northern half of Colchester County.

Any inquiries as to flight line maps and availability of this photography should be forwarded to the provided address.

6.6.6 N.S. Committee Members

Miss Nancy Prout
Lands Directorate
Environment Canada
Box 365
Halifax, N.S.

Graham Doyle
Canadian - British Consultants Ltd.
Box 1269 N
6100 Young Street
Halifax, N.S.

Bob McKenzie
N.S. Dept. of Development
Box 519
Halifax, N.S.

Desmond Lord
Environmental Protection Service
Box 2406
Halifax, N.S.

Paul E. Vandall, Jr.
Bedford Institute of Oceanography
Box 1006
Dartmouth, N.S.

John F. Wightman
N.S. Land Survey Institute
Box 10
Lawrencetown
Annapolis County, N.S.

Ed MacAulay
N.S. Dept. of Lands and Forests
Box 68
Truro, N.S.

T.W. Hennigar
Water Planning and Management
Environment Canada
Box 365
Halifax, N.S.

R.M.K. Meisner
Maritime Resource Management Service
Box 310
Amherta, N.S.

Michael S. Manett
Community Planning Division
N.S. Dept. of Municipal Affairs
Box 216
Halifax, N.S.

6.7 REPORT FROM THE PROVINCE OF ONTARIO

6.7.1 Ontario Centre for Remote Sensing

Expansion of the OCRS has been halted in 1975 due to staffing restrictions following on budgetary constraints. The staff of the Centre presently consists of six professionals and one technician on permanent staff, one professional on contract, and two secretaries, for a total of 10. The staff of the Centre has increased by one permanent-staff specialist since last year, one complement position remaining vacant.

Approximately 50 interpretation projects have been undertaken by the Centre during 1975, of which the following are examples:

-mapping of wetlands of Northern Ontario from Landsat imagery, using the VP-8 Image Analyzer, with verification provided by conventional provincial photography

-study of the applicability of thermal-scan imagery to the detection of heat loss from buildings, resulting in a proposal for a test of the method

-analysis of Landsat imagery, using the electronic density-slicing technique, for the indication and differentiation of wildlife habitats

-monitoring of the Metropolitan Toronto waterfront for landfill erosion

The OCRS has conducted two training courses in 1975 - one forest inventory-oriented photo interpretation course for the Ministry of Natural Resources, and a course on the role of remote sensing in fire suppression for the Yukon Lands and Forest Service.

The Centre continues to fulfil an information-service function through its browse facility and literature library, and through tours given to groups from industry, universities, and the public sector. In addition, six papers (listed in section 6.7.10) have been prepared in 1975 to describe methodologies of remote sensing application developed by the OCRS.

In 1975, the OCRS has leased a Beechcraft-18 twin-engine aircraft with two camera hatches, from Capital Air Surveys. The purpose of this aircraft is to further the airborne sensing capability of the OCRS, which employs 35mm and 70mm cameras to aid interpretation projects. A camera mount has recently been designed to accommodate both camera sizes simultaneously, up to four cameras at one time, and allowing the cameras to be interchanged for any combination.

6.7.2 Ministry of Transportation and Communications

The Remote Sensing Section of the Ontario Ministry of Transportation and Communications reports the use of aerial photography from provincial government sources, from CCRS, NAPL, and from private companies, in its engineering investigations; Landsat imagery was also used, to a limited extent, in hydrological studies. This Ministry has also commissioned the services of the OCRS during the past year - for a project involving river-basin measurement through density-slicing of satellite imagery, and for a study regarding the testing of the usefulness of infrared imagery to provide data on the environmental impact of highway construction. It is primarily in the area of research on the environmental impact of transportation facilities that the MTC Remote Sensing Section has been engaged in the development of new remote sensing methodologies in 1975.

This office reports that the Ministry of Transportation and Communications will continue to make considerable use of remote sensing data, and that cost-benefit analyses done on the projects carried out in 1975 have re-affirmed the efficiency of remote sensing techniques. The MTC Remote Sensing Section has been active in extending awareness of remote sensing application within its own Ministry, and has given presentations to various educational institutions.

6.7.3 Ministry of the Environment

The Ontario Ministry of the Environment, Water Resources Branch, has employed remote sensing techniques in 1975 in its water quality program. Aerial photography and thermal scanning were commissioned from CCRS in order to test the applicability of thermal infrared imagery to the analysis of thermal plumes from nuclear reactors in the Great Lakes Basin. The services of the OCRS were requested also in this program, for the density slicing of the thermal infrared imagery over Douglas Point, Ontario.

Provincial aerial photography was used in the planning of intensive water quality studies at the mouths of various rivers. Landsat imagery was used to a limited extent in the study of coastal sediment patterns in Lake Huron.

6.7.4 Universities

McMaster University has employed high-altitude colour infrared photography obtained by CCRS in drainage systems mapping for selected river basins in Southern Ontario, and for mapping land-use change in the Niagara Peninsula. Both Landsat imagery and high-altitude colour infrared photography were used for bio-physical mapping in the Pen Island area of northwestern Ontario. Landsat-1 data was also used for terrain mapping and land evaluation at two sites in the Arctic (Radstock Bay and Melville Island). The instruments used at McMaster to aid interpretation are the Bausch and Lomb Zoom Transfer Scope and Zoom 240R Stereoscope; digital analysis of Landsat imagery has been obtained from CCRS, using both the Image 100 and Bendix systems. A study has begun on the efficiency involved in applying small-scale colour infrared photography (1:60,000-scale) to urban land-use mapping: the study site is in Burlington, Ontario.

There have been four courses in remote sensing offered at McMaster in 1975, two at the undergraduate level and two at the graduate level, including the Integrated Aerial Surveys course given in conjunction with the universities of Toronto, Waterloo and Guelph. Four presentations to national and international conferences have been given in 1975 by Professor P.J. Howarth of McMaster's Department of Geography, concentrating on remote sensing application to land-use studies and terrain analysis. In addition, three papers on remote sensing application have been prepared, two being M.A. theses.

Anticipated remote sensing activities at McMaster involve the digital analysis of Landsat-1 imagery.

The Department of Civil Engineering, University of Toronto, reports the use of aerial photography (as analysed using stereoscopes) and satellite imagery, primarily in the teaching of a basic course entitled "Photogrammetry and Remote Sensing". Infrared imagery was employed by this Department in 1975 in the study of a proposed highway corridor.

The Centre for Research in Experimental Space Science (CRESS) at York University reports a number of advances in sensor technology during 1975, including the development and application of the following instruments:

-a scanning filterwheel spectrometer used in the observation of the reflectance properties of lakes

-Wide Angle Michelson Inferometer developed as a remote sensing spectrographic instrument

-a new line-scanner

-image tube spectrometer augmented by an optical multichannelanalyser as applied to assessment of oil spills on lakes

Work has been done on remote sensing of the lower atmosphere and smokestack plumes using optical LIDAR techniques, on the development of parametric theoretical models of the reflective properties of water bodies, and on the applicability of Image 100 analysis of Landsat imagery for mineral detection.

York University also continues to conduct a graduate course entitled "Physical Principles of Remote Sensing".

The University of Guelph has used Landsat imagery in the teaching of two courses in 1975 - a short course given to a group of 33 people from 23 countries sponsored by U.N./UNESCO, and an undergraduate basic remote sensing course.

The University of Western Ontario reports that it is not involved in the use of remote-sensing imagery, aerial or satellite, but rather that its remote sensing activities are related to the measurement of air pollutants, mainly by LIDAR and correlation spectrometry.

The University of Waterloo reports that aerial photography from NAPL, CCRS and the provincial government, as well as Landsat imagery, were used in both teaching and research in 1975. Landsat imagery was used in print form, but also in the form of computer-compatible tapes. The visual interpretation aids employed were the Zoom Transfer Scope, Zoom Microscope and scanning stereoscope. Computer techniques were developed for the application of the tape-form data. Four courses in remote sensing were conducted at Waterloo this year - three levels, including a graduate level, of a course entitled "Air Photo Interpretation and Remote Sensing" - and participation in the Integrated Aerial Survey course was continued.

The School of Forestry of Lakehead University, Thunder Bay, reports the use of provincial aerial photography, of photography from NAPL, and of Landsat imagery of the region. In addition, the University had black and white, colour and colour infrared aerial photography obtained by private companies. This material, along with a very well equipped interpretation laboratory, is used in the training of forestry degree and technician students. Three full-year courses in the application of remote-sensing imagery are offered. The facilities of the university are increasingly made use of by regional resource managers of the provincial government, municipal governments, and industry. The conclusion drawn by Professor H. Westbroek of Lakehead is that regional remote sensing facilities are required, operating on a smaller scale than a provincial centre, so that coverage of the region itself and remote sensing expertise could be readily available locally.

6.7.5 Private Sector

Barringer Research has made use of aerial photography from NAPL for flight planning in survey areas, and reports the use of Landsat imagery for certain areas of the province. Barringer's E-Phase program for earth-resource surveys continued in the summer of 1975, for aggregate mapping and other geotechnical purposes. The following instruments primarily related to the detection and analysis of air pollution have been developed by the company in 1975:

-AIRTRACE system for the remote sensing of chemical and geochemical signatures through aerogeochemical techniques

-laboratory remote sensing GASPEC instrument and test chamber (for NASA Langley)

Barringer is currently working on the following technological advances:

-development of an airborne laser fluorosensor with multispectral analytical capability and decay lifetime measurements

-development of a dual gas HCl/CO remote sensing gas filter correlation spectrometer

Ecologistics Ltd. of Kitchener, Ontario has reported the use of black and white photography from the provincial government and from CCRS, in approximately twenty projects on resource inventories and analysis related to topography, soil types and erodability, groundwater availability, agricultural potential, vegetation types, and other areas.

Terra-Scan Ltd. of Toronto has regularly employed panchromatic aerial photography from the Ontario Ministry of Natural Resources for geological terrain analyses of proposed subdivisions, site evaluations, hydro-geological studies, sand and gravel exploration and erosion studies. Recent aerial photography obtained by Northway Survey Corporation was used for terrain evaluation of a townsite.

Acres Consulting Services Ltd. of Toronto has used aerial photography, black and white and colour, in an environmental study for a proposed thermal generating station in Northwestern Ontario. Land use planning studies were carried out using provincial government photography. High-altitude CCRS photography was employed in a study of lakeshore vegetation, and Landsat imagery was used in flood and ice studies.

W.E. Coates and Associates Ltd. has carried out thirty projects, using for the most part black and white provincial government photography, and also photography from Northway Surveys. Colour and colour infrared aerial photography has been used in analysis and mapping of vegetation types and drainage conditions.

6.7.6 Ontario Association of Remote Sensing

The 1975 meetings of the membership of OARS have included four lectures on remote sensing use from various points of view. An Education Committee was formed to formulate and organize remote sensing courses that would be given by the Association in the future. The OARS membership list now totals 280.

It was anticipated at the end of 1974 that the Ontario Advisory Committee on Remote Sensing (OACRS) would be formed in 1975, and an executive meeting of OARS proposed the selection of individuals for recommendation to the OCRS in setting up the committee. Unfortunately, as described at the beginning of the Ontario report, expansion of the OCRS was halted in 1975 due to budgetary constraints; thus, the time of OCRS staff members has been fully committed in the completion of OCRS project work, preventing provincial co-ordination work from receiving the necessary attention. The formation of OACRS, then, has been postponed until 1976, when, hopefully, the situation may change.

6.7.7 C.I.F. Workshop on Canadian Forest Inventory Methods

Three working groups of the Canadian Institute of Forestry - Forest Surveys and Inventory; Remote Sensing; and Biometrics, Statistics and Computer Science - combined their efforts to offer a four-day workshop on the present practices of Canadian forest inventory methods, and on proposed methods of increasing the efficiency and accuracy of the inventory process. The workshop was held in Dorset, Ontario, in June. The Remote Sensing Working Group contribution consisted of the following six presentations:

Aldred, A. Progress Report on Two Co-operative Trials of F.M.I.'s Large-Scale Inventory Method with the Provinces.

Boissonneau, A. Forest Fire Damage Assessment on Landsat Imagery.

Jano, A. Timber Volume Estimate with Landsat Imagery.

Kirby, C. A Basis for Multi-Staged Forest Inventory in the Boreal Forest Region.

Thie, J. Remote Sensing Applications for Land Resource Inventories

Zsilinszky, V. and S. Palabekiroglu. Volume Estimates of Deciduous Forests by Large-Scale Photo Sampling.

On the first day of the Workshop, a tour of the OCRS facilities was arranged.

Regarding the Remote Sensing Working Group itself, it presently has close to 80 members, and its new chairman elected for 1976 is Mr. C.L. Kirby of the Northern Forest Research Centre, Canadian Forestry Service, in Edmonton.

6.7.8 Conclusions and Forecast

The year 1975 has been one of financial conservatism in many areas, and the trend has had natural repercussions in the area of remote sensing application. There seems to have been very little expansion in the range of practitioners: those who had prior experience with remote sensing continued to apply it in the same way, strengthening conviction of its usefulness. From the reports received, this seems to be particularly true of the private sector.

Within Ontario universities, financial difficulties and the resignation of some experienced staff members has resulted in the maintenance, rather than expansion, of remote sensing instruction.

Technological advances have been made during the past year by Barringer Research, and by CRESS at York University. Developments in operational methodologies of remote sensing application must remain gradual while the number of practitioners in the province remains relatively small. Nevertheless, in 1975 the Ontario Centre for Remote Sensing has continued a full schedule of commissioned projects for the development of practical techniques. The effect of budgetary constraints, however, has been noticeable within the provincial government, as several OCRS projects were cut short by clients for lack of funds, and as those agencies requesting OCRS services in 1975 were, for the most part, previously-established clients of the Centre.

However, to use OCRS experience as an example, the pattern of 1975 is not necessarily discouraging. Remote sensing in this province has a constant body of practitioners whose sound accomplishments continue to advertise the benefits of remote sensing techniques.

Looking to the future, almost all reports received from government, universities and the private sector anticipated a continuation of present activities. There are, however, certain significant programs planned to begin in 1976. The most extensive of these projects is a proposal by the OCRS for the completion of the surficial geology mapping of the province and description of the physiography of Northern Ontario, by remote sensing means. The University of Guelph also has plans to develop a methodology for identifying the best grape-growing land in Southern Ontario, and also to conduct research on the electrical properties of soils.

6.7.9 Recommendations

University of Guelph:

Scientists from CCRS should serve on graduate student supervisory committees. New channels of co-operation are required between CCRS and Ontario universities.

University of Waterloo:

CCRS (and OCRS) should actively create links with universities. Consultations regarding teaching and methodologies of application should be regular and established.

University of Toronto:

CCRS should sponsor research and development activities at universities. Such activities would have the result of extending knowledge and use of remote sensing.

Lakehead University:

CCRS should give financial aid to universities for equipment purchase, so that future users could be well trained, and so that universities could act as regional centres.

Ontario Centre for Remote Sensing:

The CCRS should make available a higher-altitude airborne sensing capability, allowing for flights up to 20,000 m. This aircraft should be equipped with a precise photogrammetric camera, multispectral cameras and scanners, thermal and radiometric sensors, and a capability for comprehensive recording of flight conditions, including navigational data.

NOTE: Barringer Research Ltd., CRESS (York University), and Remote Sensing Section, MTC, all commend the CCRS on its liaison and co-ordination efforts.

6.7.10 1975 Publications

Barringer, A.R. et al. Airborne measurements with a correlation interferometer. Aerospace Electronics Symposium, Halifax, February 4 and 5, 1975. Barringer Research Ltd. Publication TP75-154.

Barringer, A.R. et al. Examples of remote quantitative SO_2 measurements and applications with the Barringer Gospec. Barringer Research Ltd. Publication TP75-156.

Boissonneau, A.N. Use of Landsat imagery to map burns and estimate timber damage. Paper presented at Canadian Institute of Forestry Workshop on Canadian Forest Inventory Methods, Dorset, Ontario, June 24-27, 1975.

Boissonneau, A.N. and J.K. Jeglum. A regional level of wetlands mapping for the Northern Clay Section of Ontario. Paper presented at Third Canadian Symposium on Remote Sensing, Edmonton, September 22-24, 1975.

Chu, F.Y., et al. High resolution FM-CW radar for remote atmospheric sensing. Barringer Research Ltd. Publication TP75-155.

Chu, F.Y. and M. Wiszniewska. Non-constant measurements of soil moisture. Aerospace Electronics Symposium, Halifax, February 4 and 5, 1975. Barringer Research Ltd. Publication TP75-153.

Davies, J.H. et al. Recent developments in environmental sensing with the Barringer correlation spectrometer. Aerospace Electronics Symposium, Halifax, February 4 and 5, 1975. Barringer Research Ltd. Publication TP75-151.

Edwards, P. The use of high altitude photography as an improved data source for drainage system analysis. Unpublished M.A. Research Report, McMaster University.

Falconer, A. and R. Protz. Landsat data a basis for resource development. Pacific Science Congress, Vancouver, August, 1975.

Graham, C.W. Remote sensing - an aid to pipeline and hydro tower construction in agricultural areas. Paper presented at Third Canadian Symposium on Remote Sensing, Edmonton, September 22-24, 1975.

Howarth, P.J. Land use mapping of Burlington, Ontario: airborne data versus ground survey. Presented at a Symposium on Remote Sensing and Urban Studies, Edmonton, May 22, 1975.

Howarth, P.J. Remote sensing and its applications in terrain analysis. Presented to the Swedish-Canadian correspondence group in Terrain Analysis, DND, Ottawa, June 10, 1975.

Howarth, P.J. Remote sensing, land use classification and information systems. Presented at a short course on Urban and Regional Information Systems, Harvard University, July 18-31, 1975.

Howarth, P.J. Remote sensing in urban and regional planning. Presented at the Second Manitoba Familiarization Programme in Remote Sensing, Winnipeg, December 10-12, 1975.

Howarth, P.J. and M.K. Woo. The influence of scale in the remote sensing of snow cover. In Proceedings of the 32nd Annual Meeting of the Eastern Snow

Conference (in press).

Jano, A.P. Timber volume estimate with Landsat-1 imagery. Paper presented at Canadian Institute of Forestry Workshop on Canadian Forest Inventory Methods, Dorset, Ontario, June 24-27, 1975.

Kinnard, D.A. Remote sensing techniques for conducting off-street and terminal parking studies from helicopter and light aircraft. Unpublished M.A. Research Report, McMaster University.

Kirby, M. A solution of the geometric base problem in Landsat-1 multispectral scanner data by means of an affine transformation and the method of least squares. M.A. thesis, University of Waterloo.

Lawrence, G.R. and C.W. Graham. Remote sensing applied to algal problems in lakes. Paper presented at Third Canadian Symposium on Remote Sensing, Edmonton, September 22-24, 1975.

Remote Sensing Section, Ministry of Transportation and Communications. State-of-the-Art-report on the surveillance of the environmental effects of a highway facility by remote sensing.

Remote Sensing Section, Ministry of Transportation and Communications. The surveillance and prediction by remote sensing of the environmental effects of a new highway facility.

Ryerson, R.A. An investigation of agricultural data collection from aerial photographs. Ph.D. thesis, University of Waterloo.

Turner, H. The use of shadow on aerial photographs to obtain ground parameters of buildings by image processing. Ph.D. thesis, University of Waterloo.

Ward, V. and H. Zwick. Latest developments with an airborne gas filter correlation spectrometer. Aerospace Electronics Symposium, Halifax, February 4 and 5, 1975. Barringer Research Ltd. Publication TP75-152.

Wiens, R. Application of optical correlation techniques to detection of ambient air pollutants. Environmental Protection Agency Seminar (NREC), North Carolina, February 3-5, 1975. Barringer Research Ltd. Publication TP75-150.

Vlcek, J. Interpretation of infrared imagery along the proposed Highway 402. Internal report for Ministry of Transportation and Communications.

Zsilinszky, V.G. and S. Palabekiroglu. Volume estimates of deciduous forests by large-scale photo sampling. Paper presented at Canadian Institute of Forestry Workshop on Canadian Forest Inventory Methods, Dorset, Ontario, June 24-27, 1975.

6.8 REPORT FROM THE PRINCE EDWARD ISLAND REMOTE SENSING COMMITTEE

6.8.1 Airborne Remote Sensing

During 1975 the efforts of our committee were directed entirely toward the application of imagery acquired to date. No new flights were made and no new additions to our inventory of imagery were made. The objectives of our efforts this past year were:

- to develop a map defining agricultural land-use within the province;
- to map land-use in the Dunk River watershed area;
- to develop a map defining the "soil erosion potential" of various regions within the province.

Agricultural land-use was defined in terms of the acreages of various crops within a selected area. Area selections were made on the basis of similar land use characteristics interpreted from inspection of high altitude false colour infra-red 9"x9" transparencies obtained in 1973 as part of our remote sensing program involving C.C.R.S. The imagery was sufficient for about 75% of P.E.I., the remainder of the information being obtained through ground-truth operations. Cartographic work was carried out by students in the Resource Planning Unit of Holland College in Charlottetown. Final mapping was at a scale of 1:125,000.

