THE IMPORTANCE OF REMOTE SENSING FOR CANADA: PAST ACHIEVEMENTS, FUTURE NEEDS

L'IMPORTANCE DE LA TÉLÉDÉTECTION POUR LE CANADA: ACCOMPLISSEMENTS PASSÉS ET BESOINS FUTURES

E. A. Godby[1] and J. Thie[2]

ABSTRACT

Canada's economic future is dependent on the use of our comparative advantage in the natural resource sector (forestry, agriculture, energy, minerals) and our technological capabilities. Accurate and timely remote sensing information is essential to more effective use, management and growth of this sector. Annual benefits of remote sensing are estimated to be in the $200-400 million/year range. Initiatives and substantial investments are required to realize benefits. Key to success is cooperation between federal and provincial governments and industry in the planning, financing and implementation of new initiatives. Future thrusts should include reception and processing of data from the new generation satellites such as LANDSAT-D and SPOT, specification of Canadian requirements for RADAR data (RADARSAT), geocoding and integration of data into resource management information systems. Considering the significance of land resources to our economy, Canada, of all countries, has need of a strong remote sensing program.

RESUMÉ

L'avenir économique du Canada dépend de l'usage que feront les Canadiens de l'avantage qu'ils détiennent en matière de richesses naturelles (forêt, agriculture, énergie et mines) et de leurs possibilités au plan technique. Des informations exactes et opportunes, obtenues par la télédétection, sont indispensables à l'utilisation, à la gestion et à la croissance efficaces du secteur des ressources. On évalue entre 200 et 400 millions de dollars par an les avantages pouvant être tirés de la télédétection. Pour réaliser de tels bènéfices il faudra cependant mettre de l'avant diverses initiatives et faire des investissements considérables. La clef du succès réside dans la coopération entre les gouvernements fédéral et provinciaux et l'industrie, dans la planification, le financement et la mise en oeuvre de nouveaux projets. Parmi les orientations futures, il faudrait compter la réception et le traitement de données obtenues au moyen de la nouvelle génération de satellites comme LANDSAT-D et SPOT, la détermination des besoins du Canada en matière de données RADAR (RADARSAT), le géocodage et l'intégration de données aux systèmes d'information pour la gestion des ressources. Compte tenu de l'importante place qu'occupent les ressources terrestres dans notre économie, nous avons besoin, plus que tout autre pays, d'un bon programme de télédétection.

[1]Canada Centre for Remote Sensing, 2464 Sheffield Road, Ottawa, Ontario. K1A OY7

[2]Environment Canada, Canada Lands Directorate, 20th Floor, Place Vincent Massey, Hull, Quebec.

KEYWORDS/MOTS-CLÉS: Canada, Natural-Resource, Regional-Environment, LANDSAT, CIAS, ARIES, DICS, SURSAT, SEASAT, Alberta, Manitoba, Ontario, Quebec, Saskatchewan, New-Brunswick, Nova-Scotia, P.E.I., Newfoundland, SPOT, ESA, MOS.

Presented at the 7th Canadian Symposium on Remote Sensing, Winnipeg, Manitoba. September 8-11, 1981.

INTRODUCTION

Originally we were invited to present separate papers related respectively to "Remote Sensing Data Management" and "the application of Remote Sensing to Resource Management in Canada". However, we felt that we could provide a more significant contribution to this symposium by combining our efforts. This paper attempts to provide a perspective of the significance (benefits) of remote sensing to Canada, the past achievements and the future needs and initiatives required.

Remote sensing, in all its varied forms provides information for decision making. There are no benefits, but only costs, associated with remote sensing if data and information are not used in planning and management of the social, economic and environmental elements of our society.

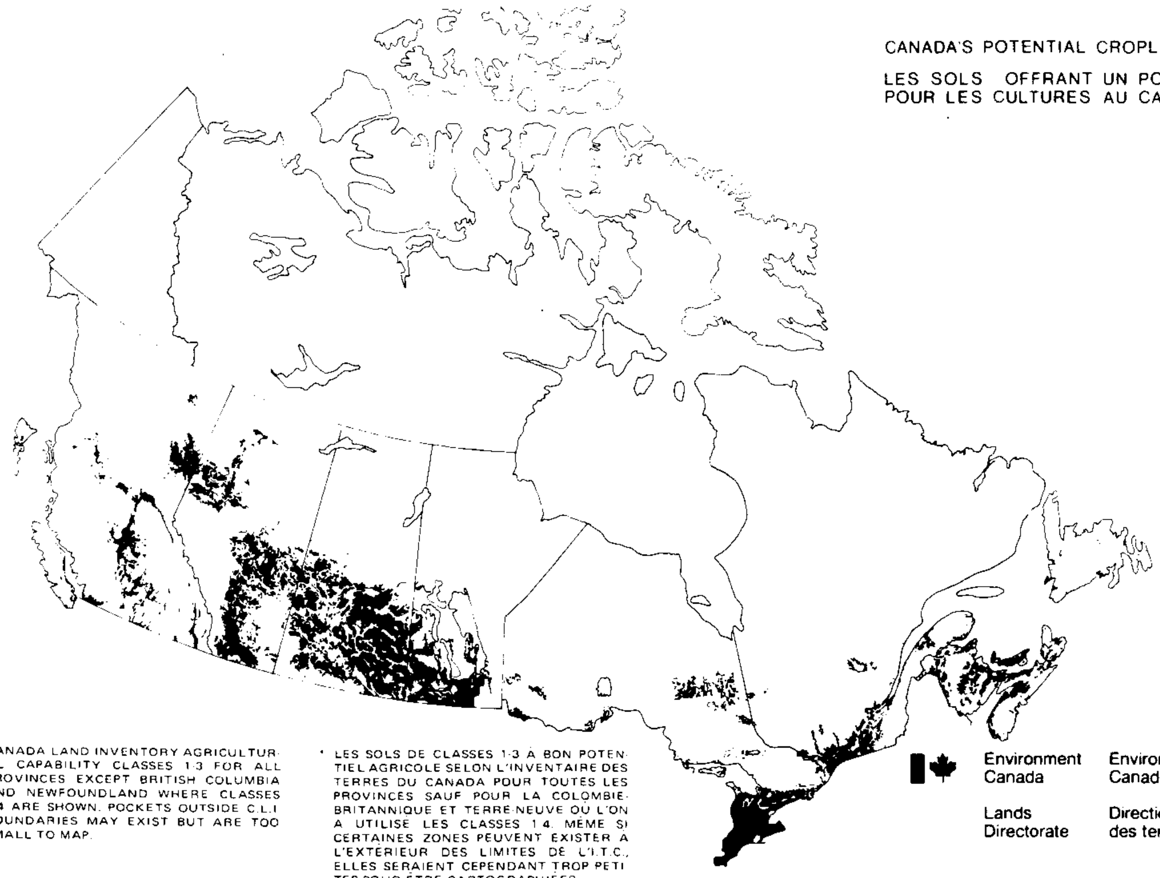
In Canada, economy and environment are intimately linked. Our economy is primarily based on the use and export of products from our resources. Remote sensing, with its ability to generate spatial data on our land and water resources and our climate, is particularly suited to contribute to improved management of these resources.

