Geomatics In Canada : Industry Overview

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Robert J. Batterham

President, Management Consulting In Geomatics Inc.
65 Rosemere Avenue, Ottawa, Ontario K1S 1A5
Tel: (613) 236-5533 Fax: (613) 236-4604

Introduction

This report is written as a guide for outside observers to the geomatics industry. The term 'geomatics' has been widely adopted in Canada, in the last ten years, as a result of a concerted effort of the Federal Government's former Surveys, Mapping and Remote Sensing Sector (now Geomatics Canada) and various other Canadian agencies and organizations which have found a need to concisely and accurately identify their fields of endeavour. It is a term that, if not frequently used, is at least well understood in the 'spatial data' community around the world.

While there is a variety of quite precise definitions for geomatics in current use, I will simply use it as a generic term to cover the disciplines of surveying (geodetic, cadastral, engineering and marine); mapping (photogrammetry, cartography and charting); remote sensing (data acquisition and application); geographic information systems (G.I.S.); and the related land information systems. It is worthy of note that a G.I.S. may be considered a tool for the analysis of land related information as well as a sub-component of the technology, automated mapping and facilities management (AM/FM). Unfortunately it is frequently used as an all encompassing term for geomatics. Another term that is rapidly becoming familiar outside of the geomatics community is 'global positioning system' or G.P.S. This is an integral component of geodetic surveying and a major contributor of data to geographic information systems.

Practitioners in the geomatics industry include service providers, hardware and software manufacturers, systems integrators, technical and management consultants and, in ever increasing numbers, former clients of the industry - the users.

Summarized Findings

Changing Nature of the Industry

The industry was born out of two significant events. One, quite well defined in terms of time and the other, a demographic continuum. The aerial survey industry developed after the Second World War when a small number of returning flyers, wishing to continue their careers in a less dramatic environment, started or joined, flying companies that specialized in the acquisition of aerial photography with precise metric cameras. Add to this the emigration of highly qualified photogrammetrists and cartographers from Europe and we had, in the fifties, sixties and early seventies, an industry that had no equal in the world. Further, the Federal Government determined a principle national need to be the establishment of complete and accurate map coverage of the country. A technical capability was matched with a large natural market.

Since then, dramatic changes have taken place with the advent of satellite and airborne remote sensing, computer-aided mapping and satellite positioning systems. Recent developments in

technology, which have had an immeasurable impact, include the explosive increase in power of the desktop computer, the abundance of sophisticated off-the-shelf software, the launching of global positioning (G.P.S.) satellites, sufficient in numbers to give 24-hour access, and many other niche technologies, allowing the creation of highly refined products and services.

The two most dramatic changes taking place today in the industry are primarily in response to new markets being opened up and former clients becoming an integral part of the industry itself. These erstwhile clients of the traditional geomatics industry are becoming so well versed in the business, courtesy of the new technologies and decreased cost in the entry level, that they can now be counted as part of the industry. These changes are facilitated by the breathtaking speed by which software and hardware is becoming available to developers and users alike.

New Players

A brief glance through the 1991-92 International G.I.S. Source Book will show over 1,000 suppliers of G.I.S. related products and services, primarily in North America. The 1996 Canadian Geographical Information Systems Source Book lists 253 companies in the 'G.I.S. related industry.' The Geomatics Industry Association of Canada has some one hundred members compared to eleven in the early days of the Canadian Association of Aerial Surveyors. The growth of the industry has been as dramatic as the growth in power of the desktop computer.

In recent years we have seen the entry into the industry of companies providing geomatics services that are oriented to applications such as forestry, environmental issues, agriculture, utilities, municipal planning and systems consulting. We can also now boast of aerospace companies providing products and services related to satellite imagery, its acquisition, downloading and dissemination.

Large multinational companies, such as SNC Lavalin, AGRA-Monenco,Tecsult, SPAR Aerospace, MacDonald Dettwiler and Hughes Aircraft of Canada have divisions generally devoted to geomatics and sometimes specifically to G.I.S. Management consulting firms, such as Price Waterhouse and the systems oriented DMR Group, routinely provide G.I.S. consulting. Public utilities and former crown corporations, such as Ontario Hydro, Hydro Québec, Canadian National and Canada Post, in setting up their own in-house G.I.S. departments also market their expertise elsewhere. Resource companies, particularly in the forestry sector, frequently acquire geomatics expertise as well as contract out for specific services.

Within the core industry itself, a number of dynamic companies have entered the industry, of which Geomatics International and Terrain Resources are prime examples, by approaching geomatics services from the applications side. They employ resource and information technology experts, and use G.I.S. as a tool in the delivery of services. They are consequently becoming major providers of G.I.S. consulting and training services.

Terrain Resources of Lethbridge, Alberta, has developed a model for applying geomatics technology that allows clients, involved in natural resource management and the environment, to

benefit in a broader fashion from geomatics in their day-to-day business needs. This model has resulted in significant sustained growth over the past five years, seeing offices open in Ontario, the United States, and New Zealand. More than 70% of sales are export.

