THE CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING

1976 REPORT

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

Dear Dr. Keys:

The sixth meeting of CACRS was able to devote more time to discussions than was the case in previous meetings, because the formal reports were written and circulated to the membership ahead of time.

I wish particularly to refer you to sections 3.6 to 3.9 which are the reports of the four workshops: Oceans, Water, Land and Vegetation. They dealt mainly with the much-debated draft CCRS three-year plan. The groups concerned themselves largely with anticipated quality, quantity and usefulness of the expected output of the plan.

The Oceans Workshop predictably pushed for more support for microwave systems over the oceans. Not having had much data previously, they are data hungry. Users in the other three workshops, having enjoyed a wealth of Landsat and airborne data for the previous four years, were naturally pre-occupied with the problem of how to transfer the successful results of experiments into operational systems. It is perhaps worth repeating here the main recommendation of the Water Workshop:

> "Considering that it may take an extended period from the proof of concept stage to an operational information system, it is recommended that a concerted effort be made to provide resources on a continuing basis to support projects designed to bridge this period. It is further recommended that it be accepted in principle that CCRS play a strong lead role in initiating, guiding and assuring continuity during the transfer period."

I am stressing this point here because top financial managers tend to become impatient in the matter of technology transfer to users.

"If the technology is so good, why do not the users recognize it and pick up the funding? How long after a successful experiment does the R & D organization have to go on funding the project?" These are the questions constantly being asked. In an attempt to handle this problem, which is at the heart of CCRS management policy, remote sensing specialists have adopted a project hierarchy as follows:

Stages in Technology Transfer Projects

1.	Instrument Development	100% R & D funding
2.	Geophysical Validation and Proof of Concept	100% R & D funding
3.	Pilot Project, Demonstration Project, Economic Validation or Quasi-operational Project	User and R & D funding
4.	Operational Project	No R & D involvement User funded

The difficult stage is number 3 because the requirements are usually more rigorous and the costs begin to escalate rapidly. The principle is similar to that of providing technological aid to developing nations.

We ask for patience, understanding and indulgence on the part of our managers in the difficult problem of technology transfer. The quicker we can get the user to pay, the greater is our success and we can then use our money to go on to the many new projects we are being asked to do and which we like to do, but we must not leave behind us a trail of unexploited technical successes. Canada has seen too many of those!

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 Camada, 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 svstems
  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 g roups as it may deem necessary to carry out this work.

2.0 SUMMARY MINUTES: CANADIAN ADVISORY COMMITTEE ON REMOTE SENSING, ARNPRIOR, ONTARIO, APRIL 4-7, 1977

2.1 INTRODUCTORY SESSION

Dr. L. W. Morley welcomed participants to the annual CACRS meeting, including two representatives from the European Space Agency. He briefly mentioned some of the changes that were taking place, particularly in the airborne and satellite programs.

Mr. Sen Mathur read a proposal to establish a new working group on the engineering applications of remote sensing (see 8.1, Appendix I).

The meeting broke into small groups to prepare the consolidated reports for presentation to the plenary session the following morning.

2.2 CONSOLIDATED REPORTS

Short consolidated reports were presented to the plenary session on behalf of the provinces by Mr. Victor Zsilinszky, the Ocean groups by Dr. Jim Gower, the Water groups by Dr. Ira Brown, the Land groups by Dr. Phil Howarth, the Vegetation groups by Dr. Fred Peet and Dr. Alex Mack, and the Technology groups by Mr. Ralph Baker. The detailed reports had all been circulated in advance.

2.3 CCRS ACTIVITIES AND PLANS

Mr. E. A. Godby, Associate Director-General, CCRS, gave a presentation to the plenary session on the current activities of CCRS, stressing the emphasis on applications support. This was followed by a presentation by Mr. Jean-Claude Henein, Chief, Program Planning and Evaluation Unit, CCRS, on the CCRS three-year plan (77-78 to 79-80) which is presently under consideration by the Treasury Board. Copies of the three-year plan in draft form had previously been circulated.

2.4 POSITION PAPERS

To provide a background for the detailed planning discussions to follow, position papers had been prepared and circulated and were now presented. Dr. Ed Shaw, Chief, Data Processing Division, presented a paper (see 3.2) on Oceans. Dr. Keith Thomson, Head, Applications Development Section, presented a paper (see 3.3) on Water. Dr. Murray Strome, Chief, Applications Division, presented a paper (see 3.4) on Land. Mr. Lee Godby, Associate Director-General, presented a paper (see 3.5) on Vegetation. These papers described the present and proposed activities in remote sensing in Canada in their particular areas.

2.5 WORKSHOP GROUPS

Following the presentation of the position papers, each of which ended with a series of questions and concerns, the conference broke into four workshop groups consisting of specialists in oceans, water, land, and vegetation. The members of these groups spent a total of eleven hours discussing the concerns and priorities as they saw them for the national program within the time period covered by the three-year plan. Some interchange of personnel between groups was made towards the end of this period.

2.6 ESA REPORT

On Wednesday morning, April 6, a presentation was made to the plenary session by Mr. John Plevin, a representative of the European Space Agency, concerning its programs and priorities in the near future.

2.7 TRAINING REPORT

Following the ESA report, Mr. Roy Slaney of the Geological Survey of Canada gave the report of his ad hoc committee which was established by the previous CACRS meeting to investigate the need for a Canadian training centre in remote sensing (see 8.2).

2.8 DISCUSSION OF RECOMMENDATIONS

On the final day of the meeting, the members reconvened in plenary session to discuss the conclusions reached and recommendations made by the individual workshop groups (see 3.6 to 3.9). Some time was also allowed for discussion of the general recommendations by the working groups, provinces, and specialty groups.

2.9 CONCLUSION

Dr. Morley closed the meeting at noon on Thursday, April 7, remarking on the amount that had been accomplished in three days, and looking forward to a successful year ahead.

3.0 POSITION PAPERS, WORKSHOP PAPERS, AND RECOMMENDATIONS

3.1 Introduction

To provide a background for the detailed discussions planned for the workshop groups, position papers had been prepared as follows, raising particular questions:

3.2	Oceans	- Dr. Ed Shaw
3.3.	Water	- Dr. Keith Thomson
3.4	Land	- Dr. Murray Strome
3.5	Vegetation	- Mr. Lee Godby

Subsequently, the chairmen of the four workshop groups prepared reports responding to the questions raised in the position papers and discussing issues and concerns felt important by the members of the workshop groups. These reports are summarized as follows:

3.6	Oceans	- Mr. Keith Greenaway
3.7	Water	- Dr. Jaan Kruus
3.8	Land	- Mr. Cal Bricker
3.9	Vegetation	- Mr. Jean Thie

Section 3.10 provides a consolidation of the recommendations presented in the formal reports of the working groups, specialty groups, and provinces. The detailed recommendations are shown in the individual reports (sections 5.1 to 7.4).

3.2 CCRS Remote Sensing of the Oceans-What Next?

E. Shaw, CCRS

Introduction: Traditionally information concerning the ocean has been gathered by ships and buoys. For surface phenomena aircraft and satellite sensors are able to survey vast areas more quickly but often provide a less quantitative measurement of the ocean parameters. The Canada Centre for Remote Sensing (CCRS) has devoted a substantial amount of its resources to ocean applications, and is commencing a major effort into microwave sensing of the oceans in a collaborative project with other government agencies.

The applications that have been pursued are sea-ice distribution, oil pollution, bathymetry, chlorophyll concentration, and work is in progress on measuring seal populations. The microwave sensors will be applied to fishing vessel surveillance, sea-ice and iceberg distribution, sea surface temperature, waves and surface winds and oil pollution.

Sea-Ice: The Arctic ocean and Labrador sea ice covered for the greater part of the year, posing great difficulties to the exploitation of off-shore oil and gas, and Arctic island mineral resources. Exploration activity has become more urgent as the known Canadian reserves are diminishing and the world price of oil is increasing. Sufficient gas has been found in the Arctic islands to consider a pipeline or liquefied gas tankers for transportation to southern markets. The Gulf of St. Lawrence is ice covered in the winter months making transportation hazardous.

Ice reconnaissance has been performed for many years in Canada using specially equipped aircraft operated for the Atmospheric Environmental Services (AES). Ice charts, produced from these flights, are relayed by radio to shipping. With the launch of ERTS-1 (LANDSAT-1) in 1972, an additional source of ice-information covering large areas in a few minutes of satellite travel became available. Research studies showed that the sea-ice images would be useful for determining ice-extent but not ice-type, if they could be produced and distributed in near real-time to the ice chart forecasters. The quick-look facility at Prince Albert was capable of recording the images on film directly from the satellite, so in 1974, a demonstration project was conducted to use photo-facsimile equipment and various communications links to relay the images to the ice-chart forecasters and directly to ships at sea. Images from the NOAA satellites, which provide more frequent coverage but at lower resolution than the LANDSAT satellites, were also included in the project. The results were encouraging and the service was continued in the following years using better land-lines and facsimile equipment and a greater volume of satellite data. AES has now developed an operational capability for reception and distribution of NOAA imagery and continues to receive LANDSAT imagery.

The present satellite sea-ice imagery is often obscured by cloud-cover and does not show detailed ice conditions, such as rafting and ridging. Side-looking radars can operate through cloud and at night and are expected to become the prime ice-reconnaissance sensor. Major ice experiments are planned in the high Arctic, east coast and Great Lakes with the ERIM X and L-Band radar and the SEASAT-A L-Band radar over the next two years.

An imaging radar should utilize the most appropriate polarization combinations, look angles and frequencies for the mission in mind. A scatterometer is a profiling radar that provides along this profile line a set of returns at different look angles, and the different polarization combinations.

The CCRS airborne scatterometer, which was modified by CRC, profiles the ground track of the aircraft, covering look-angles from 60^{0} ahead of the aircraft to 60^{0} behind, as measured from the vertical. It is dual polarized - it can transmit either a vertical or horizontal polarization and receive both the like and cross polarized returns. It operates at a frequency of 13.3 GHz.

This scatterometer has been used almost exclusively over sea-ice, both in the Arctic (over first-year and multi-year ice), and in the Gulf of St. Lawrence (first-year ice, floating and shore-fast).

The Arctic project was carried out in spring 1975 as part of the Arctic Ice Dynamics Joint Experiment (AIDJEX). Different ice categories could be distinguished with cross-polarized returns for look angles from 5^{0} to 60^{0} (from the vertical). Like polarized returns were greatly inferior, and for the more vertical incidence angles were unable to distinguish different ice categories. APS 94D SLAR data acquired by DND covered some areas several times such that the features in the imagery were at different look angles each time.

The analysis of these data supported the like polarized scatterometer results.

A more recent experiment was carried out in the spring of 1976 in which data were acquired over first-year sea-ice (floating and shore-fast) in the Bay of Chaleur. Analysis of these data showed that it was possible to distinguish between new, young and first-year ice on the basis of spatial detail and backscatter amplitude at the incident angles more appropriate to a satellite-borne radar. In this case, however, it was found that polarization was essentially immaterial.

Further flights of the scatterometer will be carried out, particularly during the SEASAT experiment when it is planned to carry out underflights with both a four channel imaging radar and the scatterometer.

Oil Pollution: Oils not only fluoresce strongly, but exhibit both fluorescent spectral signatures and fluorescent decay times that are characteristic of the oil when stimulated with short wavelength radiation.

CCRS funded initial studies of these techniques at the University of Toronto Institute for Aerospace Studies (UTIAS) in 1970. This led to the construction of a prototype fluorosensor by UTIAS which they successfully tested and demonstrated from the Scarborough Bluffs using boomed "targets" of different oils on the surface of Lake Ontario, over a hundred metres away. Subsequently, the system was brought to CCRS, installed on a DC-3 aircraft and evaluated over controlled oil spills, pulp mill effluents, water pollution and one target of opportunity, the oil spill at the Thousand Islands in July 1976.

This prototype system employed a medium power nitrogen laser emitting very short pulses of ultra-violet light. The receiver, which looked at the surface area stimulated by the laser, detected one channel of the fluorescent return selected by a spectral filter chosen for the mission. The laser power and output divergence were not adequate to allow daylight operation. Although the evaluation flights had to be carried at dusk and at night, a great deal of useful information was obtained, which, together with laboratory studies being carried out by others, indicated not only the worth of such a technique but also the characteristics which should be designed into the next generation system.

In 1975, a contract was awarded to Barringer Research, Limited, for a system that operates under daylight conditions (as well as at night), acquires complete spectral signatures and measures the decay time of the fluorescence in two parts of the spectrum. This should provide information that will not only identify whether the target is or is not oil, but also classify it into one of several broad categories. There is also a sophisticated in-flight data display and recording system. The flight evaluation of the system over oil spills and other targets will commence this year.

As a companion to the development of this new system, CCRS has been funding studies in the Biological Science Division of NRC to compile a comprehensive atlas of the fluorescent properties of oils likely to be found in Canadian waters. They are also investigating the properties of other materials of interest - pulp mill effluents, chlorophyl in vivo, etc. These studies are essential to understand just what can and cannot be distinguished by this technique and so define both its full potential and its limitations.

There is the relevant question: "Why use sophisticated laser techniques rather than more conventional remote sensing techniques?" For oil spills do indeed show up with other techniques. Both CCRS and other agencies have been investigating remote sensing techniques for identifying and tracking oil spills for several years. More conventional techniques such as photography (colour and multiband) image oil spills to varying degrees, sometimes well, sometimes not at all - depending on oil type, sea surface conditions, sun elevation, cloud conditions, etc. More important, photography cannot state that the target is oil, nor can it work at night. Infrared scanning, side-looking radar and imaging microwave radiometers will work in the dark, but are no better than photography. On the other hand, water fluorescences little, oil very strongly and in a manner different to that of other materials. This is why fluorosensing offers such a promising potential, part of which has already been demonstrated in evaluation flights.

For the recent DOT Task Force Report on the Surveillance of Vessel Source Pollution, CCRS provided an in-depth report outlining a development program which would lead to an aircraft equipped with a complement of sensors that provided data suitable for prosecuting offenders in subsequent court actions.

CCRS was appointed as the Canadian delegate to a new NATO Study Group on "Remote Sensing of Oil Pollution of the Seas". Most recently, EPS has asked CCRS to undertake a program to develop and demonstrate techniques to monitor and track oil spills in ice infested waters.

Bathymetry: An important and time-consuming part of every hydrographic survey is the surveying of the intertidal and shallow water subtidal zones along the coasts. In these areas the sounding launch must operate at slow speeds and manoeuvre around subsurface rocks and shoals. Heights of the above surface rocks and depths over the subsurface shoals must be obtained. However, in areas of complicated bottom topography, it is impossible to locate and measure all of these navigation hazards.

Two remote sensing methods for measuring water depth from the air have been under development at CCRS for the past few years in a joint program with DFE. The first is Photo Hydrography, and the second Lidar (or Laser) Hydrography.

Photo Hydrography: Mapping of elevation contours can be made by stereo-compilation of aerial photographs. A similar procedure can be used for charting surface topography of shallow coastal areas provided the attitude and altitude of the camera for each photograph can be determined. Over land, these photo control parameters are indirectly obtained by aerotriangulation of photo identifiable ground points. Over water,this facility does not exist, hence, other methods of determining the photo control parameters with an inertial platform and a radar altimeter.

CCRS has been developing such a system for DFE. The airborne component comprises an RC-10 aerial survey camera, a co-located modified LTN-51 Inertial Navigation System (INS) and a digital data airborne recording system. The ground segment is made up of the computer-controlled analytical plotter at the University of New Brunswick and the PDP-10 computer facility at CCRS.

The depth measurement capability of this system in Canadian waters is expected to range up to 10 meters (depending on water turbidity) with an accuracy of 1 to 2 feet (90% confidence). The depth measurement accuracy and the precision with which the depth data can be positioned on the charts, depends for the most part on the performance of the INS, and the navigation data processing software implemented in the PDP-10 computer. Navigation accuracy objectives consistent with charting and photogrammetric requirements are 10 meters absolute position (90%) and 30 arc seconds in relative attitude (90%) between consecutive photographs. The results of early flight trials (Sudbury, spring/75) of the hardware indicate that these performance objectives are within the capability of the system.

At present, all hardware is operational. CCRS is now concentrating on system software development which should be completed by early summer 1977. Flight trials of (a) the navigation system hardware/software, and (b) the fully integrated system are scheduled for April and September of 1977 respectively.

By 1978, it is expected that CCRS and DFE will embark on pilot projects to evaluate the benefit/cost of this new technique, especially in remote areas in the Arctic. (These are very difficult to chart by conventional methods because of both the remoteness and the short period of time each year during which the waters are ice free.)

Lidar Hydrography: Measuring water depth, using a high power pulsed laser, has a number of advantages over Photo Hydrography. These include a far superior depth penetration capability and the depth measurement is made directly from the time difference between return reflections from the top and bottom of the water surface. Attitude information is only needed to position the data correctly on a chart. A disadvantage is that present laser technology only allows a profile of water depth under the aircraft to be obtained. However, in the future it is expected that laser advances will allow one to construct a scanning system to give depth "images".

CCRS has been developing a profiling system for several years. It grew out of the highly successful fluoresensor development at UTIAS. For, by changing the gas in the laser, it was possible to transmit intense short pulses of green light, that have the least attenuation in sea-water.

This prototype lidar hydrography system was flown many times. It not only proved the concept of making such depth measurements remotely from the air, but culminated last December in producing a profile of the bottom of Kingston harbour, which matched existing charts quite remarkably.

It was however limited to shallow depths and daytime operation by the laser power, and needed a receiver with wider dynamic range to see both the intense surface return, and the very weak bottom return.

A contract, awarded to Optech Limited,

completed a feasibility study on the basis of which CCRS is funding the development of a second generation system, designed to operate during the day and at even higher altitudes, to probe to depths several times that the photo hydrography system, and automatically to record the returns over an exceptionally wide dynamic range.

Initial flights of the new system will commence later in 1977, in conjunction with those of the photo hydrography system. Subsequently, the two systems will be integrated so that the laser system can give the correct depth along the centre line of the photograghs to improve the reduction accuracy of the stereo compilation.

The new lidar hydrography system will also be used to evaluate the problems of a scanning system, and it is expected that the development of such an "imaging" system could follow shortly thereafter.

The application of these systems is not limited to the Canadian Hydrographic Service. It could have application to recreational charting, overseas charting in developing countries, and possibly to military purposes.

Ocean Colour: Chlorophyl *in vivo*, suspended sediments, shoaling, biological activity, nutrients, etc., have different spectral signatures, which change the colour of the ocean. Some inconclusive experiments with an airbone 4 channel photometer have been performed to measure chlorophyl concentrations in the ocean. LANDSAT digital data has been used with some success to measure suspended sediment loads in the Bay of Fundy.

Sea Waves: A small study was undertaken to determine the ability of the ERIM and JPL radars to image waves. The X band images were superior to the L band images in showing wave structure. But there were instances when the waves were not imaged at L band, although the sea wavelengths were higher than twice the radar resolution.

SEASAT Project Experiments

Provided that NASA will permit Canada to participate in SEASAT-A, a number of experiments to determine the effectiveness of satellite microwave data for measuring a variety of cultural and environmental features will be performed over the next two years. They can be summarized as follows:

Human Activities

1. locate and identify all ocean traffic in waters under Canadian jurisdiction or for which Canada has a responsibility;
2. monitor the positions of all floating navigation aids and locate and identify all floating hazards to navigation;
3. detect and monitor selected human activities on ice or land, in selected areas;

Natural Phenomena

4. provide frequent, accurate, timely data on the type and extent of ice coverage in navigable waters;
5. provide frequent, accurate and timely data for the preparation of weather and sea-state reports and forecasts;
6. monitor the growth of siltation in existing or potential ports and water ways;
7. provide high-resolution imagery for preparing and/or correcting maps and charts.

Aircraft radar experiments are planned to start in early 78 and the combined satellite and aircraft experiments should begin in August of 1978. Several government agencies and industrial companies are participating in these experiments. Their results will be accumulated into a report that will recommend to the Canadian Government whether or not to participate in further radar satellite programs.

The sensors that will be used in this project are:

SEASAT-A

Imaging L-Band Radar

The radar will cut a swath 100 Km. wide and yield images with 25 m resolution. It operates at a frequency of 1.35 GHz, which will penetrate all but the heaviest precipitation. The radar provides coverage up to 75^{0} N, but since the data cannot be recorded aboard the satellite, coverage will be restricted to the acquisition range of the four stations shown in Figure 1. Currently it is estimated that some 400 images, each 100 Km. x 100 Km., will be needed to conduct the Canadian experiments. The major applications are in sea-ice distribution and fishing fleet location.

Radar Altimeter

The radar altimeter will provide a very short pulse (3 ns) by which both the distance from the spacecraft to the ocean surface will

be measured (≤±20 cm rms) and the wave height determined from 1 to about 20 m (±1 or 10%, whichever is larger). The instrument, operating at 13.9 GHz, will provide geodetic, topographic, and sea-state measurements along a narrow footprint below the spacecraft (1.6-12 Km.). It is not yet certain whether data from this sensor will be available to Canadian researchers.

The remaining SEASAT-A sensors have wide swath widths and since they are tape-recorded, provide almost complete (95%) world coverage every 36 hours. Although the direct transmission data from these sensors will be received at Shoe Cove, it is not planned to convert the raw data into geophysical units. It is expected that the U.S. NOAA agency will provide processed data to the Canadian experimenters.

Microwave Radiometer

The Scanning Multifrequency Microwave Radiometer (SMMR) will be flown on both SEASAT-A and Nimbus-G. The five frequencies (6.6, 10.69, 18, 22.235, and 37 GHz) or SMMR will permit the instrument to serve as an intermediate to high wind field anemometer (no wind direction) and to measure brightness temperature related to atmospheric corrections for liquid and vapor water, sea-surface temperature and ice fields.

Scatterometer

The SEASAT-A Scatterometer System (SASS) is an active sensor operating at 14.595 GHz and is designed primarily to serve as a low to intermediate wind velocity anemometer measuring roughness related to winds with an accuracy of ±2 m/s or 10% (whichever is larger) and $\pm 20^{0}$ in angle. The swath coverage is about 1000 Km., and the range of wind-field measurement is from about 3 m/s to potentially 25 m/s.

Visible and Infrared Radiometer

The Visible and Infrared Radiometer (VIR) is a modified Scanning Radiometer (SR) flown on the NOAA series of operational satellites. The two channels provide day-and-night coverage of both cloud conditions and major ocean features.

Convair 580

ERIM Radar

This radar provides four channels of imagery, each with a resolution of 3 metres square, and covering the same 6 Km. ground swath. The 4 channels are composed of dual-polarization returns at L-band and X-band. Either horizontal or vertical polarization may be transmitted at L or X band. The present estimate for radar use by the project is 200 hours per year.

In addition to the ERIM radar the aircraft can carry several other sensors, depending on weight and ancillary equipment requirements. It is expected that the scatterometer, aerial camera and IR Scanner can be carried for most missions. It may be possible to also carry the fluorosensor, but aircraft range will likely be decreased.

Discussion

The ocean program at CCRS has been directed at sea-ice, bathymetry and oil pollution with a smaller effort in chlorophyl concentration, suspended sediments and sea-waves.

Sea-Ice

Undoubtedly information on sea-ice is important to Arctic operations of the oil, gas and mineral industries. Large potential benefits have been forecast from the use of remote sensing systems to gather this information. After several seasons of use, the additional use of NOAA and LANDSAT imagery together with the ice-reconnaissance aircraft data to prepare ice-charts has become established by Ice Forecast Central. It is known that a side-looking radar would be a considerable asset to the operational ice-reconnaissance aircraft and plans are underway to obtain this capability. The ERIM radar is being used to assess its ability to determine ice-parameters, and the SEASAT imaging radar will provide the ice-reconnaissance performance from space.

There is still a need to use modern communications technology in these ice-information systems. The MARISAT satellite could now provide a commercial service for wire and facsimile directly to shipping. Both satellite and aircraft data should be promptly relayed over high quality circuits to photo-facsimile equipment on ships. U.S. projects in the Great Lakes have shown that there was a preference for relayed radar images rather than ice-charts by the users of their products.

Bathymetry

The Canadian Hydrographic Service is interested in the bathymetry work and has pledged support in future years. This is an application which should be examined for its future

operational role. What is the projected amount of hydrographic surveying needed over the next 5-10 years? Does the speed of these new surveys make them mandatory for the Arctic? How do costs of the present ship methods and these aircraft methods compare when you include data reduction? Should both stereo-photo and lidar hydrography be followed?

Oil Pollution

In the case of oil pollution, the user agency EPS is prepared to directly fund a development program. It also appears that the latest fluorsensor under development by Barringer may overcome the limitations of its predecessor. The major problem in the battle against oil pollution in the seas is obtaining successful court prosecutions. The major spills are always accounted for without difficulty. It is the small regular spillage that constitutes a bigger problem. Perhaps a lawyer, with relevant experience, should be involved in this project. Until the fluorsensor is accepted by the courts as readily as the police radar this work will not be successful.

Research Studies

The research studies in chlorophyl measurement have shown it to be a difficult problem. The Bay of Fundy sediment load pollutions from LANDSAT data shows more promise and it could be a useful adjunct to a tidal power development.

SEASAT Project

The SEASAT project has a strong involvement with user agencies. It is based on examining the satellite and aircraft radar performance in meeting their stated requirements. These agencies are funding the experiments to measure these performances but remote sensing data will be supplied free of charge.

Stemming from the recent declaration of a 200 mile Canadian fishing limit, and plans for vessel traffic management there is a strong interest in fishing vessel location. Even, if this is a feasible technique, it is necessary to have support aircraft and ships to ensure that the regulation of our new fishing limits are imposed.

Knowledge of the wind, waves and sea-temperatures over large ocean areas should provide improved weather forecasts and better safety at sea. It is unlikely that much effort will be mounted to use SEASAT-A data for these purposes due to lack of resources. A research interest should be mounted, with the goal of providing local wind, wave and temperature maps.

Development of Canada's Arctic and offshore resources are a set of problems requiring solutions. It has often been stated that "remote sensing is a solution looking for a problem". In the cold oceans surrounding our coasts and islands, there is a meeting of these two counterpoints. At the CACRS meeting, we should examine such questions as:

Are we pursuing the applications areas which will be most beneficial to our industrial and environmental concerns?

Is there sufficient support from the user agencies?

Should our proposed activities be altered?

SAR Station Coverage

at 10° and 20° antenna elevation and maximum possible (which is limited by local to pographical featured which mask the signal).

3.3 POSITION PAPER ON WATER

K.P.B. Thomson
Canada Centre for Remote Sensing

The application of remote sensing techniques to water oriented subjects involves a number of scientific disciplines. The title above is in fact rather broad in scope and for this paper, the following activities will be defined:

(1) Water Management
(2) Hydrological Measurements
(3) Biophysical Mapping
(4) Environmental Impact

The two principal subjects are Water Management and Hydrological Measurements. Both these topics are of major concern to Canada and are in general regulated by Provincial Government agencies. The present state-of-the-art in these two areas, in terms of application of remote sensing, is summarized as follows:

(1) Water Management

Satellite and airborne imagery are used for qualitative assessment and mapping of water bodies. LANDSAT digital data is used as a tool in the inventory of lakes and reservoirs particularly in the U.S.A. LANDSAT digital data has also been used, with varying degrees of success, to provide quantitative maps of suspended sediments in rivers, lakes and ocean areas. Quantitative chlorophyll mapping using LANDSAT is still hindered by many physical problems and is not yet an acceptable technique.

For operational needs, real benefits of remote sensing can only be realized if water quality monitoring programs use remotely sensed data as a regular routine means of data collection. At the present time, the major drawback is that this will not occur unless remote sensing data can provide more quantitative measurements.

Research programs which concentrate on the quantitative aspect of water quality measurements are being carried out by a number of Canadian agencies. These include; York University, DOFE Victoria, Canada Centre for Inland Waters and CCRS. However, the level of funding and general level of effort in Canada is miserably low in comparison to that in the U.S.A. and in Europe. (Note for example the European contribution of 5 million dollars for the NIMBUS Coastal Ocean Colour Scanner Experiment.)

In addition, there are other advances in instrumentation, such as the airborne fluorosensor, which could have an important impact on water quality measurements. In the case of satellites the inclusion of a thermal infrared band on LANDSAT C will be an important advance for water studies in general. LANDSAT D with its proposed 8-bit radiometric resolution, 30 metre spatial resolution and 7 spectral bands will offer a much better view of water bodies, especially the smaller ones. It will also be a much better system for "water colour" measurement. CCRS and CACRS should anticipate that LANDSAT D will provide a significant advance in water studies and plan for this by using existing developments to educate the operational user agencies.

(2) Hydrological Measurements

In hydrological applications, the qualitative aspect of remote sensing is predominant. Satellite and airborne data are used in watershed monitoring, as base data for environmental studies of particular basins and for snow mapping.

In the case of snow mapping and basic data for environmental studies the potential benefits are large (note that basic data for environmental studies apply specifically to hydroelectric power developments). Estimates of such benefits are in the order of 0.5-1 million dollars by 1980. Once again, the critical point is that more quantitative measurements would

greatly increase the potential benefits and the operational use of remote sensing. For example, snow cover is relatively easy to map using satellite or airborne imagery, but the really important parameter is the water equivalent of the snow pack in the basin. This however, can't be measured remotely at the present time. Further research in microwave techniques is required to bring this to a satisfactory stage.

Similar constraints apply to the remote measurement of soil moisture. Potential benefits of soil moisture measurement are high for agriculture and hydrology.

The following are areas requiring research:

- Soil Emissivity Measurements
- Plant Response to Moisture Stress
- Effect of Atmospheric Conditions on Infrared Sensing Techniques
- Microwave Techniques (there is a lack of suitable instrumentation)
- Soil Water Balance Models for:
  - Various agricultural crops
  - Hydrological Purposes
- Soil Water Balance Modeling

In the area of hydrological applications, CCRS has been quite active. For example, CCRS has carried out a project on snow mapping in conjunction with the AES and the New Brunswick Department of the Enviroment. There is an active program on soil moisture and CCRS will be participating in the Heat Capacity Mapping Mission (HCMM) Satellite scheduled for 1978.

The remaining topics of Biophysical Mapping and Enviromental Impact studies integrate water related topics into their structure. Under these two headings, the qualitative aspects of remote sensing are important. However, with the development of computer classification techniques, the digital information available, for example, from LANDSAT is becoming increasingly more useful. Remote sensing here provides important data concerning water resources, drainage, total surface area of water and information on water quality. In many instances, especially in the case of environmental impact studies, remote sensing can provide an important data base in addition to the monitoring of change detection. The applications techniques that can be applied in these two areas are essentially available and operational. However, more awareness of remote sensing is required on the part of the responsible agencies or corporations. CCRS has assisted in helping agencies to become aware of the value of remote sensing technology. The James Bay Development Corporation is a good example.

Table 1 shows a list of the current activities of CCRS, which are related to water. There appears to be two essential problems regarding the realisation of real dollar benefits by the application or remote sensing in this context. These are:

(1) Remote sensing must provide quantitative measurements before real advances in use and benefits can be realised. This requires continuing support for research in visible spectroscopy, and microwave techniques in addition to fundamental hydro optics and atmospheric radiation studies. An important step that would advance research into quantitative measurements would be the provision of radiometrically calibrated LANDSAT data. CACRS should remind CCRS that after 5 years of LANDSAT, we still do not have this calibrated data. The current climate in Canada is unfortunately biased against research and thus is working against the mechanism which can produce the benefits that society now demands. Can CACRS assist in identifying this problem to the people who decide and influence science policy and budgetory priorities?

(2) The second problem, which is a common one in remote sensing, is that operational agencies are reluctant to try new techniques. In the water management sector, which includes both water quality and hydrology, this problem is made more complex for the reasons outlined in (1) above. It will, in fact, be difficult to make substantial improvements unless more quantitative measurements become a reality. Can CACRS provide more feedback to CCRS in terms of the operational requirements of regulatory agencies?

TABLE I

CCRS Activities Pertaining to "Water"

Activity or Project	Goal	Discipline
Atmospheric Correction	Quantitative measurements using LANDSAT radiance data	Water and land
Water Colour	Quantitative measurement of suspended load and chlorophyll using airborne spectrometers	Water resources and oceanography
Sensor Development	Development of active and passive instrumentation to provide quantitative water quality data	Water resources and oceanography
Soil Moisture and HCMM	Quantitative measurement of soil moisture	Agriculture, hydrology and climatology
Snow Mapping	Operational applications	Hydrology
Microwave Program	Development of microwave sensors for the quantitative measurement of hydrologic parameters	Hydrology and agriculture
Image Analysis Facility	Development of analysis techniques for operational projects utilizing multi-spectral data	Water, ocean and land
Midas Basin Study	Quantitative measurement of suspended sediment using LANDSAT. Preparation of routine maps of sediment concentration.	Bay of Fundy Tidal Power Project
Chromaticity Analysis	Development of water quality index pertaining to suspended sediment and chlorophyll using LANDSAT data.	Water resources and oceanography

3.4

USE OF REMOTE SENSING FOR LAND APPLICATIONS

- A Report to CACRS -

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ABSTRACT

A status report on the use of remote sensing for land (excluding agriculture and forestry) activities is given. Problems associated with the transfer of technology are discussed, and a number of questions concerning the measurement of benefits are posed. It appears that excellent progress is being made toward operational use of remote sensing for many applications in Canada. However, it is difficult to assess the actual benefits being derived in quantitative dollar terms. That benefits do not materialize in the form of real dollar savings demonstrated by budget reductions, is a source of disappointment, even though such a goal is unrealistic.

INTRODUCTION

For the purpose of this paper, land applications include cartography, geosciences and land mapping. The current status of the use of Remote Sensing in these disciplines is discussed. Many potential benefits have been forecast (McQuillan, 1974) for the use of this technology on a broad scale. Questions are raised as to why these benefits have not yet been fully realized, and some partial answers are suggested.

PROBLEMS IN TECHNOLOGY TRANSFER

Remote sensing in Canada is a relatively new technology. The problems associated with transferring this technology to user agencies, i. e. those entrusted with making the final management decisions with respect to our resources and environment, are complex. They are similar to those involved in any technology transfer. For example, Downs (1967) has examined the difficulties associated with effective utilization of digital computers in "urban information systems". All new technical developments tend to be viewed with uncertainty and uneasiness by the key decision makers. It is usually difficult to judge whether the new approaches are really worth the costs involved. Perhaps most important of all is the question as to how the information gathered with the aid of the new technology will affect the power and influence of the various individuals engaged in the decision making processes.

The final payoffs of remote sensing will be determined by actual improvements in action, or by actual cost reductions realized in information gathering. Ultimately, for a decision-maker to be won over by the technology, "he must perceive a net gain in his decision-making effectiveness, and hence power, at the expense of another person's." (Downs, 1967) To tell a manager that he can cut many thousands of dollars from his budget and drastically cut his staff by effective use of remote sensing may actually have a negative effect on his view of the discipline, for he may perceive his power in terms of his budget and staff. However, the person in a position to redirect the saved resources may indeed see advantages in the new technology.

There is another important factor mitigating against adoption of new procedures. Generally, any decision-maker has at his disposal an effective system for gathering the information he needs to do his management tasks. However, he normally has tight limits on the budgetary and other resources at his disposal. Implementation of a new technique usually requires diversion of already limited resources to gamble that the new approach may be more effective. To the resource or environmental manager, this may be a dangerous gamble. He normally doesn't have the resources to attempt a parallel operation, the new method and the traditional one. Moreover, his existing staff will likely have different, possibly lower skills than those required to exercise the new techniques. He knows how to do his job with current resources. He isn't certain that the new techniques will enable him to get his job done at the same or lower costs, and he doesn't have excess resources to enable him to experiment. Thus, he cannot afford to take the risk of failing to meet his goals in cost-effectiveness on the off-chance that he might exceed them with the new technology.

CURRENT STATUS IN CANADA

Some of the past achievements and current activities in the use of remote sensing in land applications in Canada are summarized in the following sections. The progress is encouraging in some areas. However, relatively little effort is being expended in determining the value of the benefits being achieved. Some of these are obvious in a qualitative sense, but nearly all are difficult to measure quantitatively.

CARTOGRAPHY

For decades, cartographers have relied heavily upon the use of aerial photographs for the production of topographic maps. In recent years, LANDSAT imagery has become an integral part of the information input into Canada's mapping program (Fleming, 1976). Much of Canada is a sparsely settled wilderness area, and in this region, LANDSAT images are providing useful map revision information. While the normal revision cycle for maps covering the more populated southern areas of the country is five years, that for the wilderness area is nominally thirty years. However, this region is not entirely static; exploration activity and development of natural resources results in construction of roads, townsites, dams and hydro-electric projects all of which must be recorded on the maps as quickly as possible. These additions are made in the form of interim revisions, as purple overprints of the new detail on published maps. Roads and power transmission lines are normally plotted from construction plans or aerial photography. It is much faster and more economical to use LANDSAT images for revision of all maps from 1: 50, 000 scale to 1: 1, 000, 000. On smaller scale maps, the accuracy is equivalent to that obtained from route photography, while on 1: 50, 000 maps, features positioned by LANDSAT imagery carry the designation "position approximate". A field check of the revised maps of the 700 km James Bay Road revealed that no changes greater than 100 metres were required. Detailed feature positioning can await normal revision procedures and in the meantime, they are plotted with an accuracy which will give the maps many years of useful life.

Relief shading on small scale mapping, such as the World Aeronautical Chart series at 1: 1, 000, 000 requires detailed study of the physiography of the landscape over extended areas. This is a laborious task when performed with hundreds of aerial photographs. Winter LANDSAT images are now providing a much more rapid assessment of the relief features, since the shadow pattern resulting from the low sun angle throws the topographic features into relief.

LANDSAT imagery has been used to revise the positions of shorelines which have changed because of flooding after completion of hydro-electric projects or because silt deposits have modified the size and shape of islands located in river deltas. "Islands" plotted on the maps of arctic regions have been found to be large ice floes. LANDSAT has been used to extend mainland photogrammetric controls to accurately locate offshore shoals.

LANDSAT imagery has made it possible to produce complete 1: 1, 000, 000 photo-map

coverage of Canada in a series of sixty-three snow-free, ice-free photo-maps. Band 6 was used for the majority of compilation to delineate water/land boundaries, while band 5 was used where cultural features predominate.

LAND USE ACTIVITY CLASSIFICATION

There is some overlap between land use studies and vegetation applications, as much of the land use classification is inferred from the type of vegetation cover (or lack thereof) observed by the remote sensing instruments. Many of the early LANDSAT investigations, particularly in the United States, concentrated on this discipline. The first major operational use of remote sensing in which the Canada Centre for Remote Sensing took an active role was the classification of the watershed of the Great Lakes for the International Joint Commission (Gierman, David M. and Robert A. Ryerson, October 1974). This work used photo-interpretation of aerial photographs and LANDSAT images to produce present land use activity statistics for the Canadian portion of the watershed, a total of 234,000 square kilometers. The methods used, while not as glamorous as the digital analysis of LANDSAT data as used in the U.S. portion of the study, provided accurate results quickly at a cost much lower than that of the U.S. work.

The success of the Great Lakes project has resulted in a number of similar projects by users at various government levels. The government of Prince Edward Island, in cooperation with CCRS, is conducting studies of land use patterns for soil erosion control and land use planning. Other major work is being carried out in the coastal areas of the Maritimes (Alfoldi, 1975). CCRS has in preparation a manual on how to use airborne and spaceborne image data to map land use activity (Ryerson, 1975). Conservation authorities, regional governments, town planners, range managers and farm extension workers have been investigating the methods and costs involved.

The territorial government of the Yukon is engaged in a pilot project, with CCRS assistance, to evaluate the operational use of LANDSAT data for producing maps useful in wildlife studies. Parks Canada is planning to produce a complete inventory of the Grasslands National Park in 1977. The Oil Sands Environmental Research Program has let a contract for the monitoring of changes in vegetation using LANDSAT and airborne thermal data.

Lands Directorate of DFE is evaluating the use of remote sensing for biophysical mapping near Kenora in Northwestern Ontario and has plans to conduct an operational mapping project in the Hudson Bay Lowlands. A study has been initiated for operational mapping in the Caribou Range. Studies are underway in the Fraser Delta area, the Lac-St-Jean region, the James Bay Hydroelectric Development, the Saugeen Basin, and the Trent Waterways (Thie, 1976).

GEOSCIENCES

Remote sensing techniques are beginning to gain wider acceptance in many geoscience activities. As yet, the routine applications are at a comparatively unsophisticated stage, relying on qualitative assessment at the reconnaissance level.

Geological information requirements fall into three primary categories: structures, lithology, and landforms. The continuity and regional perspective which is offered by certain remote sensing data sources is providing much useful structural information, particularly in areas which suffer from scarcity of conventional data due to size and/or geographic location. In general, extraction of the structural information still requires careful work by experienced geologic interpreters knowledgeable of both remote sensing system characteristics and field conditions. The limited spectral differences between many lithologic units has thus far severely limited the application of remote sensing to lithologic mapping. In most cases, lithologic boundaries are interpreted more on the basis of textures and structural relationships than on spectral differences. Those boundaries which can be interpreted, however, can be mapped with accuracies comparable to those obtainable with other techniques. Landform interpretation is reasonably advanced, particularly in surficial geologic environments. Interpretations are still mainly qualitative in

nature due to the indirect and variable relationships between interpretation criteria and ground conditions. Bio-physical approaches to automated image analysis hold much promise. However, much careful subsequent interpretation is required before the results of such analyses can be reliably used for mapping.

The greatest single problem in the use of remotely sensed data in the geosciences is consistency. These two dimensional data sources do not provide information which can be used directly to provide the 3-dimensional geologic interpretation, which is often required. The observed surface phenomena are often related to geologic parameters in only the most tenuous manner.

Advances in the application of remotely sensed data to geologic interpretation will require efforts to improve the compatibility of these with other geologic data source (eg. geophysical data). Such integration of data sources is basic to geologic interpretation. Thus the more compatible the data sources can be made, and the earlier in the interpretation procedure integration can be achieved, the greater will be the reliability of the results. The potentials for automated image analysis in the geosciences will thus be increased significantly when closer integration of data sources is possible during image analysis and when methods of extracting image information from the spatial domain are more fully developed and available operationally. Like any other exploration tool, potential benefits will be highest in areas where existing knowledge is most limited.

DISCUSSION

Substantial potential benefits have been forecast from the use of remote sensing. In the land applications for northern resource development alone, the estimated potential could be from $10 Million to $40 Million over five years (McQuillan, 1974). These benefits have been forecast largely on the basis of potential savings over the use of conventional approaches to solving the various problems. Is this a realistic approach? This is a difficult question to answer. How can the benefits achieved be measured? Only in very rare instances will an actual cost saving be reported by an agency. Rather, if remote sensing methods are adopted, the agency's productivity may rise. For example, with its present resources and conventional methods, an organization might be able to generate certain information about x square kilometers per year. With the addition of remotely sensed data, it may be able to produce similar information for nx square kilometers with the same resources. It is very unlikely that the organization would voluntarily request or accept a reduction in resources to maintain its old level of productivity. Thus, the only simple quantitative measure of benefit is the theoretical dollar saving which might have been achieved over what would have been spent to achieve this increased output with a conventional approach, or (n-1) times the budget. But the question remains, what is the real value of this increased productivity? Certainly, the funding authorities would not likely have authorized increased expenditures to achieve the increase in productivity. On the other hand, to force the agency to reduce its resources to maintain the same output would guarantee that it would not look for ways to increase productivity, since all organizations resist reductions in their size.

