Geomatics Sector • Human Resources Study

Prepared by:

Canadian Council of Land Surveyors
Canadian Institute of Geomatics
Geomatics Industry Association of Canada

Acknowledgements

The completion of this report would not have been possible without the cooperation of the many organizations and individuals who contributed their time to completing survey forms, participating in interviews, and attending meetings to discuss issues within the Canadian geomatics sector. The Steering Committee for the study expresses its appreciation to these individuals and organizations for their input and support.

Special recognition must be given to the Canadian Council of Land Surveyors, the Canadian Institute of Geomatics, and the Geomatics Industry Association of Canada, who initiated this important study and guided its completion. The leadership that they have provided, in recognizing that the geomatics sector faces critical human resources challenges, and in initiating action to address these challenges, is appreciated.

Our thanks are also extended to Human Resources Development Canada for its support of this study. The financial contribution and advice provided by the Department were crucial throughout the duration of the project.

Finally, the study has benefited from the comprehensive research and analysis conducted by Hickling Arthurs Low Corporation, with the support of professional consultants and advisors drawn from the different geomatics specialties and Canada's geographic regions. This team provided a comprehensive information base for the development of strategies and plans to deal with sectoral human resource issues.

Executive Summary

Study Objectives and Approach

In order that Canada remain a key player in the sector, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, initiated this study to address the human resources issues. Hickling Arthurs Low (HAL) Corporation was commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The prime objective of the study is to provide a cohesive national plan for the development of a Canadian geomatics workforce which can make an optimal contribution to the sector's competitiveness. The study has analyzed the sector in its global setting and determined the implications of current and future market and technology changes for the human resources in the sector. Five geomatics-related research areas; markets, industry structure, technologies, education and training, and human resources have been addressed. For each of these areas, profiles have been developed that characterize the current and forecasted Canadian situation. Based on the profiles, a number of conclusions have been developed on the human resource issues facing the geomatics sector.

Large numbers of people involved in geomatics in Canada were consulted in the course of the study. Our survey went out to about 4,000 individuals of whom about 900 responded and we interviewed over 100 active as producers and users of geospatial information in industry, government, universities and colleges. Workshops were held in five cities across the country attended by a cross section of geomatics professionals from each region. We believe, consequently, that the results are representative of the views of the geomatics community in Canada. Together with an analysis of the technology, market and business changes influencing the sector, the report constitutes a sound basis for effective planning by the Steering Committee on human resources in geomatics.

Drivers of Change in Geomatics

Markets and Technology

The study found that, during the last decade, the entire nature and structure of the industry, profession, and constituent disciplines have changed to such an extent that geomatics is practically un-definable in terms of the practitioner of ten or even five years ago. The change is so marked that a sense of identity within the geomatics sector is lacking. What was once traditional and seen as a continuing industry is now under pressure from a combination of competition and technological change. How the sector responds to these pressures will define the pattern of its future growth.

The most dramatic technology development of the late 1990's has been the Internet which is radically changing the means of delivery of geomatics products and services. In the future, we can also expect an ever increasing use of web technology by the geomatics community, not only for the collection, manipulation, management and delivery of geospatial data and products, but for education and training, advertising, business development, sales, and commercial transactions. Penetration of geospatial data is now possible into the home and small business, greatly aided by major software vendors like Microsoft who offer geospatial analysis tools bundled with their office packages.

In addition to the Internet, a number of other technologies have become very important to industry in their potential to generate growth. In our survey, these included GIS, user applications and solutions, data visualization, navigation and positioning, and communications and distribution. Technological change was seen by our respondents as enlarging their market reach but at the same time increasing competition from firms in other sectors such as information and communications technologies and aerospace. Some of the expected impacts on markets and business activity are:

- More and better data access through the web to allow data mining. This will result in “a total digital environment”, removing the need for hard copy and the associated expense. GPS and GIS will improve and be more accessible with a range of new tools. New high resolution satellite imagery was cited by a number of users as something that would have a significant impact on their operations.
- A major driver is the availability of precise, low cost, real time positioning (i.e. GNSS). In fact, some are now referring to “l-commerce” (location commerce) as a major subset of e-commerce. Positioning is now imbedded in GIS technology, services, and applications. Positioning is almost invisible, although it forms the backbone of these services.
- Non-traditional geomatics applications are emerging in which both positioning and GIS are imbedded and transparent. GIS permits making geo-information visible and smart services for decision making (traditional and non-traditional) providing easy interpretation / effective visualization. Self-help, and interactive mapping via the Web, are targeting the consumer and small business markets.
- Many see the technologies moving farther and farther out to less sophisticated users. This would lead to more opportunities for geomatics as geomatics is viewed increasingly as a management tool, leading to more applications. Like any other industry, this stage in the evolution of geomatics will go through a ramp-up period with proprietary solutions, and then consolidation plus open standards and finally true use.

Structure of the Geomatics Industry

Geomatics is a generic term covering a wide collection of disciplines. While some firms in the sector are involved in a number of these disciplines, many are narrowly focused on a single niche. This, we have found from our interviews, results in somewhat of an identity crisis within the geomatics industry in that many of its parts do not consider themselves part of a larger whole. For example, only about 8% of ‘geomatics’ firms in the Industry Canada Canadian Company Capabilities database mention the word geomatics in their descriptions.

This sense of identity is further complicated by the fact that many geomatics professionals are employed by geomatics users, and not by the geomatics industry. Also, many of the 'new' geomatics firms consider themselves to be part of the information technology industry, rather than geomatics. An additional hurdle in defining and measuring the progress of the industry is that geomatics is not an industry that is recognized in the traditional lexicon of statistical data collection agencies such as Statistics Canada. A number of issues associated with the structure of the industry have been identified.

Firm Size: The most significant characteristic of the Canadian geomatics industry is the small size of the firms; 75% are smaller than 10 people, and 98% are smaller than 100 people. This has a number of important implications, for example:

- Small firms are likely to be under capitalized. Access to capital was identified by the industry as one of the most important barriers to market development. Almost no firms have gone public in order to access capital. This lack of resources is at the root of many of the other threats faced by the industry.
- Small firms may have difficulty competing effectively in international markets. Most international projects require marketing resources, significant working capital, and broad expertise; a combination that is out of reach of most small firms.
- Small firms may have difficulty adapting effectively to technological change. Training and research require time and resources that most small firms cannot afford.

The likely outcome will be increasing consolidation in the industry. The unanswered question will be whether this occurs through mergers of Canadian firms, acquisitions by foreign firms, or failure of Canadian firms as a result of competition from foreign firms. Obviously the latter outcome is the least preferable, but unfortunately may be the most probable.

Importance of Government: Geomatics is a field that has emerged from the traditionally public sector mandate to map our world, and it continues to be impacted by government actions. Depending on the area, between 30% and 60% of industry markets are with the public sector. This is presumably down from a decade ago as a result of government cutbacks, but is still a significant proportion.

Of the major issues cited by the geomatics industry, many were related to government – for example, public sector geospatial data pricing and access, and government policies. Also government is the second most important partner for the geomatics industry (after clients) and the most important R&D collaborator.

Future Structure: There appears to be a mis-match between the current structure of the Canadian geomatics industry and the opportunities that are developing. For example, the industry is dominated by surveying, but that is the area that will experience the lowest growth in the future. On the other hand, navigation and positioning is currently the smallest segment of the industry, but is predicted to have one of the brightest futures.

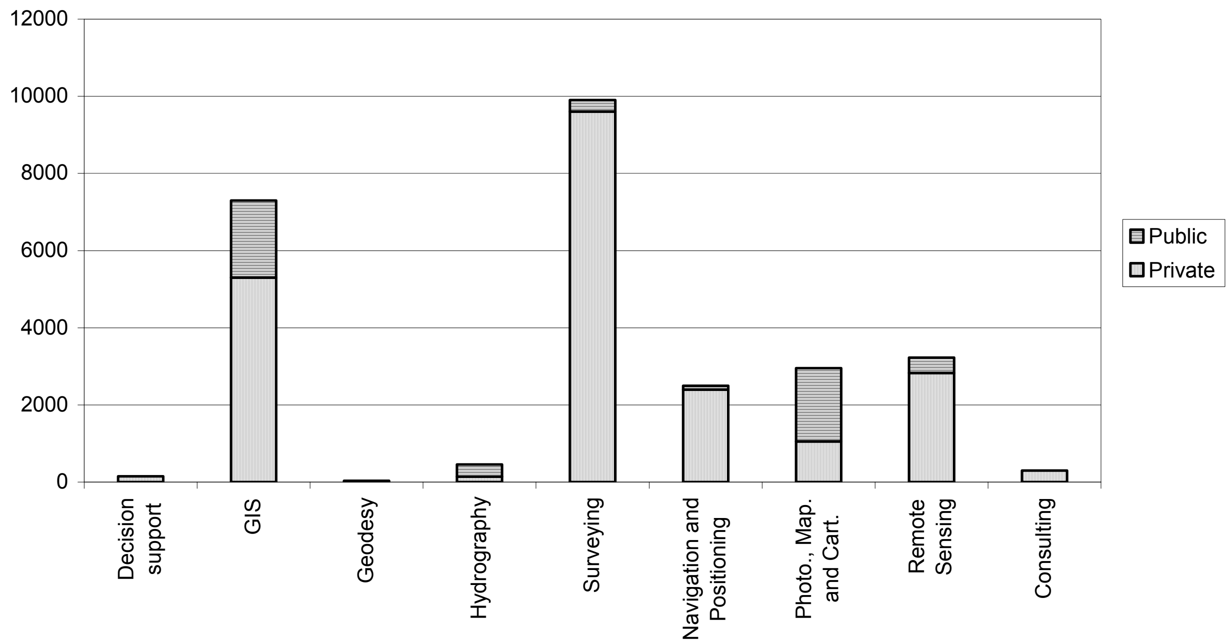
This speaks to the need for significant restructuring. One avenue ahead would be for firms to diversify from their traditional areas into new markets. However, there are concerns that this may be difficult to achieve. For example, about 60% of surveying firms are not involved in other geomatics areas. In the case of surveying, governing legislation favours small, narrowly focused firms. In other geomatics areas, the preponderance of small firms restricts opportunities to diversify.

Human Resources in Geomatics

Estimates from this study point to a current market for Canadian geomatics companies of just over $2 billion, with an employment base of about 27,000, 22,000 in the private sector and about 5,000 in the public sector. This number is expected to grow to an income base of $3 billion, employing 32,000 people in the private sector, by 2004. The study presents the distribution of the geomatics workforce by sub-sector, region, age, gender, salary, and levels of education. It is noted that over 80% of the workforce has a university degree which is a significant change from the last survey in 1991 which showed only about 15% with a degree.

The following figure depicts the number of people working in the geomatics industry by each geomatics sub-sector. Surveying and GIS dominate, and GIS is projected by this study to almost catch up to surveying by 2004. This growth of GIS is mirrored in the relatively high availability of training and education in GIS, both in the primary and secondary levels and at the post-secondary level.

Geomatics Workforce by Sub-Sector



Education and Training

An inventory of institutions and organizations providing geomatics education and training in Canada was prepared. To our knowledge this is the first such national inventory on educational opportunities in geomatics. Course information was obtained primarily from web-sites and from the catalogues/calendars of universities, colleges, and technology institutes. The inventory indicates that there are over 40 universities and 25 colleges and technical institutions providing geomatics education or training. Our study found that these institutions have been responding well to the increased need for graduates trained in geomatics; most programs have been updated to reflect changes in the industry, the market and technology, and new programs have been instituted as resources permit.

One of the issues identified in the interviews, and our interpretation of the survey results, has been the lack of awareness of geomatics among the general population of users and among the pool of potential employees. That issue has significant impact on the ability of geomatics to grow its market and to attract employees. It is in part for this reason that the dramatic growth in programs in the primary and secondary levels is so important. The emergence of geomatics education at these levels has significant implications for human resources in the geomatics industry, both in terms of the number of people that have a "geospatial awareness", the potential for early attraction to the geomatics industry and the impact on the range of geomatics skills that should be taught at the undergraduate level.

Skill sets that are the foundation of geomatics-related activities were developed through extensive consultation for each of five main geomatics areas: surveying, earth observation, GIS, cartography, navigation and positioning. The list of skills was further sub-divided into generic skills and field skills as shown below.

Generic Skills for Geomatics

Generic Skills	
Business Skills	**Technical Skills**
Financial statement analysis	Geodesy
Contract negotiation	Geographic Information Systems (GIS)
Proposal, report and science paper writing	Global Positioning Systems (GPS)
Marketing	Computer Aided Drafting systems (CAD)
The ability to secure funding	Computer hardware and software
Leadership and management skills	Data visualization and interpretation
Team skills	Data formats and transfer
Presentation skills	
Project management skills	

Field Skills for Geomatics

Surveying	Cartography
Survey law Legal surveys procedures Traditional survey equipment Computerized land information systems Global Positioning Systems (GPS) Geographic Information Systems (GIS) Computer Aided Drafting systems (CAD) Computer hardware and software Construction surveying Pre-engineering surveying Property rights systems Land planning and management Understanding/interpretation of data	Specialized equipment viz. stereo plotters, airborne survey cameras, sensors and scanners Computer graphic systems Image processing software Image interpretation Geographic Information Systems (GIS) Computer Aided Design systems (CAD) Desktop publishing Computer hardware and software File management: meta data and file transfer
Earth Observation (Remote Sensing)	**Geographic Information Systems (GIS)**
Hyperspectral/ultraspectral/radar /lidar techniques Algorithm development Spectral data exploitation Specialized equipment Large volume data mining Data visualization Data format conversion and GIS/RS integration Field campaign design and implementation In situ remote sensing validation techniques GIS/RS integration Analytical principles and procedures Electromagnetic spectrum Image acquisition, processing and interpretation	Principles of Geodesy Control survey networks Spatial referencing systems and positioning Computer Aided drafting systems (CAD) Engineering surveying Coordinate geometry Photogrammetry Computer hardware and software – external databases Surveying, earth observation and cartography Database/information structures, algorithms, design and systems Geospatial data analysis, modeling and display Spatial statistics
Navigation and Positioning	
Electronic navigation systems for positioning, navigating, guiding and controlling air, land, and sea vehicles Custom software to integrate hardware systems User interfaces for navigation and guidance systems Position-related information organized in databases Use of integrated inertial measurement units and GPS Understanding of ellipsoids, datums, map projections Application of navigation and positioning into other geomatics areas Geometrical geodesy	

Human Resources Challenges

The human resources challenges, as identified in the study, have been grouped under four headings: awareness and public image; recruitment and retention; education and training; and, professional development and certification. We present below brief conclusions and optional courses of action to guide the Steering Committee in developing a strategic and tactical plan for human resources.