Land use in the Dunk River watershed area was studied because of soil and water conservation problems associated with the relatively high agricultural activity in that region, (i.e., large livestock and crop production farm units). In 1974, Capital Air Survey Ltd. was contracted to photograph the region at an altitude of 5,000 ft. A.S.L., using false color infra-red and true color film.

The 9"x9" imagery (in transparency form, was used to develop a map (1:10,000 scale) of land use in the area which will be used to (1) asess the impact of intensive agricultural practices on soil erosion and stream sedimentation, and (2) to provide agricultural and resource planners with a much improved aid on which to base research management plans of an economic nature.

We have long recognized soil erosion as a key problem associated with the future continuity of crop production on P.E.I. However, only of late have we been able to quantitatively measure such losses and the cost to crop producers. In order to provide better direction to future expansion in the agricultural sector, a knowledge of the potential for soil erosion by water for various regions on P.R.I. became a necessity. Therefore, by combining agricultural land use with topographic and soil erodibility data for the numerous soil types on P.E.I. and using high altitude imagery to locate erosion protected areas (stream banks, hedgerows, etc), we hope to develop a map of P.E.I. showing the erosion potential. The final mapping phase will be carried out by students of Holland College, using base maps at a scale of 1:125,000.

Because of the changing agricultural scene on P.E.I., it is anticipated that, at some time in the near future, a high altitude flight will be required to update our land use information. Although most of the remote sensing work has been carried out in response to the needs of the agricultural sector, we have had a significant number of requests for use of our imagery from other government agencies and the University of P.E.I.

6.8.2 The Image 100

Early in the year, at the invitation of Dr. Bob Ryerson (C.C.R.S.), Messrs. Floyd Wilson and Norbert Stewart were provided with the opportunity to investigate the use of the Image 100 as a means of determining land use using satellite tapes. Although it was soon determined that our test areas were not as intensively groundtruthed as required, the results were encouraging. Therefore, several areas in the province have been selected as test sites and intensively groundtruthed. During the summer of 1975, we experienced one of the longest periods of clear weather on record and, thus, it is hoped that this will be reflected in the satellite imagery, allowing us to develop a much improved Image 100 print-out. It is hoped that, through the use of the Image 100, a yearly agricultural land-use map (i.e., crop acreages) for the province could be obtained, thus limiting the use of air-borne imagery for resource target areas which require detailed monitoring and survey for specific purposes.

6.9 RAPPORT DU QUEBEC

6.9.1 Coordination provinciale

Le Service de la Cartographie du Ministère des Terres et Forêts a, depuis le début de l'année 1975, la responsabilité de coordonner les activités concernant la télédétection au Québec.

En septembre 1975, M. Hervé Audet a été engagé par ce Service comme "coordonnateur provincial en télédétection". Sa tâche principale est d'établir au Québec des structures permanentes permettant aux divers utilisateurs québécois de la télédétection un meilleur accès aux moyens de saisie et d'interprétation des données. Il servira aussi de lien entre les utilisateurs de la province et le Centre Canadien de Télédétection afin de promouvoir chez-eux l'utilisation des divers moyens mis par le C.C.T. à la disposition de tous les usagers canadiens.

A la fin de l'année, le coordonnateur québécois a commencé une tournée des utilisateurs de la télédétection au sein des divers ministères provinciaux afin de mieux saisir leurs besoins et d'exprimer les possibilités que leur offre la télédétection.

6.9.2 Recherche et application

6.9.2.1 Activités en général

Quinze missions de télédétection aéroportée ont été menées par les services du C.C.T. au-dessus du territoire québécois au cours de l'année. Ces missions totalisent près de 2,500 milles nautiques. La plupart ont été effectuées simultanément avec des chambres de prise de vues et un analyseur à balayage opérant dans l'infrarouge thermique.

Certaines missions spéciales ont été menées par le C.C.T., en collaboration avec le Service de la Qualité des Eaux du Ministère des Richesses Naturelles, ce dernier possédant des inventaires au sol sur la qualité des eaux.

Ces opérations s'ajoutent au programme régulier du Service de la Cartographie du M.T.F., soit quelque 20,000 km linéaires couverts en fausses couleurs et 30,000 km linéaires en noir et blanc, aux fins de l'inventaire forestier et de la cartographie.

Les données de LANDSAT ont aussi été utilisées par des organismes québécois, soit sous forme numérique, soit sous forme d'imagerie. Les travaux des organismes suivants ont notamment été portés à l'attention du coordonnateur: la Société de Développement de la Baie James (l'ampleur des travaux de cette société mérite une attention spéciale; on trouvera en appendice 6.9.6 un rapport de ses activités en télédétection), le Ministère des Terres et Forêts (principalement au Service de l'Inventaire Forestier), le Ministère du Tourisme, de la Chasse et de la Pêche (au Service de la Recherche biologique), le Ministère des Richesses Naturelles (dans divers services), le Centre de Recherches forestières des Laurentides et plusieurs universités (voir sous-section 6.9.2.2).

6.9.2.2 Les universités

6.9.2.2.1 Université Laval

Les activités de recherche de l'Université Laval, dans le domaine de la télédétection, se sont concentrées en grande partie sur les techniques de traitement des images. Ainsi le laboratoire de télécommunication et de télédétection du département de génie électrique est-il à mettre au point un système de traitement numérique autonome des images utilisant la transformée de Fourier. On espère cette année effectuer, presque en temps réel (quelques secondes), certains traitements complexes des images, tel le filtrage spatial en deux dimensions. De son côté le laboratoire d'optique du département de physique poursuit ses travaux sur le traitement optique des images au moyen de lumière cohérente (LASER). L'achat d'un digitaliseur d'images photographiques va permettre de comparer l'efficacité relative des traitements d'images par voie optique et par voie numérique. Enfin le laboratoire de télédétection du département de photogrammétrie met au point des programmes-ordinateur permettant d'effectuer certains traitements de base, tels que corrections radiométriques et géométriques, histogrammes, impression des images, etc. ainsi que certaines analyses semi-automatiques des images par reconnaissance automatique des formes. En raison des coûts élevés de développement de tels programmes, un service d'analyse numérique des données recueillies par télédétection est offert à l'ensemble des utilisateurs québécois grâce à une subvention, dite de service à la recherche, du ministère de l'Education.

L'analyse des caractéristiques des nappes d'eau et l'étude des peuplements forestiers sont actuellement les deux secteurs principaux d'application des techniques d'analyse ci-haut mentionnées.

6.9.2.2.2 Université de Sherbrooke

Le département de Géographie de l'Université de Sherbrooke connait des activités en télédétection depuis 1971.

Les expériences en cours se réduisent essentiellement au domaine de l'infrarouge thermique. Elles ont pour but d'établir des relations entre les mesures de certains paramètres effectuées par télédétection et la mesure de ces mêmes paramètres par contrôle au sol.

Le département possède un radiomètre Barnes PRT-5 (bande de 9.5 à 11.5 microns) permettant des mesures au-dessus d'un couvert forestier, d'un pré, d'un sol nu, etc.

On effectue parfois des profils en transportant le radiomètre par avion léger. Cependant, au cours de 1976, une mission sera effectuée par les services du C.C.T. pour mieux établir les relations entre télédétection et contrôle au sol.

Contact: Ferdinand Bonn.

6.9.2.2.3 Université du Québec

Quelques constituantes de l'Université du Québec ont fait de la recherche ou des applications en télédétection. Mentionnons entre autres les six missions effectuées par le C.C.T. pour l'Université du Québec à Montréal (pour le département de Géographie surtout): ce sont les projets 75-27, 33, 34, 35, 36 et 40.

Mentionnons aussi les travaux de l'INRS - Eau, dirigés par le professeur E.J. Langham (maintenant à Environnement Canada). Ces études, certaines étant menées en collaboration avec Guy Rochon de l'Université Laval, portaient principalement sur la possibilité d'application de la télédétection en limnologie.

6.9.3. Quatrième colloque canadien sur la télédétection

Le quatrième colloque canadien sur la télédétection se tiendra à Québec, à l'hôtel Le Concorde, les 16, 17 et 18 mai 1977.

Cette décision du Bureau de direction de la Société Canadienne de Télédétection fait suite à l'invitation officielle adressée en décembre par le sous-ministre des Terres et Forêts du Québec, M. Michel Duchesneau.

L'hôte de ce colloque sera le Ministère des Terres et Forêts du Québec. Parmi les co-organisateurs, on trouve notamment l'Association Québécoise de Télédétection.

Etant tenu dans la capitale provinciale du Québec, le quatrième colloque national revêtira un aspect intégralement bilingue. Aussi les organisateurs ont-ils déjà entrepris de le doter d'un système de traduction simultanée.

6.9.4. Association québécoise de télédétection

6.9.4.1 Origine de l'Association

Tout récemment encore, à peu près aucune coordination des activités, ni même de moyen de communication, n'existaient au Québec pour favoriser l'utilisation de la télédétection. La situation peu réjouissante qui avait prévalu avant la prise en charge du dossier provincial de la télédétection par un coordonnateur fût le point de départ d'une initiative de l'Université Laval, appuyée par le Centre Canadien de Télédétection et le Ministère des Terres et Forêts. Un colloque québécois de télédétection était ainsi organisé dans le but de faire le point sur la situation de la télédétection au Québec et de créer, par la même occasion, une association québécoise de télédétection. Malgré un climat défavorable, plus de 175 personnes assistèrent à ce colloque.

6.9.4.2 Fondation de l'Association

L'Association québécoise de télédétection (A.Q.T.) était ainsi fondée le 28 novembre 1975, en même temps qu'étaient définis ses objectifs et règlements, et que son premier conseil d'administration était élu.

L'A.Q.T. se définit comme une association privée, multidisciplinaire, sans but lucratif et d'expression française.

6.9.4.3. **Objectifs de l'Association**

Le but visé par l'Association est de favoriser le développement de la télédétection dans son essence comme dans ses utilisations par différents moyens d'action dont:
- la création de mécanismes d'information et de consultation des membres et la poursuite d'enquêtes et mémoires;
- la tenue de symposiums, colloques, séminaires et conférences sur les aspects scientifiques, techniques, administratifs, ou autres, reliés à la télédétection ou à ses applications;
- l'assistance aux membres pour la publication d'articles de caractère scientifique et technique et la création, si nécessaire, d'une ou de plusieurs publications;
- la création de liens avec les autres organismes ayant des intérêts dans le domaine de la télédétection.

6.9.4.4 **Composition du conseil d'administration**

Son conseil d'administration se compose de:

Président: Julien Rivest
Rinfret, Rivest & Ass.

Vice-président: Guy Rochon
Centre Canadien de Télédétection

Secrétaire-trésorier: Yvan A. Bastien
Ministère des Richesses Naturelles

Conseillers:

- Section ADMINISTRATION PUBLIQUE
Robert Denis
Hydro-Québec

Claude Pesant
Ministère des Richesses Naturelles

- Section RECHERCHE et ENSEIGNEMENT
Gilles Ladouceur
Université Laval

Roger Paquin
Agriculture Canada

- Section ORGANISMES PRIVES
Nicholas Lee
Photographic Surveys
Claude Jobin
Aéro Photo

6.9.5 **Conclusion et perspectives d'avenir**

On prévoit pour l'année 1976 la création d'un Centre Québécois de Télédétection, rattaché au Ministère des Terres et Forêts, mais desservant tous les ministères et éventuellement tous les usagers de la province.

La façon de le doter en personnel, en instrumentation et en documentation, de même que la gamme des services à y offrir, est à l'étude.

Le coordonnateur provincial verra aussi à s'entourer d'un comité représentant les usagers de la province. Ce comité orientera la formation et la marche du futur Centre Québécois en Télédétection. De plus, ce comité représentera la province de Québec auprès du Comité Consultatif Canadien pour la Télédétection (CACRS). Le coordonnateur, membre d'office, en sera le porte-parole.

La tenue à Québec du prochain colloque national sur la télédétection sera un encouragement et un défi pour tous ceux qui, dans la province, s'intéressent à cette discipline.

6.9.6 Appendice - La télédétection à la SDBJ - Environnement

6.9.6.1 Historique

Le Service de l'Environnement de la Société de Développement de la Baie James a pris sa forme actuelle au cours de l'année 1973. On s'y est vite rendu compte que l'acquisition et le traitement de l'information concernant un territoire aussi vaste (135,000 milles carrés) seraient très difficiles et onéreux au moyen de techniques conventionnelles. Des missions aéroportées ont donc été effectuées dès 1973, une collection d'images LANDSAT fut constituée et deux personnes ont été engagées pour les différents aspects reliés à l'utilisation des données de télédétection. Il s'agit du Dr. Marc Tanguay et de Jacques David, qui ont commencé leurs travaux en 1974. Pierre Laframboise s'est ajouté aux effectifs en mai 1975 afin d'assister les deux consultants et de voir au développement et à la bonne marche du programme.

6.9.6.2 Activités en 1975

6.9.6.2.1 Acquisition des données

Le Service de l'Environnement de la Société de Développement de la Baie James

(SDBJ) a fait exécuter par le Centre Canadien de Télédétection (CCT) environ 800 milles linéaires de vol. Les capteurs utilisés comprenaient une caméra aérienne avec film 9" X 9" fausses couleurs infrarouge ainsi qu'une couverture thermique à l'aide d'un radiomètre à balayage latéral sensible à l'infrarouge thermique.

La plupart des lignes de vol furent effectuées à haute altitude (29,000 pieds), car les données devaient servir:
- à l'intérieur d'études à l'échelle régionale;
- comme données de référence pour le développement d'une méthodologie d'utilisation des images Landsat dans les études d'observation en continu de l'environnement;
- à la constitution d'un dossier photographique pré-modifications pour les sites à être aménagés.

Une partie des lignes de vol fut effectuée à plus basse altitude (10,000 pieds) car elle devait être utilisée pour la réalisation d'une cartographie thématique à plus grande échelle par photo-interprétation.

6.9.6.2.2 Evaluation de la qualité et du contenu des données aéroportées

Une étude systématique de la qualité et du contenu de toutes les photographies et images provenant du C.C.T. depuis 1973 fut effectuée. Un rapport sur la qualité fut complété pour chaque année. Ces rapports fournissent une évaluation de chaque photographie et image quant à son utilisation dans les domaines reliés à l'étude de l'environnement. L'évaluation tient compte de paramètres tels que l'exposition, le développement, les taches solaires et la nébulosité.

Une autre étude a été accomplie afin d'évaluer les photographies et images 1974 quant à leur contenu dans les différents domaines de l'environnement. La description du contenu a été effectuée en fonction de plusieurs paramètres, regroupés en huit classes: matériaux terrestres, formes de terrain, végétation, faune, drainage et érosion, masses d'eau, archéologie.

6.9.6.2.3 Observation en continu de l'environnement

Les études réalisées à l'intérieur de cette section visent entre autres à développer une méthodologie d'utilisation des images Landsat permettant la mise à jour périodique de la cartographie. Cette mise à jour a été centrée sur certains changements majeurs qui surviennent à l'intérieur du territoire de la baie de James, tels que feux de forêt et zones de coupes (elle n'a cependant pas inclus les changements liés aux travaux hydroélectriques). Ces mises à jour doivent être effectuées sur des cartes thématiques à partir d'une cartographie de base détaillée.

Nous avons proposé une méthodologie de mise à jour périodique de la cartographie des feux de forêt sur le territoire de la baie de James. Le rapport propose une méthode d'interprétation permettant d'identifier et de dater les feux de forêt agés de moins de cinq ans, à l'aide des bandes et échelles Landsat appropriées. On trouve aussi des indications pour le transfert des contours des feux de forêt sur des cartes appropriées.

Une autre étude du même genre a porté sur les zones d'exploitation forestière de la partie sud du territoire. Elle contient de plus un aperçu des possibilités d'utilisation des données aéroportées pour l'étude des changements dans le milieu liés à l'exploitation forestière: érosion, sédimentation, regénération. Une troisième recherche a été effectuée sur l'emploi des techniques de télédétection dans l'étude des effets sur l'environnement de l'exploitation minière.

6.9.6.2.4 Etude et inventaire du milieu

La photo-interprétation d'une région de quelques dizaines de milles carrés située entre le lac Albanel et la rivière Témiscamie (projet Ferchibal) a permis la réalisation d'une cartographie des types écologiques* (surface uniforme au niveau du type de sol et de la chronoséquence végétale). Les photographies couleurs au 1:20,000 ont servi de base à l'interprétation, mais d'autres échelles et types de film ont été évaluées quant à leurs possibilités pour un même genre d'interprétation.

Une étude de la végétation du littoral de la baie de Rupert devait être réalisée en utilisant des photographies au 1:20,000. Les lignes de vol n'ayant pu être effectuées selon les conditions requises (à marée basse et au milieu de la saison végétative), cette étude a été réalisée à l'aide de photographies panchromatiques au 1:31,680,

(*) Types écologiques tels qu'établis par la Section des Etudes Ecologiques Régionales du Ministère de l'Environnement fédéral dans une cartographie écologique systématique.

aidée cependant de photographies fausses couleurs infrarouge à l'échelle du 1:10,000 et du 1:60,000.

Deux essais de classification automatique des images Landsat à l'aide de l'image 100 ont été réalisés et ont démontré que le potentiel de ces techniques était lié à la qualité des données de référence entre autres des photographies aériennes interprétées.

6.9.6.3 Prévisions

Les objectifs de la SDBJ visent à développer une méthodologie d'utilisation de la télédétection adaptée au contexte du milieu du territoire de la baie James. Certains inventaires de base, dont celui de la végétation, pourraient être effectués par l'emploi de données aéroportées ou de satellite. La possibilité d'effectuer de tels inventaires est liée entre autres aux facteurs suivants: le niveau de précision requis dans l'identification des espèces ou groupements d'espèces, la superficie à cartographier, l'acquisition de données de référence adéquates (bien localisées et représentatives de la classe à identifier).

Les études d'évaluation de la qualité et du contenu des données aéroportées seront poursuivies ainsi que celles relatives à l'observation en continu de l'environnement. L'emploi des techniques de traitement automatique dans l'interprétation des images Landsat aura une place plus grande à toutes les fois que le niveau d'information requis pourra le permettre.

6.9.6.4 Appréciations et recommandations (visant la Section des Opérations Aéroportées du C.C.T.)

Nous apprécions le fait que la Section des Opérations Aéroportées tienne compte des multiples exigences des utilisateurs dans la mise au point des conditions de réalisation des missions: période de l'année, temps de la journée (heure fixe ou variable en fonction des marées basses, par exemple), conditions météorologiques, etc., et nous souhaitons qu'elle continue ainsi.

Voici cependant deux recommandations visant à une plus grande efficacité:

6.9.6.4.1 Lorsqu'un utilisateur réclame une couverture aérienne pour un territoire de très grande étendue, on ne devrait pas attendre que l'ensemble de ce territoire présente des conditions météorologiques favorables pour commencer la mission.

6.9.6.4.2 Un ordre de priorité devrait être établi pour l'exécution des lignes de vol à l'intérieur d'un même projet. Cet ordre de priorité, fixant l'importance relative des différentes lignes de vol, devrait être déterminé par l'utilisateur en fonction de ses besoins.

6.9.6.5 Publications (SDBJ - Environnement)

David, J. et Tanguay, M.G. (Interploratech Ltée), 1975.
Evaluation qualitative des films et images de télédétection, projet 73-67.
SDBJ - Environnement, Montréal, (à paraître).

David, J. et Tanguay, M.G. (Interploratech Ltée), 1975.
Evaluation qualitative des films et images de télédétection, projet 74-105 et 74-106.
SDBJ - Environnement, Montréal, 1975, 79 pages.

David, J. et Tanguay, M.G. (Interploratech Ltée), 1975.
Evaluation qualitative des films et images de télédétection, projet 75-71 et 75-72.
SDBJ - Environnement, Montréal, 1975, 33 pages.

Tanguay, M.G. et David, J. (Interploratech Ltée), 1975.
Etude du contenu des films et images de télédétection en fonction de l'environnement, projet 74-105 et 74-106.
SDBJ - Environnement, Montréal, 1975, 104 pages.

Laframboise, P., 1975.
Cartographie des feux de forêt sur le territoire de la baie de James à l'aide de l'imagerie LANDSAT (proposition d'une méthodologie de mise à jour périodique).
SDBJ - Environnement, Montréal, (à paraître).

6.9 REPORT OF THE PROVINCE OF QUEBEC

6.9.1 Provincial Co-ordination

The Mapping Branch of the Department of Lands and Forests has been responsible since the beginning of 1975 for co-ordinating remote sensing activities in Quebec.

In September 1975 this Branch hired Mr. Hervé Audet as provincial remote sensing co-ordinator. His primary responsibilty is to establish permanent structures in Quebec to provide easier access tomeans of acquiring and interpreting data for the various Quebec users of remote sensing. He will also act as a liaison between the provincial users and the Canada Centre for Remote Sensing in order to encourage them to use the various means that the CCRS makes available to all Canadian users.

At the end of the year the Quebec co-ordinator visited the remote sensing users in the various provincial departments in order to acquire a better understanding of their needs and to explain to them the possibilities offered by remote sensing.