Agencies which do adopt remote sensing to augment their information gathering capability may not be interested in documenting benefits to an extent greater than that required to maintain their own funding. Certainly, if a federal government department were to report huge savings in its operations by adopting some new techniques, it might run the risk of having these savings snatched from its budget by Treasury Board. It would be more likely to shift the saved funds as quietly as possible to some other high priority program which it wished to start up or expand.

We must ask if the predicted potential benefits are realistic. The answer is that they probably are, provided increased productivity is accepted to be of real economic value. However, it is probably not realistic to realize any actual dollar savings which would be reflected in the budgets of government or private organizations. All savings will at best be in terms of what it might have cost to do the same job in some other manner.

Next, we might ask how are we doing? Are the results to date satisfactory in terms of resource management systems in place or actively planned? In fact, from the status report given earlier, it would appear that the progress toward operational uses of remote sensing is generally much better than could have been reasonably expected in 1970. There have been disappointments; some expected applications have not adopted remote sensing, yet others have moved to operational stages much earlier than expected. Can we obtain even more rapid transfer of the technology to operational use? The proposed CCRS three-year plan suggests a stronger emphasis on demonstration projects and operational prototypes. However, a relatively small amount of the Centre's budget is available to support this activity. Will the proposed shift in emphasis by CCRS be helpful?

Finally, how should benefits be measured? Although benefit studies carefully outline the assumptions made in predicting the potential value of remote sensing, do they give a false impression? Are people expecting to see real dollar savings, rather than more productivity per unit cost? Who should be measuring the benefits? How can intangible benefits, such as sovereignty, quality of life, etc. be cast in dollar terms?

There are no easy answers to these questions. However, by considering them, it is hoped that the members of CACRS will be able to provide guidance to CCRS, as well as to user organizations. Hopefully, this will result in an accelerated realization of the potential benefits to be achieved through sensible application of remote sensing to operational management of Canada's resources and environment.

ACKNOWLEDGEMENTS

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3.5 VEGETATION

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INTRODUCTION

In the CCRS three-year plan, five projects which come under the general classification of "Vegetation" have been identified for development to the prototype systems stage in co-operation with appropriate agencies.

These are:	Completion Date
Forest Fire Mapping	31/3/78
Rangeland Monitoring	31/3/78
Specialty Crop Monitoring	3/79
Cereal Crop Information System	3/83
Forest Inventory	3/82

3.5.1 FOREST FIRE MAPPING

This is a project of the Forest Fire Research Institute and is headed by Peter Kourtz of that Institute. The project was initiated in October 1974 with the following objectives.

1. To demonstrate that reliable and inexpensive maps of important forest fire types can be produced from ERTS data.

2. To evaluate existing automated techniques for differentiating fuel type categories.

To date the CCRS MAD System has been used to produce a broad forest cover map for a 16 million hectare area of Quebec. These results show that clearcut logging areas, new logging roads, swamps and predominantly homogeneous coniferous and decidious forest stands can be distinguished.

Enhanced Landsat Images have been provided to the Société de Conservation de L'Outaouais, Maniwaki, Quebec for use in forest fire fighting operations.

Improved classifications of fuel types are now being obtained by overlaying winter and summer imagery of the area. CCRS has provided methodology support for the development of this overlay technique.

This data will be used in the Outaouais region this summer. In addition, the Kenora District and the Dryden District of Ontario have expressed keen interest in this technology and have requested imagery for the 1977 fire season.

Five hundred thousand (500,000) acres of land were also mapped for the Northern Forest Research Centre.

Assessment: This project seems well on the way to being operational. Data is now in the hands of the operators who are responsible for managing the fires.

CCRS Involvement: CCRS will continue to provide image analysis support. One quarter (1/4) man-year has been allotted for coordination and technical assistance.

3.5.2 SPECIALTY CROP MONITORING

Project SPUD-OP

Objective: To institute an operational potato monitoring system for New Brunswick.

Completion Date: Spring 1977.

CCRS Resources: Three man-months and $14K (including salaries).

N.B. Government Resources: Thirty-six man-months and $2K (not including salaries).

This project is nearing the operational stage. Good success in developing potato crop acreages using aircraft and satellite data have been achieved. An acreage map can be produced in four hours using the Image 100. New Brunswick has been well launched in this project and is now ready to continue on their own.

CCRS will provide Image 100 support and technical assistance when required.

White Bean Crop Assessment of Southern Ontario

Objective: To assess the usefulness of high-altitude airborne imagery and Landsat data for both acreage and crop condition measurement in S. Ontario for the Ontario Bean Producers Marketing Board, London, Ontario.

CCRS have devoted 3 man-months and $2,000 to this project. It has come very close to providing the acreage accuracy required which is 90% accuracy 95% of the time. The value of the sales of beans varies from 15-50 million per annum. Improved forecasts of production could result in benefits as high as $10 million. CCRS will continue support for one more growing season after which the results will be evaluated

and the Bean Producers Marketing Board will have to decide if they wish to continue on an operational basis.

3.5.3 RANGELAND MONITORING

A project entitled "Rangeland Remote Sensing Pilot Project" has been carried out by Intera Environmental Consultants Limited under DSS Contract OSZ 76-00183 awarded as a result of an unsolicited proposal.

The objective of the project was to introduce remote sensing from aircraft into operational rangeland management in Alberta and Manitoba.

The cost of the project was 43K, 5K being provided by CCRS and 38K by DSS. CCRS also provided a contract monitor. All flying and analysis was done by Intera. The equipment of the Alberta Center for Remote Sensing was used in some of the analysis.

The project has been very successful. A summary of the project is attached. The full report is available through RESORS. This is a project which has gone operational in the sense that the people who require the information are paying the full cost of acquiring it. Future CCRS activity in the area will be to monitor the continued development of the techniques and to provide assistance where appropriate.

3.5.4 CROP INVENTORY

The Spring Wheat Project and Follow-On Projects

The Spring Wheat Project started in the Spring of 1973 as a cooperative Canada/U.S. project to determine the feasibility of estimating spring wheat production through the use of ERTS data and other supporting data. Ten test sites of 2 x 10 miles were selected in the 4 Western Provinces of Canada and 6 in Montana and N. Dakota.

An International Steering Committee was set up with J. MacDowall of CCRS and Clark Ison of USDA as Co-Chairman.

CCRS contributed one methodologist to act as CCRS Project Manager, one computer programmer 2 days/week, and analyses equipment.

CDA provided one scientist to supervise the gathering of groundtruth data in the 10 Canadian test sites, and one scientist in Ottawa to devote a portion of his time to coordinating the project.

The full-time methodologist provided by CCRS left in August 1974 and was not replaced. From that period on, the project was operated by CDA and contract personnel with CCRS providing analysis facilities and data (computer compatible tapes). This project has continued on to the present and has formed the basis for the future phase of the Canadian ACRIS (Aerial Crop Information System) to be described below.

While Canada was struggling to keep its minimum program alive, the U.S. announced its multi-million dollar LACIE Project. In Nov. 1974 Canadian representatives were given a briefing on LACIE by officials from NASA, NOAA and USDA. Canada was invited to participate in the LACIE Project. Both CDA and CCRS submitted B-Budget proposals for approximately 200K each to allow a meaningful Canadian program to be developed. CDA received approval for its program starting April 1/77 but the CCRS proposal was rejected. The offer to participate in LACIE has been agreed to by CDA, EMR and E.A. and a Memorandum of Understanding "To Cooperate in the Development of a Global Crop Information System between the Department of Agriculture of Canada and the CCRS on the One Part and the USDA, NASA and NOAA on the Other Part" is being negotiated at the present time. USDA and CDA have been designate lead agencies for the U.S. and Canada respectively.

The USDA is now planning a follow-on to the LACIE Project called PAYES, (Production Area Yield Estimation System). It will be developed under USDA management and financed by USDA. The cost for hardware and software will be approximately $10 million (over 3 years) to employ 65 people.

Contracts in Support of the Crop Inventory Project

The contract works which have been carried out to date as a contribution to the Canadian Agriculture Remote Sensing Program are:

A Proposed Crop Information System Using Remotely Sensed Data - July 1974 (CCRS Contract) - $10,000

This report recommended the development of a global crop information system for Canada and that Canada begin investigations on the measurement and use of a "general biomass" index.

Donald J. Clough - Remote Sknsing and Economic Value of Errors in Wheat Forecasting - CCRS Technical Note No. 74-20, October 9, 1974

This report indicates that benefits of $10 million would result from a 2% reduction in error in the Canadian wheat domestic production forecast during the growing season. A $44

million benefit would result from a reduction in the Canadian export forecast error from 10% to 9%. The report recommends "that our initial project planning study to be carried out for about $100,000 and that subsequent systems development work be carried out at a level of at least $2 million per year over at least a five-year period. The federal make-or-buy policy should apply, with as much of the development work as possible contracted out".

M. Dwyer Rigby - Analysis of Landsat Data - $11,700, CDA, 1974/75

1975/76 - Factors Affecting Landsat Reflectance Values of Selected Crop Land in Alberta Canada in 1975 - Prepared for CCRS under contract ISQ5-0095 (DSS Unsolicited Proposal)

This was a very detailed study which examined reflectance data from 14 test sites in seven soil zones and two agro-climatic regions. They examined the reflectance variation from pixel to pixel within individual field and the average reflectance values for fields of the same crop type in different test sites they found extreme variability in both instance and concluded "signature extension" from the training site to surrounding areas was difficult or impossible. Hence training sites are required for every site. It is relatively easy however to classify to the level of Rapeseed, Summerfallow, Other Crop Types.

Global Agricultural Productivity Estimating Project - Contract ISW5-0368 (Unsolicited Proposal) - Gregory Geoscience Ltd. Amount 85K over two years.

Objective: To develop methods for utilizing satellite data to monitor growing conditions. A hierarchical approach defining the specificity of current growing conditions information was used.

(1) General growing conditions affecting all crop and rangeland.
(2) Growing conditions affecting crops.
(3) Growing conditions of specific crops.

For the least detailed indicator predicted yields agreed with published yields with less than 10% error for 10 of 11 test cases in which the least detailed indicator i.e. the general vegetation index which is determined solely from Landsat data. The published yields varied from 16.6 to 34.4 bu/acre. The accuracies achieved using a regression equation developed from 1973, 1974 and 1975 data when applied to 1976 data gave yield accuracies for three test sites as follows:

Swift Current	15.5%
Melfort	4.5%
Raymond	7.8%

An example of the Yield Vs. Biomass Index Curve for rural municipalities is attached.

Comments: This study shows real promise as the basis for the development of a technique for obtaining global yield data. It has the advantage of not straining the Landsat system, i.e. it uses broad classification categories, it does not depend on accurate area measurements and it does not depend on groundtruth measurements. For an initial system it gives the maximum information for the least cost and effort.

Evaluation of Classification Procedures and Selection of a Proto-Operational Approach for Determining Spring Wheat Acreage from Landsat Data - Contract OWS76-00233 to Gregory Geoscience Ltd. - Value 36.2K - 16.5K by CDA and 19.7K by DSS

Objective: To select from existing methods the most accurate method for identifying spring wheat in Canada from Landsat data and to refine the selected method and to use it in estimating the acreage of wheat under proto-operational conditions in four test sites using 1976 data.

Three methods tested were:

1. Visual
2. Field Classifier
3. Per Pixel Classifier (MICA)

An example of the kind of results obtained are:

Accuracies for % correct Wheat and Non Wheat:

	Wheat	Non Wheat	Total
Visual	71.7	84.1	79.4
Field Classifier	55.9	86.3	75.7
MICA Per Pixel	36	77.8	63.3

The conclusion was that the Visual interpretation method was best. The best automated classification method was the per field classifier.

The variation from test site to test site was great; for example, using the visual technique, the results for the three test sites were:

	Wheat	Non Wheat	Total
Visual - Swift Current	100	100	100
Raymond	95.2	93.6	93.8
Stony Mountain	39.2	70.7	60.2
Total	71.7	84.1	79.4

On this basis CDA are proposing to use visual interpretation from a CCT generated CRT display in their initial prototype system. This system combines has the advantages of best accuracy and low cost. Using a CCT generated CRT display gives flexibility and standardized presentation not available with photo products.

Present Status of Crop Inventory Project

CDA has proposed that a system be developed using Canadian data, preferably in association with the LACIE Program (U.S.) which will eventually provide information on crop conditions and acreages of major crops or regions for selected time periods as requested by Canadian agencies and commercial firms.

CDA have tentatively allocated funds of the Research Branch, CDA, to the development of a crop information system using meteorological and remote sensed data and also to research in remote sensing in areas such as soil moisture determination, spectral properties of crops, rangeland management, soil salinity and special crop inventories.

CDA have suggested the following funding for an Aerial Crop Information System, 77/78:

RB,CDA	CCRS	EB,PMB,CDA	OTHER AGENCIES	TOTAL
130	175	65	160	630K

The 175 from CCRS was requested as a B-Budget item and rejected. To date only the 130 from RB, CDA is assured.

It is proposed that a prototype system using visual interpretation from a CCT generated colour CRT display would be developed in Ottawa and then transferred to Winnipeg where it would be providing inputs to supplement the existing crop information system. It is estimated that the system would cost $1,000,000 over three years to develop.

CDA has established a Steering Committee for contract research recommendations for development of a crop information system. There is representation from CDA, Canadian Wheat Board, Canada Grains Council, Canadian Grains Commission, Statistics Canada, CCRS and Science Procurement of DSS.

CCRS Support

CCRS is and will continue to provide analysis facilities support and has allocated 1/4 man year directly to the project. CCRS will assume responsibility for producing the timely data required for the pilot project.

CCRS is providing additional support of a general nature -

- General methodology development.
- Joseph Cihlar is the principal investigator on an HCMM project one of the objectives of which is to measure soil moisture.
- The microwave program now being initiated could contribute to future crop inventory experiments. The methodology section (Frank Ahern) has conducted a very promising microwave scatterometry experiment over croplands.
- The methodology section is also developing a visible and improved spectrophotometer mounted on a cherry picker to do detailed spectral analyses of ground targets. The budget for this project is 209K (10.9 M/Y) initial costs plus 37K/Y operating.

Comments

Canada is the fifth largest wheat growing area in the world, 29.4 million acres, behind Russia (169.2 million), China (61.4 million), USA (52.6 million), and India (33.3 million). Its annual production (663.9 million bushels) is sixth in magnitude in the world. Canada's domestic use is small (157.1 million bushels). Canada exports more wheat per capita (20 bushels) than any other large producer. The value of these exports is in the order of 1-2 billion dollars/year.

Studies of the economic benefit of improved crop forecasting have shown large potential benefits. Apparently the product (potential benefits from improved forecasting) X (the probability of remote sensing being able to provide that improved forecasting) is still a small number in the minds of the people who hold the purse strings. However the work conducted to data in Canada, plus the relatively positive results of the LACIE project indicate that Canada should move forward in this field. It would appear that unless some very new, strong initiatives are taken, progress is going to be very slow. A system developed on the basis of using visual interpretation techniques and on providing data on crop conditions which is relatively easy and inexpensive to achieve could be the basis of a Canadian sized operational system which could grow as the new methodologies are developed.

FOREST INVENTORY

A number of forest inventory experiments have been conducted in Canada over the years. Most of these are still in the experimental stage.

A classification of the Banff-Jasper National Parks was conducted on a cooperative

project with the Northern Forest Research Centre, Lands Directorate and CCRS. Themes of pine, spruce, water, snow and meadows were classified with 80-90% of the areas studies[1]. To date there has been no follow-up on this work.

The Forest Pacific Research Centre, under contract to the Yukon Territories, worked on a forest inventory using visual interpretation techniques with 9 x 9 Landsat imagery. Jim Lee of the Research Centre used the Image 100 to analyse a few images. This work has been followed up by direct contact between CCRS and the Game Branch of the Territories Government. The potential of using Landsat for mapping animal habitat of large areas of the Yukon is being investigated.

Studies on the mapping of clear cutting of forests in B.C. have been undertaken by the Pacific Forest Research Centre and the Faculty of Forestry, University of B.C. Although the technique looks promising, it does not appear to have reached an operational stage to date.

A request has been received from the Renewable Resources Consulting Services Ltd. to use the Image 100 in a project to study caribou habitat in a pipeline corridor from Baker Lake, N.W.T. to 60°N, 97°W. This study area covers 85,000 Km^2. The analysis will require from 30-60 hours Image 100 time.

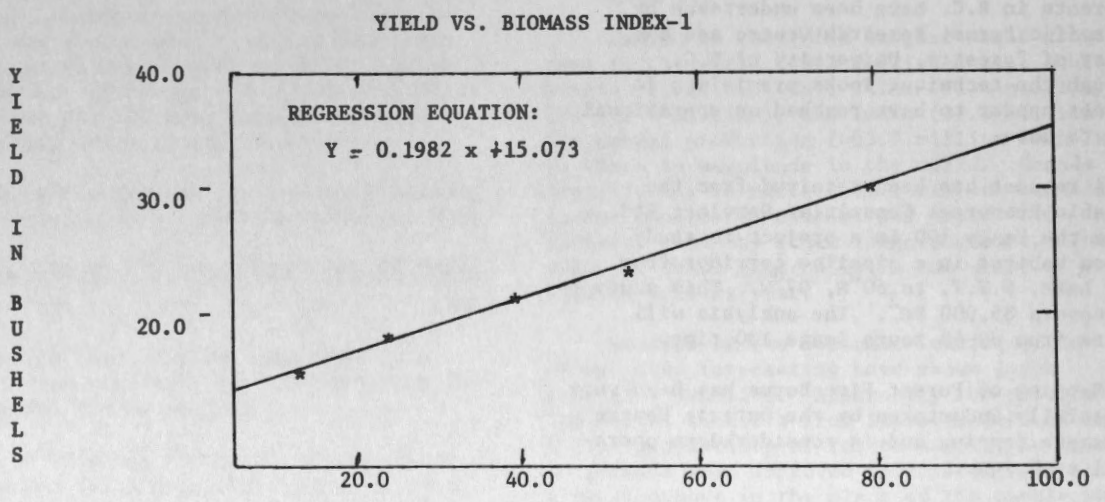
Mapping of Forest Fire Burns has been very successfully undertaken by the Ontario Centre for Remote Sensing and is considered an operational technique.

To date, no Canadian experimenters have been successful in mapping spruce budworm damage using Landsat imagery. Excellent success has, however, been achieved using 1/60,000 colour aerial photography.

CCRS Contribution

CCRS has assigned 1/4 man year to this work and will continue to provide image analysis support where required. Forest Inventory using remote sensing however, is still, in general, in the experimental stage.

1 Landsat Imagery for Banff and Jasper National Parks Inventory and Management. - Kirby, Goodenough, Day and Van Eck (Proceedings of 3rd Canadian Remote Sensing Symposium).



Published spring wheat yields for RM's versus biomass index-1 for general growing conditions in early maturity phase.

SUMMARY OF THREE 1976 PILOT PROGRAMS IN ALBERTA AND MANITOBA

	ALBERTA FOREST SERVICE	ALBERTA LANDS DIVISION			MANITOBA AGRICULTURE	MANITOBA WILDLIFE
AREA OF JURISDICTION	900,000 acres (1400 square miles) in Forest Reserve (plus northern Alberta Green area)	6 million acres (9000 square miles) in S. and Central Alberts			2 million acres (3000 square miles)	Not available
TYPE OF RANGELAND	Mainly foothills grasslands and bushlands range, (plus northern boreal areas)	Short-and mid-grass prairie			Grasslands to bushlands	Grasslands to parklands and boreal forest and wetlands
CURRENT MANAGEMENT PROGRAM	Regular inventory (15 year interval) for update of management plans for grazing allotments	Monitoring range productivity and condition on grazing leases			Beginning Inventory of all leases to establish carrying capacity over 5-year period	Evaluation of wildlife habitat especially for deer, grouse and waterfowl
OBJECTIVES FOR USE OF REMOTE SENSING	Reduce inventory interval through remote sensing interp. for better data base (range type, condition, trend, utilization)	Estimation of biomass productivity on grazing leases			Inventory of grazing leases (species assoc., condition, utilization)	Inventory and evaluation of waterfowl habitat to be used in planning and development
REMOTE SENSING FOR OPERATIONAL WORK						
TYPE(S)	FCIR photography	Landsat	FCIR photog.	35 mm	FCIR photography	FCIR photography
TIME OF YEAR	September	all season	June (end)	June July Sept.	Spring. July	July
SCALE	1:16,000	-	1:46,000	1:20,000	1:20,000	1:10,000 (approx)
METHOD OF INTERPRETATION	Visual (hand lens & stereoscope)	milti-spectral viewer	visual (stereoscope)	visual (hand lens)	visual (stereoscope)	visual (stereoscope)
PROBABILITY OF USING REMOTE SENSING IN						
1977:	100%	100%	50%	100%	80%	80%
1978	100%	100%	100%	100%	90%	100%
1979	100%	100%	100%	100%	100%	100%

3.6 REPORT OF THE WORKSHOP GROUP ON OCEANS

3.6.1 The work of the oceans group has been strongly affected by the surveillance satellite project. Ocean work represented 10-15% of the original 3-year plan ($9M annually over three years) and forms a major applications part of the surveillance satellite project (total $8M over three years).

Although most of the surveillance satellite funding comes from other departments, the Group's discussions considered the whole plan.

This project has required a diversion of $1.6M from the 3-year allocation. Currently $1M of this, for 77/78 and 78/79, has been obtained from the satellite and airborne operations budget by:

(a) deferring purchase of a laser beam image recorder; and

(b) postponing the development of an airborne SAR research radar.

3.6.2 CONCLUSIONS AND RECOMMENDATIONS

3.6.2 1. To pay for the Surveillance Satellite plan, CCRS has had to postpone its plan to acquire a SAR. The ERIM SAR is to be rented and returned in 1979. Although this is a good choice for the short-term plan and will allow the 1979 surveillance satellite recommendations to be based on experience with the best available SAR, the group is concerned about lack of a research SAR in Canada after this time.

3.6.2 2. Although SEASAT is a central part of the Surveillance Satellite plan, a Canadian microwave program is important and other components of the Surveillance Satellite Program should continue even if SEASAT is not launched or Canada cannot participate. Also, any resources made available by this change should be directed to acquiring an airborne research SAR System.

3.6.2 3. We notice the following apparent gaps in the Surveillance Satellite plan:

i) lack of work directed at use of SEASAT non-SAR sensor data; and

ii) insufficient effort on the development of assimilation methods for SEASAT type data into operational systems.

3.6.2 4. While the Surveillance Satellite project is based on microwave all-weather sensors, visible/IR Satellite Sensors due to be launched on NASA Satellites (Landsat-C, Nimbus-G and HCMM) should continue to be evaluated in small scale programs incorporating strong user involvement.

3.6.2 5. Progress or results of the Aerial Hydrography project's stereo photography work should be brought to the attention of the aerial survey industry and photogrammetric experts to promote rapid realization of projected benefits in topographic survey work and to judge the eventual usefulness of the technique for hydrography. We note that a scanning lidat bathymeter should give major benefits on a longer term.

3.6.2 6. Oil pollution monitoring (by laser fluorescence or other means) seems to be limited in usefulness for prosecution of offenders mostly because of legal problems. Legal advice appears to be needed on the operational viability of these techniques.

MISCELLANEOUS

3.6.2 7. The oceans group endorsed the recommendation of the Working Group on Ice that AES should acquire an operational side looking radar.

3.6.2 8. The Oceans Group agreed that the present CACRS working group structure should be preserved. The group pointed out that it was presently filling the role of the proposed ocean management "super group".

3.6.2 9. The group feels strongly that the LRPA be reinvestigated as a remote sensing platform to meet national non-military needs, particularly for testing semi-operational equipment and techniques.

3.7 REPORT OF THE WORKSHOP GROUP ON WATER

3.7.1. What Needs To Be Done?

The group identified four general topics of interest. For each topic, we listed specific information needs, potential users, and status of remote sensing techniques. Priorities were discussed with reference to those prepared by the Associate Committee on Hydrology (see attachment). See Table 1 for a listing of topics, etc.

3.7.2. Does the 3-Year Plan Provide For Perceived Needs?

Needs identified were matched against proposed demonstration projects (see Table 2). There was at least one proposed project against each topic, but there was no assessment of priorities by CCRS. It was difficult or impossible to relate the significance of some efforts listed under "Airborne Systems" and "Research and Development" to the needs of users. This made tracing of the flow from research and development through to operations difficult.

The group felt that projects related to oil pollution and water quality are not yet ready for demonstration, but need further "calibration" effort.

The highest need for water resources is all-weather measurement of snow water content, but there is no visibility in the plan of how much total effort is directed toward this end.

Laser bathymetry and shoal mapping are of a low priority for water resources. The same is true of ice reconnaissance for inland waters.

The mission now called "Hydrology" within applications should be renamed "Water Resources", with specific areas identified as: Run-off Forecasting, Inventory, Water Quality, and Hydraulics.

The group welcomes the proposed restructuring of the 3-year plan along selected applications lines. We would welcome a corresponding emphasis in resource assignment to technology transfer rather than technology developments.

3.7.3 RECOMMENDATIONS

Considering that it may take an extended period from the proof of concept stage to an operational information system, it is recommended that a concerted effort be made to provide resources on a continuing basis to support projects designed to bridge this period. It is further recommended that it be accepted in principle that CCRS play a strong lead role in initiating, guiding and assuring continuity during the transfer period.

It is recommended that the Limnology Working Group be integrated with the Hydrology Working Group and the resulting group be named the Water Resources Working Group.

3.7.4. RESEARCH PRIORITIES IN HYDROLOGY As Prepared By Associate Committee On Hydrology December 1976

One of the responsibilities of the Associate Committee on Hydrology is to advise the National Research Council of Canada, federal departments and other organizations regarding research and development requirements in the field of hydrology.

To fulfill this responsibility Committee Members were asked to draw on their areas of competence to define the areas in hydrology most in need of greater research and development effort. Areas in which there already were adequate efforts being made were not to be included even though the results might not be available yet. The 1976 study indicated that certain needs were of greatest national concern whereas others were directed to solution of problems within a given region having particular hydrological conditions.

National Priorities

Snowpack - Processes and Measurement

The spatial and temporal processes of snowpack formation, metamorphism and melt; how and when and how much snowmelt contributes to stream runoff, soil moisture and groundwater recharge; the effect of soil moisture on snowmelt runoff; the correlation of the processes with ground cover, relief and meteorological parameters, the variations in these processes particularly in regions of shallow variable snowcover.

Improved methods of measuring or estimating snowpack distribution, water equivalent content, melt rate and runoff both in time and space to provide more reliable input

to hydrological models for forecasting, management and research purposes. These needs include improvement of methods of measuring or estimating parameters at a point and extrapolating to provide areal data; and, the improvement of techniques for obtaining areal data in remote regions from surveys and remote sensing.

Effect of Man

Development of methods of assessing the effects of man's activities on different components of the hydrological regime in terms that can be used in hydrological models for forecasting and studying these effects. Specific information is needed on the hydrological response to activities in forestry, agriculture, urbanization, industry, energy development and river modification which result in changes in water quality, erosion and sedimentation, and water quantity. Such studies are needed to support environmental assessment activities.

Precipitation - Measurement and Analysis

Further improvement is needed in methods for directly measuring or calculating precipitation so as to provide information on the spatial and temporal variation of rainfall and snowfall on a real time basis. There is a special need for methods of obtaining information in remote areas. Such information is needed for input data to assist in the improvement and refinement of hydrological models used to study and forecast basin runoff.

Groundwater - Quality and Contamination

Determination of practical methods for detecting, preventing, tracing and overcoming groundwater contamination from inadvertent or deliberate disposal of waste products on or near the ground surface and in deep wells. Information is needed on the effects of salts, from natural and artificial sources, on groundwater quality and the effects of salts orginating from groundwater discharge on the quality of surface water and land salinization. Also information is needed on the effects of hydrocarbons and herbicides on groundwater quality. Knowledge of these processes is needed particularly in relation to groundwater in fractured rocks.

Regional Priorities

Cordillera

Knowledge of the processes of groundwater movement in fractured rocks, to improve understanding of quantitative assessment, salt water intrusion and contamination by man.

Glacier processes as related to runoff prediction and as climatic indicators. Basin precipitation and evapotranspiration in mountainous terrain for runoff forecasting.

Interior Plains

Improved methods for determining the distribution and water content of prairie snowpack and of predicting snowmelt rates and volumes. Forecasting and removing ice jams. Saline water discharge processes. Methods of determining actual evapotranspiration.

Saint Lawrence Lowlands

Better knowledge of the snowmelt process in regions of shallow, variable snowcover. Water quality as affected by man in heavily populated, industrialized areas.

Atlantic

Knowledge of the processes of groundwater movement in fractured rocks, particularly as related to quantitative assessment, salt water intrusion and contamination by man.

North (permafrost Area)

Improved methods of obtaining data over vast thinly populated areas including use of remote sensing. Better methods of measuring flow of ice covered rivers. Methods of determining actual evapotranspiration.

The above priority areas represent the considered opinion of senior representatives of federal, provincial, university and private water resource organizations in Canada and are presented for use by those involved in planning and managing hydrological research and development programs.

TABLE 1: TOPICS OF INTEREST FOR WATER RESOURCES

TOPIC	SPECIFICS	PROBLEMS	STATUS	USERS
SNOW PACK	Extent	Forest Cover Time Clouds, Sun Glint	Operational In Some Areas	- Hydro - Provincial Water Agencies
	Thickness Water Equivalent		δ Techniques	
WATER QUALITY	Macrophytes Temperature Location Of Effluents		Operational	- Hydro - Provincial Water Agencies
	Sediment Concentration Chlorophyll	Calibration	Semi-Operational Research	
	Oil Pollution	Legal	Research	- Transport Canada
INVENTORY	Land Cover Land Use Wetlands Small Lakes Hydrography		Semi-Operational Pre-Operational	- Wildlife Agencies - Environmental Agencies - Hydrographic Survey
WATER MOVEMENT	Mass Transport Environmental Impact Freeze-up Break-up		Semi-Operational	- Engineering Transport

TABLE 2: REVIEW OF PROPOSED DEMONSTRATION PROJECTS

DEMO. PROJECTS	SNOW PACK	WATER QUALITY	INVENTORY	WATER MOVEMENT	NOTES
5. Snow mapping for run-off forecast	X				Ready for demonstration, but a real user is needed. May find group of users for industrial contract. Increase funding for demonstrations.
6. Aerial hydrography charting			X		Not a high priority for hydrology. Well-defined user link exists.
7. Coastal shoal mapping			X		Not a high priority for hydrology. Well-defined user link exists.
8. Oil pollution monitoring		X			Two aspects: (a) mapping (b) identification. a) is aspect of proposed EPS cooperative program. b) is premature for demonstration.
11. Water quality monitoring		X			York photometer, etc. - needs quantitative output prior to demonstration. Really research.
12. Ice reconnaissance for inland waters				X	Gt. Lakes and Mackenzie only potentially useful. Do we need or want year-round shipping? Why repeat U.S. experiment? Low priority.
14. Environmental impact assessment				X	General consultations for engineering problems. As far as water resources are concerned, part of "consultation and liaison".

General Notes:
1) Technology transfer hindered by lack of "technical manuals".
2) Problems are regional or provincial, with need to resell in another region.
3) "Hydrology" as an application should be labelled "Water Resources", with subtopics:
Runoff Forecasting, Inventory, Water Quality, Hydraulics.

3.8. REPORT OF THE WORKSHOP GROUP ON LAND

3.8.1 1. The Workshop Group studied the proposed list of application programs, and considered that the following were of direct concern. They are listed in two groups expressing primary and secondary importance.

a) Primary

- Regional Land Use Activity (and Land Use Monitoring)
- Environmental Impact Assessment
- Geoscience Activity

b) Secondary

- Energy Conservation (formerly Heat Loss)
- Biophysical mapping in the north
- Engineering applications (new program)
- Combination of (a) aerial hydropgraphy charting and (b) coastal shoal mapping.

3.8. 2. In his introductory statement, Dr. Morley indicated that the proposed 3-year Plan represented a change in emphasis for CCRS, with more attention being given to applications development In the opinion of the Workshop Group, this is not evident in the document. It is suggested that careful attention be given to identifying those activities that are required to support the major programs at CCRS; namely, airborne and satellite data acquisition and applications development. In particular, thought should be given to reducing the activities of peripheral programs.

3.8. 3. In attempting to assign detailed priorities to the land-related programs, the group felt that the titles were too vague and all-encompassing to make this exercise worthwhile. It was recognized that in practice a pragmatic approach was usually applied, CCRS undertaking studies when they could interact with a potential user. The group felt that CCRS should be given blanket approval to execute those demonstration projects which are most likely to result in the transfer of remote sensing technology to operational use.

3.8. 4. The workshop realized that many demonstration projects have already been undertaken. Particularly in the case of the airborne program, these are frequently supported by reports from the user. The group recommended that careful documentation of all demonstration projects should be undertaken and circulated to all relevant personnel at CCRS. These should include spaceborne as well as airborne projects, and dollar-values should be appended whenever possible.

3.8. 5. Considering the funding and manpower that has been available in the past, it was felt that progress has been satisfactory and benefits achieved in excess of what could reasonably be expected. It was pointed out, however, that in many cases it is not possible to place a dollar-value on the benefits or savings that are achieved through the use of remote sensing. This, however, does not preclude the documentation of such activities. It is recommended that in all studies, CACRS and CCRS should encourage the user community to provide as much documentation as possible.

3.8. 6. Having carefully studied the demonstration projects already completed, CCRS should determine those areas that are likely to produce results and set up demonstration projects. It was noted that in the past, much of the funding for such projects came from DSS. How the funding will be carried out under the proposed three-year plan is not indicated. Before a project is undertaken, there should be assurance of adequate funding for proper analysis studies, but this funding need not necessarily be provided through CCRS. For example, if $1M is spent on a data acquisition system, a significant proportion should be made available for data analysis.

3.8. 7. Although the workshop group was asked to consider the benfit figures presented in the three-year plan, the group felt that it did not have sufficient background knowledge to comment on the appropriateness or the accuracy of the figures quoted.

3.8. 8. CCRS funding for R&D appears to be low at 5%. It is appreciated, however, that at the present time there is a stigma attached to such activities. As a result, development in support of operational activities is frequently charged to operations rather than R and D. It is suggested that these costs might be designated as "Product Process Improvements".

3.8. 9. The workshop group felt that CCRS should pay more attention to training and education. Without having seen a copy of the Slaney report, the group supported in principle the tenor of the document.

3.8. 10. The workshop group on LAND reviewed the consolidated recommendations. It identified the following as worthy of special support by this group:

In anticipation of LANDSAT-D and other high spectral and spatial resolution satellites, increased funding for research in the areas of pattern recognition and image analysis should be provided, especially through NRC grants to universities. (Data Handling)

CCRS should continue to strongly encourage implementation of demonstration projects and the development of these to an operational status particularly by facilitating wide use and adoption of available technology.

(Hydrology)

Canada, through CCRS, should express an interest in the acquisition of photography over Canadian territory from the large format cartographic camera being developed for the Space Shuttle missions. (Cartography)

3.9 REPORT OF THE WORKSHOP GROUP ON VEGETATION

3.9.1. Questions addressed:

1. Are the potential benefits realistic?

2. Are the results of data acceptable?

3. Is the proposed 3-year plan effective in achieving use potential? Should it be modified?

4. What should other agencies do?

3.9.2. Are the potential benefits realistic?

a) In general, potential benefits for Crop Information Systems appear reasonable.

b) Forest Information Benefits are too conservative. They should be in the same order of magnitude as those for Crop Information Systems.

c) Northern Resource Information benefits should be increased by about 3 times.

	Present	Adjusted
Crop Information Systems	10-44 million	10-44 million
Forest Information Systems	5 million	>10 million
Northern Resource Information Systems	670 thousand	2-3 million
Rangeland	?	?

Priority setting based on benefits should be done with much care, because intangible benefits should be considered in addition to hard ones, as well as the effectiveness (time, resources, user acceptability) with which a program can be put into place.

RECOMMENDATIONS

A. The CCRS should develop or encourage the development of a digital image analysis system that could be marketed at a price (<75k) within the financial capability of Regional establishments. This should be considered a high priority, since this was also recommended a year ago (3.3.2.1.). The benefits of such a system to the national program would be considerable as it would allow full-scale utilization of Landsat Imagery rather than piecemeal.

B. The need for effective links between digital analysis systems and geographic and resource information systems continues to be very important to the users.

3.9.3. Are the results to date satisfactory in terms of resource management systems in place or planned?

In general, results to date are considered reasonably satisfactory. Taking into consideration the problems of technology transfer to users and government funding constraints, it seems unreasonable to expect much more than what has been achieved.

DETAILS: a) FOREST INFORMATION AND MANAGEMENT

- The above general statement applies to fuel and fire mapping.

- Spruce budworm problems have not had enough investigation. This will be rectified in the coming year.

b) CROP STUDIES

- Satisfactory, but only because of the very special efforts of Dr. Alex Mack (CDA).

c) NORTHERN RESOURCE INFORMATION (BIO-PHYSICAL)

- The general statement applies. At present it is not the remote sensing technology which is holding back programs, but the availability of funds.

d) RANGELAND

- Not satisfactory, but a reasonable start has been made.

e) WILDLIFE HABITAT MAPPING AND MONITORING

- Satisfactory in Ontario, but unsatisfactory at the federal level and in some other provinces.

3.9.4. Is the proposed 3-year plan conducive to better results? How should it be modified?

Sub Question:

What are Canada's priorities?

What should be the CCRS priorities?

PROGRAMS:	PRIORITY CANADA	CCRS
Forest Fuel Type	1	3
Forest Inventory and Damage	2	2
Bio-Physical (Ecological) Class	4	4
Rangeland Monitoring	6	6
Crop Information Systems	2	1
Specialty Crops	5	5
(Quebec Project)	2	2
Wildlife Habitat Monitoring	7	7

3.9.5. BACKGROUND FOR RECOMMENDATIONS

CCRS Objectives:

1. To provide satellite and airborne data.

2. To support user applications.

Sub-Questions:

1) Has CCRS support been adequate for user programs? - in line with priority?

2) Does 3-year plan reflect vegetation priorities?

A. Forest Fuel Type:

1) Received good support.

2) ¼ my should be extended for 78/79 to ensure technology transfer.

B. Forest Inventory:

1) No significant support in past.

2) Not adequate. Quebec alone will need ¼ manyear. There are also other activities: Kirby, Lee, Oswald, Hohner, etc. ½ my scientific liaison officer is needed, but this manyear should be provided by the user agencies. Quebec may also need 3/4 my additional support.

C. Crop Information Systems

D. Specialty Crop Information System

E. Rangeland Monitoring

1) Present level of support reasonable.

2) For Crop Information System, ¼ my and 2 my backup may be required. CDA will submit detailed 2-year requirements for negotiation with CCRS.

3) ¼ my should be extended to 1978-79 to ensure follow up.

F. Biophysical Ecological Land Inventory

1) Received good support.

2) Present resource allocation and timing are adequate.

(The cost for surveying 2,000,000 square miles would be $20-100 million, duration 5-10 years. Probably Federal-Provincial program. Money main problem at present.)

RECOMMENDATION

From the vegetation viewpoint there is a significant benefit in grouping the 16 applications projects in 4 major areas: LAND, AGRICULTURE, FORESTRY, WATER, each supported by about 1 my from the Applications Division. This may assist in moving around resources in relation to changing priorities.

RECOMMENDATION

CCRS should have and use the freedom to adjust its budget to provide adequate support for the transfer of technology efforts by the user departments and agencies. Technology transfer efforts should have high priority.

3.9.6. Do the CCRS budget allocations reflect user/applications concerns?

CCRS - BUDGET

	$ Thousand		m/y	
Applications	1,017	11%	12	11%
Satellite Ops	3,051	32%	30	28%
Airborne Ops	3,741	39%	29	27%
R & D	455	5%	11	11%
Support	1,205	13%	24	22%

(O.C.R.S. BUDGET: 700k; 25 my.)

CONCLUSIONS

A. We cannot provide constructive criticism for improvement of budget allocations between the various element of the CCRS program, but there is a general feeling that Applications should receive more support.

B. We feel that a meaningful subdivision of CCRS program sub-activities is impossible using an applications matrix, and in any case, we feel there are serious dangers involved in using the applications matrix. For instance, the prime responsibility for Applications is with the user. He may have to justify the CCRS applications expenditures related to his program. In the present situation of fiscal restraints, the user department may not be receptive to that.

C. Applications should remain one of the most important elements of CCRS, but to eliminate all ambiguity related to responsibility, it should be called, "Technology and Methodology Transfer".

It is recommended that CCRS change the Applications name and that CCRS continue to justify its program along its present sub-activity structure. At most only a very broad reference to application - use areas is advisable, as shown in the table below.

	LAND	VEGETATION	WATER	CLIMATE
Technology Transfer				
Airborne Operations				
Satellite Operations				
R & D				
Support Services				

3.10 CONSOLIDATED RECOMMENDATIONS

Before the CACRS meeting, a group consisting of Dr. Jaan Kruus, Dr. Alex Mack, and Mr. Victor Zsilinszky met to consolidate the recommendations made by the working groups, specialty groups, and provinces. The detailed recommendations are found in the individual reports (see 5.1 to 7.4). Short comments by CCRS have been added where appropriate.

3.10.1 Major Resource and Funding Requests

3.10.1.1 In anticipation of LANDSAT-D and other high spectral and spatial resolution satellites, increased funding for research in the areas of pattern recognition and image analysis should be provided, especially through NRC grants to universities.

- Data Handling

- This recommendation will be referred to NRC through IACRS

3.10.1.2 CCRS should provide subsidies to ISIS to prevent a continuing increase in the cost of imagery.

- Ontario

- CCRS must point out that since ISIS are the sole Canadian distributors, they can raise prices as necessary and as permitted by DSS. CCRS will try to provide as much warning as possible of price increases.

3.10.1.3 CCRS should send representatives to provincial governments to encourage and help the establishment of provincial centres.

- Ontario, Newfoundland

- This recommendation will be referred to the Marketing and User Assistance Unit shortly to be formed at CCRS.

3.10.1.4 CACRS should strongly support the immediate acquisition of SLAR systems for the Canadian operational ice reconnaissance program.

- Ice

- See 3.2. for a status report on what is being done in this area.

3.10.2 Future Program Planning and Development

3.10.2.1 In order for Canada to maintain adequate knowledge concerning all options, planning and technological development should continue toward the long range goal of a Canadian remote sensing satellite program. This should include examination of the impact of the Space Shuttle on the design of remote sensing satellites, engineering studies on the feasibility of deploying large, high frequency microwave antennas in space, and initiation of a system design study by 1978.

- Data Handling

- This recommendation will be referred to the Surveillance Satellite Project Office, but any possible action will probably have to be delayed until after 1979. Meanwhile, studies are continuing in co-operation with ESA as well as with NASA.

3.10.2.2 In light of the importance of ocean management and resources development in the ocean surrounding Newfoundland, the Federal Government should support major research and development projects designed to provide information systems meeting user requirements in the fishery, offshore petroleum and shipping industries.

- Newfoundland

- Everything possible is being done, in light of funding restraints.

3.10.2.3 CCRS should continue to strongly encourage implementation of demonstration projects and the development of these to an operational status particularly by facilitating wide use and adaption of available technology. The following areas show most promise of success:

i) The WMO Snow Studies by Satellite Project has indicated a number of areas with strong potential for operational use.
ii) Research should be encouraged into measurement of snow under forest cover.
iii) Encouragement should be given to more effective applications of the use of existing gamma ray technology to measurement of snow water equivalent and the potential measurement of soil moisture.
iv) Attention should be given to the application of pattern recognition techniques to estimating regional and basin precipitation from cloud cover.