Awareness and Public Image

Conclusions:

- Geomatics does not have a well-defined public image which is having a negative impact on the ability of the sector to attract new entrants. Some years ago in an attempt to encompass the disciplines associated with the gathering and management of geospatial data, the term geomatics was coined. This did much to enhance the image of the industry in Canada as it neatly packaged the constituent disciplines of *inter alia* land surveying, geodetic surveying, remote sensing, photogrammetry, cartography and GIS. At that time, a fence was placed around what is now called the "traditional industry."
- Those in the field still find themselves educating not only the rest of the world, but also potential new entrants into the field, as well as new markets on the meaning of the term. Geomatics does not present an image that is understood or very compelling to the general public. It would appear now that the growth of the field has moved beyond the fence erected under the name of geomatics into a far-reaching integration of geospatial information into a wide spectrum of applications involving a plethora of technologies. Another encompassing but more recognizable term 'geospatial' has been increasing in both use and recognition around the world.

Options:

The workshops suggested a number of important steps to be taken in improving the image of geomatics and making the field more attractive to those making career choices:

- Create a "grass roots" awareness of geomatics. Start at the secondary school level to promote geomatics through information sessions in the schools and on the web, creating a presence at career days, and educating career counsellors on opportunities in geomatics.
- Demonstrate the importance of geomatics to today's society through wide-ranging public awareness campaigns sponsored by leaders in industry and government, highlighting key applications. Have governments proclaim a GIS day.
- Focus on geomatics as a key component of many day-to-day business processes – have industry leaders (CEOs) talk about the importance of geospatial information, making use of business publications like Business Week.
- Spend less time defining what "geomatics" is and more time publicizing the wide variety of applications. Demystify "geomatics". Show that geomatics is part of the new (and better known) information and communications technologies field.

Recruitment and Retention

Conclusions:

- The geomatics sector is currently facing shortages of people in selected areas eg GIS and, given the projected growth in the geomatics industry, it appears that the demand for geomatics professionals over the coming five years will increasingly exceed the numbers graduating from Canadian universities and colleges.

- Growth in demand in the US is expected to triple in the next five years which will create a further magnet drawing graduates south (significant numbers of graduates from some educational institutions eg COGS are already taking up employment in the US).
- Some view a hindrance to recruitment to be the lack of obvious career paths in geomatics (defined by some as moving on and not moving up) and growing competition for software-related skills in geomatics people from the information technology sector.
- Geomatics faculty members have not been moving but this is changing. There is no clear pattern regarding where they move, some have moved to the US, others have started their own companies in a geomatics or geomatics-related industry. A small number of faculty is now working in the broader IT industry.
- The movement of geomatics staff within users tends to be within the same organization or to other users ie larger multi-national firms or government agencies. Government agencies seem to retain their staff more in certain regions of the country than others (e.g. Quebec). In some regions, it has been noted that there is movement back and forth between government and the private sector (New Brunswick, Ottawa).
- Brain-drain is a serious concern in BC and the Maritimes. Many new graduates are lost to the US where better and more opportunities exist. Also, experienced geomatics professionals sometimes change field to work in software or Internet companies. This is especially so in Vancouver which has become a hotbed of Internet software companies. By comparison, geomatics is seen to lack growth opportunities.
- Growth in GIS and decision support approaching 20% per year is projected to lead to shortages of the more specialized individuals involved in advanced modeling. This shortage will be compounded by the drain to the US and to the IT sector. Also, high end GIS staff are projected to move into the higher margin decision support, compounding the shortages in GIS.
- It is commonly believed that all applications that are associated with the web will grow, as will GPS, business geographics, satellite imagery use, programming and modelling, data base management, process re-engineering, project and knowledge management, and those areas that add value to the data. To add value, people will have to understand geomatics and the client's needs. The market will move beyond spatial database management to data fusion, connectivity, and real-time wide-area distribution.
- Human resource implications assessed as **low, moderate** or **high** regarding:
  - **Security** of employment (demand for and maturity of technology);
  - **Availability** of new entrants (supply of suitably qualified college and university graduates);
  - Degree of **retention** of employees (stability of workforce); and
  - Susceptibility to **external demand or competition** from other technologies (higher salaries, better benefits)

Availability, Retention and Competition Comparison

Disciplines	Security	Availability	Retention	External Competition
Surveying				
Cadastral	High	Moderate	High	Low
Geodetic	Low	Moderate	High	Low
Earth Observation				
Satellite	High	Moderate	Moderate	High (IT - aerospace)
Airborne	High	Moderate	Moderate	High (IT - aerospace)
Image Analysis	High	Moderate	Moderate	High (IT - aerospace)
S/W Suppliers	High	Moderate	Moderate	High (IT - aerospace)
Geographic Information Systems (GIS)				
Systems Dev.	High	High	Moderate	High (IT sector)
Service	High	High	Moderate	High (IT sector)
GSDI	High	High	Moderate	High (IT sector)
Cartography				
Aerial Photo	Moderate	Low	Moderate	Moderate (aviation)
Photogrammetry – Systems	Moderate	Moderate	Moderate	Moderate (IT companies)
Photgrammetry- Services	Moderate	Moderate	Moderate	Low
Cartographic S/W Dev.	Moderate	Moderate	Moderate	Low
Cartography Services	Moderate	Moderate	Moderate	Low
Data Conversion	Low	Moderate	Moderate	Low
Navigation and Positioning				
GPS Dev.	High	High	Moderate	High (IT - telecomm)
GPS Services	High	High	Moderate	High (IT - telecomm)
Kinematic GPS	High	High	Moderate	High (IT - telecomm)
Vehicle Navigation	High	High	Moderate	High (IT - telecomm)

Options:

- Industry needs to reinvent itself to provide better remuneration and career opportunities. The industry needs to attract serious entrepreneurs who can create an attractive vehicle for staff to succeed financially.
- Recruitment and retention require improved opportunities for management training and continuous education at the firm level, offers to employees of equity ownership, identifying role models in an organization of successful geomatics professionals (among users, these may not be readily identifiable).
- Encourage partnerships among organizations to create broader, more attractive business environment, and flexible business networks that allow movement of personnel on a project basis.
- Market geomatics as an IT service, allowing staff to explore, learn and implement new services such as wireless location-based services. Integrate geomatics into mainstream IT organizations (some loss of autonomy but possibly good for the industry in the long run).
- Offer non-salary/non-training perks in the public sector ie incentives for technology upgrades, conferences, research time, paid-deferred leave.

Education and Training

Conclusions

- A review of the geomatics curricula in the universities and colleges in our inventory, in light of the accepted listing of skills, shows that geomatics education and training is predominantly GIS related with over 83% of post-secondary institutions providing significant GIS training. Nearly all universities offer GIS courses, and many allow GIS specializations, in undergraduate and graduate programs. Remote sensing, or earth observation courses, are the next most prevalent (75%), with an emphasis on image interpretation and multispectral analysis. Cartographic courses follow (72%), with map interpretation and map construction/design competencies widespread in introductory geography presentations.

- There appear to be more limited course offerings for surveying. Of these, geodesy, GPS, and photogrammetry are the most widely offered. CAD courses in geomatics appear to be rare in the university environment with the exception of Quebec universities but are offered through colleges and technical institutes.
- Academic institutions have been responding to the increased need for graduates trained in geomatics; most programs have been updated to reflect changes in the industry, the market and technology, and new programs have been instituted as resources permit. For example, COGS, Limoilou College, and the graduate programs at Laval (Geomatics Sciences Department), bring technically capable people with multidisciplinary backgrounds into the geomatics workforce through a post-graduate diploma program.
- The Canadian geomatics industry has historically been very strong technologically. Internationally, Canada's competitive advantage has been the technical skills of its geomatics professionals. However, the result has been a preponderance of small firms started by technologists who do not tend to have the entrepreneurial and business savvy to move their companies to the next level of size and sophistication. This will not suffice in the future as other countries become more technically astute and surpass us in a business sense. Industry has recognized this and has identified business and entrepreneurial skills as being very important.
- Land administration, mapping, and other geomatics applications in developing countries is projected to be a significant growth area. There will be a continuing demand for graduates with training in international development, project development consulting, technology transfer and systems integration. This highly competitive market is already populated by aggressive multi-national companies who will be competing for these graduates.

Options:

- A more cohesive approach to education and training in geomatics through collaboration and linkages among universities, colleges and high schools will improve the quality of geomatics education and better prepare students for careers in geomatics. The fact that geomatics tools are being introduced into the educational system at an earlier age is influencing the entry level of knowledge in geomatics. This needs to be taken into account in the design of the overall geomatics educational system
- A cohesive approach would also help to better define the respective roles of universities and colleges in providing education and training in geomatics. Joint graduate degrees with universities focusing on concepts and colleges on tools were seen as a best practice.
- Co-op programs, internships and work terms in industry were recognized as a

valuable and integral part of the educational programs in geomatics provided by universities and colleges. Industry participation in the programs through industry lecturers and reciprocal exchanges with university and college professors was also seen to be advantageous.

- Skill gaps have been identified in the mix of skills (specific geomatics technical skills, and broad IT skills) being provided by universities and colleges, on the one hand, and those required by industry (soft/business skills), on the other. Demand for soft skills including skills in management, human resources, team work, languages, cultural sensitivities, entrepreneurship, and report writing and presentations, is increasing.
- The impact of the Internet on human resources skills will be significant. The geomatics worker will, increasingly, have to be fully versed in the workings of a web-based environment, whether it be for applications development, data manipulation and sharing or data integration.
- Costs associated with some equipment can prohibit institutions from teaching leading edge technology. Equipment loans from industry and incentives to encourage the loans would be helpful. Negotiating agreements with technology vendors to make current technology available to all students was also proposed.
- Universities and colleges should research how industry is using or wants to use geomatics products or services and then align training to match on a more timely basis.

Professional Development and Certification

Conclusions:

- Professional development is a necessary component of human resources development in geomatics. The uncoordinated approach to professional development within the sector is hindering the sector's ability to develop necessary numbers of senior managers and leaders in the field. Closer linkages among the different educational levels and industry are needed for training and life-long learning.
- Professional development must not be based entirely on the need to stay current with technology, indeed there is a requirement that relevant business skills be promoted throughout the industry, as a means to grow the sector as a whole. Opportunities for geomatics professionals to increase their skills through on-line business related courses should be promoted as part of becoming a high level geomatics professional.
- Because the profile of the industry is skewed towards SMEs, professional development often happens 'organically' rather than through a planned, strategic approach. It is difficult for small firms, which are focused on sales, delivery and meeting a respectable bottom line, to plan for extensive out-of-office professional development. Indeed, when individuals show potential and skills in an area, they may often find themselves with increased responsibility and time commitments that result in real challenges in terms of time for professional development.
- The more successful firms in land surveying are branching into new business areas such as land information and GIS services. There will be demand for

business, marketing, and "broadening" courses to give the practicing land surveyor the technical understanding and knowledge to move into these new business areas.

- Professional associations keep members up to date on issues and provide information seminars, but typically do not provide comprehensive accredited training. Associations have a role if not in providing the training at least in making training opportunities known.
- On-line or e-learning, both as part of a degree and/or certificate program and as a component of on-going professional development, offers important opportunities to the geomatics sector for improving the quality and level of geomatics education and training.
- Professional development faces a number of barriers. The SME composition of the industry has led to a general lack of in-house formal career development programs. The nature of many projects, in particular international work, tends to require subcontractors (SMEs) to spend time in the field without means to study and adds to the difficulty of accessing training courses.
- On certification, a distinction was made between certification of geomatics people and certification of geomatics products. The latter was generally considered to provide a worthwhile service to the public. The perspectives on the certification of people, on the other hand, were mixed. Those in favour believe certification to be an important requirement in establishing geomatics as a legitimate profession. It was generally accepted that certification may be appropriate for those in geomatics positions that require lesser academic qualifications. Others were of the view that certification could create barriers, restricting opportunities at a time when geomatics is undergoing substantial change and making it difficult for people to move into geomatics from other sectors, in particular the ICT sector.
- A number commented that graduates of universities and colleges with degrees and diplomas in geomatics-related disciplines already carry a type of certification that gives assurance to employers of a certain level of skills. The accreditation of courses in geomatics was viewed as desirable to ensure that quality is maintained in the course offerings at these institutions.
- Certification was also seen as complicated to put in place because of the multidisciplinary nature of geomatics and the difficulties of defining the sector's scope.

Options:

- Emphasize training opportunities for the individual geomatics professional separate from the firm because of the small size of firms. Offer more flexible hours for training to fit into demanding schedules. Discussion should continue on how to be more creative in training provision and lower the cost.
- The report of the Advisory Committee for Online Learning entitled "The E-Learning E-Volution in Colleges and Universities" should be reviewed by geomatics faculties to assess how geomatics curricula could be integrated into a larger e-learning discussion.
- More formal mechanisms for providing credits for work experience and creating credit databases would be advantageous to the geomatics professional in seeking further training.

- Professional associations may not provide training although some would like to see them do that but can offer objective insights on where the industry is going, identifying the 'hot" demand areas, and focusing on the "branding" of geomatics.
- Arrange for the sharing of site licenses for online learning between firms, associations, and consortia to make it affordable for SMEs.
- Conferences and trade shows offer important training opportunities. A database of these opportunities could usefully be created by professional associations.
- Companies (over ten employees) should commit to a certain level of training (eg 5% of salary/10 days) that employees are entitled to.
- Courses that are the same throughout Canada (eg legal surveys) lend themselves to being made self-sustaining online. There is an unfilled need in the cadastral part of surveying for distance learning.
- Given the proliferation of courses and programs, especially in GIS, some quality control is going to be required. Industry needs some assurance on the quality of courses. Perhaps a voluntary certification would be simplest to put into practice.

Strategic and Tactical Plan

The Steering Committee considered this report and produced a strategic and tactical plan for addressing the human resources challenges. The plan recommends the creation of a sector council through Human Resources and Development Canada to oversee the development of human resources in the geomatics sector in Canada. The Committee's report is published under separate cover.