Through more effective use and management of the resource base, remote sensing contributes to the economy. In addition, significant benefits related to industrial development, sovereignty issues and communications aspects can be achieved.

THE REMOTE SENSING CONSTITUENCY

Canada's Resource Based Economy

In a global sense Canada has some unique characteristics. It is one of the largest countries in the world, yet has a small but technically developed population. Although its landmass is large, the cold northern climate and physiography severely limit the capacity of the land to produce agricultural and forest products. For example, only about 7% of Canada's land is suitable for agriculture and only about 25% is productive forest land. Our mineral and renewable resources are abundant in relation to our population, but in the last 20-30 years we have been faced with problems of scarcity and resource use conflicts. Our typical response has been to push back the frontiers, expand production by using more land. While this still can be done in the mineral and energy sector, expansion in the renewable resource sector can only be achieved



CANADA'S POTENTIAL CROPLAND

LES SOLS OFFRANT UN POTENTIEL POUR LES CULTURES AU CANADA.

* CANADA LAND INVENTORY AGRICULTURAL CAPABILITY CLASSES 1-3 FOR ALL PROVINCES EXCEPT BRITISH COLUMBIA AND NEWFOUNDLAND WHERE CLASSES 1-4 ARE SHOWN. POCKETS OUTSIDE C.L.I BOUNDARIES MAY EXIST BUT ARE TOO SMALL TO MAP.

* LES SOLS DE CLASSES 1-3 À BON POTENTIEL AGRICOLE SELON L'INVENTAIRE DES TERRES DU CANADA POUR TOUTES LES PROVINCES SAUF POUR LA COLOMBIE-BRITANNIQUE ET TERRE-NEUVE OÙ L'ON A UTILISÉ LES CLASSES 1-4. MÊME SI CERTAINES ZONES PEUVENT EXISTER À L'EXTÉRIEUR DES LIMITES DE L'I.T.C., ELLES SERAIENT CEPENDANT TROP PETITES POUR ÊTRE CARTOGRAPHIÉES.

Environment Canada — Environnement Canada

Lands Directorate — Direction générale des terres by more effective management of what is already being used. Government economic policies and strategies reflect the importance of improved management to increase production. Federal Government discussion papers related to 'agri-food' sector and forestry set as goals to increase productivity by at least 50% by the year 2 000. Research, technology, resource information and planning are key ingredients to more effective management and increased production.

Historically, if we may use that word related to the relatively young discipline of remote sensing, the resource sector has been the primary client for the remote sensing Technology. Particulary aerial photography played a key role in the exploration and management of our land resources. In a vast country like Canada, simply no alternative to remote sensing exists to provide accurate information on our extensive resources.

How much should the resource sector spend on a remote sensing infrastructure? How much can it afford to spend? This last question can be answered by looking at the contribution of our client to the economy.

In Canada, close to 50% of goods produced come from the resource sector (primary resource sector and primary manufacturing, Table 1).

PERCENTAGE OF TOTAL GOODS PRODUCTION: 1976

	Total Canada	Atlantic	Que.	Ont.	Man. Sask.	Alta.	B.C.
Agriculture	7.3	4.6	3.6	4.4	35.4	9.2	2.8
Forestry	1.6	2.8	1.6	0.6	0.5	0.2	7.7
Fishing	0.5	4.7	-	-	0.2	-	1.6
Mining	13.8	12.2	4.6	4.6	15.1	50.7	11.3
Other	3.9	7.4	5.4	3.1	3.9	1.9	4.2
Total Primary	27.1	31.7	15.2	12.8	55.1	62.0	27.8
Primary Manufacturing	21.2	26.6	24.6	22.4	13.1	8.2	33.1
Total Primary plus Primary Manufacturing	48.3	58.3	39.8	37.2	68.2	70.2	60.9

Table 1: Role of Resource Sectors in Canadian Economy by Region (Environment Canada, 1981)

The resource sector goods production is lowest in Ontario and Quebec and highest in the prairie provinces. The relative significance of the various sectors within each region is important for the planning of a regional remote sensing infrastructure.

The importance of the resource sector to Canada's economy is dramatized by looking at Canada's export trade. The resource sector and related sectors contribute to about 85% of Canada's non-auto exports. In fact, resource industries continue to be the dominant factor in earning foreign exchange (Environment Canada, 1981).

Within the resource sector, forestry, agriculture and energy are some of the major clients for remote sensing data. The forestry sector accounts for about 18% of our exports. It makes a larger net contribution to our trade balance than agriculture, fishing, mining and fuels put together (Environment Canada, 1981). The agri-foods sector employs about 850 thousand people; foods purchased by consumers amount to about $30.8 billion; export sales were nearly $8 billion in 1980 (Agriculture Canada, 1981). In the next decade, investments in the energy sector will expand drastically. Between 65 and 85 billion dollars will be expended related to hydrocarbon development in Canada's Territories alone!

