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SUMMARY

Since the last Congress in 1988 there has been an increase in activities in the field of photogrammetry and remote sensing in Canada. One need only mention the new efforts in global change research initiatives to appreciate the scope of these new developments. This report highlights some of Canada's activities and achievements over the period since the last Congress. Other activities in Canada have also been reported directly through the general Commission.

The last four years have seen continuing growth in the Commission IV subject area. The differences between automated cartography and spatial database concepts are more widely, and better, understood. Spatial data distribution standards are under continuing improvement, and interim standards are frequently used.

Topographic map compilation is almost entirely digital with stereo-compilation on encoded analogue equipment and on 34 analytical stereo plotters. Digital elevation model techniques produce interpolated contours. Over 1.2 million square kilometres of digital topographic mapping has been photogrammetrically compiled by various government agencies since 1988. Digital orthophoto is being combined with vector files and viewed on low-cost workstations.

Topologically-structured information prepared from cartographic files is being used in geographic information systems (GIS) by a rapidly growing group of GIS users. Updating the spatial data continues to attract funding. Remote sensing both by satellite and airborne scanners is being used for update purposes. Developments include testing geometric correction of MEIS and SAR imagery, integration of GPS positioning with inertial navigation and scanning sensors, software extensions for the digital video plotter to cope with SPOT data, and investigation and prototyping of object-oriented database structures.

The Working Group on Digital and Real-Time Close-Range Photogrammetry's most important activity during this period was organizing a successful international conference on Industrial Vision Metrology in July 1991 in Winnipeg, the result of which was an SPIE proceeding, Vol. 1526. This report describes the terms of reference and the objectives of the Working Group, the Canadian activities, and the Winnipeg conference.

Canada has played a central role in Commission VII during the 1988-1992 timeframe. Through its ISPRS member society, the Canadian Institute for Surveying and Mapping, Canada has been honoured with the responsibility for Commission VII, under the leadership of Mr. Frank Hegyi, President of Ferihill Technologies Ltd. of Victoria, British Columbia.

Canada's contributions in the field of image interpretation have continued to grow over the period since the last Congress. The contributions have been marked by a growing spirit of international co-operation. A number of partnerships have been formed with groups, both public and private, around the world on all continents.

PART I – COMMISSION IV: CARTOGRAPHIC AND DATA BANK APPLICATIONS FOR PHOTOGRAMMETRY AND REMOTE SENSING

The period since March 1988 has been one of continuing growth in the application of photogrammetry and remote sensing technologies to cartographic mapping activities. Database design and implementation have advanced significantly and the differences between automated cartography and spatial database concepts are more widely and better understood. Spatial data distribution standards are now a matter of ongoing design and enhancement by the Canadian General Standards Board and an interim exchange format is in everyday use.

Topographic map compilation is almost entirely digital with stereo-compilation being performed not only on encoded analogue equipment, but also on 34 analytical stereo-plotters – an increase from the 22 devices reported in 1988. Digital elevation model data collection by spot heights and breaklines during the photogrammetric compilation stage continues to be specified by many government mapping agencies. Contours are then interpolated. Over 1.2 million square kilometres of digital topographic mapping has been photogrammetrically compiled at 1:20 000 or 1:50 000 by the provincial and federal mapping agencies since 1988.

Orthophoto mapping continues to be used for a variety of urban and rural applications, and the last year has seen great interest in digital orthophoto production from scanned aerial photography. Given the large quantity of digital vector mapping compiled for

topographic and natural resource purposes, there is an opportunity to combine the raster orthophoto imagery. Not only mapping agencies but end users are now viewing the combined images on new, lower cost workstations.

The rapid increase in the use of geographic information systems has caused large quantities of digital mapping data to be used for analysis and reporting after combination with attribute data. The photogrammetric service industry has extended its service capability to include the preparation of topologically-structured data files for easier use in GIS applications.

Updating the large quantity of digital mapping data is receiving increased budgetary attention, and remote sensing methods continue to be extended. Satellite and airborne scanner imagery is used. Software and hardware solutions have been developed and reported upon by Canadian companies and government agencies.

A recent development for Energy, Mines and Resources Canada enables the use of SPOT satellite imagery and conventional aerial photography in a new workstation employing image correction and feature extraction to update topographic databases. An object-oriented database handles images and vector data. Experimental image mapping from a variety of sensor imagery is under evaluation.

Other developments at Energy, Mines and Resources Canada include the following:

- Co-operation between the Canada Centre for Remote Sensing (CCRS) and the Canada Centre for Geomatics is addressing the need to produce precise ortho images at 1:50 000 by the development of robust production procedures and software for the correction of all relevant geometric distortions.