Table of Contents

1. Introduction

1. Introduction

1.1 Study Terms of Reference

Geomatics is an important, world competitive, and rapidly changing sector in the Canadian economy which is facing challenges to its markets, structure, and human resources. In order that Canada remain a key player in the sector, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, initiated this study to address the human resources issues. Hickling Arthurs Low (HAL) Corporation was commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The prime objective of the study is to provide a cohesive national plan for the development of a Canadian geomatics workforce which can make an optimal contribution to the sector's competitiveness. The study has analyzed the sector in its global setting and determined the implications of current and future market and technology changes for the sector and its labour force.

Geomatics is an umbrella term encompassing a number of disciplines and activities. The scope of the term is reflected in the diversity of the professional associations sponsoring the study. In our approach, we have been guided by the definitions of geomatics used by the Canadian Institute of Geomatics and the Geomatics Industry Association of Canada, respectively:

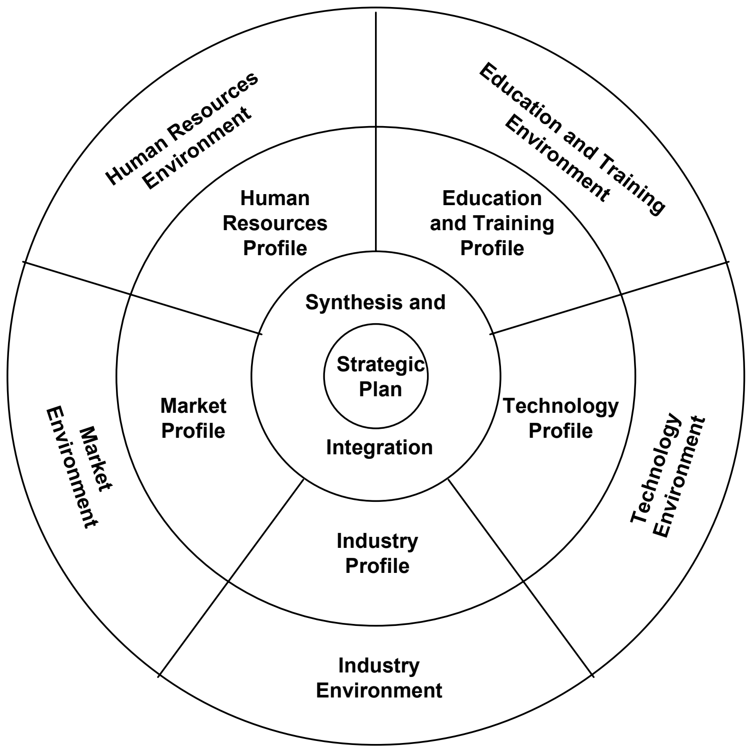
"Geomatics is a field of activities which, using a systemic approach, integrates all the means used to acquire and manage spatial data required as part of scientific, administrative, legal and technical operations involved in the process of the production and management of spatial information. These activities include, but are not limited to, cartography, control surveying, engineering surveying, geodesy, hydrography, land information management, land surveying, mining surveying, photogrammetry and remote sensing." (We have also included navigation and positioning in this list)

"Geomatics is a technology and service sector focusing on the acquisition, storage, analysis, dissemination and management of geographically referenced information for improved decision-making."

1.2 Study Approach

An overview of the structure of our study is provided in Figure 1-1. At the core is the strategic and tactical plan for human resource development in the Canadian geomatics sector that is the ultimate objective of the study. The strategic and tactical planning exercise will be founded on this report which is based on the synthesis and integration of information from five geomatics-related research areas; industry structure, markets, technologies, human resources, and education and training. The terms of reference for the study refers to these areas as modules; Module 1 (Business Environment - Market and Industry), Module 2 (Technology), Module 3 (Human Resources Profile and Outlook), Module 4 (Education and Training), and Module 5 (Strategic and Tactical Sectoral Solutions).

Figure 1-1: Study Structure



For each of the research areas, profiles have been developed that characterize the current and forecasted Canadian situation in a global context. The wider environmental context has also been assessed, covering factors outside of the geomatics sector such as economic cycles that have an impact on the functioning of the sector.

The report describes the human resources situation in geomatics in Canada today and identifies and assesses the human resources issues the country will be facing over the next few years. These issues are highlighted in the conclusions (Chapter 7) and have been drawn from our analysis of the profiles, that is, markets (Chapter 2), industry (Chapter 3), technology (Chapter 4), education and training (Chapter 5), and human resources (Chapter 6).

The profiles and this report are based on information and perspectives compiled from survey information, interviews, a literature review, workshop results, and our analysis. Information related to our data collection instruments is contained in the appendices to this report: workshop reports (Appendix A), interview list and guides (Appendix B), survey methodology (Appendix C), and literature review (Appendix D), and survey forms (appendix E). An inventory of geomatics-related courses offered by Canadian universities and colleges are available on request from the Canadian Institute for Geomatics.

Large numbers of people involved in geomatics in Canada were consulted in the course of the study. Our survey went out to about 4,000 individuals and we interviewed over 100 active as producers and users of geospatioal information in industry, government, universities and colleges. The workshops were held in five cities across the country. We believe, consequently, that the report provides a comprehensive picture of the changes that are influencing geomatics in Canada and, as such, a sound basis for effective planning by all sectors on human resources in geomatics.

The Canadian geographic coverage of the study data collection is shown in Table 1-1 which indicates the distribution of interviewees, survey recipients and respondents, and workshop participants by province.

Table 1-1: Study Geographic Coverage

	BC	AB	SK	MB	ON	QC	NB	NS	PE	NF	YT	NT	International	Total
Interviews	14	17	2	1	23	18	4	4	-	2	1	-	11	97
Surveys	91	94	12	33	258	213	36	42	5	17	3	9	51	864
Workshops	4	8	1	-	11	8	1	7	-	-	1	-	-	41

2. Market Profile

2. Market Profile

2.1 Introduction

The market profile will describe current and projected states of the market for Canadian geomatics products and services. The profile will include factors affecting the dynamics of changing user needs.

From the literature review, for the 2003 to 2004 time frame the world's total geomatics annual market may be as high as $30 to 40 billion (US) dollars, or $45 to $67 billion Canadian dollars. This number excludes the cost of the space segment. At the average income per employee for 1996 in Canada, this would be the equivalent of 496,000 people worldwide. In fact, the employment worldwide in this field is far more – earnings per employee are far lower overseas. China alone has 60,000 people in their National Survey Department alone, and an estimated 30,000 involved in remote sensing. Many more are involved in GIS, GPS, and related services at the National and state levels.

A number of $30 to $40 billion dollars for the worldwide market (or about $24 billion for 2000/2001 and $26.5 billion for 2001/2002) is meaningless in the context of what this may mean to Canada and the human resource issues faced by its geomatics sector. Dealt with first here are the market issues, each of which impacts human resources: training, education, availability of suitable human resources as and when needed, recruitment and retention. The key market issues are: what will Canada's market share be – and in which areas? What is driving the market? What factors affect Canada's share? What opportunities may exist to improve market share? What threats exist that may reduce market share or income? What will be the human resource impacts of these opportunities and threats?

The market profile as defined for this study includes an assessment of the factors affecting the market in general, those impinging on the Canadian segment of the industry in particular, and a market forecast based on a combination of literature review, information coming from the detailed interviews, an extensive survey of the geomatics sector (professionals, industry, education institutions, research institutions, users) and an analysis performed by the team. This information is collected and presented with the intent of then projecting the nature and extent of the market's impact on key human resource parameters.

It should be noted that some of this review includes proprietary information derived from studies purchased by the consulting team, as well as some purchased by Geomatics Canada and its constituent branches. While these proprietary market studies, largely done for markets outside Canada, provide specific information for these markets, they are not regarded here as being definitive, specific enough for our purposes, and/or entirely accurate. This is so for a number of reasons. First and foremost, many are dated and have not adequately forecast the drivers we discuss here that are now driving the market. Second, most do not deal with the specifics of Canada. Third, some are self-serving, having been done for clients advancing one or another of the involved technologies. Fourth, the methodology in some seems questionable – to the point where some seem to have double counted elements of the market. While we have used these various studies to test our own hypotheses, they are not cited here in detail. For that reason, this report does not reveal specifics of any one study and can therefore be regarded as being open for release to the Canadian community.

This report responds to the specific market requirements as set out in the Request for Proposal:

- Market drivers underlying the projected growth trends;
- Barriers to domestic and international market access;
- Competitiveness factors in the geomatics market;
- Breakdown of the geomatics market by major market segments (private and public sectors);
- Market growth forecasts (2000-2005) by major market segments.

The interviews and survey conducted within the study to date have not only confirmed that there is a great deal of change taking place, with more projected for the future, but also that the change is accelerating and that there is a great deal of uncertainty about where that change will take us in terms of the market, demand for human resources, as well as the growing problems of recruitment and retention now being encountered in the more visible high technology sector. The disagreement between different groups interviewed on where the future will take us is clear. Some see tremendous growth and success, while others see stagnation and some businesses failing. There is in part as a result a growing schism in the community and lack of clarity of the sector's sense of identity. What has emerged is one double-barreled finding: at no time since World War II have there been more opportunities for geomatics in Canada, and at the same time there have never been more threats than are now looming over the industry.

As we catalogue the bewildering array of market drivers, barriers, threats, and opportunities – all overlaid by rapidly changing policies and interests among our own governments, as well as those of our clients and competitors, it has made the task of market assessment seem at best daunting. There appear to be too many variables and too many "what-ifs" to accurately forecast the future market. However, we have here tried to identify the basic assumptions behind our projections. We have been given more confidence in these projections having had the benefit of the inputs of a highly experienced team, backed by a world class industry, and a set of governments seemingly ready to embrace change in geomatics and use it to the advantage of Canada and its industry.

2.2 Market Drivers

2.2.1 Introduction: Defining the Market Drivers

As has been recognized in the RFP, and is further demonstrated through the interviews, surveys and literature review, the industry is changing rapidly and dramatically with even more change projected over the coming two years. As has been recognized by many key figures in and observers of the industry, a key factor has been the convergence of technologies and the growing awareness of the importance of spatial data, especially as it is delivered to the desktop[1].

[1] See S.J. Camaratta quoted in GeoAsia Pacific Conference 2000 Opening Panel Session, summary published in the December 2000 issue of Geo-Asia Pacific Magazine.

During the last decade, the entire nature and structure of the industry, profession, and constituent disciplines have changed to such an extent that geomatics is practically un-definable in terms of the practitioner of ten or even five years ago. There is some question as to what is included in geomatics – a sense of identify is lacking. Indeed, the leader of one major institution with geomatics in its name, and included in the group of mandatory interviews, told us in a follow-up to an interview that his institution was not in geomatics! The pace of change continues to accelerate at such a rate as to demand the acknowledgement of the need for a new technology, business and human resource model - a new Canadian vision for the next ten years.

The industry is changing dramatically with the influence of technology on data production, storage and distribution. These changes are having a marked impact on employment in the geomatics sector as well as on education and training. In the 1960s for example, typing was a "commercial" subject, not generally taken by those going on to university. Today, under the name "keyboarding," typing is a useful subject especially for those going on to higher education. What role will international organizations play in the market? Will there be a new focus on international aid in our field with the recognition that geomatics is one of the fundamental elements of infrastructure? How will those specializing in international development be trained and to what level of competence? Will there be a new mapping program in Canada as may be inferred from a recent RFP? What can one infer from recent interest in CIDA in the field? What changes in data pricing and distribution policy will take place as a result of another study currently being done?

Obviously the factors driving these changes are many, complex, and overlapping in their impact on human resources. Some are cumulative – adding more impetus to change as each is brought to bear. Other factors tend to cancel each other out – leading to a situation that may not be changing at all in some respects. This section attempts to address the nature of the market drivers identified in the literature, by those interviewed, and by the team we have brought together to focus on the study. These are then brought together in the main body of the report in terms of their impacts on human resources.

The key pressures on the geomatics sector can be characterized along several axes, each of which has a different impact on each sub-sector, from remote sensing to land survey, making analysis of the sector especially challenging for those lacking a clear understanding of the field, the technology, its many sub-disciplines, and how they are changing. The market drivers include: technological pressures, competitive pressures, economic pressures, government policy pressures, business pressures, and human resource factors, all of which interact with each other and all of which are also overlaid by changes in the more general business context. In addition, there are a series of more specific elements that have been identified through the interview process and through the analysis of the survey results. These are all presented below, and elaborated upon in the following sections.

2.2.2 The Economy

Geomatics is becoming more and more like other sectors of the Canadian economy. It is subject to the same Internet pressures, globalization, requirements for sound financial management, and it is increasingly being bought up by foreign (often US) interests. The key business pressures that must be dealt according to the industry survey and interviews are the management and application of technology, change management (including management of growth), financing, and the continuing issue of marketing.

The geomatics industry is influenced by national economic trends and hence suffers to a certain extent with general downturns, and benefits from general upturns. This is reflected in the industry survey in which 78% saw the international business environment as very influential or influential, while 88% saw the national business environment as very influential or influential and 84% saw the regional environmental as being either influential or very influential.

Geomatics activity seems particularly linked to the cycles prevalent in natural resources (forestry in British Columbia, agriculture in Saskatchewan, mining in Northern Ontario, oil and gas in Alberta, and off-shore activity in Nova Scotia and Newfoundland). This linkage, identified in several interviews is born out by the responses to the industry survey in which almost 75% saw commodity prices as being important factors influencing change in the industry, and a significant number of companies saw the natural resource areas as their primary markets. Some geomatics segments, such as GIS and remote sensing, seem to be largely immune to such cycles. Indeed, some have remarked on the fact that growth in remote sensing has often been seen in the face of severe economic problems. In such cases it has been argued that economic problems often turn into growth opportunities for geomatics. The reason for this is that, in such times, industry and governments seek to become more efficient and the use of geomatics can often lead to more efficient operations[2].

As the Canadian economy is changing more and more from a natural resource economy to a knowledge-based economy, there is debate as to the impact on geomatics. In Alberta, for example, the oil and gas industry, while still important, is no longer dominant – technology, manufacturing, and services have greatly increased in value according to recent studies by government and industry groups cited in the press. As technology and services become more important, it would appear to some observers that the need for certain geomatics services and products will increase. This appears to be the case from the interviews, and from the industry survey there are clear indications of where growth is expected to be greatest. Decision support, GIS, and navigation and positioning are all identified as having high growth potential as a result of a number of factors including the convergence of a number of technologies and movement of geomatics to the desk top, while land survey is looked at as being primarily flat or in decline. However, careful study of the industry survey results suggests that such statements about land surveying may be overly simplistic. This is explained in more detail below.