In both the agricultural and forestry sector signficant increases in production are possible through more effective use of the resource, R&D and better use of technology. The agri-food sector output can be increased by two-thirds (Agriculture Canada, 1981). In forestry, a 50% increase in harvest is possible (Canadian Forestry Service, 1981).

It is clear that the very significant contribution of the resource sector to the Canadian economy can continue to grow through better resource management. Remote Sensing is one of the technologies required to make this happen.

The Role of Remote Sensing in Resource Management

How does remote sensing contribute to more effective resource management and what is the significance (benefit) of that contribution?

The resource management process can be broken down into several phases, i.e.:

1) objective/opportunity/problem definition phase
2) inventory/information analysis phase
3) planning/policy development phase
4) implementation/operation phase
5) monitoring/controlling phase.

remote sensing contributes to the inventory and monitoring phase. By providing accurate and timely information. It improves development of policies and plans. As well, it assists in the implementation of plans and operational management by providing effective monitoring and control information. It follows that inventory specialist (phase 2) and operational managers (phase 5) are our direct clients.

These two groups of clients have been making effective use of conventional forms of remote sensing. Aerial photographs form the back-bone of forest inventories, soil and geological surveys, land capability and land use inventories.

In the past, most users had little difficulty justifying the cost of aerial photography. Foresters, for example, carry out large and costly aerial surveys to support the preparation of management plans and the monitoring of woodland operations. Private companies acquired the equipment and the skills to carry out the airborne operations to satisfy the demand. The immediate (and primary) user paid for the data acquisition, carried out the interpretation and reaped the benefits. A simple 'infrastructure' assured that benefits of aerial photographs were available to everyone.

Rapid advancements in sensor developments, satellite platforms and digital data analysis have changed the past perspective drastically. An individual user cannot finance the launching of a satellite, the development and purchase of sophisticated sensors or its own receiving station. Now a complex 'infrastructure' is required to assure that benefits from remote sensing technology are achieved. At its foundation is cooperation between governments (federal and provincial) and industry.

The federal government as well as a number of provincial governments have recognized their important role in the development of this infrastructure. However, the total Canadian investment in remote sensing is just a fraction of the potential and immediate benefits.

A range of benefit-cost studies have been carried out by McQuillan (1973, 1975, 1979) and others. Results show that total annual benefits of satellite remote sensing for land and ocean applications may be as high as 400 million dollars annually.

ACHIEVEMENTS IN THE LAST DECADE

This conference is being held almost a decade after the launch of the first LANDSAT satellite. That decade of remote sensing activity was essentially dominated by LANDSAT with its visible and infrared sensors. SEASAT made a brief appearance and gave us a glimpse of the enormous potential of space radar.

As we look to the future from this vantage point we can see that the next decade will be far different from the last. Firstly, there will be more advanced satellites launched by countries besides the United States and the services are going to cost more than we've been accustomed to paying. This means new choices as well as more opportunities for Canada. We have to decide what this remote sensing data is worth to us, to what extent and on what terms we are going to participate in the remote sensing programs of other countries, and the role Canada is going to play in the global scene during the next and succeeding decades.

Before looking to the future we should take a brief look at what has happened to remote sensing in the last decade and see if we can detect any trends which will help to point us in the right direction.

LANDSAT Ground Stations

When the ERTS program was originally announced in the 60's, NASA favoured the concept of centralized reception and distribution of the data. In 1971, L.W. Morley et al introduced a fundamentally different concept -- the data should be received, processed and distributed regionally so as to better involve the regions of the world in the remote sensing technology and to make the data available in virtual real time so that it could be used for monitoring purposes -- which is where the major strength of satellite remote sensing lies. This paper showed how the entire land mass of the globe could be covered by 20 ground stations (Figure 2).

Now, a decade later, there are 15 stations with 3 others planned in Indonesia, Upper Volta and Kenya. Figure 3 shows the only gaps which exist in the present and planned coverage

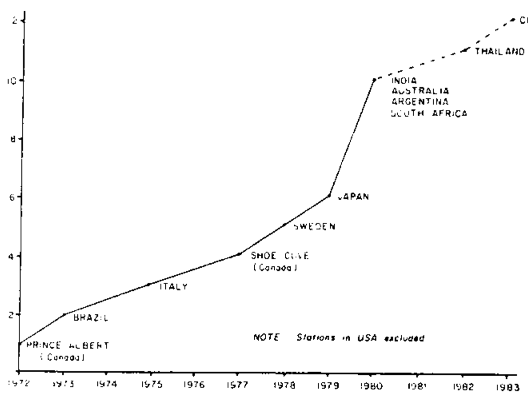


Figure 4 Cumulative growth in international ground stations.

of the land areas of the globe are in Russia, Central America and New Zealand. This example