Geomatics International has grown and thrived by applying geomatics tools, primarily G.I.S., to serve client needs in the resource sectors. All its geomatics expertise has been built around core expertise such as forestry, environmental, planning, training, education and, more recently, business geographics. Growth has been rapid with a wide network of offices being established across Canada, in the United States, the United Kingdom and Germany.

Once-small land survey companies, of perhaps no more than nine or ten employees, are growing at impressive rates as they embrace the new positioning technologies (G.P.S.) and G.I.S. The technology has elevated them into an entirely new marketplace.

Changes in Structure

While new companies have arrived on the scene (and some have departed) there has also been a period recently of structural change to some of the major players. McElhanney Geosurveys, once a principle provider of traditional mapping services, has withdrawn from this field of endeavour in favour of concentrating on geophysical surveying. MacDonald Dettwiler (MDA) of Vancouver merged with Orbital Sciences Corp. of Virginia in late 1995. MDA is the world's leading supplier of commercial remote sensing ground stations. Orbital is a space technology company that designs, manufactures and operates a broad range of space products and satellite-based services. Last year these companies reported earnings of $110 million and $222 million respectively.

Intera Information Technologies has been divesting itself of various divisions. The Tydac Spans G.I.S. Division was sold to PCI and the Geographic Services Division is in the process, after being courted by a number of large companies, of becoming a publicly traded company on the Alberta Stock Exchange. The new company will be called Intermap Technologies Ltd. Through a wholly owned subsidiary, Intermap Technologies Inc., located in Denver, it will acquire, from the Environmental Research Institute of Michigan (ERIM), the rights to commercially exploit the Synthetic Aperture Radar for Elevation System (IFSARE System).

SSiG Holdings Limited was founded in 1994 by Bergecap and COM DEV International Ltd. to exploit emerging opportunities in the earth observation and geomatics marketplaces, both in Canada and worldwide. In 1995 BCE Capital Inc. and SNC Lavalin Inc. took equity positions in the company, thereby establishing one of the most significant corporate interests in the geomatics community in recent years. SSiG's innovative approach includes the acquisition, in whole or in part, of leading geomatics companies and the creation of strategic alliances with research and development establishments, in order to form the critical mass needed to execute national and international projects on a scale likely unattainable by any single company in the industry.

The Company conducts its business through wholly owned subsidiaries in the geomatics service sector. Amongst them are Photosur Géomat International, Geomatics International, an

oceanography space technology provider - Satlantic and an earth observation data acquisition company - IOSAT. Emphasis is placed, not only on data acquisition, but on the rapidly expanding market value-added services. SSiG's plan of action focuses on: strategic alliances with major interests in the space industry and with data providers and users; securing financing for major projects related to earth observation; and the participation in research and development with government, academia and commercial space research centres. It is the stated intent of the company to build the organization to a level where it can generate sufficient revenues and profits to justify participation and investment in space system infrastructure projects such as Radarsat II and new airborne remote sensing platforms. The various commercial segments of the recently renamed SSiG Group Inc. can be broadly categorized into two principle domains - 'geomatics systems' and 'earth observation value-added services'. These encompass the business sectors of environment; agriculture; forestry; mining; energy; oceans and atmosphere; land management; utilities; defence; and business geographics.

Strategic Alliances

In the last five years significant movement towards innovative strategic alliances has taken place. Traditionally, as in most industries, these alliances have occurred when two or more companies, with compatible or even competitive capabilities, have colluded to address international opportunities or large national projects. More recently we have seen alliances between different governments (LRIS in the Maritime provinces), between provincial governments and the private sector (examples include Québec, Ontario and B.C.) and between the Federal Government and the private sector (Geomatics Canada and a number of private sector consortia).

One of the more successful alliances is the Corporate joint venture between the B.C. surveys and mapping industry, B.C. Trade and the B.C. Ministry of Environment, Lands and Parks. Together they have formed a company, International Geomatics Services (IGS), to market the industry's expertise overseas. This private sector expertise is supplemented, on a partial cost recovery basis, by government employees with specialized knowledge in those activities usually falling within the public domain. Specifically these would include land titles, geomatics policy and programme administration. To date a number of international projects have been completed and the group is becoming increasingly active overseas. One notable project involved 14 of IGS's 20 companies in surveying a proposed 460 km natural gas pipeline from western Argentina to Santiago, Chile.

Another alliance that has been formalized in corporate terms is NovaLIS, the former Atlantic LRMI (Land Records Management Infrastructure) in Nova Scotia. This is a joint venture company consisting of the Eastern Group of Halifax, Geoplan Consultants of Fredericton and Alex Miller and Associates of Toronto. NovaLIS has, in turn, entered into partnership with the Government of Nova Scotia, selected municipalities and regional planning commissions to develop a land information management programme that will complete the development of primary databases and implement a multifunction land records management system province-wide.