There are a number of similarities with the high technology sector. First is the fact that there are now a number of individuals who have been involved in successful geomatics business ventures that are now operating as business consultants and investors across Canada. Dr. John MacDonald of British Columbia, Michael Kirby of Ottawa, and Guy Rochon of Montreal are but three examples. The presence of such individuals and the interest of new consulting groups in this business area should bolster the success

[2] See ***GIS User***: April 1998, page 60.

rate from what it has been, if all other factors remain constant. The assumption of constancy is one that should, of course, be questioned, given the rapid changes that are taking place.

However, regardless of any other changes or factors being considered, location decisions must be made. Targeted marketing is increasing dramatically, and technology itself has become both a medium to deliver geospatial information, while the technology industry is at the same time becoming a user increasingly dependent upon geo-spatial information. This is all coming about as a response throughout the business community to society's growing spatial awareness and use of spatial data in decision making at all levels from personal to corporate. Technology is such an important driver in so many different ways that is discussed separately elsewhere.

The question remains, with the current focus that much of the industry appears to have on natural resources, as seen from our survey and interviews, how well will the industry be able to adapt? Some have argued that the natural resource industries have already become involved in the first wave of the knowledge industry – these industries are already using significant elements of high technology. Geomatics, these people would argue, is simply one of the first knowledge tools to be adopted. If this is the case, then we can expect to see further exports of the application and tools associated with the application of this knowledge in other markets in response to the convergence of technologies. Based on the importance of natural resources and environment to the respondents to the industry survey these are still important areas and will continue to be important areas. Another critical factor in shaping market drivers is that much of the use of such information requires some local knowledge. It seems hard to conceive of a firm based in India or Indonesia doing a forest map, building a forest GIS, or updating subtle changes in an environmental map of a Canadian region. These sorts of jobs will, more likely than not, remain here as will others that require some level of local knowledge. It is not difficult to conceive of offshore companies making a topographic map or a DEM.

In less developed countries the need for geomatics is increasing, and can be expected to increase exponentially in the coming decade. This has been recognized by several international organizations, such as the IADB, UN, World Bank, etc[3] as well as by various agencies of the Government of Canada. This is in part discussed in the following section.

Another factor related in part to the economy is the fact that Canada (and the rest of the world) is becoming more spatially aware. Press coverage of everything from GPS to earth observation is on the rise. Land titling, environmental monitoring in Vietnam, pronouncements of former Vice President Gore of the USA, and many more geomatics-based stories have appeared in Canada's national media over the past year. Furthermore, general as well as business press coverage of these stories has been increasing – from the use of GPS in cars to the importance of geospatial data infrastructure. Similar press coverage has been evident in many of the so-called developing nations for some years. The

[3] See for example: Constance, Paul. (1998) "Geographic Imaging: Mapping in the Information Age" A Special Supplement in ***IDB America*** Inter American Development Bank, Washington, D.C. September-October 1998. Pp. 11-18; Hamilton, R. (2000) "Beyond Economics" "Is Geography Destiny" and "A Demographic Opportunity" in ***IDB America*** Inter American Development Bank, Washington, D.C. March-April 2000. Pp 2-9.; and footnote 4.

consulting team has in their files many examples from India, Malaysia, Thailand, China and other countries dating back into the mid-1980s. Quite simply, we are living in a world that is much more spatially aware than it was when the last major mapping programs were begun in Canada.

2.2.3 Government Policy Pressures

Government policy is important to geomatics in several often inter-related ways. In our survey, almost 95% of the respondents identified government policies as being influential or very influential in influencing change. Almost 94 % suggested data pricing was influential or very influential as well. In addition, our survey indicted that 76% of those in industry see partnerships and strategic alliances with governments to be important or very important for their success in business activities.

Governments serve in positive ways as clients, supporters of research, keepers of standards, sponsors of foreign aid, supporters of exports, and windows on international opportunities, demonstrators of local capability, and catalysts for industrial development. All of these have been identified by those interviewed by the study team. In addition, the study has identified a number of ways in which governments can impact the market in negative ways. These are reflected in both the interviews and the results of the survey. First, government (at all three levels) remains a key client. Purchasing decisions and purchasing policy (such as make-or-buy, contracting out) helped build the early geomatics industry in Canada. In this way, governments have long been catalysts for industrial development. Removal of some of the competitive pressures (to win federal business for example) resulted in some decline in international competitiveness of the Canadian aerial surveying and mapping industry through late 1970s and into the 1980s. In addition to a large influx of what is seen to be strategic funding under Geoconnections over five years aimed at developing a national geospatial data infrastructure (the capacity to connect people to geographic data across Canada), a contract has recently been let to investigate the business case for creating a new topographic data base, or revamping the existing one. The first is certain to impact the market, and the need for people trained in the field. The second has the potential to spur the development of industry, which will in turn be in a position to meet offshore needs for products and services.

While this may present a rosy picture, it does not obviate two other drivers – the need to develop adequate human resources and the competitive factors in the market place. Canada’s competition is not idly sitting by waiting for us to catch up or keep ahead of them. Globalization in the field is now a reality. This is further discussed below. In addition to being a client, governments have also had an integral role to play in the case of geomatics in research through in-house R&D, as well as by providing funding through a variety of innovative programs, including contracting out, contracting support and systems development, unsolicited proposal funds, NSERC support of research, etc). The government has been a significant employer of researchers – scientists, engineers and other professionals who often returned to university or went on to careers in industry.

In remote sensing, many senior researchers in both government and academe are nearing retirement age and will have to be replaced in both government and industry has already begun this renewal process, a process greatly complicated by the massive cutbacks of 1994-96. Usually government research tends to be in pre-commercial areas, or in the development of highly specialized and expensive systems. GIS and GPS, vibrant commercial sectors on their own, have not benefited greatly from recent government research, although it is clear that governments have, to a large degree, met their enabling roles quite well. This is reflected in the interviews conducted with industry.

In the interviews, it was said that over the past twenty years government support for remote sensing has been adequate, although a focus on radar for some time was seen as detrimental to the development of other areas. Over the same period the only significant research in mapping by governments appears to have been done by remote sensing. The NRC, which once had a significant group doing ground-breaking work in photogrammetry, has been out of mapping R&D for many years. This focus on remote sensing research by the federal government, some have said, explains the rapid increase in the number of companies involved in remote sensing, and the stagnancy in mapping.[4] Others suggest that the situation is far more complex and involves elements like data distribution and pricing policies.

Initially, base mapping programs were almost all driven by governments at the federal and provincial level. However, that model is, according to our interviews, rapidly evolving. Data sharing has seen the involvement of utilities, the private sector and crown corporations. Access to satellite imagery, access to GPS and augmented GPS signals – all of these have impacted geomatics. While Canada has adopted a quasi-commercial model for RADARSAT, for example, some competing systems (both planned and existing) distribute or will distribute information for free, or nearly so, disrupting the market.

The government should have a key role to play in maintaining consistent standards. However, the question of standards has been raised as a key issue during more than one of the interviews with major users. In our industry responses, standards were seen to be very influential by almost 19% and influential by almost 53% as barriers to market development. One individual noted that it was easier to do work across the US border into Canada and vice-versa than it was between certain provinces. Furthermore, with the rapid aging of the federal topographic data base, and the rapid growth of provincial digital base mapping programs at an effective scale on the order of 1:20,000, provincial programs are taking on more importance in many applications than the federal data base. This provincial activity and the potential for new federal funding can be expected to lead to significant new contracts opportunities domestically, offsetting to a certain extent the current downward trend in mapping service sales brought about by the "faster-cheaper-better" results offered by better software, converging technologies and low-cost off-shore services.

Another aspect of policy seldom discussed outside of the profession is the legal basis or legal framework for surveying and mapping. The obvious first topic under a discussion of legal framework is the cadastre. At the recent GeoAsia Pacific meeting in Bangkok, Ulrich Neunfinger, CEO of Sicad Geomatics, stated during the Opening Panel Discussion that the fundamental problem

[4] A comprehensive history of geomatics in Canada from 1947 to 1994 can be found in McGrath and Sebert, 1999.

holding back development in Russia was the lack of a legal framework for the cadastre or land holding system. With that cadastre in place, development can continue. This legal aspect is all too often taken for granted but is, in fact, the basis for much of the activity of the land survey industry in Canada.

At one time when buying property it was taken for granted that one would consult with a lawyer and a land surveyor to ensure that the legal description was both accurate and consistent with what was on the ground. Indeed, in some areas one could not obtain a mortgage without a recent land survey. Now, however, many home buyers are purchasing title insurance for a fraction of the price of a legal survey. Paradoxically, the negative impact on the survey profession from such an approach can be expected to increase in Canada where the population has had a long history of good service from the land survey industry. Because the land survey profession has typically done a "good job", people are willing to buy insurance – gambling that their title is secure.

While the cadastre is the first obvious choice to discuss under legal basis, there are many other legal aspects that have impacted or which could impact the industry. In some jurisdictions forestry companies must file information proving that what they cut was what (and where) they were supposed to cut. In some other situations, "before and after" aerial photography must be used to show that the surrounding environment has been returned to its original condition after construction of a highway or pipeline. Through the popularization of the use of before and after imagery by many general interest magazines with high readership (such as National Geographic and Canadian Geographic), we can expect that the public's awareness of such applications to expand. With that expansion, it seems logical to assume that the public's expectation that imagery will be used in this way will also increase. The legal precedent is clear: aerial photography has long been accepted in courts of law, as was shown in a survey of the environmental remote sensing literature some years ago by CCRS.[5]

At the proverbial stroke of a pen, government actions can create or destroy a segment of the geomatics industry. It is expected that for some aspects of the industry, the industry will grow over the coming years as a result of government edict. While Canadian government policy has usually been supportive of the geomatics industry, a recent study by Ryerson et al (1999) suggests that there is still room for improvement. One of the key areas of support includes international aid and trade. Recent progress includes an initiative undertaken by the Canadian Space Agency, working with Geomatics Canada and industry (one of the senior consultants involved here), which convinced a major UN gathering that geo-spatial data was as essential to a nation's infrastructure as energy, transportation, communication, education, and health.[6]

According to some in industry, this advance by two branches of government and industry could become of more benefit to other

[5] See Ryerson, R.A. (1994) "The Application of Remote Sensing and GIS to Environmental Data Collection: A Review" Invited Keynote Paper International Conference on Remote Sensing and GIS: Environmental Planning Hyderabad, India. A longer version was distributed at various workshops on environmental remote sensing hosted by CCRS in 1994-1995.

[6] See the Adopted Propositions from Committee II Agenda item 11, Economic and Societal benefits related to "The Workshop on Developing Indigenous Earth Observation Industrial Capabilities in Developing Countries" in the Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, Austria. July 27, 1999.

countries than to Canada if action is not taken by the government to move forward to support the development of geospatial infrastructures as part of aid programs. While other countries directly supported by their aid agencies have already begun to take advantage of this new reality, Canada has been somewhat slower off the mark. However, having had similar programs in the past, and having begun to look at geomatics much more seriously in the past year, recent signs in this area in Canada are encouraging.

We understand that CIDA's Asia Branch has prepared an internal document on geomatics and its application in development with the informal assistance of industry, and a recent review of the CIDA sponsored and CCRS executed ProRADAR project identified it as one of the best of more than 200 development projects and activities the reviewers had ever reviewed[7]. While the more independent IDRC has not recently funded significant new activities, for a long time it played a catalytic role in geomatics, recognizing as it did the important role of geomatics in a developing nation's infrastructure. CIDA's policy could dramatically affect the future growth of the industry.

In the more traditional area of export support, DFAIT has conducted several general analyses of the geomatics markets over the past few years in areas as diverse as the Chicago region, New England, Mexico, etc. Many in the Trade Commissioner Service have received familiarization presentations in various aspects of geomatics as part of their training before being posted overseas. In early 2001, all of the Trade Commissioners dealing with Sub-Saharan Africa were given a presentation under the auspices of GIAC on the role of geomatics, especially within the context of development.

In addition, there has also been an active group of space counsellors and space-oriented trade officials funded by DFAIT and the CSA. These individuals are located at space-faring nations – those in Paris and Washington dealing with remote sensing are most germane here. The new space counselor in Paris, Florian Guertin, has spent more than 25 years involved in remote sensing at CCRS and the CSA. As well, there are knowledgeable people dealing with the development banks based at the embassies in Manila (ADB), Washington (IADB and World Bank), and Abidjan (AfDB). As well, Trade Commissioners have been posted to New York to work on United Nations procurement. Generally, these people are senior, experienced, and based in key places for geomatics sales. All have been passing leads to Canadian industry either directly or through industry associations; if this continues, it will undoubtedly yield benefits.

Most companies involved in exporting, especially of products, believe that it is particularly important for their home governments to buy and use the technology. Certainly in the Surveys and Mapping Branch and in CCRS, this was quite common some years ago. Our study has determined that many exporters no longer rely on the federal government to do so, but increasingly local or provincial governments have become demonstrators of local capability in geomatics. Others have recognized that budget cuts over the past few years have resulted in fewer funds with which to buy such equipment.

Contracting out has generally been beneficial. However, at times it has been negative in terms of its implementation. It

[7] The review team was headed by Dr. Eduardo Quiroga,of Kirkland, Quebec.

has been beneficial in that it has resulted in the development of expertise in industry to serve the needs that governments have, thus leading to an exportable capability. The implementation has not always been helpful. In some cases competition for these often large contracts has been so intense that the price paid has been too low to make a profit.

One Vice President of a small profitable export oriented service company with 25 employees noted that they spent over $100,000 developing a capability, were certified, and yet won no work. "All of the business went to people who bought the contracts, who low-balled the bid to win the work. They eventually failed to fully deliver, and none of them were really involved in export and none of them ever won any international work. And yet other countries were begging for people to bid. There were millions of dollars of contracts. Since we and another export-oriented company won nothing in Canada we were excluded from these bids and those who did win the work were never sound enough to be able to bid. Frustrating!"

While governments can and do have many positive impacts on geomatics, as noted above they can unwittingly also have a negative impact. In addition to issues surrounding standards, contracting policy, lack of a showcase, etc. noted above, governments can confuse the market place by competing with the private sector or by having inconsistent policies. Indeed, in several cases during interviews some government agencies (both federal and provincial) involved in geomatics were seen as competitors and are no longer part of some exporters marketing programs.