6.9.2. Research and Application

6.9.2.1 General activities

Fifteen airborne remote sensing missions were made by CCRS over Quebec territory during the year, totalling close to 2,500 nautical miles. Most of them were made simultaneously with cameras and an infrared thermal scanner.

Some special missions were made by the CCRS in co-operation with the Water Quality Service of the Department of Natural Resources, who possess ground truth inventories on water quality.

The operations are in addition to the regular program of DLF's Mapping Branch, namely some 20,000 linear kilometers covered in artifical colour and 30,000 linear km in black and white, for purposes of forest inventory and mapping.

LANDSAT data was also used by Quebec agencies, either in numerical or in image form. The work of the following agencies in particular was brought to the co-ordinator's attention: the James Bay Development Corporation (the volume of work done by this corporation deserves special attention; a report of its remote sensing activities appears in appendix 6.9.6), the Department of Lands and Forests (primarily the Forest Inventory Service), the Department of Tourism, Fish and Game (the Biological Research Service), the Department of Natural Resources (various branches), the Laurentian Forest Research Centre, and several universities (see subsection 6.9.2.2).

6.9.2.2 Universities

6.9.2.2.1 Université Laval

Université Laval research activities in the area of remote sensing are centered mainly on image processing techniques. The Electrical Engineering Department's telecommunications and remote sensing laboratory is in the process of perfecting an autonomous numerical image processing system using the Fourier transform. This year they hope to do, almost in real time (a few seconds), some complex image processing using coherent light (LASER). The purchase of a photographic image digitizer will make it possible to compare the relative efficiency of optical and numerical image processing. Finally, the Photogrammetry Department's remote sensing laboratory is perfecting computer programs which make it possible to do certain basic processing, such as radiometric and geometric corrections, histograms, image printing and so on, as well as certain semi-automatic image analyses by automatic pattern recognition. Because of the high cost of developing such programs, a service for the numerical analysis of remote sensing data is offered to all Quebec users, as the result of a "research service" subsidy from the Department of Education.

The Analysis of underground water-level characteristics and the study of forested areas are the two main sectors where the analysis techniques mentioned above are now being applied.

6.9.2.2.2 Université de Sherbrooke

Université de Sherbrooke's Geography Department has been involved in remote sensing since 1971.

The experiments now underway are confined essentially to the area of thermal infrared. Their objectives are to establish relationships between the measurements made of certain parameters by remote sensing and measurements made by ground truth control of the same parameters.

The department owns a Barnes PRT-5 radiometer (9.5 to 11.5 micron band) whcih can make measurements above a forested area, a meadow, bare ground and so on.

Profiles are sometimes made by transporting the radiometer in a light airplane. However, the CCRS services will conduct a mission in 1976 to better establish the relationships between remote sensing and ground truth control.

Contact: Ferdinard Bonn

6.9.2.2.3 Université du Québec

Some of the Université du Québec campuses have done research into or have applied remote sensing. We should mention, among otheres, the six airborne missions that the CCRS conducted for the Université du Québec in Montreal (for the Geography Department primarily): they are projects 75-27, 33, 34, 35, 36 and 40.

We should also mention the work of the INRS - Water, directed by Professor E. J. Langham (now with Environment Canada). These studies, some of which were done in cooperation with Guy Rochon of Université Laval, covered primarily the possibility of applying remote sensing in limnology.

6.9.3 Fourth Canadian Symposium on Remote Sensing

The fourth Canadian Symposium on remote sensing will be held in Québec City, at the Le Concorde Hotel, on May 16, 17, and 18, 1977.

This decision by the Board of Directors of the Canadian Remote Sensing Society follows the official invitation issued in December by the Québec Deputy Minister of Lands and Forests, Mr. Michel Duchesneau.

The Québec Department of Lands and Forests will be hosting this conference. The Association québecoise de télédétection (Québec remote sensing association) is one of the notable co-sponsors of this conference.

Since it is being held in the Quebec provincial capital, the fourth national conference will take on an integrally bilingual aspect. The organizers have already undertaken to provide a system of simultaneous translation.

6.9.4 Assocation québecoise de télédétection

6.9.4.1 Origin of the Association

Until very recently, scarcely any co-ordination of activities, or even of means of communication existed in Québec to encourage the use of remote sensing. The unfortunate situation that had prevailed before a co-ordinator assumed responsibility for the provincial remote sensing file was the starting point for an initiative by Université Laval, supported by the Canada Centre for Remote Sensing and the Department of Lands and Forests. A Québec remote sensing conference was organized in this way for the purpose of assessing the current remote sensing situation in Québec and to create, at the same time, a Québec remote sensing association. Despite unfavourable weather conditions, more than 175 people attended this conference.

6.9.4.2. Founding of the Association

Thus the Association québecoise de télédétection (AQT) was founded on November 28, 1975. Its objectives and by-laws were defined at the same time, and its first board of directors were elected.

The AQT defines itself as a private, French-speaking, multi-disciplinary, non-profit assocation.

6.9.4.3. The Association's Objectives

The Association's objective is to encourage the development of remote sensing and its uses in various ways, including:

- Creating mechanisms whereby information may by acquired and members consulted, pursuing investigations and issuing briefs:
- holding symposia, discussions, seminars, and lectures on the scientific, technical, administrative and other aspects related to remote sensing and its applications;
- assisting members in publishing articles of a scientific and technical nature and creating, where necessary, one or more publications;
- creating links with the various organizations interested in the field of remote sensing.

6.9.4.4 Composition of the Board of Directors

Its board of directors consist of:

President:	Julien Rivest Rinfret, Rivest & Associates
Vice-Pres.:	Guy Rochon Canada Centre for Remote Sensing
Secretary-Treasurer:	Yvan A. Bastien Department of Natural Resources

Members:

PUBLIC ADMINISTRATION Section

Robert Denis
Hydro-Québec

Claude Pesant
Department of Natural Resources

RESEARCH AND INSTRUCTION Section

Gilles Ladouceur
Université Laval

Roger Paquin
Agriculture Canada

PRIVATE AGENCIES Section

Nicholas Lee
Photographic Surveys

Claude Jobin
Aero Photo

6.9.5 Conclusion and future prospects

A plan exists to create a Québec Remote Sensing Centre in 1976, attached to the Department of Lands and Forests but serving all departments and possibly all provincial users.

The means of providing it with personnel, equipment and documentation and the range of services that it will offer are under study.

The provincial co-ordinator will undertake to form a committee representing provincial users. This committee will direct the formation and operation of the future Québec Remote Sensing Centre. Moreover, this committee will represent the province of Québec on the Canadian Advisory Committee on Remote Sensing (CACRS). The co-ordinator, an ex-officio member, will be its spokesperson.

The fact that the next national symposium on remote sensing will be held in Québec will constitute a source of encouragement and a challenge for all those in the province who are interested in this discipline.

6.9.6 Appendix - Remote Sensing at JBDC - Environment

6.9.6.1 History

The Environment Service of the James Bay Development Corporation assumed its present form during 1973. It quickly became apparent that acquiring and processing information pertaining to such a vast territory (135,000 square miles) would be very difficult and burdensome if conventional techniques were used. Therefore, airborne missions have been under way sine 1973, LANDSAT images have been collected and two people have been hired for the various aspects related to the use of remote sensing data (Dr. Marc Tanguay and Jacques David, who began their work in 1974).

Pierre Laframboise was added to the staff in May 1975 to assist the two consultants and to see that the program develops and functions properly.

6.9.6.2 Activities in 1975

6.9.6.2.1 Acquisition of data

The Environment Service of the James Bay Development Corporation (JBDC) had approximately 800 miles of flight line done by the Canada Centre for Remote Sensing (CCRS). The sensors used included an aerial camera with 9" x 9" infrared artificial colour film and a thermal line scanner sensitive to infrared thermal.

Most of the flight lines were done at high altitude (29,000 feet) because the data had to serve:

- in studies on a regional scale;
- as reference data for developing a methodology of using Landsat images in continuous environment observation studies;
- in compiling a photographic file on the sites before they are developed.

Some of the flight lines were done at a lower altitude (10,000 feet) because they were to be used in making thematic mapping on a larger scale by photo-interpretation.

6.9.6.2.2. Assessing the quality and content of the airborne data

A systematic study was made of the quality and content of all the photographs and images that have come from the CCRS since 1973, and a report on quality was done for each year. These reports provide an assessment of each photograph or image with respect to its use in the fields related to the study of the environment. The assessment will take such parameters as exposure, development, sunspots and cloud cover into consideration.

Another study was conducted to evaluate the 1974 photographs and images with respect to their content in the various environmental fields. The content was described in terms of several parameters, grouped into eight classes: earth materials, landforms, vegetation, fauna, drainage, erosion, bodies of water and archaeology.

6.9.6.2.3 Continuous observation of the environment

The studies done in this section are aimed, among other things, at developing a methodology for using Landsat images which makes it possible to update mapping at periodic intervals. This updating was centred on certain major changes that occur within the James Bay territory, such as forest fires and tree-cutting areas (it did not, however, include the changes related to the hydroelectric works). The updating changes must be made on thematic maps from a detailed basic mapping.

We have proposed a methodology for periodically updating the mapping of forest fires in the James Bay territory. The report proposes an interpretation method which makes it possible to identify and date forest fires that occurred less than five years ago, using the appropriate Landsat bands and scales. Indications for transferring forest fire contours onto appropriate maps are also being discovered.

Another study of the same nature covered the lumbering areas in the southern part of the territory. Moverover, it contains a glimpse of the possibilities of using airborne data in studying changes in the environment related to lumbering: erosion, sedimentation and regeneration. A third type of research has been done into the use of remote sensing techniques in studying the effects of mining on the environment.

6.9.6.2.4 Study and inventory of the environment

Photo-interpretation of an area of thirty or forty square miles located between ake Albanel and the Temiscamie River (the Ferchibal project) made it possible to map the ecological types*(uniform surface with respect to soil type and chronological sequence of plant life). The colour photographs at 1:20,000 served as a basis for interpretation, but other scales and film types were assessed with a view to using them for a similar type of interpretation.

A stuy of the vegetation on the Rupert Bay coast line was to be conducted using photographs at 1:20,000. Since the flight lines could not be done under the necessary conditions (during low tide and in the middle of the growing season), this study was done with the help of panchromatic photographs at 1:31,680, assisted however by infrared false colour photographs at the scales of 1:10,000 and 1:60,000.

Two automatic classification tests were done on Landsat images with the help of the Image-100, and they demonstrated that the potential of these techniques was related to the quality of the reference data and, among other things, of the interpreted aerial photographs.

6.9.6.3 Forecasts

The JBDC's objectives are to develop a methodology for using remote sensing which is adapted to the environment of the James Bay territory. Certain basic inventories, such as the vegetation inventory, could be carried out using airborne or satellite data. The possibility of carrying out such inventories depends, among other things, on the following factors; the level of precision required in identifying species or groups of species, the surface area to be mapped and the acquisition of adequate reference data (well located and representative of the class to be identified).

Studies for evaluating the quality and content of airborne data will be pursued along with those connected with the continuous observation of the environment. The use of automatic processing techniques in interpreting Landsat images will become more important when the level of information required permits.

6.9.6.4. Recommendations (for the Airborne Operations Section, CCRS)

We are aware of the fact that the Airborne Operations Section takes the many requirements of the users into consideration in carrying out the mission: time of year, time of day (fixed or variable time in relation to low tide, for example), weather conditions and so on, and we hope that it will continue to do so.

However, here are two recommen-

*Ecological types are established by the Regional Ecological Studies Section of the federal Department of the Environment in a systematic ecological mapping.

dations to improve efficiency:

6.9.6.4.1 When a user requests aerial coverage for a very large territory, the project should be flown even if part of the area is cloud - covered.

6.9.6.4.2 An order of priorities should be established for making flight lines within one project. This order of priorities, which would determine the relative importance of the various flight lines, should be established by the user in relation to his needs.

6.9.6.5 Publications (JBDC- Environment)

David, J. and Tanguay, M.G. (Interploratech Ltd), 1975 Evaluation qualitative des films and images de télédétection (qualitative assessment of remote sensing films and images), project 73-67 JBDC - Environment, Montreal (to be published)

David, J. and Tanguay, M.G. (Interploratech Ltd), 1975 Evaluation qualitative des films et images de télédétection, projects 74-105 and 74-106 JBDC - Environment, Montreal, 1976 79 pages

David, J. and Tanguay, M.G. (Interploratech Ltd), 1975 Evaluation qualitative des films et images de télédétection, projects 75-71 and 75-72 JBDC - Environment Montreal, 1975 33 pages

David, J. and Tanguay, M.G. (Interploratech Ltd), 1975 Etude du contenu des films et images de télédétection en fonction de l'environment (study of the contents of remote sensing films and images in term of the environment), project 74-105 and 74-106 JBDC - Environment, Montreal, 1975, 104 pages

Laframboise, P. 1975 Cartographie des feux de forêt sur le territoire de la baie de James à l'aide de l'imagerie LANDSAT (propostion d'une Méthodologie de mise à jour périodique) (mapping of forest fires in the James Bay territory with the help of LANDSAT imagery (proposal for a periodic updating methodology) JBDC - Environment, Montreal (to be published)

6.10 REPORT OF THE PROVINCE OF SASKATCHEWAN

6.10.1 Airborne Remote Sensing

Four major airborne programs were mounted by Saskatchewan investigators during 1975. These were directed to environmental monitoring of potash mines, the spring wheat program, lignite resource evaluation and geologically oriented studies of the Qu'Appelle Valley. All flights were completed in acceptable time frames and imagery quality was described as good to excellent.

6.10.2 Spaceborne Remote Sensing

Only limited use of Landsat imagery is occurring in Saskatchewan. Several investigators have been severely hampered by loss of imagery on tracks 40 and 41. This has been particularly troublesome with respect to the spring wheat program. The availability of ISISFICHE appears to have generated interest in imagery of areas outside the province, particularly in the academic community. Users of computer-compatible tapes where frame dropping is experienced report difficulties in delivery of U.S. generated tapes of Saskatchewan scenes. Further problems were occasioned due to format differences in the U.S. product. In addition to Landsat, some work has been carried out employing NOAA imagery in snow and forest fire investigations. These investigations are at a preliminary stage.

6.10.3 Technical

There was no move towards establishment of a remote sensing centre during the year. Informal sharing arrangements between various laboratories continued quite effectively. Several new programs in the pattern recognition area were mounted. One of these concerns applications of small computers in pattern recognition. The other dealt with production of surficial geology maps of the La Ronge and Reindeer areas utilizing pattern recognition principles. A final report on the latter project is in progress.

6.10.4 Applications

As previously, Saskatchewan applications of remote sensing continue to fall into a research category rather than an operational category with the notable exception of the airborne survey of potash mine environments. The latter procedure is now considered a routine operational program.

6.10.5 User Liaison

Contact between investigators and CCRS operations was maintained through the Saskatchewan Research Council. Investigators commented favourably on the effective communication maintained through all stages of involvement with the air operations group.

6.10.6 Training

Remote Sensing training is largely confined to the university. In addition to courses in air photo interpretation several classes are offered at senior undergraduate and graduate levels in which remote sensing is a major topic. Enrolments in remote sensing courses average about 8 students per year. In addition, a briefing session on airborne operations was conducted by CCRS. A similar session is planned for the spring of 1976.

6.10.7 Conclusion and Forecast

Although present users of CCRS airborne program are expected to maintain their interest in the coming year, only modest growth in this sector is forecast. Utilization of satellite imagery is less certain. Investigators, particularly those with interest in agriculture, will require more reliable acquisition of scenes in the Prince Albert - Saskatoon area to effectively continue envisaged programs.

6.11 CONSOLIDATED PROVINCIAL RECOMMENDATIONS

6.11.1. Representatives of six of the provinces (Manitoba, New Brunswick, Newfoundland, Ontario, Prince Edward Island, and Québec) met in Toronto on October 20-21, 1975, and prepared the following consolidated recommendations to CACRS:

a) Regional depositories and retrieval systems for LANDSAT images and air photos should be established as warranted by local needs.

b) LANDSAT imagery processed through the National Air Photo Library should be repeatable on the basis of quality. Often this does not seem to be the case, and therefore better quality control should be exercised in the processing of LANDSAT imagery.

c) Support should be given to the investigation of methods of standardizing aerial photographic image quality by defining the specific undesirable factors affecting the image, such as film exposure, sun angle, atmospheric dispersion, photographic reproduction, etc.

d) Another training course should be offered patterned on the Hull, Quebec course of 1972. This could provide more training opportunities for users and potential users of remotely sensed data than are presently available.

e) All requests for airborne remote sensing projects should be channelled through the appropriate provincial centres.

7.1 REPORT OF THE AES PANEL ON REMOTE SENSING

7.1.1 Airborne Sensing

Just prior to 1970 the Lakes and Marine Applications Section of the Atmospheric Environment Service developed an operational methodology for measuring surface water temperatures from an aircraft using infrared thermometry. The Airborne Radiation Thermometer (ART) technique has since been refined to the point that accuracies are now deemed to be within 1 degree celsius in the absolute and better than one half degree relative. The objective of an on-going program is to complete one survey per month on each of the Great Lakes during the ice-free season. The ART data are used to estimate monthly mean surface water temperatures of, and monthly evaporation from, the Great Lakes in support of a lake level prediction program. The data are also used in studies of Great Lakes basin climatology and air/water interaction processes and as aids in forecasting the weather of the Great Lakes and ice freeze-up on the St. Lawrence River.

The AES ice reconnaissance data-acquisition system presently consists of a pair of Electra aircraft modified for dual visual and remote sensing data collection techniques. The visual observations remain the primary data source, but are increasingly complemented with information collected by ground mapping radar, infrared line scanner, radiation thermometer, and laser profilometer. These data sources are coordinated in real time to provide an ice chart indicating ice types, concentration, topography, snow cover, boundaries, melt status, etc. In addition to the above, selective aerial camera photography is undertaken for climatological purposes. A time annotation and data-logging system for the sensors is currently being integrated for installation by the spring of 1976.

The AES is also involved in remote sensing from stratospheric balloon platforms. High altitude research balloons are currently used for cosmic ray research, infrared astronomy and atmospheric studies. Measurements of the concentrations of various trace gases in the stratosphere and troposphere are made by remote sensing techniques in the visible and infrared spectral regions. Measurements of solar absorption by molecular constituents have been made by observing the setting sun from the balloon float altitude. Remote sensing instruments working in the far infrared have been used to measure trace constituents in atmospheric thermal emission by limb scanning from balloon float altitude and by measurements of the change of thermal IR emission during balloon ascent. Atmospheric constituents, successfully measured by remote sensing from balloon platform during the past year include freons, ozone, water vapor, N_2O, NO, NO_2, HNO_3, HCL, CLO, and aerosols. As demonstrated by the French program, high altitude research balloons also provide excellent platforms for the acquisition of high altitude remote sensing imagery and photography. For example, the status of the Canadian prairie wheat crop could be surveyed with flights in August.

Remote sensing techniques have been used to detect frost prone areas in the Niagara Region. In the springs of 1974 and 1975 studies were conducted by the Horticultural Research Institute of Ontario and the Atmospheric Environment Service with the cooperation of Canada Centre for Remote Sensing to test the feasibility of using thermal infrared techniques in defining areas of greater and lesser frost danger during radiation frost conditions in the Niagara Region. Preliminary results are very encouraging. The thermal images taken from 2000 ft. provide very high resolution and can define different thermal regimes within individual fields. Apparent black body temperatures given by these images approximates the true surface temperature with sufficient accuracy for a 2^oC resolution. Atmospheric effects on the radiometer measurements have not yet been considered, but it is believed that they are not significant in this case since only the relative surface temperature among fields is required. Physiographical features influence the thermal regime, but the type and condition of the cover seem to be the more apparent factors in the thermal infrared images. Surface emissivities, though very important in evaluating true surface temperatures, do not appear to be significant within the required 2^oC accuracy. The reason seems to be that most soils are saturated with water in the spring and the sky is usually cloudless at the time of observation.

Daytime false colour infrared photographs are also used. They are found to be extremely useful in complementing thermal infrared data. They provide an excellent means for field identification and cover classification, and there appears to be a relationship between the colour density and the expected surface temperature of a field. However the use of this qualitative relationship appears limited.

7.1.2 Spaceborne Remote Sensing

The Atmospheric Research Directorate has completed the installation of its HRPT reception system. The system has been designed as a multi-user system to serve both the operational and the research needs of the AES. Because of the design of the system, non-AES users can have relatively low cost access to computer compatible data in real-time as well as the more conventional imagery.

Tests are under way to demonstrate the system's capability to transmit geometrically corrected imagery over land-line to remote photo facsimili. At present the tests are restricted to the Toronto Weather Office at the airport, but arrangements are being made to transmit the data across the country using the AES facsimile circuits. After the tests have been satisfactorily completed, a dedicated mini computer system will be installed in the Satellite Data Laboratory to tailor outputs to meet the needs of the major weather offices and provide a zoom capability for critical weather situations.

As part of the research and development program of the Aerospace Meteorology, a colour TV output device is being acquired for the Satellite Data Laboratory computerized reception facilities. This system will provide a rapid output device for research and development studies as well as permitting studies on the potential of false-colour enchancements for use in AES operational programs.