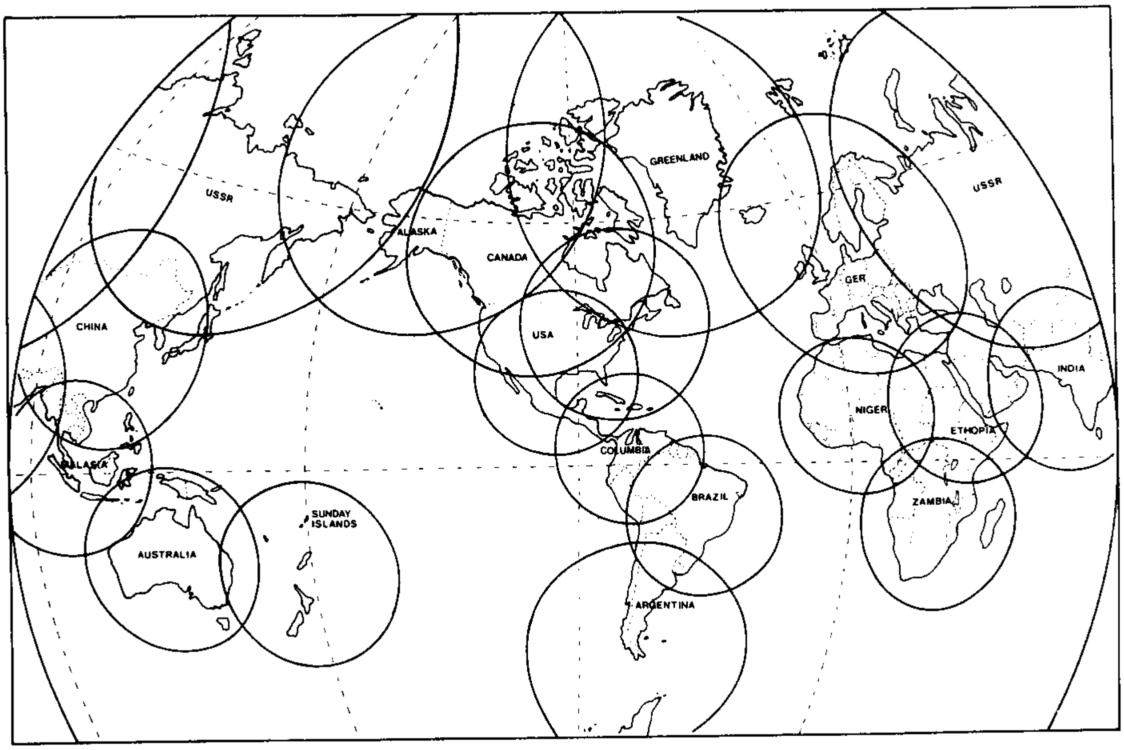


Figure 2: Proposed global receiving station network (Morley et al, 1971)

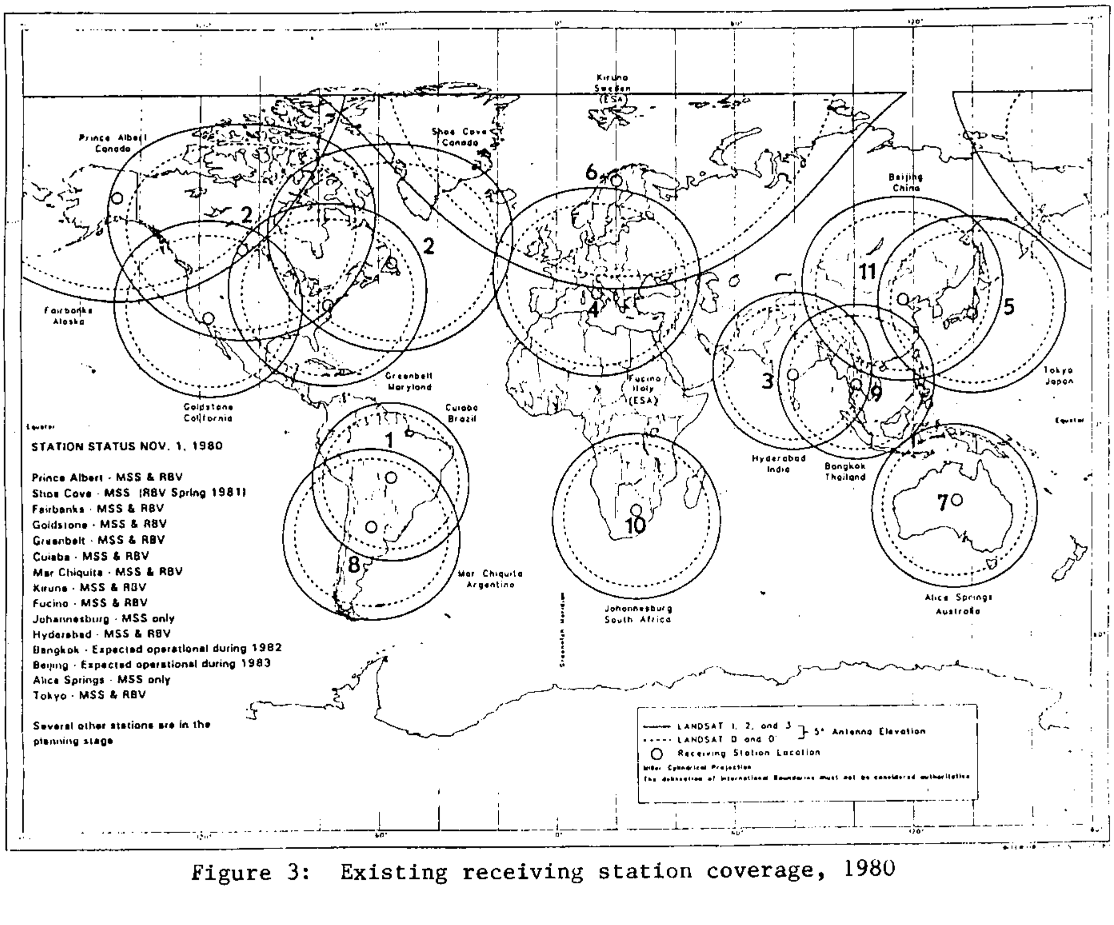


Figure 3: Existing receiving station coverage, 1980

of forethought and accurate prediction of the way events are going to move is one that we would like to be able to emulate in forecasting events in the next decade.

Computer Assisted Analysis of Data

One indicator of a long term commitment to the remote sensing field is the extent to which various agencies in the country are investing in image analysis systems which cost in the range of $100,000 to $1,000,000.

In 1972 analysis was conducted mainly by visual means and there was only one image analysis system in Canada. Since that time there has been a rapid growth throughout Canada in the capability to do machine assisted analysis. At the present time there are a dozen digital analysis systems and 5 analogue image analysis systems operating in Canada (Fig. 5) and at least two other digital systems are on order.

