Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

THE CANADA CENTRE FOR REMOTE SENSING

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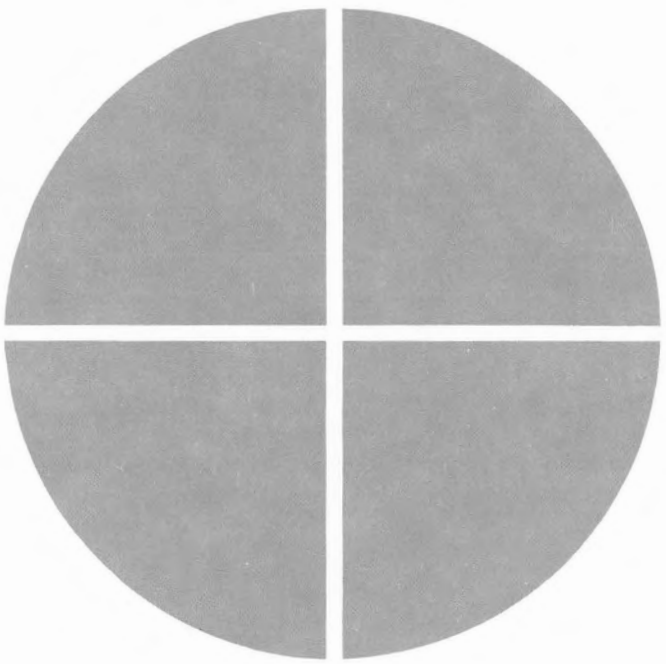

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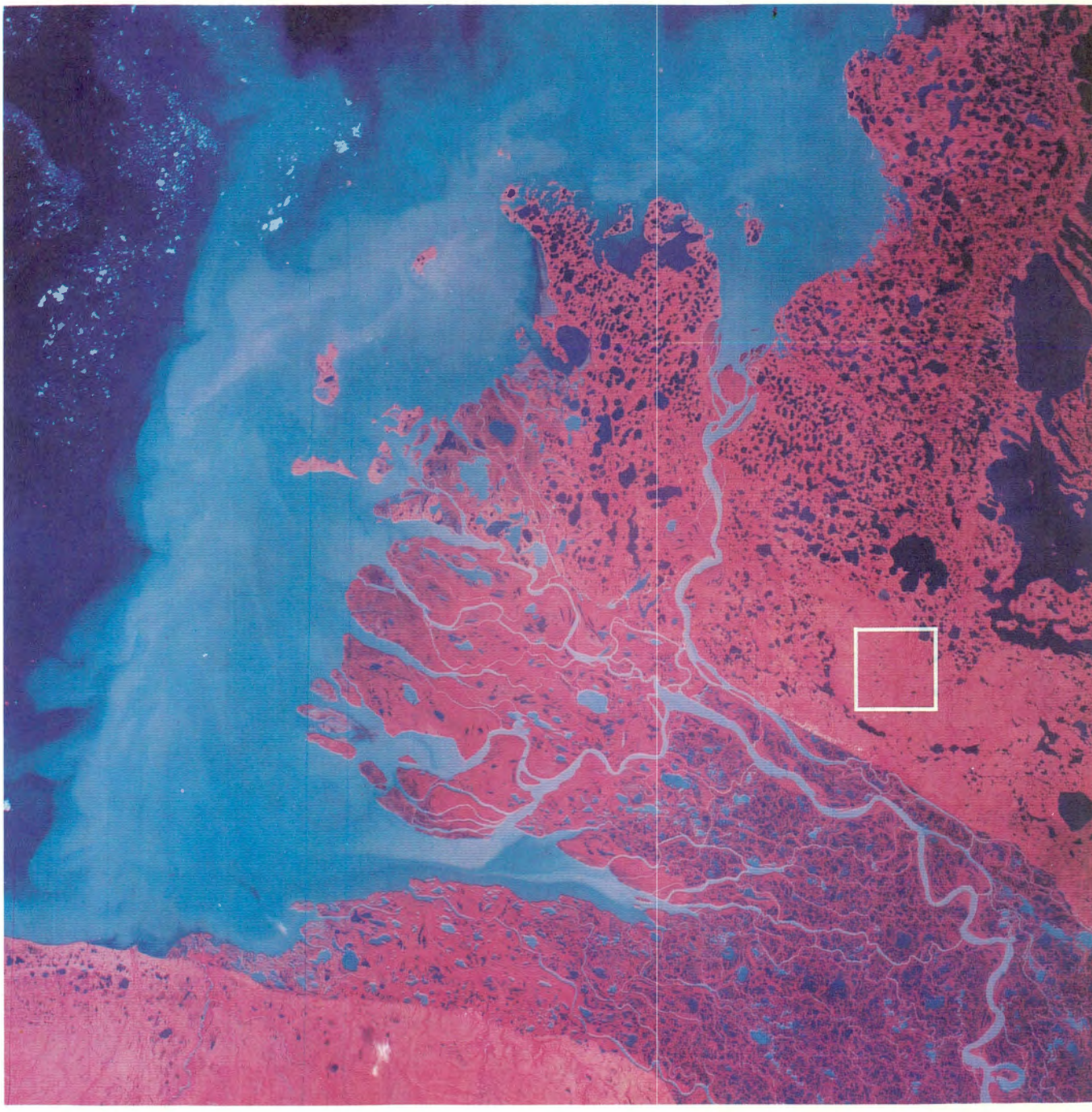
Remote sensing, the sensing or measuring of some properties of an object from a distance, is a space age answer to longstanding problems in resource management — problems which are particularly challenging to a country like Canada. The challenge, inherent in the vastness of the country, has increased with population growth, industrialization and northern development.