- Hydrology

- CCRS is doing as much as it can with the resources available.

3.10.3 Promotion of Practical Applications

3.10.3.1 CCRS should promote the practical applications of remote sensing with special reference to:

i) Preparation of a guide for potential users whose interest areas are application projects. These users would be researchers extension personnel, agricultural producers and industry.

ii) Offering of courses to special interest groups who are involved in application projects. For example, a course could be given to a specific group involved in crop identification and special reference could be made to those particular agencies involved with it.

iii) Provision of funds for the development of a guide to agricultural applications of remote sensing with a view to increasing the number of practical users.

- Agriculture

iv) Dissemination of information about LANDSAT and its applications through the publication of technical manuals and sample studies.

- Geography

v) Preparation of a national list of user-oriented applications, preferably including comparisons with traditional methods, with respect to time and costs.

- Ontario

- Two manuals, on agriculture and land use, are now being prepared. The recommendation in toto will be referred to the Marketing and User Assistance Unit.

3.10.4 Sensors and Systems

3.10.4.1 In view of the planned Canadian surveillance satellite program (including participation in SEASAT-A) user familiarization experiments should begin immediately using aircraft-borne imaging radars and complementary sensors.

- Ice

- This recommendation is referred to the Surveillance Satellite Project office, which is presently co-ordinating such experiments.

3.10.4.2 Full support should be given to the further development of multispectral data acquisition system with high spectral resolution that would be readily available to Canadian users.

- Agriculture

- This is being done.

3.10.4.3 Canada, through CCRS, should express an interest in the acquisition of photography over Canadian Territory from the large format cartographic camera being developed for the Space Shuttle Missions.

- Cartography and Photogrammetry

- Individual principal investigators should put in requests through CCRS for forwarding to NASA.

3.10.5 Information

3.10.5.1 To ensure access to the existing data base by all potential users, a Canadian data management systems should be developed immediately. Moreover, the management of data should be made an integral part of the development of all new remote sensing systems.

- Ice

- An interdepartmental committee is working on this.

3.10.5.2 CCRS should ensure that radar imagery and associated ground truth be brought to the attention of all qualified and interested investigators.

- Oceanography

- This is being done, and requests for proposals for experiments will be sent out shortly.

3.10.5.3 A program should be initiated to "sell" remote sensing to the executive level of resource management agencies across the country.

- Ontario

- This recommendation is referred to the Marketing and User Assistance Unit.

3.10.5.4 The Applications Division of CCRS should compile information on international remote sensing application, for distribution to the provinces.

- Ontario

- This will be done through the CCRS newsletter.

3.10.5.5 Costs of all remote sensing products and services should be established as far in advance as possible (a full fiscal year) - especially for LANDSAT products.

- Geography

- This is being done as far as possible.

3.10.5.6 CCRS should establish a computer based file similar to RESORS to contain a list of people experienced in RS interpretation and data handling and a list of private firms engaged in RS interpretation.

- Nova Scotia

- This recommendation will be investigated for feasibility.

3.10.5.7 Que le Centre canadien de télédétection expose très clairement sa politique de priorités concernant la fabrication des images LANDSAT. Qu'il fasse aussi connaître, de façon realiste et honnête, les delais auxquels l'usager doit s'attendre lorsqu'il commande soit une image nouvelle, soit une image déjà cataloguée.

Cette information pourrait être contenue dans un bulletin d'information à jour, expliquant en même temps les techniques actuelles de fabrication, d'une image, les techniques de reproduction ainsi que la procédure exacte qu'on doit suivre pour demander la fabrication d'une image nouvelle ou commander une reproduction.

- Québec

- It is recognized that occasionally unavoidable delays in producing imagery occur, and CCRS will attempt to inform customers, when such delays occur, how long they will have to wait for the imagery.

3.10.5.8 Que le Centre canadien de télédétection entre dans un fichier informatise, au fur et à mesure de leur progression, l'état d'execution de missions de télédétection aerienne, de sorte que les centres provinciaux de coordination, en interrogéant ce fichier par terminal (a la façon du système RESORS ou du système IISS), puissent être rapidement in formés des circonstances d'execution. Ou pourra ajouter à ce fichier les programmes d'estimation des couts.

- Québec

- CCRS will investigate the cost of producing this service.

3.10.5.9 Que le Centre canadien de télédétection constate la marge consideréable séparant la réalité de ses intentions louables vis-a-vis la traduction de certains documents d'information qu'il publie (CAS type: Voir CACRS 1975 report, No. 9.3.8.). Que cette marge soit reduite à des proportions décentes.

- The government translation bureau's services are overloaded and efforts will be made to find alternative sources of translation.

3.10.6 Marketing

3.10.6.1 The marketing activities of the individual agencies involved in Remote Sensing should be examined in depth to determine those activities which could be combined to increase the overall marketing impact and perhaps lower marketing expenditures for all concerned.

- Reproduction and Marketing

- This recommendation is unclear, and further clarification is requested from the working group.

3.10.6.2 Canadian industry should be encouraged to benefit from Canadian involvement in foreign satellite programs.

- Oceanography

- This is being done.

3.10.6.3 CCRS should look into the feasibility of producing CCT's for selected portions of full LANDSAT scenes.

- FMI

- This is presently being investigated by the Applications Division.

3.10.7 Organization

3.10.7.1 The working group meetings, normally held between the annual CACRS meetings, should be consolidated in a manner analogous to that now proposed for reporting purposes.

- FMI

- CCRS encourages this, as far as it is considered feasible by working group chairmen.

3.10.7.2 In 1976 little information was received from the CACRS working groups. These groups should be reorganized or their work made more effective and their communication with users' groups improved.

- Newfoundland

- Some working groups never met in 1976. In other cases, minutes were not distributed. If chairmen send minutes to CERS (Mr. J-C Henein), they will be distributed from there.

3.10.7.3 Organization of the new "ocean management" working group should allow for continued existence of the Oceanography Working Group in its present form.

- This is happening as requested.

3.10.7.4 The Agriculture Working Group should establish a subgroup on the applications of remote sensing for crop identification studies.

- Agriculture

- This action may be taken by the Agriculture Working Group without reference to CACRS.

3.10.8 Operational Digital Analysis Systems

3.10.8.1 A digital analysis system shhould be made available at CCRS for which the first priority is the user concerned with the development of operational applications of LANDSAT data, for example, in implementing current research into an operational crop forecasting system.

- Geography, Agriculture

- Such a system is normally available at CCRS, but peak periods of overload do occasionally occur.

3.10.9 Training

3.10.9.1 Because of 1) the increase in variety of remote sensing data, and 2) the lack of any good extension papers and/or demonstration models, CCRS should support the development of teaching modules for sale to High Schools, Community Colleges and Universities.

- Agriculture

- CCRS will try to make known what is presently available in this area.

3.10.10 Quality of Imagery

3.10.10.1 CCRS should make continued efforts to maintain the best possible geometric quality of their products. In view of the recent disclosure of systematic differential scale changes associated with the earth rotation effect at extreme geographic latitudes, a study should be initiated to analyse these potential errors and modify current correction procedures.

- Cartography and Photogrammetry

- This is a very specific request which is presently being worked on at CCRS.

3.10.11 Recommendations Not Requiring CACRS Action

3.10.11.1 National Research Council grants should be supplemented by grants from the provincial government, to enable private industry to undertake research and development programs (e.g. 1/3 federal government investment, 1/3 provincial government, 1/3 private company).

- Ontario

3.10.11.2 CACRS should express appreciation to V. Zsilinszky, Ontario Centre for Remote Sensing for hasting the Agric. Working Group in Toronto on November 4 and 5, 1976.

- Agriculture

3.10.11.3 The NAPL catalogue kit, including both contemporary and historical coverage, should be provided to all provincial centres.

- Ontario
- referred to NAPL

3.10.11.4 CCRS should consider having one of the next Canadian Symposiums on Remote Sensing in the Maritime Area.

- **Nova Scotia**
- **referred to Canadian Remote Sensing Society**

3.10.11.5 The Remote Sensing Science and Technology Conference should be scheduled either together with, or farther apart from, the general Canadian Synposium to permit greater attendance.

- **Ontario**
- **referred to Canadian Aeronautics and Space Institute**

4.0 REPORTS OF THE CANADA CENTRE FOR REMOTE SENSING

4.1 Historical Highlights

1968

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

1969

July 22: Cabinet Committee on Scientific 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. 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.

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 working groups. These working groups are sub-committees 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.

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. 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 (9) Sensors.

April 1: Canada Centre for Remote Sensing was 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 sensng 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 is 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 temorary 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 ongoing 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 Association 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.

Experimental tracking and reception of NOAA satellite data.

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

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.

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

June 6: Alberta Remote Sensing Centre 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's, Nfld., awarded to MacDonald, Dettwiler and Associates, Vancouver.

1975

January 23: Launch of LANDSAT-2.

March 31-April 3: Fourth CACRS meeting, Montebello.

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.

1976

February: ISIS began to produce and distribute all black-and-white LANDSAT products from Prince Albert.

March 29-April 1: Fifth CACRS meeting, Arnprior, Ontario.

April: Scientific and technical co-operative agreement signed between CCRS and CNES.

September: 1976-77 authorized budgetary level of $8,966,000 and 106 man-years.

December: Cabinet approval of joint submission by EMR and other interested government departments regarding participation in the proof-of-concept SEASAT experiment.

4.2 REPORT OF THE DATA ACQUISITION DIVISION

4.2.1 Introduction

1976 has been somewhat of a mixed year insofar as DAD activities have been concerned. On one hand considerable effort and progress has occurred on major programs such as Aerial Hydrography, Microwave Remote Sensing and Industrial Involvement. However much of this activity has been either planning, preparatory and/or preliminary, with much of the visible accomplishments yet to come.

By mid 1976 all DAD aircraft except the Convair 580, were certified by MOT and being operated by Innotech/Intera for CCRS.

The proposed airborne microwave program was developed to the cabinet submission level, with considerable planning underway for user related experiments and associated hardware development.

The aerial hydrography program has progressed to the point where fully integrated system tests are scheduled for mid 1977.

The Innotech/Intera Transfer Plan Report was received in early 1976 and has been reviewed in considerable detail, with the result that a joint company proposal for an operational remote sensing facility is expected shortly.

In addition to the above DAD has continued its ongoing activities in the area of Airborne Operations and Systems and Sensor Development. Detailed summaries of all of the above are contained in the following sections.

4.2.2 Airborne Operations

4.2.2.1 Operations Summary 1 April 1976 to 31 December 1976

a) Aircraft Utilized:

1 Falcon, 2 DC 3's

b) Projects Tasked:

Falcon	43	
C-GRSB	33	
C-GRSA	10	TOTAL 86

c) Projects Flown:

Falcon	32
C-GRSB	26
C-GRSA	10

TOTAL 68

d) Projects Cancelled: 14

e) Total Line Miles to Date:

Falcon	7,270
C-GRSB	4,022
C-GRSA	1,911

f) Line Miles by Agency:

Federal

Agriculture Canada	357
Atomic Energy of Canada	16
DFE Atmospheric Environment Service	132
DFE Canadian Forestry Service	0
DFE Canadian Wildlife Service	119
DFE Inland Waters Branch	257
Dept. of Indian and Northern Affairs	0
Dept. of National Defence	102
EMR Canada Centre for Remote Sensing	1,924
EMR Geological Survey of Canada	35
EMR Interdept. Committee on Aerial Survey	272
Parks Canada	114
Transport	46
Total	3,374

Provincial

Alberta Dept. of the Environment	15
Alberta Remote Sensing Centre	328
British Columbia Forest Service	428
Hydro Quebec	494
James Bay Development Society	330
Manitoba Dept. of Agriculture	804
Manitoba Dept. of Mines	440
Manitoba Dept. of MREM	1,381
Manitoba Dept. of Municipal Affairs	378
Ontario Bean Producers Marketing Board	18
Ontario Ministry of Agriculture	189
Ontario Ministry of Natural Resources	0
Ontario Ministry of the Environment	225
Ottawa Hydro	0
Quebec Dept. of Natural Resources	107
S.P.E.Q.	369
Societe de L'Energie de La Baie James	619
Yukon Game Branch	56
Yukon Lands and Forests Service	881
Total	7,062

Industry

British Columbia Research Council	203
Hamel, Ruel and Associates	490
Hudson's Bay Oil and Gas Company Limited	56
Simpson Timber Company (Alberta) Limited	350
Total	1,099

University	
British Columbia University	58
Calgary University	631
Guelph University	480
Laval University	15
Quebec University (Montreal)	200
Sherbrooke University	216
York University (CRESS)	40
Toronto University	28
Total	1,668

4.2.2.2 Operational Sensors

a) Vinten Cameras

The new Presenty controller has been erratic in operation and wiring changes made in an effort to reduce failures have introduced unreliable camera operation. In addition, there is the possibility that the cameras will be required by DND and therefore unavailable to CCRS. A plan for solution to these problems has not yet been developed, therefore at this time it is uncertain whether in-camera annotation will be available for 70 mm photography.

4.2.2.3 Aircraft

a) General

All CCRS aircraft have now been converted to civilian registration. The two DC 3 Dakotas, C-GRSA and C-GRSB, were converted with minimum of delay last year and were both available for service during all of the past year, except for the period of November and December when C-GRSB was out of service for engine change.

b) Falcon

Conversion of the Falcon to Civilian status was somewhat more involved. During inspection of the aircraft a deterioration of metal components in the area of the camera ports was discovered. Because of the possibility of structural failure these areas had to be reworked with the result that the aircraft was not available until July.

c) Convair 580

The modification of the Convair 580 by Innotech Aviation is in its final phase. The aircraft is expected to be delivered this spring and the installation and commissioning of different systems and sensors will be completed in July, 1977. The aircraft is provided with two 21 inch glass ports (one 21 inch port could be open with a pressure dome), one 28 inch and one 34 inch open port with pressure domes.

It has an upward looking port for a skylight reference, one drift sight (NF 22) down-looking port and provision for the installation of two PRT 5's. The electronic boxes are installed in two double 19 inch racks and four 19 inch single racks. Provisions are made for the installation of a Daedalus IR scanner, as well for the Scatterometer, Marconi Doppler MG712 and Colour TV camera.

The modifications also included the upgrading of the aircraft avionics and the layout of the instrument panel. The arrival of this aircraft will boost considerably the effectiveness and the capability of the airborne program for carrying out special projects involving:

i. Long range (reduction in transit time) which will be especially useful in the Arctic;

ii. A requirement for a multi-sensor complement, which is not possible at the present time utilizing the DC 3's or the Falcon;

iii. Performing operational demonstrations for projects such as Aerial Hydrography which would benefit from the increased speed during flight lines of the Convair compared to the DC 3 since the navigation system position error growth is primarily dependent on flight time rather than distance travelled.

4.2.3.1 Aerial Hydrography Project

The Aerial Hydrography and Airborne Bathymetry Projects have recently been brought together under one "roof" (Aerial Hydrography Project) with the ultimate goal of forming an integrated photo/lidar hydrographic system for charting shallow coastal waters. The two Projects have been renamed the Photo and Lidar Hydrography Projects. The status of each is summarized below.

a) Photo Hydrography Project

The Photo Hydrography Project is a joint venture conducted by CCRS and the Marine Sciences Directorate of DFE. The purpose of this Project is to combine photogrammetric and navigation technology to form a unique system for the remote measurement of shallow water depths and the generation of hydrographic charts. The Photo Hydrography System (PHS) includes both airborne and ground based equipment. The airborne component comprises an RC 10 aerial survey camera, an LTN-51 Inertial Navigation System (INS) and CCRS's Airborne Data Acquisition

System (ADAS). The ground segment is made up of the computer-controlled analytical plotter at the University of New Brunswick and the PDP-10 computer facility at CCRS. The airborne equipment is used to gather photographic and navigational data over the waters to be charted. These data are processed post-flight on the PDP-10 computer and analytical plotter to provide the required hydrographic charts.

The depth measurement capability of the PHS in Canadian waters is expected to range up to 10 meters (depending on water turbidity) with an accuracy of 1 to 2 feet (90% confidence). The depth measurement accuracy and the precision with which the depth data can be positioned on the charts, depends for the most part on the performance of the INS, and the navigation data processing software implemented in the PDP-10 computer. Navigation accuracy objectives consistent with charting and photogrammetric requirements are 10 meters absolute position (90%) and 30 arc seconds in relative attitude (90%) between consecutive photographs. The results of early flight trials (Sudbury, spring/75) of PHS hardware indicate that these performance objectives are within the capability of the system.

At present, all PHS hardware is operational. CCRS is now concentrating on system software development which should be completed by early summer 1977. Flight trials of (a) the navigation system hardware/software, and (b) the fully integrated system are scheduled for April and September of 1977 respectively.

b) Lidar Hydrography Project

In the past year a number of flights were flown using the old CCRS profiling lidar bathymeter. The data obtained on these flights have been used to construct a 6 mile long profile of the bottom of Kingston harbour. This profile, in which the bathymeter penetrated up to 25 feet of water, corresponds almost exactly to a profile extracted from the published hydrographic chart of the area.

The original CCRS lidar bathymeter, which was a modification of the fluorosensor, has now been retired as it is expected to have the Mark II Bathymeter ready for flight testing in the late summer of 1977.

The Mark II Bathymeter has been designed to demonstrate the performance that will be required if an operational scanning system is built. The Mark II sensor is a profiling sensor designed to operate at altitudes up to 2500 meters in daylight. The system under such conditions has a performance figure of $\alpha d = 6$. (The optical attenuation coefficient at the lidar wavelength to be used, α, varies between 0.5 and 1.0 m^{-1} in typical coastal waters. The depth, d, is the ultimate depth to which the bathymeter can map.)

Thus under typical conditions the system should be able to measure water depths between 6 and 12 meters. Under more favourable conditions depths of up to 30 meters will be charted. For example if the platform is operated at an altitude of 150 m. a system performance figure of $\alpha d = 9$ may be possible.

Progress on this project was slower than had been anticipated; however, a number of contracts have now been let for the construction of components of the Mark II sensor. A significant amount of work has also been done on the data processing techniques required to extract the water depths from the lidar returns.

4.2.3.2 Identification of Oil Spills Chlorophyll and Water Pollution

a) Laser Based Techniques

The construction of the Mark III Remote Sensing Laser Fluorometer is almost complete now at Barringer Research Limited in Toronto. This new profiling sensor uses a pulsed laser emitting light in the UV to excite fluorescence. The fluorescence emission is measured in 16 spectral channels and there are two additional channels in which the fluorescence lifetime can be measured. The sensor is designed to operate at altitudes of up to 2500 feet under day or night conditions. The data is recorded either on a computer compatible magnetic tape or on ADAS.

The instrument has the potential to identify and classify oils into broad groups. Chlorophyll concentration in water and other quality parameters may also be measured. Other possible uses will include crop identification, forest surveys, mapping the distribution of insecticides in aerial spraying operations, and the identification and mapping of selected geological anomalies.

A laboratory study to measure the fluorescence emission spectra and fluorescence lifetimes of oils has now been completed. The contractor has compiled an atlas of the fluorescence characteristics of the 40 samples. The study, which simulated the performance of the Mark III fluorosensor, showed that the airborne sensor should be able to classify oils into three broad categories: crude, bunker, and light refined products.

The old laser fluorosensor was also test flown a number of times. Perhaps most notable were the flights over the Thousand

Islands Oil Spill in June 1976. CCRS was able to demonstrate a very quick reaction time to an environmental emergency. Some initial studies were also begun on the variation in amplitude and pulse width of the backscattered laser as it passes over different terrain surfaces. This information is necessary for an understanding of the fluorescence lifetime measurement as it will be made by the Mark III fluorosensor.

b) Spectroscopic Based Techniques

i. MSS

An 11 channel Daedalus/MDA Multi-Spectral Scanner was delivered last spring. Offering 10 channels in the visible and near infra-red,and an eleventh in the thermal infra-red, this MSS has its data recorded digitally in the air with optional correction for S-bend distortion. This in-flight geometric correction of the across track tangent law distortion was specially developed for CCRS, and is believed to be unique.

Two further special features allow the spectral channels to be mixed to match Landsat passbands, and acquire histograms of the data in the 11 channels.

The scanner is under test and evaluation and will be used in the coming year on special pilot projects.

ii. MEIS

A new generation two channel prototype "solid state" multi-spectral scanner developed by MDA limited, has just been delivered to CCRS. This Multi-Spectral Electro-optical Imaging System (MEIS) consist of two identical units, each of which has a 512 element silicon detector linear array in the focal plane of an imaging lens. The units are bore-sighted, and each has a different easily interchanged filter in front of the lens to define its spectral channel. In flight, the system will look vertically down with the arrays aligned across the line of flight. The data is digitized and recorded in the Daedalus MSS format for ease of data reduction.

This system will be extensively tested both in the laboratory and from the air to evaluate this new concept, and it will be utilized on a few, special pilot projects.

4.2.3.3 Mapping the Distribution and Thickness of Sea Ice and Fresh Water Ice

Further sea ice identification from the air has been investigated with the CCRS 13.3 GHz scatterometer.

Data was acquired over first year sea-ice (floating and shore-fast) in the Bay of Chaleur in spring 1976. Analysis of this data has shown that it is possible to distinguish between new, young and first year ice on the basis of spatial detail and back-scatter amplitude at the incident angles more appropriate to a satellite borne radar. This complements the previous analysis of multi-year Arctic ice which showed it was possible to distinguish between the different Arctic ice categories on the basis of backscatter, to a much greater extent with cross-polarized data. In the case of the more recent first year ice results, it was found that the polarization was essentially immaterial.

It appears at this stage that an imaging radar for sea-ice classification should preferably have like and cross-polarized channels (but at minimum the cross-polarized channel) operating at the steeper incident angles appropriate to a satellite borne system.

Further joint work with the Communications Research Centre further evaluated their X-band impulse radar on the CCRS experimental aircraft. Flights over the Ottawa River demonstrated its ability to measure fresh water ice thickness, to produce real time hard copy results in the air, and to record the data for further post flight processing.

4.2.3.4 Mapping of Atmospheric Pollutants

Delivery was taken of a new spectroscopic non-dispersive gas sensor of the "Gaspec" family developed by Barringer Research Limited. The incoming radiation to the sensor is detected in a dual beam manner. One arm of the sensor detects directly the incoming radiation and the other detects the radiation after spectral filtering by a cell containing a sample of the gas it is desired to quantify.

The sensor is set up for CO monitoring, and has undergone initial flight trials to evaluate its performance. Sensor modeling will enable better assessment of future development needs to be made.

4.2.4 Active Microwave Airborne Sensor Plans

Substantial progress was realized during 1976 toward obtaining a high quality fine resolution multiband imaging radar for use aboard the CCRS CV-580 aircraft. The aircraft radar program is one element of the Microwave Surveillance Satellite initiative, for which approval in principle was granted by Cabinet early in 1977. The radar, belonging to the Environmental Research Institute of Michigan

(ERIM), may be leased and operated through the services of Intera and Innotech and employed in scientific and applications experiments for the benefit of several Canadian departments and other users.

The radar operates at wavelengths of 25 cm and 3cm, with dual polarization available on both. The imagery will be the best now available for civilian purposes anywhere in the world. It will provide Canada with a unique and critical data base for approaching the evaluation of Seasat A results (an orbiting 25 cm imaging radar to be launched by the U.S. in May, 1978), and for placing in context the various imaging microwave requirements of users. These results are expected to impact upon future sensor requirements for Canada, for both satellite and aircraft systems.

4.2.5 Industrial Involvement in the Airborne Program

The industrial involvement team, Innotech Aviation of Montreal and Intera Environmental Consultants of Calgary, have been actively participating in all aspects of the program. The aircraft and technical services contract, which runs to March 31, 1978, is in full operation with approximately 30 staff involved in airborne remote sensing operations. This year, due to budgetary restrictions, airborne operations were limited to approximately 700 hours of Falcon and DC-3 flying. However next year, with the introduction of the Convair 580, it is expected that flying activities will rise to the 1000-1200 hours level.

The Transfer Plan report was submitted March 1976 and has been the subject of considerable review. The main purpose and emphasis of the report has been the mechanism for shifting the operational (or potentially operational) activities from CCRS to industry. To ensure the effectiveness of this program Innotech/Intera have been actively engaged in attending working group meetings and evaluating the potential long term and immediate market for remote sensing services. The next significant step, more or less in line with the Transfer Plan report, is expected to be an amendment to the current contract which will see the establishment of a dedicated remote sensing company offering services to the national and international community. As a result of this, and in line with the original concepts of industrial involvement, CCRS will be concentrating its efforts in the areas of applications development projects, sensor and systems research and development, and major remote sensing development programs such as the Aerial Hydrography Program.

4.2.6 Airborne Facility Availability to Users

The Data Acquisition Division has continued to make its facilities available to other agencies, both for their own projects and for joint projects involving CCRS. It is presently planned to broaden the scope of utilization of DAD facilities to include operational activities by proposing a new schedule of charges for the Airborne Cost Recovery Program. In 1977 it is expected to include operational use of the four DAD aircraft on a hourly lease basis.

76- 1	AIRBORNE OPERATIONS	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 2	AIRBORNE OPERATIONS	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 3	AIRBORNE OPERATIONS	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 4	AIRBORNE OPERATIONS	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 5	VAN RYSWYK DR. A.L.	AGRICULTURE CANADA
76- 6	OSWALD E.T.	D.O.E. CANADIAN FORESTRY SERVICE
76- 7	CIHLAR J.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 8	BUTTRICK S.C.	BRITISH COLUMBIA UNIVERSITY
76- 9	FLEMING J.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 10	BONN F.J.	SHERBROOKE UNIVERSITY
76- 11	BELL J.	DEPARTMENT OF INDIAN AND NORTHERN AFFAIRS
76- 12	GROSS H.	D.O.E. INLAND WATERS BRANCH
76- 13	MCRITCHIE DR. H.D.	MANITOBA DEPARTMENT OF MREM
76- 14	MCRITCHIE DR. H.D.	MANITOBA DEPARTMENT OF MREM
76- 15	IVERSON S.L.	ATOMIC ENERGY OF CANADA
76- 16	NIELSEN J.	MANITOBA DEPARTMENT OF AGRICULTURE
76- 17	KOVACS T./POOLE P.	PARKS CANADA
76- 18	RINGROSE DR. S.	MANITOBA DEPARTMENT OF MREM
76- 19	BROWN P.	MANITOBA DEPARTMENT OF MUNICIPLE AFFAIRS
76- 20	FERGUSON HOWARD	D.O.E. ATMOSPHERIC ENVIRONMENT SERVICE
76- 21	PROTZ R.	GUELPH UNIVERSITY
76- 22	BHEREUR P.	QUEBEC UNIVERSITY (MONTREAL)
76- 23	NIJDAM G.	HAMEL, RUEL AND ASSOCIATES
76- 24	REYNOLDS PETER	D.O.E. INLAND WATERS BRANCH
76- 25	NYLAND E.	YUKON LANDS AND FOREST SERVICE
76- 26	WIEBE J.	ONTARIO MINISTRY OF AGRICULTURE
76- 27	LARGE PEGGY	MANITOBA DEPARTMENT OF MINES
76- 28	MCDONALD BRENT	MANITOBA DEPARTMENT OF MINES
76- 29	JOHNSTON A.	AGRICULTURE CANADA
76- 30	DEMPSTER N.R.	SIMPSON TIMBER CO. (ALBERTA) LTD.
76- 31	PAGLIN R.	AGRICULTURE CANADA
76- 32	AHERN F.J.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 33	GIBSON J.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 34	BASU DR. P.K.	AGRICULTURE CANADA
76- 35	WALSH D.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 36	CHATTERJEE DR. R.M.	ONTARIO MINISTRY OF THE ENVIRONMENT
76- 37	CHATTERJEE DR. R.M.	ONTARIO MINISTRY OF THE ENVIRONMENT
76- 38	CROWN P.H.	AGRICULTURE CANADA
76- 39	CROWN P.H.	AGRICULTURE CANADA
76- 40	CROWN P.H.	AGRICULTURE CANADA
76- 41	CROWN P.H.	AGRICULTURE CANADA
76- 42	IRWIN P.S.	TRANSPORT CANADA
76- 43	MILLAR DR. J.B.	D.O.E. CANADIAN WILDLIFE SERVICE

76- 44	MILLAR DR. J.B.	D.O.E. CANADIAN WILDLIFE SERVICE
76- 45	BROADWELL C.	ONTARIO BEAN PRODUCERS MARKETING BOARD
76- 46	LAFRAMBOISE P.	JAMES BAY DEVELOPMENT SOCIETY
76- 47	BRICKER CAL	ALBERTA REMOTE SENSING CENTRE
76- 48	BRICKER CAL	ALBERTA REMOTE SENSING CENTRE
76- 49	BOHN A.	BRITISH COLUMBIA RESEARCH COUNCIL
76- 50	O'NEIL R.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 51	SYDOR M.	D.O.E. INLAND WATERS BRANCH
76- 52	JAQUES D.	CALGARY UNIVERSITY
76- 53	MCCOLL W.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 54	CAILLE A.	S.P.E.Q.
76- 55	O'DONNELL N.	MANITOBA DEPARTMENT OF MREM
76- 56	FINNIS J.M.	BRITISH COLUMBIA FOREST SERVICE
76- 57	GAUTHIER J.P.	QUEBEC DEPARTMENT OF NATURAL RESOURCES
76- 58	HOEFS M.	YUKON GAME BRANCH
76- 59	LE SAUTEUR D.	PARKS CANADA
76- 60	LADOUCEUR G.	LAVAL UNIVERSITY
76- 61	KEMPER J.B.	D.O.E. CANADIAN WILDLIFE SERVICE
76- 62	HAFFNER D.	ONTARIO MINISTRY OF THE ENVIRONMENT
76- 63	SOUCY A.	SOCIETE DE L'ENERGIE DE LA BAIE JAMES
76- 64	LAURIER R.	HYDRO QUEBEC
76- 65	ARNOFF S.	CALGARY UNIVERSITY
76- 66	MILLER DR. J.R.	YORK UNIVERSITY (CRESS)
76- 67	BALLANCE R.G.	DEPARTMENT OF NATIONAL DEFENCE
76- 68	BRIGHTON MAJOR F.	DEPARTMENT OF NATIONAL DEFENCE
76- 69	SOMMERFELDT DR. T.G.	AGRICULTURE CANADA
76- 70	ZWICK DR. H.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 71	HARDY N.W.	TORONTO UNIVERSITY
76- 72	O'NEILL R.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 73	O'NEILL R.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 74	MORTON J.A.	E.M.R. INTERDEPARTMENTAL COMMITTEE ON AERIAL SURV
76- 75	JAIN S.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 76	AHERN F.J.	E.M.R. CANADA CENTRE FOR REMOTE SENSING
76- 77	SLANEY V.R.	E.M.R. GEOLOGICAL SURVEY OF CANADA
76- 78	WOOLNOUGH D.F.	ALBERTA DEPARTMENT OF THE ENVIRONMENT
76- 79	ZIMMERMAN P.	HUDSON'S BAY OIL & GAS COMPANY LTD.
76- 80	TREW D.O.	ALBERTA DEPARTMENT OF THE ENVIRONMENT
76- 81	GALBINS J.	TRANSPORT CANADA
76- 82	BRICKER CAL	ALBERTA REMOTE SENSING CENTRE
76- 83	MORTON J.A.	E.M.R. INTERDEPARTMENTAL COMMITTEE ON AERIAL SURV
76- 84	LAWRENCE G.	ONTARIO MINISTRY OF NATURAL RESOURCES
76- 85	LAWRENCE G.	ONTARIO MINISTRY OF NATURAL RESOURCES
76- 86	MC AULEY J.	OTTAWA HYDRO

4.3 DATA PROCESSING DIVISION

4.3.1 INTRODUCTION

The major change in Landsat activities for 1976 has been the development of the Portable Receiving Station which has recently been moved to Shoe Cove, Newfoundland. We have continued to read out data from the LANDSAT I and LANDSAT II satellites for use in our Ice Reconnaissance, Forestries, and Agricultural programs. The Prince Albert station will continue to be our prime station for LANDSAT coverage when Shoe Cove is operational, the latter being used to provide the 10 most easterly orbits that cannot be received by Prince Albert.

The bulk image production function is to be moved from Ottawa to Prince Albert and Shoe Cove, leaving Ottawa to perform digital precision processing and production of specialized products.

4.3.2 PRINCE ALBERT SATELLITE STATION

The 26 metre auto tracking antenna at Prince Albert is capable of RBV, MSS and NOAA VHRR reception and recording. The CRT "Quicklook" camera system is capable of producing 70 mm film images of all of these sensor data. The quicklook products are generated routinely for distribution to users within a few days or a few hours by facsimile. The higher quality black and white photographic products are now reproduced and distributed from PASS using negatives supplied from the electron beam recorders (EBRs) at Ottawa. The Bank 6 LANDSAT data is used to prepare two sets of microfiche catalogues, one for each of the two LANDSATS. The Fiche are distributed daily to twenty agencies.

The small four meter antenna which was introduced last year at PA has proven successful for reception of NOAA VHRR data in both normal and backup formats, but suffers from a slight salt and pepper effect on the imagery when receiving LANDSAT data. The receiving margin is approximately 1.5 db and cannot tolerate the lack of centering of the main beam under manual control. In mid 1977 we are taking delivery of a multi image processing system (MIPS) which will perform the bulk production of imagery, and CCTs and provide a computer fax capability.

The MIPS equipment is being assembled by a Vancouver company for installation at PASS during the summer of 1977. Consisting of a minicomputer based processing system, data formatter, and a high resolution laser beam film recorder, real time imaging of four bands simultaneously of the LANDSAT MSS onto 9 1/2" black and white film is possible. The data can be from the telemetry downlink or existing high density tape recorders. Computer Compatible Tapes in the standard system corrected format and facsimile data direct from computer core may be generated after satellite orbit, from the high density tape. The hardware and software of MIPS is being made as similar as possible to the PERGS (see Shoe Cove) equipment to facilitate maintenance and future upgrades at the two receiving sites.

The Inland Waters Directorate of Environment Canada in cooperation with CCRS will install at the Prince Albert Station a data collection platform service to be operational in May or June of 1977. The system will be capable of receiving, decoding, processing, storing and distributing DCP data received from the GOES and LANDSAT satellites upon request.

The receiving system and facility are being provided by CCRS at Prince Albert. The decoding, processing, storing, and distribution system is being designed, fabricated and installed by SED Systems of Saskatchewan under contract with the Department of Supply and Services, Inland Waters Directorate of DOE. The system will stand alone from the present LANDSAT receiving system and will allow users to communicate with the system via dial-up telephone lines, or via telex. Modems will be required to connect telephone lines to the communication multiplexer. At present the four user communication channels are as follows:-

- 110 baud telephone dial up
- 300 baud telephone dial up
- 50 baud Telex dial up
- possibly higher data rates to be determined

More information on the use of the system can be obtained from Dr. Robert Halliday, Inland Waters Directorate, Hull, Quebec, or Roy Irwin, Station Manager, Prince Albert Satellite Station, Prince Albert, Saskatchewan.

4.3.3 SHOE COVE STATION

The Portable Earth Resources Ground Station (PERGS) was assembled and tested for several months at a site on the Vancouver International Airport. During a six week 'operational' phase the LANDSAT and NOAA spacecraft were tracked and representative data including quicklook imagery, CCTs, and facsimile products were produced. Some software diagnostic routines and hardware modifications were done at this time.

The system was then moved in the autumn of 1976 to the Shoe Cove Satellite Receiving Station (SCSS) site near St. John's, Newfoundland. The last months of 1976 were used in installing the antenna, trailer and associated equipment on the prepared mounts and hardsurfaced pads. Operational reception of LANDSAT and NOAA data will begin in early 1977 and routine production of digital and image data will be started in the second quarter of 1977.

The system consists of a 10 metre antenna and a trailer housing the reception, the processing electronics, and a small photographic laboratory. This system is capable of receiving LANDSAT MSS and NOAA VHRR data and producing quicklook products, computer facsimile signals, CCTs, and high density tape recordings. The high density tape recorder is a digital modification of a video tape recorder and can accommodate a bit rate of 7 1/2 megabits per second. Up to 30 minutes of data can be held on these tapes but the format is unique and does not contain all of the calibration information in the NASA HDDT format. The CCTs are produced in the format, described in our March report (CCRS Research Report 75-3), for both the LANDSAT and NOAA VHRR data. Due to the small quantity of data received by this station, this is the medium that we will use for transferring data from Shoe Cove to the Ottawa or Prince Albert facilities. Apart from some of the peripherals the MIPS and PERGS systems have a high degree of commonality in hardware and software. If the laser beam recorder system works out successfully at Prince Albert, it is intended to buy a similar machine for Shoe Cove.

4.3.4 DPD DATA HANDLING FACILITY

The Sheffield Road data handling facility contains three systems, an airborne remote sensing data processing system; a dedicated LANDSAT processing system; and a large scale computer for routine computing and image analysis. The Image Processing System built in 1972 has produced all of our products to date. It is capable of handling the RBV data in analog fashion and will be upgraded to handle the LANDSAT C RBV data next year. The Digital MSS data can be converted into sequential 4 band images. These images can be automatically registered for colour products by a colour composite enlarger that uses pin registration of the spocket holes to achieve colour registration. The IPS system can also produce thematic products by converting enhanced computer compatible tapes to black and white spectral separates. A mosaic of Canada has been generated from the bulk MSS imagery.

All products are annotated using the world reference system numbers and a computer retrieval system is used for searching for images by location, quality, cloud cover and time period. This, the information retrieval system, is run on the time-sharing computer, which contains a variety of peripherals including a scanning microdensitometer and colour display. The latter have been developed into a flexible digital interpretation facility.

A continuous strip film recorder has been built for producing images from CCTs and from Airborne Infrared Line Scanners. This system can produce 900 pixel wide strips from LANDSAT, NOAA, radar and other sensors, having the advantage of avoiding the photographic colour composite procedures. It has been used extensively for the generation of colour coded thermographs from airborne sensors, for day and night IR imaging from NOAA, for daytime visual imagery from NOAA. Two additional units are to be built for attachment to the Image 100 and the Multispectral Analyser and Display (MAD) Systems.

4.3.5 PRECISION DIGITAL CORRECTION

At present, only the major systematic errors are removed from LANDSAT and airborne digital imagery processed by CCRS. Some higher accuracy corrections are available on special request basis, using software. In applications such as agriculture it has been found that precise radiometric and geometrically registered images taken at different stagesin the growth cycle are needed to give good classification of the types of crops. Also, the images can be corrected to a particular map projection so that they can be directly related to existing map information.

CCRS is developing a general purpose digital image correction system (DICS) capable of performing radiometric sensor and

scene dependent corrections, geometric rectification, temporal registration, 16-point two-dimensional resampling and spatial filtering, on multi-channel digital imagery 8-bit data. The system consists of a DEC PDP-11/70 minicomputer, a RAMTEK colour display unit and a special purpose micro-programmed high speed corrector subsystem developed by OVAAC8 International Inc. The correction process is performed in two passes: correction parameter acquisition pass and the image correction pass. A library of ground control points containing digital imagery and cartographic information will be necessary to support the precise geometric correction operation.

4.3.6 AIR PROCESSING SYSTEM

Present airborne data collection systems record remotely sensed analogue or digital data in several formats. The sensors can be grouped into navigation and time parameters; profiling sensors; imaging sensors.

The data processing system developed at CCRS for handling airborne data begins with the conversion of the high density aircraft magnetic tapes to standard computer compatible format magnetic tapes. These computer compatible tapes (CCTs) are then processed to extract data for each sensor. Data from several sensors can be time correlated and provided to the user as plots, listings, CCTs or film prints.

The systems objective is to provide processed data to users of standard operational sensors and to provide easy access to data for experimentors and those engaged on sensor development projects.

User data products and capabilities include temperature sliced colour coded pictures from IR scanners, 11 channel multispectral scanner data on computer compatible tape, interactive enhancement and analysis of airborne imagery data on CCRS systems, and data for the geometric correction of airborne scanner data.

4.3.7 COMPUTER OPERATIONS

General usage of the Time-sharing System increased quite heavily during the year. Complaints came at an increasing pace from users remote to the main building who dial-in to the computer. However, this problem was solved late in the year when we were finally able to increase the number of ports from eight to fourteen. Further, the Alberta Remote Sensing Centre was given a dedicated port at this time for DATAROUTE access.

Unfortunately, the other problem area, tape drives, could not be addressed due to severe budgetary restrictions. The problem is two-fold: too few drives, and their high rate of down time. We hope to partially alleviate this quite vicious problem early in 1977 with the acquisition of two (and hopefully five or six more in 1978) 'super' drives.

Users with large amounts of data (i.e. a LANDSAT image) were directed more and more to private disc packs, and we can now handle most of the demand, having four spindles available at all times. Again due to budget cut-backs, we were forced to lay-off staff and cut back to two shifts at both the main computer centre, and on the Image 100. All information pertaining to computer-oriented services available including peripherals, media, timeslots, scheduling, etc. may be obtained by telephoning the Shift Supervisor on duty.

We now have a computer utilization and accounting system so that any user, on request, may get a detailed accounting of his usage of the Timesharing System.

4.3.8 SATELLITE SURVEILLANCE TASK FORCE

An interdepartmental task force was established in spring 1976 to study the surveillance needs of government departments and to what extent these needs could be satisfied by satellites. The group recommended that radar was a prime sensor for surveillance and that participation in SEASATA would provide the earliest opportunity for verifying performance of a satellite radar.

Recently a related Cabinet submission was approved for an experimental program involving:

1. Reception of SEASAT A data at Shoe Cove Satellite Station.
2. Development of a digital processor for the radar signals.
3. An experimental flying program using a rented radar system.
4. Developing a side-looking airborne radar.
5. Studying the effects of the ionosphere and sea-clutter on radar images.
6. Conducting space-radar performance verification experiments.
7. Exploring the opportunities for international co-operation in a radar satellite

program.

4.3.9 PRODUCT STATISTICS

The product statistics for our operations are shown in Table 1. There has been a decline in sales of photo products caused partly by an increase in product prices. We have not yet introduced a charge for our computer tapes but are seeking authority to do so at this time. At the same time we are introducing a royalty on all our products to offset the reception fee charged by NASA. We are expecting to recover 35% of our fee in this manner.

TABLE 1

	1974	1975	1976(to mid Oct.)
B & W Products	70,000	52,000	30,000
Colour Products	13,000	10,500	8.175
Master Scenes	25,500	45,700	64,000
Total Orbits Received	1,465	2,566	2,634
ISISFICHE Subscriptions	-	22	21
Facsimile	246	500	300
Dollar Volume	$150,000	$140,000	$170,000
CCT	430	559	377
Tape- EBIR	-	319	249
Backlog (Orbits) I	1,416	1,618	1,635
II	-	560	600

REPORT OF THE APPLICATIONS DIVISION

4.4.1 Introduction

Facing ever increasing demands on the Division's personnel and facilities, planning during the past year has focussed on consolidation. Efforts have been directed toward the identification of prime areas of applications potential as a framework for future activities and resource allocations. Systematic consolidation of the Division's image analysis facilities has been undertaken in order to accommodate increases in the volume and sophistication of demands and to more fully realize the potential capabilities of the equipment involved. Efforts to broaden and intensify contacts and interaction with users have continued this year, in recognition of the ultimate requirement for viable technology transfer.

4.4.2 Personnel

Although the Division has seen little absolute growth in manpower, a number of personnel changes have occurred during the past year. Dr. Ron Brown has joined the Methodology Section and Carolyn Goodfellow has filled the position in the Applications Development Section left vacant by Guy Rochon's return to teaching at Laval University.