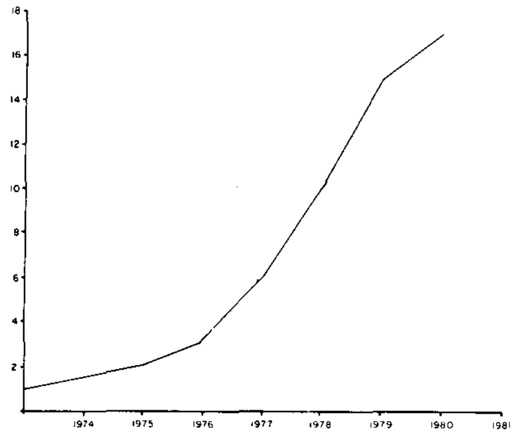


Fig. 5. Cumulative growth in Canadian image analysis system installations.

One would expect that as the sale of image analysis systems increases so would the sale of computer compatible tapes. Initial sales of tapes were for use in experiments using the CCRS CIAS and the Department of Environment ARIES system. The demand levelled off, but has now started to grow again as the availability of image analysis systems increases. Also the demand for the DICS (digital image correction system) products has grown rapidly since its introduction in 1979. The DICS product is geometrically corrected and referenced to the National Topographic Map System. In future, users will be able to accurately overlay and compare data acquired from any imaging satellite or aircraft sensors and integrate effectively with other geocoded data basis.

Florian Guertin describes future aspects of DICS in another paper in these proceedings.

Radar

So-far these developments have dealt mainly with the visible and infrared part of the spectrum, but the last decade has seen the development of a Canadian capability in radar to meet Canadian needs.

Under the SURSAT project, Canada participated in the NASA SEASAT project. SEASAT was a satellite which carried, among other sensors, a synthetic aperture radar which was of interest to Canada for use in Arctic operations and transportation. Although the satellite has a short life, the project:

a) demonstrated the usefulness of radar to ice reconnaissance in the Arctic and off-shore and to other resource management problems;
b) developed a competence in the user community throughout Canada in the use of SAR data;
c) resulted in Canada having a first class airborne research facility which can acquire data in three bands - X, L and C (this facility has just completed a six-month mission in Europe for the European Space Agency); and,
d) developed a capability in industry in the processing of SAR data.

This project led to the present interdepartmentally managed RADARSAT project, the objective of which is to develop a Canadian satellite SAR capability to meet perceived needs for Arctic operations and navigation in the late 1980's. This project is described in a paper by Ed Shaw in these proceedings.

Industrial Capability

During the past decade Canada has developed an industrial capability which can both meet domestic needs and has a respectable export record. It is important to look at this record when trying to answer the question of whether to buy from outside Canada, or to develop Canadian expertise. The answer to this question is dependent on the forecasts for the world need for remote sensing products and services. It is not worthwhile developing a Canadian industrial capability to meet a one-off Canadian requirement.

In the area of Ground Stations, it was shown that the earth is now virtually covered by stations. Canada has had a big part to play in the provision of these ground stations (Fig. 6). It would appear that once the world has been covered, and that has nearly happened, that the situation would be rather stable and static.

It is more likely, however, that this one time coverage of the earth by LANDSAT stations, which is nearly completed, is only the first wave. The second wave is now starting -- the upgrading of these stations to LANDSAT-D and SPOT, etc. capability and the introduction of improved products and image analysis facilities.

The third wave will be to equip the stations for radar capability and to move toward integrated informaton systems, all of which Canada has both the need and the plans for. The rest of the world has the same needs.

Provincial Remote Sensing Programs

At the provincial level much has been achieved in remote sensing. There is however, somewhat of an imbalance between the strong federal government initiatives taken and planned and what has happened in various provinces. A number of provinces have set up Remote Sensing Centres, or some other forms of infrastructure, which assures that their agencies and industries can utilize new technologies and information sources. Others have taken a 'wait and see' attitude and therefore their users can achieve limited benefits.

To integrate new remote sensing data and related technology into the resource management process a special effort has to be made. This effort may and should vary according to province, region or discipline reflecting physiographic, economic (Table 1) and social, or organizational realities. The 1981 meeting of the Canadian Advisory Committee on Remote Sensing, (CACRS) addressed the issue of roles, functions and activities which are required to assure integration of remote sensing and realization of benefits. At least 7 distinct roles/functions are required (Thie, 1981):

1) Coordination, related to the acquisition of information, R&D, investments in expensive hardware.
2) Research & Development of new applications critical to the province or region.
3) Technology Transfer from R&D agencies to users.
4) Provision of Advice and Information to assure users can adequately plan 'new' applications
5) Provision of Training re. new technology.
6) Provision of facilities, equipment for the analysis of remote sensing data which are too expensive for most users to acquire.
7) Provision of services related to the acquisition and analysis of data for 'clients' who do not have the technical capability.

Although the level of activity varies considerably from province to province, the overall involvement indicates a strong commitment to the practical application of remote sensing (Zsilinszky, Chairman IPTASC, 1980 personal communications). Alberta, Manitoba and Ontario started their Remote Sensing Centres all in 1973. Quebec started its centre in 1976. A short description of each of the provincial programs follows. The descriptions are based on personal communication with the provincial representatives to CACRS and reflect the 1979-80 budget year.

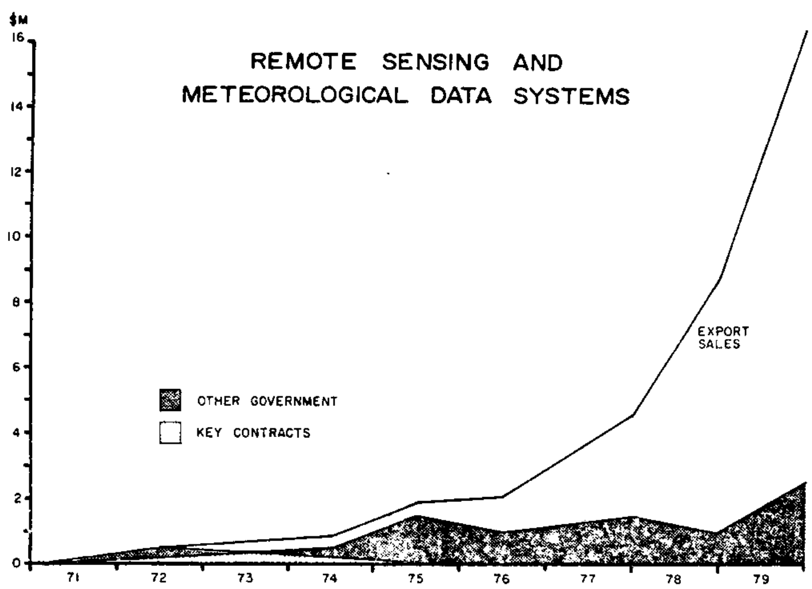


Figure 6: Export sales of groundstation technology by Canadian industry

Condensation of the information by the second author (Thie) may have resulted in some inaccuracies.