In the mid-1990's a consortium consisting of SNC Lavalin, Intera Information Technologies, LaserScan International and Geomatics Canada successfully undertook a $20 million project in

Mexico. This was the first example, in the geomatics sector, of the Federal Government partnering with Canadian industry on a successful international project of this magnitude. Since then there has been a number of public/private sector consortia of convenience. Currently one such consortium with Terra Surveys is executing a digital mapping project in Saudi Arabia. It should be noted that there have been a number of less than successful attempts to address international opportunities, namely a five year odyssey with the Saudi Ministry of Defense and Aviation and a costly courting of the Bangkok Metropolitan Authority.

Current Federal/industry initiatives in the area of international business include the formation of an Export Business Network through the GIAC Export Group. At its December '96 meeting, the Group decided to proceed with the next step towards establishing the network, provisionally called 'GeoCan International'. This will involve the creation of a network hub, an inventory of member core competencies, the investigation of comparable networks and the identification of a specific contract opportunity as a test case.

In 1994 a Cabinet Minute of the Province of Ontario directed that an industry strategy be jointly developed by the Province and the geomatics industry. The Ministry of Economic Development and Trade and the Geomatics Industry Association of Canada co-ordinated the development of the strategy. The purpose was "to create a blueprint for improving the competitiveness of the Ontario geomatics industry....and to build a meaningful partnership with the Ontario Government..." After a delay with the change in government, the strategy is now being implemented and a steering committee, comprising four members of the provincial government and four senior industry representatives, has been formed. There is now opportunity to move this strategy forward quickly and significantly. The Ontario Ministry of Natural Resources (OMNR) has suggested the submission of a joint government/industry proposal for funding the development of the common spatial data infrastructure for the Province of Ontario. In principle, this will include conversion of existing data to common standards, collection of new data in strategically important areas, and development of single-window access to provincial land and resource data holdings. Involvement of the private sector could include contract activity related to data collection/conversion, participation in a private/public sector partnership to operate the data access mechanism, and potential downstream value-added business opportunities resulting from much more convenient access to government data. OMNR has consulted extensively within government to determine support for such a submission, and has received a favourable response. A proposal could be prepared in the 1996/97 fiscal year with an expected funding request of up to $50 million. If the proposal is approved, project implementation will include eventual calls for proposals to establish a government/industry partnership to provide access to government-wide land and resource data holdings.

Industry Boundaries

Long gone are the days when the industry was an easily identifiable and definable entity. The companies that comprise the industry have such varying degrees of involvement in geomatics that it is sometimes difficult to accurately define their interest. Depending upon the attribution of importance attached to geomatics within an organization, one can delimit the industry's

boundaries around 200 companies or 2,000 companies. Governments variously describe the geomatics companies under engineering, informatics, aerospace or professional services. The industry is fast approaching a size that could see geomatics as a definable entity for the purpose of statistics gathering. Currently it is very difficult to quantify sales, revenues, exports, size of workforce and market potential. Consequently anyone courageous enough to do so tends to become an instant 'guru' and is oft-quoted until the figures are revised by someone of equal courage.

Economic Environment

During the last five years, Canada's economy in general has been reflected in the geomatics industry, with one notable exception - British Columbia. The industry there has grown significantly based on the resource sector and the Provincial Government's digital basemapping programme.

What has struck home to me is the difference in the pace of growth in the industry in the U.S.A., which has seen considerably more spending on infrastructure renewal than here in Canada. Consequently the favourable comparison to the U.S.A. that the Canadian geomatics industry received ten years ago no longer exists when applied today to technology or its application. A mitigating factor for Canadian industry is its capacity and capability to market its services overseas. Canadian technology and companies are very well received and this fact accounts for a net growth in revenues from overseas projects.

Market statistics are selective and sporadic, and frequently unsupported by verifiable data, but I have yet to find past long-term projections that have not fallen short of the eventual outcome. Indeed, there are local and regional economic recessions that affect in the worst way the reputations of those who would gaze into the crystal ball in search of good news for the industry. But at the national and international levels, and when taken over periods of time not necessarily exceeding even five years, the growth of the geomatics market has been singularly impressive.

A 1996 feasibility study prepared by Golder Associates shows the world market for digital mapping and related services to be $4.3 billion annually. PlanGraphics estimates an annual demand for topographic mapping to be over $500 million. In 1994 Daratech reported that Canada and the U.S.A. accounted for 43%, Europe 31% and the Far East 15% of the worldwide geomatics market. In 1993 Industry Canada estimated the Latin American market to be between $650 million and $1.5 billion for the five year period between 1993 and 1998.

The image processing and remote sensing market is approaching $130 million in annual sales of data and is growing by up to 30% per year. SPOT Image reported worldwide revenues for 1994 of $55 million, 22% higher than for 1993. The U.S. Department of Commerce predicts that by the year 2000 the annual market for satellite imagery will grow to $2.6 billion - this from just over $500 million in 1994. The significance of these figures is that they represent sales of data. To the geomatics industry and its clients the significance is in the added value of economic activity based on those data. KPMG, in its MAPSAT Market Review of 1992, states that the minimum ratio of

raw data to added value is 1:3 and can go as high as 1:15 in high-value markets. In that same report KPMG calculates a possible value-added market of between $700 million to $960 million by the turn of the century. What do all these figures mean? Well, only time will attest to their accuracy, but they exceed, by many times, the projections of ten to twenty years ago. This is principally due to our changing understanding of the business we are in and its role in society. The technology, which initially drove the expansion of the market, now simply facilitates its growth.