The issues most frequently laid at the foot of government in Canada according to our interviews and analysis that negatively impacts the development of geomatics are the policies surrounding digital data distribution, pricing, and use. Pricing was noted as a factor affecting change by almost 94% of those in industry and as a barrier to market development by 86% of industry respondents. It was noted by a number of those interviewed that pricing policies in the United States have resulted in broader and deeper penetration of geomatics in that country, with benefits accruing to the geomatics industry and those who use the technology, with a negative impact on their Canadian –based competitors. While this is not a focus of the present study, and while there is another contract in place to study this issue under the Geoconnections Policy Node, it should be recognized that the price issue is seen to be critical by users and industry alike.

The analysis of the barriers to business development more fully explores some of the more interesting relationships between government policy and market development.

2.2.4 Technological Drivers

Technology has almost always driven at least some parts of the geomatics sector. It can be argued from our findings that this continues to be the case. While technology is discussed more fully in Chapter 4, it is brought out here inasmuch as it affects the market.

Our study shows that the Internet has become a commonly cited reason for there to be an exploding demand for geospatial data. Over 92% of the respondents to our industry survey have identified the Internet as a major factor affecting change. Quite simply, the Internet provides a mechanism for low cost dissemination of both data and tools. When one begins to cross tabulate these – dissemination, tools, data, and the Internet, we come up with most of what is seen as important in technology today.

Interest in geomatics is also now being shown by those from outside the traditional geomatics fields. One of the more complex issues brought on by this broader interest is that the need for and value of precision in measurement in certain circumstances is not always shared by those from outside the field. The difficulty is that some want high precision everywhere - whether it is needed or not while many others see no need for any precision. It is clear that the base information must be reliable and accurate. It is equally clear that not all users will need the same level of precision, nor require the same level of training. For example, for a person using geo-demographics to target the mailing of their literature, if the house address is correct and the person they expect to live in the house does indeed live in that house, then the marketer will be happy. However, if you are installing a gas line to that house, you will need to know within a few centimeters where the buried hydro, telephone and other services are located.

The implications for human resources and education are significant. While there will remain a need for the highly specialized geomatics specialist, our interviews and results suggest that there will be a growing demand for those with a solid background in a user discipline (forestry, urban planning, etc), with a general understanding of the geomatics field.

Standards will remain important for at least the base information. One individual interviewed stated that standards are a way of maintaining hegemony over the field from interlopers. Another noted that it is essential to ensure that our data and decisions based on these data are trusted. Another said that such standards are needed to avoid lawsuits. Our interviews and survey results suggest that all are reasons to different segments of the community.

In addition to the Internet a number of other technologies have become very important. These are discussed in Chapter 4 which summarizes our survey results on the significance of the technologies for industry (Table 4-1).

2.3 Barriers to Domestic and International Market Access

2.3.1 Introduction

Barriers to market access can be discussed under several headings. The substantive ones used here are domestic and international. Others encountered through the literature review, conducted interviews and several surveys would group them as policy, technology, and standards.

While the literature has been reviewed elsewhere in this study, it is useful here to review the 1996 report by the Interagency Committee on Geomatics at http://cgdi.gc.ca/iacg/iacg/barrier1.htm. It identifies the barriers which that group saw to the use of geomatics. The reader is referred to the original source for a more complete discussion and examples - here only the key points are presented.

The major barriers were seen to be both technical and policy related. Data and data delivery systems were not well structured to deliver information and the necessary policies and information are often lacking. In addition, standards were an issue.

Policy issues included: data ownership and use (including issues such as copyright related to who owns what at what stage of the value added chain); data directories that accurately provide users with information on what data are available; cost recovery (which is in conflict with encouraging broad general use); liability associated with use –

including poor decision making and accidents (hydrographic and aeronautic charts are the most obvious cases); and limited use – if there was wide scale use, there would be more knowledge, broader applications and likely some serendipity.

Technological issues include: the need for high speed telecommunications networks; GPS used to replace certain elements of the survey industry for positioning information; data acquired with old technology (and thus not compatible with new or other data).

Issues related to standards include data compatibility standards, data exchange standards, data quality and documentation standards, and the entire field of standards development. Under each one can find a great deal of discussion and detail. The results of this study suggest that many of the technical issues have been or are being dealt with – many through Geconnections. Similarly, many of the policy issues also seem to be if not well in hand, at least well understood, with remedial actions being planned or taken under Geoconnections.

2.3.2 Domestic Access

Over 92% of industry respondents saw the ability of the market to absorb new ideas to be either a very influential or influential barrier to market development (Table 2-1). The question that must be asked is, is this not a failing of the industry's marketing? By definition, the market cannot be "wrong". Almost 91% saw data access in the same way. 86% of industry respondents saw price of data as a very influential or influential barrier to domestic and international market development. 83% saw access to capital as very influential or influential. A similar percentage saw cost of technology in the same way. Few saw standards as very influential (under 19%) but 54% saw them as influential.

A previous study (Ryerson, 1999) noted that one of the most critical business factors in the geomatics industry in Canada is lack of investment, followed by inadequate marketing and business development expertise in the industry. The first is born out by this study, while the second is in a way as well – the most important limitation noted was the inability of the market to absorb new ideas. It is marketing and business development that will encourage the use of these new ideas.

Table 2-1: Barriers to Growth and Market Development

Barriers to Market Access	Very Influential	Influential	Not Influential
Ability of the market to absorb new ideas	45.65%	45.65%	8.70%
Access to capital	36.26%	46.15%	17.58%
Absence of standards	18.89%	54.44%	26.67%
Access to data	45.83%	44.79%	9.38%
Cost of doing business internationally	38.89%	38.89%	22.22%
Cost of technology	34.00%	51.00%	15.00%
Non-tariff barriers - provincial	14.29%	29.67%	56.04%
Non-tariff barriers - international	14.77%	34.09%	51.14%
Pricing of data	43.62%	42.55%	13.83%
Problems with receiving payment	15.79%	38.16%	46.05%
Subsidized competition from abroad	28.09%	24.72%	47.19%
Other	38.46%	7.69%	53.85%

All too often these problems are exacerbated by the technical orientation of those leading the smaller innovative companies. Technology pull has tended to be the norm in the industry in Canada and elsewhere. Recently a number of individuals without a strong technical geomatics background have headed relatively successful companies. With rapid changes in technology, and the need for the ability to synthesize several technologies, it is not clear whether or not the time of the technical "whiz" is over. Regardless, however, it is clear that the ability to understand the technology, identify a niche market, convince that market that you can solve its problems, are all critical in removing barriers to the market.

While there are differing standards and procurement policies from province to province, and while there has been some passionate discussion on this topic by some of those interviewed, the survey does not end up highlighting it as an across-the-board issue. While non-tariff inter-provincial barriers were seen as important by some of those interviewed, and while some spoke with great passion on the subject, in the industry survey only 12.5% saw them as very influential and 26.3% as influential. This suggests that there is a marked difference of views across different geomatics sectors.

2.3.3 International Access

Cost was seen as a very influential barrier to accessing the international market by 39%, while another 39% saw it as influential. This result suggests that many of those involved in the Canadian industry already know what it takes to work internationally.

The intervention of government in the market has caused some interesting shifts in the commercial market. Examples include the Indian series of satellites, the new pricing policy for Landsat compared to the more commercial systems, the different approach to pricing of geo-spatial data in Canada (high) and the USA (low), and the access to data (generally easy in developed countries and difficult in developing countries). In addition there are non-tariff trade barriers. In the USA, standards for mapping associated with highways and the military all but preclude the use of Canadian-made technology. However, in our survey non-tariff trade barriers were seen as influential or very influential by only 49% of respondents. It was seen as very influential by only 15%. This result is somewhat surprising given the difficulties reported in the interviews of certain segments having difficulties in accessing some types of contracts in some jurisdictions.

While not specifically identified with international market access in the survey, receiving payment is most often associated in many people's minds with international work. It was considered to be very influential by only 15% of respondents and influential by another 40%.

Even less influential to the industry at large was the issue of subsidized competition from abroad. 47% of the responses suggested that industry saw it as not influential. However, a significant minority of 28.1% saw it as very influential, and another 24.7% saw it as influential. This appears to vary by the area of geomatics in which companies work. It would appear that those more active in exporting see this as more of an issue. It was often raised by major service companies in mapping and remote sensing in both interviews and in the survey.

Related to market understanding, which has been seen as a key barrier to market access, is the widening gulf called a "digital divide" by Dr. C. He[8] of the FAO. This divide or gap is between those who have ready access to and use of digital geomatics information and those who don't. This typically splits along lines of developed and undeveloped countries. Interestingly, those now under-developed countries who seem to be making rapid strides forward are often the same ones that have strong geo-spatial data programs. Dr. He has suggested that there is a chain of issues concerning spatial information availability, accessibility, understandability and usefulness which must be understood and studied to overcome this imbalance in geospatial data use. These are the same issues that must be understood and overcome to effectively market geomatics products and services overseas.

A final international factor is NAFTA. While NAFTA should make it easier to sell into the United States and Canada, our interviews suggest that this is not the case. "There is only free trade in one direction" said one senior individual in a large firm. Others have found that selling into the United States is, if anything, easier than selling in Canada. While there are opportunities, there are cross-border issues that will not soon disappear. However, a number of Canadian companies have been and are very successful in the United States – using a combination of low cost, solid experience, high technology, and aggressive marketing. A key factor for success in the USA market is having an office in the United States – and treating it as a different market. One interview suggested that the USA is sufficiently different that you have to treat it as different to be effective. An earlier study[9] determined that companies that have US offices sell far more into the US than those who don't. Interestingly enough, US companies are advised to treat Canada as a separate market by their trade officials and industry associations.

A related issue is the fact that Canadian consultants often experience difficulties entering the USA and more seriously, citizenship barriers prevent those with dual Canadian-non USA citizenship to serve as subcontractors to American prime contractors across a range of quasi-sensitive high technology sectors, including many associated with remote sensing. This effectively limits the ability of many

8 He, C. (2000) "Bridging the Geo-information Gap" KeyNote Presentation, XIXth ISPRS, Amsterdam, July 2000.

9 Ryerson et al, 1999.

Canadian companies to provide products and services to US companies and agencies. This has been the major stumbling block for RADARSAT II – one of the factors causing Canada to enter into discussions and sign a contract with a European supplier. Similarly, the tax regime in the USA related to rolling over capital gains coming from investment in business gives US companies a significant advantage in buying Canadian companies compared to Canadian investors.

A third point of consideration in NAFTA is Mexico. Mexico is both an opportunity and a threat. Its mapping companies (some using Canadian technology) can already compete for base mapping programs. It can be expected that competition will increase. However, at the same time, there would appear to be an opportunity to sell more technology, more high level consulting services, and some of the infrastructure needed to make effective use of geospatial data.

2.4 Competitiveness Factors

Competitive pressures are coming from many directions. These pressures will have an impact on the success rate of the firms in or entering the business. These pressures, as evidenced by our survey and interviews, appear to be intensifying over time. The pressures come from larger cash-rich companies moving from the so-called dark or military intelligence world, as well as from high technology players like Microsoft and Oracle who see opportunity in the geospatial business. Oracle, for one, has moved very quickly in providing its products with a spatial dimension. Microsoft has a team of over 100 people developing its spatial products. An independent analysis of Microsoft's products published in Dimensions Magazine suggests that MapPoint could be bigger and more widely used than PowerPoint.

Technology is pushing geomatics to the desktop, lowering prices, and hence lowering barriers to entering the business – worldwide. Technology is demystifying the theory of many of the technical approaches to the discipline. What were once cumbersome and highly complicated series of calculations and analogue representations of algorithms are now embedded code in microprocessors. Evidence of this can be found in the $200 hand-held GPS units from Radio Shack or the combination of diskette and graphics cards that now replace analogue and analytical photogrammetric processes. When put into the hands of technically competent individuals in low-wage countries, such tools can have a dramatic impact on Canadian business. One CEO has told us that he intends to reduce his workforce here to almost zero and have the work done overseas. "I can charge my clients 25% less, reduce my costs by 50% - and still make 25% profit. I would be crazy not to do it." Job losses in such businesses seem inevitable.

Technology is also providing powerful tools for clients to use – be they in forestry, mining, municipal planning, the insurance industry, banking or retail. The fact that Microsoft is now offering a rudimentary GIS as a low cost option in Office 2000 suggests that the geomatics industry will never be the same. If Microsoft MapPoint sales projections hold true, the number of GIS-enabled seats in the United States will have tripled over the past 18 months. Technology is, as well, leading to new sources of data, new methods of distributing that data, and in effect to a whole new data provision industry that some maintain will bury the existing service industry, and which others suggest will be the salvation of the industry. Which it will be will have a profound impact on the demand for human resources over the coming five years. Whichever it is, and evidence from the literature, and analysis of our interviews and surveys suggest that demand will continue but that skill requirements will change.

Competitive pressures exist for all companies – large and small. Small companies face pressures from competition from larger better financed companies. The larger companies see certain elements of their business attacked by smaller niche-oriented companies. The typical mid-sized geomatics company employing 15-25 people sees competition from both sides – from large companies and very small companies. All Canadian companies involved in map creation also face competition from offshore suppliers. Consider that a digital photogrammetric technician in Canada is paid $28,000 per year, a similar person in Mexico will be paid about $10,000 (at the very high end), while an Indonesian may be paid as little as $2000. Even if productivity by the offshore people is only 50-75% that of the Canadian worker, access to low cost technology (as is being provided by successful Canadian companies) has in many cases made the offshore suppliers as cost-efficient as their Canadian counterparts who are often using exactly the same technology.

There will also be competition from those diversifying from related industries such as Boeing and Astrium. Still others have emerged from this industry with visions of creating a larger more all-encompassing business activity – like ESRI and MDA.

Larger multinational firms with access to capital, technology, and management resources are pushing down into smaller markets that were at one time too costly to reach and serve for the larger companies. The Internet has changed that. Market access and market understanding are now relatively unencumbered. It is a simple matter for a large company to sell from their large expensive data base over the Internet – with relatively low margins and potentially large profits. This is clear from the results of our survey mentioned above.

The most important signpost for this sort of activity was the $1.1 billion purchase of Mapquest by America On-Line. Inflated though it may have been, it is a serious wake-up call to those in the geomatics industry. The Internet has also allowed the resource manager in Regina, Saskatchewan to know exactly what the resource manager in Reno, Nevada is paying for similar information. Even more importantly, those entities operating across borders can easily compare what information costs them in different locations – and make decisions accordingly.