Plans are being completed to add the reception capability for atmospheric sounding data to permit experiments with real-time processing for weather forecast support and to allow corrections to be made to the VHRR data to account for atmospheric absorption and radiation in the infrared band.

The AES operates two APT receiving stations at Halifax and Vancouver; a new photo facsimile transmission will be introduced early this year to distribute these data to major weather offices across the country. In addition, the Halifax station has been upgraded to receive WEFAX transmissions from the SMS-GOES satellites.

The AES is also involved in the NIMBUS-6 Solar Backscatter Ultraviolet and Total Ozone Mapping System experiments. Dr. Carl Mateer, Deputy Director, Atmospheric Processes Research Branch, has been selected by NASA to be a member of the Experimental Team.

7.1.3. Technical Developments

The AES has developed an acoustic sounding system and has used acoustic techniques in field studies including the New Brunswick Spruce Bud Worm Project and in the joint MOT-NAE-AES STOL project at Rockcliffe Airport Ottawa. Recent developments in this area are extremely promising and the AES will probably become increasingly involved in this type of remote sensing.

There is also considerable interest in the use of lidar systems to determine atmospheric structure, stability, temperature and chemistry. The AES, through contract studies, is developing lidar systems to support its air quality studies.

Simultaneous measurements taken with three Remote-Sensor Correlation Spectrometers (COSPEC) have been used to study the dispersion characteristics of the plume from a 387 m stack in Sudbury, Canada. The data obtained have been used to determine plume ground paths which demonstrate curvature due to cyclonic effects and other variations in wind direction, plume boundaries and relative and absolute lateral diffusion due to turbulence, meandering of the plume and wind shear.

Results to date have indicated that horizontal and vertical variations in wind direction play a major role in the diffusion processes at distances of a few kilometres and more from the stack and that on the average the plume meander downstream influences the plume size near to the stack. Both effects, combined to produce lateral standard deviations in the plume that depart significantly from Pasquill-Gifford values both near and far from the stack.

In addition, the use of the correlation spectrometer to determine dispersion parameters has yielded some insight into the diffusion processes which affect the plume. This information has been used to determine the conditions under which this type of remote sensing can be applied to the calculation of mass fluxes and emission values.

A computer-facsimile interface has been developed, under contract from the Satellite Data Laboratory, by Muirhead Ltd. This interface allows direct output from a computer to standard photo facsimile devices either in the laboratory or via normal land lines to remote locations. Several other systems of this type have been sold as a result of this contract. A modified system is now under development to permit more rapid output to modified photo facsimile equipment in the Satellite Data Laboratory.

7.1.4 Applications and Benefit Analysis

As part of the AES Beaufort Sea Project, a contract was let to the University of Alberta to carry out research and development on digital enhancement and processing of Scanning Radiometer data to assist in interpretation in Arctic latitudes to support weather and ice prediction. This study was under the supervision of the Meteorological Services Research Branch and was carried out with the assistance of the Arctic Weather Central. The techniques developed are equally applicable to VHRR data and will result in more effective operational utilization of satellite imagery.

The Hydrometeorological and Environmental Impact Research Division is applying VHRR imagery in a snow cover mapping experiment being done under a WMO project "Snow Studies by Satellites". This Division of AES has undertaken responsibilities for studies of the Saint John Basin (Maine, Quebec, N.B.). It is planned to use daily VHRR coverage to map snow and ice cover and snow melt and ice break-up periods will be of prime interest. It is anticipated that ERTS multi-spectral imagery is being used to augment VHRR coverage and to provide further ground truth information for the project. This project was begun last winter and will continue through the next few years. It requires VHRR imagery in both the Visual and Infrared Spectral bands, close to real-time, on a weekly basis. At the present time these data are being provided by the Satellite Data Laboratory and the National Environmental Satellite Service.

The Agricultural and Forest Meteorology Section has plans for using VHRR imagery to study snow cover extent, forest fire detection, phenomenological stage detection, snow accumulations and to aid crop identification and acreage determination. The latter requirements will probably necessitate the use of ERTS imagery but VHRR coverage may provide for the extension of information from the ERTS data to areas where daily VHRR coverage only is available. VHRR infrared coverage also may be applicable to topographical studies related to frost protection problems.

Following a co-operative gamma radiation survey over Southern Ontario with Geological Survey of Canada and Inland Waters Directorate, and the analysis and publication of results in 1974, AES purchased a small portable gamma spectrometer in 1975. The instrument is a model DISA-400A produced by Exploranium Corporation and investigations will be carried out to test its applications to soil moisture and snowpack water content in various modes: mounted in situ, hand-held, transported by surface vehicle, and flown over the surface by helicopter or fixed-wing aircraft. In the first phase of these studies, the instrument has been modified for automatic remote operation in a fixed location on a tower at the Woodbridge experimental site. A heated box was designed to house the equipment and minimize calibration drift. An automatic 35 mm camera system has been interfaced to record the digital display at pre-selected intervals. Lead shields have been designed to allow for periodic checking of the background sky radiation compoment. "Ground-truth" observations are being obtained at the site through a variety of techniques, since a WMO project to investigate soil moisture and snow measurement techniques is being carried out concurrently.

7.1.5 User Liaison

The mechanisms for user liaison vary but generally requests for support or information from new users are channeled through the office of the Assistant Deputy Minister or the DOE Coordinator on Airborne and Satellite Sensing. After the appropriate AES component has been identified and the request approved, an AES contact is named who liaisons directly with the user. Internally liaison is via normal inter-Directorate channels or via the AES Panel on Remote Sensing.

7.1.6 Training

The first Arctic Weather Centre Refresher/Workshop Satellite Program was held at the Edmonton International Airport during the period 12 - 14 November, 1975. The satellite workshop program was organized by the AES Training Branch as part of the larger Arctic Refresher/Workshop. A total of about 60 meteorologists and technicians, split into two groups, participated in the satellite workshop. The purpose of the workshop was to bring together and summarize the most recent and authoritative information on the use of satellite imagery in analysis and forecasting. In addition, many workshop sessions provided for active participation to develop practical expertise in the interpretation and analysis of satellite imagery in support of AES forecasting operations.

7.1.7 Conclusion and Forecasts

The AES is entering a period during which remote sensing both from the ground and space will play an increasingly large role in gathering data to meet the needs of AES operations. By the end of the next decade the conventional observational networks of today will have given way to spaceborne remote sensing platforms supplemented by surface based remote sensing systems and relatively few immersion sensing systems.

7.2 OCEAN AND AQUATIC SCIENCES (PACIFIC REGION)

During 1975 the Remote Sensing Section was occupied with spectroscopic measurements of water colour using the 256 channel silicon diode spectrometer, with tests and target position measurements using the MIDAS Marine Inertial Data Acquisition System, and with photography in support of other programs at O.A.S. (Pacific). Also, analysis of image data from N.O.A.A.'s VHRR radiometer continued for sea surface temperature measurements with S. Tabata (Offshore Oceanography), and altimeter data has been received from the GEOS-3 satellite for wave height analyses.

Other on going programs in oceanographic remote sensing at O.A.S. (Pacific) are ice movement and ice cover analysis from satellite imagery in the Beaufort Sea Project and tracking of drifting buoys using aircraft and satellite position measuring systems (Offshore Oceanography). The airborne hydrography project continues with the development of photographic techniques using the C.C.R.S. Airborne Data Acquisition System (ADAS) for camera attitude and position measurements, and with plans for airborne laser bathymetry.

7.2.1 Aerial Spectroscopy Using the 256 Channel Silicon Diode Spectrometer (R. Neville)

The instrument was installed in a Beaver float plane and used on a number of trial flights during the spring of 1975. Spectra were collected viewing the water at the Brewster angle through a polarizing filter and were compared with ground truth provided by the University of Victoria. These showed the expected changes in blue/green ratio with chlorophyll content and also demonstrated that the chlorophyll fluorescence line near 680 nm could be used as a chlorophyll indicator for low level flights even under cloudy conditions. Further investigations of this fluorescence line are being made using spectra from a research ship, a dock and over a CEPEX enclosed environment bag. Laser induced fluorescence lines were also measured in the laboratory.

The spectrometer was flown on a C.C.R.S. D.C. 3 during the joint chlorophyll sensing experiment off Yarmouth, N.S. in August 1975, soil spectra were collected in the lower Fraser Valley in support of research at U.B.C. and the equipment was shipped to Ottawa in November 1975 for a flight in a C.C.R.S. D.C. 3 for the Geological Survey. This flight has, however, had to be postponed.

The spectrometer has been a useful source of high quality fast scanned digital spectra covering 380 to 1065 nm with a resolution of about 10 nm, and should prove useful in an even wider range of research projects. The airborne installation allows for removal of dark currents, collection of sky spectra and monitoring of the resulting spectral ratios.

7.2.2 MIDAS - Marine Inertial Data Acquisition System (J. Gower, R. Grasty and B. Oliver)

The system has the same LTN-51 inertial platform as the ADAS units operated by C.C.R.S. but has less data acquisition capacity and is more compact. Bench and truck trials showed that the system can form the basis of an extremely precise track recovery system. Removal of the measured INS velocity drift in ground tests gave positions accurate to about 20 ft over a half hour run in a truck.

The system is now being flown in a Beech 18 aircraft belonging to the B.C. Provincial Government. This aircraft is extremely suitable though somewhat cramped, since it has a transparent nose dome as well as camera and drift sight hatches. An electronically read gun sight system mounted in the nose is used to point out the directions of reference positions at sea level as the aircraft passes approximately overhead. The sight allows the aircraft's position to be defined to about ± 30 ft, and sightings at 10 minute intervals are sufficient to define the INS drift errors to this same accuracy. The position of any intermediate target pointed out by the sight can now also be calculated to ± 30 ft accuracy. Tests with the system have so far included position measurements of coastal navigation markers and of freely drifting drogues.

The system has also been used to form thermal images from the output of a mechanically scanned PRT-5, giving 400 ft resolution over a swath width of 5 miles. Soil spectra gathered in the lower Fraser Valley were also collected using the MIDAS system in the Beech 18, with the spectrometer data being recorded along with track and time information. Further track recovery and mapping software are now being written for this system.

7.2.3 Photography in Support of Other Programs

A variety of photography was carried out over the year to develop and demonstrate techniques and to support other programs.

7.2.3.1 Balloon Photography

Series of 35 mm photographs were taken from a balloon over Rupert Inlet on Vancouver Island, B.C. to map the upwelling of mine tailings at different states of the tide. The balloon had a volume of 1600 cu ft and, filled with helium, provided a net lift of about 60 lb. This was used to carry a motor driven Nikon camera equipped with a fisheye lens and triggered at 10 minute intervals by a self contained intervallometer. The streamlined shape of the balloon allowed it to remain near the zenith in most wind conditions and it could be conveniently handled and flown from a small launch by a crew of two.

Several useful series of pictures were obtained for cost and effort that compares very favourably with other means of photography. Danger of collision with aircraft somewhat limits the technique to remote areas, though special arrangements could be made with local air traffic control, and small problems should exist for flying the balloon below 500 ft. A single inflation needed about $300 worth of helium and took several hours, so that the balloon must be stored inflated overnight. In this experiment the balloon was damaged by an overnight storm and a better mobile cradle and mooring is clearly needed.

The balloon was flown by Dr. Miyake's group at U.B.C. uncer contract to J. Gower.

7.2.3.2 C.C.R.S. Falcon Flight Over Vancouver

At the request of O.A.S. (Pacific) the C.C.R.S. falcon flew two sets of high level colour photography and thermal scanner imagery over Vancouver and the Fraser River plume on June 11 (see oceanography working group report).

7.2.3.3 Ships in English Bay

In support of a surface current survey of Burrard Inlet, a series of 8 mm time lapse pictures were taken at 10 minute intervals from a mountain side to show the orientation of ships in English Bay. The fixed location of the camera made the film easy to analyse and even though the target scene was viewed at a glancing angle of less than 10° the ship orientations could be measured to $\pm 20^{\circ}$ during the daylight periods of June 1 to June 10, 1975.

7.2.4 N.O.A.A. VHRR Thermal Imagery Enhanced to Show Sea Surface Temperatures (J. Gower, D. Truax and S. Tabata)

Thermal VHRR imagery can be enhanced to show variations in sea surface temperature as small as 0.5°C. These images show the effects of coastal upwelling as well as other more transient temperature changes which may be associated with winds or fresh water runoff. Some enhanced images are available from N.O.A.A., but, to give good coverage of the area off the B.C. coast, taped data was ordered and software was developed to display the enhanced imagery. Comparisons with Station PAPA and other ship data are still continuing, though preliminary results were shown at the Canadian Meteorological Society meeting at U.B.C. in May 1975.

7.2.5 Ice Studies Using Satellite Imagery (J. Marko)

Landsat and N.O.A.A. VHRR imagery are being used to follow ice motion and changes in ice cover as part of the Beaufort Sea Project. A complete microfiche library of Landsat images is held at Pat Bay. Landsat images are used to study small areas in detail while the VHRR imagery gives a full picture of Beaufort Sea and Arctic Island ice conditions. J. Marko and R. Thomson have recently published (Geophys. Res. Lett. 2, 431, 1975) an interpretation of a trellis-like pattern in Beaufort Sea ice, visible on VHRR images as being caused by planetary waves in the water. The pattern has a repeat scale of about 120 km and consists of lines through pack ice of relatively open water which can also be seen with greater resolution on Landsat images.

7.2.6 **Target Tracking for Surface Current (J. Garrett)**

In the second and final year of the Beaufort Sea Project, the Offshore Oceanography group used approximately 200 hrs of aircraft time tracking drifting drogues marked with radio beacons in a 100 by 300 km area of the Beaufort Sea. The radio beacons allowed the drogues to be located by the aircraft to a few hundred metres accuracy and the aircraft position was monitored using a Decca chain. Final accuracy of the locations was less than 1 km. Sea surface currents were successfully measured, though problems were experienced with weather and with aircraft scheduling. The latter was much worse now that the aircraft had to be shared with another research project.

About 70 targets were tracked. These were deployed from the air and had an average useful life about a week before being washed ashore or caught in ice.

Most of the cost and problems in this project resulted from use of the aircraft. Aircraft charter costs $90,000 and the seventy targets cost $300 each.

Satellite buoy positioning systems avoid these problems. The cost of the buoy and its electronics is much higher, about $5000 each for typical systems, which would lead to prohibitive expense where buoy lifetimes are short. In the open ocean, however, a buoy can continue to send meteorological and sea surface data as well as position data for a year or more via satellite and such a system becomes very attractive.

For the First Garp Global Experiment (1979) it is planned to deploy such buoys, and a number of buoy designs are being tested. Five buoys were deployed in the Pacific in December 1975 to be tracked by Nimbus-6 and initial position data indicates that location errors are less than the ± 10 km expected. Failure rate of the electronics was high in this experiment. The five deployed drogues and one other moored at the institute site at Pat Bay, are the survivers from a batch of 10.

Continued availability of this type of system is assured in the operational TIROS satellite series. This will include the French 'Argos' system which will be operated by C.N.E.S., who will charge users for the cost of the service.

7.2.7 **Aerial Hydrography (N. Anderson, J. Watt)**

Analysis of photographs taken with a camera rigidly attached to the LTN-51 inertial system in C.C.R.S.' ADAS has been slowed by delays in processing ADAS data, and in acquiring suitable flight test data. N. Anderson has now moved to Ottawa, leaving J. Watt as the O.A.S. (Pacific) representative on the project.

While it should be possible to take stereophotography with reduced ground control using the inertial system, developments in laser water depth measuring systems are proceeding rapidly, especially in the U.S. military and oceanographic communities. Optech has submitted a design based on a survey of these systems and the state of the art, but new funds are needed to procure this system. At present, the design is being refined in experiments at C.C.R.S. with their existing system.

7.2.8 **Conclusions**

The MIDAS and spectrometer systems have provided a large quantity of new and interesting remote sensing data, and most of the year for the Remote Sensing Section was spent in analysing this. We were fortunate to have R. Grasty for the year from the Resource Geophysics and Geochemistry Division, Geological Survey of Canada to help develop automated track recovery methods using MIDAS. R. Neville (post-doctoral fellow) has collected a wide variety of water reflectance spectra and has now developed analysis techniques and software. B. Oliver (post-doctoral fellow) joined the group in August 1975 and has worked on target position measurements with MIDAS.

Although the group has sensor and navigation equipment, we have no flight facility on the West Coast and are very grateful to the B.C. government for the Beech 18 aircraft. This is only a temporary arrangement and we hope to see a C.C.R.S. West Coast detachment arrive soon. So far, this has been delayed by budget cuts.

We are also in close contact with local aircraft operators, but since our present operation requires complex equipment installation with only a very low number of flying hours, a commercial arrangement would be mutually unattractive. An average of one flying hour per week has kept us busy with data analysis for the past three months, and so long as all data is of research nature, collected for us alone, the number of flying hours will not go much above two hours per week. Installation and removal of equipment takes at least half a day each.

Ocean and Aquatic Sciences has planned to take a major role in Canada's contribution to NASA's SEASAT program. J. Gower is a member of the ocean dynamics advisory subcommittee. Experiments to test the capability of SEASAT sensors include use of GEOS-3 altimetry data (see oceanography working group report) and of thermal infrared satellite imagery. O.A.S. (Pacific) is also prepared to play a role in any sensor tests in the northeast Pacific.

In general, the development of remote sensing has fitted well with the oceanographic program at O.A.S. (Pacific), with the major foreseeable problem being lack of a suitable research flight facility.

7.2.9 Appendix

Personnel working for the Remote Sensing Section, O.A.S. (Pacific) during 1975:

J.F.R. Gower	Head
J.S. Wallace	Electronics Technician
R.A. Neville	NRC Post-doctoral Fellow
B. Oliver	NRC Post-doctoral Fellow
R.L. Grasty	Research Scientist on secondment from the Geological Survey of Canada, Ottawa
D. Truax	Contract Computer Programmer

7.3 SPECIALTY CENTRE REPORT OF THE FOREST MANAGEMENT INSTITUTE

7.3.1 Introduction

During 1975, budgetary restraints, staff transfers, and language training limited, to some degree, the activities of the Remote Sensing, Forest Appraisal and Integrated Resource Survey Programs of the Forest Management Institute (FMI).

Nevertheless, integrated resource surveys, relying heavily on the utilization of remote sensing data, were underway or being completed in a number of National Parks; the Landsat Program remained a high priority with emphasis on a number of promising applications; the Large-Scale Photo Inventory system was successfully tested in Nova Scotia and Alberta and it is planned to incorporate the method into one of these provinces' inventories; research into digital image processing and interpretation is now supported by an in-house low-cost minicomputer system; and a strong research program continued in the area of field spectroradiometry and another program introduced which culminated in the production of pilot forest stereo-orthophotomaps.

7.3.2 Airborne and Satellite Remote Sensing

Our operational integrated resource surveys still rely to a large degree on airborne photographic remote sensing. More than 700 line miles of photography was acquired during the year to provide data for surveys in a number of National Parks and to provide calibration data for Landsat investigations into spruce budworm damage, particularly in New Brunswick.

The present status of Landsat applications in Canadian Forestry was described in an invited paper by Sayn-Wittgenstein and Wightman presented at the 10th International Symposium on Remote Sensing at Ann Arbor. A summary, with respect to FMI endeavors, is extracted from that paper as follows:

> "One of these applications is in integrated biophysical surveys where Landsat has probably found ready acceptance because it has not revolutionized procedures, but added a new perspective and plays a complementary role in an improved procedure.
>
> The most significant operational applications of Landsat data have been in the mapping of broad forest cover types and recent forest fires. Experiments dealing with the charting of high water levels and tornado damage were also successful and satellite data would find practical application if the need should arise.
>
> A major attempt is now being made by the Forest Management Institute, the New Brunswick Department of Mines and Resources and the Maritimes Forest Research Centre, to map severe spruce budworm damage and possibly several other levels of damage in New Brunswick. This project, which to date relied on a maximum likelihood classifier (Goodenough and Shlien 1974) and the GE Image 100 system, has run headfirst into the problem of definition of ground truth: precisely at what point does a dead balsam fir stand become a healthy hardwood stand (if hardwoods are succeeding fir) and exactly when does a group of conifers in a hardwood area become a coniferous stand, rather than a few isolated trees that should be ignored? These problems of definitions and minimum area to be recognized are always present, but they become of vital importance in the broken-up and scattered patterns of damage and forest types which prevail in the area. This insect, the most serious forest pest in Canada, poses special difficulties to interpreters: unlike the gypsy moth or the hemlock looper, it does not strike suddenly and kill rapidly leaving clear outlines of damaged areas, but rather the damage tends to be the cumulative effect of many years; the transition from damaged to healthy stands is subtle and healthy foliage of underlying shrubs and associated hardwoods confuses interpreters."

The study will continue, but it is now realized that it is more long-term than first realized, bearing in mind the limitations of present Landsat sensors and the inherent spectral and spatial complexity of the damaged forests.