- Multi-stereoscopy using SPOT imagery allows the use of more than one pair of images for the improvement of the mapping results by 10-15%. Work continues in extending the solution to include MOS, SEASAT and other satellite and airborne sensors.

- The SPOT Digital Video Plotter (SPOT-DVP) extension undertaken by Laval University, CCRS and the Canada Centre for Geomatics is producing a prototype system on a 386 personal computer together with superimposed vector data. A split-screen display provides a stereo image by using a simple viewing mirror assembly.

- Considerable effort has improved the process for the complex geometric correction of digital airborne imagery from MEIS and SAR. The objective is to produce a system which combines high geometric accuracy and strong spectral differentiation. MEIS, GPS and inertial navigation equipment have recently been integrated and initial results are promising.

- Work continues on shape from shading using SAR data and also on interferometric SAR using two antennae.

Various database structures have been investigated, including object-oriented solutions. These have been successfully prototyped for particular applications. On-line spatial data distribution solutions are under development to meet the rapid response requirements expected by GIS customers in the next five years.

PART II – REPORT ON ISPRS WORKING GROUP V/1

Working Group V/1 on Digital and Real-time Photogrammetry was originally established in 1984 to investigate the use of the all-digital photogrammetry in close-range applications and machine vision. Since then, the interest in this working group has grown so rapidly that its topic has been extended to five new working groups in Commission V for the 1988-1992 period. For this period the terms of reference were:

- Real-time vision systems for metric measurement.
- Near-real-time, but fully automated, vision systems with relaxed time constraints.
- System hardware and software integration.
- Demonstration of real-time and near-real-time systems in actual application environments.

The Working Group, co-chaired by S. El-Hakim (National Research Council of Canada) and K.Wong (University of Illinois) has over sixty active members from all over the world. Canadian activities were mainly at the National Research Council, the Canadian Space Agency, Laval University, University of Calgary, and several private industries such as the aerospace and the auto industry. At the National Research Council, a complete system named VCM (vision co-ordinate measurement) has been developed and released this year. It is now being used for several projects with industry and also in medical applications. At the Space Agency, the SVS (space vision system) has been undergoing development for over a decade. The system will be tested by Canadian astronaut Steve MacLean on a space shuttle mission in September 1992. Other systems are now being developed at Laval and Calgary Universities for specific applications in co-operation with industry. Private Canadian industries have also been active during the past four years. Standard Aero Ltd., Bristol Aerospace, Vision Research Engineering Group, Otto Bock Orthopedic Ltd., SAMI Inc., Imago Corp., Dominis Engineering, to name just a few, have at least conducted significant research and development to implement real-time photogrammetry for their various applications.

In July 1991, the Working Group organized a conference for its members at the City of Winnipeg. Over forty participants attended the conference from eight countries, including 21 from Canada. Eighteen papers were presented over two days, including six from Canada. The papers were printed as SPIE (the international society for optical engineers) Proceedings Vol. 1526 (212 pages). Plenty of time was allowed for the presentations and the discussion of issues, and it proved that that there are still many outstanding problems which require solutions before real-time photogrammetry is widely applicable. Some of these problems are: the complete automation, robustness, and flexibility; the edge definition and measurement; the consistent and high accuracy in a practical industrial environment; and the availability of a practical, fast and precise calibration procedure. In spite of these problems, many successes have been reported, particularly due to the advances in hardware and the development of application-specific systems rather than general purpose systems.

To conclude, it is important to note that over the past several years, Canada has been a world leader in real-time photogrammetry, both in research and industrial applications.

PART III – REPORT ON CANADIAN ACTIVITIES RELEVANT TO COMMISSION VII

Introduction

With the breadth and depth of effort, trying to summarize Canada's remote sensing activities related to image interpretation is now virtually impossible. The balance of this report attempts to place the work in Canada related to Commission VII in the appropriate context, reporting on the dominant trends, Commission VII activities, the Canadian setting for image interpretation activities, and research and publishing activities.

Dominant Trends

As reported to the ISPRS in 1988 by Dr. S. Pala, remote sensing in Canada has continued to move from the research and development stage to the operational stage. This has been facilitated by a broader penetration of geographic information systems (GIS) into the resource management field and stronger programs in data marketing, technology transfer and industrial development.