With the possibilities offered by remote sensing for surveying and monitoring these vast and largely uninhabited areas, it is not surprising that Canada has embarked on an ambitious remote sensing program. The Canada Centre for Remote Sensing (CCRS), a branch of the Department of Energy, Mines and Resources, is the central agency in this nationwide remote sensing program. A major objective of the program is to ensure that data and facilities available are used to Canada's maximum benefit.

Through the endeavours of CCRS, Canada is reading out, processing and distributing Landsat and NOAA satellite data from its two receiving stations and has a centralized airborne remote sensing program. Available through the Centre are computer analysis facilities for use in image enhancement and analysis. Consulting, analysis and interpretation services, airborne data acquisition facilities and satellite data of various kinds are available on a country-wide basis either directly through CCRS or its contracting firms.

Vancouver from the Air



WHAT IS REMOTE SENSING?

The Landsat satellite and airborne data collection systems are elements in a technology called remote sensing, which allows man to extend and supplement his senses, so that he can observe and measure his environment from a distance.

The eye is only sensitive to a very small portion of the electromagnetic spectrum, the "visible" region. Cameras are sensors which operate in the visible region and produce a permanent record of what the eye sees. Other sensors have been developed which can 'see' in those parts of the spectrum which lie above the visible region (the ultraviolet region) and below the visible region (the infrared region and the microwave region). Special photographic films, sensitive to the near infrared region, infrared scanners which can measure the temperature of an object at a distance and radar devices which can see through clouds are examples of sensors which operate in the non-visible portions of the spectrum.

Satellite data provide us with a broad perspective that cannot be achieved by other means. For example, an image of the Mackenzie River Delta taken by satellite, shows 13,225 square miles of a remote area in a way which could not be duplicated by any traditional technique. To obtain comparable coverage by aircraft would require many hours of flying time and the piecing together of approximately 100 separate images. Some would be taken at times significantly different from others so that, because of varying light, cloud cover and perspectives, one part of the mosaic could not be accurately compared with another.

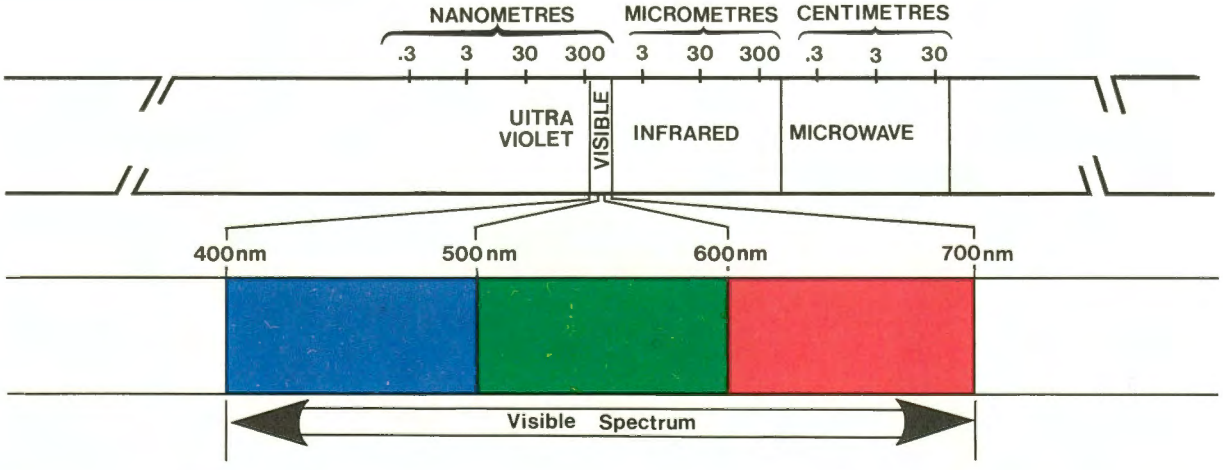
On the other hand satellite data have the disadvantage of lower resolution than aircraft data. In addition, at times we may require data more frequently than available from the fixed cycle of a satellite. When fine detail and frequent observation are required, airborne data must be used, either alone or as a supplement to satellite data.

To gain maximum benefit from vast quantities of remote sensing data collected by satellite and aircraft, ordinary visual methods of interpreting photos must be supplemented by automated methods which can handle masses of data in a fast, accurate and repeatable way.

Interesting and exploratory projects are continually being conducted at CCRS in order to discover new and better methods of collecting, analyzing and applying remotely sensed data.

ELECTROMAGNETIC SPECTRUM

REMOTE SENSING WAVELENGTHS



This satellite image shows a 100 mile square area of the Mackenzie River delta in the Northwest Territories. The silt-laden waters of the Mackenzie flowing into the Beaufort Sea show marked colour contrast with the myriad of clear lakes in the upper delta. Variations in colour in the land areas illustrate the different vegetation communities. The sedges and willows along the coast gradually change to spruce, willow and alder communities in the older parts of the delta.

Agricultural patterns, Stony Mountain, Manitoba False colour infrared image taken from aircraft at 7000′ in May of 73

THE CENTRE

Remote sensing is being applied in Canada to help manage our resources and monitor environmental changes. To further the development and use of this technology the Canada Centre for Remote Sensing was established in 1972 as the central element in a national program on remote sensing.