7.3.3 Integrated Resource Surveys and Urban Forestry

Integrated resource surveys for a number of National Parks were underway or completed during the year. The final report on Kejimkujik National Park (N.S.) is now available and the report on the extension portion of the Vegetation Types of the Mackenzie Corridor is now completed. Fundy (N.S.), L'Anse Aux Meadows (Nfld.) and Pukaskwa (Ont.) National Parks are now in the final mapping stages and reports will soon be published. During the 1975 field season a reconnaissance survey was undertaken in Nahanni National Park (N.W.T.) and drainage and preliminary vegetation maps are under preparation. In addition reconnaissance work and base map preparation commenced in St. Lawrence Islands and Georgian Bay Islands National Parks in Ontario.

In the Urban Forestry program a brochure and map, based on an earlier integrated resource survey of Gatineau Park, was prepared for the National Capital Commission, the National Museums of Canada, and is now available as a vegetation interpretation document for the general public. Land use and vegetation maps, derived from aerial photography and ground samples, have been completed for the National Capital Greenbelt and will be made available soon.

7.3.4 Large-Scale Photo Inventory System

The Forest Management Institute for a number of years has been developing a forest inventory method based on large-scale 70 mm sampling photography. The aim is to eliminate most of the expensive ground work required to collect tree species, height, diameter and volume data. The photography is typically of scale 1:1000 — sufficiently large for individual trees to be identified and measured photogrammetrically — flown in strips or short bursts over selected sample areas and dependent only on airborne data for control. A low-altitude vegetation-penetrating radar altimeter and lens axis tilt indicator were specially developed to provide the data. The measurement procedure, to produce the required inventory statistics, has been partially automated through the use of digitizers and computers.

The method was tested on a small operational forest inventory and, this year, two full-scale demonstration projects were carried out in cooperation with Provinces of Nova Scotia and Alberta. The Nova Scotia trial has been successfully completed, the Alberta project will be finished in 1976. Plans are being laid to incorporate the large-scale photo method as part of one of the provincial inventories.

7.3.5 Digital Image Processing and Related Technical Developments

In the autumn of 1974 the Institute set itself the task of developing an independent capability for the interpretation of digital remotely sensed data. Three operating modes were evaluated — a service bureau mode, a minicomputer based, in-house, mode, and a combination (in-house and service bureau) mode. The in-house mode was selected because it would result in the most economical, versatile, easily available and convenient system. The Institute therefore purchased a micro-programmable minicomputer, a magnetic tape transport, a 100 megabyte disc drive, a graphics display terminal and a console terminal. This equipment was delivered in late October 1975 and within a few days Landsat CCT's were read.

Expansion for 1976 calls for the interfacing of the Institute's digitizer table and color television display. It is hoped that the Institute's system will serve as an example of a low cost digital interpretation system. At the present time a software package for image interpretation on the minicomputer is under development, and the hardware is also being used for the development of a geographic information system.

The feasibility study on the applicability of digital Landsat imagery to forest mapping in the Larose Forest test area was concluded by the comparisons and accuracy analyses of all the methods used. These included single and multidate classifications based on four, as well as only two spectral bands, by the general-type computer and results obtained when classifying the same scene by the Image 100. The classification was successfully accomplished to the level of coniferous forest, deciduous forest, and other forest land. The classification accuracy ranged from 67% to 84% depending on the date (dates) of the scene recording and whether the classifier was single or multidate. Individual tree species groups could not be differentiated. On the basis of our experience this level of classification would require a significantly higher ground resolution; possibly 20 m x 20 m.

When the classification results are to be displayed graphically as on the thematic maps, the confusion tables are somewhat inadequate for the expression of mapping accuracy, i.e., the error in class location on a map. Consequently, a new accuracy measure, the mapping accuracy was introduced to supplement the confusion tables whenever a hard copy pictorial display of classification results is required. A paper summarizing these results was presented at the Tenth International Symposium on Remote Sensing of Environment (Kalensky and Scherk, 1975 — See Recommendations).

7.3.6 Field Spectroradiometry

The field measurement of spectral patterns of the visible and near-infrared radiation reflected from the canopy of different tree species continued in 1975. The objective of the study is to evaluate which tree species and when and with what accuracy can be differentiated on the basis of their spectral reflectance. This is important for interpretation of small-scale aerial and space images in which the spatial image variation caused by differences in size, shape and distribution of trees is no longer detectable and the differences in spectral signatures of ground classes become the principle interpretative criteria.

The 1975 program included measurement of several typical tree backgrounds including shrubs, grass, and bare land. Data analysis concentrated on the effects of site and phenological stage on the species spectral reflectance. The results were presented at the Third Canadian Symposium on Remote Sensing (Kalensky and Wilson, 1975).

7.3.7 Forest Stereo-orthophotomaps

The invention of stereo-orthophotography and the development of hardware and techniques for stereo-orthophotomapping in Canada during the last decade may entirely change the concept of large and medium-scale thematic mapping. The Forest Management Institute is the Scientific Authority for development of the first electronic stereo-orthophoto printer manufactured by GESTALT INTERNATIONAL LTD. of Vancouver and recently produced the first forest map based on stereo-orthophotographs. The main advantage of stereo-orthophotomapping is the ability of combining photointerpretation and mapping into one procedure. Consequently, it would be no longer necessary to transfer (and to degrade during the procedure) the interpreted data into a line base-map. Instead, delineation of the object classes is done directly on the stereo-orthophoto base-map, and the line map, when needed, can be prepared as an overlay.

Equally important is that the stereo-orthophotographic technique permits the production of accurate large and medium-scale thematic maps without requiring expensive and complex photogrammetric stereo-plotters. The reason is that the relative and absolute orientations needed for reconstruction of a stereo-model, its levelling, positioning and scaling are already completed during the production of stereo-orthophotographs. All that is needed is a simple instrument for observation of the stereo "ortho-model" and for recording the results of its interpretation. This can be done either graphically, directly on the orthophotograph, on the overlayed transparency, digitally, or simultaneously in both modes.

7.3.8 Storage, Retrieval and Display System for Forest Resource Information

The objective of this study is to develop a minicomputer-based information system for forest resource data. Following an examination of alternative systems, a Varian minicomputer has been acquired, and work has started on system development. An interactive digitizing, editing and display sub-system will be operational by July, 1977.

7.3.9 Training

Again the Institute was called upon to organize or assist in remote sensing training programs in Alberta, British Columbia and Nova Scotia. In November Mr. Wightman was invited to contribute to the joint UN and FAO Regional Seminar on Remote Sensing Applications hosted by the Government of Indonesia in Jakarta.

7.3.10 Recommendations

- that in support of the FMI 1974 recommendation "to establish common, standard criteria to test the validity of the results of Landsat experiments", the following publication be considered as a basis for implementing such a recommendation:

  Kalensky, Z. and L.R. Scherk. Accuracy of forest mapping from Landsat Computer Compatible Tapes. Proceedings of the Tenth International Symposium on Remote Sensing of the Environment, Ann Arbor, Michigan, October 1975.

- that Canada should press for multispectral sensor packages on board future satellites which provide a minimum resolution of 20 metres by 20 metres.

7.3.11 APPENDIX I: Current Bibliography

Aldred, A.H. 1975. Summary of progress on implementation of an inventory method based on large-scale aerial photographs. Proceedings of Workshop on Canadian Forest Inventory Methods by CIF Working Groups, Dorset, Ont. June, 1975.

Bonnor, G.M. 1975. Cluster sampling with large-scale aerial photography in forest inventories. Dept. of Environ., Can. For. Serv., For. Manage. Inst., Inform. Rep. FMR-X-80; 26 p.

Crosson, L., F. Peet, D. Read. 1975. Agricultural crop reflectance studies using Landsat-1 data. Proc. of the Third Can. Symp. on Remote Sensing, Edmonton, Alberta, Sept. 1975.

Gimbarzevsky, P. 1975. Biophysical survey of Kejimkujik National Park. Dept. of Environ., Can. For. Serv., For. Manage. Inst., Inform. Rep. FMR-X-81, Sept., 1975, 136 p.

Kalensky, Z. and D.A. Wilson. 1975. Spectral signatures of forest trees. Proceedings of the Third Canadian Symposium on Remote Sensing, Edmonton, Alberta. Sept. 1975.

Kalensky, Z. and L.R. Scherk. 1975. Accuracy of forest mapping from Landsat computer compatible tapes. Proceedings of the Tenth International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan. October, 1975.

Mack, A., F. Peet, L. Crosson. The cooperative Canada-U.S. crop prediction project. Proc. of the Third Can. Symp. on Remote Sensing, Edmonton, Alberta. Sept. 1975.

Nielsen, U. 1975. More on distortions by focal plane shutters. Photogrammetric Engineering and Remote Sensing, February, 1975, p. 199-201.

Peet, F. 1975. A technique for locating ground calibration data on Image 100 output. Dept. of Environ., Can. For. Serv., For. Manage. Inst., Inform. Rep. FMR-X-84.

Peet, F. 1975. The use of invariants in the transformation of registration of images. The Canadian Surveyor, Vol. 29, No. 5, Dec. 1975.

Sayn-Wittgenstein, L. and J.M. Wightman. 1975. Landsat applications in Canadian forestry. Invited Paper, Proceedings, Tenth International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, October 6-11, 1975.

Wightman, J.M. and E. Jorgensen. 1975. The role of remote sensing in urban forest management. Proc., 26th Ann. Meeting of the Int. Shade Tree Conf. — Toronto, Ont.

7.4 SPECIALTY CENTRE REPORT OF THE LAND CLASSIFICATION, INTEGRATED SURVEYS AND REMOTE SENSING DIVISION, LANDS DIRECTORATE

7.4.1 Introduction

The objective of Remote Sensing studies in the Lands Directorate is to evaluate airborne and satellite remote sensing for ecologically based land classification, land use mapping and monitoring. Emphasis is on the development of applications for operational survey activities in land resource inventories which are being carried out or planned at national and provincial levels. In addition to research and application development activities, advice and training is provided to federal and provincial inventories and, land use and land resource mapping.

The Division was established in its present form during early 1975. During this year new positions were filled, but because of language training of new scientists, research activities were limited.

7.4.2 Bio-physical Classification

A number of studies are underway or planned to evaluate the use of airborne and satellite remote sensing for bio-physical classification in Northern areas. At some time in the near future, integrated resource inventories will be carried out north of the Canada Land Inventory area. The effectiveness of remote sensing will be tested in various parts of the boreal, sub-arctic and arctic zones.

In the *Churchill* area, northern Manitoba, at the fringe of the north boreal and sub-arctic zone, visual and automated (supervised, unsupervised, temporal) interpretation methods of airborne and satellite remote sensing are used to classify a 1:250,000 scale map sheet on a land type and land system basis. Resulting maps are overlaid using the Canada Geographic Information system (C.G.I.S.) and differences in classifications calculated on a land system, land district and map sheet basis.

During 1975 assistance was provided to the *Northern Resource Information Program* in Manitoba. This is bio-physical mapping carried out by a provincial team for an area of 130,000 sq. miles over a period of about 5-7 years. This winter, as part of this project fieldwork was completed for about 50,000 square miles to provide for a rapid preliminary bio-physical mapping using visual interpretation techniques of LANDSAT. In subsequent years the practical value of the preliminary mapping will be assessed when this same area will be covered by the Manitoba team.

In the Arctic on *Melville Island* the value of automated LANDSAT imagery interpretation for an integrated land classification is being tested by Dr. P.J. Howarth of McMaster on a contract basis. Original Classification was recently completed by an interpreter team representing G.S.C., C.W.S., E.M.S., (Barnett et al).

To further develop the bio-physical classification system, research has recently started in the integration of land and water classification systems and the classification of environmental dynamic phenomena. Both projects will involve testing and applying remote sensing data.

7.3.3 Coastal zone Classification

The Lands Directorate Atlantic Regional Office in Halifax, Nova Scotia, carried out, in cooperation with the Canada Centre for Remote Sensing, studies to evaluate remote sensing for coastal zone classification work. This included the analysis of satellite data as well as airborne. A special flight with air-borne multi-spectral scanning was carried out over the test sites. These activities are preliminaries to the planned Coastal Resources Inventory and Mapping Program for the Atlantic provinces.

7.3.4 Land Use Mapping and Monitoring

Research in the use of computer processing of LANDSAT data for Canada Land Inventory Land Use applications is being carried out by Geogory Geoscience on a contract basis. Principal investigator is Dr. J. Shubert. The test are carried out in Peace River area in Alberta (NTS:84C) and the Whitemud River water shed in Manitoba.

Other research concerned with Land Use Mapping and Monitoring using Remote Sensing in the Lands Directorate is being undertaken by the Resources Mapping Division. ECOLCON Canada through an unsolicited proposal has just completed a contract in December, 1975, updating the CLI land use maps for 21 Census Metropoliton Areas in Canada using aerial photography. The map information will be fed into the Canada Geographic Information System. Other research where Remote Sensing is a principal tool for gathering land use information will be published in the near future under the titles "Rural Land-Use Changes in the Ottawa-Hull Urban Region" and "Rural to Urban Land Conversion in Canada". The Resources Mapping Division plans additional research in Remote Sensing in order to develop a Canada Land Use Monitoring Program (CLUMP).

7.3.5 Conclusions

As a result of language training, the Lands Directorate program in Remote Sensing had a slow start in 1975; activities should increase in the following years.

CCRS cooperation, mainly in the form of making facilities available for research, has been very good during the past year and this is certainly very much appreciated by the Lands Directorate.

7.3.6 Appendices

7.3.6.1 Appendix I - List of Lands Directorate Staff involved in Remote Sensing.

Ottawa-Hull:

Mr. J. Thie - Land ecologist; bio-physical classification.

Mr. D.M. Gierman - Geographer; land use.

Mr. T. Pierce - Forester; land classification (Forestry and Recreation).

Dr. D.M. Welch - Fluvial geomorphologist; Land-Water Integration.

Mr. E. Wiken - Pedologist; land classification

Mr. G. Ironside - Biologist; dynamic phenomena.

Atlantic Region:

Dr. G.E. Beanlands - Coastal zone classification.

Mr. N. Lopoukhine - Forester; coastal zone classification, bio-physical.

Ms. N. Prout - Geographer; bio-physical & Coastal zone.

Quebec Region:

J.L. Belair - Pedologie; bio-physical Land Classification

7.3.6.1 Appendix II - Publication, Reports and Papers since 1974, related to Remote Sensing applications.

Beaubier, P.H. and T. Pierce 1974: "Recreation-Tourism Evaluation, Northern Land use Information Series". Lands Directorate, Environment Canada, Ottawa-Hull.

Ducruc, J.P. and R. Zarnovican 1974: "Photo-interprétation semi-automatique: Essai d'application a un inventaire phytoécologique dans la Péninsule Québec -Labrador". Proc. Symp. on Rem. Sens. I.S.P., Comm. VII, Banff, pp. 419-729.

Gierman, D.M., G. Moran, R. Ryerson, W. Switzer "Remote Sensing and Canada Geographic Information (CGIS) for Impact Studies".

Gierman, David M., Robert A. Ryerson: "Land Use Information for the Great Lakes Basin". Final Report to Technical Committee B, Great Lakes Pollution from Land Use Activities Reference Group, International Joint Commission, 1975.

Ryerson, R and D.Gierman: "Land Use Mapping in the Great Lakes Basin". Report on the Canadian Sector of Task Bl. Prepared for the Great Lakes Pollution from Land Use Activities Reference Group, International Joint Commission, Windsor, 1974.

Ryerson, Robert A., David M. Gierman: "A Remote Sensing Compatible Land Use Activity Classification". Technical Note 75-1, May 1975, Canada Centre for Remote Sensing, Energy Mines and Resources Canada.

Tarnocai, C and Thie, J., 1974: "Remote Sensing and Permafrost", Workshop/ Symposium on Permafrost Hydrology and Geophysics, February 1974, Calgary, Alberta.

Tarnocai, C. and Thie, J., 1974: "Permafrost and Remote Sensing", Second Canadian Symposium on Remote Sensing", Guelph, Ontario.

Thie, J., Tarnocai, C., Mills, G.E. and Krestof, S.J., 1974: "A rapid Resource Inventory for Canada's North by Means of Satellite and Airborne Remote Sensing". Second Canadian Symposium on Remote Sensing, Guelph, Ontario.

Thie, J., 1974: "Remote Sensing for Northern Inventories and Environmental Monitoring" in Proceedings of Technical Workshop to Develope and Integrate Approach to Base Data Inventories for Canada's Northlands, pp. 81-97. April 17-19, Toronto, Ontario.

Thie, J., 1974: "Distribution and Thawing of Permafrost in the Southern Part of Discontinuous Permafrost Zone in Manitoba", ARTIC Journal, Arctic Inst. of North America, Vol. 27, No. 3, September 1974, pp. 189-200.

Thie, J and Wachmann, C., 1974: "Remote Sensing for Environmental Monitoring and Impact Assesment", Symposium on Remote Sensing and Photo-interpretation, International Society for Photogrammetry Bannff, Alberta.

Thie, J. 1975: "Remote Sensing Application for Land Resource Inventories", in proc. of a workshop on Canadian Forest Inv. methods, CIF - U of T. June 1975, Dorset, Ontario. University of Toronto Press. pp. 62-71

REPORTS OF SPECIALTY CENTRES

7.5 Report of the Canada Centre for Inland Waters

7.5.1 Introduction

The Canada Centre for Inland Waters is a designated Specialty Centre for the remote sensing of water resources. In addition to applied studies, the Remote Sensing Section performed fundamental research in such areas as pattern recognition studies utilizing satellite and airborne data, the optical properties of lake water, and the application of remote spectral measurements to water-quality definition.

Many CCIW programs, such as satellite studies and lake optics, are continuing programs which attempt to utilize remotely-sensed data as a means of evaluating lake behaviour in terms of both long- and short-term processes. New projects are initiated as the applications of remotely-sensed data emerge or as deemed appropriate through management priorities.

7.5.2 LANDSAT-1 Program

The Canada Centre for Inland Waters has been actively involved in the analysis of satellite data since the launch of ERTS-1 (renamed LANDSAT-1) in 1972. Computer techniques have been established for the handling and processing of computer-compatible tapes supplied both by the Canada Centre for Remote Sensing in Ottawa and the EROS Data Centre in Sioux Falls. Much of the satellite activity has been discussed in previous CCIW Specialty Centre reports and several publications discussing the scientific content of satellite data collected over the Great Lakes are now in the literature (see Appendix II). The data from LANDSATS-1 and -2 comprise the major research effort of the Remote Sensing Section at CCIW and applications of the synoptic reviews supplied by such space stations have been both scientifically stimulating and satisfying from a resource management standpoint.

7.5.3 Lake Optics Program

The CCIW program on lake optics continued in 1975. Extensive optical measurements were performed by ship cruises on Lakes Erie and Ontario. These measurements included beam transmittance, upwelling and downwelling irradiance and colour indices. These parameters have provided important information on lake circulation, water mass identification, turbidity characteristics, and biomass concentrations.

One of the major aims of the "in situ" optical program is to assist in the realistic appraisal and interpretation of comparable optical data collected remotely above the water surface. The results from the lake optics studies have also appeared in the current literature (Appendix II).

7.5.4. Airborne Program

The CCIW airborne program was considerably de-emphasized in 1975. However, valuable data was collected by CCRS overflights of the Niagara River Peninsula, Big Creek drainage basin, and reaches of the shoreline of Lake Ontario. Overflights were also initiated by CCIW and included as test sites are the Niagara River plume and the Douglas Point and Nanticoke generating stations. Reports on these studies will soon be forthcoming.

7.5.5. Technical Developments

The Remote Sensing Section has maintained a close interest in the field of data retransmission and has participated in the "GOES" and "LANDSAT" satellite programs.

It has also participated, along with contracts issued to W.R. McNeil and Associates and York University, in the collection and evaluation of data from a four-channel photometer which was extensively flown over Lakes Erie and Ontario during the summer and autumn months of 1975. This work is rapidly nearing completion.

CCIW has also initiated the development of a multi-purpose instrument designed to simultaneously measure "in situ" values of such optical parameters as transmission, volume scattering functions, and volume reflectance as a function of depth and wavelength. It is anticipated that this device will be ready for the 1976 field season.

7.5.6. Applications to Land Drainage Problems

Two southern Ontario basins (Big Otter Creek and Big Creek), which provide inputs into the Lake Erie system, were selected as test-sites to determine the applicability of LANDSAT digital data to hydrologic flow studies. It was demonstrated that infra-red spectral analysis of the apparent radiance data collected over frozen surface areas in winter months (conditions of minimal surface run-offs) allows a delineation of the groundwater discharge and recharge areas in direct agreement with ground observations requiring several years to obtain. Similar classifications have been shown to be feasible during summer months despite extensive vegetative canopies.

7.5.7. Conclusions and Forecasts

It is the expressed hope of the Remote Sensing Section at CCIW that the field of remote sensing, especially with regard to the study of water, will be directed towards much more fundamental studies of the scientific aspects of the remote sensing of natural resources. This suggests a much stronger emphasis on the interpretation of already collected data (e.g. satellite), although not necessarily at the expense of collecting new information.

Despite the fact that the Remote Sensing Section is delighted at the response to and acceptance of remote sensing techniques by other members of the CCIW scientific community (and to a lesser extent by the limnological community in general), it still must sadly note that the interpretative skills of the users are still painfully subordinate to their methodology skills. CCIW intends to play an active role in attempting to correct this disparity.