While most think of the USA and its large firms and dominant providers of software and low cost service providers from developing countries (often owned by larger multi-national firms such as Agra Baymount operating in KL and Singapore from their Florida base) as the competition, others are also emerging. Australia for example has begun to aggressively develop its own approach to competition and international business.

While the Internet has allowed large companies to move into smaller niche markets, it has also allowed the so-called basement operators to emulate larger companies – with web pages, direct selling, etc. Furthermore, the rapidly reducing cost of software tools has made many of these same basement operators competitive with larger firms in terms of technology. Our interviews do suggest that there are many ways in which the larger companies will remain competitive – access to training, standards, and source information to name but a few.

These same reduced costs of software coupled with more automation and intelligence built into software have also seen many companies in developing countries become both cost and quality competitive with Canadian firms. Companies in Mexico with annual salaries half those of Canada are, according to information collected, almost as accurate and almost as fast as Canadian counterparts against whom they have been measured – at about one-half the cost.

The firms in the middle are under intense pressures to find, occupy and defend a specific niche – and in some cases grow either larger or smaller to compete. Smaller firms, often more nimble, but certainly with fewer resources, have their own peculiar situations with which to deal. Some will be able to ride excellent ideas to growth and success. One group surveyed projects growth of 700% over the next two years, while a number of others project growth as high as 300%. The industry is no longer one for the risk-adverse weak of heart, or those without a well developed business plan and the funding and managerial capacity to achieve the targeted growth. Some will be small but highly profitable companies, and others will maintain a precarious existence, while still others will fail. The controlling factors appear to be solid management, marketing, and strategic planning.

Other competitors include multinationals now entering the business, those emerging from the "dark world" (or military intelligence community) in the USA, similar groups from Europe and elsewhere, as well as those from the emerging economies of the former Soviet Union. One interesting characteristic of the industry noted in the 1999 study done by our team is that few companies in the geomatics mapping, GIS, and remote sensing service business seem to reach more than 150 people. Those that do seem to either fail or dramatically downsize within three years. We believe that this is directly linked with the factors that must be assessed as part of this study – human resource management and business management.

In summary, competition is heating up as the industry worldwide seems poised for growth. Some in the Canadian industry look at the competitive situation with great trepidation. Others, including many of those interviewed and surveyed see it as providing tremendous opportunities for growth and profit. Both would appear to be right according to our analysis in this and earlier studies. As ever, a few are ignoring the situation. Those that do can be expected to disappear. That is a reality that no government policy will be able to prevent in an industry that has become as competitive as that which we are studying.

2.5 Market Growth Forecasts (2000-2005) by Major Market Segments

2.5.1 Introduction

As noted in the literature review, the markets for geomatics have been the focus of a large number of studies. The difficulty in making any projection here is threefold.

- Are these sub-sectors the correct ones to use?
- What is the base level of sales?
- What are the projections for the future?

In response to the first question, we have proposed the areas identified used for our survey response. These are: cartography, navigation and positioning, GIS, decision support, geodesy, land surveying, hydrography, remote sensing, photogrammetry, and consulting. Should these be broken into products and services?

Can they be so subdivided? One might also use the various applications areas in which work is done – agriculture, forestry, mining, etc. We have elected to provide commentary about the likely markets in the applications areas, and concentrate on the technical areas listed above, broken down where possible into products and services.

The second question on current sales is the hardest one to answer. While there have been some excellent summaries of the market done in the past for remote sensing and GIS (especially product sales), determining sales in most of the other areas is far more problematic. Furthermore, determining worldwide markets is, relative to determining sales in Canada, an easier goal. We have not found any current Canadian sales volume estimates for GIS products and services, never mind for sub-sectors such as cartography, photogrammetry, and the like. The available studies tend to be older, incomplete, or highly targeted. As an example of the latter, we do have access to a recent assessment of the GPS markets done by Andersen Consulting for Geomatics Canada. Their numbers are verifiable through corollary sources. We also have projections done by various consulting firms for various branches of the government, including two on remote sensing by this author.

The remaining source of information is the survey conducted as part of this activity. While it represents but a sample, there are a number of strengths associated with it. The response rate is as high or higher than that obtained by others. There is far more detailed information tied to market growth and a wide range of issues in human resources. Our literature review and association with the most complete study of this sort ever done in the USA (which has a five year time-table and a multi-million dollar budget) suggests that this HRDC-supported study is the most comprehensive look ever undertaken anywhere of geomatics at the intersect of human resources, markets, and the future. The survey results are used to calibrate existing estimates and project them into the future along with the associated human resource requirements.

The third question, projecting sales into the future, is relatively straightforward. It is based on a combination of survey results and our analysis. We have individual company-by company projections of growth in sales and employment. If we take these responses as the norm, assess them in light of the situation in the market, we can come up with an idea of growth. The only issue is how one takes into account the many complex and inter-related factors discussed above and how they affect the market.

Much of the worldwide market in remote sensing and GIS has already been reviewed in several proprietary studies to which we have had access through studies owned by the consulting team, purchased by the consulting team, or provided by the clients. In terms of GIS, the material we have examined is, compared to the literature review, both more detailed and newer since we have accessed the most recent versions of the major commercial studies by Daratech, as well as materials from several newer studies available either on-line or from the clients. The finest breakdown of interest to us here is North American. Projecting estimates for Canada alone is not usually possible.

If we look at the numbers cited in the sections following, 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.

2.5.2 Remote Sensing and GIS Markets[10]

2.5.2.1 Limitations to Market Assessments

In the study by Batterham (1997), sources cited state that "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." These numbers provide an excellent lead into the discussion of these markets. Taken at face value, these assessments seem reasonable and seem to be from reputable sources – such as the US Department of Commerce. However, as with many market assessments in this field, one should take a great deal of care in using them. The balance of this section explains this, and the market in GIS and remote sensing, in some detail.

The size of the global remote sensing market as projected by a variety of studies (Frost and Sullivan, KRS (Kodak Remote Sensing), May and Bossler, Industry Canada/GIAC, etc) varies considerably. The fact that there are many different numbers cited as the "market" may appear confusing to one just entering or beginning to study the field. The variability in the projected market is accounted for by the fact that the studies are counting and comparing not only the product but the tools used to produce the product.

Some studies include just satellite data sales – the value of remotely sensed data sold. Others include the fees charged to ground station operators plus the data value. Still others include both airborne and space-borne data sales and call it all remote sensing. Some include the value added to these data – usually taken to be between four and ten times the value of the data sold - depending upon the nature and use of the raw data. Other studies include the total value of the sensors, ground stations, satellites, etc. In some studies one can find double counting: they total the income of the system integrators plus the income of all of the sub-assembly suppliers.

The larger numbers tend to include the value of the satellites, sensors, launch, all data sales, ground station fees, ground stations, processing software, image interpretation, and integration of image data into a GIS. The biggest question in all of this is where one should draw the line between value added and GIS. The studies citing the remote sensing field as being in the $10 billion dollar range typically count more of the GIS activity than would normally be accepted in an accounting sense.

Some studies total the market for a given country. Some take into consideration changes in exchange rates, while others don't. Some count the assigned costs to government activities in economies dominated by central government spending – where there is almost no real cash expenditure on remote sensing. How does one compute the value of the input of an engineer in a developing country compared to that of a worker in Canada? For example, there may be twenty people doing image interpretation in a given agency in a developing country. They receive housing, schooling for their children, access to health care, and are paid wages far below what they would make in Canada. How does one

[10] Much of this section is drawn from the literature review performed for this study. It is presented here to provide a complete picture of the situation leading up to the assignment of numbers to the various markets.

assign a value to their work to arrive at the "value of remote sensing market" in their country? Is this really a market or an activity to which someone has arbitrarily assigned a market value?

In such cases, the concept of realizable market is useful. How much of the market is accessible to offshore suppliers? Of that market, how much is accessible to Canada? While Canada has been very successful in winning open bids in the remote sensing market, the fact (and problem) is that not many bids are really open, and not much activity is part of a true market.

In hindsight, general market assessments often seem to miss some of the key trends. Some have significantly underestimated the market (see the KRS study analyzed and referenced in May and Bossler), while others may have been overly optimistic. Some are looking at benefits not markets, while others seem to confuse the two terms. As can be expected, the market assessments that are done by those without some grounding in the field seem to be less accurate in projecting beyond current trends.

With each new major advance in satellite remote sensing, there is an increase in market size. In part this is a function of technology driving demand.[11] Furthermore, the ease with which market size or increase has been predicted appears to be directly proportional to the ease with which users have been able to understand and use the new data. This is in turn related to the similarity of the new data source to existing sources of information. For this reason, Landsat Thematic Mapper and SPOT imagery were both relatively easy to use for those experienced with colour aerial photography. RADARSAT imagery was less easily adapted to existing systems, and the literature suggests that hyperspectral will fall between these two "extremes."

In previous commercial market assessments reviewers have generally been unable to look beyond the next major shift in technology or capability. It is as if anything beyond the next major product advance has been lost in the shadow of what is just over the horizon. To date, the major advances have been the introduction of Landsat TM, the introduction of SPOT, and the introduction of RADARSAT. It will be noted that Landsat MSS has not been cited here as a "major advance". We argue that this is so because there was little commercial or operational market in any but a few cases.

The next major advance that is being touted is the introduction of high spatial resolution imagery. That market has been projected to be huge – pushing sales of imagery toward the billion dollar range. The CSA sponsored study by Kim Geomatics (1999) was of the view that these projected market numbers for high spatial resolution imagery, which is, after all, a replacement for aerial photography and some digital airborne imagery, are exaggerated. (This is especially so given that, in some cases, the prices cited for the high resolution satellite imagery are, in fact, greater than that of aerial photography.)

2.5.2.2 Remote Sensing Market Projections

There are more estimates of the remote sensing market's size than there are definitions of what should be included – and there are many different definitions. What we have done here is review the available studies, note how they differ, one from the other, and then based on the best of the existing studies, and material collected for

[11] See Asker, 1992

this study, we have projected growth and total value.

Frost and Sullivan and May and Bossler (Mapsat) provide what seem to be both unbiased and realistic assessments of what is likely to happen in the space imaging market. Frost and Sullivan state that the satellite image market is expected to be US$139.8 million in 1998, up 17.5% from US$120 million in 1997. This is taken to be the total image product sales including enhanced products, ground station fees, and products sold by Value Added Resellers (VARs) of SPOT, Landsat, IRS and RADARSAT. This number is considered to be accurate. It is expected that this market will grow by 28.6% through 2004 (assumed to be three years after launch of a hyperspectral system) when it will be US$698.3 million. Interestingly, May and Bossler projected growth in data sales of 29% from 1995 to 2000, also based on high resolution data. (As noted below, both groups have been used as sources in a third projection.) Compounded growth is projected to be closer to 40% over the next few years. It is not clear if the one report used the other as a source.

Frost and Sullivan suggest that commercial remote sensing revenues were US$2.1 billion in 1997. This number includes all airborne and space-borne data sales, but no additional services or technology. The airborne market is projected to rise by a more modest 12.0%. While they note that the airborne market is mature, they suggest (and we agree) that there are many specialized applications that will use airborne imagery combined with other data sources, integrated in a GIS. Some have even begun to use the term "Space GIS" to refer to the integration of space-acquired imagery and geographic information derived from other sources[12]. As noted elsewhere in this report, where one draws the line between these two fields creates a definitional problem. The value of hyperspectral airborne imagery is not specifically included in this projection, but it too will add to the overall value.

MacDonald (1999) suggests that there is a gap in knowledge between the users and the suppliers of satellite imagery – the users don't know much about the satellite imagery (and don't care so long as their needs for information are being met), while on the technology side there is limited knowledge of users needs and how to convert satellite imagery to information that will meet the users needs. This gap accounts for the lower use of satellite data than one might expect. It is incumbent upon the remote sensing industry to bridge this gap to make satellite imagery truly operational – i.e. cost-effective and self-financing.

May and Bossler projected total sales of raw and value-added products of US$800 million by 2000, compared to Frost and Sullivan's $US218 million. Asker (1992) citing a KPMG Peat_Marwick study which gives a range of $US560-730 million by 2000, "(and) it could hit US$1.3 billion." Contributors to the May and Bossler study include NASA, KPMG Peat Marwick, and a number of others. Its completeness stems in part from the fact that it built upon a number of other studies, as well as its attention to explaining the methods used.

The estimate of US$800 million for value-added products (i.e. for interpretation and data integration services) for 2000 is now considered to be a reasonable number. This is in addition to the US$218 million for products and access fees. A few years ago this estimate may have been higher. An earlier set of studies done in industry and reported by Ryerson (1994/95) suggested that Canada would achieve applications services sales on the order of US$200 million including sales related to GIS/space data and airborne data integration. These

[12] See Spacevest.

sales were to be driven by environmental applications.

Applications sales are not on target to achieve this result for a number of reasons. Globally, the market is smaller and growing somewhat slower than expected because of the failures of high resolution and hyperspectral satellites, and the Asian economic troubles. In Canada, which has an export driven industry, these global factors have been exacerbated by the level of investment in the private sector, some re-structuring in the domestic industry, delays in R&D caused by government cut-backs and, until recently, the over-riding and understandable emphasis on RADARSAT.

A more reasonable number for Canada for data and services would now likely be on the order of $80 million for the year 2000 for imagery and services – 7 to 10% of the world market. The really interesting numbers come from the year 2004 (assumed to be three years after launch of a hyperspectral system) and beyond when the market is projected by many to dramatically increase.

It is again worth underlining that the market for optical remote sensing imagery, and products and services derived from it, has consistently been underestimated around the world. Projections of growth in sales by the marketing staff at CCRS through the early-mid 1980s were consistently running at 80% per year, and were often criticized as being too optimistic. But these targets were met five years in a row, including during a recession. The projections for CCRS were based on estimates of market penetration, current use, and probable conversions among new users. We expect that the same will happen with hyperspectral as has happened with other optical sensors – sales will exceed what traditional market surveys tell us.

Two studies carried out in 1998-1999 have dealt with the impact of hyperspectral data specifically: one by Dornier and another by Kim Geomatics – both are proprietary. That by Dornier of Germany was done in support of their own hyperspectral program. The Dornier study interviewed over 300 people worldwide. Dornier projects the total market to be about $393 million for agriculture, about $18 million for forestry, $36 million for the environment, $81 million for geology, and $161 million for cartography (which includes land use mapping and some other thematic mapping. At the time of the review, these numbers had yet to be validated. Their un-validated total is $689 million. In the Kim Geomatics study, the value for applications and data on a global basis totals $546 million. Although the Dornier numbers are not validated, we assume that these numbers – about 25% apart, seem reasonable. Were it not for problems associated with obtaining cloud free data in areas of rain-fed agriculture, the market associated with agriculture would be even be higher.