Overview of Technology - Direct and Associated

Operating Systems - UNIX, Windows, NT

To date the single most important factor in the development of software has been the operating system of the workstation computer. UNIX is ubiquitous in this arena but increasingly, software is being ported to, or written for, DOS and Windows as desktop computers become more powerful. Some is even available on the Macintosh platform. Limiting factors have traditionally been processing and data transfer speeds, storage capacity and type of media, video capability and, of course, price. As the operating systems of these desktop computers improve or change (Windows 95 and NT for PC's and Mac OS 8 for Macintosh) and the possibility of a convergence of workstation and desktop platforms, one can only feel confident of the pace of development of ever-increasingly sophisticated software being within reach of the most modest budgets.

The Internet

The most dramatic technological development of the late 1990's is the Internet. This has the potential for radically changing the means of delivery of geomatics products and services. Twenty years ago a final map product would be delivered in the form of a paper or mylar map without a digital file (even if the data had been gathered using computers). Ten years ago the same product would have been a by-product or proof of a digital file that would have been delivered on a nine-track magnetic tape. Today that same product can be sent to a client via a direct telephone line or via the Internet. The client itself may be the first to produce a hardcopy plot and then only after manipulating the data.

One of the more successful initiatives to come out of Geomatics Canada in the last two years is the development of the National Atlas Information Service (the National Atlas was its conventional forerunner) and its establishment on the Internet as a web site. This is the first of a series of geographic and topographic databases to be made accessible via the Internet over the next few years. More and more we are seeing web sites dedicated to geomatics companies, public agencies, products and services. Web sites are frequently the first source of information leading to commercial transactions between companies and clients. Deliveries of digital geographic data are routinely made to clients via the Internet. All of this activity now takes place because of an enabling technology and despite its lack of high capacity infrastructure.

Market Sub-Sectors, Products/Services

Positioning Technology

One of the market areas that is seeing dramatic growth is that which is served by global positioning systems. Positioning technology (a phrase that frequently replaces geodetic surveying) generically describes global positioning systems (G.P.S.). The advent of this technology was characterized some fifteen years ago by geodetic surveyors in some remote corner of the earth waiting for two or three satellites to be in position to determine a ground co-ordinate. Frequently the window of opportunity was only open for one or two hours per day. The equipment was very expensive and bulky. Like computers, today the hardware is portable and even hand-held. Units can cost a few thousand dollars and, due to the size of the 'constellation' of satellites, observations can be taken 24 hours each day anywhere around the globe.

For this author the reality of the technology and its impact on everyday life was driven home just three years ago when I read, in an Air Canada in-flight magazine, an advertisement for a Panasonic hand-held G.P.S. receiver, targeting those who like the outdoor life, priced at a little over $1,000. Now one can purchase a receiver for $299.99 (batteries included) at Canadian Tire!

Today we see similar but more precise systems being used in:

- vehicle navigation (dispatch and tracking);
- aircraft and marine navigation;
- satellite navigation;
- agricultural applications such as crop spraying (both by aircraft and tractor);
- forestry applications;
- aerial photography acquisition; and
- emergency services (police, fire and ambulance).

I wish to highlight two products that have come to my attention during the preparation of this report.

G.P.S. Database

The first is from IDI (Intelligent Databases International). It is a database fully describing over 280 automatic vehicle location and navigation (AVLN) systems developed around the world. It is the only database of its kind and provides information on approximately 85% of all known products related to AVLN. It contains the following:

- colour schematics showing the characteristics of each system;
- company and contact names, addresses, telephone and fax numbers;
- target markets, applications and costs;
- positioning sensors: G.P.S., dead reckoning, Loran C, RDSS, cellular and FM based;

- digital map types: Etak, Navtech, geographic data file, Japanese DRMap; and
- communications: UHF/VHF, cellular geostationary/LEO satellite.

Clients include component manufacturers, consumers, consultants, educational institutions, AVLN systems providers and the military community.

GISMObile

From NovAtel Communications Ltd. of Calgary, Alberta, comes an array of G.P.S. products that include antennas, G.P.S. cards for desktop computers, software interfaces for Windows and GISMO™.

GISMO stands for 'G.I.S. mobile' software and is considered by industry observers to be a fast-rising G.P.S. star. It captures co-ordinates with sub-metre accuracy for data entry into a geographic information system. It allows the user to collect, display and combine geo-referenced attribute data with both vector and raster files. Its applications include any task that requires accurate tracking of features on the ground for utilities, urban and municipal data, oil and gas sector, agriculture, the environment and natural resources. It can be installed in a vehicle; a farm tractor for accurate coverage of crop sprays; an aircraft for air photo navigation and camera control; and hand-held for tracing physical features on the ground. Traditionally, in order to populate a geo-referenced database, data has been manually digitized or scanned from conventional products such as maps, plans and charts. Those data where the co-ordinates are known, such as on legal plans, and some linear features, such as pipelines, have simply been keyed in. Now co-ordinates can be collected directly from the field and, with an accuracy that far exceeds traditional methods, entered directly into a geographic information system.