To help ensure that the Canadian remote sensing program is truly interdepartmental and national, two advisory committees have been established:

The Interagency Committee on Remote Sensing is the senior co-ordinating body for the national program on remote sensing. Members, persons at the assistant deputy minister level from interested federal government departments and agencies, advise on policy and financial matters.

The Canadian Advisory Committee on Remote Sensing consists of the heads of the provincial remote sensing organizations, the chairmen of 13 disciplinary and technologically oriented working groups, the heads of four specialty centres and representatives from certain other organizations. Alberta, Manitoba, Ontario and Quebec have set up remote sensing centres with full-time staff, and the other provinces have representatives to co-ordinate activities within the province and act as a liaison with CCRS.

The activities of the Centre can be divided into five categories:

Applications, under which new uses for remote sensing data are developed and demonstrated and projects are undertaken in co-operation with users;

Satellite Operations, under which satellite data are received, processed and distributed;

◄ The Image 100

Airborne Operations, under which four specially equipped aircraft are operated for Canadian scientific investigators;

Research and Development, under which new data analysis methods and new sensors and data acquisition systems are developed, and

User Services, under which facilities and technical information is made available to the user on a routine basis.

Applications

Scientists from the Applications Division work directly with user agencies to carry out projects in many fields. The projects lend opportunity for the testing of new remote sensing methods and techniques in their applications to resource management. Applications in forestry, agriculture, land use and water resource studies are currently being tested. Methods are also being developed to carry out a coastal resource inventory and to map physical features in the north.

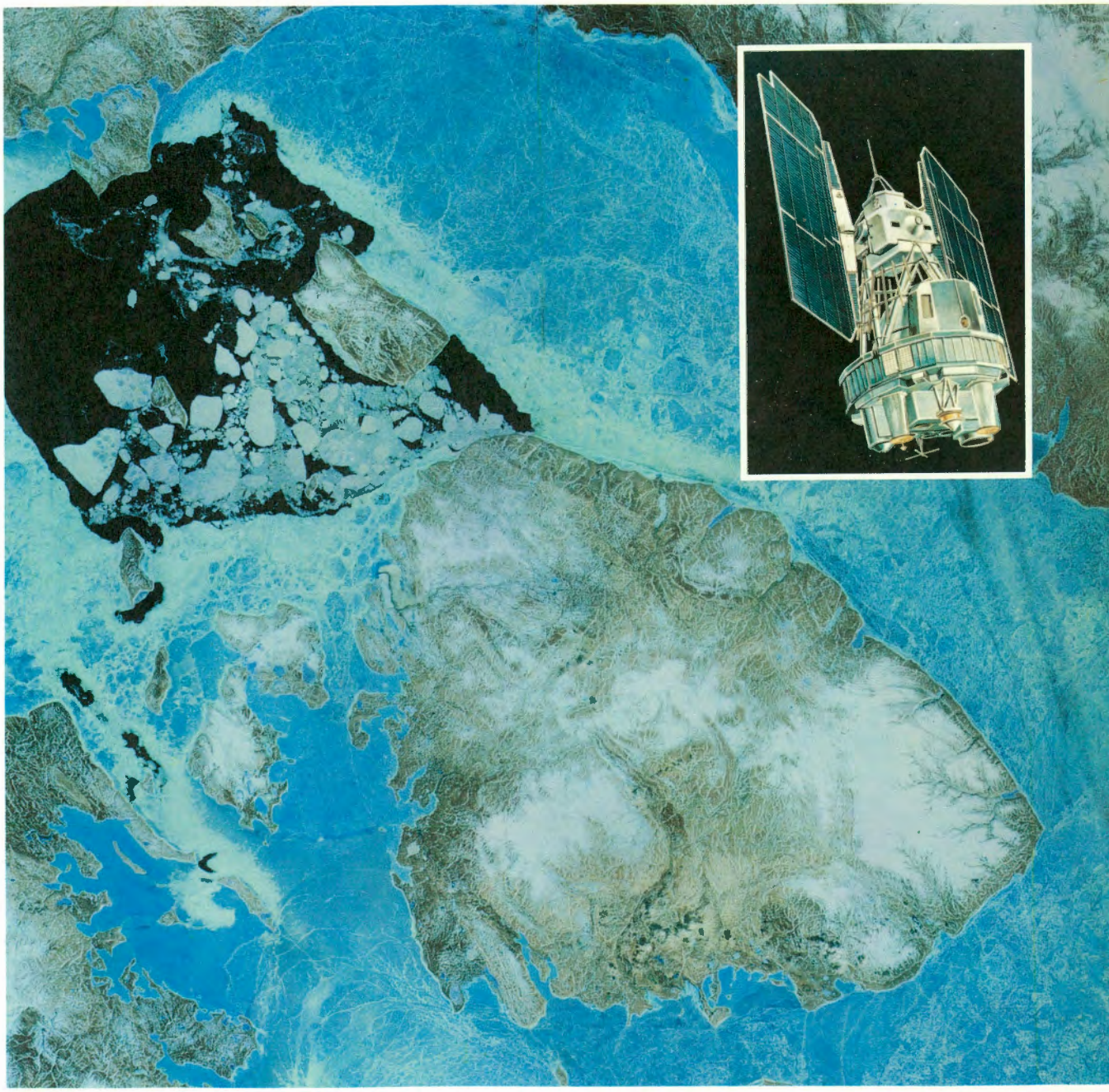
Working space, where resource managers and environmental scientists can use the most up-to-date and sophisticated analysis equipment, is provided at the Centre's data analysis laboratories. These laboratory facilities are available to all users. In some cases interested agencies, government and private, have seconded personnel to the Centre for both short and long term periods. The "visiting scientists" work and interact with the scientific and technical staff at CCRS.