The Division has been fortunate to acquire the services of several post-doctoral fellows at various times during the past year: Dr. Morris Goldberg, Dr. Ravindra Kumar, Dr. P.M. Narendra, Dr. Suresh Jain, and Dr. Victor Odenyo.

Ms. Gloria Leckie has recently joined the Division as Assistant Head of the Technical Information Service, replacing Brian Silcoff, who accepted a position at the National Library of Canada. Gloria will be working with Brian McGurrin in the consolidation of our Library resources and in the expansion of other user reference services. Growing interest in remote sensing applications among outside users has been reflected in increased requests for accommodation by visiting scientists and secondees. The Division hopes to continue its policy of welcoming such representatives from Canadian government agencies, universities and other countries, however limitations of space and resources in the Division will necessitate careful planning and coordination of all visits in future.

4.4.3 Facilities

4.4.4.1 Digital Analysis Equipment: Utilization of the digital analysis equipment in the Division has continued at a high level. This sustained demand further emphasized the value of a program of system consolidation and close user liaison.

In 1976 significant progress was achieved in the ongoing development of the CCRS Image Analysis System (CIAS), which includes the Image-100, and a PDS colour read-write microdensitometer. Both sub-systems contain dedicated minicomputers which are interconnected through a 44M word disk drive and an interprocessor communication link. The Image-100 includes a PDP 11/70 computer with 128K words of core, three terminals, two high speed tape drives, the Image-100, a printer/plotter, and a lineprinter. The PDS colour microdensitometer is a precision, flat bed type scanning microdensitometer interfaced to a PDP 11/40 minicomputer. The complete system will facilitate digital analysis of photographic products, and will permit the production of precise colour photographs from digital output tapes.

The Division supports, in addition to the CIAS, 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 applications research activities and demonstration programs.

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 or enhance any band or combination of bands, or to 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, and methods to be used, the quantity of data to be analysed, as well as the desired output products. At present, no charge is made for the use of these systems.

4.4.3.2 Visual Analysis Equipment: A wide range of visual analysis equipment is available within the Applications Division, including stereoscopes and light tables, a spot densitometer, a density slicer and a colour additive viewer. A hard copy device and the capability to superimpose map information have recently been added to the density slicer system. During 1976, a colour additive viewer and density slicer have been loaned to Newfoundland and Québec by CCRS.

4.4.4 Applications Division Projects

Scientists from the Applications Division have been involved in many research projects during 1976. Most of these projects involved joint effort with federal and provincial agencies, and Canadian industry. The projects fall into several general categories.

4.4.4.1 Agriculture, Land User:

- Evaluation of remote sensing techniques for speciality crop acreage measurement in Ontario and New Brunswick.
- The application of remote sensing to the determination of crop acreage, field sizes, rate of harvest, idle land, and woodlot distribution.
- Preparation of a manual for land use mapping with remote sensing.
- Preparation of a manual for crop identification and mapping using remotely sensed data.
- The development of remote sensing techniques for agricultural resource mapping in semi-arid regions of Kenya.

4.4.4.2 Water Resources, Hydrology:

- An attempt to develop a quantitative LANDSAT water quality index using the chromaticity transformation.
- An investigation of the characteristics and utility of LANDSAT MSS High Gain Data with special emphasis on the study of water quality, bathymetry and atmospheric effects.
- Mapping of the spatial and temporal distribution of suspended sediment as a prelude to the Fundy Tidal Power Development.
- Investigation of digital analysis of MSS data for the detection and mapping of snow under a forest canopy.
- An experiment involving the applications of microwave scatterometry techniques to sea ice study.
- The application of thermal infrared remote sensing to the mapping of sea ice.
- Establishment of operational techniques for the detection of chlorophyll and turbidity in water.
- Study of SAR imagery of ice (with DFE, C-Core, ERIM)

4.4.4.3 Geosciences:

- An evaluation of the use of LANDSAT

data for the mapping of surficial geology in various regions of Canada.

- Case studies in the application of LANDSAT data to geologic mapping for mineral exploration.

- Soil moisture determination by thermal IR remote sensing.

4. 4. 4. 4 Resource Evaluation and Monitoring:

- Monitoring the environmental impact of construction activities on the swamp lands in the proximity of Mirabel Airport.

- Integration of geomorphic and hydrologic information from small scale aerial photography.

- An assessment of LANDSAT imagery for use in biophysical land classification in Saskatchewan.

4. 4. 4. 5 Atmospheric Sciences:

- Investigations toward the provision of corrections for atmospheric effects on LANDSAT data.

4. 4. 4. 6 Management Activities:

- Representing the interest of users of the IMAGE-100 in the planning of future software and hardware developments for this system.

- Design, organization and management of a CIDA-sponsored project to develop an operational remote sensing capability in Peru.

- Participation in the establishment and operation of the Newfoundland Remote Sensing Facility as a Winter Works Project.

- Management of a visiting scientist seminar series.

4. 4. 4. 7 Digital Analysis Methodology:

- Investigation of clustering methods and development of rapid clustering procedures.

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

- Investigation of methods for radiometrically correcting LANDSAT data.

- Investigation of methods for geometrically correcting LANDSAT data.

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

- Research on feature selection techniques.

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

4. 4. 4. 8 Remote Sensing Systems Development:

- Development of the CCRS Image Analysis System (CIAS) Investigation of methods for optically analyzing synthetic aperture radar imagery. Implementation of a black and white microdensitometer.

- Development of an image analysis processor for fast Fourier transforms and maximum likelihood classification.

- Design and implementation of a reflectance spectroscopy facility.

4. 4. 5 Technical Information Service

The Technical Information Service provides a focal point for remote sensing in

Canada, and serves as a specialized node in a national network of scientific and technical information services. Professional staff maintain a large collection of remote sensing and related literature and slides, and an extensive LANDSAT satellite imagery library, as well as selected NOAA and Skylab imagery. They prepare CCRS reports for publication, distribte them, prepare displays, exchange information with other remote sensing facilities in Canada and abroad, and handle many initial user contacts and requests.

TIS attempts to provide an effective interface between information suppliers and information users through comprehensive acquisition of remote sensing publications, in English and French, and by cataloguing the subject content of these publications in machine-readable form so that they may be quickly located by the user. This has been accomplished by the funding and development of a remote sensing on-line retrieval system (RESORS) which is equally accessible from all parts of Canada, and by providing reference and loan services to the Canadian remote sensing community.

During the past year this service performed 4,648 information searches, supplied over one hundred thousand bibliographic references, and responded to 5,590 photocopy requests. During the same period RESORS staff acquired and indexed over 4,000 technical papers.

4.4.6 Publications and Presentations

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5.1 REPORT OF THE WORKING GROUP ON AGRICULTURE

5.1.1 AIRBORNE REMOTE SENSING

Twenty-one projects involving 3679 nautical miles were completed by the Data Acquisition Division, CCRS over agricultural areas involving experimental programs on crop classification, crop conditions, yield detectants, crop loss assessment, rangelands productivity, and land use. Several additional projects were completed by commercial agencies where sufficient research had been completed to provide a basis for defining specifications, particularly for the use of Infrared photography (False color) to meet specific requirements in relation to a disease study on beans and to a pasture program. Inability to obtain high quality imagery in New Brunswick and parts of British Columbia (Dawson Creek) was a serious problem to the overall program due to a variety of reasons. The acquisition and development of high quality image-processing of thermal I.R. taken in the Lake Erie area of Ontario in connection with a land evaluation program for a specialized crop was of particular interest during 1976. A preliminary program was begun in support of the HCMM satellite.

Most of the imagery obtained was 9x9 infra-red false-color, visual color, and thermal Line Scan taken at a range of altitudes from 2,500 to 36,000 ft. to provide a wide variety of scales for use in experimental, research and evaluation programs alone and in association with Landsat programs. Nearly half of the programs involved multidate imagery to meet imagery requirements for sequential and seasonal changes of vegetative conditions.

5.1.2 SPACEBORNE REMOTE SENSING

Development of methods for classifying crops and estimating crop conditions from satellite imagery was of prime interest under the Canadian-U.S. Spring Wheat Program (LACIE), under a CCRS-Provincial Program on Rangelands, and in a Special Crops Study in New Brunswick. Using a biomass indice procedure a high relationship was obtained from Landsat data (July) and Crop Reporting Yields (Harvest) for areas represented by the Spring Wheat Test Sites over a 3-year period ($r^2 \geq .95$). The results indicate less than 10% error may be expected 90% of the time in studies sponsored by Canada Dept. of Agriculture and Dept. of Supply and Services (Gregory Geoscience Consultants Ltd. Ottawa).

5.1.3 TECHNICAL DEVELOPMENTS

Yield losses from Bacterial Blight of Field Beans in Southwestern Ontario were determined on a routine basis in 1976.

Measurable levels of blight was detected by aerial/photography in 49 of 59 fields in a test area of 15 sq. miles near Hensall, Ont. Corn aphid infestation has been detected on I.R. color film and methodology developed for estimating the amount of infestation on a field basis. Photographically-enhanced and computer analyzed procedures determined levels of corn aphid infestation.

Recent preliminary field studies using active nicrowave radiation support previous laboratory results indicating possibility of measuring soil moisture within the root zone independent of the physical and chemical components of the soil system. Presently most microwave systems have measured moisture only in surface layers (mm's).

Highly illuminated areas on aerial photography from the spectral reflection of the atmosphere and the ground have seriously reduced the effectiveness of numerically analysing aerial-based imagery by either manual or automatic density scanning procedures. Initial results of characterizing such uneven illumination and correcting selected aspects of the imagery have markedly reduced the undesirable illumination in the final image in recent study conducted by the National Research Council of Canada.

5.1.4/5.1.5 APPLICATIONS AND BENEFIT ANALYSIS
5.1.6/5.1.7 USER LIAISON AND TRAINING

In 1975 a feasibility study on the application of remote sensing to operational programs in rangeland management under a contract sponsored by Canada Dept. of Agriculture and Department of Supply and Services (Intera Environmental Consultants Ltd.). This was followed by a proposal (Intera Environmental Consultants Ltd.) sponsored by Canada Center for Remote Sensing and Department of Supply and Services for a pilot program in 1976. Four rangement agencies in Western Canada cooperated in this program to provide the necessary intermediary stage between experimental-feasibility study programs and operationally oriented remote sensing programs. The pilot study was organized to enable each respective agency to assess the operation in relation to their own informational requirements. The four participating agencies were (1) the Forest Land Use Branch, Alberta Forest Service, Alta. Dept. of Energy and Natural Resources (Edmonton); (2) the

Lands Division Alta. Dept. of Energy and Natural Resources (Lethbridge); (3) the Crown Lands Division, Man. Dept. of Agriculture; and (4) the Renewable Resources Division Man. Dept. of Renewable Resources and Transportation Services. Assistance in training and interpretation of the remote sensing imagery was provided depending on the previous experience of the range managers with remote sensing. A documented report by Intera summarized the results involved from all agencies, evaluated the application of remote sensing to their operational range management programs, and detailed recommendations on future operational work needed in this area.

The emphasis in the interpretation of the False Color I.R. aerial photography (35mm, 70mm, and 188mm) and Landsat imagery (Color composite I.R.) was on the use of relatively simple and inexpensive methods that could be later utilized within range management agencies at current levels of funding and expertise for their operational programs. A range in scales and methods were used to obtain the various types of information needed (species identification, plant community associations, biomass productivity, general range condition.

Indirect measures and structured keys have been developed for use with aerial photography and used for analyzing form type in agricultural land-use planning (R. Ryerson). Such data can be useful for producing economic data about agriculture, are inexpensive to collect and sufficient for many types of analyses. Potentially operational would be acquiring information in relation to level of production, extension, financial assistance, and land-use change programs.

5.1.8 CONCLUSION AND FORECAST

5.1.9 RECOMMENDATIONS RELATED TO:

1) CACRS

a) That full support be given to the further development of a multispectral data acquisition system with high spectral resolution that would be readily available to Canadian users.

b) Because of the increase in variety of remote sensing data and lack of any good extension papers and/or demonstration models, be it resolved that C.C.R.S. support the development of teaching modules for sale to High Schools, Community Colleges and Universities.

c) That C.C.R.S. promote the practical applications of remote sensing with special reference to:

i) Preparation of a guide for potential users whose interest areas are application projects. These users would be researchers, extension personnel, agricultural producers and industry.

ii) Offering of courses to special interest groups who are involved in application projects. For example, a course could be given to a specific group involved in crop identification and special reference could be made to those particular agencies involved with it.

iii) Provision of funds for the development of a guide to agricultural applications of remote sensing with a view to increasing the number of practical users.

d) Because of i) the advantages to Canada of knowing about potential world food shortages; ii) the positive research results (to date) in crop identification by remote sensing; and iii) the lack of time available on the Image 100 at C.C.R.S., be it resolved that C.C.R.S. strongly support the purchase of a computerized classification instrument such as the Image 100 which would be continually available for operational users. The purchase of this equipment would shorten the time required to implement current research into an operational crop forecasting system.

2) Agriculture Working Group Activities:

a) The Agriculture Working Group establish a subgroup on the applications of remote sensing for crop identification studies.

b) Appreciation be expressed to V. Zsilinszky, Ontario Centre for Remote Sensing for hosting the Agric. Working Group in Toronto on November 4 and 5, 1976.

5.1.10 APPENDIX 1. CURRENT PROJECTS

5.1.10.1 1976 Completed Projects In Relation To Agriculture and Land-Use by CCRS
* Other agencies

Project No.	Requesting Agency	Principal Investigation	Geographie Area	Alt. ASL (ft)	Camero Format	Lens (Inch)	Film	Date (s) Flown	Shipped	Nautical Miles
76										
-5	Ag.Can.(Kamloop)	AL.Ven Ryswyk	Lac du Bois, BC	35,200	9x9	6	2443	Sept 1	Sept 30	15
					9x9	6	2445			
					IRLS					
					PRT5					
-10	Sherbrooke Univ.	F.J. Bonn	Sherbrooke Que	2.500	70	3	2405	May 28		70
				11,000	70	3	2405	June 1		
					70	3	2424	June 4		
					70	3	2443	June 5		
					IRLS			June 10		
					PRT5					
-18	Man Dept MREM Municipal Aff.	S. Ringrose	Lake Man/L Wpg	36,800	9x9			July 27	Aug 25	361
					70			Nov. 5	Nov 17	
					70					
					70					
					70					
					IRLS					
					PRT5					
-19	Man Dept M	R. Brown	Brandon, Man	35,000	9x9	35	2443	July 20	Aug 25	378
					70	3.0	2405			
					70	3	2405			
					70	3	2424			
					70	3	2425			
					IRLS					
					PRT5					
-21	Guelph Univ.	R. Protz	Lake Erul Ont	5,700	9x9	6	2443	Apr 9		
				15,500	9x9	6	2445	Apr 30	May 25	430
					IRLS					
					PRT5					
-23	Hamel, Ruel 4	G. Nijdam	Richelieu River	10,000	9x9	6	2443	May 10	26	462
					9x9	6	2445	June 5		
					IRLS					
					PRT5					

-26	Ont Min of Agric	J. Wiebe	Niagara Ont.	6,000	0x9	3.5	2443	Apr 23		118
				15,000	9x9	6.0	2443	30	May 21	
					IRLS			May 13		
					PRT5					
-29	Agr Can (Lethbridge)	A. Johnston	Stanely Alta	14,500	9x9	6	2443	Aug 22	Sept 22	14
					70	3	2424			
					70	3	2405			
					IRLS					
					PRT5					
-55	Man Dept MREM	N. O'Donwell	The Pas, Man	35,000	9x9	3.5	2443	Aug 16		485
					70	3.0	2405	Sept 19	Oct 21	
					70	3.0	2405	Sept 20/Oct 21		
					70	3.0	2424			
					IRLS					
					PRT5					
-60	Laval Univ	G.Ladouceur	Eastern Township	2,600	9x9	6	2443	July 28		15
					9x9	3.5	2443			
					IRLS					
					PRT5					
-69	Ag Can (Lethbridge)	T.G. Sommerfeldt	Claresholm Alta							
			Raymond	13,200	9x9	6	2443	Sept 14	Oct 29	82
					9x9	6	2405			
					IRLS					
					PRT5					
-78	Alta Depat of Env.	D.F.Woolnough	Vegreville	18,000	9x9	6	2443	Sept 16/Oct 20		15
			Alta	11,000	70	3	2445			
					70	3	2405			
					70	3	2405			
					70	3	2424			
					IRLS					
					PRT5					
-31	Ag Can (Ste Foy)	R. Paquin	Quebec City- Mont.	15,500	9x9	6	2443	June 1		38
					9x9	6	2445	June 4		
					IRLS			June 5		
					PRT5					
-34	Ag Can (Ottawa)	P.K.Basu	Picton Ont.	6.600	9x9	6	2443	July 5	July 16	24
					IRLS					
					PRT5					

-45	Ont Bean Prod	C. Broodwell	Clinton/Chatham Ontario	31,000	9x9 9x9 IRLS PRT5	3.5 6.0	2443 2445	Aug 17	Sept 16	18
-47	Alta Rem Sensing	C. Bricker	Lethbridge Alta Red Deer Medium Hat Calgary Edmonton	 21,000 36,000	 9x9 70 70 70	 3.5 3.0 3.0 3.0	 2443 2445 2405 2405 2424	 July 28 July 22 Sept 14	 Sept 1 1 Nov 12	 135
-48	Alta Rem.S.Center (Edmonton)	C.Bricker	Camrose alta	14,400	9x9 9x9	6 6	2443 2445	Aug 21 Sept 14	Sept 14 Oct 9	65
-52	Calgary Univ.	D.Jacques	Suffield Reserve	4.500 32,000	9x9 IRLS PRT5	6	2443	Aug 21	Oct 4	98
-95	PEI Dept of Ind and Com	N. Hall	P.E.I.	1,200 2.400	70 70 70 70 IRLS	3 3 3 3	2443 2443 2448 2448	Mar 3		186
-96	N.S. Energy Corenchl	J.Frenah	Nova Scotia	1,500 3,000	70 70 70 70 IRLS	3 3 3 3	2443 2443 2448 2448			510
XX	Ag, Can (Ottawa)	P.Crown	Test Sites (Spring	18,000	9x9	6	2443	July 15		160

5.1.10.2 APPENDIX II. LITERATURE CITED

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5.1.10.3 APPENDIX III. LIST OF GROUP MEMBERS (APRIL 1976)

1. 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) March 75 - March 78.

2. Mr. P. Crown, (Secretary), Alberta Institute of Pedology, University of Alberta, Edmonton Alberta, T6G 2E3 (403-432-4587) March 75 - March 78.

3. Mr. E. Brach, Engineering Research Service, Canada Department of Agriculture, Ottawa, Ontario, K1A 0C6, (613-994-9561) March 75 - March 78.

4. Mr. John Buchan, Plant Industry Branch, Saskatchewan Department of Agriculture, Administration Building, 3085 Albert St., Regina S4S 0B1 (306-527-1661) March 76 - March 79.

5. K. Wilkinson, Agricultural Division, Statistics Canada, #5 Temporary Building, Ottawa, Ontario K1A 0L7 (613-994-9888), September 75 - March 78.

6. Dr. L. Crosson, (Resigned)

7. Mr. Peter Mosher, Plant Industry Branch, P.O. Box 1600, Fredericton, N.B., E3B 5H1, (506-453-2108) March 76 - March 79.

8. Mr. A. Johnston, Research Station, Agri. Canada, Lethbridge, Alberta T1J 4B1, (403-327-4561) September 75 - March 78.

9. Mr. T.V. Martin, Canadian Wheat Board, 7th Floor N., 423 Main St., Winnipeg, Manitoba R3C 2P5 (204-985-3432) September 75 - March 78.

10. Dr. R. Paquin, Chercheur Scientifique, Station de Recherches 2560, Chemin Gomin, Ste. Foy, Québec, G1V 2JC (418-694-4020) March 74 - March 77.

11. Dr. R. Protz, Department of Land Resources Science, University of Guelph, Guelph, Ontario (519-824-4120) Ext. 2481, N1G 2W1, March 76 - March 79.

12. Dr. Awni Raad, Director, Soil & Crops Division, Department of Agriculture & Forestry, P.O. Box 1600, Charlottetown, P.E.I., (902-892-1267) March 75 - March 78.

13. Mr. F. Wind, Economics Branch, Crop Statistics, Ministry of Agriculture and Food, 1200 Bay Street, Toronto M7A 1B6 (416-965-1064) September 75 - March 78.

14. Dr. R.S. Rust, Economics Branch, Canada Department of Agriculture, Sir John Carling Bldg., Ottawa, Ontario K1A 0C5, (613-994-5571) March 74 - March 77.

15. Dr. A.L. van Ryswyk, Research Station, Canada Department of Agriculture, P.O. Box 940, Kamloops, British Columbia, V2C 5N5, (604-376-5565) September 73 - March 79.

16. Dr. R. Ryerson, Canada Centre for Remote Sensing, Department of Energy, Mines and Resources, 717 Belfast Road, Ottawa, Ont., K1A 0Y7, (613-995-1212) March 75 - March 78

17. Mr. A. McLeod, Research Coordinator, Sask. Wheat Pool, 2625 Victoria Avenue, Regina, Saskatchewan, S4P 2Y6 (306-596-4411) March 76 - March 79.

18. Mr. J. McKinnon, Prairie Agri. Photo, Carman, Manitoba (204-745-3718) September 75 - March 78.

19. Mr. C. Tarnocai, Department of Soil Science, University of Manitoba, Winnipeg, Manitoba (204-474-8153) R3T 2N2, March 74 - March 78

20. Dr. V. Wallen, Chief, Crop Diseases Loss Section, Ottawa Research Station, Canada Agriculture, Ottawa, Ontario K1A 0C6, (613-994-5555) March 75 - March 77.

Honorary Lifetime Member

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

5.2 REPORT OF THE WORKING GROUP ON ATMOSPHERIC SCIENCES

5.2.1 Training

The Working Group on Atmospheric Sciences organized a Workshop on Atmospheric Effects of Remote Sensing in cooperation with the Atmospheric Environment Service Panel on Remote Sensing. The topics covered at the workshop varied from acoustic sensing problems to atmospheric effects on remote sensing systems operating in the visual, thermal infra-red and microwave systems. The total registration was about 50 with representatives from the federal government, provincial governments, universities and industry. Interest in this aspect of remote sensing is obviously high and will increase as objective digital analysis of remote sensing becomes more widely used. The general feeling of the participants was that the workshop should be repeated every few years.

5.2.2 Conclusion and Forecast

Nineteen seventy-six was a year of inactivity for the Atmospheric Sciences Working Group. At the last meeting of CACRS it was decided to reorganize some of the CACRS working groups to better meet the changing applications of remote sensing within Canada. The Working Group on Atmospheric Sciences was singled out as one of the groups that needed significant changes in its terms of reference and was possibly to be divided into two parts, both subgroups of other working groups. The first subgroup, probably part of the Sensor Working Group, would concern itself with the Physics of Remote Sensing with emphasis on the effects of the atmosphere on airborne and spaceborne remote sensing. Members of this subgroup would be atmospheric scientists specializing in either remote sensing of atmospheric constituents or atmospheric effects on remote sensing. The second group would be made up of weather forecasters and would be concerned with the applications of data from non-meteorological satellites to weather forecasting and the impact of weather forecasting and surface meteorology on operational systems utilizing remote sensing techniques. It was suggested that this second group would probably be a sub-group of an Ocean Management Working Group. Unfortunately, the committee set up by CACRS to carry out the re-organization has been unable to complete its task. Meetings of the Working Group on Atmospheric Sciences were postponed until clarification of its future role had been obtained.

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.

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

In conjunction with the Canada Centre for Remote Sensing, the Canadian Hydrographic Service, and the University of New Brunswick work in progressing on the establishment of camera orientation parametres derived from the inertial navigation system (LNT-51) for the purpose of photogrammetric restitution of coastal photographs and the measurement of water depths. Correction of refraction for underwater points is carried out rigorously using the Analytical Plotter. The system was tested over the Sudbury test range and accuracy of ±0.5m in X and Y position and ±30 secs in pitch and azimuth was achieved.

5.3.2 SPACEBORNE REMOTE SENSING-SPACE TRIANGULATION USING SATELLITE IMAGERY

Studies at Laval University's Dept. of Photogrammetry (Mr. M.E.O. Ali & Dr. A.J. Brandenberger) on the combined aerial triangulation of SKYLAB photography and high altitude aerial photography were completed. High altitude(h=20km) aerial photography blocks were adjusted into short SKYLAB photography strips by means of a 3-dimensional block triangulations. Under favourable conditions an RMS error of ±20m is to be obtained for X and Y. Such an accuracy is sufficient to provide ground control for planimetric mapping at 1:250,000 and eventually up to and including 1:100,000. A study project for determining planimetric control from LANDSAT by utilizing several consecutive passes of the satellite is underway, also at Laval University.

5.3.3 TECHNICAL DEVELOPMENTS

A grid-modified polynomial transformation of satellite imagery has been developed by Dr. V. Kratky, NRC. Imagery produced by line scanners, and vidicon cameras, radio-transmitted to the ground and photo-reproduced in computer controlled electron- or laser-beam devices inevitalby results in geometric distortions of the images. These distortions can be corrected by a polynomial transformation. A modification of the analytical formulation increased solution efficiency and significantly reduced computation time and improved the accuracy of the solution(see Bibliography).

5.3.4 APPLICATION

The Surveys and Mapping Branch, EMR continued its use of LANDSAT imagery for the provision of revision information for new roads and reservoirs. With the development of a new aeronautical chart series at 1:500,000 having shaded relief, use of the imagery for this purpose is expected to increase. The imagery was also used successfully to position offshore hydrographic features(see Bibliography) for 1:50,000 mapping and to assist in hydrographic surveys of uncharted features along the coast of Labrador.

The Manitoba Remote Sensing Centre reported the use of LANDSAT imagery to map a large forest fire area southwest of Island Lake where approximately five townships were burned in 1974. This mapping was done for a total cost $88.00 and covered a total area of 120,907 acres. In addition to this use, map revision for roads was also carried out.

Mapping companies involved in providing cartographic and exploration services are using space imagery in a variety of ways. In the pre-planning of major construction projects where vast territories are traversed, suitable routes and possible alternatives are readily defined on enlarged copies of LANDSAT imagery. Preliminary cost estimates for implementation and construction can be approximated and direct planning of initial work tasks can be set forth. Recent examples of such projects have been a 900km railroad location study in Morocco, a similar study of 525km in Egypt and a 1,200km pipeline route in the Northwest Territories.

Weather satellites are providing useful information for the coordinated movement of photographic and geophysical airborne operations.

In areas of the globe lacking satisfactory map coverage, enlarged LANDSAT images provide a suitable base for placement of photographic and aeromagnetic flight lines. In conjunction with Doppler and other electronic navigation systems these "flight maps" have allowed completion of photographic and geophysical surveys in previously unexplored areas, and the enlarged LANDSAT imagery has, on occasion, served as a base for the compilation of planimetric maps on which the aeromagnetic information is presented.

5.3.5 CONCLUSION

LANDSAT imagery is accepted in the cartographic community and is in routine use for the purposes described in Section 5.3.3. It is unlikely that there will be any major change in cartographic applications from space imagery until a photogrammetric camera system is deployed in space. Future interest in this field centres on the large Format Camera to be developed for the Space Shuttle missions.

5.3.6 RECOMMENDATIONS

The Working Group formulated the following recommendations of its annual meeting.

It is recommended that continued effort is exercised by CCRS to maintain the best possible geometric quality of their products. In view of the recent disclosure of systematic differential scale changes associated with the earth rotation effect at extreme geographic latitudes, a study should be initiated to analyse these potential errors and modify current correction procedures.

It is recommended that Canada, through CCRS, express an interest in the acquisition of photography over Canadian Territory from the large format cartographic camera being developed for the Space Shuttle missions.

5.3.7 APPENDICES

5.3.7.1 Appendix 1 - Current Bibliography

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

5.4.1 Introduction

Two meetings of the full working group were held during 1976. In addition to continuing its monitoring of developments in the high-density digital recording field, the group focused upon the problems expected with future systems such as LANDSAT-D. During 1977, the group will investigate the problems associated with data distribution for satellite radar data. It was not possible to carry out the working group's plans to sponsor a Workshop on Synthetic Aperture Radar during 1976. The working group will consider the desirability and feasibility of sponsoring such a workshop at a later time, probably the summer of 1979.

5.4.2 Canadian Participation in Remote Sensing Satellite Programs

During the past year, a Mission Concept Definition Study of an operational remote sensing satellite system was completed and a task force on surveillance satellites made recommendations to the government. Canada should continue planning an early technological development activity towards the long range objective of an operational Canadian Remote Sensing Satellite program. Failure to do so will leave Canada in a position of merely reacting to satellite program proposals from other countries. Canada should maintain the option of a Canadian remote sensing satellite program as her stake in this vital technology and as her contribution to co-operative world wide efforts which will require several types of remote sensing satellite programs to cover all of the potential applications. In keeping with stated government policy on the implementation of space programs and the encouragement of Canadian industrial capability in this field, a remote sensing satellite program which has substantial practical and economic benefits to many areas of Canadian activity, can be well justified in the future.

One of the largest hurdles in bringing satellite remote sensing technology to operational fruition for many applications is that of achieving frequent and regular coverage of specific areas. At this time, it does not appear that U. S. satellite program proposals address this problem other than by launching a larger number of satellites. Canadian work should continue to focus on satellite systems which provide wide swath width, optimum orbit geometry for efficient coverage and microwave sensing through cloud cover.

The U. S. SEASAT program, which involves a satellite launch in 1978, will be a major step forward for microwave remote sensing and Canada should be ready to incorporate results of the SEASAT mission into plans for the future. Specific activity in the satellite related area should consider the following:

a) the impact of the Space Shuttle on future remote sensing satellite design;

b) the feasibility of deploying large antennas in space that operate at up to 10 GHz;

c) initiation by 1978 of a preliminary system design project to obtain detailed feasibility and cost data.

The sub-working group on Canadian Participation in Remote Sensing Satellite Programs will be addressing itself, in a general manner, to item (a) above and will aim to issue a report on the subject in late 1977.

5.4.3 Use of Remote Sensing CCT Data

In the working group's 1975 report, it recommended that a new CACRS working group be formed to concern itself with data formats and exchange of analysis techniques. CACRS in turn, recommended that the Working Group on Data Handling and Satellite Technology form this group as a sub-group of itself. This is now being done under the leadership of Mr. Fred Potts. Users of computer compatible tapes supplied by CCRS are now being canvassed to determine those with the most experience in dealing with remotely-sensed digital data on computer systems, other than those operated by CCRS. It is expected that the first meeting of this group will be held early

in 1977.

5.4.4 Recommendations

1. In order for Canada to maintain adequate knowledge concerning all options, planning and technological development should continue toward the long range goal of a Canadian remote sensing satellite program. This should include examination of the impact of the Space Shuttle on the design of remote sensing satellites, engineering studies on the feasibility of deploying large, high frequency microwave antennas in space, and initiation of a system design study by 1978.

2. In anticipation of LANDSAT-D and other high spectral and spatial resolution satellites, increased funding for research in the areas of pattern recognition, and image analysis should be provided, especially through NRC grants to universities.

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5.5 REPORT OF THE WORKING GROUP ON FORESTRY, WILDLANDS and WILDLIFE

During 1976, the previous chairman of the Forestry, Wildlands and Wildlife Group, Dr. Leo Sayn-Wittgenstein, resigned at the end of his term. Subsequently, Mr. Luc Jobin of the Laurentian Forest Research Centre was appointed chairman, but due to commitments to other projects he was not able to keep the appointment. No meetings of the group were held in 1976 and no report was prepared but it is expected that the activity of the Working Group will resume as soon as a new chairman is appointed.

5.6 REPORT OF THE GEOGRAPHY WORKING GROUP

5.6.1 Airborne Remote Sensing

During 1976 seven airborne projects designated as being of geographical interest were planned. All were for federal or provincial government agencies, except for one short flight requested by a university. In the end, however, only four of the missions were completed. None of the Geography Working Group members was associated with these projects, but as far as is known, they were completed with the usual efficiency.

A decrease to only 7 projects from a total of 28 two years ago may appear to represent a drastic drop in interest in the airborne program. In part this has been brought about by the move towards cost recovery. At the same time, however, it is not a true reflection of the use of data recorded through the airborne program. In several cases known to members of the Working Group, photography recorded in previous years is being used in current projects.

In last years report, members expressed concern about possible pricing policies that may be introduced during the transfer of the airborne program to industry. At the time of writing there is still no clear statement on this matter. Several members expressed concern that a person who initially requests airborne data has to pay proportionately a much larger cost than any subsequent user of the data. A more equitable arrangement would seem to be called for, or preferably the initial user should have some control over the availability of the data for a specified period of time. Members of the Working Group also felt that a certain portion of aircraft time should be devoted to applications development with costs of flying being subsidized. As was stated last year "only a policy of research time dedicated to applications development seems consistent with the aims of C.C.R.S. While the group supports the ultimate aim of cost recovery in the airborne program, 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".

Several members of the Working Group have encountered the thermal imagery produced by the Data Acquisition Division during the past year. Favourable comments were made on its quality and the introduction of the colour enhanced imagery was seen as a positive aid to easier interpretation.

The Working Group was pleased to hear of the progress made in using a balloon as a sensing platform. In spite of its comparative cheapness, members felt that one or more balloons plus camera systems should be made available on a rental basis during the initial evaluation period. Although it is realized that the payload is limited, it was suggested that the possibility for economically obtaining multispectral data from such a platform should be considered.

5.6.2 Spaceborne Remote Sensing

As last year, it was with regret that members noted that "C.C.R.S. still does not provide a simple statement of the LANDSAT program nor of the value and use of the image products". At C.A.C.R.S. last year, four working groups put forward a series of suggestions through which C.C.R.S. might "increase its efforts at marketing and acquainting the public with LANDSAT imagery". The preparation of the book "Eye in the Sky", written by D. Harper, is a step in the right direction, but cannot be considered as a substitute for a Technical Guide or publication similar to the Information Bulletin produced by the Airborne Operations Section of C.C.R.S. At the Working Group meeting in December it was learned that two special-purpose manuals concerned with land use and with crop inventory are in preparation. The publication of these manuals should be of particular interest to the user community. It is hoped that other developments in this direction can be reported by C.C.R.S. at the time of the C.A.C.R.S. meeting. Although the problem of manpower at C.C.R.S. is appreciated, members of the Working Group feel that the preparation of suitable publications should receive high priority in present activities.

Although earlier in the year there were complaints concerning the quality of black and white LANDSAT imagery, this problem appears to have been rectified. Particular mention was made of the excellent quality of some of the LANDSAT colour transparencies now being produced by N.A.P.L.

An area of concern to Working Group members during 1976 was the fact that the IMAGE 100 was not available from May to September. It is understood that this was due

to changes being implemented on the system. This five-month break is known to have caused inconvenience to several outside users and no doubt affected the work of others at C.C.R.S. The situation that occurred during 1976 highlights a dichotomy that is still apparent in the development of remote sensing. One part of the remote-sensing community is concerned with rapidly developing the technology of remote sensing. The need for this is clearly recognized, but it should not be at the expense of the other part of the community, namely users concerned with applications development. It is felt that at the present time the IMAGE 100 is being used to serve two masters, systems development and operational user, with more attention being given to the former. The result is dissatisfaction on both sides. It appears to the Working Group that there is a need for a digital system in which the emphasis is on meeting the requirements of the user. If necessary, consideration should be given to developing a system that is dedicated to the user. Only in this way can the development of operational uses based on digital analysis be given adequate testing.

As the number of IMAGE 100 users increases, the need to employ the system in the most efficient manner becomes more important. The establishment of a committee to review all applications for time on the IMAGE 100 is seen as a valuable move. In addition, Working Group members feel that advice from scientists in the Applications Development Section should greatly aid the new user in a speedy transition through the inevitable learning period.

Several members of the Working Group felt that advanced planning on costs of satellite data should be undertaken. As with the airborne program, price increases for all LANDSAT products and services should be announced at least a year and preferably longer in advance. The reasons for imposing the $200 charge per LANDSAT digital image during 1976 are realized, but such sudden increases do not assist attempts at long-range planning. Related to the $200 cost of LANDSAT digital images, it was pointed out that for a person concerned with monitoring of a comparatively small area, over several passes, the cost of tapes can become a major item. It was suggested that in such cases it should be made possible to have only the relevant area loaded on to the computer compatible tapes. The costs could then be prorated to the number of lines of data being used.

5.6.3 Technical Developments

The Working Group itself is not directly concerned with the introduction of technical developments. Following on from last years recommendation, however, that LANDSAT imagery be geometrically corrected so that it can be readily related to existing maps, the Working Group was pleased to note that this service will be made available in 1977.

5.6.4 Applications and Benefit Analysis

The number of geographers directly involved in developing applications for remote sensing is comparatively small. One of the major areas of interest,however, is the question of biophysical or ecological land classification. Several geographers are using both aerial photography (particularly small-scale colour infrared photography) and LANDSAT imagery in this type of study. The LANDSAT imagery is being used on an experimental basis in both its visual and digital formats.

A geographer is also undertaking a study of airborne and LANDSAT data for the inventory and monitoring of rangeland. Three range management agencies in the prairie provinces are involved in a pilot program which is designed to develop remote sensing as a fully operational tool for range management. INTERA,the company carrying out the study, has worked with each agency to plan an appropriate pilot program for a chosen study area, to carry out the necessary ground surveys in conjunction with acquisition of colour infrared photography and LANDSAT imagery during the 1976 growing season, to provide in-house training in data interpretation and analysis, to assist in the interpretation of the data, and to evaluate the results of the pilot program. It is anticipated that at the conclusion of the program each range management agency will possess the expertise to carry on with remote sensing within their operational programs.

5.6.5 User Liaison

There are two aspects to user liaison. The first concerns the relationships between C.C.R.S. and the user community. In this area, the Working Group has noted a recent improvement in both the content and the timing of the Newsletter, although the transmission of information by this means could still be more efficient. There are no doubt a variety of reasons which cause delay during production of the Newsletter and the Working Group would like to encourage C.C.R.S. in its efforts to overcome these and provide an even better service. It is worth emphasizing that the

Newsletter has an important value providing not only information to the remote-sensing specialist but also an impression of C.C.R.S. to many interested parties at present on the fringes of remote sensing. With regard to these fringes, however, it is suggested that they be tidied by an updating of the mailing list for the Newsletter, as many of the present recipients must already be beyond the fringe.

A second aspect of liaison involves the Working Group and the user community. As the Working Group was without a chairman from April until the late fall, user liaison on a formal basis was limited during 1976. At the present time, however, a short technical session and an open meeting of the Working Group are being planned for the Canadian Association of Geographers Annual Meeting to take place in Regina during June, 1977. From discussions at the Working Group meeting in December, it was felt that it is in the area of user liaison that the Group can make its most valid contributions, by acting as a catalyst for technical sessions at scientific meetings and by preparing or assisting in workshops.

5.6.6 Training

The Working Group was pleased to note a positive response to its recommendation, combined with a similar recommendation from the Working Group in Geoscience, that "C.A.C.R.S. should establish an ad hoc interdisciplinary committee to investigate the need for a Canadian training centre for the analysis of remotely-sensed data, ..." It is with interest that the Working Group waits to hear the report from the committee that has been established to consider this question.

It should be pointed out, however that C.A.C.R.S. is not the only organization that is currently concerned with training in remote sensing. The topic is also of interest to the Space Science Coordination Office of the National Research Council of Canada. In a letter to universities, the Director of the Office states that in a report entitled "Canadian Research Opportunities in Space", there is identified "a need for improved training in science for potential users of satellite remote sensing". The chairmen of departments of geography in Ontario universities are also interested in the extent of remote-sensing training at the graduate level. A report on this topic is at present being prepared for the group. With its responsibilities to the national program of remote sensing, it is hoped that C.A.C.R.S. can provide advice and direction on the whole question of training in remote sensing.

5.6.7 Conclusions and Forecast

It is still a fact that there are comparatively few people actively concerned with developing methodologies and procedures for using information from the newer types of remotely-sensed data in the various environmental disciplines. As is consistent with its mandate, it is realized that C.C.R.S. must continue to place its major emphasis in the area of technology development. There is a danger, however, that the technology will outstrip its application, unless an impetus is given to applications development.

It is often suggested that potential users will turn to remotely-sensed data if a definite need is perceived. It is suggested, however, that this is unlikely to occur during times of economic restraints and unemployment. There will obviously be a certain reluctance to invest money in the development of new procedures, and probably the purchase of new equipment, when the final outcome of a particular investigation is uncertain. The threat of innovation and the possibility of new procedures inducing redundancy are very real considerations which also militate against a major interest in applications development at the present time. The Working Group feels that until a stimulation is given to applications development, the gap between it and technology development will continue to increase.

5.6.8 Recommendations

As can be seen from the previous sections, there are a number of recommendations that can be made. At the request of the C.A.C.R.S. Planning Committee, however, these are being limited to three. The Geography Working Group identifies the following recommendations as being of prime importance at the present time.

5.6.8.1 It is recommended that costs of all remote sensing products and services be established as far in advance as possible. It is understood that for the airborne program, charges are at present being established one year in advance. Such a policy should also be applied in the LANDSAT program. Thus, at the start of the 1977-78 financial year, all costs of products and services for at least the 1978-79 financial year should be made available to the user community. In cases where a program is to be continued over a two or three year period, it should be made possible for the investigator to negotiate firm prices for the duration of the project.

5.6.8.2 During 1976, the IMAGE 100 was unavailable for almost half a year due to system developments and building modifications to accommodate these. This emphasizes the dichotomy between systems development and operational use. It is recommended that a digital analysis system be made available at C.C.R.S. for which the first priority is the user concerned with the development of operational applications of LANDSAT data.

5.6.8.3 As recommended in the last two C.A.C.R.S. Reports, the Geography Working Group feels that high priority should be given to disseminating information about LANDSAT and its applications through the publication of technical manuals and sample studies.

5.6.9 Appendix I
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5.7 REPORT OF THE WORKING GROUP ON GEOSCIENCE

5.7.1. The previous Working Group Chairman, Dr. A. L. Gregory, retired in the spring of 1976 after serving for 6 years. The appointment of a new Chairman was delayed while it was determined whether or not the Working Group should continue to function in its present format or perhaps be combined with some other group. Some concern was expressed during the 'quiet' of 1976 that the Working Group should be revived. As a result Dr. Morley called a meeting in February 1977 at which it was generally agreed that a Geoscience Working Group is needed. An election was held which resulted in the appointment of V. R. Slaney as the new Chairman. The first official meeting of the group will be in May, after the CACRS Conference.

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5.8 REPORT OF THE WORKING GROUP ON HYDROLOGY

5.8.1 Airborne Remote Sensing

Airborne radiation thermometry (ARTS) surveys of the Great Lakes in the Saint Lawrence River continue to be undertaken on an operational basis by the Atmospheric Environment Service. In extention of this, new work is being undertaken using satellite infrared data to obtain surface water temperatures of the Great Lakes.

In Prince Edward Island available films stocks of low altitude false colour IR are being used to locate existing subsurface drainage systems as a part of land management use study.

Aerial photography of dye plumes for the detection of the effects due to thermal pollution were undertaken in two areas - New Brunswick and Saskatchewan. In the New Brunswick study a balloon with a motorized camera was towed behind a boat along a tributary of the Saint John River. The Saskatchewan Research Council used vertical photographs to study the mixing length and dispersion rates by qualitative calculations from photographic density slicing and quantitatively from fluorometric samples taken from the river at the same time. The Saskatchewan Research Council, for the fifth year flew a small prairie watershed for studies of the area of snowmelt involved with runoff. The University of Saskatchewan again flew a short and long wave radiometer from a helicopter during prairie snowmelt.