Cadastral Opportunities

The 1990's have seen such radical change in the world's social structures that have not been seen since the Second World War. One outcome of these changes is a growing democratization in not only the former communist countries but also in the developing world, regardless of political ideology. Key to democratization is the empowerment of the populace. Nowhere is this more effective than in the ownership of land that frequently is in the hands of the state or the affluent. Before land can be transferred to the people, either in ownership or the right to use it, that land must be adequately located, described, registered and valued. This process is the underlying motivation for a legal cadastre or registry of land and its ownership.

No description of land can take place without fixing its position relative to its environment. This means today that it be geo-referenced which entails surveying, mapping, the creation of 'parcel mapping' and land information systems. Canada has pioneered the technologies surrounding this activity. They are cadastral surveying, geodetic surveying (G.P.S.), digital mapping, G.I.S. and land titles registration. Frequently the expertise necessary for these programmes resides in the public sector (both provincial and, in the case of Canada Lands, federal). The expertise, both

technical and professional, in the component technologies lies in the private and academic sectors. Canada leads the world in the application of these technologies and our expertise is being used in Asia, Latin America, Eastern Europe and the former Soviet Union.

In Canada we are at the stage where the technologies are mature but the programme delivery mechanisms are being developed according to provincial and regional political ideology and economic conditions. In many provinces alliances are being, or have been, struck between the provincial governments and industry to collect the base data and compile digital records of transactions. In some cases components of the process are handled by government agencies on a fully commercial basis. The variety of corporate entities across the country that have been created amply illustrates the diversity of the country and the imagination of its people. The industry is playing an increasingly important and influential role in the gathering, processing, managing and dissemination of land information that was once the sole purview of public agencies. Further, some companies are now designing the information systems and data infrastructures that will deliver publicly held geographic information.

Atlantic LRMI

I have mentioned the Atlantic Land Records Management Infrastructure (LRMI) as an example of a strategic alliance. A corporate partnership, itself in partnership with two levels of government in Nova Scotia, has been created to collect geographic data, land ownership data and create a geo-referenced database. LRMI's responsibility includes the creation and maintenance of:

- cadastral data: property maps, subdivision plans, original surveys and parcel index ata;
- title registry: deeds, affidavits, mortgages and other registry documents;
- assessment data: maps, sales history, income and expense data;
- land use;
- administrative boundaries; and
- civic addressing.

The principle benefits of this approach are the integration of the collection and flow of information within land records agencies, streamlined business processes and an infrastructure that can be used by other land records applications, developed by end-users or third-party application developers. The Land Records Management Infrastructure software is designed for use by national and local governments throughout the world.

A Case Study - Argentina and the Southern Cone

Geomatics programmes deigned to build modern infrastructures for land and resources information management are underway in Argentina, Bolivia, Peru, Chile and Mexico.

In Argentina the use and management of geomatics technologies form the backbone of the 'Cadastral Transformation Programme' currently in implementation in most of the provinces with World Bank funding. The primary output of the programme will be a base for an equitable

property taxation system. However some of the provinces are working towards the creation of a geomatics infrastructure to support all aspects of land and resource development and management.

The drive behind these provincial projects is the 'programme for Financial Restructuring and Economic Development.' The programme was initiated in 1990 and financed through a loan to the Argentine Government by the World Bank and the Inter-American Development Bank. The programme totals U.S. $600 million and is designed to support a number of initiatives leading towards provincial fiscal reform and re-organization of the public sector.

A series of workshops funded by the Canadian International Development Agency (CIDA) have been organized by the University of New Brunswick (UNB) and the International Training Centre (ITC) of the Netherlands, with the aim of starting the process of technology transfer, at the managerial level, to ten of the provinces. The ultimate goal is to promote Canadian expertise to such an extent that the Canadian geomatics industry will be able to take advantage of the coming commercial opportunities. Further workshops are planned for 1996/97 and a proposal for another such project, involving the Champlain Institute, UNB and member companies of the Geomatics Industry Association of Canada, is being assembled for submission to CIDA in the coming months.

Mapping

Falling within the term mapping, we find a number of activities that generally describe the process of portraying geographic features, be they topographic, planimetric, cultural, demographic, thematic; digital or conventional; raster or vector; cartographically reproduced or photogrammetric manuscript.

Simplistically speaking, photogrammetry is the procedure by which information is transferred from aerial photographs, through a process known as stereo or mono restitution, to a map or a data file. Cartography is the process by which that map or data file is reproduced by manual or computer-aided drafting into a form that is a final product. Traditionally this has been a published map.