British Columbia. In B.C., provincial and federal governments and industry have invested heavily in remote sensing. A number of centres of expertise exist where digital image analysis can be carried out. Coordination of activities is now carried out through the Inventory Branch of the Ministry of Forests. The Ministry of Forest in cooperation with CCRS, MOA and the Pacific Forest Research Centre (CFS), carried out a feasibility study using satellite image analysis to monitor changes and depletion of the forest and range resources. As a result, the entire Province will be monitored in 1981 using this methodology.

Alberta. The objective of the Alberta Center is "to administer, coordinate and develop remote sensing for the survey and management of natural resources and environment". Functions provided are: coordination, advice, training, and facilities. It operates with a budget of about $250K and 5 staff. About $100K is available for demonstration projects. The center has been active in training, in particular through a yearly multidisciplinary course which has attracted scientist from across the country. The Centre has been involved in demonstration projects in the fields of forestry, range management, wildlife habitat and agriculture. In 1981 the Centre will acquire a digitial image analysis capability.

In Saskatchewan An Inter-agency Committee on Remote Sensing was formed to coordinate remote sensing activities. The University of Saskatchewan in Saskatoon is acquiring a digital image analysis capability.

Manitoba. The Manitoba Remote Sensing Centre (MRSC) is integrated with the provincial air photo library. The staff of 11 (5 1/2 Remote Sensing 5 1/2 Library) operate with a budget of about $224K in remote sensing. The Centre provides coordination, advice, facilities, interpretation and aerial photographic services. Its interpretation facilities include an analog image analysis system. The operation of the 70 mm supplementary aerial photography system is fully self supported. About 10,000 line miles are flown annually. Cost-recovery services related to major remote sensing projects started in 1979. They increased from $30K in that year to $110K in 1980. The Centre is involved in a wide range of demonstration projects including mapping of caribou winter range in Northern Manitoba. In cooperation with the University of Manitoba, the Centre provides discipline-oriented remote sensing training programs.

Ontario. The mandate of the Ontario Centre for Remote Sensing is to promote integration of remote sensing into resource development, environmental protection and land use management. It has a staff of 16, with an additional 18 on contract. Its budget is $1.2 million per year of which about $750K was cost recovered in 1980. The success and rapid expansion of this centre originates in the fact that all 7 functions are aggressively pursued. At an early stage, investments were made in analog and digital analysis equipment. R&D carried out by the centre resulted in a number of major cost-recovery programs, such as thermal scanning for heat loss, land use mapping from satellite and supplementary aerial photography capability, to name a few. In addition the OCRS has an in-house airborne sensing facility.

Quebec. The Quebec Centre for Remote Sensing Coordination was established in 1976 within the Department of Lands and Forests. It provides coordination and has a well-equipped interpretation facilities and image library. In cooperation with the University of Laval and the Canadian Forestry Service, a digital image analysis system was required.

In New Brunswick, Nova Scotia, P.E.I. and Newfoundland, coordination of remote sensing activities is provided through provincial remote sensing committees and/or coordinators. The Nova Scotia Land Survey Institute is operating as a remote sensing centre (supported by a Canada Works grant), provide training and is acquiring a digital image analysis system. The Maritime Resource Management Service, providing photogrametric and cartographic services, is increasing its role in remote sensing and information systems. In Newfoundland, Memorial University provides interpretation facilities. Applications development work reflects regional issues such as spruce budworm damage, agricultural land use, ocean and sea ice studies.

There is no doubt that the need for remote sensing at the provincial level is growing. Existing centres play a key catalytic role in the integration of remote sensing in the Management process, through demonstration projects, facilities, training and advice. The impressive growth in cost-recoveries in Ontario and Manitoba demonstrates the rapidly expanding market. OCRS doubled its revenues from $350K in 79-80 to about $750K in 80-81. In the same years Manitoba moved from $30K to $110K. The importance of the service role cannot be overemphasized. It allows a centre to expand facilities and expertise; encourages R&D and involves usually technology transfer. Even more important, it prepares the 'soft' market for regular services by private industry.

Concluding one can say that over the last decade remote sensing has developed well in Canada. There exists now an informed user community moving rapidly into the use of new analysis techniques. These are provincial centres and coordinating bodies to foster technology transfer, and a good and growing industrial capability. This infrastructure of agencies and capabilities should allow us to plan effectively for the future and realize the benefits of remote sensing. However, provincial investments in Remote Sensing in general have not kept pace with federal government initiatives and funding. This imbalance may have to be adjusted in the next decade to assure benefits to resource management to materialize fully.

THE NEXT DECADE

The next decade will certainly be different from the last. There will be many more satellites with improved performance. There will be a move towards commercialization of satellite systems and, therefore, increased costs. There will be increased international activity and competition, but also there will be increased opportunities. There will be international efforts to rationalize the many satellite systems in orbit and planned. It will be important for Canada to decide on and establish its position in the global scene.