Equipment available in the Centre's analysis facility consists of both conventional analogue photo-interpretation equipment and complex computer-controlled systems for the analysis of the satellite and airborne data.

Satellite Operations

The United States' NASA (National Aeronautics and Space Administration) Landsat satellites orbit the earth fourteen times a day at an altitude of 494 nautical miles. Every eighteenth day brings to completion another detailed scan of the Earth's surface from 81°N to 81°S. Under an agreement between NASA and the federal government, CCRS receives data from the Landsat satellites, processes the data into image form, and distributes the images to users in the country.

The Multispectral Scanner (MSS), carried by Landsat I and Landsat II, senses the electromagnetic radiation from the Earth's surface in four nar-



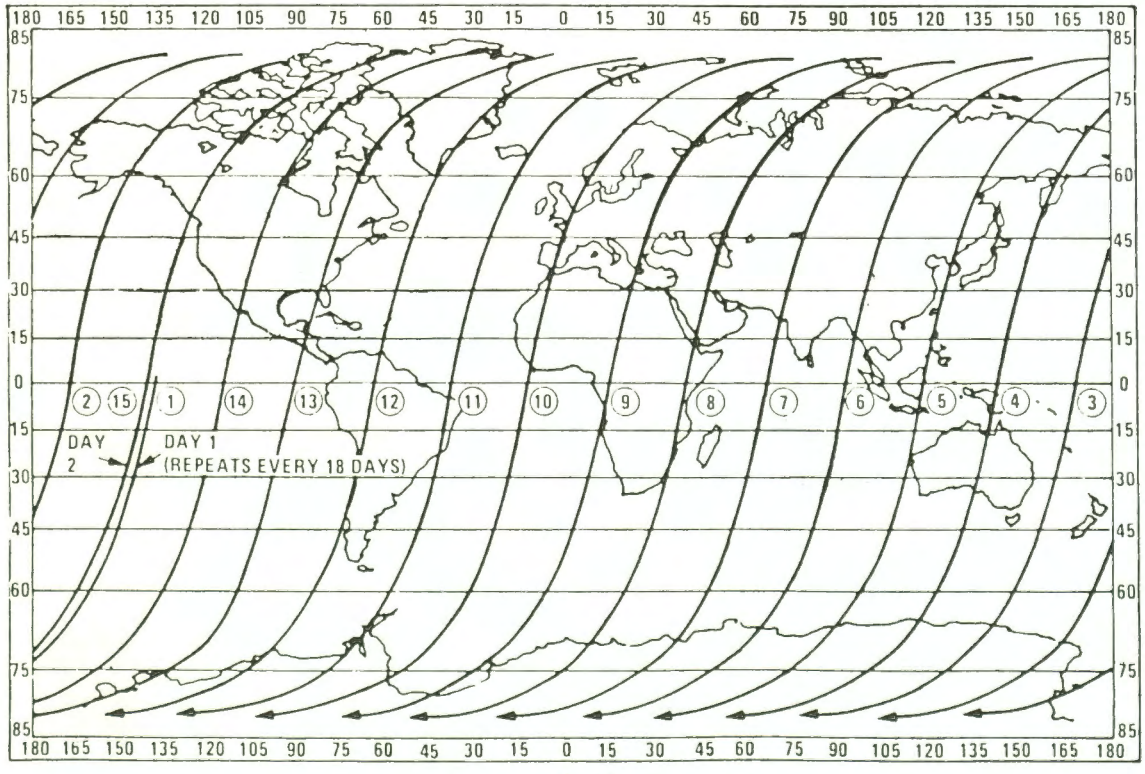
Open water between Cornwallis Island and the Grinnell Peninsula as seen from the Landsat satellite.
black – open water — light blue – thin ice

row regions of the electromagnetic spectrum called bands, which are numbered 4 through 7 and have the following characteristics:

	Wavelength Sensed (Nanometres)	Resolution (Metres)
Band 4	.5 to .6 (Green)	80
Band 5	.6 to .7 (Red)	80
Band 6	.7 to .8 (Infrared)	80
Band 7	.8 to 1.1 (Infrared)	80

The information is transmitted to the two ground receiving stations at Prince Albert, Saskatchewan and Shoe Cove, Newfoundland, and sent to CCRS for processing into image form. Black and white images representing each of the four spectral bands can be produced or any three bands can be combined to produce a colour image. For those investigators interested in digital analysis, the data can be provided in a form compatible with their own computer (computer compatible tape or CCT).

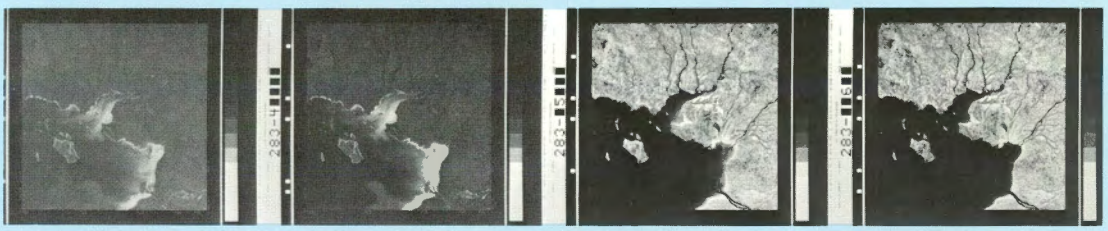
The Prince Albert Station is operated under contract by SED Systems Limited of Saskatoon and the Shoe Cove Station is operated under contract by NORDCO Limited of Newfoundland. ISIS



Typical Landsat Daily Ground Trace

LANDSAT PRODUCTS

Satellite Images of James Bay, Quebec.