Photogrammetry

Photogrammetry today encompasses a number of procedures and ever more sophisticated products. As instrumentation plays a decreasingly important role in the process, and software assumes the pivotal role, one would expect a commensurate decrease in price. As analogue photogrammetric equipment was replaced by analytical instruments, the median cost started to fall even though high-end solutions were very much more expensive. More recently the analytical instruments, essentially hybrids of the precision analogue mechanical machines and the more computerized instruments, have given way to a much more computerized production environment. The desktop computer is rapidly replacing the photogrammetric instrument. This

we call 'softcopy' photogrammetry. Instead of viewing the image space in three dimensions through highly precise optical trains, the raster image of the aerial photograph, or remotely sensed scene, can be displayed on a single computer screen and viewed stereoscopically. This accomplished by polarizing two images and projecting them to a pair of 'spectacles' worn by the operator.

Softcopy Photogrammetry

Softcopy photogrammetry has the potential to replace traditional photogrammetry and orthophotomap production. An orthophoto is, as the name implies, a rectified or 'corrected' photographic image. It is corrected for distortions introduced by aircraft attitude and topographic irregularities. An orthophoto, therefore, is as positionally accurate as a linemap created by traditional photogrammetric methods. It is, however, a photographic image and is a very much more pictorial depiction of the earth. The potential for this technology to overtake the industry is indeed great and already non-traditional mapping companies are now producing maps via the softcopy method. Former clients of the geomatics industry now can produce their own maps, admittedly in limited applications and usually focused on one sector, such as forestry.

In the next two to three years one can expect further developments in this area, especially in the software and the human/machine interface. Traditional suppliers of photogrammetric services can expect increased competition from non-traditional companies because of the lower start-up cost and a lessened requirement for highly technically qualified staff. Conversely the market for these services is growing because of increased affordability and the greater diversity of end-products and services available to clients.

A good example of the development and application of softcopy photogrammetry at a low cost level is provided by Pacific International Mapping (PIM) of Victoria, B.C. The product, a suite of software tools called MAPS 3D, is priced under $6,000 for a basic license with supplementary utility modules around the $2,000 mark.

The most notable full production use of soft copy-photogrammetry has been undertaken by IMT of Vancouver, B.C., which uses a comprehensive system developed and marketed by its affiliate International SysteMap Corp. The core product, DiAPS, contains a full suite of modules that replace all commonly used photogrammetric instruments - from simple point transfer devices to complex orthophoto instruments. The product incorporates open architecture and runs on Microsoft Windows NT™ and Bentley MicroStation 95®

Digital Cameras

A concurrent development to softcopy photogrammetry is the development of the digital camera or charge couple device (CCD) array. Sensors currently exist and are in use in aircraft and land-based vehicles but they have not challenged the primacy of the traditional optical camera, or more to the point, the high picture quality attainable from today's cameras and films. That will change

when the CCD technology is perfected and when faster and larger capacity storage is developed. Then digital images will be captured by aircraft and satellites alike. This development will be complementary to softcopy photogrammetry due to the ease with which data will be transferred from the sensor to the desktop computer.

Cartography

Cartography is the grandparent of all the constituent disciplines of geomatics yet it is one of the last to be so dramatically influenced by the microchip. Admittedly the technology has evolved in an accelerated fashion during the last 20 years. Nevertheless the artistic nature of cartographic representation has necessitated its awaiting the arrival of faster processors and more sophisticated 'pseudo artificial intelligence.' During the revolution of digital mapping many organizations were still employing manual cartographic techniques in order to produce a final product.

Today, software has evolved to the point where all cartographic procedures can be accomplished within a computer environment. Small scale topographic and thematic maps, hydrographic charts and aeronautical charts are all being produced digitally from start to finish. The prime motivation for developing the technology has come courtesy of the Federal Government's 'polychrome' mapping. This is the production of full colour National Topographic Series (N.T.S.) maps. As the industry adopts the standards and specifications of programmes such as this, the development of increasingly sophisticated software is fostered for positioning text, editing and cartographic generalization.

National Atlas Information Service

No discussion of cartography can take place without mention of the Atlas. Canada's National Atlas was first published in 1906. The seventh and last conventional edition of the Atlas comprised separate unbound sheets covering some 200 themes. Today the atlas is available on the Internet. It has its own World Wide Web site and has received rave reviews from users and browsers throughout Canada, the United States and overseas. The National Atlas Information System (NAIS) on the Internet provides global access to information about Canada for those such as students, journalists, librarians, researchers, planners, writers and demographers. For Geomatics Canada this is just the tip of the iceberg insofar as making national geographic or topographic databases accessible on-line.

Marine Geomatics

Canada's coastal zones, the Atlantic, Pacific and Arctic, constitute the longest national coastline in the world. Add to that the shores of the St. Lawrence and the Great Lakes and one finds ample motivation for advanced technology and a marine geomatics industry second-to-none in the world. Similar to traditional mapping and cartography, Canadian marine geomatics, which includes hydrographic charting, has had much cause to be advanced technologically and institutionally to address the huge need for geographic information. Marine geomatics is what is

euphemistically known as the 'wet side' of cartography. It involves the surveying and data gathering, by various methods, of the shoreline and sea floor. Whilst the positioning principles are the same as on the 'dry side,' the acquisition of aerial photographs is somewhat redundant. It is hard to stereo-restitute waves! The technology employed includes G.P.S., airborne laser mapping systems, acoustic multibeam systems, electronic charts, airborne and satellite remote sensing.