Satellites

The following satellites are now planned for the 1980's:

U.S.A. -- LANDSAT D	1982
France -- SPOT	1984
Japan -- MOS-1	1985
ESA -- ERS-1	1986
Canada RADARSAT	1989-90
India	
Brazil	
China	
Indonesia and the Netherlands	

LANDSAT-D. Approval has been recieved to upgrade Canadian stations to a minimum LANDSAT-D standard. LANDSAT-D and D^1 will carry the MSS as well as the Thematic Mapper. The Thematic Mapper will have seven spectral channels and a resolution of 30 m. This compares to the four spectral channels and 80 m resolution of the MSS.

SPOT. The French SPOT satellite is of great interest to many users in Canada because of its high resolution (20 m colour and 10 m panchromatic) and because of its stereoscopic capability. The airborne multispectral scanner simulations have been conducted in Canada with both LANDSAT and SPOT data. These will be shown in a later paper in this symposium. France has established a company, SPOT IMAGE, to handle the marketing of the data from SPOT. Canada is presently holding discussions with CNES regarding a possible agreement for the read-out of SPOT data in Canada.

MOS-1. Canada is keeping in contact with Japan regarding the MOS-1 satellite and has expressed an interest in reading out the data. MOS-1 will contain a pushbroom scanner with 4 channels at a resolution of 50 m and a swathe of 100 km, a mechanical scanner operating in the visible and thermal infra-red to measure sea-surface temperature and a microwave scanning radiometer to measure water content of the atmosphere.

ESA. Canada is participating in the ESA remote sensing preparatory program which will lead to the launch of a satellite in 1986. This satellite will contain radar and is of interest to Canada for that reason. It will also contain a radar altimeter to measure wave height. A decision on whether to continue participation in the total program (at a cost of approximately $60M) must await the outcome of the Phase B studies which will start early in 1982.

RADARSAT. The Canadian RADARSAT is an interdepartmental program with EMR as lead agency. Approval has been obtained for a $17M program to do the studies and development which will allow firm options for a Canadian radar capability to be placed before Cabinet in the fall of 1982. These options include co-operation with the U.S.A., cooperation with ESA or an all-Canadian satellite. Secondary sensor options for the satellite are also being considered. In view of the uncertainties in the LANDSAT program, Canada's present vulnerability to foreign unilateral price increases, and the need for Canadian users to have a secure source of data, a sensor operating in the visible and infra-red region is one of the options being considered. One advantage of having a domestic satellite is that it would allow Canada to negotiate reciprocal agreeements with other countries for read-out rights on their satellites to augment our own coverage rather than having to pay hard cash for the data.

Other planned Satellites. India launched a satellite in 1979 using USSR facilities. This satellite (BHASKARA) carries two TV-cameras. Other satellites in the series are planned.

Brazil has made public its intention to develop a remote sensing satellite. China is planning a remote sensing satellite for launch this year. Indonesia and the Netherlands are studying a satellite with equatorial orbit.

Increased Costs. The Reagan administration has announced its intention to introduce full cost recovery and commercialization into the LANDSAT program more rapidly than had been planned by the Carter administration.

A new pricing policy will be initiated in fiscal year 1983 and no earlier than October 1, 1982. The price structure will be announced during the last half of calendar year 1981. The increase will be 2 to 5 times the fee currently charged. Fees will be re-assessed annually and may be adjusted as necessary to recover the cost of operating the LANDSAT system (but not the capital cost through LANDSAT D[1]. Only MSS is being considered for pricing now. The thematic mapper will be considered later. The initial price structure proposed for foreign ground stations consists of an annual fee which would include a fixed number of scenes to be acquired, plus a charge for each scene acquired beyond the first number. Thus, the station charges for Canada could increase from the present $250,000 to from $800,000 to $2,000,000. In addition, it is obvious that we will have to be much more selective in the coverage obtained. Blanket coverage such as we have obtained in the past will not be affordable. If this station fee was to be recovered from the sale of products, it would mean a price increase for products ranging from 3 to 7 times. In addition, France is planning to charge for access to SPOT data on a per scene basis.

It is of interest to note that COMSAT has presented to the U.S. government their EARTHSTAR plan under which they would purchase the GOES, NOAA and LANDSAT satellites and consolidate these three remote sensing programs into a single integrated commercial system. It is possible, therefore, that Canada could be paying for weather data as well as earth resource data.

It is certain, therefore, that the prices for satellite data are going to increase. In order to absorb these cost increases without disrupting the Canadian Program, we will have to have a clear picture of the Canadian needs and benefits. Also, there will have to be more federal-provincial discussion. Fortunately the infrastructure needed to address the problem on a national basis is already in place in the form of the Canadian Advisory Committee on Remote Sensing (CACRS).

International Consultation

In recognition of the need to examine ways in which the many satellite systems now being developed could be either standardized or made complementary, Canada hosted a multi-lateral meeting of space-competent nations on May 8 and 9, 1980. The meeting was attended by representatives of the U.S.A., France, Japan, ESA, India and Canada. The meeting discussed the means of improving the coordination of remote sensing satellite systems which might be beneficial to both operators and users. It was agreed that this dialogue should be continued and that regional meetings in S.E. Asia, South America and Africa sould be undertaken to bring the needs of the user states to the attention of the satellite operators in the implementation of their programs. The regional meeting for Africa, organized by Canada and France, took place in March 1981 as did the meeting for S.E. Asia, arranged by Japan and India. The meeting for Latin America, arranged by the U.S.A. is planned for late 1981 in Brazil. The second multi-lateral meeting, to be organized by EAS, will take place in France in early 1982. This meeting will allow a continuing dialogue on the complementarity of future satellite systems.

How do we Cope Technically?

Assuming that we are able to survive the future price increase, there is a problem of coping technically with all the data which could be acquired from a variety of satellites. It is evident that for monitoring purposes and to acquire data frequently enough, it would be helpful to have data from more than one satellite. However, it should also be possible to overlay the data so that it can be compared or used to obtain a better classification or analysis. The way to proceed, as has been demonstrated by the DICS product, is to geo-code the data and reference it to the National Topographic Map Series. When this is done, data from any satellite can be overlain.

It is now proposed to upgrade the stations at Prince Albert and Shoe Cove so as to be able to produce these products with fast turn-around for those environmental monitoring problems. This project, called 'MOSAICS' was recently approved by the Federal Cabinet and is described elsewhere in these proceedings by Guertin.