Studies of the use of gamma radiation for determination of snow water content and soil moisture continue though activity was low during the year. The Atmospheric Environment Service at their Woodbridge Experimental Site are using a small portable gamma spectrometer mounted about one meter above the surface close to a large sensitive weighing lysimeter to take in-situ readings during snow free and snow covered conditions. This work should lead to a better quantitative understanding of airborne readings.

The Environmental Radioactivity Section of National Health and Welfare operates a nation wide network of stations in cooperation with Department of Fisheries and Environment, provincial and private agencies to study the spatial and temporal variations of natural gamma radiation. The detectors are small thermal luminescent dosimeters. They are placed at one meter above ground at the beginning of the observation period and collected afterward to be read in the laboratory. The readings can be used to determine the water equivalent of the snowcover or the soil moisture content. The advantages of this method are the cheapness and re-usability of the detectors which do not require a power supply. The flexibility and ease of field operations. The method is primarily useful for providing better ground truth for airborne gamma surveys.

Several aerial survey contractors now have the capability to complete high sensitivity airborne gamma ray spectrometry. While this capability, developed for the mineral industry, could be adapted to measuring water equivalency of snow, no such commercial application has been reported. However, the Environmental Management Service Ontario Region and Inland Waters Headquarters are cooperating in a planned pilot study to fly the whole of the Lake Superior basin on contract.

A series of research flights with the objectives of seeing what can be learned about the properties of snow on the ground from microwave data (SLAR) is being conducted over the experimental forest and farm at Fredericton in March 77. This study is related to the problem of determining snow under forest cover as mentioned elsewhere. This is particularly an exercise in multispectural analysis using CCRS facilities. The data is being picked up on return flights of aircraft from the C-CORE/ERIM Sea-Ice Project off the Labrador Coast.

The Quebec Water Quality Service has been conducting a summer experiment near Quebec City, co-jointly with the "Equipe télédétection" lands and forests. It used a 70 millimeter camera flown on a captive balloon platform to try to identify aquatic vegetation around Lake St-Augustine. The vegetation could then be directly linked with water quality in the lake. The results are still not complete.

5.8.2 Spaceborne Remote Sensing

The Canadian contribution to the WMO Snow Studies by Satellite Project was brought to a successful conclusion with the presentation of five reports at the International Seminar held in Geneva in October. The Canadian studies were coordinated through the Task Force on Snow and Ice (H.L. Ferguson, Chairman) of the CACRS Working Group on Hydrology. Reports were prepared by scientists from AES, Inland Waters Directorate of EMS, B.C. Hydro and the Canada Centre for Remote Sensing. A number of provided agencies "ground truth" data for the projects. Basic

imagery used in the analysis was NOAA/VHRR Imagery received by the AES Satellite Data Laboratory in Downsview, enhanced to facilitate snow cover analysis. This was supplemented by LANDSAT I and II data for the period February to April 1976. Snowcover analyses using conventional surface data only were compared to analyses based on surface, some airborne and satellite data.

Report No. 1 - by D.A. Sherstone, summarizes the results of studies of 7 basins in the mountainous region of western Canada from May to October, 1975. Comparisons were made of analyses of NOAA visible and IR and LANDSAT imagery, independent analyses of NOAA data carried out by Mr. S. Schneider (N.E.S.S. Washington) and B.C. Hydro analyses on snowline flights (provided by Mr. U. Sporns). In general lower values of percentage snow cover were obtained by the author than those from snowline flights.

Report No. 2 - by U. Sporns, covers the Columbia River drainage above Mica Dam where the basin percentage snow cover is used as a direct input for similation models for hydroelectric power and reservoir operations. The report describes aircraft "snowline flights" carried out by B.C. Hydro and compares results with analyses of NOAA, visible and IR data provided by NOAA/NESS, in 1975 and 1976. An attempt was made to analyse digital LANDSAT data but it was found that there was insufficient cloud free data for operational purposes and data are not currently available soon enough for real time applications. At lower elevations coniferous tree cover is too dense to permit recognition of snow cover using NOAA Satellite Imagery. Difficulties are encountered in distinguishing between snowcover and bare limestone rock with NOAA visible imagery however this problem can often be resolved using NOAA daytime IR imagery. Because of the lack of ground truth information, it is not possible to say whether or not satellite data are of comparable accuracy to the aircraft data or how either method compares to true values.

Report No. 3 - by R.J. Prins, covers the Lake-of-the-Woods Watershed where lake levels are regulated by an International Control Board. Analyses of NOAA-4 imagery, obtained from Washington, were carried out for the snowmelt season of 1975-1976. In many areas, because of forest cover the positioning of the snowline was interpolated from lakes and clearings and felt to be rather uncertain and subjective. No reservoir release decision has yet been made on the basis of satellite imagery analysis. However, the technique is sufficiently promising that analyses will be continued in 1977.

Report No. 4 - by H.L. Ferguson and S. Lapezak, deals basically with the analyses of NOAA-4 imagery for the Saint John and Souris basins, obtained directly by the Atmospheric Environment Service in Toronto, for the period February to April, 1976, and supplemented by LANDSAT images received from Prince Albert, Saskatchewan with a time lag of a number of months.

In the Saint John Basin while a relatively large amount of conventional surface snowcover data is collected, as compared to other areas in Canada, little of this information is currently available in real time and much of it takes the form of weekly to monthly observations. Analyses of basin snow cover using surface data alone are compared to results using both surface and satellite data. A snow survey aircraft flight was carried out on April 15, 1976 and simultaneous images obtained by aircraft, NOAA-4 and LANDSAT-2 are compared. Problems of interpretation of NOAA imagery particularly in forested areas, and ground truth problems are discussed. Independent analysis of NOAA imagery carried out by NOAA/NESS in Washington during 1975 and 1976 snowmelt season and transmitted via facsimile circuit to the flood forecast center in Fredericton with a time lag of 1 to 2 days were used operationally to check and adjust sub-basin snow cover values used in the SSARR model for predicting streamflow on the Saint John River.

In 1976 analysis was carried out on 15 enhanced NOAA-4 images of the Souris Basin and reference was also made to 11 LANDSAT images. There is evidence that image brightness in a given area can be calibrated to yield a rough estimate of the snow depth in areas of shallow snowpack over flat grass-land with relatively uniform land use. The high-resolution LANDSAT images were found to be useful in detecting snow in individual gullies which could not be resolved by the NOAA imagery. This is important since in this type of terrain significant snowmelt runoff may originate from snow accumulated to many meters depth in gullies as compared to the few centimeters in adjacent fields.

Report No. 5 - by T. Alfoldi describes the analyses of computer compatible tapes of LANDSAT data using the General Electric Image - 100 and the Bendix Aerospace Modular Interactive Classification Analyser (MICA) at the Canada Centre for Remote Sensing. Three images were analysed: the LANDSAT-II images of New Brunswick, including part of the Saint John Basin, for 21 February and 15 April, 1976, and the LANDSAT-1 image of Baffin Island for 11 August, 1974. A scheme is proposed for developing operational procedures on the image 100.

For the past two years Gregory Geoscience Limited has operated a subscription service that provides weekly small scale reports on the cover of snow, lake ice and sea ice in the Yukon and Northwest Territories. The snowline and ice cover on lakes is also forecast for two weeks in advance of the report data. The reports are based on LANDSAT, NOAA and daily meteorological data. Experience during the break-up to freeze-up season in both 1975 and 1976 show that forecasts have an average accuracy of better than plus or minus three days. Further improvements in forecasting are planned especially for the transition zone between forest and tundra.

A new approach to quantitative geomorphology has been developed by W. Good and E. Langham using discriminant analysis of factorial correspondence using selective LANDSAT imagery in various parts of Canada. Factors were developed from 21 parameters describing lake shape. Research on the hydrological applications is still proceeding.

The Quebec Underground Water Service has been using LANDSAT imagery to try to recognize aquifers from the geological evidence. It is also planning to use captive balloon technology in hyrogeological work.

A version of the principal components image enhancement program is available on the PDP 10 system and the Image 100, for all users of the Bendix Multispectral Analyser Display at CCRS Sheffield Road. It has been used for water quality studies in Lake St-Jean, recession of snowline on glaciers and in the Canadian Cordillera.

B.C. Hydro is supporting a study to estimate aerial precipitation in certain B.C. drainage basins through analysis of clouds as seen on NOAA Satellite imagery and tapes by relating cloud type classifications and cloud top temperatures to their average rainfall production over the basins. They are also supporting a study for measurement of snow cover to provide input to runoff simulation models. This developed from a 1973/74 study using ERTS data and will modify procedures to use NOAA data on larger basins to define spectral signatures of snow under various conditions and to discriminate between snow and clouds or sun-glint.

5.8.3 Technical Developments

The highgain mode of the LANDSAT MSS provides a three time amplification of the detected radiance before digitization resulting in a three time increase in the radiometric resolution and range of the lower third of the normal sensitivity range of bands 4 and 5. This feature provides an expansion of the low-radiant data in these bands to better describe water features, shadowed areas and other "dark" objects. As an example, a barely perceptable sediment or pollutant plume in a lake that nearly matches the background water in tone may be more easily defined on a "high gain" image, or, the snowline on the shadowed part of a mountain may be more definitively located using high gain data.

The Quebec Hydrometrical Service has been operating a GEOS communication platform on an experimental basis since 1976 about 20 miles south of Chicoutimi to test the reliability of hydrometric and meteorological instruments in cooperation with the Meteorological Service. So far water levels, relative humidity, precipitation intensity and a battery voltage check have been transmitted. Readings are recorded every 15 minutes and a transmission of 12 readings is made every 3 hours. Data is received from Washington via Toronto on the meteorological communication system.

5.8.4 Applications and Benefit Analysis

Applications are covered in other sections and there have been no specific benefit analysis studies reported.

5.8.5 User Liaison

The main effort in user liaison was the holding of the 9th Hydrology Working Group Meeting in Charlottetown, PEI August 25-26, 1976. This meeting was held primarily for exchange of information with local users of remote sensing and was attended by 10 observers who took an active part in discussion and made presentations on work underway in the Atlantic area.

5.8.6 Training

A workshop on Remote Sensing of Soil Moisture and Groundwater was held in Toronto, November 8 -10, 1976. It was organized by the Canadian Remote Sensing Society in cooperation with the Hydrology Working Group of CACRS. Approximately 60 persons attended, representing the interests of agriculturalists and hydrologists primarily but also of those involved in the development of remote sensing methods as well as those interested in the applicability of current technology to particular field problems. The technical program was designed within rather broad terms of reference and considered any indirect method of measurement to be an appropriate topic for discussion. The first technical session served to introduce the problem faced by the

agriculturalists and hydrologists with respect to soil moisture and groundwater. The three sessions which followed considered the application of surface, airborne and space borne techniques respectively to the sollution of these problems. The final session was devoted primarily to an open discussion. A tour of the facilities of the Ontario Centre for Remote Sensing was arranged for the afternoon.

The state-of-the-art with respect to operational aspects determining soil moisture and/or groundwater with airborne techniques does not appear to have progressed very far since the launch of LANDSAT in 1972. On the other hand, technology for new satellites, sensors, processing equipment, etc. is progressing at an almost unbelievable pace. The main applicability of remote sensing as noted from papers presented at this workshop still appears to be in classification and inventory surveys. Interpretation of subsurface features, with the exception of conventional geophysics, is primarily accomplished by inference from features or characteristics of the land surface or vegetation. Depth penetration remains in the realm of further research using longer wave-length electromagnetic radiation. Measurement of soil moisture using radioactive means can be classified as almost operational for the most part. Although the transfer of this technology to airborne status is still in the experimental stage. Some better promise for the measurement of soil moisture on an airborne basis appears to exist in the microwave frequencies.

The proceedings of the Workshop may be obtained from Mr. P. Cobbett, Canadian Aeronautics and Space Institute, 406-77 Metcalfe Street, Ottawa, Ontario K1P 5L6.

5.8.7 Conclusion and Forecast

In the field of hydrology there is a tendency to think of remote sensing as an end in itself rather than as a useful tool that must be used in combination with others. This tool has proven its practical value in research but considerable effort is still needed to get it widely used on a regular operational basis. At present it is closest to being operational in measuring snow cover and snow water content. Operational snowcover mapping for selected important drainage basins in Canada could be accomplished most efficiently by one central office, utilizing the best techniques, and developing expert knowledge and experience. Cooperation between the most knowledgeable agencies, CCRS, AES and IWD, would be required to prepare a suitable development program which could be implemented by an appropriate agency.

Near real time snowmelt data is being obtained largely from NOAA weather satellite data and is checked by more detailed LANDSAT imagery. Results indicate that the major obstacles to overcome are forest cover and delays in receiving data. The greatest potential for improvement appears to lie in automated analysis and integration of data from improved microwave sensors. Developments in this direction also hold promise of an ability to measure snow water equivalent and possibly soil moisture though sensors with greater ground penetration will be needed for the latter and for groundwater.

The need for real time information, particularly as related to flood forecasting, requires continued attention to rapid processing and distribution of data. The specialized skills and equipment required would indicate the need for close coordination of effort possibly at a centralized facility. Such a facility could also develop an ability to provide area precipitation and estimates of basin precipitation which is a year round requirement.

5.8.8 Recommendations

The Hydrology Working Group recommends that CCRS continue to strongly encourage implementation of demonstration projects and the development of these to an operational status particularly by facilitating wide use and adaption of available technology. The following areas show most promise of success.

i) The WMO Snow Studies by Satellite Project has indicated a number of areas with strong potential for operational use.

ii) Research should be encouraged into measurement of snow under forest cover.

iii) Encouragement should be given to more effective applications of the use of existing gamma ray technology to measurement of snow water equivalent and the potential measurement of soil moisture.

iv) Attention should be given to the application of pattern recognition techniques to estimating regional and basin precipitation from cloud cover.

5.8.9 Appendices

5.8.9.1 Appendix I - List of Group Members

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5.9 REPORT OF THE WORKING GROUP ON ICE

5.9.1 AIRBORNE REMOTE SENSING

5.9.1.1 Passive Microwave Radiometer

The 4.99, 13.4 and 37 GHz radiometers used in March-April 1976 at AIDJEX Big Bear were mounted on the Flextrack vehicle and surveyed the remaining sections of ground-truth test sites. Together with the surveys of April and October 1975 sequential changes over melt-freezup seasons have been analyzed.

5.9.1.2 Scatterometer and Infrared

In Spring 1976 the CCRS DC3 flew the scatterometer, IR linescanner and visual sensors over the sea ice off the coast of Labrador (off Cartwright) and Forteau Bay, Newfoundland. Extensive ground truthing from shore to the shorefast ice limit was carried out by C-CORE and Memorial University. The same instrument package was flown over shorefast ice near the proposed nuclear power site at Bay of Chaleur, New Brunswick and over floating ice south of Prince Edward Island in Northumberland Strait.

Colour IR was flown by the International Ice Patrol for C-CORE, over icebergs at various heights for iceberg grounding and statistical studies.

5.9.1.3 Radars

The Ice Research Program of Defence Research Establishment, Ottawa, took a leading role in Exercise BRISK, a joint UK/Canadian operation to obtain coordinated, near-simultaneous top and bottom profiles of ice in the Arctic Ocean. HMS Sovereign carried out a triangular cruise to the pole, with Dr. Peter Wadhams (Scott Polar Research Institute) in charge of profiling, while the MP and EU Argus flew most of the same track with SLAR, laser profiler and IRLS. DREO will analyze the SLAR and IRLS imagery, the profile analysis will be conducted by SPRI.

The Communications Research Centre has recently completed major modifications to the DND AN/APS-94D SLR system aboard an Argus aircraft. The microwave sub-system has been made coherent, and new signal processing sub-systems have been added to provide:

1. a coherent MTI mode
2. a doppler beam-sharpened FTI mode with improved azimuth resolution by factors of up to 20, using the existing AN/APS -94D on-board, real time display
3. a fully synthetic aperture imaging mode using the on-board film display to record interferograms for subsequent optical processing on the ground. An associated project at DND/DREO provides an optical processing system.

These objectives have now been met and successful imagery obtained in all of the new modes. The resulting new radar is now a candidate for development in industry to meet Canadian requirements.

In August 1976, detailed airborne ice thickness mapping surveys were carried out in the Yukon Territory using the University of British Columbia 840 MHz pulsed radar system. The three glaciers surveyed (Rusty, Trapridge and Hazard) are all known to be cold and excellent results were obtained. In addition, a reconnaissance traverse in the vicinity of the NW col of Mt. Logan was flown with the purpose of guiding the selection of a suitable ice coring site. Maximum thickness sounded was 450m.

Bottom profiling of icebergs and pressure ridges is being attempted using the UBC 840 MHz airborne radar system. Work is being carried out in cooperation with Innovative Ventures Ltd., Calgary. It is hoped to convert the system from photographic to analogue magnetic recording to allow subsequent ground-based digitization and computer processing.

5.9.1.4 Aerial Photography

The Imperial Oil drilling program in the Beaufort Sea relied once again on a series of photo reconnaissance flights for knowledge and prediction of ice conditions in 1976.

Glaciology Division, Fisheries and Environment Canada, utilized aerial photography in many of its studies. In particular, photogrammetric and interpretive techniques were used for stream velocities and breakup of ice at various Arctic Island locations and the Mackenzie River, for river crossings of the proposed Arctic Island pipeline and for regional mass balance studies in the Queen Elizabeth Islands.

5.9.2 SPACEBORNE REMOTE SENSING

LANDSAT imagery has been used by Glaciology Division for a study of the surging Tweedsmuir Glacier. Imagery of the Beaufort Sea, Arctic Islands and east coast is being used by the Oil Industry to augment and improve historical ice data for these areas.

LANDSAT and NOAA infrared imagery has been utilized extensively at the Institute of Ocean Sciences in Victoria in studies of possible oil-spill trajectories associated with future petroleum developments in the Sverdrup Basin and Lancaster Sound in the Arctic Islands.

5.9.3 TECHNICAL DEVELOPMENTS

Preliminary discussions have taken place between the Transportation Development Agency of MOT, Canadian Coast Guard, AES/Ice Branch, CRC and Carleton University for the development of a "tactical" radar system for sensing sea ice thickness. This will probably be mounted on a ship-based helicopter, with calibration of the system for ice dielectric properties on an area basis being carried out by thickness observations at the ship as it moves along.

The Atmospheric Environment Service, Fisheries and Environment Canada, has completed a set of specifications for a SLAR system for ice reconnaissance purposes. A contract was let and completed for an Ice Reconnaissance Systems Definition Study. Implementation of the results of the study would produce a system to integrate all of the remote sensors (including SLAR) for map compilation on a uniform scale, and would also incorporate the data annotation outputs.

An automatic data annotation system is being installed on the current ice reconnaissance aircraft and will be operational in the 1976/77 winter season. This will probably speed up the annotation on the large volume of camera, laser, IRLS and ART data.

Development work on a passive microwave radiometer for measuring ice thickness, by SED Systems Ltd., terminated during the year. A committee is being organized to examine the next approach to the problem, but no further effort will be made to use UHF radiometry.

5.9.4 APPLICATIONS AND BENEFIT ANALYSIS

Atmospheric Environment Service has used the laser profilometer, infrared line scanner and ART on an operational basis when conditions warranted their use. High quality satellite imagery from NOAA-VHRR (year round at Data Laboratory, Toronto) and LANDSAT (summer only at Ice Forecasting Central) were copied by telephone facsimile in near real-time for input to the daily ice forecast charts and broadcast ice charts. Also ice information was broadcast direct from aircraft to ships as preliminary data extraction was being done during flights.

5.9.5 TRAINING

The Specialist Workshop on Remote Sensing of Ice has been delayed but a good response received from intending participants.

Memorial University and C-CORE are holding a course on "Radar Systems for Remote Sensing" in January 1977.

5.9.6 FORECASTS

The next major milestone which needs to be achieved over the next two years is the development of an operational active microwave imaging system for our ice reconnaissance program. Canadian shipping interests are pursuing plans to build ships for operations in the Arctic Islands starting operation as soon as the summer-fall period of 1977. In order to support this industry initiative, Canada should be in the position to provide near real time accurate ice information to ships operating in ice infested waters.

5.9.7 RECOMMENDATIONS

The Working Group on Ice recommends that:

1. In view of the planned Canadian surveillance satellite program (including participation in SEASAT-A) user familiarization experiments should begin immediately using aircraft-borne imaging radars and complimentary sensors. These experiments should put a heavy emphasis on the acquisition and analysis of ground-truth information together with the remotely sensed data. The program should include the rental of a system such as the ERIM dual frequency radar (such a project is underway) to do initial correlation between X and L-band imagery. It should also include the development of a multisensor aircraft system for experiments including verification of SEASAT-A data. This system should be capable of Arctic flights and should be specified in consultation

with user groups such as the oil and gas industry (APOA and EPOA) the marine transportation industry and government agencies.

2. CACRS strongly support the immediate acquisition of SLAR systems for the Canadian operational ice reconnaissance program, as these are the only existing technology systems which can provide all-weather day/night ice observations over broad areas, on an economical basis. There is an urgent need to establish a year round data base for Arctic areas prior to the commencement of extended-season industrial off-shore operations.

3. To ensure access to the existing data base by all potential users, a Canadian data management system should be developed immediately. Moreover, the management of data should be made an integral part of the development of all new remote sensing systems.

5.9.8 APPENDICES

5.9.8.1 Appendix I - Current Projects

Summary of current research on snow and ice in Canada - 1976 by R. Frederking, Associate Committee on Geotechnical Research, Technical Memorandum No. 118, National Research Council of Canada, May 1976.

Glaciological Investigations in Canada - 1976 by C.S.L. Ommanney, Glaciology Divsiion, Department of Fisheries and the Environment, Ottawa, submitted to Ice (New Bulletin of International Glaciological Society), February 1977.

5.9.8.2 Appendix II - Current Bibliography

Bibliography of Canadian Glaciology, 1975 and 1976. C.S.L. Ommanney, Glaciology Division, Department of Fisheries and the Environment, Ottawa, 1977.

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5.10 REPORT OF THE WORKING GROUP ON LIMNOLOGY

No meetings of this group were held in 1976 and no report has been prepared.

5.11 REPORT OF THE OCEANOGRAPHIC WORKING GROUP

During 1976 the oceanography working group, jointly with the ice working group, arranged a SEASAT workshop at St. John's, Newfoundland. This was hosted by Memorial University (Faculty of Engineering and Applied Science) for June 14 to 16, 1976. The ninth meeting of the oceanography working group was held on the morning of June 16 to enable members to contribute suggestions to the experiment planning session of the workshop held in the afternoon. Although the business of the working group was dominated for 1976 by consideration of the U.S. SEASAT program and its implications for Canada, the interests of individual members cover a wider range. See for example section 7.2 for the report from the Patricia Bay Institute.

5.11.1 SEASAT

The Canadian oceanographic community has a strong interest in the capabilities for all weather sea surface measurements that will be tested in SEASAT A and that should then become operational in a full SEASAT system. The scale, accuracy and coverage of data that it will provide, however, are not such as to make SEASAT a major component of any currently ongoing oceanographic program in Canada. The emphasis of oceanographic programs may well change in the future to reflect needs for continental shelf surveillance, wave forecasts and provision of other data services, in which case SEASAT and even a future Canadian surveillance satellite will become extremely relevant. The emphasis of Canadian oceanographic participation should therefore be on a scientific evaluation of the data.

Although the imaging radar on SEASAT will obviously provide important data on ice distribution, the accuracy of wave data is still uncertain. Defocussing effects occur for moving targets. Images of wind waves may be particularly susceptible to this since motions associated with them are more random and their wavelengths approach the resolution limit of the SEASAT synthetic aperture radar (SAR). Swell patterns should be more visible and several demonstrations of his have been made with airborne data. Internal wave patterns give rise to characteristic surface slick patterns of varying surface roughness which should be easily visible to the SAR and have been seen on airborne imagery. Investigations of SAR capabilities are proceeding using a variety of airborne radar systems such as those belonging to NASA, ERIM or DND (Canada).

Points brought out at the working group meeting relevant to Canadian participation in SEASAT and use of data are:

1. The air-sea interaction group of the Bedford Institute of Oceanography maintain a tower approximately 10 km east of Halifax. This can be an important source of ground truth for airborne and later for satellite experiments. Wave rider buoys are also deployed at a number of points off the east coast.

2. Station PAPA can provide wave and wind data at its station off the west coast of Canada and this has now been supplemented by NOAA buoys at several points in the Gulf of Alaska.

3. The oil companies are prepared to provide data from drilling platforms, but more detailed negotiations will be needed for specific data sets.

4. There is an interest among companies involved in offshore drilling on the frequency of occurrence and intensity of internal wave patterns. These can cause considerable subsurface currents and turbulence. A particular area of interest would be Flemish Pass.

5. Airborne and orbiting radars should be able to pick up roughness patterns in coastal areas that are associated with movements and mixing of different water bodies. Coverage of coastal areas will yield relatively more data from the SAR than for areas offshore. Other sensors are restricted by their lower spatial resolution to the open ocean.

6. The wave climate group of OAS is interested in wave data from SEASAT and can provide assistance in analysis of wave imagery or data. Analysis of GEOS-3 wave data is already underway in OAS.

7. Altimeter data has application to tidal studies on both the east coast where tidal power generation in the Bay of Fundy is still under discussion, and the west coast where offshore tidal data has recently been collected from the tops of sea mounts.

8. There are interests at Memorial University in iceberg tracking which can

provide sea surface current information as well as being a topic for the ice working group.

9. Oil spills detection, mapping and tracking is of priority interest for Canada and tests should be arranged of SEASAT's capability in this area. In particular it should be made possible for SEASAT to use accidental oil spills as targets of opportunity by allowing for quick response in the scheduling of radar imagery.

10. All weather sea surface temperature mapping would be useful in a number of Canadian programs, but the accuracy (to about 1°K) and low resolution (more than 100 x 100 km) is a severe limitation.

11. Other satellite oceanographic sensors will be of interest to Canada, particularly the Coastal Zone Colour Scanner which in clear, cloud-free areas should be able to map out surface chlorophyll distribution patterns.

12. Further laboratory scale studies of radar/sea interactions are needed.

5.11.2 Pre-SEASAT Experiments Using Airborne Radar

To test possible applications of SAR imagery a number of useful target areas were identified.

1. Bedford Institute air sea interaction tower.
This should provide a nearly continuous record of wind and wave data. Contact S.D. Smith, Bedford Institute for scheduling information.

2. Coastal waters of Eastern Canada.
This area is of great importance to Canada for shipping and fishing. It has been the subject of many studies including surface currents, water productivity, tides and waves. A network of wave-rider buoys is in operation. Contact is J.R. Wilson, OAS, Ottawa for details on these.

3. Ocean Weather Station PAPA.
A regular record of wind and wave information is kept for this site (145°W 50'N), and the ship allows the possibility of additional ground truthing equipment and personnel being included for specific periods.

4. Inshore waters of B.C.
Strong tidal interactions and mixing allow a study of internal waves, tide lines and river plumes. Imagery is needed for this area. An experiment is being planned to use the laser Capillary wave slope measuring device constructed by D.R.E.P. to give ground truth during an L and X band radar over-flight.

5. Flemish Pass.
An area of interest for oil drilling operations for which internal or surface wave information is required.

6. Arctic areas.
Imagery of oceanographic interest may well be collected in open water areas during experiments designed to evaluate remote sensing of ice. It is important that such data be brought to the attention of the appropriate Arctic Oceanography groups.

5.11.3 Possible SEASAT Experiments

Final planning must await full approval and funding for Canadian participation in the SEASAT program, but experiments will probably centre on the areas listed above. The proposed airborne experiment in coastal waters of B.C. is of interest to the NOAA Seattle Laboratory as well as to OAS and DREP and could form the start of a series of experiments to continue through the SEASAT A experiment period.

5.11.4 Membership Changes

M. Khalil (Rimouski, Que.) resigned from the working group.

C. Gautier (Rimouski, Que.) has been invited to join.

S.E.G. Wilson (Imperial Oil) has joined the working group and has been recognized by the APOA/EPOA as their official representative in CACRS.

5.11.5 Recommendations

1. That organization of the new "ocean management" working group allow for continued existence of the oceanography working group in its present form.

2. That CCRS should ensure that radar imagery and associated ground truth be brought to the attention of all qualified and interested investigators.

3. That Canadian industry should be encouraged to benefit from Canadian involvement in foreign satellite programs.

5.11.6

Appendix I

Oceanographic Working Group Membership List

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Production Research Division
Imperial Oil Ltd.
339 - 50 Ave. SE
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(403) 259-0234

5.12 REPORT ON THE WORKING GROUP ON REPRODUCTION AND MARKETING

5.12.1 Airborne Remote Sensing

Although statistics show that approximately 15% fewer line miles were flown this year than in the same operational period last year,there was a gain of 16.7% in the total items produced. The increased use of twin RC 10 cameras with colour and false colour film in lieu of the four 70 mm, single RC 10 camera sensor package, plus an increase in secondary orders,has resulted in a considerable increase in remote sensing colour production by NAPL/RC this year (see Appendix II).

Delivery time of products to users was consistent with the previous year and in most instances was within the required time frame specified.

Delivery of final flight line index maps by CCRS has been far behind schedule throughout the year. This caused serious delays at NAPL in the updating of the Coverage Catalogue system and in the microfilm program for remote sensing indexes.

5.12.2 Spaceborne Remote Sensing

ISIS has overcome initial production problems experienced and complaints are now reduced to a minimum. Production is lower than anticipated. Prices of photographic products were raised in June, 1976 and total sales have since decreased each month,with the largest decrease attributed to Federal and Provincial Governments. The private sector is still purchasing Landsat imagery and now represents 58% of the clients served. It is anticipated that the cost of a black and white contact print may soon be raised to $5.00 or $6.00 due to increased production costs, and the royalty fee being considered by CCRS. CCRS will start charging for computer compatible tape production when Treasury Board approves their submission.

Discussion with clients and attendance at conferences reveals a positive move to make more use of satellite imagery, as practical applications are being recognized. Thus, in spite of increased costs, an increase in sales and use of Landsat imagery is predicted. Statistics indicate a substantial growth in the facsimile transmission service provided by ISIS. It is hoped that this growth will continue and that the service will become a major source of ISIS income.

Gregory Geoscience has compiled a slide series of interesting Landsat images complete with a descriptive test of each image. When copyright action is complete, the package will be marketed to interested clients in a variety of organizations and scientific disciplines.

5.12.3 Surveys and Mapping

Strict quality control of all production stages has resulted in repeatibility of standard colour on a regular basis. Adjustment to colour reproduction for specific reasons or image enhancement will only be undertaken at customer request.

Microfilmed survey imagery and viewing equipment have been sent to Provincial Government centres at Calgary,Edmonton,Winnipeg and Amherst. A complete package will soon be set up in either Vancouver or Victoria. Each centre is costing Surveys and Mapping approximately $14,000.00.

Microfilming of 1976 aerial survey and airborne remote sensing imagery, plus all mosaics is in the preparation stage, and operations will commence shortly.

A proposal to riase the price of air photo products by approximately 12% is awaiting approval by the Minister.

The Canada Mosaic Project was completed in July 1976. The National Air Photo Library is the agency responsible for the sale and distribution of Canada Mosaic products.

5.12.4 Research and Development

In February 1976, procedures were altered in the production of 70 mm EBIR film output. Up to that time, this output was a 70 mm positive from which the Reproduction Centre produced colour master negatives on Kodak Aerocolor Negative Film (2445). To provide ISIS with a first generation, high quality, 70 mm black and white production negative, it was necessary for EBIR's to generate a negative image from which the Reproduction Centre produced the colour master negative on Kodak Ektachrome Aerographic Reversal Film (2448).

Colour comparison tests of the two films proved that while colour rendition is similar, product quality was being sacrificed. Using 2448 resulted in a decrease of colour fidility and balance and an increase in contrast, losing the subtle mid-tones that are necessary to agricultural and geological interpreters and researchers.

The Reproduction Centre will return to the original higher quality procedure using 2445 film when ISIS receives and operates the Laser Beam Image Recorder proposed for Prince Albert Satellite Station.

5.12.5 Recommendations

It is recommended that the marketing activities of the individual agencies involved in Remote Sensing be examined in depth to determine those activities which could be combined to increase the overall marketing impact and perhaps lower marketing expenditures for all concerned.

5.12.6 Appendices

5.12.6.1 Appendix I

REPRODUCTION CENTRE (NAPL)
LANDSAT PRODUCTION COMPARISON

Product		1 Apr 74 5 Jan 75	1 Apr 75 4 Jan 76	Percent Difference	1 Apr 76 3 Jan 77	Percent Difference
Customer Products						
Contact Prints	- Black and White	34,072	18,077	-46.9	2,767	-84.7
	- Colour	5,710	4,642	-18.7	4,218	- 9.1
Contact Transparency	- Black and White	9,217	7,810	-15.3	39	-99.5
	- Colour	3,534	2,737	-22.6	2,410	-11.9
Duplicate Negatives	- Black and White	385	285	-26.0	215	-24.6
	- Colour	81	58	-28.4	48	-17.2
Enlargements	- Black and White	685	798	+16.5	30	-96.2
	- Colour	276	225	-18.5	265	+17.8
Total Customer Products		53,960	34,632	-35.8	9,992	-71.1
Total Customer Revenue		$154,386	$110,704	-28.3	$50,534	-54.4
Production Products						
Continuous Printing		23,971	18,372	-23.4	9,450	-48.6
Film Processing		43,158	60,313	+39.7	68,164	+13.0
Master Negative	- Black and White	66,227	45,558	-31.2	9,461	-79.2
	- Colour	12,774	10,845	-15.1	12,254	+13.0
Total Production Products		146,130	135,088	- 7.5	99,329	-26.5
Total Production Revenue		$195,814	$152,907	-21.9	$98,540	-35.6
Landsat Mosaics			892*		2,222	
Landsat Mosaic Dollar Value			$ 14,968*		$37,285	
Total Products		200,090	170,612	-14.9	111,543	-34.5
Total Dollar Value		$350,200	$278,579	-20.5	$186,359	-33.1

* Reproduction of Landsat Mosaics commenced in July, 1975.

5.12.6.2 Appendix II

REPRODUCTION CENTRE (NAPL)
PRODUCTION COMPARISONS

Programme/Products	1 Apr 74 5 Jan 75	1 Apr 75 4 Jan 76	Percent Difference	1 Apr 76 3 Jan 77	Percent Difference
Total Items Produced					
Aerial Survey	638,989	574,579	-10	507,965	-11.6
Airborne Remote Sensing	80,615	67,867	-15.8	79,210	+16.7
Landsat	200,173	170,719	-14.7	111,628	-34.6
Total	919,777	813,165	-11.5	698,803	-14.1
Aerial Survey					
Black and White	419,995	359,939	-14.3	317,845	-11.7
Colour	69,736	73,873	+ 5.9	72,951	- 1.2
Black and White Film Processing	55,683	31,473	-43.4	26,654	-28
Colour Film Processing	59,379	78,737	+32.6	66,148	-16
Diapositives	32,202	22,855	-29	23,324	+ 2.1
Airborne Remote Sensing					
Black and White	24,564	17,780	-27.6	6,208	-65.1
Colour	17,607	16,324	- 7.3	34,056	+108.6
Black and White Film Processing	17,514	14,924	-14.8	13,069	-12.4
Colour Film Processing	20,932	18,709	-10.6	25,847	+38.2
Landsat					
Black and White	67,880	45,346	-33.2	12,501	-72.4
Colour	10,114	7,726	-23.6	6,976	- 9.7
Black and White Master Negatives	66,227	45,558	-31.2	9,461	-79.2
Colour Master Negatives	12,774	10,845	-15.1	12,254	+13.0
Film Processing	43,158	60,613	+40.4	68,214	+12.5
Landsat Mosaic Reprints		892*		2,222	+149.1
Revenue					
Product Dollar Value	$1,183,506	$1,310,660	+10.7	$1,146,443	-12.5
Less S & M	257,180	270,770	+ 5.3	276,011	+ 1.9
Net Revenue	926,326	1,039,890	+12.2	870,432	-16.3
Unit Strength **	75	68	-9.3	61	-10.3

* Reproduction of Landsat Mosaics commenced in July 1975 ** As of last date in reported period

5.13 REPORT OF THE WORKING GROUP ON SENSORS

No report has been received from the Working Group on Sensors for 1976.

6.1 REPORT OF THE ALBERTA REPRESENTATIVE

6.1.1 Airborne Remote Sensing

Fourteen flight requests supporting projects were submitted to the Canada Centre for Remote Sensing (CCRS); ten were completed and four cancelled.

The program was coordinated between the Canada Centre for Remote Sensing and each requestor on a day to day basis to ensure, where required, imagery and ground truthing were simultaneous. The Center's staff provided advice and assistance in the selection of aircraft sensors, flight planning, cost calculations, and handled the administrative details.

The coordination of requests at the provincial level has proven to be advantageous to requestors, the Alberta Center, and CCRS.

6.1.2 Spaceborne Remote Sensing

The Center provides a mail, telephone, or in-person Landsat order facility to persons wishing to select satellite imagery. Scenes may be selected from a Landsat catalogue, computerized catalogue updates, and Integrated Satellite Information Services' ISISFICHE received daily of each satellite's Canadian coverage. The Center has also a terminal and dedicated line to CCRS's RESORS.

The Center's Imagery Library contains Landsat Black and White contact prints of the province and repetitive scenes of selected areas in all wavebands and color composite renditions. Transparencies are being phased in as they provide a more interpretive product.

There has been in the past year a great increase in the number of out-of-Alberta requests for Landsat and other data.

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. The Center has specialized interpretation equipment - more has been added this past year, and offers staff assistance in its operation. A technical library and document retrieval system is available.

The Alberta Remote Sensing Center is now located at:

Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6
(403)427-2381

The new location provides more space for the increased number of persons using the Center and has tailor-made facilities for the Center's additional equipment.

6.1.4 Training

The Alberta Remote Sensing Center in cooperation with the Faculty of Extension, University of Alberta, conducted the Fourth and Fifth Alberta Remote Sensing Courses. Each course has been oversubscribed with participants from the Atlantic to the Pacific and the Yukon to Nevada.

Instruction was provided by University of California scientists headed by Professor R.N. Colwell, CCRS scientists headed by E.A. Godby, and Canadian scientists from many agencies.

The Canada Centre for Remote Sensing provided, as in past courses, excellent support. It's contribution is very much appreciated.

6.1.5 Special Projects

Many agencies of the federal and provincial government, universities, and the private sector in Alberta have developed and employed remote sensing projects in various fields. Technological advances in remote sensing techniques have been significant and of practical value to users. Information concerning projects carried out by Alberta agencies and scientists may be obtained from the Alberta Remote Sensing Center.

6.1.6 Conclusions

There has been a continued increase in the use of remote sensing in Alberta.

6.1.7 Appendix I

Alberta Advisory Committee on Remote Sensing

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6.2 REPORT OF THE BRITISH COLUMBIA REPRESENTATIVE

This report is again being submitted by Mary Redmond of the Resource Analysis Branch, now part of the Environmental and Engineering Services of the B.C. Ministry of the Environment.

6.2.1 Airborne Remote Sensing

Very few airborne projects were requested in British Columbia in 1976; four of five projects were flown involving 471 nautical miles (the cancelled project was for 12 nautical miles).

6.2.2 Spaceborne Remote Sensing

There has been renewed interest in satellite imagery this year, but this has been offset by the unexpectedly large increases in the cost of the tapes and black and white enlargements. There appears to be a market for images at a scale of 1:250,000 but cost is a major deterent at present.

6.2.4 Applications

This year remote sensing has been applied to a wide variety of topics in British Columbia, some of which are listed briefly below.

6.2.4.1 The LANDSAT mozaics have been used as presentation tools instead of maps.

6.2.4.2 Satellite imagery is being used as the frontispiece for a soils report.

6.2.4.3 LANDSAT imagery has been used at 1:1,000,000 and 1:250,000 for climate network planning, snowline mapping and smoke-plume distribution.

6.2.4.4 Some mapping of surface temperature distribution has been done near Kelowna using thermal scan information.

6.2.4.5 There has been an evaluation of LANDSAT data for forest pest detection and damage appraisal surveys in British Columbia.

6.2.4.6 Work has been done on developing a methodology for updating areas of logging and burns. Experiments have been done in classification using the Image 100 Principal Components Colour Enhancement, supervised and unsupervised classifications in the Williams Lake area. This has been a joint federal - provincial venture.

6.2.4.7 Some similar experimenting has been done by our branch in the classification of a few images in Northern British Columbia, but this work has not been completed due to the volume of data generated to be handled, and our changing priorities.

6.2.4.8 The Multi-Channel Spectrometer has been used to attempt to map the organic matter and exchangeable cations in soil, and correlate this to spectral reflectance of samples on the ground and in the lab.

6.2.4.9 Density slicing of multi-spectral photography has been tried to obtain the chemical soil conditions, but correlation between different images has not been possible.

6.2.4.10 Successful work has been done using an optical visual enhancement technique (Colour Additive Viewer). This has been used very successfully for mapping clearcut logging. Also, three levels of rangeland have been identified, as has a level corresponding to one classification level on the B.C. Biogeoclimatic map. Arboreal lichen has been photointerpreted for variation in tidal marshland communities, and also work on the extra-visual detection of forest damage.

6.2.4.11 Detailed mapping has been done on the Meager Creek Slide using the 1975 CCRS photography.

6.2.4.12 Other information on work being done in British Columbia is included in the Report of the Ocean and Aquatic Sciences, Pacific Region.

6.2.6 User Liaison

This has been minimal again, but increased in the latter part of the year because of an increasing interest in satellite imagery expressed by other provincial government ministries, especially Forests and Highways.

6.2.8 Conclusion and Forecast

With the growing interest in trying to utilize satellite data, it is recommended that each province should have one or more designated offices to hold a

reasonably current computer printout of available images on fiche for that province's Fleming centres. These offices should be advertised in the CCRS Newsletter. It could possibly be done in conjunction with the planned NAPL Centres.

6.2.10 Miss C.M. Redmond
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Location 839 Academy Close

6.3 REPORT FROM THE MANITOBA PROVINCIAL REPRESENTATIVE

6.3.1 AIRBORNE REMOTE SENSING

During 1976 there were nine requests submitted through the Manitoba Remote Sensing Centre for Airborne Remote Sensing projects. This included six requests that were re-submitted from the 1975 program. There was a high success rate this year with eight areas completed. The remaining request was cancelled early in the season.

The Centre continued to operate its 70 mm Supplementary Aerial Photography Service. This year there were over 10,000 line miles flown for requesting agencies to assist in planning and operational functions.

6.3.2 SPACEBORNE REMOTE SENSING

The Isisfiche subscription was continued during the year as a readily available source of information on Landsat imagery. The number of requests for prints remained the same with government being the main purchaser. However, there was an increase by private agencies, especially the mining industry.

6.3.3 USER LIAISON

The Manitoba Remote Sensing Centre continued to maintain interpretation equipment, keep up-to-date files on aerial photography and satellite imagery coverage and provide assistance with remote sensing techniques for operational use. These services are offered free of charge to all Manitobans to encourage and assist in the development of remote sensing for specific needs. During 1976, over 1200 people visited or made inquiries to the Centre. Their needs ranged from information that could be satisfied in a few minutes to assistance on projects that lasted several weeks.

6.3.4 TRAINING

During the year, training consisted of "in-house workshops" primarily for students from the University of Manitoba and the University of Winnipeg. There has been a great deal of interest shown by the geography students in remote sensing. Many of the participants are regular visitors at the Centre to use the equipment available for project work.