Available literature on the industry lists twenty-seven companies offering geomatics services in the marine environment. A number of these companies are members of the Geomatics Industry Association of Canada and are actively involved in traditional geomatics projects. Naturally enough, one finds most of these companies based on the east or west coasts. There are three specialized research facilities:

- the Atlantic Centre for Remote Sensing of the Oceans (ACRSO) in Bedford, Nova Scotia;
- the Canadian Centre for Marine Communications (CCMC) in St. John's, Newfoundland; and
- the Industrial Chair in Ocean Mapping, University of New Brunswick in Fredericton, New Brunswick.

Partnerships of the public, private and academic sectors provide complete coastal and ocean capabilities and expertise for the domestic and foreign markets. Products and services developed to address Canadian needs have been successfully applied to:

- coastal zone information management;
- cable and pipeline route surveys;
- site investigations, environmental assessments and monitoring;
- hydrographic, geophysical and oceanographic surveys;
- fisheries acoustics and habitat management; and
- marine engineering projects.

There are eleven universities with relevant programmes across the country, including those that have geomatics engineering programmes related to the land side.

The Department of Fisheries and Oceans, through its Canadian Hydrographic Service (CHS), is charged with the responsibility for marine geomatics. The Service maintains a head office in Ottawa with regional institutes or laboratories with coastal and ocean information industry programmes in British Columbia, Ontario, Québec and Nova Scotia. It is engaged in research and development activities with universities in these regions and in the United States.

Multi-Beam Sonar

The University of new Brunswick's Chair in Ocean Mapping has been working with the CHS and industry to exploit the development of multibeam sonar scanning. One of the principle problems was the high volumes of data generated which has given impetus to the development of a suite of software tools that have greatly alleviated this problem. The tools are now marketed by Universal Systems of Fredericton, New Brunswick, and with the growing acceptance of multibeam sonar some 50 licenses have been sold worldwide. One of the most dramatic achievements has been the

development of a real-time processing tool that allows the display of fully mosaiced swath bathymetry and imagery as a survey progresses.

The recent developments in ocean floor mapping have challenged the ability to visualize the data. Research has recently focused on visually exploring datasets in a 3D model using a joystick and actually flying through, around, under and over the image on the screen. This mode of visualization allows users to easily extract the critical information from a complex dataset and greatly enhances the usefulness of seafloor mapping data. Viewing in full stereo is accomplished with the use of LCD glasses in much the same way as softcopy photogrammetry.
Applications include:

- geological exploration;
- route location for underwater utility lines;
- exploration for shipwrecks and other navigational and fishing hazards; and
- G.I.S. database population.

This technology is attracting worldwide attention and, together with many other products and services, is helping Canada maintain a leadership position in the world of marine geomatics.

Underwater Photogrammetry

Another interesting application in this field combines the principles of close-range terrestrial photogrammetry (the photogrammetric measurement of vertical or near vertical features) and the marine environment. Precisely calibrated stereo cameras are used to photograph underwater structures and the stereo photographs are then placed in a conventional or digital stereoplotter. Measurements are taken to a very high degree of accuracy and compared with previous readings or known dimensions describing the surface of the object. The resulting differences indicate the deformation or degree of erosion of the structure. Applications include all underwater structures such as piers, pilings, bridge supports, ocean oil rig supports and flow control mechanisms. The technology is one that is not abundant in the private sector in Canada but, with the growth of offshore activity, represents a growing market.

Remote Sensing

According to some industry observers, over the next ten years the market for remote sensing products and services, which has been growing 15% annually, is likely to exceed $15 billion. Hand in hand with G.I.S., from a technology point of view, it will continue to be the fastest growing sector in geomatics. Remote sensing will serve a growing number of applications including military, geological, agricultural, forestry, land use, the environment, hydrology, sea ice monitoring and topographic mapping. No introduction to a discussion of remote sensing in Canada would be complete without reference to the Canada Centre for Remote Sensing (CCRS). The industry was born out of the Centre and, even today, there is no government organization more supportive of the Canadian geomatics industry than CCRS. At times almost 50% of the technicians and scientists working within the Centre are employees of firms under contract or in

partnership with the CCRS. Today, CCRS's role is changing, but one hopes that it will manage to find a place, equally supportive of industry, in the geomatics community of tomorrow.

Currently independent software functions will become increasingly integrated. These include mapping, G.I.S. and image analysis. There will be lower prices leading to much wider use of the technology and the Internet will play a much more important role in its distribution. G.P.S. will be used routinely for the geo-referencing of data and resolution will increase to the point where satellite images will replace aerial photography in many more applications.

Future Impact on Aerial Photography and Mapping

Current technology dictates, depending upon one's background, that for scales larger than 1:50,000, aerial photographs are needed to produce accurate topographic maps while satellite imagery may be used for change detection only. That will soon change as new satellites are launched with new sensor technology allowing for much higher resolution than previously achieved. Using LandSat and SPOT images, Geomatics Canada has been experimenting with remote sensing for data acquisition for its N.T.S. Programme. Until recently these images, using projection equipment such as Gregory Geoscience's Thematic Mapper™, have been used for change detection only in the revision cycle, necessitating the acquisition of more costly aerial photography. With the advent of G.P.S., higher resolution images and a precise geodetic base upon which to overlay the images, the revision process will soon be reliant only upon remote sensing.