7.5.8. Recommendations

Specialty Centres must assume principal leadership in the interpretation of remotely-sensed data pertinent to their disciplinary expertise. To responsibly execute this leadership, they should possess both interpretative skills and interpretative facilities. While the obtaining of appropriate interpretative skills is the sole responsibility of the Specialty Centre, the obtaining of interpretative facilities might be accelerated by the assistance from the Canada Centre for Remote Sensing. We, therefore, recommend that:

a) CCRS encourage the independent development of remote sensing expertise at the Specialty Centres;

b) CCRS should, where possible, support in whatever manner appears appropriate, the obtaining by Specialty Centres of necessary interpretative facilities such as data analysis and display systems, hardware and software computer packages, and image enhancement devices.

7.5.9. Appendices

7.5.9.1. Appendix I - List of Staff Members

Dr. R.P. Bukata, Head, Remote Sensing Section

Mr. J.E. Bruton

Mr. J.H. Jerome

Mr. H.W. MacPhail

Mr. A.G. Bobba

Mr. W.S. Boham (until September, 1975)

Ms. L. Bhaskar

Appendix II - Remote Sensing Bibliography

Bukata, R.P. and W.D. McColl (1973). The utilization of sun-glint in a study of lake dynamics. Proc. Symp. on Remote Sensing and Water Resources Management, AWRA, p. 351.

Bukata, R.P. and J.E. Bruton (1974). ERTS-1 digital classifications of the water regimes comprising Lake Ontario. Proc. Second Canadian Symposium on Remote Sensing, 2, 627.

Bukata, R.P. and J.E. Bruton (1974). The application of telemetered ERTS data to lakes research. Proc. Second Canadian Symposium on Remote Sensing, 2, 495.

Bukata, R.P., G.P. Harris and J.E. Bruton (1974). The detection of suspended solids and chlorophyll a utilizing digital multispectral ERTS-1 data. Proc. Second Canadian Symposium on Remote Sensing, 2, 551.

Bukata, R.P., W.S. Haras and J.E. Bruton (1974). Space observations of lake coastal processes in Lake Huron and Lake St. Clair. Proc. Second Canadian Symposium on Remote Sensing, 2, 531.

Bukata, R.P., W.S. Haras, J.E. Bruton and J.P. Coakley (1974). Satellite, airborne, and ground-based observations of suspended sediment transport off Point Pelee in Lake Erie. Proc. Conf. on Human Environment, Warsaw, Poland. (In press).

Bukata, R.P., W.S. Haras and J.E. Bruton (1975). The application of ERTS-1 digital data to water transport phenomena in the Point Pelee-Rondeau Area. Verh. Internat. Verein. Limnol., 19, 168.

Bukata, R.P. and J.E. Bruton (1975). LANDSAT-1 observations of nearshore phenomena in the Great Lakes. Submitted for publication.

Bukata, R.P., J.E. Bruton, J.H. Jerome, A.G. Bobba and G.P. Harris (1975). The application of LANDSAT-1 digital data to a study of coastal hydrography. Proc. Third Can. Symp. on Remote Sensing. (In press).

Bukata, R.P., E.B. Bennett and J.E. Bruton (1976). LANDSAT-1 observation of an internal standing wave pattern in Lake Superior. Submitted to 19th Conf. Great Lakes Res.

Bukata, R.P. (1975). Use of ERTS-1 in the observation of nearshore phenomena in the Great Lakes. Invited paper at the 18th Conf. Great Lakes Res.

Bobba, A.G., R.P. Bukata and J.E. Bruton (1976). Application of LANDSAT-1 digital data to groundwater discharge in a lake basin. Submitted to the 19th Conf. Great Lakes Res.

Haras, W.S., R.P. Bukata and K.K. Tsui (1975). Historic records and scientific observations on changes in certain geophysical aspects of the Great Lakes' shorelines. Can. J. Geology. (In press).

Harris, G.P., R.P. Bukata and J.E. Bruton (1975). Satellite observations of physical and biological activity within the Great Lakes. (In press).

Jerome, J.H., R.P. Bukata, J.E. Bruton and E.B. Bennett (1976). Determination of organic and inorganic particle concentrations from simultaneous measurements of the optical transmission and volume reflectance in lake water. Submitted to the 19th Conf. Great Lakes Res.

Jerome, J.H., W.R. McNeil and F.C. Elder (1975). Optical indices for in-situ and remote classification of lakes. Proc. 18th Conf. Great Lakes Res. (In press).

MacPhail, H.W. (1973). Data retransmission via satellite field year 1972. CCIW Internal Report.

McNeil, W.R., K.P.B. Thomson and J.H. Jerome (1975). The application of remote spectral measurements to water quality monitoring. Aerospace Electronics Symposium.

Rao, S.S. and R.P. Bukata (1975). The delineation of a point source plume characterized by anisotropic propagation of bacterial populations. Submitted for publication.

Thomson, K.P.B. and J.H. Jerome (1975). Transmissometer measurements of the Great Lakes. IWD Scientific Series No. 53.

Thomson, K.P.B. and J.H. Jerome (1974). Digital level slicing of IR imagery for thermal plume studies. CCIW Unpublished Manuscript.

Thomson, K.P.B., J.H. Jerome and H.W. MacPhail (1974). A simple colour meter for limnological investigations. IWD Scientific Series No. 49.

Thomson, K.P.B., J.H. Jerome and W.R. McNeil (1974). Optical properties of the Great Lakes. Proc. 17th Conf. Great Lakes Res., IAGLR.

Thomson, K.P.B. and J.H. Jerome (1974). In-situ colour measurements on the Great Lakes. IWD Scientific Series No. 51.

Thomson, K.P.B., S. Ross and H. Howard-Lock (1974). Remote sensing of oil spills. Memoirs of the 1974 CSPG Symposium. (In press).

Watson, N.H.F., K.P.B. Thomson and F.C. Elder (1975). Sub-thermocline biomass concentration detected by transmissometer in Lake Superior. Verh. Internat. Verein. Limnol.

7.6 AEROMAGNETIC REMOTE SENSING AT THE FLIGHT RESEARCH LABORATORY OF THE NATIONAL AERONAUTICAL ESTABLISHMENT

Aeromagnetic system development, both for military and geophysical applications, continues utilizing the NAE North Star aircraft. The general objective of the NAE MAD program over the past year has been to achieve a degree of aircraft interference compensation and other noise suppression such that the ASQ-501 magnetometer can be used to its capability of 0.01 gamma resolution.

Technical developments to date include automatic aircraft interference and gradient interference compensation algorithms for post flight analysis and computer generated software compensation developed for in-flight use. An algorithm has been devised for determining orthoganality and scale factor corrections to the manoeuvre magnetometers used in aircraft interference compensation. Also, an improved total field counter has been developed with a signal that is quieter than the delay line discriminator output and better suited for downstream signal processing. A digital integrated doppler/VLF navigation system enhances positional accuracy for geomagnetic surveys and other tasks. A digital data acquisition and onboard processing system can handle parameters from various sources - aeromagnetic, aircraft, navigation and special project. The technical feasibility of specialized projects such as gravity measurements and retransmission of VLF information via satellite has been demonstrated.

A Convair 580 aircraft is being modified as a replacement for the North Star aeromagnetic research aircraft.

7.7 REPORT OF THE CANADIAN ASSOCIATION OF AERIAL SURVEYORS

7.7 Airborne Remote Sensing

CAAS member firms flew 23.562 hours of airborne remote sensing in 1975, resulting in the acquisition of 2.326.431 line miles of acceptable data meeting ICAS and GSC specifications. Dr. P.J. Hood (GSC) reports that industry flew 1.132.665 line miles of airborne geophysical data acquisition alone during the year for a total value of $16,500,000 of which $10,500,000 was earned outside of Canada. In excess of one million line miles of airborne single and multi-camera photographic imagery was obtained using most available film-filter and multi-spectral techniques.

7.7.2 Spaceborne Remote Sensing

In practical terms, spaceborne remote sensing met with minimum commercial utilization during the year. Satellite imagery continues to be used in project planning and broad resource interpretation, particularly for forestry, agriculture, geology and land use purposes.

7.7.3 Technical Developments

Commercial airborne data acquisition requires precise navigation and work continued during the year in perfecting the application of a number of airborne electronic systems to the companies' needs. Inertial guidance platforms, Loran C, Toran, Radist, RPS (Motorola) Decca and Doppler were all utilized during the year.

Doppler Satellite Terrain Positioning was utilized on a number of contracts.

Work continued in digital recording, automated processing of data, as well as digitizing imagery for computer controlled mapping systems.

7.7.4 Applications and Benefit Analysis

Commercial survival requires at least full cost recovery so it is self-evident that at least an equal or greater benefit results from industry's activities. Airborne geophysical data recording, processing and evaluation is a principal tool in prospecting for petroleum, minerals, water and geothermal activity. Infra-red scanning and thermal mapping add a new dimension as well as extended applications. Airborne photographic imagery is acquired and interpreted by industry for forestry, agriculture, geology, ecology, soils and land use investigation purposes. A typical example in 1975 is the following:-

The U.N.D.P. had an emergency requirement for a detailed study of the sub Sahara rivers in connection with the compaign to eradicate "river blindness" and to resettle the valley lands. In this connection they needed immediate aerial photography of valleys and regions in Togo, Dahomey, Upper Volta and the Ivory Coast, all of it calling for dual cameras, photo scales varying from 1:75,000 to 1:20,000, with various combinations of film involving panchromatic, infra red, and false colour infra red. The work included photo interpretation and preparation of geomorphological maps, vegetation maps and land capability maps. Total value of the work was in excess of one million dollars.

A member firm was awarded the contract in international competition largely because no other company could come up with the required number of aircraft, survey cameras, and photo interpretation experts at short notice.

This is probably the largest airborne remote sensing contract to be let so far and it is significant that it came to the Canadian air survey industry. The competition was French and British.

7.7.5 User Liaison

During 1975, member firms maintained close contact with resource managers in most concerned federal departments and every province and territory of Canada, as well as resource managers in 108 countries of the world where services have and are being provided by the Canadian aerial survey industry. The nature of most projects, with particular regard to weather and timing, requires the closest possible liaison with users and this is effected at all times.

7.7.6 Training

In house training of employees continues within the individual companies in the operation and applications of new sensors. Unfortunately, the bid by the aerial survey industry to become more closely involved in the transfer of CCRS activities to the private sector was negated by government, and the opportunity for industry familiarization with

CCRS operations has to a large extent been lost.

7.7.7 Conclusions and Forecast

It is regretted that the criteria given to a proposal evaluation process has resulted in the alienation of the aerial survey industry and a state of confrontation with CCRS rather than one of cooperation in the commercial application of viable new generation airborne sensors and technology.

It is common knowledge now that the government of Japan has entrusted the exploitation of remote sensing technology to a firm incorporated for the purpose by Japan's five leading aerial survey companies. A similar situation exists in Europe where it is understood that the leading aerial survey firms of five countries are planning to join in a common remote sensing corporation.

Similar support and trust has been denied Canada's aerial survey industry, recognized world-wide as the leader in the field. The aerial survey industry will no doubt survive but will evidently be at a severe disadvantage in international remote sensing competition. At the same time, Canada's very significant investment in remote sensing will be in serious jeopardy against formidable international competition from Japan and Europe.

7.7.8 Recommendations

1. It is recommended that every effort be made to utilize the extensive marketing and operational capabilities of Canada's aerial survey industry in achieving commercial benefit from the country's heavy expenditures in remote sensing research and development.

2. It is recommended that the government put a halt immediately to the use of government owned aircraft and equipment in direct competition with the private sector.

8.1 REMOTE SENSING IN THE NETHERLANDS

R.H.J. Morra
Meetkundige Dienst
Rijkswaterstaat
The Hague
The Netherlands

With pleasure and more than normal interest, our Institute accepted Dr. Morley's invitation to give a presentation on the situation in the Netherlands with regard to remote sensing.

In the summer of 1968, Dr. G.P. de Loor of the Physics Laboratory of the Dutch National Defence Organization drew the attention of our civilian organizations to the capabilities of remote sensing techniques.

This started two types of activities in the same year:

(a) "Rijkswaterstaat", part of the Ministry of Transport and Water Control was the first government organization to be involved; it began by making some practical experiments for a first orientation.

(b) I.T.C. made a proposal to the Minister of Education and Sciences for a study on possible remote sensing applications in the Netherlands.

First, I will review the activities within "Rijkswaterstaat", second, what happened after the I.T.C. proposal, and third, what we expect in the near future. Where relevant, I will include information on organization.

The "Rijkswaterstaat" is mainly a technical-oriented government organization with responsibilities in the following fields:

- Protection of our country against floods;
- Design, construction and maintenance of harbours and waterways, highways, bridges, sluices, tunnels, dikes, dams, etc;
- Traffic safety control on highways and inland waters;
- Management and control of fresh water resources;
- Prevention and reduction of water pollution.

RWS (Rijkswaterstaat) has a yearly budget of approximately $1 billion and employs 12,000 people in 24 divisions. Those divisions are either regional or specialized. The regional divisions are primarily concerned with maintenance and management, while the specialized divisions are involved in the design and construction of bridges and sluices, and give technical and scientific support in these areas.

One of these specialized divisions is the Geodetic Survey Division with 530 employees. It has a photogrammetric section and also takes care of the aerial survey for RWS, by using black-and-white, colour, and false colour photography. Another specialized division is the Data Processing Division with 235 employees. Here the computer facilities of RWS are centralized, with 2 IBM 370/165 computers, and a planned 50% increase in the near future.

The remote sensing activities of RWS are centralized in the Geodetic Survey Division. We are strongly supported operationally by the Data Processing Division and for research by the Physics Section of the Division of Water Management and Water Control, and by the Physics Laboratory of the National Defence Organization.

Although traffic management in the North Sea area does not now exist, we still must prepare ourselves in the technical and operational field in order to be ready if and when it might be decided to introduce traffic management. In the late sixties, when RWS had started the construction of a new entrance to the harbour of Rotterdam for tankers with a tonnage of 250,000 tons and more, we were looking for methods to survey the Dutch part of the continental shelf, connected with oil-pollution, sea-going traffic, swell and waves.

You will not be surprised to hear that we were interested in the possibilities of remote sensing at that time. Thanks to Dr. de Loor, practical experiments were organized in 1969 for a first impression on the usefulness of remote sensing techniques. The Dutch Royal Air Force performed some flights with an IRLS. The British Royal Radar Establishment also flew with an X-band and a Q-band real aperture SLAR, over sea as well as over inland areas. Those experiments showed us that remote sensing techniques are valuable, but not simple at all.

Preparations were begun in the area of hardware, data-processing and interpretation. The activities were organized in 2 project groups. One group was to deal with hardware like platforms, sensors, equipment, registration and processing. The other group was to deal with interpretation and software. The Physics Laboratory of the National Defence Organization and the National Aerospace Laboratory (NLR) are supporting both activities under contract.

A Reconofax was made available by the Dutch Royal Air Force, and an X-band real aperture SLAR with horizontal polarization by the British Royal Radar Establishment. These sensors are flown by the NLR. Recently, an Army LLLTV was added. We are convinced that merely looking at images will not give a better understanding of the underlying physical phenomena, so most remote sensing flights are done in combination with carefully prepared ground and sea truth measurements. The results on both sides are analysed and correlated.

For SLAR the following research projects had been started by early 1975.

- Radar echo on waves;
- Directional spectra of waves;
- Oil detection on water;
- Mapping of inland areas;
- Ice detection and classification;
- Traffic on the North Sea and inland waters;
- A literature study on the influence of vertical polarization on the radar reflection at the sea surface.

The first three projects basically deal with the fundamental principles of the interaction between radar and waves. The detection of oil-pollution, for instance, is actually the detection of areas where the waves are damped by oil.

Not all flights are carried out over Dutch territory. At the invitation of the Institut Français du Pétrol, we participated in 1975 in an experiment on the detection and handling of oil spills in the Bay of Biscay. The results are positive and will be published by I.F.P. this year. Although we do not have ice on inland waters every year, ice detection and classification is of interest to RWS in connection with shipping, ice breaking and runoff from rivers. So we took the opportunity offered to us by the Swedish Space Corporation to participate with SLAR in a Swedish-Finnish ice project in the Bothnian Gulf in 1975, in which many sensors were used. The results will be published by the Swedish Space Corporation. Our report on the SLAR results is available at CCRS.

From our SLAR experiments some interim conclusions can be drawn at the moment:

- The direction of the wave propagation can be observed very well at windforces between 1 and 5 or 6 on the Beaufort scale. At low windforces the waves are not very pronounced, but form regular wave patterns with long wave crests. Capillary waves, modulated by the wind, result in very good image quality. At increasing windspeed the waves become more pronounced with shorter wave crests, and consequently, the wave pattern becomes spiky, resulting in more speculative imagery.

- There is a certain qualitative agreement in wave spectra as derived from SLAR imagery and from sea truth measurements. It is expected that this fact will strongly support the studies on oil detection by SLAR. Oil can be detected by SLAR, but there are still questions left about conditions, limitations and reliability of detection.

- The geometric resolution of the available SLAR is not as good as it could be. We use 8-foot antennae instead of 15-foot because of the limitations of the available aircraft, a Queen Air. Also, instrument development has been cut off by the British Government at this time, causing some limitations in this particular SLAR. For mapping of inland areas, this SLAR is not very useful.

- SLAR imagery has given good results regarding the distribution of ships at sea, but no information can be derived with regard to identification, size and course. Further investigations on those subjects are transferred to the infrared studies.

Our infrared studies started in 1972. The following projects are under study:

- Circulation of watermasses in coastal areas;
- Runoff through large sluices;
- Thermal pollution, caused by industries and power plants;
- Leakage through and under dikes;
- Oil-pollution;
- Density and dynamics of shipping.

As the scale of the temperature differences of the subjects can vary from large to small we modified the Reconofax VI to an absolute scanner. Preliminary conclusions on the interim results of the IR studies can be given:

- The geometric and thermal resolution of the modified Reconofax scanner is adequate for the listed projects.

- The dynamics of circulating watermasses in coastal areas can be studied with the help of sequential flights over the area during a tidal cycle. There is also a probability that the mixing of fresh water with sea water in river mouths can be studied.

- On a somewhat smaller scale than the study of watermasses in coastal areas, the runoff through large sluices deals with the same problems.

- Detection of thermal pollution caused by industries and power-plants is promising, especially in tidal areas where the dynamic characteristics are of importance.

- Studies of leakage under and through dikes are somewhat promising. Stationary leakage, caused by a constant potential difference between water bodies and the adjacent agricultural areas, can be detected very well. However, the phenomena of non-stationary leakage caused by high floods must be understood very well in order to detect small temperature differences at the right moments. Interaction of the temperature variations of the vegetation and the soil obscures the temperature differences to be observed.

- Detection of oil with IR was positive. Final results are not yet available.

- Detection of ship traffic with IR has been carried out to provide information on density and dynamics. The identification problem met with in SLAR studies was considerably less in the IR studies. Because of the temperature differences in the wakes, dynamic characteristics can be derived. The velocity of a ship can be established by making two flights in a small time interval to complete the dynamic information.

Although the main effort up till now has been put on SLAR and IRLS, a modest start has been made with MSS. Based on the results obtained last year it was decided that a detailed sea-truth measurement program must be carried out. This program is now under preparation and will be carried out from a drilling platform. The considerable effort and contribution of Mr. Brunsveld van Hulten of RWS in our investigations and the contribution of Dr. de Loor of the Physics Laboratories should be mentioned here.

This concludes for the moment our discussion on the RWS activities, on which we spend about $400,000 yearly, not including personnel and processing costs.

In the beginning of this presentation I mentioned the NIWARS. This stands for Netherlands Interdepartmental Working Community on Application of Remote Sensing techniques. This organization was set up as a result of the ITC proposal, and its task is to support research on possible applications in the Netherlands during a 5-year period and to report the results to the Cabinet council, and further, to advise in good time about the follow-up to the present remote sensing activities in the Netherlands. It has a Steering Committee formed by representatives of a number of Dutch Ministries: Agriculture, Economic Affairs, Defence, Transport and "Waterstaat", Science, Education, Recreation, Town and Country Planning. Groups of scientists from these Ministries work together supported by some young scientists employed at the NIWARS.

The NIWARS started on a temporary basis in 1971 after 18 months of preparation. It will terminate on January 1, 1977, after having spent about $4 million in 5 years.

The areas of activities covered by the groups are, agriculture, geology, soils, "waterstaat", data processing, and physics. Computer facilities are made available by Rijkswaterstaat. Most projects are of a fundamental nature, e.g. theoretical studies, mathematical models, and ground-based measurements, supported by airborne data. Infrared, multispectral and microwave techniques are involved, with IR and SLAR flights being performed by the NLR, the MSS flights by CNES/GDTA.

The NIWARS has restricted its investigations to applications for which sensors which are available in the Netherlands can be used in a more or less operational way. Techniques in an experimental stage are not being considered.