6.3.5 CONCLUSION AND FORECAST

The services and facilities of the Manitoba Remote Sensing Centre continued to be used at about the same level as during 1975. There is still considerable interest in remote sensing methods and techniques for every-day operational use. However, the most common complaint is the lack of time to develop or to change over from the present working system. There is a very definite need for regional applications development.

6.4 REPORT OF THE NEW BRUNSWICK REPRESENTATIVE

6.4.1 Airborne Remote Sensing

Requests for four airborne remote sensing missions were submitted to CCRS; two operations were military projects, the third was concerned with snow melt and flood predictions and the fourth a test on an oil slick tracking buoy.

New black and white aerial photo coverage of the province at a scale of 1:20 000 is nearly completed. The flying has been done over the past three years and forms the basis of a new provincial forest inventory.

6.4.2 Spaceborne Remote Sensing

There is continuing interest in the LANDSAT images that are being obtained by the province, with enquiries from new users for information about matching the requests of repeat users.

Some of the projects started in the last couple of years are being maintained and are producing useful results. The attempt to identify areas with high tree mortality due to the spruce budworm attack has not been pursued due to a variety of circumstances. The emphasis has been switched to identifying areas that are relatively non-susceptible to budworm damage.

6.4.6 User Liaison

User liaison is very informal; if a request for information can be answered, it is; if not, the enquirer is referred to CCRS and to a specific contact where possible.

6.4.8 Conclusion and Forecast

The use of conventional aerial photography remains high in the province. Interest in the use of some of the more advanced remote sensing products is beginning to broaden as more people are becoming aware of the subject.

6.4.10.1 Appendix I - Current Projects

A project to determine the amount and extent of forest fire fuel is being done in co-operation with the Forest Fire Research Institute. Color enhanced enlargements of segments of a LANDSAT image have been provided to the provincial forest protection group for ground truthing and assessment of usefulness. Results of the work within one frame appear promising. An offshoot of this project is the assessment of areas that are non-susceptible to spruce budworm attack to permit a closer control on the area that requires spraying.

An infra-red thermography study of provincial government buildings is about to be started. The preliminary work has been completed successfully and the project is waiting to purchase the necessary equipment.

6.5 REPORT OF THE PROVINCE OF NEWFOUNDLAND, 1976

6.5.1 Airborne Remote Sensing

The 1976 airborne remote sensing program was concerned with various projects of data gathering over land and sea. The Newfoundland Forest Service acquired 1:12,500 scale color aerial photography for a large section of the Island (Appendix IV-1). Black and white photography at a scale of 1:30,000 was carried for the Provincial Crown Lands covering the area of the new national park and a portion of the Burin Peninsula (Appendix IV-2 and 3), and selected communities were photographed with 1:12,000 scale black and white photography. The Newfoundland Wildlife Service conducted 1:4,000 scale 70 mm color infrared photography over a small experimental area for caribou census (Appendix IV-4). In selected areas aerial photography, thermal mapping, and radiometric and scatterometer data were obtained over sea ice and water by C-CORE (Appendix IV-5 and 6).

6.5.2 Spaceborne Remote Sensing

Memorial University has a standing subscription of LANDSATFICHE and selected NOAA imagery.

The 1976 Newfoundland Remote Sensing Winter Works Project has accumulated an extensive library of LANDSAT imagery of Newfoundland and Labrador, which is available for viewing at the Provincial Crown Lands Office. A list of the LANDSAT imagery is included in the report "Remote Sensing in Newfoundland.[g]

6.5.3 Technical Developments

Studies have been carried out by C-CORE to determine color balance shifts of color infrared film resulting from exposure through various densities of color compensating filters.[i] The color balance shift was worked out using a scanning micro-densitometer and statistical analysis.

6.5.4 Application and Benefit Analysis

A brief summary of the 1976 projects carried out by various agencies is given below.

(a) Agriculture

The soil survey program to produce agriculture capability maps was continued in 1976. The interpretation is being carried out on 1:50,000 scale black and white aerial photographs. The field work has been completed for the Sandy Lake area (NTS 1:250,000 scale).

(b) Forestry

(i) Provincial - The Provincial Forest Management Inventory was continued in 1976 using 1: 12,500 scale normal color aerial photographs.

(ii) Federal - In connection with the Newfoundland Forest Inventory a bio-physical land classification was carried out for Inventory Unit 14. Units were mapped at "land type" level and maps having a scale of 1:12,000 were produced.

(c) Nfld. Provincial Lands Branch

The Lands Branch, in co-operation with the Halifax Office of the Federal Land Directorate, has completed two coastal resources inventory and mapping pilot projects.[e and f] The published reports contain four color-printed resource maps: geology (relief and bathymetry, mineral occurrence, bedrock geology, surficial geology, and bottom sediments); renewable resources (vegetation cover, wildlife habitat, and fishery activities); potential land use patterns (existing land use, large land holdings, potential agricultural land, road system, hydro system, navigational aids, shipwrecks, and municipalities and planning areas); and coastal systems with land capability analysis (agriculture, forestry, recreation, ungulates, composite high priority areas, shoreline classification, and coastal classification).

(d) Provincial Mineral Development Branch

As a routine work this Branch is conducting surficial deposits and bedrock mapping using aerial photographs and LANDSAT imagery.

(e) Provincial Wildlife Service

As a part of the provincial caribou census program the Avalon calving ground was inventoried in 1976 with seventy mm. 1:4,000 scale color infrared photography to count animals.[b] Concurrently, a

visual census was obtained. Results indicated that a 9 x 9 ins. format 1:3,500 scale color infrared photography would be the most appropriate for this kind of work.

(f) Nfld. Remote Sensing Winter Works Project

Within the framework of this project several experiments were conducted using LANDSAT imagery. Forest fire damage was monitored in southern Labrador on nine LANDSAT images. Many old and recent burns were visible on the satellite imagery. The second project attempted to determine the minimum river width on various bands of imagery. Small rivers showed up causing dark areas, but the minimum width of these rivers could not be determined because there was no defined break between water and land. An attempt was made to develop an identification key for important natural and man-made features--shape, size, tone, texture, and important characteristics of these features were studied on imagery of the four spectral bands.

(g) NORDCO

This organization mapped the periodic changes of the Labrador Icepack boundary in 1976.(h) The usefulness of various remote sensing techniques in sea ice investigation was also investigated.

(h) C-CORE

In 1976 C-CORE conducted several major remote sensing projects.(j and k) Photographic studies were directed toward developing better utilization of color infrared film by using color compensating filters for ice reconnaissance. Thermal infrared studies have been carried out on data obtained over a test site and on data collected by the International Ice Patrol over the Grand Banks. Data from sequential flights has been plotted and contoured to obtain a quasi-synoptic thermal pattern of the Grand Banks. A microwave scatterometer was used to obtain radar data of the shorefast ice at Forteau and Cartwright. The collected data is being analysed jointly by C-CORE and CCRS to construct backscatter curves relating the surface snow and ice conditions at Forteau and Cartwright.

(i) Engineering Department - MUN

This year's activities centered around research concerning analysis of SLAR data of icebergs. The geometric properties of SLAR imagery in relation to plotting icebergs were investigated in connection with the preparation of an iceberg distribution map for the Saglek area.(d) The identification of icebergs on SLAR pictures is being investigated using density contouring techniques and statistical analysis. The previously developed bird census technique was tested for the automatic count of greater snow geese and black ducks.

6.5.5 User Liaison

User liaison was well served by the Newfoundland Remote Sensing Winter Works Project. Unfortunately, no continuation of this project was provided either by the Federal or by the Provincial Government. However, an Ocean Information Center was established by NORDCO, C-CORE, and the Engineering Department of MUN. This center provides minimum service to remote sensing users through library facilities and collected LANDSAT and NOAA imagery.

The Newfoundland Users Group of Remote Sensing met twice in 1976. On the first meeting the following topics were discussed:

(i) remote sensing winter work projects
(ii) past activities
(iii) future plans

The second meeting was held in late April. D. Bajzak gave a summary of the proceedings of the 1976 CACRS meeting. An explanation of the functioning aspect of CACRS (its purposes and objectives in light of provincial participation) was given by T. Alfoldi of CCRS. The success of the winter works project was evaluated and the following resolutions were passed:

(i) that representation be made to the appropriate parties to form an officially recognized Remote Sensing Provincial Committee;

(ii) that a letter of representation be drawn up and forwarded to the Provincial Resources Ministers requesting that a Provincial Coordinating Remote Sensing Unit be established.

Actions were taken on both of these resolutions by the Users Group but with no apparent results from higher levels of government.

6.5.6 Training

A short course was conducted in Newfoundland in 1976. The Provincial Forest Service in cooperation with the Federal Forest Management Institute and Newfoundland Forest Research Center organized a one-week course in land and vegetation interpretation. A five day field trip across Newfoundland followed the classroom instructions.

The regular Remote Sensing course offered by the Engineering Department of MUN is becoming more attractive every year. The yearly enrollment is on the upswing.

6.5.7 Conclusions and Forecast

With the introduction of the 200 miles ocean management limits Canada will exercise control over an extensive area of ocean. This will greatly enhance the nation's ocean oriented activities. The required information for this work will have to be provided, in part, by remote sensing. In connection with resource development off Labrador, extensive data gathering must be conducted with remote sensing providing a significant proportion of the data. To meet these tasks an excellent start has been made in Newfoundland with the establishment of a Satellite Receiving Station in Shoe Cove designed to start receiving LANDSAT and NOAA imagery in early 1977. This station will also have a significant role in receiving SEASAT data. C-CORE has recognized the importance of remote sensing in resource development, therefore they have developed an ambitious program for 1977 (Appendix I). Memorial University is well equipped with a remote sensing data analysis lab which is used for both teaching and research. The instruments in this lab are continuously upgraded and supported with various computers. In spite of this progress the lack of a Provincial coordinating body and a Provincial information center is hindering the optimum use of remote sensing in Newfoundland.

6.5.8 Recommendations

The following recommendations are submitted to CACRS from Newfoundland:

(a) In light of the importance of ocean management and resource development in the ocean surrounding Newfoundland the Federal Government should support major research and development projects designed to provide information systems meeting user requirements in the fishery, offshore petroleum and shipping industries.

(b) Because of the importance of the Provincial Remote Sensing Information Centers the Federal Government should help to set up such a center in Newfoundland.

(c) In 1976 little information was received from the CACRS working groups. These groups should be reorganized or their work made more effective and their communication with users groups improved.

6.5.9 Appendices

6.5.9.1 Appendix I - Current Projects

Most of the projects discussed in section 6.5.4 are continuous long term works. In addition to these the C-CORE is proposing the following projects for 1977:

1. "SAR 77"

   Synthetic aperature radar project sponsored jointly by Department of Supply and Services (Scientific Authority, Department of Environment), Defence Research Establishment, Ottawa, U.S. Office of Naval Research and C-CORE.

2. Remote Sensing Balloon

   Programme to test suitability of helium balloon as a remote sensing platform. Balloon provided by Canada Centre for Remote Sensing plus technician. C-CORE to cover film processing and field costs.

3. Ground Based Photographic Remote Sensing

   C-CORE programme to test N9 camera and other photographic instrumentation systems for use in ground based remote sensing studies.

4. Sea Surface Thermal Contouring

   The data reduction of airborne radiation thermometer information and the application of error correction and contour mapping applications.

5. Ship In Ice

   Reduction of remotely sensed data from Ship In Ice helicopter and ground truth programmes.

6. Satellite Photography Analysis

   The analysis of LANDSAT and NOAA satellite data using image analysis equipment at MUN.

7. Photographic Studies

   A continuing study on Colour Infrared Film

Type 2443 to determine possible methods of ice classification.

8. Thermal Infrared Analysis

   A continuing study using data recorded over the 1976 field sites. Comparison of various interpretation methods.

9. Scatterometer Analysis

   A continuing study using data collected over sea ice and water during the 1976 field season.

10. Image Analysis Programme

    A continuing study to facilitate maximum use of image analysis equipment at MUN.

11. Helicopter Camera Mount

    Design of a helicopter camera mount and PRT 5 mount for use in remote sensing projects.

12. Feasibility Study for Light Aircraft SLAR System

    An investigation into the design and use of a SLAR system for light aircraft to be used as a research tool by C-CORE.

13. Feasibility Study for Light Aircraft Camera System

    An investigation into the use and modification of a light aircraft to carry a 9" x 9" metric camera for use as a research tool.

14. Laboratory Studies of Sea Ice

    A programme to attempt to duplicate in the lab conditions encountered in the field. This programme also includes the reduction of all remote sensing ground truth data. The aim of the programme is to improve ground truthing techniques.

15. Remote Sensing Using Sounding Rockets

    An unsolicited proposal to DSS will be submitted in April outlining a programme to undertake various remote sensing studies using a Black Brant VI rocket.

16. Iceberg Deterioration Rates

    Using data from Project 4 a programme will be undertaken to computer map the data and determine iceberg deterioration rates from International Ice Patrol data.

6.5.9.2 Appendix II - Current Bibliography

(a) Bajzak, D., 1976. Interpretation of Vegetation Types on Side Looking Airborne Radar and on Thermal Infrared Imagery. Paper presented at the XVI IVFRO World Congress Subject Group 56.05. Norway, Oslo.

(b) Fong, D.W., 1976. Aerial Photo Census of Avalon Caribou. Project No. 77C-2 report. Newfoundland Wildlife Service.

(c) Gustajtis, A., 1976. Iceberg Population Distribution Study - Labrador Coast. C-CORE report.

(d) Jennings, J., 1976. Side Looking Airborne Radar Project off Saglek. MUN Co-op work report.

(e) Lands Branch and Land Directorate, 1975. Coastal Resources Inventory and Mapping Program - St. George's Bay Pilot Study. Report Newfoundland Department of Forestry and Agriculature and Environmental Management Services, Environment Canada.

(f) , 1975. Coastal Resources Inventory and Mapping Program - Conception Bay Pilot Study. Report Nfld. Dept. of Forestry and Agriculture and Environmental Management Service, Environment Canada.

(g) Newfoundland Remote Sensing Facility, 1976. Remote Sensing in Newfoundland. Newsletter.

(h) NORDCO, 1976. Information Circular. NORDCO.

6.5.9.3 Appendix III - List of Group Leaders

The following is a list of members of the "Users Group" who are responsible for information dissemination concerning their own field of activities in Newfoundland:

(a) Dr. A.A. Bruneau, MUN. Provincial representative.

(b) Dr. D. Bajzak, MUN. Users Group Leader, alternate Provincial representative, interpretation techniques and technical developments.

(c) Mr. K. Beanlands, Provincial Government. Lands.

(d) Mr. J. Bouzane, Federal Government, Federal Forestry.

(e) Mr. B. Delaney, Provincial Government, Provincial Forestry.

(f) Dr. R.T. Dempster, MUN. Glaciology, Member of CACRS working group.

(g) Mr. C. Langford, NORDCO, projects.

(h) Dr. J. MacPherson, MUN, Geography.

(i) Mr. E. Mercer, Provincial Government, Wildlife.

(j) Dr. R. Peters, MUN, Oceanography, member of CACRS working group.

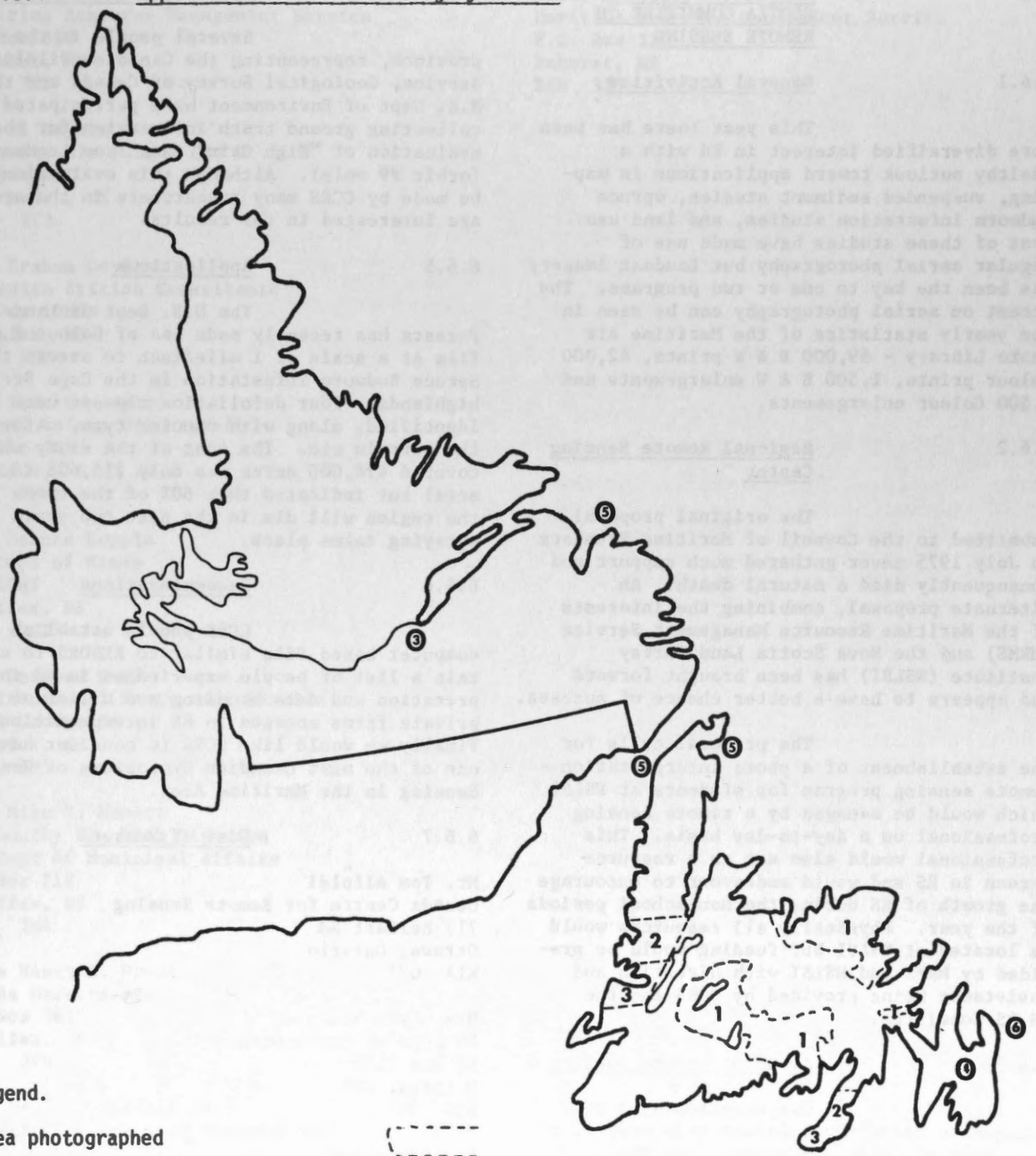
(k) Mr. D. Sudom, Provincial Government, agriculture.

(l) Mr. D. Vanderveer, Provincial Government, Geology, Member of CACRS working group.

(m) Mr. H. Whelan, Provincial Government, mapping.

(n) Mr. R. Worsfold, C-CORE, projects.

6.5.9.4 Appendix IV - Airborne Imagery - 1976.



Legend.

Area photographed

Location of airborne sensing O

Systems used	Symbol
1:12,500 scale color negative photography	1
1:30,000 scale black and white photography	2
1:12,500 scale black and white photography in selected communities	3
1:4,000 scale 70 mm color infrared photography	4
Daedalus PRT5, RC-10, and scatterometer data	5
Daedalus and scatterometer data	6

6.6 REPORT OF THE NOVA SCOTIA COMMITTEE ON REMOTE SENSING

6.6.1 General Activities

This year there has been more diversified interest in RS with a healthy outlook toward applications in mapping, suspended sediment studies, spruce budworm infestation studies, and land use. Most of these studies have made use of regular aerial photography but Landsat imagery has been the key to one or two programs. The accent on aerial photography can be seen in the yearly statistics of the Maritime Air Photo Library - 69,000 B & W prints, 42,000 Colour prints, 1,500 B & W enlargements and 1,500 Colour enlargements.

6.6.2 Regional Remote Sensing Center

The original proposal submitted to the Council of Maritime Premiers in July 1975 never gathered much support and consequently died a natural death. An alternate proposal, combining the interests of the Maritime Resource Management Service (MRMS) and the Nova Scotia Land Survey Institute (NSLSI) has been brought forward and appears to have a better chance of success.

The proposal calls for the establishment of a photo interpretation - remote sensing program for students at NSLSI which would be managed by a remote sensing professional on a day-to-day basis. This professional would also act as a resource person in RS and would endeavour to encourage the growth of RS during the non-school periods of the year. Physically all resources would be located at NSLSI but funding would be provided by MRMS and NSLSI with direction and assistance being provided by CCRS and the NS RS Committee.

6.6.3 Airborne Remote Sensing

Two agencies have been engaged in aerial photography this past year: N.S. Dept of Lands and Forests and MRMS. Lands and Forests had Queens and Lunenburg counties covered in true colour at a scale of 1:10,000 and all counties except Halifax, Hants and part of Colchester covered in colour infra-red at a scale of 1:5,000. MRMS only accounted for $\sim$ 50 line miles (half B & W and half Colour) covering a variety of projects in several areas.

6.6.4 Spaceborne Remote Sensing

Several people in the province, representing the Canadian Wildlife Service, Geological Survey of Canada and the N.S. Dept of Environment have participated in collecting ground truth information for the evaluation of "High Gain" data from Landsat II (orbit #9 only). Although this evaluation will be made by CCRS many researchers in the area are interested in the results.

6.6.5 Applications

The N.S. Dept of Lands and Forests has recently made use of Colour I.R. film at a scale of 1 mile/inch to assess the Spruce Budworm infestation in the Cape Breton highlands. Four defoliation classes were identified, along with species type, nature of the terrain etc. The cost of the study which covered 478,000 acres was only $15,608 (3.3¢ an acre) but indicated that 60% of the trees in the region will die in the next two years if no spraying takes place.

6.6.6 Recommendations

CCRS should establish a computer based file similar to RESORS to contain a list of people experienced in RS interpretation and data handling and a list of private firms engaged in RS interpretation. Finally we would like CCRS to consider having one of the next Canadian Symposiums on Remote Sensing in the Maritime Area.

6.6.7 List of Members

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6.7 REPORT FROM THE PROVINCE OF ONTARIO

The following report is based on the replies received to a questionnaire, with the exception of information on the activities of the Ontario Centre for Remote Sensing (OCRS). Twelve replies were received to the date of writing of this report, out of thirty-three agencies contacted. Of these twelve, three were government offices, three were educational institutions, and six were private consulting companies.

6.7.1 Airborne Remote Sensing

The Route and Site Selection Division of Ontario Hydro reported the use of 1:50,000-scale aerial photography from NAPL and 1:120,000-scale colour coverage from CCRS, in addition to standard provincial photography and photography taken by Hydro itself.

The Remote Sensing Section of the Ministry of Transportation and Communications reported using aerial photography from both the federal and provincial governments and from private companies, but was unable to state the volume used of each type. The Ministry requested image acquisition services from private companies.

The Water Resources Branch of the Ministry of the Environment reported the use of provincial photography and colour and false-colour photography, and estimated a total of 300 images. This Ministry requested two airborne sensing missions of CCRS during 1976, one to provide coverage of the Pickering Thermal Generating Station and Toronto Harbour, and the other to provide coverage of a portion of the Lake Huron coastline.

With regard to thermal sensing, the Ministry of Transportation and Communications reported that its applicability was under study, while the Ministry of the Environment reported that thermal scanning had been used on both of their requested flight missions.

In 1976, the Ontario Centre for Remote Sensing (OCRS) made use of a small volume of aerial photography from NAPL, a much larger volume of standard provincial photography, and flew approximately 200 hours of supplementary aerial photography missions. The OCRS requested three thermal scanning missions in 1976, two of which were completed.

Two universities replying to the questionnaire (Toronto and Western) did not report the use of aerial imagery. Sir Sandford Fleming College in Lindsay, Ontario reported using fairly large quantities of aerial photography in the teaching of photo interpretation and forestry technical courses. Approximately 1000 - 1500 provincial aerial photographs were used, 200-300 photographs from NAPL and 200-300 from private companies. In addition, the College has received various examples of imagery from the OCRS, and from the Forest Management Institute.

The private companies who replied to the questionnaire reported extensive use of airborne sensing. Acres Consulting Services Ltd. reported using approximately 300 aerial photographs, both black and white and colour. Barringer Research used photographs from NAPL for mosaic purposes, and carried out its own airborne sensing program of several thousand contract survey miles, in Canada and the United States, using its aerogeochemical prospecting technique, AIRTRACE. Beak Consultants Ltd. reported using a relatively small volume of aerial photography from federal sources, and were involved in subcontracting aerial flights to other firms. Robinson, Merritt and DeVries of Toronto reported using mainly aerial photographs from private companies and standard provincial photographs, with about 20% of the total volume used coming from federal sources. Ecologistics Ltd. of Kitchener used primarily photography from Ontario Hydro, and small amounts from other sources. The largest reported user of aerial photographs was Ecoplans Ltd. of Waterloo, which used 2,000 prints from NAPL, 2,000 from a private company and 200 standard provincial photographs. This company appears to have its own large-scale airborne operation as well.

None of the private companies reported using thermal imagery.

6.7.2 Spaceborne Remote Sensing

With regard to the use of satellite imagery, the Route and Site Selection Division of Ontario Hydro and the Remote Sensing Section of the Ministry of Transportation and Communications reported limited use, while the Ministry of the Environment reported none.

The OCRS made extensive use of Landsat imagery during 1976, purchasing coverage with a total cost of nearly $10,000, including all Canadian coverage on microfiche. The Centre rarely obtains satellite imagery for the specific purpose of a single study, but rather

attempts to include all usable coverage of the province in its library, in both print and transparency format. Landsat imagery is one of the data sources for a large proportion of the Centre's commissioned projects and research work.

Sir Sandford Fleming College reported the use of approximately 100 black andwhite Landsat prints and 20 colour prints for teaching purposes. Some transparencies were also used.

The six private consulting companies which replied reported limited use of satellite imagery. Acres Consulting Services Ltd. reported the use of colour composites as well as black and white prints.

6.7.3 Technical Developments

The Water Resources Branch of the Ministry of the Environment reported beginning to develop a system of automated computer reduction of waterborne thermal plume data, through the use of computer-compatible tapes of thermal scanner data.

The OCRS developed a number of new interpretation techniques in 1976, including the interpretation of aerial thermal scanning imagery for building heat loss and the use of analogue electronic analysis in studies of forest regeneration success and wildlife habitat. The Centre's electronic image analyzer was extended in 1976 to include a storage capacity of 600 images. With regard to the Centre's small-format aerial photography operation, a number of developments have been made, including the design of a camera mount to accommodate four Hasselblad cameras at one time.

The Department of Civil Engineering of the University of Toronto carried out research on the thermal properties of soil and vegetation using the AGA Thermovision Camera.

The Faculty of Engineering Science of the University of Western Ontario reported extensive involvement in the development of remote sensing techniques such as lidar and correlation spectroscopy, for the detection of air pollutants.

Among the private consulting companies, only Barringer Research Ltd. reported technical developments in remote sensing. The instruments this company has developed are as follows:

- an airborne geochemical prospecting system (AIRTRACE)
- a correlation interferometer and two electro-optical trace gas detectors (GASPEC and COSPEC)
- a laser fluorosensor, which will be particularly applicable to studies of water quality

6.7.4 Applications and Benefits

In 1976, the Route and Site Selection Division of Ontario Hydro employed various types of aerial photography as an aid to studies of physiography, topography, valley morphology, forest vegetation, and land use. Landsat imagery was consulted in the inventory of general land use patterns and geological-drainage features. In addition, the Division commissioned the OCRS to map wetlands and disturbance to vegetative cover in Northern Ontario, a project undertaken with Landsat imagery verified by aerial photography. The benefits of remote sensing use recognized by Ontario Hydro are the time/cost efficiency with respect to regional inventories, the repetitive coverage, and the possible application of automated analysis methods.

The Ministry of Transportation and Communications applied the interpretation of aerial photography to the planning, design, construction and maintenance phases of its programs. This is a well-established technique, with proven benefit to the Ministry.

The Water Resources Branch of the Ministry of the Environment obtained contract photography over Pickering G.S. and Toronto Harbour, and over a portion of the Lake Huron shoreline, including black and white, and true and infrared colour coverage. The objectives of the photography were to map sediment plumes, detect near-shore aquatic plant growth, and revise basemaps of certain study areas. In addition, CCRS conducted thermal scanning of these areas for the analysis of spring tributary plumes and the detection of thermal influences on nearshore coastal processes. The benefits of remote sensing use in near-shore lake studies were reported to be efficiency, completeness of the data provided, and economy.

The OCRS undertook an extensive and varied program of remote sensing application in 1976. The following are highlights:

- the mapping of cutovers, burns and wetlands by electronic analysis of Landsat imagery, for a large portion of the province

- continuation of the development of a methodology for the detection of building heat loss by means of aerial thermography

- forest regeneration success surveys and fuel mapping from satellite imagery

- continuation of the development of an aerial forest sampling methodology

The OCRS did not conduct any formal analyses of benefit/cost ratio in 1976, but affirms the practical value of the use of remote sensing imagery for studies related to resource exploitation and management.

Acres Consulting Services Ltd. applied aerial photography to ice reconnaissance, environmental impact studies and water resource studies. Landsat imagery was applied to a river basin study in Thailand.

Barringer Research Ltd. continued to apply remote sensing technology to the evaluation of air quality and mineral and geothermal exploration.

Ecologistics Ltd. of Kitchener has applied the interpretation of aerial photography to natural resources inventory for planning and environmental assessments. This company found that the use of remotely-sensed data significantly reduced the amount of field survey necessary in preliminary studies, and was particularly valuable in providing information required after the end of the field season.

Robinson, Merritt and DeVries of Toronto reported using the interpretation of aerial photography for flood studies, investigations of property damage, terrain analysis and forest assessment. The company used satellite imagery in one study, to gain an overview of an area outside Canada.

Ecoplans Ltd. of Waterloo applied the interpretation of aerial photography to the analysis of terrain and vegetation.

Beak Consultants Ltd. used aerial photography in vegetation and landform typing, wildlife habitat evaluation and the assessment of land use. Satellite imagery was used in assessing the environmental impact of development, in broad-scale land use inventories, and in the assessment of siltation and erosion. The use of remotely-sensed data was reported to be essential in saving time and money.

6.7.5 User Liaison

The OCRS continued to offer a source of remote sensing imagery, literature and expertise to individuals from government, industry and the public, within and beyond the province. In the summer of 1976, the Centre conducted a tour of several of the regional offices of the Ontario Government in order to present the practical value of remote sensing techniques to resource managers at the operational level. The Centre also continued its practice of giving guided tours and presentations to a wide variety of groups, on request.

6.7.6 Training

The OCRS was involved in three formal training courses in 1976:

- a photo interpretation course for the Forest Inventory Section of the Government of Saskatchewan

- a photo interpretation course for the Ontario Ministry of Natural Resources

- participation in a photo interpretation course given by the Ministry of Transportation and Communications

In addition, members of the OCRS staff participated in the First Canadian Symposium on Thermography and Energy Conservation (Toronto and Montreal, December, 1976) and in the Seminar on the Remote Sensing of Soil Moisture and Groundwater (Toronto, November, 1976).

The University of Toronto hosted and participated in the Remote Sensing Short Course given by the Ontario Association of Remote Sensing in May, 1976. A sourse has also been developed within the Faculty of Forestry, entitled, "Forestry Applications of Aerial Photography and Remote Sensing".

Sir Sandford Fleming College made plans to upgrade remote sensing-related courses for technicians and technologists.

Within the group of private companies, Acres Consulting Services Ltd. reported having conducted a photo interpretation course for its staff with respect to vegetation, landforms and land use, wildlife habitats, and engineering parameters.

Robinson, Merritt and DeVries took part in a seminar course in land use planning at the University of Guelph. Barringer Research Ltd. reported being more active in 1976 with regard to attending symposia and conferences.

6.7.7 Conclusion and Forecast

The Ministry of Transportation and Communications and the Ministry of the Environment both expressed confidence in the future of remote sensing use in their fields, although the Ministry of the Environment reply noted that economic restraints stand in the way of extensive remote sensing use in water resources management.

The Ontario Centre for Remote Sensing continues to perform a large volume of work in practical applications, and foresees a widening of the user community. It is the belief of the Centre that, while economic restraint works against the trial of new methods, it may also work against dogmatic maintenance of traditional procedures, if the benefit/cost effectiveness of remote sensing can be convincingly demonstrated. Within its own activities, the Centre expects best to demonstrate the efficiency of remote sensing through a major project that has received approval to begin in 1977/78, the completion of the surficial geology mapping of Ontario and the preparation of a physiographic description of Northern Ontario.

Among private consulting firms, Acres Consulting Services Ltd. expects a 3% increase in remote sensing activity in the near future, and expects that the nature of the applications will diversify.

Robinson, Merritt and DeVries anticipate the continuing use of conventional photography, with the application of other imageries, such as thermal infrared and Landsat, particularly to monitoring programs.

The comments of the other consulting firms which reported point out areas within the provincial and federal remote sensing programs which need improvement. They are included in the next section of this report.

6.7.8 Recommendations

The desire most often expressed was for more published information on practical applications, on both provincial and national levels. The recommendations of all the reporting agencies have been summarized in this section.

(a) A national list of user-oriented applications should be prepared, preferably including comparisons with traditional methods, with respect to time and costs.

(b) A program should be initiated to "sell" remote sensing to the executive level of resource management agencies across the country.

(c) CCRS should provide subsidies to ISIS to prevent a continuing increase in the cost of imagery.

(d) The NAPL catalogue kit, including both contemporary and historical coverage, should be provided to all provincial centres.

(e) CCRS should send representatives to provincial governments to encourage the establishment of provincial centres.

(f) The Applications Division of CCRS should compile information on international remote sensing application, for distribution to the provinces.

(g) The Remote Sensing Science and Technology Conference should be scheduled either together with, or farther apart from, the general Canadian Symposium, to permit greater attendance.

With specific reference to the Ontario remote sensing program, the following recommendation was made:

National Research Council grants should be supplemented by grants from the provincial government, to enable private industry to undertake research and development programs (e.g., 1/3 federal government investment, 1/3 provincial government, 1/3 private company).

6.7.9 1976 Publications

Lawrence, G.R. Ontario Centre for Remote Sensing airborne thermal sensing program for the detection of building heat loss. Presented to the First Canadian Symposium on Thermography and Energy Conservation, December, 1976.

Ross, D.I., R.M. Chatterjee and N.D. Herzog. Evaluation of airborne thermal IR mapping of cooling water discharges from generating stations. Presented at the 19th Conference on Great Lakes Research, University of Guelph, May, 1976.

Ross, D.I. and J.D. Kinkead. Selected aspects of operational thermal IR mapping of cooling water discharges from generating stations, BNPD Site - Lake Huron. Ontario Ministry of the Environment Report, November, 1976.

Zsilinszky, V.G. Think operational remote sensing! Opening address to the Seminar on the Remote Sensing of Soil Moisture and Groundwater. Toronto, November, 1976.

Barringer Research Ltd. reported, but did not itemize, numerous technical papers presented at international conferences in 1976.

6.8 REPORT ON THE PRINCE EDWARD ISLAND REMOTE SENSING COMMITTEE

6.8.1 Spaceborne Remote Sensing

For some time, complete implementation of numerous resource oriented programs of the P. E. I. Department of Agriculture and Forestry (Technical Services Branch and Forestry Branch) have been hampered and/or delayed by the lack of reliable current land use data. Although airborne remotely sensed imagery was considered, the province-wide application of program implementation and subsequent cost of conventional imagery on a time scale made it unfeasible. Groundtruth data collection, again on a continuous updating scheme, was also out of the question. However, use of satellite imagery and the Image 100 System was given serious consideration. Dr. Ryerson (CCRS) was contacted, and visited Prince Edward Island in July, 1976. At that time, we discussed our needs, and he strongly advised us to at least try the Image 100 System. Following more formal discussions, project objectives were defined as follows:

- to determine acreages of idle land, potatoes, corn, and other inter-tilled crops
- to determine the rate of potato harvest through the fall (using time sequence of LANDSAT) to aid in decision of time available to establish fall cover crops
- to determine pattern of field sizes for all crops (part of a hedgerow program)
- to define the extent of fall ploughing versus spring ploughing
- define surface drainage conditions which cause delays in seeding and problems in soil trafficability
- to assist in a forest species inventory; i.e., alder, white spruce, etc., to provide estimates of wood fuel if Prince Edward Island goes to wood burning electrical generation.

The program gained approval of both the government of Prince Edward Island and CCRS, and training/test areas were selected. A total of six (6) were chosen, but groundtruth operations were carried out on only five (5) due to a time limitation. Each area was about one square mile (640 ac.) in size. All groundtruth data was categorized, coded, and put on orthophoto maps (1:5,000 scale). However, groundtruth operations were completed out too late to provide image analysis for harvesting rates in 1976. Nonetheless, field size measurements are being made and land use analysis data is expected before the spring of 1977.

It is anticipated that this will be an on-going program which will provide us with ever current land use information, providing we supply CCRS with valid groundtruth data. Needless to say, if successful, this system will be considerably cheaper and less time-consuming than alternate methods. To date, we have had numerous requests for updated land use information, which we hope to be able to supply early in 1977. As for our own Branch, most of the suggested types of information will be used in our land management program, which is designed to assist farmers in adopting economic soil conservation practices.

6.9 RAPPORT DU QUEBEC

6.9.1 Coordination provinciale

Le centre de coordination provinciale du Québec, au service de la Cartographie du ministère des Terres et Forêts, compte maintenant une équipe de quatre personnes. Une sténo-dactylo et deux professionnels se sont joints en août 1976 au "coordonnateur provincial en télédétection". Un des professionnels s'occupe de la documentation et de l'information technique et scientifique. L'autre a comme principale responsabilité de mettre sur pied un laboratoire de traitement et d'interprétation des données.

6.9.1.1 Documentation et information

Le centre a mis l'accent sur l'accessibilité à l'usager québécois des documents et de la littérature sur la télédétection. Il possède un terminal permettant d'interroger les fichiers RESORS et IISS du C.C.T. On y trouve aussi une collection d'images Landsat et un abonnement à ISISFICHE, en plus d'une visionneuse permettant de consulter ces microfiches.

6.9.1.2 Démonstrations de moyens

Au cours de 1976, on a procédé à une série de démonstrations d'équipements de saisie ou de traitement des données. Un équidensitomètre et un synthétiseur multispectral du C.C.T. ont été placés en démonstration au service de la Cartographie du M.T.F. pour une période de 6 mois. Le ballon captif du C.C.T. a suscité beaucoup d'intérêt. Outre une démonstration sur l'île d'Orléans en juillet, le ballon a donné des résultats très intéressants au cours de 4 missions au Québec, particulièrement au cours d'une expérience relative à l'écoulement et au mélange des eaux de la Chamouchouane, au Lac St-Jean.

Une série de zones test, désignées par divers organismes gouvernementaux intéressés à la télédétection et représentants plusieurs thèmes différents, ont été photographiées à l'aide d'une chambre à objectifs multiples (multispectrale), en vue d'une étude ultérieure sur le synthétiseur multispectral compatible à cette chambre. On n'a pas encore de conclusion sur la validité de ce système (I^2S), le synthétiseur n'ayant pas encore été disponible à Québec.

6.9.1.4 Bulletin d'information

Le centre québécois de coordination de la télédétection s'est doté d'un organe de liaison avec les usagers de la télédétection de la province, par la publication d'un bulletin d'information: LA TELEDETECTION AU QUEBEC. Ce bulletin paraît depuis octobre 1976 à une fréquence approximativement mensuelle.

6.9.2 L'Association québécoise de télédétection

6.9.2.1 Activités en 1976

Fondée en novembre 1975, l'A.-Q.T. compte maintenant plus d'une centaine de membres regroupés en trois sections: "Administration publique", "Recherche et enseignement" et Secteur privé".

Les activités principales en 1976 se sont concentrées surtout sur la structuration et la consolidation de cette nouvelle association à caractère scientifique. Ainsi, au point de vue juridique, a-t-on procédé à l'incorporation de cet organisme en une association à but non lucratif.

Malgré ces préoccupations, et outre sa participation à l'organisation du 4e Symposium canadien sur la télédétection, l'A.-Q.T. a organisé conjointement avec l'Université Laval, et avec la collaboration du C.C.T., un cours intensif de trois jours sur la télédétection. Quarante personnes ont suivi ce cours donné en novembre dernier. Dans la même semaine, consécutivement, l'A.Q.T. a également tenu son premier symposium à Québec.

6.9.2.2 Programme de 1977

Il est prévu que cette phase d'organisation débouche en 1977 sur une série d'actions importantes:

- organisation d'un congrès québécois sur la télédétection, à Montréal, les 3 et 4 novembre prochain. Ce congrès vise à faire un tour d'horizon des possibilités réelles, tant techniques, administratives qu'économiques, d'intégrer efficacement et rapidement la télédétection à la gestion des ressources naturelles du Québec.
- lancement d'un bulletin d'information et de liaison paraissant à tous les deux mois.
- organisation d'une série de cours intensifs sur différents aspects de la télédétection et ce, dans diverses villes du Québec.
- lancement possible d'une revue scientifique portant sur la télédétection.
- organisation et coordination de projets pilotes visant à développer de nouvelles applications et à les transférer auprès des responsables de la gestion des ressources naturelles.

6.9.3 4e symposium canadien sur la télédétection

Le quatrième Symposium canadien sur la télédétection se tiendra à Québec, les 16, 17 et 18 mai 1977. Le ministère des Terres et Forêts (M.T.F.) s'occupe de l'organisation locale de cette réunion, avec la participation de l'Association québécoise de télédétection (A.Q.T.). Le Comité d'organisation locale, présidé par Hervé Audet (M.T.F.), comporte cinq responsabilités distinctes, confiées aux personnes suivantes: Hospitalité - Marcel Simard (M.T.F.); Exposition commerciale - Claude Jobin (A.Q.T.); Planification technique - André Grenon (M.T.F.); Publicité locale - Robert Talbot (M.T.F.); Bilinguisme et traduction - Benoît Drolet (M.T.F.). Le président s'était entouré de quatre conseillers d'expérience pour démarrer l'organisation.

6.9.4. Vocabulaire anglais-français de la télédétection

Un comité spécial formé de représentants de la Régie de la langue française, du ministère des Terres et Forêts, de l'Université Laval, de la Société de développement de la Baie James et du Centre canadien de télédétection travaille sur l'élaboration d'un dictionnaire anglais-français de la télédétection. La visée immédiate du comité est de produire un premier document pour le 4e Symposium canadien sur la télédétection, en vue d'assister la traduction des communications.

Le travail de ce comité pourra déboucher ultérieurement sur la préparation d'un lexique anglais-français de la télédétection.

6.9.5 Remarques

Le centre québécois de coordination de la télédétection a entretenu en 1976 de très bonnes relations avec divers interlocuteurs du C.C.T. ou de la P.N.A. et a obtenu de ces organismes, de façon générale, une collaboration très positive. Il y a eu cependant quelques points moins heureux. Comme il serait trop long d'énumérer tous les points positifs, on ne s'arrête que sur les autres.

6.9.5.1. Imagerie Landsat

Dans sa campagne de promotion de la télédétection par satellite, le coordonnateur provincial en télédétection a maintes fois mentionné, parmi les avantages que représente cette technique, la disponibilité rapide de l'imagerie Landsat. Or, dans les faits, on a parfois rencontré des délais inconcevables. On ne peut recevoir une image nouvelle avant 2 mois et il a fallu attendre, dans un cas en particulier, jusqu'à 4 mois avant d'obtenir de l'imagerie d'années antérieures.