However, once the satellite and aircraft data is available in geo-coded form, new possibilities for analysis are opened up. Then this geo-coded image data can be combined with other geo-coded resource data. The satellite data can then be easily overlain on soil, forest, geological data bases, etc. This will make for much more effective use of the data, and in many cases, the satellite data will be useful in updating the data bases. This concept is imbedded in a project called 'TOPAS' (Terra Observation Pattern Analysis System) and approval is obtained for the first phase of this project.

How do we Cope Organizationally?

It is evident that to meet the challenges of the future, Canadians have to get their heads together. Initiatives and expenditures at federal, provincial, university and industry level have to be integrated into a cohesive national program reflecting clients needs now and in the future. Considering the long lead times involved in putting up satellites and developing specific technology, long term planning should be a key factor of cooperation.

Quite a lot is at stake! Various studies have estimated the annual benefits of satellite remote sensing to the use of our land, water and energy resources (McQuillan, 1973, 1975, 1979). The amounts vary, but tend to increase with the comprehensiveness of the study. McQuillan (personal communication) estimates total benefits of satellite remote sensing to be in the order of $200-400 million annually. In fact, if hydro carbon developments unfold as predicted this lower figure would be reached by benefits in this sector alone. Considering the annual contribution of the resource sector to the Canadian economy and the importance of resource information in decision making this figure seems realistic, if not conservative.

What is required to achieve those benefits? A Canadian satellite, RADARSAT, is planned for ocean applications. Benefit studies and provincial positions taken by IPTASC indicate that dependable land resource information is essential to resource management. A Canadian land resource satellite may be the answer or at least an expansion of the RADARSAT to include visible sensors is required.

Another essential ingredient for success is the integration of technology and information in the management process: technology transfer, integrated resource management information systems, and an effective organizational infrastructure.

An important coordinating mechanism is the Canadian Advisory Committee on Remote Sensing (CACRS). This Committee, in operation since 1972, has representation from all provinces as well as from a dozen discipline-oriented or technology working groups. CACRS has been the major guide to the national remote sensing program, particularly the federal component.

Cooperative planning and financing of major new initiatives by the federal-provincial governments and industry will be the key to the success of remote sensing in Canada. Federal and provincial governments in particular should

1) cooperate in long term and strategic planning of their respective programs;
2) develop a mechanism for cooperative financing a major new technological initiative;
3) Involve industry in the planning and implementation of new initiatives to maximize industrial benefits;
4) develop formal agreements which deal with jurisdiction, roles and interlinking respective infrastructures.

CONCLUSION

The future for remote sensing in Canada looks exciting. With our extensive water and land resources and our economic dependance on the use of those resources, we have as great a need for remote sensing from satellites as almost any country in the world. Remote sensing capabilities have developed well in Canada. A strong user community and an excellent and growing industrial capability exist.

However, more than ever, cooperation between all levels of government and industry is required to develop the successful use of remote sensing in the future. We should particularly exploit our uniqueness and needs: the combination of technological capabilities and natural resource applications.

The key thrusts of this long range strategy are:

1) Continued supply of high quality, timely data, relevant to Canadian users related to land and water resource and urban Environments.

2) Preparation for the reception and processing of data from the new generation satellites (LANDSAT-D and possibly SPOT).

3) Development of an effective infrastructure to bring remote sensing information to users through a network of data processing and analysis facilities in the provinces, federal agencies and industry.

4) Integration remote sensing information into resource management information systems through production of geo-coded data (e.g. MOSAIC) and analysis systems (e.g. TOPAS) and the

development of linkages with other provincial and federal geo-information systems.

5) Strengthen the role of the Canadian Advisory Committee on Remote Sensing to provide better input from the provinces; develop formal agreements between federal and provincial governments related to cooperative planning, organizing and financing of major new initiatives.

7) Conduct research programs for Canadian radar (ocean) and land satellites with options for participation with other countries but maintaining the option for an all-Canadian satellite.

8) Participate in the international debate regarding compatible and complementary remote sensing satellite systems with the objective of arriving at a system that will meet Canadian and world needs at an affordable price.

REFERENCES

Agriculture Canada. 1981. Strategy for the Agri-Food Sector. Federal Government Discussion Paper. Can. Dept. of Agr. Ottawa.

Canadian Forestry Service. 1981. Federal Policy on Forestry Sector. Fed. Gov't. Discussion Paper. Dept. of Environment, Can. For. Serv. Ottawa.

Environment Canada. 1981. Economic Strategy and Canada's Resources. Environmental Conservation Service, Ottawa; report prepared by DPA Consulting Ltd., Vancouver.

Harrison, J.M., L.W. Morley and A. Gregory. 1972. Planning for a Global Remote Sensing Information System. Vol. 33, Science and Technology, American Astronautical Society.

LANDSAT Ground Station Working Group. 1981. Minutes from the Third User Services/Data Management Workshop, Canberra, Australia.

McQuillan, A.K. 1973. Benefits of Remote Sensing of Sea Ice. Research report 73-3. Canada Centre for Remote Sensing, Ottawa.

____________. 1975. Benefits of Remote Sensing in Canadian Northern Resource Development. Research report 75-6AX, Canada Centre for Remote Sensing, Ottawa.

____________. 1975. The value of Remote Sensing in Canadian Frontier Petroleum Operations. Research report 75-AJ. Canada Centre for Remote Sensing, Ottawa.

McQuillan, A.K. and W.M. Strome. 1979. An Evaluation of LANDSAT-D for Canadian Applications. Proc. 13th International Symposium on Remote Sensing of Environment. Ann Arbor, Mich.

Task Force on Land-Use Policy, 1980. Land Use in Canada. Lands Directorate, Environment Canada, Ottawa.

Thie, J. 1981. The role of Provincial Remote Sensing Centres/Organizations. Discussion Paper presented to Canadian Advisory Committee on Remote Sensing.