Euroconsult (1991) listed a number of factors causing blockages in growth: supply and demand, the lack of a commercial approach by leading suppliers, lack of information and training, the conservative nature of users, the difficulty of integrating remote sensing with other information, the dominance of public sector supply, inadequacy of human, financial and technical resources, data costs, data delivery, and weaknesses in data processing and interpretation methods. In addition to some of the above, other limiting factors identified in a 1996 geomatics study (IACG) but also relevant to remote sensing, include cost, lack of suitable format, encumbrances on data use, data dissemination, and lack of consistent standards. However, more recent studies (Ryerson, 1999) indicate that many of these blockages are disappearing or have disappeared.

According to Frost and Sullivan, the major growth is projected to come in “high resolution panchromatic and multispectral imaging” at one metre resolution used for surveillance and base mapping. They see demand varying over this period based on “armed conflicts, economic situation, border incursions, natural disasters, and infrastructure crises.” These are all areas in which we see the useful application of hyperspectral imagery.

The number of countries that can use space imagery is projected by Frost and Sullivan to double from 25 to 50 by 2004. This is very important for the hyperspectral market as will be seen below. Hyperspectral data, because of its volume, “shelf-life,” and the nature of applications will generally have to be delivered closer to the area being imaged than is often the case with Thematic Mapper imagery where a small service bureau in Vancouver can supply enhanced products of exploration areas in South America for a client elsewhere.

The Frost and Sullivan conclusions on market size and market penetration fall within limits that we suggest range from reasonable to optimistic, given the fact that they have not included hyperspectral data in the mix.

There has also been a recent fundamental change in market conditions that has not been mentioned in the literature. With the successful launch of Landsat 7, data is being offered at the cost of filling the user request (COFUR). The price for a Landsat scene (up to the precision geocoded level) is now around $600 as opposed to around $4,000 as it was for Landsat 5. The net effect of this will be dependent on the elasticity of the market. It will take about six times the volume of sales to achieve the same total sales figure at the data level. This may not be achieved, but the availability of lower cost data may lead to larger sales of information products. This may well have a ripple impact across the entire geomatics area.

A 1999 study done for CCRS had as its focus the penetration of the USA market by Canadian industry. The assessment was done by interviewing those companies known to be active in the USA. As part of the review of the Canadian Geomatics/EO Industry's participation in the US market, 28 of the largest and best-known Canadian Geomatics firms were contacted, and interviews were conducted with senior management. The interview group was biased toward remote sensing and GIS. Traditional aerial survey and mapping firms were represented in the survey in part because of the long standing links between these firms and later remote sensing development and exports. It is estimated that the interview group represented between 50% and 75% of the total sum of Canadian Geomatics product and service exports to the US. This was later confirmed through discussions with a number of independent observers. It was believed that no more than 25% of all geomatics products and services exported to the USA were missed.

The survey accounted for an estimated US$49.7 million in Canadian geomatics revenues from the United States. Of this, some US$19 million or 39% represented Canadian-owned shareholdings. The significant non-Canadian contributor to Canadian geomatics exports to the US was the then-Orbital Sciences-owned trio of MDA/Triathlon/RADARSAT. Interviewees reported that over US$36 million or 74% of the US export revenues were remote sensing related. Only US$6.4 million or 13% of the revenues were identified as being derived from "value-added" activities. These (value-added) companies are doing about 27% of their business in the United States, compared with 20% for the remaining respondents to our e-mail questionnaire. Both values were higher than was expected.

Of the US$19 million in US revenues reported by Canadian-owned geomatics companies, US$14.7 million or 76% of the dollar-volume of business was conducted through US branch offices. Of the 28 firms surveyed, seven had US branch offices. Six of the seven firms were Canadian-owned.

The US sales of these companies totalled $54 million, made up of value-added sales of about $9.6 million, and $44.4 million of other sales. As noted above, the value-added represented 27% of all sales of these companies and the $44.4 million represents but 20% of total sales. Taking these values and expanding back into the Canadian and other markets, the 1999 value-added sales of these companies was $35.5 million, while the non-value-added sales totaled about $220 million. Total sales then were about $255.5 million. If we assume that among the remaining 190 companies said to be involved in remote sensing on the CCRS web site, and those not included in the 1999 study listed in the geomatics source book, we estimate that the total additional number of employees who are providing products and services not captured under independent consultants totals approximately 240, spread across 190 companies. We assume that their income would total approximately $21 million, evenly split between value-added and technology.

As a further check, an assessment of employee numbers was done. We determined that the twenty-nine companies profiled in the Geomatics Source Book 2000 that did remote sensing employed 1220 staff in that area. The companies included some but by no means all of those interviewed in the 1999 study. This suggests that the total of 2800 staff may be high, or that the assumed income per employee is higher than the $90,700 assumed for each. Given the close links of remote sensing to high technology, and the reported income per employee of MDA (a public company) it may well be that there are fewer employees than we had calculated.

Working back on the other side of the equation, one can also gain an insight into the mapping market and size of that business. Remote sensing was a significant element of business for 18 of the respondents to the questions concerning growth. Fully one-third of them saw their growth exceeding 100% per year, leading to a projected annual growth rate of 39%. This projection must be tempered with the realization that of those projecting this outstanding growth, half were one or two person companies. On the positive side, several larger companies (with from 10 to 100 employees) are also projecting such growth. Those in remote sensing have often been accused of being overly optimistic. While there are factors leading to optimism – more free information, better access to data – there are also more concerns about competition, access to specialized data, and the like. For this reason, we will downplay the growth prospects of our survey and move towards a more subdued projection.

Table 2-2: Summary of Telephone Survey Results (1999 Study)

Item	$(US)	% of Total
Canadian Geomatics Exports to the US	49,700,000	100%
Canadian-Owned Geomatics Exports to the US	19,300,000	39%
Remote Sensing Related Exports to US	36,000,000	74%
Value – Added Exports to US	6,400,000	13%
US-Office Revenues of Canadian-Owned Companies	14,700,000	76%
US Branch Offices	7 of 28 firms	25%

Technology sales could rise dramatically if, for example, Canada takes a key role in a new space program in space-borne hyperspectral work. A GlobeSAR-like activity run by the private sector could increase services sales by as much as 7% per year for two years. Radarsat II will increase technology sales within the timeframe. What the long-term prospects are beyond the 2004 window are somewhat less easily projected because of these uncertainties.

We project an increase of just under 16% over the next four years in remote sensing services, with a highly variable increase from year to year in technology sales with an impact not unlike a 12 to 15% increase.

Given the domination of several key suppliers in these areas, it is clear that faltering by any one of them could reduce the growth substantially, as could a decrease in Canadian space activities. Key people for the services side will be able to integrate different forms of information, "think spatially, but understand client's business areas". There will be significant growth in using high spatial resolution satellite imagery. The technology side will draw on electrical engineers, physicists, and software engineers. The technology side of remote sensing, along with the navigation and positioning area will face the greatest hurdles in recruiting and retaining technical staff. For this reason salaries and benefits can be expected to grow in these areas.

The 2004 market for remote sensing technology will approach $375 million, while that for services will approach $80 million.

2.5.2.3 GIS and Decision Support Market Projections

GIS Market

To date few studies in the public domain have directly assessed the GIS market. Daratech does provide an assessment of the GIS market in which they review the performance and activities of many of the key players in remote sensing, including PCI, ERDAS, and even the satellite image suppliers. The GIS market is said to be over $US6 Billion in 1995, although Daratech suggests that this may include some double counting. In 1993, the base year for a number of studies, according to GIS World (1994) the total GIS market was US$2.2 billion, with software sales of US$474 million. Daratech placed software sales at US$495 million in 1994, a year later.

The "core business" as Daratech calls the direct software and hardware sales and services in GIS is relatively easy to estimate. The real difficulty is apparent looking at the two numbers given by the two groups for the GIS market just one year apart: US$2.2 billion vs. US$6 billion (It should be noted too that these are not projections but after the fact statements of market size).

It is obvious that there is no clear definition of what falls in the GIS market. Quite simply, the numbers are not consistent. Since many of the benefits of remote sensing are said to begin after the results of information extraction enter the GIS environment, one must be very careful in how numbers are used, expanded, and analyzed from the GIS market.

What of this GIS software market (the US$474 – 495 million referred to above) is remote sensing image processing software is open to some discussion. Looking at the sales today of the major players: PCI, ERDAS, ENVI, and ER Mapper suggests that current civilian sales are in the vicinity of US$30 million based on assessments made by Kim Geomatics. We have been unable to find independent estimates of sales related to satellites, satellite components, sensors, ground stations, image processing software, or much detail on applications areas of the market, although a variety of indicators do exist.

The Daratech estimates for GIS core business (software and hardware sales and related services) for North America in 2000 is $792.45 million. If we assume that Canada's share of the North America market is between 7% and 9% (based on economic activity, population, size of area and number of political jurisdictions), core business GIS in Canada is between US$55.5 and 71.3 million, or between Cdn$83.25 and $107.0 million. Our survey responses from several major suppliers suggest that the 7 to 9% estimate is, if anything, somewhat low. While there are major imports of GIS (from the likes of Intergraph, and ESRI), there are also exports of some product (from Autodesk Canada and PCI), as well as a great deal of service activity by major suppliers. Specialty services and software are sometimes imported (e.g. for MLS applications), but equivalent services (forest GIS, and flood mapping services for example) are also exported. Furthermore, the major importers maintain a significant employment base for technical support, development and sales in Canada, composed largely of Canadians.

Based on the Daratech breakdown and amount of value added services that result downstream from core sales, there is typically a service multiplier, a back-end or systems integration multiplier, as well as a hardware multiplier. We will not attribute the hardware multiplier to geomatics. (While the GIS vendors typically sell some specialized hardware, much of that is in any case not manufactured in Canada.) Daratech estimates that value added resellers have sales approximately 0.21 times the sales of the core business, and the end user community spends approximately 4.6 times the core business activity on services.

Based on a core business activity in Canada of $83 million, this yields a value-added reseller activity of approximately $17.4 million, and downstream user activity (excluding sales of additional hardware) of $381.8 million. This includes what users spend in-house as well as what they may spend on services from geomatics companies. However, since the objective is to estimate employment, this is not an altogether inappropriate way of measuring the activity. Furthermore, given how much of it is being contracted out, this is not unreasonable.

Total GIS activity in Canada for 2000 is in the vicinity of $482 million.

Growth will be substantial. The 27 industry respondents involved in GIS projected the fastest growth. Again, we are not convinced that growth on the order of 50% per year is practical across the industry. The median growth as projected by industry in our survey is 25% per year for the next two years. 13 of 27 project growth of 15% per year. While it is clear that some of the more aggressive and successful will meet these higher targets, it is our opinion that many of those will move into the higher margin and more sophisticated decision support market. Indeed, that is beginning according to the signs in our survey.

We project growth in GIS in the area of 15 to 20% per year. The 20% is not likely attainable over the longer term, although it can be expected that the market will nudge the 20% barrier in two of the coming five years.

This is higher than in certain recent projections for the North American market as a whole, but it would appear that Canada is now playing some catch-up to the US. Further, as our economy seems to be fostering more confidence among the business community and as awareness of technology in general and spatial technologies specifically increases, this will help the market.

The 2004 GIS market will be $900 million.

Decision Support

One area noted as worthy of separation from GIS is that of decision support. Decision support is in some cases rolled into what Daratech calls services drag – or non-core services. Using a GIS to manage a city and inventory street furniture, or other physical resources for a resource industry is seen to be a different area of business than providing a link between geographic data, financial information, and business process software in what is commonly being called a spatial decision engine[13]. Interviews with the resource industry, utilities, transportation, retail, and engineering firms suggest that this is a growing business area with a great deal of potential impact in making core business more efficient. It would appear from our interviews, and previous proprietary studies of this business area done by team members, that there are some twenty to thirty groups currently using GIS and associated technology in this sophisticated manner across Canada, each employing between three and twenty geomatics technicians and professionals. While not strictly part of the GIS industry, the application is clearly within the private sector, requires advanced understanding of GIS, spatial decision making, and the like.

The current number of people involved in decision support systems is estimated to be on the order of 150 people, with a value of about $14 million.

Growth in the field of decision support will be among the most dramatic of all. Further, its need for information will drive other segments. While only 4 companies responded that they are involved in decision support, they project an annual growth rate of 34%. None of the companies that responded can be characterized as a basement operator. While small (4, 6, 10 and 40 geomatics employees), all are of a size where growth can be expected. As society as a whole becomes more spatially aware, and as the advantages and benefits are seen by others, growth will be as explosive as any of the high technologies that have become pervasive in our society.

Based on annual growth approaching 35%, we are projecting a minimum decision support market of $45 Million for 2004.

That will include some software and integration, as well as, primarily services. The major employees will be discipline specialists or geographers with knowledge of business processes, geospatial

[13] The concept was advanced by M. Lowings and M.D. Thompson in a presentation on geomatics organized by the Geomatics Industry Association of Canada at Environment in the America's, Montreal, 1997.

relationships, and GIS. This may be an underestimate.

2.5.3 The Surveying, Mapping and GPS Markets

2.5.3.1 Mapping and Photogrammetry

Surveying and mapping have often been linked in their analysis, much as remote sensing and GIS have been. In a review of market studies, Batterham (1997) cites a number of estimates for this market area. "A 1996 feasibility study 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 the previously cited 1994 Daratech GIS study, North America accounted for 43%, Europe 31% and the Far East 15% of the world-wide 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." In 2000 the equivalent numbers from Daratech were North America 45%, Europe 36%, the Far East 13% and other 6% of $1,761 million. The drop in the share of the Far East vs. Europe and North America can be attributed to the 1997 economic collapse in Asia and the recent ramping up of GIS in Europe.

While these numbers are large and quite impressive in and of themselves, they all pale beside the recent acquisition of MapQuest by America Online (AOL) for US$1.1 billion. AOL has seen the value of spatial data applied in a different non-traditional context. Market assessments for mapping and more traditional geomatics are, for the most part, based on straight line projections from the past to the future. They tend to look at what areas have been mapped and what areas have yet to be mapped. They tend not to take into consideration major shifts in demand, new markets, new applications and new requirements. They certainly have failed to take into consideration shifts in technology and the Internet and all of the ramifications. The value placed on mapping and the acquisition of mapping companies by non-traditional players (such as MDA, for example) is an indication that the mapping market has changed. We suggest here that the value that will be put on the future market is likely far larger than what has been stated in the studies referenced above.