Des usagers très importants perdent ainsi confiance en cette technique. C'est pourquoi on présente la recommandation 6.9.6.1.

6.9.5.2 Mosaïque Landsat

Des erreurs de toponymie apparaissant sur les feuillets au 1:1 000 000 de la mosaïque Landsat de la P.N.A. ont été signalées par la Commission de géographie du Québec au Comité permanent canadien des noms géographiques. Il s'agit de toponymes apparaissant sur la partie québécoise de la mosaïque.

6.9.5.2 Information en français

Le rôle du centre québécois de coordination de la télédétection serait grandement facilité si on palliait à la rareté de l'information émanant du Centre canadien de télédétection en langue française. Il y a aussi un problème concernant la qualité des traductions. Il serait souhaitable qu'une partie de l'information soit de version originale française. Pour l'immédiat, voir la recommandation 6.9.6.3.

6.9.6 Recommandations

6.9.6.1 Que le Centre canadien de télédétection expose très clairement sa politique de priorités concernant la fabrication des images Landsat. Qu'il fasse aussi connaître, de façon réaliste et honnête, les délais auxquels l'usager doit s'attendre lorsqu'il commande soit une image nouvelle, soit une image déjà cataloguée. Cette information pourrait être contenue dans un bulletin d'information à jour, expliquant en même temps les techniques actuelles de fabrication d'une image, les techniques de reproduction ainsi que la procédure exacte qu'on doit suivre pour demander la fabrication d'une image nouvelle ou commander une reproduction.

6.9.6.2 Que le Centre canadien de télédétection entre dans un fichier informatisé, au fur et à mesure de leur progression, l'état d'exécution de missions de télédétection aérienne, de sorte que les centres provinciaux de coordination, en interrogeant ce fichier par terminal (à la façon du système RESORS ou du système IISS), puissent être rapidement informés des circonstances d'exécution. On pourra ajouter à ce fichier les programmes d'estimation des coûts.

6.9.6.3 Que le Centre canadien de

télédétection constate la marge considérable séparant la réalité de ses intentions louables vis-à-vis la traduction de certains documents d'information qu'il publie (cas type: voir CACRS 1975 report, no 9.3.8.). Que cette marge soit réduite à des proportions décentes.

6.9 REPORT OF THE PROVINCE OF QUEBEC

6.9.1 Provincial Coordination

The Quebec provincial coordinating centre of the Mapping Service, Department of Lands and Forests, now has four members on its staff. In August 1976, the provincial remote sensing coordinator was joined by a shorthand typist and two professional members. One of the latter is in charge of documentation and technical and scientific information and the other is primarily responsible for setting up a laboratory to process and interpret data.

6.9.1.1. Documentation and Information

The Centre emphasizes accessibility of documents and literature on remote sensing to Quebec users. It has a terminal which is capable of interrogating C.A.C.R.S. RESORS and IISS files. There is also a collection of LANDSAT images and a subscription to ISISFICHE in addition to a viewer for consulting microfiches.

6.9.1.2. Demonstration of Equipment

During 1976, the Centre held a series of demonstrations of data capture and data processing equipment. The CCRS multispectrum synthesizer and data slicer were demonstrated at the Mapping Service of the Department of Lands and Forests over a period of six months. There was considerable interest in a CCRS captive balloon. A demonstration was given on the Ile d'Orleans in July. In addition, the balloon produced extremely interesting results during four missions in Quebec, mainly during an experiment involving the flow and mingling of the Chamouchouane waters at Lake St. Jean.

A series of test zones selected by various government agencies interested in remote sensing and representing various different areas of concern, were photographed by means of a multilens (multispectral) chamber for later study on a multispectral synthesizer compatible with this chamber. No conclusions have yet been drawn as to the validity of this I^2S system since the synthesizer is not yet available in Quebec.

6.9.1.4. Information Bulletin

The Quebec remote sensing coordinating centre puts out an information bulletin entitled LA TELEDETECTION AU QUEBEC, (Remote sensing in Quebec) as a means of reaching remote sensing users in the province. The bulletin has been published on a more or less monthly basis since October 1976.

6.9.2 The Quebec Remote Sensing Association

6.9.2.1 Operations in 1976

A.Q.T. (Association québécoise de télédétection - Quebec remote sensing association) was founded in November 1975 and now has over one hundred members divided among its three sections - "Public Administration"; "Research and Education" and "Private Sector".

In 1976, the main concerns of the association involved setting up and consolidating its structure. It was incorporated as a non-profit organization.

Despite these concerns and preoccupations, the A.Q.T. took part in the organization of the 4th Canadian Symposium on Remote Sensing and organized an intensive three-day course on remote sensing with Laval University and the cooperation of the CCRS. Forty people attended the course which was given last November. Following this, during the same week, the A.Q.T. also held its first symposium in Quebec.

6.9.2.2. 1977 Programme

In this phase of the organization, a series of important operations are planned for 1977:

- the organization of a Quebec congress on remote sensing to be held in Montreal on November 3 and 4, 1977. The purpose of the congress will be to study the actual technical, administrative and economic possibilities of effectively and rapidly integrating remote sensing in the management of natural resources in Quebec.
- put out a bimonthly information bulletin to serve as a link between the association and remote sensing users.
- organize a series of intensive courses on different aspects of remote sensing in different cities in Quebec.
- possibly put out a scientific journal on remote sensing.
- organize and coordinate pilot projects to develop new applications and refer them to the heads of natural resource management.

6.9.3 4th Canadian Symposium on Remote Sensing

The 4th Canadian Symposium on Remote Sensing will be held in Quebec on May 16,17 and 18, 1977. The Department of Lands and Forests

(D.L.F.) is in charge of local organization with the participation of the Quebec remote sensing association (A.Q.T.). The local organising committee, chaired by Hervé Audet (D.L.F.) includes five distinct areas of responsibility, headed by the following persons: Hospitality - Marcel Simard (D.L.F.); Commercial Exhibit - Claude Jobin (A.Q.T.); Technical Planning - Andre Grenon (D.L.F.); Local Publicity - Robert Talbot (D.L.F.); Bilingualism and Translation - Benoît Drolet (D.L.F.). The Chairman was assisted by four experienced advisers in setting up the organization.

6.9.4. English-French Remote Sensing Vocabulary

A special committee, made up of representatives from the Régie de la langue française, the Department of Lands and Forests, Laval University, the James Bay Development Corporation and the Canada Centre for Remote Sensing, is working on an English-French remote sensing dictionary. The committee's immediate objective is to produce an initial document for the 4th Canadian Symposium on Remote Sensing to help in translating the papers.

The committee's activities may ultimately lead to the preparation of an English-French glossary on remote sensing.

6.9.5. Comments

In 1976, the Quebec remote sensing coordinating centre maintained excellent relations with various representatives from C.C.R.S. or N.A.P.L. and in general obtained excellent cooperation from these organizations. There were some weak points, however. As it will take too long to list all the positive aspects, we shall concentrate on the not-so-positive.

6.9.5.1 Landsat Imagery

In his promotion campaign for remote sensing by satellite, the provincial remote sensing coordinator repeatedly mentioned the rapid availability of Landsat imagery as one of the many advantages of this technique. Actually, however, there have occasionally been inconceivable delays. It takes two months to receive a new image and in one particular case, four months elapsed before the imagery of previous years could be obtained.

As a result, major users lose confidence in this technique. We are therefore presenting the recommendation discussed in 6.9.6.1.

6.9.5.2 Landsat Mosaic

Toponymic errors on the 1:1,000,000 N.A.P.L. Landsat mosaic charts have been pointed out by the Quebec Geography Commission to the Canadian Standing Committee for Geographic Names. The place names involved are on the Quebec portion of the mosaic.

6.9.5.2 Information in French

If the scarcity of information in French from the Canada Centre for Remote Sensing were corrected, the role of the Quebec remote sensing coordinating centre would be considerably facilitated. The calibre of the translations is another problem. It would be advisable to have some of the information written directly in French. For the moment, see recommendation 6.9.6.3.

6.9.6 Recommendations

6.9.6.1 That the Canada Centre for Remote Sensing very clearly outline its policy on priorities concerning the production of Landsat images. Also that it give the user a fair and realistic idea of the time required to obtain a new image or an image that has already been catalogued. This information could be contained in an up-to-date information bulletin which at the same time would explain the current techniques for producing an image, techniques for reproduction as well as the exact procedure that should be followed to request the production of a new image or to order a reproduction.

6.9.6.2 That the Canada Centre for Remote Sensing enter the state of implementation of air remote sensing missions in a computerized file as the missions progress so that the provincial coordinating centres may be rapidly informed of the circumstances of implementation on interrogating the file through a computer terminal (as in the case of the RESORS or IISS system). The file could also contain cost-estimate programs.

6.9.6.3 That the Canada Centre for Remote Sensing make note of the considerable discrepancy between its praiseworthy intentions with regard to the translation of some of the information documents it publishes and the reality (example: see CACRS 1975 report, no. 9.3.8). That this discrepancy be reduced to reasonable proportions.

7.1 REPORT OF THE AES PANEL ON REMOTE SENSING

The major emphasis of the AES remote sensing program is in the application of proven remote sensing technology in support of AES research and development programs. Most of the projects listed below fall into this category.

7.1.1 Atmospheric Research Directorate

(a) Development continues on Regional modelling with boundary information supplied by large scale models and by the latest hourly and asynoptic data such as vertical temperature profiles from satellites.

(b) An automated real-time radar-echo prediction procedure (0-3 hours) was run for 6 months in the summer of 1976 by McGill University under contract for MSRB. The evaluation of the forecasts are currently being carried out by McGill and the Quebec Region.

(c) A data processing facility is being developed for a variety of meteorological satellite data processing functions such as: geometric and radiometric correction, image registration, image enhancement, applications research and archival of satellite data.

(d) A program is underway to produce absolute thermal radiation flux maps of the earth's surface. These maps would incorporate a correction for atmospheric effects. The results have a broad range of applications, including east and west commercial fishery, effluent detection and monitoring in areas such as the Great Lakes, small area modelling, hydrological energy balance modelling.

(e) Investigations are being carried out into the effects the earth's atmosphere has on outgoing radiation, the objective being to make corrections to satellite derived measurements for these effects, particularly, water vapour and aerosols.

(f) The application of satellite derived measurements to several problems is being attempted. Among them: hydrological energy balance studies, climatic change, snow and ice cover mapping.

(g) The Satellite Data Laboratory of the Aerospace Meteorology Division continues to acquire direct weather satellite data from U.S. meteorological spacecraft. Visual and thermal Infra-red data from the Very High Resolution Radiometer (VHRR) system of the NOAA series of weather satellites is acquired by "S" Band receiving equipment direct from the orbiting spacecraft and digitized for computer processing and the output of imagery for operational and research uses. Processed data suitable for national facsimile circuit transmission is distributed to major weather centres in near real-time to produce high quality photographic imagery at each of the centres equipped to receive it. Data is sent out from both day and nighttime orbits approximately every twelve hours. Special ice and other types of full resolution and enhanced satellite imagery is distributed by dialed broadband telephone circuits to specific users such as the Ice Forecast Centre in Ottawa.

Meteorological Infra-red and visual imagery from the GOES series of geostationary weather satellites is directly acquired from the WEFAX transmission system. Early in 1977 "GOES-tap" data, acquired from the Visual Infra-red Spin Scan Radiometer (VISSR) of the GOES spacecraft and centrally processed and sectorized by U.S. Data Utilization Station for landline distribution, will be available in the laboratory from a landline drop on the "GOES-tap" trunk circuit at Buffalo. This will make available sequential satellite coverage at approximately half hour intervals in both visual and infra-red modes day and night for storm tracking applications and research in support of forecasting system developments.

h. Weather radar data were archived on film and magnetic tape on a 5-day per week program. Hardware/software development continued. The resolution in height and time of the recorded data was about doubled. Raindrop distribution data were collected throughout the rainy season. The variation in reflectivity, rainfall rate and drop distributions, their interrelationships and the effects of droplet growth are being studied. Coincident airborne drop distribution spectrometer data is also being used.

i. Measurements of the continental sferics activity were made by a VLF analyser and its relationship with thunderstorm activity was studied. Good correlations were observed for all seasons except winter. Potential gradient, air earth current density and polar conductivities were measured as the data source. Studies to investigate the biological effects of atmospheric ions were undertaken in cooperation with the University of Toronto and McGill.

j. Experimental studies of the stratosphere are continuing in the Atmospheric Processes Research Branch, in order to assess the effects that anthropogenic pollutants such as freons, SST's, and nitrogen fertilizers have on the ozone layer.

Results of the STRATOPROBE II balloon flights which were flown from Yorkton, Saskatchewan in August, 1975 have been analyzed. The vertical profiles of nitric oxide, nitrogen dioxide, and nitric acid were found to be much the same as the profiles measured during STRATOPROBE I from Churchill in July, 1974. Measurements of freon and N_2O were obtained from the stratospheric air samples taken during the 1975 campaign. The measured values of nitrogen compounds from STRATOPROBE I and II and the freon measurements of STRATOPROBE II are in good agreement with the nitrogen and chlorine photochemistry schemes assumed in stratospheric pollution models.

In 1976, two flights of STRATOPROBE III were flown from Yorkton in August. The payload configuration was similar to that of the chlorine configuration of 1975. Changes were the replacement of the GASPEC by the scanning NO_2 spectrometer and the addition of a UV flux meter to measure the absolute solar flux between 190 nm and 210 nm. Remote sensing measurements of ClO and Hcl may have been achieved.

Ground based measurements of NO_2 and total ozone were carried out at Yorkton during the STRATOPROBE III operation. The NO2 measurements were made with a spectrophotometer which is basically the same as the NO_2 balloon spectrophotometer. The ground ozone measurements were made with a Dobson spectrophotometer which was stationed at Yorkton for the balloon campaign.

k. Daily surface-based measurements of total atmospheric ozone, made with the Dobson ozone spectrophotometer, continue at Churchill, Edmonton, Goose, Resolute and Toronto. The vertical ozone profile from the earth's surface to about 30 km is measured by balloon sonde each Wednesday.

Observational testing and development of the new ozone network spectrophotometer is continuing. The new instrument is being compared with the Dobson instrument and the performance of the new instrument is being evaluated. A contract has been awarded for the development of a commercial version of the new instrument.

ℓ. The National Atmospheric Radiation Centre (NARC) calibrated 116 radiometers during this period. An intercomparison of working standard radiometers was held at Mt. Kobau, B.C., during August. A special series of measurements of solar radiation on inclined surfaces was commenced in November at the Meteorological Research Station, Woodbridge, at the request of the Division of Building Research, National Research Council. A new ventilation device for pyranometers has been designed and constructed. The device is now under test and should prevent the accumulation of dew, rain, and snow on pyranometers. A new type Voltz sunphotometer has been constructed and preliminary testing gave satisfactory performance during calibration at Boulder, Colorado.

m. The Hydrometeorology and Environmental Impact Research Division reported the results of the WMO Snow Studies by Satellite Project on the Saint John and Souris Basins. Basic imagery used in the analysis was NOAA/VHRR imagery received by the AES Satellite Data Laboratory in Downsview, enhanced to facilitate snow cover analysis. This was supplemented by LANDSAT I and II data for the period February to April, 1976. Snow cover analyses using conventional surface data

only were compared to analyses based on both surface and satellite data.

The division has, for the past number of years, carried on a program to determine the performance of various precipitation gauges for the measurement of snowfall and snow samplers for the measurement of snowpack. The gauges used in the study are: M.S.C. Nipher shielded snow gauge, Fischer and Porter Recording Precipitation Gauge, Universal Recording Precipitation Gauge, and the Tretykov Precipitation Gauge. Results indicate that the M.S.C. Nipher Shielded Snow Gauge gives superior performance.

Field studies were continued and a number of reports were written in support of the Working Group on Precipitation, Evaporation and Soil Moisture of the WMO (CIMO). In November the Working Group on Hydrology of the Canadian Advisory Committee on Remote Sensing (CACRS) and the Canadian Remote Sensing Society sponsored a Workshop on Soil Moisture and Groundwater.

A contract to study the energy balance of areas partly covered by snow was let to the University of Toronto.

n. The division is involved in two hydrometeorological modelling projects. The purpose of the Large-Scale Water-Balance Project is to produce national maps which provide improved estimates of mean precipitation, evapotranspiration and runoff.

The WMO Saint John Basin WWW Project examines the present and potential applications of the World Weather Watch to operational hydrology. A computer program for determining daily areal precipitation by sub-basin has been developed for use with the SSARR streamflow forecast model. A progress report on the multi-agency international project was prepared for the meeting of the WMO Commission for Hydrology in Ottawa in July.

o. Work has continued in the development of a Laser Radar (Lidar) for atmospheric dispersion studies. Ground based remote sensing of pollutants is continuing with the participation of teams in the Alberta Oil Sand Environmental Research Project and in the Sudbury INCO Plume Dispersion Study.

A methodology has been developed to extend the range of operation and stabilize the baseline drift of commercial COSPECs. The use of this methodology has allowed the detection of the INCO plumes as far as 400 km (over Toronto). Further developments include the application of these instruments in joint ground and airborne based surveys.

7.1.2 Central Services Directorate

(a) The Atmospheric Environment Service conducts programs of ice observing and ice forecasting and provides data and advisory services to support Canada's national and international interests. The complete ice program, which has been developed primarily in support of marine navigation, is now one of the most extensive and complex in the world.

Data gathering is mostly by reconnaissance aircraft, equipped with laser profilometer, infrared scanner, camera array, brute force radar, airborne radiation thermometry, special navigation aids, and special communications facilities. Areas of operations cover the Laurentian Great Lakes, St. Lawrence River, and coastal areas from Gulf of St. Lawrence across the Arctic to the Beaufort Sea. Data collected include ice extent, type (age), floe sizes, ice topographic features, water openings, snow cover, state of ice deterioration. Satellite data from orbiting weather satellites and LANDSAT imagery are incorporated into forecast and climatological outputs. Fifteen to twenty years of ice data for Canadian waters is now available. Highlights in 1976 include participation by the Branch in the Beaufort Sea Project to support initial offshore drilling, ice climatological studies of various areas, and development of SLAR specifications for an all weather ice reconnaissance system.

(b) 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.

7.2 REPORT OF INSTITUTE OF OCEAN SCIENCES - PATRICIA BAY

During 1976 the remote sensing section was involved in satellite oceanography (infrared sea surface temperature and radar wave height measurements), airborne observations of coastal B.C. waters using the MIDAS Marine Inertial Data Acquisition System, a detailed water colour analysis using the 256 channel spectrometer and imagery and photography in support of other programs.

7.2.1 Airborne Oceanography

The Midas system has now been developed to the stage where aircraft track recovery is accurate to better than 10 meters at all times and the positions of targets and ocean features sighted by the operator can be measured to the same accuracy. The system has been used to map surface currents in Haro Strait using floating targets deployed by launches. Interactions of water bodies at tide lines can be followed by recording both tide line and target positions. The system has also been used in an ocean dumping exercise off Point Grey and to follow the development of the Fraser River plume. Instruments have now been added to record the wind velocity at the aircrafts flying height. This is to be used to support tests of drift models for oil spills in Juan de Fuca Strait.

An examination of the effects of different vertical distributions of chlorophyll on water colour and fluorescent line height was carried out in Saanich Inlet using the 256 channel spectrometer. Previous measurements here and elsewhere show that chlorophyll concentrations can be estimated and mapped from the air, but that data tends to show only concentrations near the surface. Since layers of high chlorophyll concentration are often present at various depths, the resulting maps can be misleading. Preliminary analysis shows that it should be possible to deduce information on the vertical distribution of chlorophyll from an aircraft using both colour and fluorescence data from the spectroscopy.

The spectrometer was also used in Ottawa for water colour measurements by the Canada Centre for Remote Sensing and for measurements of soil spectra by the Geological Survey of Canada.

7.2.2 Satellite Oceanography

The usefulness of infrared sea surface temperature measurements has been demonstrated in many parts of the world as well as by our own analysis of NOAA VHRR data for the B.C. coastal waters. We have encouraged the construction of a permanent west coast satellite receiving station in Vancouver and are developing a minicomputer image enhancement facility to process the data to our own requirements.

An application of visible satellite data was dramatically demonstrated by a frame from the temporary station operated for a month in April/May 1976 in Vancouver. This showed vortex streaks developing in the atmosphere behind the Aleutian Islands in a way that could be used to test fluid mechanical theories of interest to oceanography.

GEOS-3 radar altimeter data continued to arrive during the year, but in small volume and with numerous complications that are hampering U.S. and Canadian analysis projects. It appears that waveheights (H 1/3) should be measurable to .5 meters along the satellite track, and future satellite systems such as SEASAT where a set of 3 satellites will give fuller ocean coverage, should considerably improve reporting of ocean wave conditions and could also be used in weather forecasting. Since sea surface elevation is also measured, a project to analyse ocean tide heights is also planned.

Planning for prototype SEASAT A project continues with J.F.R. Gower on the NASA team for the synthetic aperture radar experiment and on the Canadian Committee for SEASAT A participation.

7.2.3 Imagery and Photography in Support of Oceanographic Programs at Patricia Bay

To support the programme of current measurements in Haro Strait being carried out by the Coastal Oceanography section, surface current measurements were made with the MIDAS system (described above), 3 thermal scanning flights were arranged over the area and oblique photographs of a small but critical area off San Juan Island were recorded at 10 minute intervals during daylight hours continuously for 2½ months.

The thermal scanning flights were made by Intera Environmental Consultants using a Cessna 206 aircraft flying at an altitude of 16000 ft. The imagery showed fronts between water bodies of different

temperatures, with evidence of upwelling, and of surface stratification as revealed by ship wakes. Such imagery could be recorded repeatedly day or night, but cloud free conditions are required.

The oblique photography was taken by an unattended super 8 time lapse camera attached to a tree near the top of Mt. Dallas on San Juan Island. Fronts associated with the incoming tide pass close to the foot of the mountain and could be seen on the film on 57 days out of 73. Front velocities could be deduced on 24 occasions and timing was accurate to about 10 minutes.

7.2.4 Remote Sensing of Ice

Interest of the Arctic Marine group has shifted from the Beaufort Sea to the Arctic Islands where exploration and pipeline routes are planned. The work involves strain (deformation) and dynamics measurements using a continuous series of NOAA VHRR imagery with addition of selected frames from Landsat 1 and 2.

7.2.5 Buoy Location and Data Collection Systems

Dr. J. Garrett is manager of the Canadian contribution to the FGGE (First GARP Global experiment) Buoy Project, and chairman of the international participant committee. The Canadian contribution will consist of 100 buoys measuring atmospheric pressure and surface water temperature with the ARGOS system on TIROS N doing the tracking and data relay. The FGGE Buoy project will deploy a total of 300 buoys south of 20° south latitude by Jan. 1979 to test the effect of the additional data input on world weather predictions.

Other related work includes development of a thermistor chain sensor for buoys to relay vertical temperature structure and an experiment with a direct readout system for the Random Access Measurement System on Nimbus 6 to allow self-contained satellite positioning operations to be conducted on a local scale.

7.2.6 Aerial Hydrography

OAS is continuing to support this project with 1 man year seconded to CCRS for the stereo photographic, shallow water survey program. Current technical difficulties involve vibration levels at the INS/survey camera module, and disagreements between orientation data produced by the INS, and that derived from photogrammetry by Dr. Masry at UNB. OAS has not been able to contribute to development of lidar bathymetry, but this is recognized as having high potential for aerial hydrography. Funds have been requested for 1978 to support later phases of the CCRS project.

7.3 SPECIALTY CENTRE REPORT OF THE FOREST MANAGEMENT INSTITUTE

7.3.1 Introduction

During the year a virtually frozen budget and the secondment of two senior officers to Southeast Asia curtailed some of the activities of the Remote Sensing, Appraisal and Integrated Resource Classification Programs of the Institute. These three programs, however, all of which are involved in remote sensing activities, made considerable progress during the year.

The report which follows departs somewhat from previous reporting format whereby this year the three FMI programs are described under separate headings. A description of the broad objectives of each program is presented, followed by selected highlights of achievements during 1976.

7.3.2 The Remote Sensing Program

The main objective is to carry out research and develop procedures for the use of all remote sensing techniques, and recently with emphasis on satellite remote sensing, for the collection of such data. These techniques will be used for the management and conservation of the forest resource and for the rapid appraisal and monitoring of critical situations such as forest fires, insect damage, and pollution damage. In the broadest sense, Canada needs the program primarily to develop and apply methods of standardizing nationally, the operational acquisition of qualitative and quantitative information concerning the forest ecosystem. The recent rapid development of remote sensing techniques, particularly those utilizing high-altitude airborne and satellite-borne sensors, is making possible the acquisition of such information for the entire country. Such information can be presented as automatically interpreted images, maps or statistics.

The Forest Management Institute is building a versatile, relatively inexpensive and yet relatively complete, digital interpretation system around a minicomputer. Most digital image interpretation systems for remotely sensed data are, today, implemented on large, expensive, general purpose computers and/or special purpose hard-wired classifiers. Because these systems are often situated at remote distances from the user, may be available only during off-hours, are usually expensive to use and may not incorporate all the features desired, there is a necessity for an alternative. This alternative system should be local, available during normal working hours, and relatively inexpensive to use, install, and maintain.

The system at present consists of a minicomputer, magnetic tape drive, a 100 megabyte disc drive, a user's terminal, a digitizing table and a colour television display. Future expansion calls for the acquisition of an image digitizing device and a hard-copy colour output device.

Software development is proceeding in the areas of input programs, preprocessing programs, classification programs, post-processing programs and output programs. One post-processing program, which is crucial for forest thematic mapping, and which involves the removal of all regions on a classified picture which are less than a specified area, has been developed and the results were published (Forest Management Institute Report FMR-X-90 — Davis/Peet).

During the 1976 field season, field spectroradiometric data was collected to account for temporal variations in reflectance patterns of the same tree stands. The analysis of these data awaits the return of Mr. Kalensky who has been in Indonesia since August, 1976, as a result of obtaining a Research Award from the International Development Research Centre. Based in Jakarta, Mr. Kalensky is assigned to BAKOSURTANAL, the Indonesian Mapping Agency, where he is applying his work in thematic mapping from Landsat digital data, to land use mapping of selected Indonesian test sites on the islands of Lombok and Bali. Mr. Kalensky returns to the FMI in August, 1977.

In September, 1976, a contract was signed by DSS and the Treasury Board authorizing Computing Devices Company (a division of Control Data Canada, Ltd.) to commence work on this project. The work, officially begun on October 1, 1976, is based on an unsolicited proposal originally submitted by the company in December, 1974. FMI was designated as Scientific Authority to monitor the progress and assure the success of this project.

The proposal involves research and development work leading towards an operational system for extracting resource and environmental data from digital remote sensing (scanner) data. The initial emphasis is on Landsat data but the results will equally apply to remote sensing data collected from aircraft. The proposal, to be completed over a 24-month period, involves

two elements, namely equipment development, and research into methods of classifying and presenting resource and environmental data as interpreted images, maps and statistics. When the work is completed, an efficient and versatile image analysis system will be available, providing assured access for elements of DFE, particularly the Lands, Wildlife and Inland Waters Directorates of EMS.

7.3.3 The Forest Appraisal Program

The main objectives of the program involve development research into systems and methods for collecting, processing and presenting forest and related resource information. Work has concentrated on the use of large-scale air photos for accurate tree measurements and on the use of digitizers and computers to process the measurements rapidly and to produce the required forest resource statistics. The Program is also concerned with the development of computer-based data storage and retrieval systems for integrating, condensing and presenting various kinds of resource information in a readily usable form. The development of large-scale photography has reached the point where it is being tested and demonstrated as an operational system; the computer-based storage, retrieval and mapping is a new undertaking.

Recent developments in the large-scale photography system include the very successful field testing of the system in collaboration with the Alberta Forest Service. As a result, the Inventory Division of the Forest Service will likely incorporate the system as a routine component of its inventory procedures. One interesting result was that tree heights, photogrammetrically measured on the photographs, were more accurate than those obtained with conventional tree measuring devices normally used on the ground. The two methods compared with the actual tree heights of the subsequently felled trees. In the past the system has been tested in the tropics; in Guatemala in 1968 and in Surinam in 1973. A third test of a modified system will be undertaken in Costa Rica in early 1977. The use of large-scale photographs for the measurement of tropical trees and the selection of the best photo specifications for the task were reported upon and published during the year (Forest Management Institute Report FMR-X-86 — Aldred).

Developments in computer-based geographic data storage, retrieval and mapping systems are helping to solve the data handling and presentation problems. The feasibility of using existing systems has been examined and some conclusions reached. For example, the large systems, presently available, were found to be too expensive and cumbersome to use. On the other hand, the smaller systems were generally found to be too narrowly defined to fully meet our needs without some additional development and modification. Efforts are underway to complete the development of a small system and build around it an in-house computer-based mapping system adequate for our requirements.

Related work concerned with the presentation of resource data is underway to identify the advantages and limitations of orthophoto maps. Black and white orthophotographs, scales 1:5,000, 1:10,000 and 1:20,000, have been produced of the Gatineau Park but further work is required to assess the usefulness in the presentation of line data and resource descriptions (Kalensky and Leblanc, 1975, 1976). Both colour and stereo orthophotographs are also being explored as a means of enhancing the usefulness and clarity of resource data presentations.

7.3.4 Integrated Resource Classification Program

As part of its research and development program during the past decades, the Forest Management Institute has conducted numerous studies dealing with the appraisal of forest resources in various parts of Canada. These studies are usually initiated at the request of government agencies requiring basic information on forest resources in selected areas in order to plan and control anticipated forest activities, or to assess the environmental impact of potential development in the North (e.g. pipelines from the Arctic to southern Canada). From a systematic analysis of aerial photographs and ground information collected during the field inspections, some 300 maps have been compiled covering an area of over 100,000 square miles at scales of 1:15,840, 1:63,360 and 1:125,000, mainly in the Yukon and the Mackenzie District of the Northwest Territories. This work, in addition to supplying the requesting agency with the information they needed, provides FMI researchers with an opportunity to develop and test survey methods based on an intensive application of remote sensing technology and photo interpretation techniques.

The approach presently used at FMI for the classification and survey of primary natural resources in national parks is essentially the hierarchical classification system proposed by the National sub-Committee on Biophysical Classification (Lacate, 1969), and the surveys are often referred as "bio-physical" or "integrated survey of biophysical resources". This method is based on a systematic stratification of the land surface and delineation of ecologically significant segments of the

landscape composed of a pattern of landforms, vegetation and open water bodies. Since distribution and growth of natural vegetation are closely associated with the physiography of the area, the land features are mapped first to provide a physical base, relatively independent of successional or man-introduced changes, for the evaluation of biological and water resources. The hierarchical structure of this classification method, where the work proceeds from the recognition of general landscape patterns toward the classification of specific components of this pattern, has several advantages. It allows the most effective use of remote sensing technology, reduces or eliminates unnecessary and costly duplications and has a built-in provision for subsequent, more intensive investigations in selected areas.

Several scales, ranging from 1:5,000 to 1:100,000 are used for resource data presentation and compilation of resource maps and overlays. The St. Lawrence Islands and Georgian Bay Islands National Parks, for example, are mapped at scales of 1:10,000 and 1:5,000, L'Anse aux Meadows at the scale of 1:10,000, Kejimkujik and Fundy National Parks at the scale of 1:12,500, Pukaskwa and Prince Albert National Parks at the scale of 1:25,000 and 1:50,000, while South Nahanni National Park at the scale of 1:50,000 and 1:100,000. During 1976 base-maps have been completed for Nahanni National Park, and mapping for both St. Lawrence Islands and Georgian Bay Islands National Parks are virtually completed.

7.3.5 Training

During the year, research staff at the FMI were involved in workshops on Integrated resource surveys in Halifax, N.S., Cornwall, Ont., and Winnipeg, Manitoba, and prepared or contributed to training seminars in St. John's, Nfld., Halifax, N.S., Vancouver, B.C., Calgary, Alta., and Whitehorse, Y.T.

7.3.6 Recommendations

- that CCRS look into the feasibility of producing CCT's for selected portions of full Landsat scenes.

- that the working group meetings, normally held between the annual CACRS meetings, be consolidated in a manner analogous to that now proposed for reporting purposes.

7.3.7 APPENDIX I: Current Bibliography

Aldred, A.H. 1976. Measurement of tropical trees on large-scale aerial photographs. Dept. of Environ., Can. For. Serv., For. Manage. Inst., Inf. Rep. FMR-X-86.

Dapaah, S.K., L.E. Philpotts, A.R. Mack, and F.G. Peet. 1976. Effects of soils and seasonal time on accuracy of crop identification in southwestern Ontario from 1974 LANDSAT-1 Imagery. Can J. of Plant Science, in press.

Davis, W.A. and F.G. Peet. 1976. The recognition and reclassification of small regions on digital thematic maps. Dept. of Environ., Can. For. Serv., For. Manage. Inst., Inf. Rep. FMR-X-90.

Davis, W.A. and F.G. Peet. 1976. A method of smoothing digital thematic maps. Remote Sensing of the Environment, in press.

Gimbarzevsky, P. 1976. Integrated survey of biophysical resources in national parks. Proc. National Committee on Bio-physical Classification, Petawawa, Ontario, 26-29 May, 1976 (In Press).

Kalensky, Z. 1976. Automation of thematic mapping based on remote sensing and computerized image interpretation. Presented at UN/FAO Training Seminar, Lenggries, Bavaria, 9-21 August, 1976.

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Nielsen, U. and A.H. Aldred. 1976. Can tropical forest inventories benefit from recent developments in aerial photography. Proc. XVI IUFRO Congress, Oslo, Norway, 20 June - 2 July, 1976.

Peet, F.G. 1976. A digital image interpretation system for under $100,000. Dept. of Environ., Can. For. Serv., For. Manage. Inst., Inf. Rep. FMR-X-97.

7.4 SPECIALTY CENTRE REPORT OF THE LANDS DIRECTORATE, DEPARTMENT OF FISHERIES AND ENVIRONMENT.

7.4.1 Introduction

Remote sensing continued to play an important role in the activities of the Lands Directorate in 1976. The evaluation of airborne and satellite techniques for ecologically-based land classification, land use mapping and land use monitoring form the major objective of these programs. The development of applications for operational land resource surveys and provision of advice and training to federal and provincial authorities is also being pursued.

The Land Classification, Integrated Surveys and Remote Sensing Division stabilized as a cohesive working group during the year. A remote sensing ecologist, Mr. Clay Rubec, has been added to our staff to act as a liaison between CCRS and Lands Directorate activities.

7.4.2 Ecological (Biophysical) Land Classification

Airborne remote sensing remains essential to operational ecological land classification programs in Canada. The value of visual and automated satellite interpretation techniques for operational purposes is directly tied to the level of mapping detail required and ecological as well as physiographic complexity inherent in study areas. Limited success in biophysical mapping has been attained through studies in the Churchill, Manitoba area by J. Thie of Lands Directorate and by Dr. P.J. Howarth (under contract, McMaster University) for Melville Island, N.W.T.

A further study has been initiated to evaluate remote sensing for operational mapping in the Caribou Range (unsolicited proposal, Dr. J.S. Rowe, Department of Northern Studies, University of Saskatchewan, Saskatoon). The physiographical more complex boreal forest and lowlands of Northwestern Ontario near Kenora (Experimental Lakes Area) is also being examined. Further research will concentrate on the use of satellite imagery for mapping and description of environmental phenomenon for ecological land classification.

The formation of the Canada Committee on Ecological (Biophysical) Land Classification in 1976 was accomplished through the cooperation of DFE, CDA, EMR and DINA and provincial departments. The Committee seeks to further develop methods and systems for ecological land classification and to provide technical cooperation to federal and provincial agencies. The Land Classification, Integrated Surveys and Remote Sensing Division of Lands Directorate provides the secretariat and present chairperson for the Committee.

Preliminary ecological Land use and recreation potential mapping as part of the Northern Land Use Information Series continues for mid-Arctic regions. Five CCELC working groups, land/water integration studies and an Urban Biophysical Workshop comprised related activities during the year.

7.4.3 Land Use Mapping and Monitoring

During 1976, the Resources Mapping Division of Lands Directorate has utilized aerial photography for rural-urban land use change studies. Land use conversion statistics for 71 Canadian cities have been compiled with publication slated for early 1977. A land use case study for Ottawa-Hull using the Canada Geographic Information System (CGIS) was published.

The use of computer processing techniques for analysis of satellite data for CLI applications has been examined by Dr. J. Schubert on contract. Three automated techniques, including the Image 100 and MAD systems at CCRS and a LAND ANALYSIS program implemented at DFE, are compared in terms of accuracy, limitations and costs. The Resources Mapping Division continues to examine possible applications of such automated remote sensing interpretation to develop a Canada Land Use Monitoring Program (CLUMP) in urban and key agricultural areas.

Special attention is being given to land-use mapping within an ecological framework. The concept of land use systems as equivalents to the ecological land system will be tested.

7.4.4 Lands Directorate Regional Offices

Remote sensing imagery have been effective tools with Lands Directorate scientists in Vancouver, Burlington, Quebec City and Halifax.

The Lands Directorate, Halifax, has utilized satellite and airborne imagery for biophysical studies in Labrador and coastal resources inventory experiments. A paper by T.T. Alfoldi at CCRS under contract to Lands Directorate is currently in preparation. In Vancouver, Lands Directorate staff continue to utilize airborne and satellite imagery for

coastal zone inventory, Fraser River delta studies, and development impact studies. However, no specific remote sensing research has yet been initiated.

The Lands Directorate in Quebec has been actively engaged for several years in biophysical surveys of the Lac-St-Jean region and the James Bay Hydroelectric Development. In Burlington, Lands Directorate scientists have frequently utilized imagery for land use studies in the Saugeen Basin, Trent Waterways and Experimental Lakes Area. Through cooperative programs, wetland ecology and automated wetland classification are also being investigated.

7.4.5 Conclusions

The year, 1976, has been an active one for Lands Directorate staff. Despite major departmental restructuring near the end of the year, it is evident that effective working groups in Ottawa and the regions will be maintained. The cooperation of remote sensing agencies such as CCRS has been most appreciated during this year. Lands Directorate trusts that cooperative programs will continue to prosper.

7.4.6 Appendices

7.4.6.1 Appendix I List of Lands Directorate Staff involved in Remote Sensing.

Ottawa-Hull:

Mr. J. Thie - Land Ecologist; biophysical classification.

Mr. D.M. Gierman- Geographer; urban-rural land use change.

Mr. T.W. Pierce - Forester; forestry and recreation land classification.

Mr. D.M. Welch - Fluvial geomorphologist; land/water integration.

Mr. E. Wiken - Ecologist; land classification, pedology and biology.

Mr. G. Ironside - Biologist; dynamic phenomenon, wildlife.

Mr. C. Rubec - Ecologist; remote sensing, land classification.

Atlantic Region:

Dr. G.E. Beanlands - Coastal zone classification

Mr. N. Lopoukine - Forester; biophysical surveys.

Ms. N. Prout - Geographer; coastal zone classification.

Quebec Region:

Mr. J. L. Belair - Pedologist; biophysical classification.

Ontario Region:

Mr. G.M. Wickware - Geographer; biophysical land surveys.

7.4.6.2 Appendix II - 1976 Publications, Reports and Papers related to Remote Sensing Applications.

Alfoldi, T.T. (1977). The use of satellite imagery for an inventory of coastal resources in the Atlantic Provinces, CCRS contract for Lands Directorate, Atlantic Region, in preparation.

Gierman, D.M. (1976). Rural Land Use Changes in the Ottawa-Hull Urban Region, Lands Directorate, Occasional Paper #9, Ottawa, 85 pp.

Gierman, D.M. (1977). Rural and Urban Land Use Conversions in Canada, Lands Directorate Occasional Paper, Ottawa, in prepartion.

Howarth, P.J. (1976). An Evaluation of LANDSAT Imagery for Land Classification on Eastern Melville Island, NWT, Canada, Lands Directorate,Report, Ottawa, April 1976, 158 pp.

Pierce, T.W. and Thie, J. (1976) Biophysical Land Classification in the Environmental Management Service, Department of the Environment, Proc. 1st Meeting, Canada Committee on Ecological (Biophysical) Land Classification, Petawawa, Ontario May 25-28, 1976.

Schubert, J.S. (1976) Computer Processing of LANDSAT Data as a Means of Mapping Land Use for the Canada Land Inventory, Lands Directorate Interim Report 76-3, Ottawa, 162 pp. plus Appendices.

Thie, J. (1976) An Evaluation of Remote Sensing Techniques for Ecological (Biophysical) Land Classification in Northern Canada, Proc. 1st Meeting, Canada Committee on Ecological (Biophysical) Land Classification, Petawawa, Ontario May 25-26, 1976.

Thie, J. (1976) An Evaluation of Remote Sensing Techniques for Ecological Land Classification, Proc. 2nd Ann. W.T. Pecora Memorial Sym., Oct. 25-29, 1976, Sioux Falls, South Dakota.

Welch, D.M. (1976) The Integration of Water into Ecological Land Classifications, Proc. 1st Meeting, Canada Committee on Ecological (Biophysical) Land Classification, Petawawa, Ontario May 25-26, 1976.

8.1 REPORT OF THE ONTARIO ASSOCIATION OF REMOTE SENSING

8.1.1 INTRODUCTION

In Ontario, since the early sixties, it had been the practice of a nucleus of Photo Interpreters from various disciplines to get together and discuss items of common interest. During the early seventies, the number of persons involved with remote sensing had increased substantially and the rudiments of our organization was in being. This organization, called the "ONTARIO ASSOCIATION OF REMOTE SENSING" (OARS), was formally constituted in July 1973 in order to accommodate the interests of the many people so involved.

8.1.2. FUNCTIONS AND RESPONSIBILITIES

8.1.2. 1. Objectives

Briefly, some of the OARS objectives are:

a) to develop the understanding and use of remote sensing in the Province of Ontario,

b) to encourage the open and free exchange of information between the users of remote sensing in Ontario, and

c) to comprehend and promote the understanding of remote sensing at national and international levels by interacting with other similar associations and agencies.

8.1.2. 2. Activities

The major activities of the OARS are at present managed by 3 committees:

a) MEMBERSHIP AND INFORMATION COMMITTEE

This committee is responsible for developing the understanding and use of remote sensing by recruiting new members and by disseminating information relating to remote sensing and OARS activities.

b) EDUCATION COMMITTEE

The main responsibility of this committee is to organize and conduct formal courses in order to develop and promote the use of remote sensing. The first Remote Sensing 3-Day Short Course was held in May 1976 with 38 registered participants. The second Short Course on Remote Sensing Applications to Environment, Agriculture and Forestry will be held on April 25-28, 1977.

c) PROGRAM COMMITTEE

To encourage the open exchange of information on remote sensing matters is the main responsibility of this committee. On the basis of the interests and the requirements of the membership, the committee organizes bi-monthly lectures on various remote sensing themes.

8.1.2. 3. Publications

The Association publishes a quarterly newsletter which focusses on items of special interest to the membership.

8.1.2. 4. Liaison

Through its officers and various committees, the Association maintains liaison with various government agencies, associations and educational institutions at Provincial, National and International levels.

8.1.3. MEMBERSHIP

Membership in the OARS is open to individuals with an interest in the practice of Remote Sensing. Students are encouraged to join the Association at a nominal fee.

At present there are about 250 members on record. These members represent various professions, disciplines and organizations in Ontario:

a. Disciplines: Engineering,
Geology,
Pedology,
Forestry,
Agriculture,
Biology,
Geography,
Instrumentation, and
Education.

b. Organizations: Government agencies,
Crown corporations,
Private consultants,
Universities,
Community Colleges, and
other educational institutions.