Black & White
Band 4
Green
.5 - .6μ

Black & White
Band 5
Red
.6 - .7μ

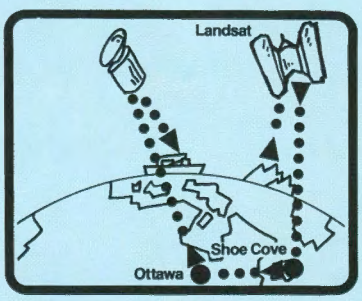
Black & White
Band 6
Infrared
.7 - .8μ

Black & White
Band 7
Infrared
.8 - 1.1μ

Combination of bands 4, 5 & 6 produce colour composite of James Bay

CCT

ERTS FICHE



FAX

Limited of Prince Albert, Saskatchewan has exclusive rights to distribute all satellite data products which include ISISFICHE© and facsimile transmissions.

ISISFICHE© is a unique Canadian service which provides the subscriber with a daily look at Band 6 of all data including that with complete cloud cover, which have been transmitted by Landsat satellites to the two receiving stations. The data are reduced to three microfiche cards per satellite per day which are usually distributed to users within three or four days of the satellite overpass.

For those users requiring near real time satellite imagery, ISIS Limited offers a facsimile service. The users must, however, acquire compatible receiving equipment. Imagery can usually be transmitted within a few hours of its reception at Prince Albert or Shoe Cove. For further information contact ISIS Limited. (See enclosed address sheet.)

Airborne Operations

To provide Canadian users with operational airborne data, the Data Acquisition Division of CCRS operates four aircraft: two DC-3 aircraft used for low level operations and testing new sensors; a Falcon Fan-Jet which can operate at altitudes up to 36,000 feet and a Convair 580 which has a long range capability for use in the Arctic and over the oceans. All aircraft are flown and operated under contract to CCRS by Intertech Limited (a remote sensing company owned by Innotech Aviation of Montreal and Intera Environmental Consultants of Calgary).

Users are required to pay partial flight costs during the period when sensors are in operation; full costs for material expended and for data processing. Photographic film is processed by the National Air Photo Library Reproduction Centre which is located in the CCRS headquarters; data from non-photographic sensors are processed at CCRS. At the conclusion of the project the master photo negatives are normally placed in National Air Photo Library; additional copies of the data can then be acquired by anyone through that agency. Electronically recorded data are retained on master tapes within CCRS. The Centre will provide copies in the required format (CCTs, hard copy, etc.) on request.

The number and type of sensors carried in the aircraft may vary according to the capabilities of individual aircraft and the requirements of the mission to be flown. Sensors may be operated singly or simultaneously. The aircraft are also fitted with sophisticated navigation equipment to ensure accurate flight-line control. A complete description of the aircraft, sensors and airborne operations is contained in a handbook "Information Bulletin — Airborne Operations".

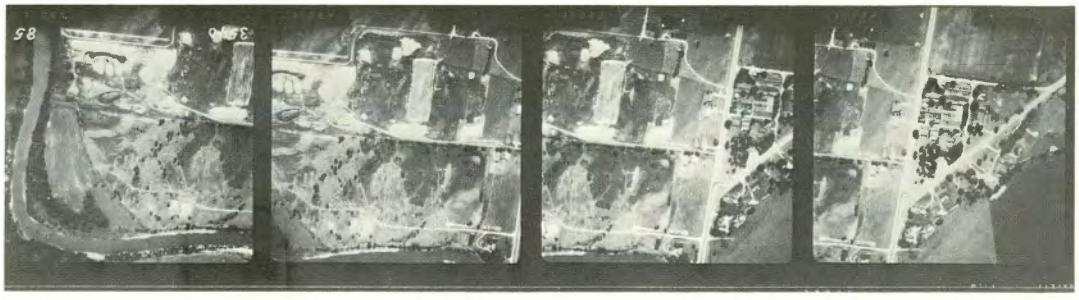
Research and Development

CCRS maintains a strong research effort in the development and evaluation of new sensing devices. The Centre has funded the design and development of several airborne instruments, many of which are at the forefront of sensor technology.

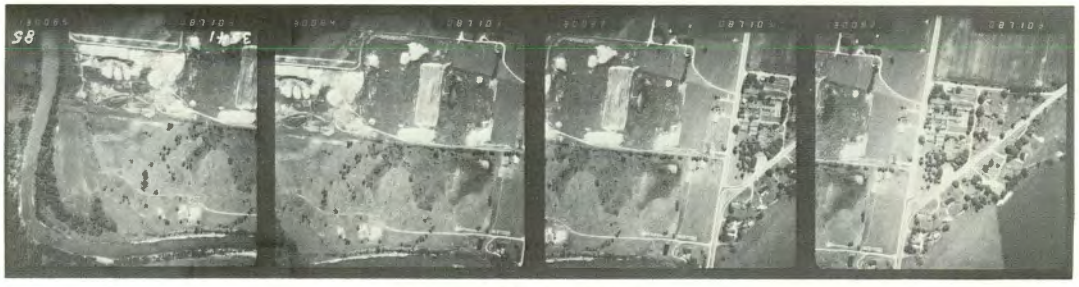
One such sensor which is under development, and is designed to detect surface pollution, is a laser fluorosensor. The sensor measures the characteristics of the fluorescence of floating pollution when the latter is stimulated by a pulsed ultraviolet laser on the aircraft. The sensor detects oil spills, for example, because the spills fluoresce differently from other materials floating on water.