The geological projects are directed towards mapping of delta areas, e.g. of arable land, grass areas. Soils projects are underway mainly in the areas of hydrology and soil patterns. Vegetation study projects are directed mainly to the classification and detection of diseases in agricultural areas, forests, and natural vegetation in outer-dike areas. Some of those projects are fundamental studies, e.g. radar clutter of vegetation and soils. For some projects, Waterstaat support is given and a study is in process for detection of those parts of roads and highways which have a specific sensitivity for icing conditions.

Data processing software has been developed for geometric correction, mapping, automatic classification, and so on. Together with other institutes like the Physics Laboratory and the Agricultural University and others, physical studies are made related to the reflection and emission coefficients of bare soils and vegetation, thermal behaviour of grasslands, micro-climate factors and so on. Those studies are motivated by the need for quantitative results of remote sensing data obtained with a minimum of ground truth to support the interpretation.

It is not within the scope of this presentation to go into more details about the present results of those studies. The final report of the NIWARS is expected to be published next year.

The Steering Committee of the NIWARS has to recommend to the Council of Ministers what the follow-up should be in the field of remote sensing activities after the NIWARS tasks are fulfilled. An interim report on this subject was prepared last year, consisting of three parts:

(a) Potential applications of remote sensing techniques.

(b) Inventory of needs in the Dutch community.

(c) Proposals for the future.

I can be very short about the potential applications here, as they have been demonstrated all around the world. Based on these facts and on literature searches, a general description is given for management purposes.

The inventory of needs in the Dutch community may be of greater interest to you. I will summarize the information, given by a number of departments.

- The Department of Culture, Recreation and Social Work:

  This Department considers remote sensing of interest in the areas of preservation of the scenery and open air recreation. For protection of the landscape it is necessary to detect changes in a sufficiently detailed manner. Obviously, there is a strong relationship with hydrology, vegetation behaviour, pollution and so on. Also disturbances in sceneries like the influence of roads, rubbish dumps, lowering of ground water levels and so on, although known in general, create a need for more timely information about their influence. Remote sensing is considered as an additional tool to field-work by this department.

- The Department of Agriculture and Fishery:

  In the sectors of agriculture and horticulture information is desired on the amount and distribution of the several types of grown vegetation, on crop prediction, and on the health condition of the vegetation. For forestry, classification is desired, and information on health condition of trees, especially for early detection of diseases, is required.

  Also aspects such as land use, the behaviour of natural areas and the influence of human activities on those areas, hydrology and soils are of interest. Up to now the information has been obtained by conventional methods. The feeling in this department is that remote sensing can be of interest if more and better information can be obtained in a faster and more efficient way.

- The Department of National Housing, Town and Country Planning:

  Two main areas of interest in relation with remote sensing are indicated: inventories of soils, vegetation and land use, and registration of human activities.

  It is evident that information about land use is important for planning purposes. Inventories of soils and vegetation are of interest for studies on the properties and potential of the natural environment. Numbers, density and spreading of traffic on land and water and of people in recreation areas are of interest, as well as urbanization, (especially control and analysis), local climate as part of environmental studies in cities and in the country, and pollution.

This department makes considerable use of data gathered by other departments. It is felt that these data can be obtained better and more cheaply by remote sensing than by conventional methods. This feeling is based on experiences all over the world and on the studies within NIWARS.

- The Department of Transport and Waterstaat:

For many purposes, adequate data acquisition is an absolute requirement for Rijkswaterstaat. At sea and on inland waters, observations are carried out in many ways, using measuring poles, boats, ships, and aircraft applying conventional techniques. Therefore, RWS was very interested in the early remote sensing techniques, especially for observing thermal pollution by power plants and industries, oil- and chemical-pollution, shipping movement at sea and on inland rivers, swell and waves, movement of watermassess in coastal areas, leakages through and under dikes, etc. There are disadvantages to these conventional techniques:

- Measuring poles can only be installed near banks and coasts;
- Measurement from poles and vessels are point measurements. The results have to be extrapolated over relatively large areas;
- Wind, sea state, clouds and dependency on light conditions are considerable limitations;
- Many phenomena to be observed have a dynamic nature and often occur over larger areas.

This summarizes the inventory of needs for the present, made by the Steering Committee of the NIWARS. The proposal for the post-NIWARS period, starting around the end of this year, is based on the state-of-the-art in the world, on the results of the Dutch investigations, and on the inventory of needs in the Netherlands.

The quintessence of this proposal is the implementation of remote sensing techniques in the potential Dutch user community. (These applications should be supported by additional research in physics.) The user community consists, practically speaking, of government institutes and regional authorities. Recommendations are made regarding the organization of the user community and regarding the scientific and technical support required.

It is not very difficult to explain the contemplated organization for this audience. Generally speaking, the proposed organization is more or less analogous to the Canadian framework: an interagency committee for the overall management, the users organized in working groups, the scientific support given by available specialized institutes, like laboratories and universities. The technical support is to be given by the Rijkswaterstaat, being the largest technical organization in our government in which many technical disciplines and facilities are available. This technical support will be the responsibility of the Survey Department in close co-operation with the Data Processing Division. It is also proposed to make an adequate remote sensing aircraft available for multi-purpose use, which will mean an investment of about $8 million.

The interdepartmental Consulting Committee on Science Management has considered this NIWARS proposal to be sensible, but a further evaluation has to be made. For this purpose a small interdepartmental committee has been installed, having the task to evaluate the proposal, to plan the future and to assure the continuity of remote sensing after the NIWARS period.

The first question to be answered is how strong are the needs indicated in the NIWARS report and mentioned earlier in this presentation. Here I am entering our problem areas. I will put this question in other words and make two questions out of one:

- How to convince the Treasury Board to spend money on new projects, knowing that such a Board gives a critical and often a suspicious ear to people asking for money. And to be honest, financial people must have that attitude, especially in the present economic situation which is not very favourable for starting new activities.

- How to convince the potential users that they really need remote sensing. In many cases they are accustomed to conventional methods, overlooking limitations and ineffectiveness. To be honest again: Why should those often busy people tire themselves out looking at not easily accessible and more or less mysterious techniques. When they do look at them they discover that they have to make a great effort to earn the benefits. Who can blame those future users for this attitude? Only those who have problems to solve and who have no alternative methods available will not hesitate in deciding to use remote sensing.

There is another argument often used against the introduction of remote sensing in the Netherlands. Our country is, as you know, small, well cultivated, with a high density of pollution, and well mapped, or in other words, every square inch is known. Some people, therefore, argue that there is no need for remote sensing. Insiders in remote sensing, however, know that this argument is debatable, especially with regard to dynamic phenomena, but how do we convince the outsiders?

I will state that these problems on the financial and users' side are not intrinsically Dutch and not even peculiar to remote sensing. They actually are inherent with progress and with the introduction of new techniques and new tools. It just takes time and often much effort to overcome this stage.

Looking over our problem area, you can see that at a minimum we must continue on the level we are now, that is, a relatively small group of interested people working in an airborne remote sensing program with a Queen Air with all its limitations.

It may perhaps strike some of you that I have not mentioned satellite techniques and observations in our remote sensing activities. But from what I said before about our cultivated, small-sized, well-mapped country, you will understand that satellite observations at the present stage of sensor development are not very useful for us. However, we are interested in this subject and our country takes part in the European satellite activities.

Mr. Chairman, I am now coming to the end of this presentation. I want to thank you very much indeed for your invitation and your hospitality for more than one reason. It is not only the real pleasure I have in visiting your country. I am also happy to have the chance to learn about the way in which your national organization works, your problems and the answers you have found, indications of how to overcome our problems and how to incorporate your experience in the areas of management, applications and technical support of remote sensing.

8.2 FORESTRY INFORMATION SYSTEMS IN CANADA*

A. Bickerstaff**

Introduction

This paper has three objectives: first, to outline the technical and economic goals of forest management; secondly, to sketch the information systems required to achieve those objectives, and finally to conclude with some personal opinions of how well present systems meet requirements and what improvements might be effected.

The level of intensity of forest management obviously influences requirements and systems. However, in Canada, most forest management is controlled directly or indirectly at the provincial level where there is a requirement for information systems that will permit both the planning of current operations and the long-term development of management units ranging in size from several hundred to several thousand square miles, as well as the strategic planning of forestry operations on a regional or global basis. My comments on information systems are, therefore, in provincial contexts, since these encompass a broad spectrum of requirements.

The federal role in forest management, except for the Yukon and Northwest Territories, and a few limited federally-controlled areas elsewhere, is limited mostly to research and development, and in the specific field of forestry information systems to the consolidation on a national basis of data provided by the provinces and to some developmental work in improved information systems.

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**Consulting Forester, R.R.2, Woodlawn, Ontario, KOA 3MO.

INFORMATION REQUIRED FOR TECHNICAL FORESTRY OPERATIONS

Forestry is concerned with the management of forests for man's use. The uses may vary. One of the earliest uses was to provide a suitable habitat for game to be hunted by royal landowners. However, technical forestry had its origins in Europe beginning in the seventeenth century to provide a continuing supply of building material and fuel for an increasingly complex society. This concept of forestry, i.e., the sustained production of wood products, has remained dominant for several hundred years. More recently, there have been increasing social pressures for the management of forests for alternative uses such as recreation, aesthetics, wildlife habitat, watershed control and the management or preservation of wilderness conditions. No matter what the objectives of management are, the acquisition and retrieval of both quantitative and qualitative information on the forest resource is essential.

The information systems discussed herein are primarily oriented to wood production but with minor adaptation they can provide much of the data required for other management objectives.

Forests are dynamic populations where growth and mortality occur amongst a complex of sub-populations defined by species, age and environmental factors. To manage forests to man's best advantage, either for the short term or the long term, quite specific types of information are needed on these sub-populations. For current use, the primary requirements are how much of what species is in which location and what are the technical and economic problems in utilizing it? From the long-term standpoint, additional requirements are how much of what species can various areas produce per year over long periods of time at differing levels of management or investment input. For such long-term planning, a knowledge of age-class distribution and a measure of the productive capacity of the area are essential.

Management units require manipulation of age classes if their productive capacity is to be maintained and utilized most advantageously. A unit which contains all mature timber is comparable to having a high capital investment earning no interest and depreciating in value. Conversely, an area with young, unmerchantable timber is equivalent to an asset having little present capital worth but very high growth potential. From a long-term forestry investment standpoint, the best combination is a gradation of age classes so that there can be a periodic harvest at the point where the average annual growth and marketability of stands is at an optimum.

Forestry information systems must provide the technical and economic data base necessary to achieve these objectives.

GENERAL REQUIREMENTS FOR FORESTRY INFORMATION SYSTEMS

There are three considerations involved: the kind of information required, the level of integration at which it is to be used, and the precision necessary for each type of information.

The kind of information required, regardless of level or reliability, is basically to determine forest conditions, i.e., areas and volumes by species composition, age and size class, merchantability and, for future production, also site quality or growth capacity. Such information must be available in organized, tabular form for at least four levels of integration - the stand (5 to 500 acres), the compartment (1 to 80 square miles), the management unit (50 to 5,000 square miles), and the administrative region comprising a number of management units or an entire province.

The reliability of these estimates is a complex problem depending on the variables or attributes under consideration, and the area involved. The commonly accepted rule-of-thumb is that major variables such as volume for a management unit should have a standard error of 10 per cent or less at the 95 per cent probability level.

To provide such data it is convenient to recognize two phases in information systems, i.e., acquisition and retrieval.

DATA ACQUISITION OR FOREST INVENTORY

All forestry data acquisition in Canada involves sampling procedures. There are basically two sampling systems, one requiring mapping of the forestry conditions previously described, and the other statistical summaries of forest conditions within arbitrarily defined areas. Those involving mapping are by far the most common.

Where mapping is employed, the usual procedure is to delineate on air photographs, areas, called stands, which appear relatively homogeneous with respect to species composition, height, density and sometimes site conditions. Black-and-white panchromatic photography at scales of between 1:10,000 and 1:50,000 with 1:15,840 a favourite is standard but colour is becoming more common. At such scales three to six species groups, 20-foot height classes and 20 per cent crown closure classes can usually be recognized with reasonable accuracy. The main strata mapped are sampled in the field to determine actual species composition, size classes, volumes, age, etc. by stratified random sampling or other unbiased techniques. The preliminary typing is often corrected or refined following the field sampling.

Systems of sampling where mapping is not involved are of two kinds and have some advantages in data manipulation, but lack of maps tends to mitigate against their wide-spread use. One common system involves the interpretation of randomly-selected points on air photographs to provide a percentage distribution of stand conditions mentioned previously for the mapping technique. A proportion of the photo-interpreted points is checked on the ground and measured for volume and photo-interpreted variables. The PI data are then adjusted accordingly.

The second system or continuous forest inventory involving non-mapping procedures requires the establishment of permanent plots on a systematic basis so that the plots are a representative sample of the area in question. Four or five large companies in Canada use this system; it is more common in the United States. The major advantage is that change, i.e., growth and depletion, are derived directly from remeasurement.

DATA RETRIEVAL AND LEVELS OF INTEGRATION

The basic forestry information unit where mapping is employed is the stand, i.e. an area over which the variables involved are more or less homogeneous. Where mapping is not involved, the plot is the basic unit and is usually between 1/10 and 1/5 acre in size, or sometimes of variable size with size related to the conditions sampled.

All stands or plots are usually serially numbered for future referencing. Those having similar characteristics are merged to provide average values for compartments which are the bookkeeping units of forestry. The compartment is usually a township, a map sheet, a watershed or a political subdivision. The selection of this bookkeeping or compilation unit is perhaps the most critical factor governing flexibility in the retrieval of forestry information. Compartment summaries normally indicate areas and volumes by species of the main forest types by age or size classes. They can be combined at higher levels of integration but they cannot readily be subdivided.

When compartment data are merged at the management unit level they provide all quantitative information necessary for current and future operations of the management unit.

Summaries of forestry data at the management unit level are usually the most detailed information provided as public information by provinces. Some provide information only for groups of management units or for the entire province.

Data retrieval and display systems vary widely between provinces, particularly with respect to flexibility in the form of computer printouts at different levels of integration.

THEORY AND PRACTICE

The foregoing has sketched the general concepts common to forestry information systems more or less in the abstract. I would now like to give you my impressions about the real-life situation from two aspects. First, a few general comments on present status and, secondly, some specific examples of weaknesses that might perhaps be eliminated by the application of existing or emerging technologies related to data acquisition or display.

At present, the methodology for data acquisition appears superior to its subsequent retrieval and display.

Within each province data acquisition systems, often at two levels - management and reconnaissance, are fairly well developed and standardized. About one-half of the provinces have their main forest areas covered by a consistent and fairly recent system of survey; all have those areas covered by some system. No two provinces use the same system of sampling or classification. In all provinces, coverage is sketchy or non-existent for the more northerly boreal or sub-arctic areas, and for areas where agriculture is dominant.

Data retrieval systems, while mostly computerized, are in a state of flux. They are somewhat rigid with limited report formats partly because of the non-standardized nature of the input data. Very few systems can present data in graphic or map form on a practical operational basis.

However, to me, the chief limitation of forestry information systems in Canada lies not in the information they produce, but in that which they do not produce.

FORM OR FUNCTION

All information systems are a compromise between what one would like and what one can afford. Forestry systems rely very heavily on aerial photography and other imagery in conjunction with sampling systems designed to minimize field work. Therefore, it is not surprising that there is a strong tendency to produce information that can be readily handled by the system rather than the data really required for management pruposes. This weakness shows up in almost all systems and a few examples may indicate the nature of the problems.

Age

The age of forest stands is the most essential independent variable required to estimate current and future productivity, in terms of volume - the primary dependent variable.

But, age cannot be determined directly from air photographs and it is relatively time-consuming to determine during field sampling. As a result, stand height is often substituted for stand age, with correlations between the two established by very sketchy sampling. This weakness is not evident from a superficial examination of published statistics.

Volume

The design of sampling systems to estimate volume is a statistician's delight and there is no question that the total volume of all species on an area can be determined quite precisely and at reasonable cost. The catch here is that such a figure is of little practical value unless it can be broken down into the various components required for management. The first obvious breakdown is by species groups with the crudest and most common grouping being by hardwoods and softwoods, i.e., trees with broad leaves and trees with needles - not very sophisticated - especially if some species have no market value. But even when volumes are stated by species, the figures may be meaningless from a utilization standpoint. A classic example is the enormous volume of aspen or poplar presented in inventory reports. While this is the most abundant broad-leafed species, only a very small and unknown proportion is economically useable because of high defect or size limitations. This product suitability often cannot be determined from present inventories. "Merchantable" volume further complicates the volume figures since an increase in utilization limits reduces volumes while lowering the limits increases apparent volume.

Economic Supply

The cost of harvesting and transporting wood to a mill governs the economic supply, i.e., it is a function of location. Although the problem is well recognized, no operational system can yet provide more than a crude approximation of supply levels because of the computational and conceptual complexities involved.

Growth or Productive Capacity

Long-term productive capacity, which ultimately governs the amounts that can be harvested, varies greatly both within and between regions. For commercially operable forests, the range is between 5 and 150 cubic feet per acre per year and is usually approximated from the height or volume/age relationships of existing stands. Actually, it is the resultant of two components - the type of trees on the area as determined by forest inventories and by the physical characteristics of the site which are often available from independently-conducted land inventories. The failure to integrate the forest and land data into common forestry information systems greatly limits the operational use of much existing valuable data for management planning and decisions. However, the problem is recognized and considerable developmental work is in progress to improve the situation.

SOME CONCLUSIONS

From the examples I have used to illustrate a few problem areas, one might conclude that Canadian forestry information systems are a horrible mess. However, that is not my conclusion.

At the provincial level, systems now in use have provided generally adequate information for the intensity of forest management being practiced. But with increasing demands upon the forest, management intensity is also increasing rapidly. Management decisions are becoming much more complex because of competing uses for forest areas, and because of the impact of forestry operations on other sectors of the economy or on environmental values. Most provinces are now viewing their forestry information systems in a broader context and either adding other natural resource information to existing systems, or investigating the feasibility of more flexible retrieval systems. This will permit better evaluations of technical and political alternatives for both short- and long-term strategic planning through mathematical modelling and related techniques.

At the federal level, prospects for an adequate national forestry information system are more promising than ever before. This is chiefly because of the standardization of measurement units and definitions by most forestry organizations when they convert to the metric system in the near future. Federal, provincial and industrial specialists in forest inventory and wood measurement who have been working together for several years on metric conversion problems have agreed on technical issues. An initial policy meeting on the rationalization of forestry statistics is scheduled for the near future.

Remote Sensing

At a meeting of remote sensing specialists, I would be remiss if I did not offer a brief, personal and simplistic opinion on possible operational applications to Canadian forestry data acquisition systems.

Most of the forest area in Canada with current or potential economic value has already been covered by at least one forest inventory that provided information at the levels of integration mentioned earlier. For these areas, the chief requirement is more detailed information on stand conditions. Large-scale imagery by specialized sensors, that can discriminate between the quite specific stand or site characteristics required for more intensive management has a high potential. Small-scale or satellite imagery in such areas may be limited to adjusting inventories for gross depletion from cutting operations, fires, insect infestations, etc.

For northern areas not yet covered by regular forest inventories, the proportion of forest is small and usually of little economic value. Here, satellite or other small-scale imagery, combined with limited photo sampling and ground checks, should be adequate for forestry purposes and most biophysical mapping.

For those interested in much more comprehensive reviews, papers from a symposium on "Canadian Forest Inventory Methods" held in June, 1975 are highly recommended. (Can. Inst. For., 1975. Proc. Workshop on Can. Forest Inven. Methods. Univ. Tor. Press. 283 p.). Papers presented at it are listed below.

R.M. Dixon (Keynote Address)
The Changing Objectives of Canadian Forest Inventories.

A. Bickerstaff Forest Resource Appraisal in Canada.

V.G. Smith	An Overview of Canadian Forest Inventory Methods
R. Caesar	Canadian Industrial Forest Inventory Methods - State of the Art.
T. Cunia	Inventory Designs in Europe and the United States.
J. Thie	Remote Sensing Applications for Land Resource Inventories.
A.H. Aldred	Summary of Progress on Implementation of an Inventory Method Based on Large-Scale Aerial Photographs.
C. Kirby	A Basic for Multi-Staged Forest Inventory in the Boreal Forest Region.
A.N. Boissoneau	Use of LANDSAT Imagery to Map Burns and Estimate Timber Damage.
A.P. Jano	Timber Volume Estimate with LANDSAT-1 Imagery.
J. Thie *et al*.	The Canada Land Inventory, its Status and Uses.
D. Euler	Inventory of Wildlife Habitat.
E.M. Cressman	Inventory for Extensive Recreation Management.
R.H. Swanson	Inventory for Watershed Management.
B.B. Delaney	The Management Inventory for Newfoundland.
F.J. Hutcheson	The Application of Digital Computers to Forest Inventory in Newfoundland.
B. Payandeh and T.L. Tucker	Application of Subjective Probability and Weibull Distribution in Evaluating Cost Effectiveness of Regeneration Techniques.
D.A. MacLeod and L.C. Newman	The Use of Time Series Analysis in Simulation.
B.B. Eav and T. Cunia	Reliability of Regression Estimates: A Simulation Study.
T.W. Hartranft	"3P" Sampling and the "STX" System.
V.G. Zsilinszky and S. Palabekiroglu	Volume Estimates of Deciduous Forests by Large-Scale Photo Sampling.
G.M. Bonnor	Field Sample Plots: A Review of Types and Applications.
F. Hegyi	Growth Modelling in an Operational Planning Context.
K.J. Mitchell	Stand Description and Growth Simulation from Low-Level Stereo Photos of Tree Crowns.
J.V. Stewart	Economics and the Physical Stock of Timber in Canada.
G. Kondor	Reconciling Inventory Growing Stock and Mill Receipts.
J.A. Mervart	Timber Utilization Standards, Forest Inventory and Operational Cruises.
B.M. Smith	Metric Conversion.