8.1.4. THE OARS AND CCRS

The Association appreciates the interest shown by the Canadian Advisory Committee on Remote Sensing and the invitation to this annual meeting.

Individually, members of our Association have received very satisfactory service from the C.C.R.S. We believe that continual interest and support from the Centre, especially in the case of Dr. Morley and his senior staff, will be of great benefit to our members and will aid in fulfilling the objectives of our Association.

8.1.5. LIST OF OFFICERS FOR 1977

President: Mr. B. Sen Mathur
Remote Sensing Section
Ministry of Transportation and Communications
Downsview, Ontario

Vice President: Dr. David K. Erb
Dept. of Geography
University of Waterloo
Waterloo, Ontario

Secretary-Treasurer: Mr. Lawton Tam
Remote Sensing Section
Ministry of Transportation and Communications
Downsview, Ontario

Past President: Mr. Ernest D. Scullion
Northway Survey Corp. Ltd.
Toronto, Ontario

Councellors: Dr. Brestislav Boucek
Natural Resources Division
Sir Sanford Flemming College
Lindsay, Ontario

Mr. Lykle de Vries
Robinson, Merritt & de Vries Ltd.
Toronto, Ontario

Mr. John D. M. Phillips
Cartographic Services Ltd.
Unionville, Ontario

Mr. John F. Gartner
Gartner Lee Associates Ltd.
Willowdale, Ontario

Mrs. Ivanka Wile
Water Resources Branch
Ministry of the Environment
Rexdale, Ontario

Mr. Thomas T. Alfoldi
Applications Division
Canada Centre for Remote Sensing
Ottawa, Ontario

Mr. S. J. Glenn Bird
Bird and Hale Ltd.
Toronto, Ontario

Prof. Stanley H. Collins
School of Engineering
University of Guelph
Guelph, Ontario

Dr. Phillip J. Howarth
Dept. of Geography
McMaster University
Hamilton, Ontario

Dr. Simsek Palabekiroglu
Ontario Centre for Remote Sensing
Ministry of Natural Resources
Toronto, Ontario

Committee Chairman:

Membership and Information: Mr. Ernest D. Scullion
Northway Survey Corp. Ltd.
Toronto, Ontario

Education: Dr. Jaroslav Vlcek
Faculty of Forestry and Landscape Architecture
University of Toronto
Toronto, Ontario

Program: Mr. S. J. Glenn Bird
Bird and Hale Ltd.
Toronto, Ontario

Appendix I: Proposal For Establishing An "Engineering Applications" Working Group

A) RECOMMENDATION

Since the early stages of development, remote sensing has demonstrated obvious potential for Engineering Applications. Over the years, a lengthy list of such applications have been developed and established by the engineering communities throughout the world. Some of the major examples are:

- Transportation Engineering: In the planning, design, construction and maintenance of various transportation modes.
- Geotechnical Engineering: Geotechnical information concerning engineering soils and materials is a common practice for site selection (of various engineering projects).
- Design of Bridges and Culverts: Provision of the design data through the analysis of drainage, watershed and soil conditions.

- Environmental Studies: Many major engineering projects are using remote sensing to monitor and predict the effects of construction and engineering practices on the environment.

Today, in Canada, remote sensing is used by government agencies and consulting engineers in many engineering projects, and research is being conducted continually to further its applications. Depending on the activities of an organization, remote sensing can be used extensively in many phases of its operations. As an example, the Ministry of Transportation and Communications, Ontario, has the responsibility to plan, design, construct and maintain such varied transportation facilities as highways, railways, transit systems, airstrips, etc. Remote sensing has already had many proven benefits and the Ministry employs a group of 20 Engineering personnel at the Head Office and Regional level to provide this service. Also, several consulting Engineers rely extensively on airphotos and other types of imagery in the delivery of their services to their clients.

At present, at least in one province, Ontario, there is an Association to meet the need for a vehicle for the dissemination and exchange of information and for a forum to discuss matters of mutual interest. However, such an association serves a variety of persons possessing different backgrounds and interests, some of which are represented by established "working groups" at the national level, such as the CACRS working groups.

Regarding the "engineering applications" of remote sensing, it appears that the applications and development in Ontario, at least, can be improved. So far, the availability of information to an individual depends on his personal contacts. Developmental activities are based on very specific and localized needs. Dissemination of information, in this case by the OARS, can only be limited because of geographical boundaries and because other disciplines have to be served as well. Moreover, the mechanism has been informal and is dependent on volunteered information. Consequently, it is possible that similar applications, procedures or developments in engineering are being carried out by various parties without any of them knowing what the others are doing. The same condition may exist in other provinces.

The establishment of a working group for "Engineering Applications" will improve the dissemination of information and coordination of efforts in this area. Specifically, it will serve to:

1. consider, evaluate and describe the state-of-the-art of engineering application of remote sensing,
2. identify parameters relevant to engineering applications in Canada,
3. identify on-going programs,
4. identify and recommend areas of potential engineering applications (and perhaps set priorities),
5. coordinate research and development activities,
6. encourage and facilitate contact between users and development groups.

* This proposal has been made specifically by the Ontario Ministry of Transportation and Communications.

8.2. REPORT FROM THE COMMITTEE TO INVESTIGATE THE NEED FOR THE ESTABLISHMENT OF A TRAINING CENTRE IN REMOTE SENSING IN CANADA

8.2.1. Introduction

Almost every year, the Canadian Advisory Committee on Remote Sensing (CACRS) annual report carries appeals, from one or more working groups, for increased support of education in remote sensing (2,3,4,5,9,10). On the final day (April 1st) of the 1976 CACRS meeting, it was agreed to form an ad hoc committee to consider the need for a training centre in remote sensing.

8.2.2. CACRS Proposal

The proposal adopted after a short discussion reads:

> CACRS should establish an ad hoc interdisciplinary committee to investigate the need for a Canadian training centre 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.

8.2.3. Committee Members

A committee of CACRS members was appointed at the meeting, and are listed in Appendix 1.

8.2.4. Scope of the Investigation

Early in the first meeting of the committee, it was decided that rather than consider the pros and cons for a single training centre, an attempt should be made to:

(1) Assess the present status of remote sensing in Canada.
(2) Try to recognize deficiencies.
(3) Propose corrective action.

8.2.5. Forms of Education

The committee considered the various ways in which a person develops expertise in remote sensing technology. These were seen to fall into 2 broad groupings.

(1) Unstructured studies, which include literature studies, attendance at symposia, visits to laboratories, to universities, to government institutions and on the job training.
(2) Structured studies, which, excluding courses at high schools, consist of:

    (2.1) Courses at universities or colleges of advanced technology. Such studies are characterized by an extended learning period (usually several months), theoretical aspects are emphasized, studies are widely based with emphasis on the 'general case' and on multiple solutions.

    (2.2) Short courses offer a shorter learning period in which theoretical considerations are, of necessity, more restricted, and emphasis is placed on practical aspects. Such courses tend to be 'mission oriented'.

The committee considers that both forms of structured study are essential.

In the near term, short courses provide a mechanism for the rapid transfer of technology (7) which helps to turn established scientists into specialists in remote sensing. Such courses encourage the maintenance of professional standards and offer a mechanism by which specific regional problems can be solved. (6).

Over the long term, the universities and colleges of advanced technology will deserve much more of our attention because they will provide our next generation of scientists, hopefully armed with sufficient theoretical knowledge for them to carry out useful research in their several disciplines.

8.2.6. Structured Courses

The committee attempted to assess the value of the structured courses given in Canadian universities and colleges and to obtain a factual base to work on.

(1) A listing of university and college courses on remote sensing or courses with a remote sensing component was compiled using university and college calendars, personal enquiries and other published sources (1,8). The final listing is presented as Appendix 2.

(2) The committee also wrote to all regional remote sensing centres where such exist, and to regional representatives where there are no centres, asking for opinions and information on the status of education and educational needs in remote sensing, both in the particular region and in Canada as a whole.

A. Short Courses

As regional representatives point out, their short courses are considered to be very worthwhile since they are almost always over-subscribed and have received very positive feedback from attendees. The committee generally agrees with the regional opinions although it notes that such courses are not evenly distributed throughout the country. The coverage is locally inadequate particularly in the eastern Canada and, possibly, in British Columbia. Secondly it is noted that while some of the courses are given on a regular basis, many of them are not, and no attempt is made to coordinate courses curricula. A list of short courses given in Canada between 1975 and 1977 is attached to this as Appendix 3.

B. University and College Courses

The size of the listing of courses given in Canadian universities and colleges (Appendix 2) was a surprise to the committee. Many of the courses listed are concerned with airphotos alone, and in many others, the remote sensing components are very minor.

The general feeling of the committee is that the size of the listing does not reflect the real status of remote sensing courses in Canada. The regional representatives,too, were unanimous in suggesting that university courses are inadequate.

Few universities have more than one or two interested teachers, facilities in terms of equipment and materials are mostly inadequate; experience of the teachers is often limited and variable; there are no Canadian 'centres of excellence'. It must be emphasized again that this is the opinion of the committee, supported by that of regional representatives, and cannot be supported in quantitative terms.

8.2.7. Upgrading University and College Courses

An interesting feature of higher education institutions and one perhaps little appreciated by non-academics, is the very high degree of independence enjoyed by these institutions. Without the assistance of large amounts of ready capital, it would be extremely difficult to influence universities and colleges to introduce new courses or to expand existing ones. The committee has no funds to command, and so must look to other ways of encouraging remote sensing techniques. Clearly the best approach will be to encourage changes from within the teaching centres.

8.2.8. Training Overseas Students

The committee considered the need for providing training in remote sensing methods to students from overseas.

It was noted that both CIDA and IDRC pay for a small number (20-50/year) of overseas students to undertake remote sensing courses in both Canadian and foreign training centres.

Every year more bilateral and multilateral agreements are reached which include training components.

At an international level, there is a movement towards the establishment of an international network of educational and research institutes in remote sensing (11).

Notwithstanding these arguments, the committee feels that improvement to the present teaching situation in Canada should first of all attempt to satisfy the needs of Canadians students rather than encourage the establishment of facilities specifically for foreign students.

8.2.9. A National Training and Research Centre

The committee also feels that however desirable it might be to establish a national or international (I.T.C. - type) centre specializing in teaching and research into remote sensing, such a centre would be impractical at the present time, both on political grounds - decentralization being a key word in Federal Government thinking - and financial grounds, in that education being a Provincial responsibility, it is difficult for a province to support a national or international educational institution. There remains the possibility of independent financing which has not been explored by the committee.

8.2.10. Recommendation

The committee, therefore, recommends that a new Working Group on

Education be created by CACRS to include representatives from universities, colleges and regional centres.

The functions of this committee might be:

(1) To create a forum of opinion concerning the need for improvements in the teaching of remote sensing
(2) To consider the common elements of a cirriculum.
(3) To encourage debate on the need for a national centre for the analysis of remotely sensed data.
(4) To establish more effective communication between aid granting agencies in the Federal Government (MOSST for national programmes, CIDA and IDRC for international ones) and in Provincial Governments and the universities and colleges of Canada.

A number of university and college teachers have indicated their interest in strengthening the teaching of remote sensing. Their names have been forwarded to the chairman of CACRS for consideration as members of the proposed new Working Group.

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Appendix 1

List of Committee Members

H. Audet .....Ministry of Lands and Forests, Québec City.

I.C. Brown .....Inland Waters Directorate, Ottawa.

A. Gregory .....Gregory Geoscience Ltd., Ottawa.

A. Mack .....Soil Research Institute, Ottawa.

L. Sayn-Wittgenstein .....Forest Management Institute, Ottawa.

V.R. Slaney (Chairman) .....Geological Survey of Canada, Ottawa.

Statistical Summary of Remote Sensing Courses in Canadian Universities and Colleges

Province	Universities & Colleges with Remote Sensing Courses	Number of Courses Listed				Active Provincial Remote Sensing Centres
		Under Graduate		Graduate		
		Partial	Full	Partial	Full	
Newfoundland	1	1	3	5	0	-
New Brunswick	1	1	4	0	3	-
Nova Scotia	4	3	2	0	0	-
Quebec	12	9	22	1	12	-
Ontario	26	33	34	2	12	X
Manitoba	3	5	10	0	1	X
Saskatchewan	2	1	2	0	0	-
Alberta	4	6	6	2	1	X
British Columbia	5	8	8	0	2	-

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Newfoundland								
Memorial University, St. Johns.	Geography	GEO 3220	Air Photo Interpretation	R.D. Worsfold	Term	U'grad.		
	Engineering	ENG 8421	Remote Sensing		"	"		
		ENG 9104	Random Signal Processing			Graduate		
		ENG 9105	Digital Filtering			"		
		ENG 9112	Ocean Accoustics			"		
		ENG 9001	Ocean Engineering Concepts			"		
		ENG 9091	Advanced Statistical Analysis			"		
	Forestry	FOR 2021	Introduction to Forestry II		Term	U'grad.		includes A/Pl. interpretation
	Biology	4210	Remote Sensing		"	"		
New Brunswick								
U. of New Brunswick, Fredericton.	Forestry	FOR 3302	Introd. to Photo-Interp. and Remote Sensing	F.S. Oliver	Term	U'grad.		
		FOR 3322	Photo-Interp. for Forest Engineer	W.H. Hilborn	"	"		
		FOR 3312	Topography and Photo-Interp. for Engineer	W.H. Hilborn	"	"		
		FOR 4302	Photo-Interp. and Remote Sensing	F.S. Oliver	"	"		
		FOR 6300	Photo-Interp. and Remote Sensing	Oliver & Hilborn	Term	Graduate		
		FOR 6310	Problems in Photo-Interpretation & Remote Sensing	W.H. Hilborn	Term	Graduate		
	Survey Eng.	6521	Remote Sensing	Derenyi	"	"		
		4342	Remote Sensing		"	U'grad.		

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Nova Scotia								
Acadia U., Wolfville.	Geology	221/222	Air Photo Interpretation		Year	U'grad.		for geology, archeology, agriculture, includes remote sensing alternate years.
		271	Geomorphology		"	"		includes analysis of airphotos
Dalhousie U., Halifax.	Geology	242b	Geomorphology	D.J.W. Pipes H.B.S. Cooke	Term	U'grad.		air photos & Landsat for landform analysis.
Nova Scotia Technical College, Halifax.	Mining Eng.	414	Engineering Geology	H.G. Sherwood				
Nova Scotia Land Survey Institute, Lawrencetown.			Introd. to Photointerp. and Remote Sensing	J. Wightman				
Quebec								
U. of Sherbrooke,	Geography	2233	Télédétection I	J.-Marie Dubois	Term	U'grad.		A/Photos
		2333	Télédétection II	J.-Marie Dubois	"	"		A/Photos
		3733	Télédétection III	F. Bonn	"	"		Infrared
Bishop's U., Lennoxville.	Geography	110b	Techniques in Geographic Analysis	Hilmo	Term	U'grad.		A/Photos
		221A	Methods in Historical Geography	Ross	"	"		A/Photos
Concordia U., Montreal.	Geography	301A	Maps and Presentation of Statistical Data		Term	U'grad.		includes A/ photos
	Geology	N352	Photogeology		"	"		includes A/ photos
		N216	General Geology Lab.		"	"		includes A/ photos
		441A	Geomorphology		"	"		
	Civil Eng.		Techniques of Air Photo Interpretation		"	"		
		N431	Geology	M.P. Duplessis	Year	U'grad.		includes A/ photos

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Quebec (Cont.)								
McGill U , Montreal.	Geography	183-635	Interpretation Methods-Air Photos and Imagery	J. Parry	Year	Graduate		
		183-201 AB	Introd. to Cartography and Air Photo Interp.	Drummond	Year	U'grad.		includes A/ Photos
		183-308 A	Air Photo Interpretation and Remote Sensing	J.T. Parry	Term	U'grad.		
		183-633	Remote Sensing	J.B. Bird B.J. Garnes T.L. Hills T. Lloyd	Year	Graduate		
			Sensor Technology	J. Lewis				
	Geology	186-535	Photogeology	Elson	Term	Graduate		
McGill U.-Faculty of Agric. & Food Science Ste. Anne de Bellevue	Soil Science	372-420 A	Soil Survey	Millette	Term	U'grad.		includes A/ photos
U. of Montréal, Montréal.	Geography	1442	Initiation à la Photographie Aérienne		Term	U'grad.		
		2010	Télédétection		"	"		alternate years
		2120	Photo-Interprétation en Géographie Physique	P. Gangloff	"	"		
		6520	Télédétection		Term	Graduate		
	Geology	3300	Photogéologie	P. David	Term	U'grad.		
Ecole Polytechnique U. de Montréal, Montréal.		7.506	Photogéologie Appliquée	J. Bérard M. Tanguay	Term	U'grad.		
U. of Laval, Québec.	Forestry	14274	Photo-Interp. Eco. géomorphologique	R. Héroux	Term	U'grad.		
	For. et Geodesie		Teledetection I	B. Bernier		U. grad.		418-656-2327
	Physique		Physical Principals of Remote Sensing	H. Arsenault		Graduate		418-656-2650
	Genie Electrique		Hardware Image Processing	M. Fournier				418-656-3556
	Geography	GGR10566	Analyse de Photos Aériennes	J. Bernier P. Clibbon G. Tremblay	Term	U'grad.		

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Quebec (Cont.)								
U. of Laval, Québec.	Photogrammétrie	PGM11369	Ph. Int. du Terre Récréatif, de l'eau et de la Faune	G. Ladouceur	"	"		
		PGM11367	Photo-Int. du Territoire Forestier	G. Ladouceur	"	"		
		PGM13228	Photo-Interp. du Territoire Urbain	G. Ladouceur	"	"		
		PGM14297	Introd. à la Télédétection et Photo-Interp.	G. Ladouceur	"	"		
		PGM60615	Resources Remote Sensing and Photointerp.		"	"		
			Numerical Treatment of Remote Sensing Data		Term	Graduate		
			Remote Sensing Applications in Limnography			"		
			Forest Resources Image Interp. & Cartography		"	"		
			Remote Sensing Data Acquisition Technologies		Term	Graduate		
			Remote Sensors		"	"		
			Resources Rem. Sensing Project Planning		"	"		
U. du Québec à Montréal	Géographie		Photo-interprétation II	C. McNicol-Robert	Term	U'grad.		
U. du Québec à Chicoutimi	Géographie		Principals of Remote Sensing	G.H. Lemieux	Term	U'grad.		
John Abbott College (CEGEP), Ste. Anne de Bellevue.	Forest Management		Photo-Interpretation		Term			
Vanier College (CEGEP), Montreal.	Geography	320-110-75	Maps and Mapping	R.G. Adamson P.M. Frost	Term			A/Photos mentioned.
Ontario								
Brock U., St. Catherines.	Geography	200	Cartography and Remote Sensing		Year	U'grad.		
	Geology	282	Photogeology		"	"		includes Remote Sensing from air craft & satellite
Carleton U., Ottawa.	Geography	202	Air Photo Interpretation	M.F. Fox	Term	U'grad.	90	includes photogrammetry & air photos
	Geology	111	Geology, the Environment and Man I and II	P.A. Hill	Term	U'grad.	60	A/Photos included

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Ontario (Cont.)								
U. of Guelph, Guelph.		232	Terrain Measurements		Term	U'grad.		includes photogrammetry, quantitative photo interp. & Remote Sensing.
	Engineering	361	Photo Interpretation		"	"		for soils, land use, urban planning rural development.
	Soil Science		Resources Field Camp			"		includes A/Photo
	Geology	250	Remote Sensing		Term	"		
			Integrated Aerial Survey	Vlcek, G. Gracie, Gun, D.J. Erb, S. Collins	Year	Graduate		includes Remote Sensing
Lakehead U., Thunder Bay	Geography	2210/11	Topographic Mapping and Remote Sensing		Term	U'grad.		includes A/Photo & Remote Sensing for geography
		2350/51	Geography of the Land Surface		"	"		A/Photos for Landforms
	Geology	2141	Structural Geology		"	"		A/Photos for Landforms
	Forestry	2065	Photogrammetry and Photo Interpretation	H. Westbroek	Term	U'grad.		
		4165	Remote Sensing & Photogrammetry-Application to Forest Problems		"	"		
		2565	As 2065	H. Westbroek	Term			for Forest Diploma
Laurentian U., Sudbury.	Geography	3031/3036	Air Photo Interpretation		Term	U'grad.		
		3032/3037	Remote Sensing of the Environment		"	"		application to geographical research.
McMaster U., Hamilton.	Engineering		Geology for Engineers		Term	U'grad.		includes A/Photo
	Geography	3V3	Remote Sensing I		"	"		physical principal emphasis on photographic system
		4V3	Remote Sensing II		"	"		Airborne and Space systems data manipulation and analyst

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Ontario (Cont.)								
			Remote Sensing and its Geographical Applications		Term	U'grad./ Graduate		
		6V3	Introduction to Remote Sensing		Term	Graduate		
			Integrated Aerial Surveys		Year	Graduate		
U. of Ottawa,	Geography	2103	Landforms, Map Reading & Photo-Interpretation	H. French	Term	U'grad.	33 23	last year (75) summer (76)
		4101	Remote Sensing of the Physical Environment	P. Johnson	"	"		
		4503	Photo-Interpétation et Inventaire des Resources	H. Gagnon	"	"	11	
		2503	Formes de Relief, Lectures de Cartes et Photo-Interprétation	H. Gagnon	"	Graduate	26 46	days nights
		5516	Télédétection de L' Environment		Term	Graduate		
Queen's U.,	Geography	110	Man's Physical Environment	McCaughey Rutherford Gilbert	Year	U'grad.	163	includes A/Photo
		216	Soils and their Significance to Man	Rutherford	Term	U'grad.	61	includes A/Photo
		242	Photogrammetry and Photo Interpretation	McGarath	"	"	27	
		340	Cartographic Design and Map Production	Castner	"	"	24	includes A/Photo
	Geology	111	Elementary Geology	W.A. Gorman	"	"		includes A/PL.
		333	Terrain Evaluation		"	"		landform studies with A/Photos.
Royal Military College, Kingston.	Civil Eng.	357	Introduction Geotechnics	W.A. Gorman	Term	U'grad.	25	includes A/Photo of landforms.
		361	Photogrammetry	Maj. Parent	Term	U'grad.	16	includes A/Photo & Remote Sensing systems for highway engineering.
U. of Toronto, Toronto Erindale College (828-5285)	Geography	271E	Methods of Environment Analysis	J.C. Munday C. Houston	Term	U'grad.		
		373E	Remote Sensing of Environment	J.C. Munday	Term	U'grad./ Graduate		instruments & methods
U. of Toronto, Faculty of Forestry.	Forestry	202	Photo Interpretation	J. Vlcek	Term	U'grad.		
		468	Forestry Applications of Air Photography and Remote Sensing	J. Vlcek	"	"		

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Ontario (Cont.)								
U. of Toronto, St. George Campus	Geography	207S	Air Photo Interpretation	Dr. Vandereyk	Term	U'grad.		1st year course
		308F	Elements of Photogrammetry & Remote Sensing	Dr. Vandereyk	"	"		3rd year course
U. of Toronto, Scarborough College.	Geography		Remote Sensing of the Environment		Term	U'grad.		Introduction to theory analysis and interpretation.
U. of Toronto Graduate Studies		1420	Integrated Aerial Surveys	J. Vlcek G. Gracie R.C. Gun S. Collins P. Howarth D.J. Erb	Year	Graduate		
	Geotechnical Engineering		Air Photo Interpretation	J. Vlcek	Term	Graduate		
	Geography		Remote Sensing Applications	J. Munday	"	"		
Trent U., Peterborough.	Geography	210a	Survey & Remote Sensing	W.J. Copeland	Term	U'grad.		
U. of Waterloo, Waterloo.	Earth Science	342	Geomorphology		Term	U'grad.		includes Air Photos.
	Geography	275	Introduction to Air Photos Analyses & Remote Sensing		"	"		
		375	Air Photo Interpretation & Remote Sensing I		"	"		
		470	Air Photo Interpretation & Remote Sensing II		"	"		
		471	Air Photo Interpretation & Remote Sensing III		"	"		
			Techniques: Air Photos Interp. & Remote Sensing, Computer Mapping, Model Building & Statistical Methods		Term	Graduate		
		602	Air Photo Interpretation & Remote Sensing I		"	"		includes stereophotos & map production
		603	Air Photo Interpretation and Remote Sensing II		Term	Graduate		Thermal I.R., Radar Multiband Photography, Satellites.
		604	Integrated Aerial Surveys	J. Vlcek G. Gracie R.C. Gun S. Collins P. Howarth D.J. Erb	"	"		

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Ontario (Cont.)								
U. of Western Ont., London.	Geography	243b	Remote Sensing	Luckman	Term	U'grad.		
U. of Windsor, Windsor.	Geography	301b	Air Photography Interpretation & Photogrammetry	Trenhaile	Term	U'grad.	15-20 est.	
		426b	Glacial Geology II	Gravenor	Term	U'grad.	15-20 est.	includes air photos.
	Geology	412b	Engineering Geology	Hudec	Term	U'grad.		A/Photos for site evaluation
		462b	Geophysics II	Dave Simons	Term	U'grad.	10-15	Radiometric & thermal techniques (3 weeks only).
Wilfrid Laurier U., Waterloo.	Geography	204/254-3	Field Techniques and Research Methods in Physical Geography		Term	U'grad. Honour		air photos included.
		100-44	Introduction to Geology		Term	U'grad.		air photos included.
York U., Toronto.	Centre for Experimental Space Science (CRESS)	518.3	Physical Principals of Remote Sensing		Term	Graduate		
			Remote Sensing of Earth Resources		"	"		
		522.3	Data Analysis		"	"		includes Remote Sensing Data.
Algonquin College, Ottawa	Civil Technology		Photogrammetry		Term			Intro. to air photos and a/ph. interpretation.
Cambrian College, Sudbury.	Civil Engineering	211-5	Civil Projects		Term			includes air photos.
Humber College, Toronto.			Air Survey Techniques		Term			
		330.054	Air Photo Interp. I		"			A/Photos for Site Evaluation.
		330.055	Air Photo Interp. II		"			A/Photos for Site Evaluation.
Northern College, Haileybury, Kirkland Lake, Porcupine.			Photo Interpretation		Term			Air Photos for highway construction & forestry
		SU-2-51	Air Photo Interpretation		"			Technician Course.

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Ontario (Cont.)								
Ryerson Polytechnic, Institute, Toronto.	Civil Technology	CVL164	Photo Interpretation		Term			Introduction
			Remote Sensing Applications		"			
		CVL160	Soil Science		Term			air photos included.
			Remote Sensing Systems & Techniques		"			
	Geodetic Sciences	GDS208	Air Photo Interpretation I		"			for land use & engineering.
		GD308	Air Photo Interpretation II		"			for highways, flooding, pollution.
Sir Sandford Fleming College	Forest Technology	475-322 & 323	Photo Interpretation I		Term			Introd. to Air Photos & Remote Sensing.
		477-522	Photo Interpretation II		"			for forestry & wildlife problems
		477-622	Remote Sensing		"			for forestry
Manitoba								
Brandon U., Brandon.	Geography	260	Manitoba-A Practical Geography		Term	U'grad.		
		390	Air Photo Interp.		"	"		Introduction
		490	Remote Sensing of the Environment		"	"		U.V. A/Photos, Thermal IR, Radar.
U. of Winnipeg, Winnipeg.	Geography	2303	Aerial Photography		Term	U'grad.		includes some remote sensing.
		3304	Remote Sensing		"	"		
		4302	Remote Sensing		"	"		
		4304	Advanced Remote Sensing		"	"		includes speakers from Manitoba, Remote Sensing Committee.
	Earth Science	7.462	Photogeology and Remote Sensing		"	"		

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Manitoba (Cont.)								
U. of Manitoba, Winnipeg.	Landscape Architecture	31-610	Terrain Analysis		Term	U'grad.		includes remote sensing.
	Geography	53-242	Introductory Cartography and Map Interpretation		Year	U'grad.		includes air photo interp.
		53-454	Remote Sensing and its Geographic Applications		Term	U'grad./ Graduate		
	Earth Science	7.353	Applied Geomorphology & Pleistocene Geology		Term	U'grad.		includes air photos.
		7.349	Glacial Geology and Geomorphology		Term	U'grad. Honours		includes air photos.
		7.462	Photogeology & Remote Sensing		Term	U'grad.		
		7.735	Remote Sensing in the Earth and Planetary Sciences		"	"		
Saskatchewan								
U. of Regina, Regina.	Geology	207	Maps and Air Photo Interpretation		Term	U'grad.		
U. of Saskatchewan, Saskatoon.	Civil Engineering	333A	Air Photo Interpretation	E.K. Saues	Term	U'grad.		
		580A	Remote Sensing					
Alberta								
U. of Alberta, Edmonton.	Geography	501	Remote Sensing and Photointerpretation		Term	U'grad.		introduction for physical & cultural geography.
	Geology	380	Geomorphology		"	"		includes air photos.
		390	Engineering Earth Sciences		"	"		air photos.
		391	Engineering Geology		"	"		air photos.
		592	Photogeology and Remote Sensing		Term	Graduate		
	Civil Engineering	684	Engineering Geology & Terrain Analysis		"	"		air photos for engineers.
U. of Calgary, Calgary.	Geography	307	Elements of Physiography		Term	U'grad.		includes air photos.
		333	Air Photo Interpretation		"	"		introduction.
		433	Remote Sensing in Geography		"	"		air photos and radar.

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
Alberta (Cont.)								
U. of Calgary, Calgary.	Geology	441	Structural Geology		Term	U'grad.		air photos included.
		473	Geomorphology		"	"		includes air photos.
		571	Applied Geology		Term	Graduate		includes air photos.
	Environmental Design	655	Terrain Analysis		Term	U'grad.		remote sensing applied to terrain.
U. of Lethbridge, Lethbridge.	Geography	2030	Interpretation of Aerial Photographs		Term	U'grad.		air photos, Slar, Thermal I.R. for physical & social sciences.
N. Alberta Inst. of Technology			Intro. to Remote Sensing	C. Bricker	Term			
British Columbia								
U. of B.C., Vancouver.	Civil Engineering	576	Civil Engineering Uses of Aerial Photographs		Term	U'grad.		large scale air photos.
	Forestry	442	Photo Interpretation of Forest Lands		Term	U'grad./ Graduate		
		443	Remote Sensing in Forestry		"	"		
		542	Advanced Studies in Forest Photogrammetry		Term	U'grad.		photo interp. & classification.
		543	Selection Topics in Remote Sensing	P.A. Murtha	Term	U'grad.		weekly seminar.
	Geography	101	Introduction to Physical Geography		"	"		includes air photos.
		370	Air Photograph Analysis		"	"		includes remote sensing.
		470	Remote Sensing in Geographical Engineering		"	"		for land inventory & resource mapping.
	Soil Science	417	Interpretation & Use of Soil Survey Information		"	"		
Simon Fraser U., Burnaby.	Geography	250	Cartography I		Term	U'grad.		includes air photos.
		351	Cartography II		"	"		photographic methods & map making.
U. of Victoria, Victoria.	Geography	322	Air Photo Interpretation	C.W. Howatson	Term	U'grad.		
		423	Advanced Cartography		"	"		includes air photos.

	Department	Course Description	Course Title	Lecturer	Length	Course Level	No. of Students 1976	Notes
B.C. (Cont.)								
B.C. Institute of Technology, Burnaby.	Forestry	45-106	Photo Interpretation & Mapping I		Term			
		45-206	Photo Interpretation & Mapping II		Term			
Capilano College, Vancouver.	Geography	221	Air Photo Interpretation		Term			U.V., A/photos, Thermal I.R., multispectral.

APPENDIX 3

Training Courses on Remote Sensing Held in Canada, 1975-1977

February 25-March 01, 1975	Remote Sensing Training Course	University of Manitoba, Winnipeg.
March 07-08, 1975	Geological Applications of Remote Sensing	University of New Brunswick.
February 1975	Third Alberta Remote Sensing Course	University of Alberta, Edmonton.
May 03-05, 1976	Short Course in Remote Sensing	Ontario Association of Remote Sensing, University of Toronto.
May 12-30, 1975	UN/UNESCO-CIDA Short Course on Remote Sensing	University of Guelph.
1975	Remote Sensing for Agriculture and Forestry	University of Alberta, Edmonton.
December 10-12, 1975	Familiarization Programme in Remote Sensing	University of Manitoba, Winnipeg.
January 28-March 31, 1976	Remote Sensing for Agriculture and Forestry (10 evenings)	University of Alberta, Edmonton.
February 23 to 27, 1976	Fourth Alberta Remote Sensing Training Course	University of Alberta, Edmonton.
February 1976	Supplementary Aerial Photography (for Ontario Government personnel)	Ontario Centre for Remote Sensing.
March 29-April 02, 1976	Concepts of Environmental Management	Intera-Environmental Consultants Ltd., Calgary.
June 14-16, 1976	Seasat Workshop	Memorial University, St. Johns.
1976	Remote Sensing for Agriculture and Forestry	University of Alberta, Edmonton.
1976	Atmospheric Effects of Remote Sensing - a Workshop	Atmospheric Sciences Working Group, Toronto.
1976	Photointerpretation for Forest Inventory	Ontario Centre for Remote Sensing.
January 10-13, 1977	Radar Systems for Remote Sensing	C-Core, Memorial University, St. Johns.
February 1977	Fifth Alberta Remote Sensing Course	University of Alberta, Edmonton.
1977	Remote Sensing in Resource Management (for Ontario Government personnel)	Ontario Centre for Remote Sensing.
October 02-04, 1975	Photointerpretation and Remote Sensing - a Workshop	Nova Scotia Land Survey Institute, Lawrencetown.
November 08-10, 1976	Remote Sensing of Soil Moisture and Groundwater	Canadian Remote Sensing Society, Toronto.
November 08-10, 1976	Remote Sensing	University of Laval and L'Assoc. Québec de Télédét.

9.0 REPORT OF THE ACTION TAKEN BY CCRS AS A RESULT OF THE 1975 CACRS RECOMMENDATIONS

The following is a summary describing some of the action taken by CCRS to respond to the recommendations presented at the last CACRS meeting. The numbers cross-reference to the 1975 CACRS report.

3.2.1.1 While Canada has not yet developed Remote Sensing Experiments which would be carried out using the Space Shuttle, the possibility for bilateral or multilateral programs exists. Possible co-operation with the USA is obviously enhanced by Canada's contribution of the Remote Manipulator System (RMS) to the Space Shuttle.

The possibility of co-operative Earth Observation work with Europe is being furthered in two ways:

a. CCRS and the European Space Agency have an agreement to exchange information, promote co-operative projects and exchange personnel;

b. Canada is exploring the possibility of upgrading its relationship with ESA which might supersede (1) above.

The most immediate interest for Canada vis-à-vis ESA in the field of remote sensing is the coming definition study for a European Resources satellite. Sensors which image in the visible, IR and Microwave portions of the spectrum are proposed for that satellite.

3.3.1.2.a Work is actively underway on the development of a production facility for the routine generation of digitally corrected computer compatible tapes. This facility will take raw satellite data and perform appropriate radiometric correction. From a set of stored ground control points each image will be geometrically corrected to be within a one-half pixel error limit. Phase I of this production facility will be operational in mid 1977.

During 1976 a production operation was established to take Daedalus airborne infrared sensed data and convert it to a computer compatible tape. This, in turn, can be routinely converted to temperature values and a themogram image generated, in which specific colours represent specific temperatures.

3.2.1.2.b CCRS has actively promoted the use of computer compatible tapes and has established imagery and non-imagery CCT standards for airborne sensed data, for Image 100 and for VHRR visual and infra red data obtained from NOAA satellites on the PERGS system. It is continuing to play an active role in making suggestions for the further development of the JSC CCT format standard.

3.2.1.3 This independent development of remote sensing expertise is encouraged, within the organization's existing financial and manpower resources.

3.2.2.1 a. More aircraft would be required to provide this service.

b. Crews work on established frequencies with ships. Two transceivers are available on request and are used extensively.

c. This is done whenever possible, but notice of aircraft charges will be late this year due to negotiations concerning the Transfer Plan.

d. This has been possible through 1976/77 but has never been requested.

e. Always in effect.

3.2.2.2 A computer print-out consolidation of all projects is provided in the 1976 report.

3.2.2.3 Provision for the scatterometer has been made on the Convair 580 aircraft and the present aircraft schedule indicates the system will be installed and checked out before January 1978. Also, efforts are being made to have a multi-channel SAR installed on the Convair.

3.2.2.4 CCRS can arrange for such data now, at the user's expense. Specific project proposals have not been submitted.

As an alternate we have purchased four 70 MM cameras with 1.5" lenses. This will provide scales of 1:280,000 when flown at a 30,000 foot altitude. (This is essentially the same scale as would be given by a 3" lens at a 70,000 foot altitude.)

3.2.3.1 EMR has been designated as the lead agency in the Microwave Surveillance Satellite Initiative, which includes support for Seasat-A

and an airborne synthetic aperture radar capability. (See the pertinent sections for a more complete summary of these developments e.g. paragraph 4.2 of report.)

3.2.3.2 A study was conducted during 1976 by the GTA group to determine data communication needs of CCRS, including the need for distributed data processing. Sample data keyed to a 1:250,000 UTM map projection can be made available for evaluation.

3.2.4.1 Data from ADAS including the flight parameters are now being processed by the Data Processing Division and the software for this task has been updated to an operational status.

3.2.5.1 a. CCRS has always done so

b. CCRS does so on request

c. Funding is very limited for this; however, CCRS will consider outstanding research proposals from universities.

d. CCRS does not have the funding nor mandate to supply equipment to universities.

3.2.5.2 An ad hoc committee to study this subject was set up under the chairmanship of Mr. Roy Slaney and a report was presented at the 1976 CACRS meeting (see 8.2).

3.3.2.1 CCRS is continuing to seek methods of implementing this recommendation.

3.3.3.3. A draft document has been prepared for review by CACRS.

3.3.3.5 Atmosperic correction work is continuing at CCRS. Some of these techniques are now available to users of CCRS image analysis facilities.

3.3.5.1 This sub-working group of the Data Handling Working Group is being formed under the leadership of F. Potts.

3.3.5.2 Dr. W. Bruce of the Applications Division has been working full time on international projects for more than a year. CCRS has also been heavily involved in the planning for a Regional Centre in Upper Volta serving all of West Africa.

10.0. PARTICIPANTS IN CACRS MEETING

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for Chairman
Working Group on Ice

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Provincial Representative
of Québec

Dr. Denes Bajzak
for Provincial Representative
of Newfoundland

Mr. Ralph C. Baker
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Mr. Robert Bone
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Mr. Cal D Bricker
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Mr. Leon Bronstein
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Dr. Ira C. Brown
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Mr. Brian Bullock
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Mr. D. Neville Davis
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Mr. Donald Daw
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Dr. J. Neil de Villiers
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Ms. Betty Fleming
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11.0 TABLE OF ACRONYMS USED IN THIS REPORT

ADAS	Airborne Data Acquisition System
AES	Atmospheric Environment Service, DFE
AIDJEX	Arctic Ice Dynamics Joint Experiment (U.S. - Canada)
AQT	Association québecoise de télédétection
ARTS	Airborne radiation Thermometry Survey
CAAS	Canadian Association of Aerial Surveyors
CACRS	The Canadian Advisory Committee on Remote Sensing
CASI	Canadian Aeronautics and Space Institute
CCIW	Canada Centre for Inland Waters
C-CORE	Centre for Cold Ocean Research Engineering, Newfoundland
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
CIAS	CCRS Image Analysis System
CIDA	Canadian International Development Agency
CNES	Centre national d'études spatiales
CRC	Communication Research Centre, Department of Communications
CRESS	Centre for Research in Experimental Space Science (York University)
CRT	Cathode Ray Tube
CSFR	Colour Strip Film Recorder
DAD	Data Acquisition Division, CCRS
DFE	Department of Fisheries and the Environment
DICS	Digital Image Correction System
DINA	Department of Indian and Northern Affairs
DND	Department of National Defence
DOC	Department of Communications
DOT	Department of Transport
DRE	Defense Research Establishment (DND)
DSS	Department of Supply and Services
EBR	Electron Beam Recorder
EDC	Eros Data Centre (US)
EMR	Department of Enery,Mines & Resources
EPS	Environmental Protection Service, DFE
ERIM	Environmental Research Institute of Michigan
ERTS	Earth Resources Technology Satellite (U.S.) (Name changed to LANDSAT Jan/75)
ESA	European Space Agency
FAO	Food and Agriculture Organization (UN)
FAX	Facsimile
FGGE	First CARP Global Experiment
FMI	Forest Management Institute (DFE)
GEOS	Geodetic Satellite (NASA)
GOES	Geostationary Operational Environmental Satellites (2/5) SMS - Synchronoms Meteorological Satellite
GRAMS	Ground Reproduction and Monitoring System (CCRS)
GSC	Geological Survey of Canada, EMR
GTA	Government Telecommunications Agency/DOC
HCMM	Heat Capacity Mapping Mission (Proposed Satellite - U.S.)
HDDT	High Density Digital Tape
IACRS	Interagency Committee on Remote Sensing
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.
ISISFICHE	Daily LANDSAT coverage of Canada produced on microfilm by ISIS
IWD	Inland Waters Directorate, DFE
JPL	Jet Propulsion Laboratories, California
JSC	Johnson Space Center, NASA (U.S.)
LACIE	Large Area Crop Inventory Experiment(U.S.)
LANDSAT	U.S. Remote-Sensing Satellites (formerly ERTS)
LRPA	Long-range patrol aircraft (DND)
MAD	Bendix Multispectral Analyzer Display
MADCON	Software for digital processing with MAD
MADUSE	Former name for MADCON

MARISAT	Maritime Comm. Satellite (COMSAT General)
MEIS	Multispectral Electro-optical Imaging System
MICA	Modular Interactive Classification Analyser software for digital processing
MIPS	Multi Image Processing System
MOSST	Ministry of State for Science and Technology
MRMS	Maritime Resource Management Service
MSD	Marine Sciences Directorate, DFE
MSS	Multispectral scanner on LANDSAT
MTF	Ministère des Terres et Forêts
MUN	Memorial University of Newfoundland
NAPL(RC)	National Air Photo Library (Reproduction Centre), EMR
NASA	National Aeronautics and Space Administration (U.S.)
NATO	North Atlantic Treaty Organization
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
NORDCO	Newfoundland Oceans Research and Development Corporation
NRC	National Research Council
NSLSI	Nova Scotia Land Survey Institute
OARS	Ontario Association for Remote Sensing
OAS	Ocean and Aquatic Sciences, DFE
OCRS	Ontario Centre for Remote Sensing
PASS	Prince Albert Satellite Station
PERGS	Portable Earth Resources Ground Station (Shoe Cove, NFLD)
PHS	Photo Hydrography System
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
SCSS	Shoe Cove Satellite Station
SEASAT	Ocean parameter observing satellite due for launch in 1978
SLAR	Side-Looking Airborne Radar
SMD	Scanning Microdensitometer
SMMR	Scanning Multifrequency Microwave Radiometer
SMS	Small Meteorological Satellite (U.S.)
SRC	Saskatchewan Research Council
TIROS-N	U.S. meteorological satellite
TIS	Technical Information Service (CCRS)
UTIAS	University of Toronto Institute for Aerospace Studies
UTM	Universal Transverse Mercator System
VHRR	Very High Resolution Radiometer (AES instrument)
VIR	Visible and Infrared Radiometer
VISSR	Visual Infrared Spin Scan Radiometer (a sensor on the GOES Satellite)
WEFAX	Weather facsimile
WMO	World Meterorological Organization

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