Convair 580

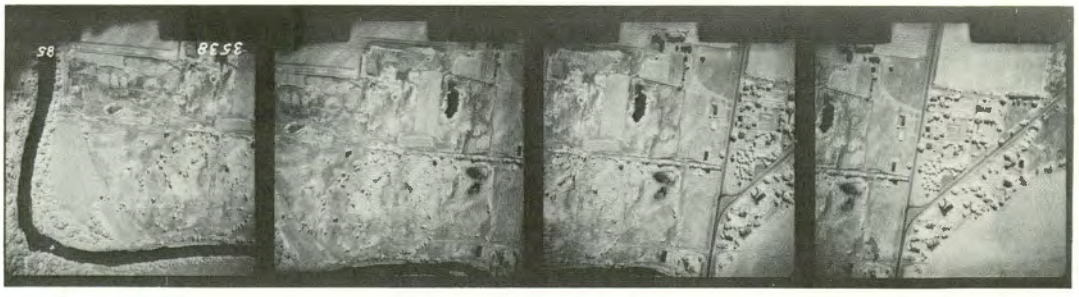
Typical CCRS Airborne Project



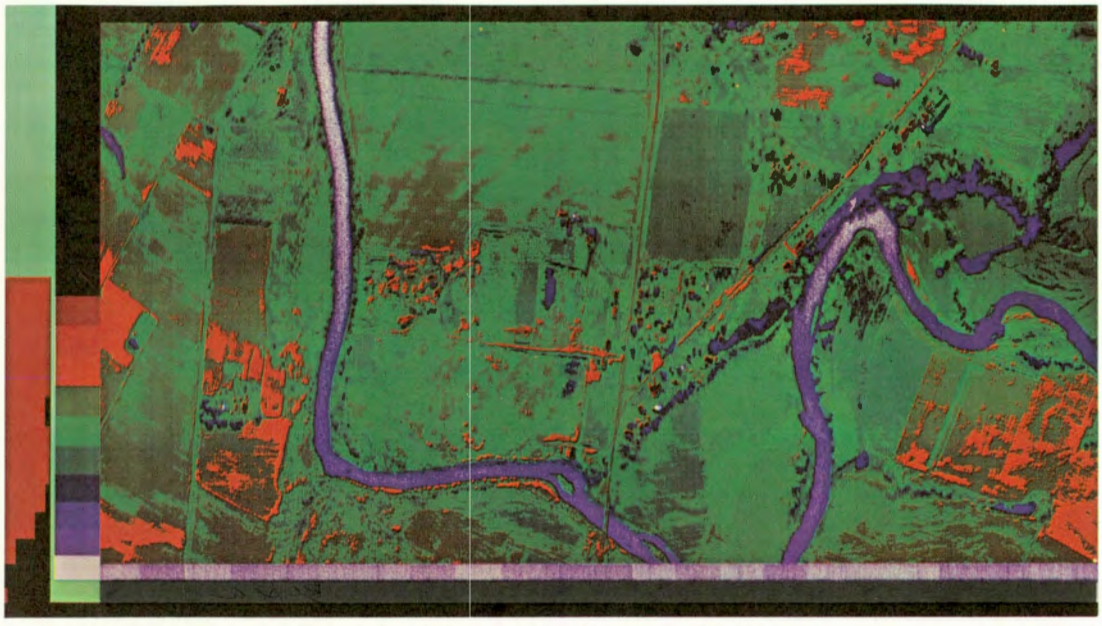
70 mm Vinten Camera
3″ lens, .6 - .7μ filter



10 mm Vinten Camera
3″ lens,.5 - .6μ filter



70 mm Vinten Camera
3″ lens, .7 - .8μ filter



Daedalus Infrared LineScanner 8 - 14μ

RC10 Camera
6″ lens NAV filter

RC10 Camera
6″ lens, .525 - 2X AV filter

Another sensor is the laser bathymeter which is being developed to measure water depth remotely from the air by optical echo sounding. A pulsed green laser is directed at the water, and the time difference in arrival of the surface and bottom returns represents the water depth.

In the microwave area, a scatterometer has been used for several years to gather data on the microwave scattering properties of sea-ice, in particular. This information is necessary for defining and optimizing the parameters of imaging radars for use from airborne and satellite platforms for surveillance of the Arctic.

Other work is concerned with the development of improved visible, and near infrared multispectral imagers with no moving parts, for use in aircraft and satellites, capable of measurements not possible with rotating or rocking mirror multispectral scanners.

To support the development and evaluation of these and other sensors, sophisticated data acquisition and navigation systems have been developed and are carried on the R and D aircraft.

As a complement to the research on sensors, CCRS also carries out research on the spectral and spatial properties of natural objects, such as crops and forests. Systems have been developed for automatically identifying the areal distributions of particular crops and forests. The results may be tabulations of acreages or thematic maps or digital tapes for transferring information to Canada's geographic data bases. Research and development in methods for rapid analysis and interpretation of visible, infrared, and microwave imagery is carried out to support such applications as environmental impact studies, heat loss mapping in urban areas, mineral and petroleum exploration, renewable resource inventories and pollution monitoring.