Current research and development focuses on applications of C-band radar in preparation for RADARSAT, information extraction using as tools expert systems and information integration through GIS. Also central to Canadian efforts has been spectroscopy and image corrections (both geometric and radiometric). In addition, monitoring of large-scale phenomena is being planned as part of Canada's contribution to global environmental monitoring. Of particular importance in this regard is the close attention being paid to calibration and image corrections appropriate for NOAA and other data sources whose nature is not always properly considered in large-scale monitoring.

Technology transfer and training activities continue to focus on bringing remote sensing to users in Canada and overseas. Much of the activity within Canada in this area is being done at the provincial level by remote sensing centres, academic institutions, centres of excellence, and, increasingly, by the private sector. At the national level, a program to better assist the Canadian International Development Agency (CIDA) in using remote sensing is now in place through a Memorandum of Understanding between the Canada Centre for Remote Sensing (CCRS) and CIDA. This has already strengthened Canada's ability to deliver effective international programs. Other activities of note include the Global Change Encyclopedia (Geoscope) headed by Canada, and Canada's significant support to the Third Edition of the Manual of Remote Sensing by providing the Editor-in-Chief.

Commission VII International Activities in Canada

Canada, through its ISPRS member society, the Canadian Institute of Surveying and Mapping, has been given the responsibility for Commission VII under the leadership of Mr. Frank Hegyi, President of Ferihill Technologies Ltd. of Victoria, British Columbia.

In 1990 Canada hosted the mid-term symposium on Global and Environmental Monitoring in Victoria attended by some 400 specialists from around the world. Two publications are the result. One is the 912-page symposium proceedings published as the International Archives of Photogrammetry and Remote Sensing, Vol 28, Part 7-1. The second (currently being produced by the University of Waterloo) relates remote sensing to global monitoring from a Canadian perspective, encompassing invited papers from a number of leaders in remote sensing in Canada.

The various working groups of the Commission have been busy, with Canadians leading several of these and contributing to the others. The spirit of international co-operation has marked the activities of all of the Commission VII working groups. This is something in which the world-wide ISPRS community should take pride. We in Canada have been honoured to have been active participants with our scientific colleagues from all continents. We are particularly pleased with the growing involvement of participants from regions and countries which have not been traditionally active in Commission VII. We hope that this is a trend which will continue to increase during the next four years. The regional seminar and reporting work by Working Group 6, headed by Dr. Bruce Forster of Australia, has been a particularly useful model which should be encouraged in the future.

The Canadian Setting for Image Interpretation

Over the reporting period Canada's remote sensing activities related to image interpretation have continued to grow, even in the face of the economic uncertainty of the last two years. This is in part the case because of a concentration on exports and international activities by an efficient industry and in part because GIS/RS linkages have been maturing at a rate only a few of us would have predicted a few years ago.

There are now over 120 private and public companies involved in the field in one capacity or another. They range from large multinational companies to small one- or two-person consultancies (For a detailed summary, see Ryerson, 1991). Four universities offer Ph.D. degrees with specialization in the field, while another twenty offer extensive programs at the masters level or senior undergraduate level. As well, over twenty government laboratories are involved in a large, generally well co-ordinated research, development and technology transfer program in remote sensing. Current estimates place as many as 3000 private-sector employees working in the field, with as much as 50-70% of all activity being exported or done overseas. A recent review of the general organizational framework and situation of remote sensing in Canada has been published elsewhere (Ryerson, 1991). That work summarizes the reasons for Canada's success, the government agencies involved, the work in academe, the role of industry, and the focus of industry's activity.

Research and Publishing Activities

According to estimates prepared by the CCRS RESORS System, Canadians have published one contribution per working day from 1988 to the present – a total of over 1000 papers. It is obviously impossible to summarize the range and depth of that work in any substantive way for this report. The balance of this section outlines the type of work being done and the focus within the topical areas dealt with by each of the seven Commission VII working groups and the Inter-Commission Working Group.

An analysis of the papers published shows that in four major applications-oriented journals, Remote Sensing of Environment, International Journal of Remote Sensing, Photogrammetric Engineering and Remote Sensing, and the Canadian Journal of Remote Sensing, approximately 100 papers have been published by Canadian researchers. These have covered all of the major areas of interest of Commission VII. In addition, many more papers have been published in a range of journals which are more related to technology issues involving spatial information extraction and expert systems.

Over the past four years two major changes have occurred in Canada in terms of publishing. First, the Canadian Remote Sensing symposia have been changed from being a refereed symposium every eighteen months with delayed publication of proceedings to being an annual symposium contributing to the so-called unrefereed grey literature produced for distribution at the time of the symposium. This has all happened at the request of the Canada Centre for Remote Sensing which has asked that the symposia be held annually to facilitate the networking considered to be important for the continued co-ordination of the activities of, particularly, the research community as it interacts with industry.