9.0 REPORT OF THE ACTION TAKEN ON THE 1974 RECOMMENDATIONS OF CACRS

9.1. Introduction

This section relates some of the decisions and actions taken during 1975 as a result of the recommendations contained in the 1974 report of the Canadian Advisory Committee on Remote Sensing. Numbers in brackets refer to the reference numbers in the 1974 report.

9.2. Matters Considered by IACRS

9.2.1 A report on the implications of cost-recovery charges in the airborne program was requested by IACRS, prepared by a sub-committee chaired by Dr. Jaan Kruus, and subsequently approved by IACRS. (3.2.3.)

9.2.2. Support for additional funding to be provided to CCRS is under continuous action by IACRS and some success has been realized. (3.2.4.)

9.3. Airborne Remote Sensing

9.3.1. CCRS airborne operations staff have avoided reserving overly large volumes of airspace and no conflicts with provincial missions were reported in 1975. (3.4.3.)

9.3.2. CCRS pilots have kept the regional centres informed of their flight plans before and after each flight. (3.4.4.)

9.3.3. Invoices for airborne sensing projects and products have been mailed to the user within the same fiscal year as the project unless the project was flown in the final month of the fiscal year, as delays of up to 30 days must be expected. (3.4.5.)

9.3.4. Technical and administrative problems are such that CCRS cannot consider the use of commercial aircraft in regular airline service for daily monitoring. (3.4.6.)

9.3.5. CCRS agrees that priority be given to the development of SLAR, scanning microwave radiometer and an airborne MSS, and is seeking funding for these developments. (3.4.8)

9.3.6. The Applications Division is conducting experiments, in cooperation with users, with the scatterometer, and plans are in hand for renting a SLAR to obtain experimental data (3.4.9.)

9.3.7. While budgeting restrictions at present do not allow the installation of a retro-launcher or "chute" for deploying air-droppable sensors, space for such a device has been preserved in the Convair 580 modification plan. (3.4.10)

9.3.8. The Airborne Program Handbook has been revised and reissued along with a French translation. (3.4.20.)

9.3.9. The provincial centres are now being provided with original negatives of aerial photographs of their regions, and may therefore prepare index maps that meet their requirements. (3.4.23.)

9.3.10. Standardization of image quality for aerial photographs is being undertaken by experts from CCRS, NAPL, and ICAS. When completed, the standards will be widely distributed. (3.4.25., 3.7.18.)

9.3.11. It is hoped that the National Air Photo Library, in cooperation with provincial governments and private industry, will compile information on all aerial photography done in Canada. Index maps for remote sensing scenes are, of course, available now, and outline the following operational parameters: area, track, film roll number, frame numbers, scale, date flown, sensor, lens, filter, format, film type, altitude flown. These indexes are available in mapsheet or microfiche form at NAPL, CCRS, and some provincial centres, and may be purchased from NAPL. Indexes are not produced for a roll of film unless the quality is good. (3.5.17., 3.5.18.)

9.3.12. Techniques for setting film exposure to solar radiation measured for each spectral band are being employed on a quasi-operational basis. (3.5.1.)

9.3.13. Provincial centres are automatically notified of all airborne remote sensing projects in their regions. (3.5.2.)

9.3.14. CCRS is in favour of establishing an airborne detachment in the Pacific Coast region, but funding is not at present available. With support from the Marine Sciences Division, DOE, further attempts to obtain funding will be made. (3.5.3.)

9.3.15. CCPS is working with the LRPA Office to try to provide for civilian remote sensing missions using the LRPA. (3.5.9.)

9.3.16. Any agency may request the use of true-colour film rather than panchromatic at its own prerogative. (3.7.9.)

9.4. Spaceborne Remote Sensing

9.4.1. CCRS is providing support for a vigorous microwave program and is actively pursuing studies for a Canadian microwave satellite. A submission to Cabinet is now in the final stages of preparation. A detailed evaluation has been made of the costs and benefits of aircraft, balloons, drones, rockets, and spacecraft as part of the overall studies. (3.3.8., 3.3.9., 3.5.8., 3.7.10., 3.7.11.)

9.4.2. The problems created by the "blind spot" at Prince Albert have been removed by the installation of a small second antenna. (3.4.11.)

9.4.3. Continual efforts are being made to improve the production of consistent and timely LANDSAT data. Recently work has been done on the electron-beam recorder vacuum systems, focussing, and density control. The colour system has been changed to provide consistency over time periods, and work is under way to improve geometric stability and colour registration. (3.4.21.)

9.4.4. Undodged radiometrically corrected LANDSAT imagery is now available on request. (3.4.22.)

9.4.5. The NAPL-RC is now as dust-free as is possible without further heavy expenditures. (3.4.24.)

9.4.6. The Multiple Image Processing System (MIPS) being developed for installation at Prince Albert in 1977 will provide S-band and earth rotation correction, as well as radiometric correction, for VHRR data. (3.4.26.)

9.4.7. CCRS is continuing its commitment to the LANDSAT data collection platform program, and is prepared to support its expansion if a user proposal is made. (3.4.27.)

9.4.8. The feasibility of a national data processing and communications system is being explored, and facsimile transmissions from Prince Albert are available and can be expanded for operational use. Consideration is also being given to the use of a future Canadian UHF satellite for relaying satellite data. (3.4.28.)

9.4.9. A new Canadian receiving station is being installed at Shoe Cove, Newfoundland, in 1976, and will provide regular coverage of the east coast and off-shore areas. (3.5.5.)

9.4.10. There is continual liaison between Canada and the U.S. on the SEASAT program and plans are being made to read out SEASAT data at Shoe Cove. Further Canadian participation in the SEASAT program is, however, subject to a U.S. decision to permit international participation. (3.5.6., 3.7.12.)

9.4.11. LANDSAT mosaics in an NTS format have now been completed for all of Canada at 1:1,000,000. (3.5.10.)

9.4.12 CCRS is endeavouring to expand the World Bank catalogue of "best" LANDSAT images to cover all of Canada. (3.7.15.)

9.5. Technical Developments

9.5.1. CCRS is working towards the development of a low-cost ($50,000.) digital analysis system. (3.3.6.)

9.5.2. CCRS is maintaining awareness of technical developments particularly in the areas recommended by the 1974 CACRS meeting. The Data Processing Division is keeping a watching brief on global positioning systems and satellite data-relay systems; the Sensor Section is responsible for pyroelectric vidicon and linear and two-dimensional optical arrays; and the GEOLE navigation satellite system is being investigated by the Data Processing Division. (3.4.7.)

9.5.3. A Reflectance Spectroscopy Subcommittee of the Sensor Working Group has been formed, and it has prepared a comprehensive bibliography in the area of the non-photographic spectral reflectances and emittances of rocks, soils and other materials. (3.4.31.)

9.5.4. The requirements for oceanographic measurements for which new sensor development is required have been noted but no methods are presently available for such development. (3.4.32.)

9.5.5. Work is under way to develop a geometric corrector which will allow temporal registration of LANDSAT images. CCT's with adequate correction will be available on request in late 1977. (3.5.4.)

9.5.6. Bridge funding through DSS can be made available for sensor development projects if user departments will provide funding for the project beyond its initial development. CCRS is also continuing inhouse sensor development and is attempting to obtain funds to undertake a major program in the microwave area. (3.6.1., 3.6.2., 3.7.13., 3.7.16.)

9.6. Applications

9.6.1. CCRS staff have attended POLEX

meetings and have kept abreast of developments. (3.2.1.)

9.6.2. CCRS agrees that the emphasis of the national remote sensing program should change from experimental to operational remote sensing systems, and asks for the full support of user agencies in doing so. (3.3.1.)

9.6.3. CCRS has been involved in the Canadian Crop Information Experiment study with the Department of Agriculture and a report to IACRS has been prepared by the Chairman of this multi-disciplinary study group. (3.3.5.)

9.6.4. Canada is supporting an international open-sky policy with regard to remote sensing by satellites, and is actively involved in remote sensing projects around the world through CIDA and IDRC. (3.3.11., 3.3.12.)

9.6.5. CCRS is sponsoring research into the development of accurate soil-moisture measurement systems, and the Geological Survey of Canada is starting a comprehensive program to measure the electrical properties of soils. (3.5.7.)

9.6.6. Although CCRS is placing highest priority on applications projects in the areas of ice reconnaissance, ocean management, and agriculture, the need for adequate priority on applications projects in the area of land, forest, and wildlife managment is recognized and followed in practice. (3.7.7.)

9.6.7. To aid in long-term planning, CCRS is preparing a five-year plan for activities and the Applications Division tries to work as closely as possible with user agencies to plan coherent applications programs in their areas of need. (3.7.8.)

9.6.8. The facilities of the CCRS airborne program are available for the development of effective remote sensing systems for forest-fire mapping services, in co-operation with the responsible agencies. It must be pointed out, however, that once these systems are developed to the operational point, they become the responsibility of the operating agency which would normally be expected to pay commercially competitive rates to the industrial participant in the airborne program. (3.4.29.)

9.7. User Liaison

9.7.1. CCRS has established a system whereby one staff member is identified as the specific contact point for each of the working groups, specialty groups, and provincial centres. (3.3.2., 3.4.17., 3.4.19.)

9.7.2. CCRS intends to provide a marketing and user services section to cover both airborne and satellite remote sensing. It is also recognized, however, that marketing is a prime function of the industrial components of the Canadian remote sensing program. (3.3.4., 3.4.13.)

9.7.3. The CCRS analysis equipment such as the Image-100 is freely available to users on request. There is at present no charge for such use. When cost-recovery is implemented for the use of interpretation equipment, consideration will be given to subsidizing the cost of research projects. (3.3.7., 3.4.12.)

9.7.4. CCRS has now begun a policy of informing the members of CACRS prior to the CACRS meeting of what action was taken on the recommendations of the previous CACRS meeting. (3.4.14., 3.7.3., 3.7.6.)

9.7.5. CCRS has compiled and circulated a list of the secretaries of all the working groups and is prepared to circulate minutes of working group meetings to interested parties on request. (3.4.16.)

9.7.6. The CCRS Newsletter is now published on a quarterly basis and sent to the entire CCRS mailing list (approximately 4000 names). Articles by provincial centres, specialty groups or working groups are welcomed and published when submitted. Information is provided on new programs and international development when possible. User feedback on the content of the newsletter is always welcome. Please forward any contributions or comments to Dr. Keith Thomson, 717 Belfast Road, Ottawa, K1A OY7. (3.5.13., 3.5.14., 3.5.15.)

9.7.7. Due to costs of printing and reproduction, CCRS regrets that it cannot undertake the responsibility of supplying provincial centres with reference texts and technical articles which are of reprint quality, but it is prepared to photocopy articles on request . (3.6.4.)

9.8. Training

9.8.1. Although CCRS cannot undertake the full responsibility for providing training in the field of remote sensing, the Applications Division has started work on three applications handbooks. The Peru project which is funded by CIDA will include the development of a comprehensive course syllabus. (3.3.3.)

9.8.2. When manpower is available, the Applications Division hopes to compile and publish comprehensive case histories on the applications of remote sensing in many fields. It is also felt, however, that is the responsibility of principal investigators to provide written reports on projects, whether successful or not. (3.4.15.)

9.8.3. CCRS feels that the provision of further comprehensive training courses such as the one offered in Hull in 1972 is in the mandate of the provincial centres. CCRS is, however, glad to provide technical and scientific support to any training undertaken by provincial agencies and universities. News regarding remote sensing training courses and workshops in North America is published regularly in the CCRS Newsletter. (3.4.30.)

9.8.4. Until interpretive equipment, methods and skills are more widely available throughout Canada, CCRS is playing a leading role in training in methods of automatic analysis, and is encouraging the wider use of computer-compatible tape analysis of satellite data. (3.5.11., 3.5.20.)

9.8.5. CCRS is preparing a glossary of remote-sensing terms, and a French version is also being prepared in co-operation with l'Association québecoise de télédétection. (3.5.19.)

10.0 PARTICIPANTS IN CACRS MEETING MARCH 29 - APRIL 1, 1976

M. Hervé Audet
Provincial Representative
of Québec

Dr. Denes Bajzak
for Provincial Representative
of Newfoundland

Mr. Ralph C. Baker
Chief
Data Acquisition Division
CCRS

Mr. William G. Best
Provincial Representative
of Manitoba

Mr. Robert Borbridge
Integrated Satellite Information
Systems Ltd. (ISIS)

Mr. Cal D Bricker
Provincial Representative
of Alberta

Dr. Ira C. Brown
Chairman
W.G. on Hydrology

Dr. Robert Bukata
Chairman
W.G. on Limnology

Mr. Brian Bullock
Intera Environmental Consultants Ltd.

Mr. Trevor Butlin
Data Processing Division
CCRS

Mr. A.A. Buys
for Chairman
W.G. on Forestry, Wildlife and Wildlands

Mr. Ralph O. Chipman
Outer Space Affairs Division
United Nations

Dr. Donald J. Clough
Consultant to CCRS

Mr. T. Colahan
Innotech Aviation Ltd.

Mr. Des M. Curley
Administrative Officer
CCRS

Dr. J. Neil de Villiers
Data Acquisition Division
CCRS

Ms. Betty Fleming
for Chairman
W.G. on Cartography and Photogrammetry

Mr. E.A. Godby
Associate Director-General
CCRS

Dr. David G. Goodenough
Applications Division
CCRS

Dr. James R. Gower
Chairman
W.G. on Oceanography

Mr. Keith Greenaway
Dept. of Indian and Northern Affairs

Dr. Allan F. Gregory
Chairman
W.G. on Geoscience

Mr. Douglas Hardwick
National Research Council

Mr. Jean-Claude Henein
Chief
Program Planning and Evaluation Unit
CCRS

Mr. Bernard A. Hodson
Data Processing Division
CCRS

Dr. Philip A. Howarth
for Chairman
W.G. on Geography

Dr. Jaan Kruus
DOE Co-ordinator
for Remote Sensing

Dr. Philip A. Lapp
Chairman
W.G. on Sensors

Ms. Frances Macdonnell
Personnel Administrator
CCRS

Dr. Alec R. Mack
Chairman
W.G. on Agriculture

Mr. Don McKinnon
Dept. of National Defence

Mr. Ernest J. McLaren
Data Acquisition Division
CCRS

Mr. Don McLarty
President
Canadian Association of Aerial Surveyors

Dr. Archie K. McQuillan
Program Planning and Evaluation Unit
CCRS

Dr. L.W. Morley
Director-General
CCRS

Mr. R.H.J. Morra
Rijkswaterstaat
The Netherlands

Mr. Graeme Morrissey
Chairman
W.G. on Atmospheric Sciences

Ms. Margaret Murphy
Secretary
CCRS

Mr. George Nitschky
for Chairman
W.G. on Photo Reproduction

Dr. Edryd Shaw
Chief
Data Processing Division
CCRS

Mr. Burtt Smith
Provincial Representative
of New Brunswick

Mr. Jean Thie
Canada Lands Directorate
DOE

Dr. Keith P.B. Thomson
Applications Division
CCRS

Mr. John McG. Wightman
Forest Management Institute
DOE

Mr. Victor Zsilinszky
Provincial Representative
of Ontario

11.0 TABLE OF ACRONYMS USED IN THIS REPORT

ADAS	Airborne Data Acquisition System
AES	Atmospheric Environment Service, DOE
AIDJEX	Arctic Ice Dynamics Joint Experiment (U.S. - Canada)
ANIK	Canadian communication satellite
AQT	Association québecoise de télédétection
BIO	Bedford Institute of Oceanography (DOE)
CAAS	Canadian Association of Aerial Surveyors
CACRS	The Canadian Advisory Committee on Remote Sensing
CASD	Computing and Applied Statistics Directorate (DOE)
CASI	Canadian Aeronautics and Space Institute
CCIW	Canada Centre for Inland Waters
CCRS	Canada Centre for Remote Sensing
CCT	Computer Compatible Tape
CDA	Canada Department of Agriculture
CFASU	Canadian Forces Airborne Sensing Unit
CFS	Canadian Forestry Service
CGIS	Canadian Geographic Information System
CIDA	Canadian International Development Agency
CIF	Canadian Institute of Forestry
CIMM	Canadian Institute of Mining and Metallurgy
CNES	Centre national d'études spatiales
CRC	Communications Research Centre, Departments of Communications
CRESS	Centre for Research in Experimental Space Science (York University)
CRT	Cathode Ray Tube
CSFR	Colour Strip Film Recorder
DCP	Data Collection Platform (LANDSAT)
DICS	Digital Image Correction System
DINA	Dept. of Indian and Northern Affairs
DND	Department of National Defence
DOC	Dept. of Communications
DOE	Dept. of the Environment
DRB	Defense Research Board
DRE	Defense Research Establishment (DND)
DSS	Depart. of Supply and Services
EBR	Electron Beam Recorder
EDC	Eros Data Centre (US)
EMR	Dept. of Energy, Mines & Resources
EOS	Earth Observing Satellite (proposed - U.S.)
EROS	Earth Resources Observation Systems (U.S.); prior to 1969 s.satellite
ERTS	Earth Resources Technology Satellite (U.S.) (Name changed to LANDSAT January, 1975)
ESSA	Environmental Science Services Administration (U.S.)
FAO	Food and Agriculture Organization (UN)
FAX	Facsimile
FMI	Forest Management Institute (DOE)
GCP	Ground Control Point
GRAMS	Ground Reproduction and Monitoring System (CCRS)
GSC	Geological Survey of Canada
HCMM	Heat Capacity Mapping Mission (Proposed Satellite - U.S.)
HF	High Frequency
IACRS	Interagency Committee on Remote Sensing
ICAS	Interdepartmental Committee on Aerial Surveys
IDRC	International Development Research Centre
IISS	Image Inventory Search and Summary
IMAGE-100	Interactive Multispectral Image Analysis System (CCRS)
INS	Inertial Navigation System
IRLS	Infrared Line Scanner
ISIS	Integrated Satellite Imaging Systems Ltd.
ITC	Department of Industry, Trade and Commerce
IWD	Inland Waters Directorate, DOE

JSC	Johnson Space Center, NASA (U.S.)
LACIE	Large Area Crop Inventory Experiment (U.S.)
LANDSAT	U.S. Remote-Sensing Satellites (fomerly ERTS)
LARS	Laboratory for Applied Remote-Sensing (Purdue University, Indiana, U.S.)
LBR	Laser Beam Recorder
LLLTV	Low Light Level TV
LRPA	Long-range patrol aircraft (DND)
MAD	Bendix Multispectral Analyzer Display
MADCON	Software for digital processing with MAD
MADUSE	Former name for MADUSE
MICA	Modular Interactive Classification Analyser software for digital processing
MIPS	Multi Image Processing System
MOSST	Ministry of State for Science and Technology
MREM	Ministry of Resources and Environmental Management (Manitoba)
MSD	Marine Sciences Directorate, DOE
MSS	Multispectral scanner on LANDSAT
MTC	Ministry of Transportation and Communications (Ontario)
MTF	Modulation Transfer Function
MUX	Multiplexer
NAPL(RC)	National Air Photo Library (Reproduction Centre)
NASA	National Aeronautics and Space Administration (U.S.)
NIMBUS	Weather and Earth Atmosphere Satellites (U.S.)
NOAA	National Oceanographic and Atmospheric Administration (U.S.). Also, a series of environmental satellites operated for that administration
NRC	National Research Council
NTS	National Topographic System (mapping)
OARS	Ontario Association for Remote Sensing
OAS	Ocean and Aquatic Sciences (DOE)
OCRS	Ontario Centre for Remote Sensing
PASS	Prince Albert Satellite Station
PERGS	Portable Earth Resources Ground Station (Shoe Cove, NFLD)
POLEX	An international polar experiment of the Global Atmospheric Research Project
PRT	Precision Radiation Thermometer
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
SCMR	Surface Composition Mappling Radiometer on NIMBUS (U.S.)
SEASAT	Ocean parameter observing satellite (U.S.)
SLAR	Side-Looking Airborne Radar
SMD	Scanning Microdensitometer
SMS	Small Meteorological Satellite (U.S.)
SRC	Saskatchewan Research Council
TIS	Technical Information Service (CCRS)
TSS	Time-Sharing System
UHF	Ultra-High Frequency
UTIAS	University of Toronto Institute for Aerospace Studies
VHRR	Very High Resolution Radiometer (AES instrument)
VLF	Very Low Frequency
WMO	World Meteorological Organization

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