CCRS User Services

The main contact between the outside user and CCRS is the Marketing and User Assistance Unit. This unit is responsible for providing information on the Centre and its activities and facilities, accepting orders for all CCRS products including Landsat data and airborne remote sensing data, answering enquiries and receiving complaints and suggestions.

User services also include the CCRS Technical Information Service (TIS). It includes a library of remote sensing books, reports, reprints, slides, films and reference material, as well as a large collection of Landsat imagery.

Most of these library resources are catalogued in computerized systems so that users anywhere in Canada with access to a computer terminal may personally search the library files for information. Documents on applications and techniques of remote sensing, in English and French, may be located through RESORS (Remote Sensing On-Line Retrieval System).

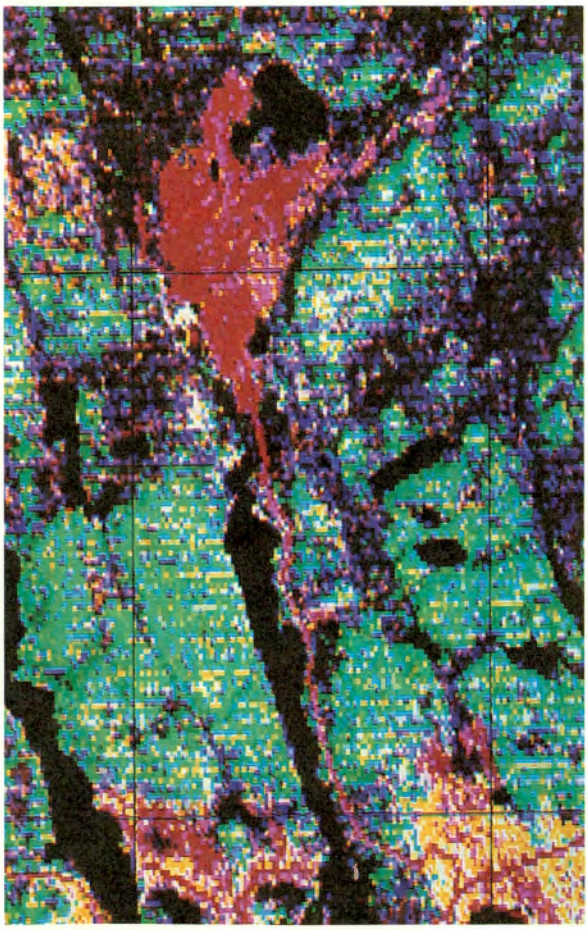
Landsat imagery can be located through an on-line computerized catalogue called Image Inventory Search and Summary (IISS). Users may obtain a list of images corresponding to any Canadian geographic area of interest qualified by degree of cloud cover, and spectral band quality.

TIS also maintains a manual microfiche index to Landsat imagery, ISISFICHE.

Other image products on file include a selection of Skylab (an American space mission), and NOAA imagery, airborne flight line index maps and a visual library containing documentation and sample imagery from completed projects. Processed imagery includes a selection of black and white and colour prints, transparencies, and 70 millimetre 4 band transparencies. An international microfilm file, excluding the United States, is also maintained so that Canadian users can determine which satellite imagery is available for other parts of the world. International data must be ordered from the Eros Data Centre. (See address sheet.)

Library facilities at CCRS

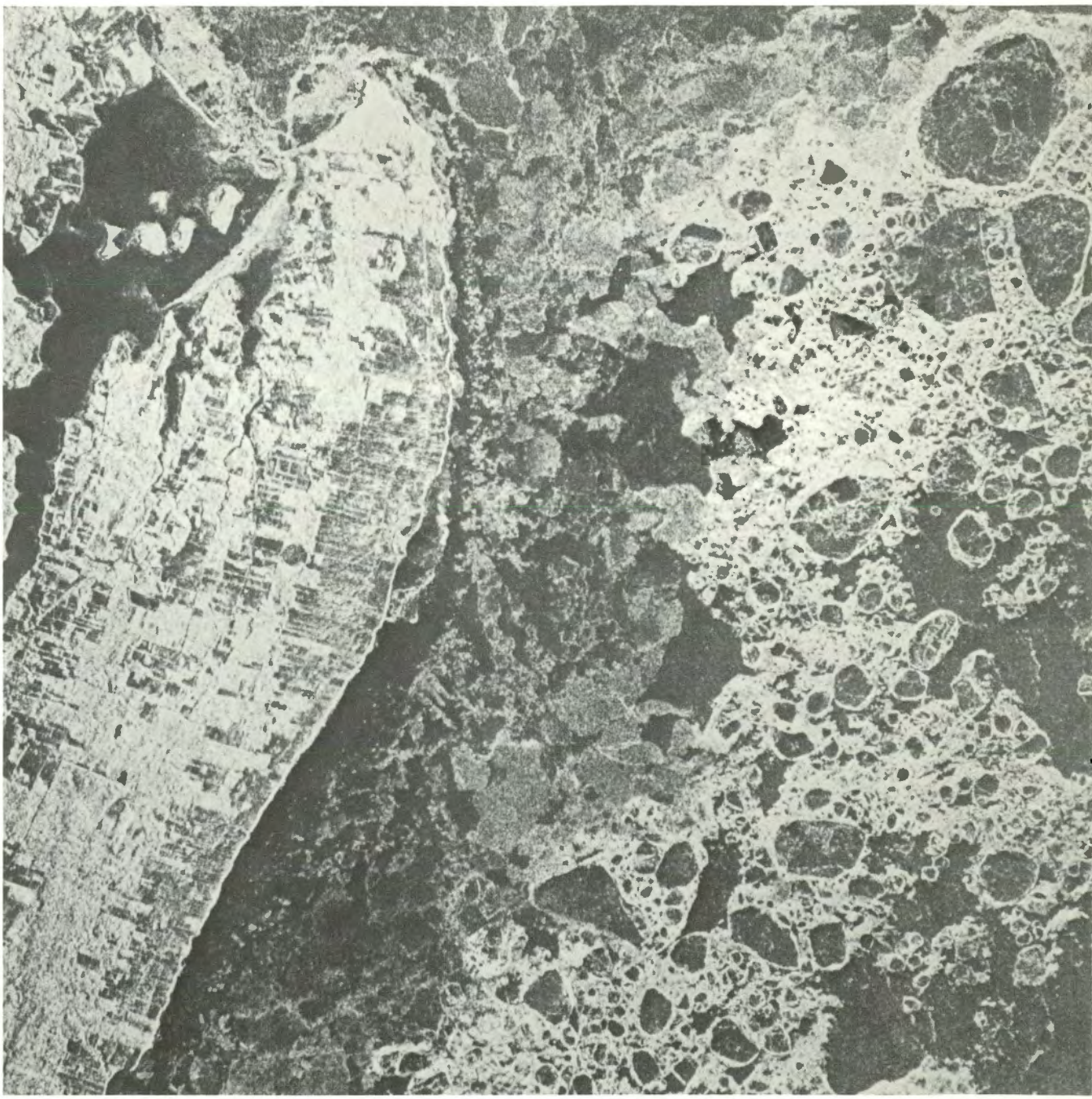
Anyone wishing to avail themselves of any of the above services or to make further enquiries should contact the Marketing and User Assistance Unit. (See address sheet.)