U.S. Declassification of Data

An emerging factor in the drive towards greater use of satellite data comes as a result of the end of the Cold War and the decreasing emphasis on military security that has been a perennial bedfellow of the remote sensing industry since its inception. Previously classified data is now becoming available for commercial and public use. Sensor technologies are also benefiting from this relaxation of security measures and the technology is fast being transferred to industry.

Commercial Satellites

For the first time in the history of remote sensing, the private sector is launching and controlling satellites for commercial applications. This will greatly increase the availability and diversity of imagery, both sensed and photographed. It will also affect the price of data. Commercial operators will have to amortize the costs of construction and launch as well as the ongoing maintenance of the satellites. Previous satellites have been completely or partially developed at public expense. Counterbalancing this pressure to push the prices upward will be the competition factor. There will be no monopolies and therefore competitive market conditions will apply. The outcome of this dichotomous situation will be of interest to the entire community. EarthWatch of Boulder, Colorado, one of the first companies to commission a fully commercial satellite, will soon launch the EarlyBird optical satellite.

EarthWatch has received two of the four licenses granted for commercial satellite launches by the U.S. Department of Commerce. EarlyBird will provide panchromatic 3-metre resolution images and multispectral 15-metre images. QuickBird, to be launched later in 1998, will provide panchromatic 0.82-metre resolution images and multispectral 3.28-metre resolution images. MacDonald Dettwiler will assist in constructing EarthWatch's main image data archiving and processing as well as similar secondary archiving facilities for distributors.

Radarsat

In 1995 Canada launched the world's first 'operational' radar remote sensing satellite. It has been a collaborative effort of the Canadian Space Agency, Canada Centre for Remote Sensing and the private sector. Early results indicate that it is functioning well and the data is meeting all expectations. The significance of radar data is that it is daylight and weather independent. Radar sensors therefore are functional 24 hours per day and see through cloud cover. Some areas in the world that are under constant cloud cover may now be imaged and mapped. Radar images are very much like X-rays and penetrate cloud, haze, shallow water and can be used to gauge ice thickness, soil moisture and even determine, by surface patterns, geological structures never before seen.

Radarsat International Inc. (RSI)

RSI comprises four companies in partnership, each holding 25% ownership. They are Spar Aerospace Ltd., COM DEV Ltd., Lockheed Martin Corp. and MacDonald Dettwiler (MDA). RSI has worldwide distribution and marketing rights to Radarsat data as well as Canadian rights to data from other satellites.

As a result of the launch in 1995, about two dozen ground receiving stations around the world will need to be upgraded to receive the radar data. This should benefit one of the partners, MDA, which is the world's leading supplier of ground receiving station equipment and upgrades.

Airborne Remote Sensing

While much attention is paid to satellite remote sensing, there is an increasing market for airborne remotely sensed images beyond the conventional optical data acquisition or aerial photography. Radar images taken from an airborne platform are as dramatically advantageous over aerial photographs as are those taken from space. One such example is the previously mentioned IFSARE System from ERIM and Intermap Technologies. It consists of two radar antennae mounted in a Lear 36 jet aircraft and associated airborne and ground-based processing equipment. The system is capable of producing detailed digital maps in any cloud or light conditions. These maps are approximately ten times more accurate than those produced from satellite images.

Concluding Remarks

In the process of illuminating the ten or twelve products or services emerging to influence the geomatics sector in the next two to three years, I have taken some liberties with the terms of reference. I have produced somewhat of a selective overview that reflects in no small way those events and issues that I personally think are of significance. Technology forecasting is an imprecise discipline that uses scientific procedures to arrive at similar results as our best educated guesses. I have simply chosen the best guess approach where I have attempted to lead the reader towards a substantive and qualitative conclusion.

One thing is clear, the industry is in a state of flux. The clients are becoming increasingly conversant with the technology at the same time as the cost of entry is plummeting. Geomatics is becoming a strategic and seductive technology and is gaining a very high profile around the world. Canada has played a major role in its development and her industry is well placed to reap the benefits, but governments must develop or support a national strategy. They must combine their resources to focus the potential in our industry, academic institutions and public sector. What now will be the role of government within the geomatics community? As the emphasis shifts from data capture to data management, from a well defined geomatics industry to a broadly based user community, where should we put our resources to position Canada as a leader, not only in the technology, but in addressing the institutional issues that arise out of societal demands for geographic data?

There is a wealth of opportunity, not only in the U.S.A. and overseas, but also here in Canada. In papers such as these we tend to overlook the domestic marketplace in favour of the greater prospects in such places as Latin America, Asia, Russia and Eastern Europe. The challenges are still here to be met. This is a country where geographic diversity and dimensions still present the best impetus for the advancement of geomatics.

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The author is interested in receiving your views and comments for updating this report for a future release. He can be reached at *rbat@fox.nstn.ca*

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