In an effort to broaden the base for the dissemination of high-quality papers and to replace the refereed symposia, the Canadian Journal of Remote Sensing has moved from a twice-yearly publication to a quarterly publication. With more issues the Journal can now feature special issues and more international work.

Canadian Activities Relevant to Commission VII Working Groups

With over 120 companies, twenty universities, twenty government laboratories and one paper a day being published, it is impossible to do justice to the program in Canada in remote sensing in such a small space. What follows is intended to give an overview. Those seeking more information are urged to contact the author or RESORS at CCRS.

Working Group 1 concerns itself with Physical Measurements and Signatures in Remote Sensing. An active research program in these areas has involved both visible and IR as well as radar in Canada. Considerable attention has been paid to the proper understanding and calibration of sensors – both airborne and spaceborne. Laboratories across Canada from universities and government have been involved.

Working Group 2, chaired by Dr. Pamela Salloway, President of PAMAP Technologies of Canada, covers Spatial Information Extraction and Manipulation. This area has been a key one in the general advancement of the application of image interpretation in Canada and elsewhere. Considerable effort has been invested by governments, universities and the private sector. This has culminated in companies and products which barely existed at the time of the last ISPRS Congress. A central focus of the work in Canada has been on the effective integration of imagery into the GIS environment to provide both updates of the GIS and a background for vector and thematic information. New products and services have already resulted from the research effort in this domain.

Working Group 3 covers Renewable Resources, such as forestry and agriculture. These have been central areas of activity in both research and in the development of operational applications. Over the past four years the central focus of much of the federal research in these areas has been on radar applications in preparation for Canada's own RADARSAT planned for launch in the 1994/95 timeframe. Activities in the provinces have included work preparatory for radar as well as the continuation of the application of other airborne and spaceborne sensors to inventory and monitoring. A particularly noteworthy activity is headed by the Province of Quebec and industry in a project called PROGERT. The project is aimed at developing a high-resolution, solid-state airborne sensor with a 6000 pixel swath for forestry applications – notably for disease and vegetation stress.

Working Group 4 deals with Non-Renewable Resources. As with Working Group 3, much of the work in this area has involved the use of radar. In this case, however, there has been special emphasis on the integration of geophysical data with radar for mineral exploration. As well, there is considerable work done within the area of oil exploration. As a result of the nature of the work, however, very little is published related to the use of remote sensing within the oil and mineral exploration private sector. An ERIM Specialty Symposium related to these areas was held in Calgary within the reporting period.

Working Group 5 deals with Water and Atmospheric Remote Sensing. The atmospheric and ice-related work is centred within the federal government's Atmospheric Environment Service, with co-ordinated work being done within CCRS and the university community as well. Work on remote sensing related to water quality and ocean and lake dynamics has long been a focus of the federal departments of Fisheries and Oceans and Environment, with scientific support in some areas related to the oceans and hydrology being supplied by CCRS. Preparatory work for radar imagery from satellites has been a focus of much of the research. Private sector capabilities in airborne radar have become the basis of a significant part of the operational ice monitoring off the coast of eastern Canada. In hydrology work has looked at areas as diverse as flood mapping with radar, and modelling water equivalent of snowpacks with radar and other imagery.

Working Group 6, dealing with Human Settlements, has had similar problems to those working in this domain elsewhere. The area has not been as well funded as the other areas, although significant work has resulted. Methods have been developed to monitor and map land use changes using satellite imagery from both SPOT and TM, and work has begun on assessing the usefulness of ERS-1 radar imagery for urban studies.

Working Group 7 is chaired by Dr. David Goodenough, Chief Scientist of CCRS (currently seconded to Forestry Canada). Work in this area has been done within CCRS co-ordinated with a number of other laboratories across Canada. The current major effort is to develop a new generation of system which can take advantage of the concepts of expert systems while also using geographic information to improve image interpretation. Contracts for a prototype system have been let to Canadian industry.

An Inter-Commission Working Group on Global Monitoring is chaired by Dr. Leo Sayn-Wittgenstein, Director General of CCRS. In this area Canada has been active in several projects involving the developing of a better understanding of the boreal forest and frozen environments and their role in global processes. As well, Canada is leading an international effort to develop a global change encyclopedia which will provide on a CD-ROM a compendium of information on the global environmental situation, much of it derived from space observations.

Reference:

Ryerson, R.A., 1991. Remote Sensing in Canada. GEOCARTO International, 6(3):79-83.