Using Landsat data, the Hooked Lake area (Northwest of Maniwaki, Quebec) has been classified by computer to make a thematic map

black — water
red — recent clear cut roads
yellow — regenerated clearcut
green — harwood and mixed wood
purple — conifers

This colour imagery of the Kawartha Lakes area of Ontario was used to develop maps which show accurate outlines of the beds of aquatic plants. The maps are being used to develop cutting patterns for the mechanical harvesting program.



Radar Image of ice formations in the Northumberland Strait, south of Prince Edward Island

A LOOK TO THE FUTURE

Five major events will influence the development of the remote sensing program over the next five years.

Landsat C

Landsat C (Landsat III once in orbit) is to be launched in the spring of 1978 and will have the same four bands plus two additional sensors:

Four of the RBV frames will cover one MSS frame. This high resolution capability is expected to be especially useful for cartography.

Landsat D

Current NASA plans call for the launching of Landsat D in late 1981. This satellite will carry a thematic mapper which will have six spectral channels. Five of the channels will have a spatial resolution of 30 metres and the sixth, in the thermal infrared band, will have a resolution of 120 metres.

	Wavelength Sensed (Nanometres)	Resolution (Metres)
Band 8	10.4 — 12.6	238
Vidicon (RBV)	.505 — .750	40 (approx.)

The satellite will be in a 705 km polar orbit, sun synchronous (98.2 degrees inclination, with an equatorial crossing of 9:30 local time). The repeat cycle will be every 16 days.

NASA are also considering the inclusion of the MSS in Landsat D to provide continuity to those users who have developed systems utilizing MSS data.

Seasat

Seasat, scheduled for launch in the spring of 1978, is an oceanographic satellite carrying a number of sensors operating in the microwave portion of the electromagnetic spectrum. These sensors have the advantage of being able to 'see' through cloud. Canada is planning to participate in the NASA Seasat experiment as a step toward defining Canadian requirements for a surveillance satellite capability. The sensors to be carried on this satellite will be designed to measure ocean parameters such as surface winds, gravity waves and sea surface temperature, and to map sea ice. The most important sensor to Canada is the imaging radar which will be able to map sea ice as an aid both to offshore oil drilling operations and to Arctic shipping.

To supplement the Seasat experiments, airborne experiments will be conducted with an advanced two-frequency (L-Band and X-Band) imaging radar mounted in the CCRS Convair aircraft.

The Heat Capacity Mapping Mission (HCMM)

The HCMM will carry a single sensor, the heat capacity mapping radiometer, on a small dedicated satellite. The orbit of this satellite is adjusted so that day and night passes over an area will be made within 24 hours. The repeat cycle will be 8 days. By taking the difference between the data acquired on the day pass and the night pass, the thermal heat capacity characteristics of surface materials can be measured. These measurements will be useful in identifying various rock and mineral types and measuring soil moisture. The satellite is scheduled for launch in early 1978.

Test data will be available to experimenters in Canada.

SPOT-1

An experimental high performance satellite (SPOT-1) has been announced by CNES (Centre National d'Etudes Spatiales) of France for launch in 1983. The satellite will carry two side by side push-broom scanners with a swath width of 60 km each and resolution of 20 m in a 3-band mode in the visible spectrum and 10 m in single band mode, as well as an experimental stereoscopic capability.

CONCLUSION

Progress in remote sensing is made every day with each new project. Yet today, even at this early stage of the application of remote sensing to resource management, Canadians already have a tool with which to better understand and manage the country's resources.