Based on the 1999 study for CCRS, it was determined that the mapping sales to the USA were approximately $20.5 million. This was seen to be in the vicinity of 25% of the income for these companies. Based on our interviews and our survey, it would appear that this is within the correct ballpark. However, with the rapid change in technology, services, client needs, the impact of GIS, digital data and the like, it is increasingly difficult to separate out cartography from photogrammetry (and indeed, certain aspects of remote sensing and GIS).

The grouped category of cartography and photogrammetry is now taken to have a market of $95 million in 2000.

According to our survey results, industry participants in this market are quite positive in their outlook. 20 respondents placed the average growth at an astounding 48%. However, one company (with over 20 employees) also involved in GIS and remote sensing projects growth of 500%, while three others (with under 20, under 5 and 1 employee, respectively) project 300%. While it is quite possible that the companies involved may achieve these growth levels, even without them the growth is a more than respectable 16% per year. Given the movement of a number of large companies into the business, the involvement of some well-known entrepreneurs, the transformation of the business into a content provider, and the development of national infrastructure as a key component of many international aid programs, significant growth is possible.

We project a lower growth over the next year (7 to 10%), and then substantial growth in the next year (15%), followed by potentially explosive growth in the last three years. The market in 2004 could reach $170 million, depending on new programs within Canada and elsewhere and Canada's competitiveness.

It can be expected that the need for content for GIS and decision support systems will also drive part of this growth.

2.5.3.2 Hydrography

Hydrography is another small niche market that is difficult to define in terms of commercial activities. We have not included offshore seismic work.

Based on the Geomatics Source Book 2000, inputs from interviews, and the survey, we have arrived at a hydrography market of $12 million employing 140 people in 2000.

Some of that work is in the sale of software and systems, and is in some places counted as part of GIS and in some others as part of hydrography. Here we have split it. The service work appears to be scattered, for the most part, as relatively small parts of larger activities. That being said, the market is seen as quite buoyant, with growth projected to be at about 10% per year by the larger player, and much larger by the smaller players who responded to the survey. (One very small company projected an increase of 200%, two others saw 25%, and the last 10%.)

In this case we have weighted the larger company's assessment and have projected an 11% rate of growth. The projected market for 2004 is $18 million.

2.5.3.3 Navigation and Positioning - GPS

GPS is another market area that has undergone explosive growth. According to Gibbons in the Big Book on GPS**,** the consensus of the industry places annual growth in GPS markets in the 25 to 40% range. The most aggressive forecast, cited by Allied Business Intelligence - ABI, places compound growth at 84% per year through 2004. The more aggressive projections assume "strong penetration into the wireless handset market and other embedded application-specific integrated circuit markets". A 1998 US Department of Commerce estimates worldwide sales at $6 billion in 1999, and at $16 billion by 2003. The ABI study suggests the 2005 sales will only be $14 Billion. A 1997 survey by Booze Allen and Hamilton projected a cumulative market in Europe from 1998 to 2007 for satellite positioning equipment and services as $38.5 billion. Frost and Sullivan project worldwide cumulative sales from 2005 to 2023 (including both GPS and the European Galileo) to be about $250 billion. Frost and Sullivan (© 2000) predicted annual growth rates in GPS at between 18 and 10 % from 2000 to 2004, leading to North American forecasts of growth from $2,448.2 million in 2000 to $3,848.1 million in 2004.

Arthur Andersen Consulting has placed the market for GPS in Canada at 7% of that projected by a study they cite by the U.S. National Research Council. The ten year forecast so derived for Canada was $US1.4 billion, including users with requirements for less than one meter accuracy. Andersen then assumed that most users would not have enhanced systems and thus the forecast over five years was for Cdn$1,398 million, divided into $489 million for land vehicle, $154 million for maritime, $266 million for geomatics, $294 million for aviation, $154 million for consumers, and $42 million for military. It was further concluded that there was the opportunity for above average adoption of GPS in Canada. An interesting sidebar is that of Canadian GPS manufacturers some target as much as 90% of their production to export. In addition there is a growing group of software providers and niche players in GPS in Canada.

In other words, dollar estimates are highly variable, as are growth projections. This leads Gibbons to note that quantifying and qualifying GPS markets is “a much more complicated undertaking than many of the reports will admit.” This is in part a function of the size and nature of what is sold – everything from a $20 chip in another item, to a receiver that can cost $10,000. One study puts the number of chips at 7.6 million in 1999 (worth $148 million), increasing to over 162 million (worth $2.2 billion) in 2004. Gibbons concludes that what is needed is a GPS scorekeeper.

To provide an indication of relevant market share by the GPS segment, we refer to the US Department of Commerce study as cited by Gibbons. In it, sales by 2003 are projected to be as follows: car navigation - $4.7 billion; consumer – $3.8 billion; OEM - $.690 billion; surveying, mapping and GIS - $3.120 billion; aviation $0.71 billion; marine - $0.21 billion; military - $0.185 billion. Gibbons notes two trends: a 30% annual decrease in hardware costs and an increase in embedded software in commercial solutions.

There are also government policy factors that influence the market. The effect of Selective Availability (SA)[14], now removed, was critical. At present, the government must provide six years notice before changing free access to GPS. Europe has planned its own GPS system (Galileo) to ensure that control over such a critical tool is not subject to outside political pressures. Without SA, sales are expected to increase as much as 60% over the period.

Other government policy decisions could also have a profound impact. One could envision a situation in which the government may require wireless communications service providers to have an emergency location capability. It is not hard to imagine the impact if every cell-phone in the US was mandated to contain a GPS chip. The range of low-per-unit cost (but high total value) services could be immense. A number of these have been noted by Gibbons – from road-side assistance and traffic reports to emergency response. What is even more intriguing for the niche-oriented Canadian business community are the spin-offs that such market penetration would spur.

To obtain the estimate of the GPS market from the Arthur Andersen study, we can look at the North American estimates from 2000 to 2004 from Frost and Sullivan. They total $15,747.7 million. Of this total, 15.5% is for 2000, and 24.4% is for 2004. Transferring these numbers back to the Arthur Andersen study,

The GPS market in 2000 in Canada should be 15.5% of $1,398, or $217.3 million, while the 2004 estimate should be $341.6 million.

It is easy enough to then break down the projected sales in each segment, over time, although it is clear that these values will vary over time from segment to segment

[14] Selective availability is the intentional degradation of the SPS signals by the Department of Defence. Without SA, the potential accuracy is on the order of 10-30 metres vs. 100 metres with it.

since the different markets are developing at different speeds. To verify these numbers, using the rule that sales in Canada will be 7% of those in the US, and that Mexico will be 1.5% (and ignoring the Arthur Andersen contention that adoption of GPS is expected to be higher in Canada), the Frost and Sullivan estimates yield sales in 2000 of US$2,448.2 million in North America, and using the formula above, $237 million in Canada. Assuming that sales remain constant between Canada and Mexico, the estimated sales level in 2004 for North America from Frost and Sullivan will be $US3,848.1 million and $372 million. Given that the Mexican market may be higher, and the general lack of precision, the fact that these two independent estimates come out with numbers within 10% of each other is very encouraging.

Another area in which there is significant projected growth market is in land administration, mapping and other geomatics applications in developing countries.

Ryerson and Batterham (2000) argue that geomatics is a fundamental part of a nation's infrastructure, a position supported by the 1999 UN Conference on Space held in Vienna. Williamson et all (2000) also argue that land administration is a key component of sustainable development. McGrath and Metcalfe (1999) have also outlined how important cadastral information is in development. Adding this together suggests that this area represents a market that goes far beyond what one normally associates with mapping and surveying. One CEO interviewed suggested that this international application is the forgotten frontier of Canadian land surveying. The fact that much of the market helps countries derive tax income (from land) and provides an asset (land) to assist poor rural residents in developing countries further suggests that modernization of records will be a growth area. While we have been unable to identify a quantitative source for estimating this market, it can be supposed that it will be significant, albeit much of the labour provided will be local.

2.5.3.4 Geodesy Market

The geodesy market has been a difficult one to define.

Based on the Geomatics Source Book 2000, our survey and interviews, the market for geodesy (which here does not include positioning of pipelines for example) is approximately $3 million and employs 30 highly trained individuals. Our survey suggests that the area will grow at 11% per year to about $5 million in 2004.

2.5.3.5 Surveying Market

Based on information collected from web sites, our survey, and telephone requests made to the provincial land survey associations there are a total of approximately 2,950 who are members of provincial survey associations or the CLS (496 hold the CLS designation). There are some who are members of more than one provincial association – and many CLS are also registered with a provincial organization. If we can assume that there is no more than 200 double counted in this way (and leaving some room for error on the down-side) there are about 2750 practicing land surveyors in Canada. Of this number at least 275 to 300 are employed in government and academe. We can assume that there are 2400 in private practice. For each one, there seem to be three to four employees at a technical field crew level. This adds about 7200 additional staff to a total of 9600 in the private sector.

We estimate that the 2000 market level for surveying would be about $870 million, based on a $90,500 income per employee.

The Land Survey growth prospects are based on 26 responses from the survey. It is interesting to note that of the 19 companies projecting the lowest growth rates (below 7.5% per year), 13 are involved in land surveying – or half of the land surveying sample. Of the 33 companies projecting higher growth rates (over 25% per year), but three companies are involved in land surveying. Of these, the two projecting 50% growth are active in GIS and navigation and positioning, while the one company projecting 100% growth is a one person company. With the three outliers included the projected growth rate is 12%, without them, it is 9%.

It is also clear that the vast majority of companies projecting solid growth involved in land survey are doing more, and offering more services involving navigation and positioning, GIS, mapping, and engineering. It would appear that they are transforming their businesses into one dealing with spatial information. However, it seems from our analysis that the growth rate for traditional land surveying will barely match inflation and growth of the economy. Technological or legal changes could alter the situation in a negative way quite dramatically, although the latter will take more time than the time frame for our projection. It is also interesting to note that in the main, the land survey side is projecting growth in sales but not in staff. The number of support technical staff per land surveyor, now at an estimated 3 to 4, can be expected to drop, relative to the number of land surveyors.

We are projecting an increase for land surveying of 8% per year, based on a flat 3-5% for traditional land survey, and a more robust figure for those transforming themselves into new business areas. We are assuming that there will be one year of near zero growth at 2004 is approached. Further, we project a relative increase in dollars earned per employee, which in turn will be offset by purchase of technology. If more land surveyors do not begin to make that transformation to adding more value and services, then growth will be lower. If the industry transforms itself at a faster rate and moves to more offshore work, the growth could far exceed what is here projected.

The last estimate and projection to deal with is that of consulting. We define consultants as those who sell advice – they do not "do" geomatics. It is clear that the consulting business has been growing dramatically. A combination of changing attitudes to self-employment, and market demand have come together to make consulting one of the faster growing segments of the industry. A number of senior people from government and industry, as well as highly specialized technical people have left to start consulting companies. In addition, a number of successful firms in the provision of products and services have found that offering consulting helps build knowledge of the market.

2.5.4 Consulting

We estimate that, in total, there are as many as 300 consultants working in the area – primarily as individuals or working in small two or three person companies. Based on an average income per employee of $100,000, the 2000 income would be $30 million.

This is based on the Geomatics Source Book 2000, the survey, and an inventory of those known to the author. Those working for firms in mapping, management consulting, GIS, etc. are often involved in consulting, but are more difficult to assign to this sub-sector than are, for example, those working strictly as unaffiliated consultants. Many of those working for firms selling products and services are in one sense or another involved in business development – often paid for by the client.

The 18 companies doing consulting that responded to the question on growth suggest that growth in the consulting field will grow by 41% per year over the next two years. While the field has been growing dramatically, and while it shows every indication of doing so for the coming two years, it is highly unlikely that the growth will continue at the rate projected by the group that responded – a group typified by being involved in the higher technology end of the business.

We have therefore dramatically downplayed the growth prospects to 15 to 20% - depending upon the area in which one is working. Those areas expecting significant growth either internationally or domestically will support more consultants than will those areas not increasing. We believe that by 2004, total consulting income may be as high as $52 million, employing approximately 500 people.

2.5.5 Market and Employment Projections

The estimates for all sub-sectors of geomatics are a current market for Canadian geomatics companies of just over $2 billion, with an employment base of 21,790 in the private sector. Those figures are projected to grow by 2004 to an income of $3.08 Billion, employing 32,000 people. The breakdown of the private sector market by income and employment for 2000 and 2994 for the various sub-sectors of geomatics is given in Table 2-3.

This employment estimate for the year 2000 does not count the 5,000 or so people employed in the public and academic sectors – as many as 300 surveyors, an estimated 400 in remote sensing, over 2,000 in various mapping endeavours, and at least a like number in GIS in all three levels of government across Canada. Non-military employment in geomatics in Canada today, therefore, stands at close to 27,000.

Table 2-3: Private Sector Market Estimates in Millions of Canadian Dollars.

Sub-Sector	Current (2000, *Estimated*)		Projected (2004)	
	Market	Employment	Market	Employment
Decision support[15]	14	150	45	500
GIS[16]	482	5300	900	9950
Geodesy[17]	3	30	5	50
Hydrography	12	140[18]	18	195
Surveying[19]	870	9600	1095	10950
Navigation and positioning	176	1940	341.6[20]	3400
Navigation and positioning (only geomatics[21])	41	455		
Photogrammetry, Mapping, and Cartography	95	1050	170	1875
Remote sensing (Services)	46.5	515	80	900
Remote sensing (Technology)	231	2310	375	3750
Consulting	30	300	52	500

[15] The differentiation between GIS services (non-core – see next footnote) and decision support is difficult to draw. We interviewed a number of major multi-national firms using GIS and geomatics to support decision making related to their core business – from transportation to engineering, forestry, and retail. The employment is significant, as is the impact of geomatics on the corporate bottom line.

[16] The GIS figure includes $83 million core business as defined by Daratech plus sales of those from outside the core business of GIS. A "core" business provider as defined by Daratech is one of the forty or so leading vendors of software and services. Typically the category does not include those who add value, do major integration, or run or develop systems as a pure service business.

[17] Geodesy is sometimes taken to include positioning and engineering surveys. Here we include those doing geodesy commercially as cited in the GIS source book. While this is likely an underestimate, the numbers are very small.

[18] This does not include the 320 employees of the Canadian Hydrographic Service.

[19] Surveying includes cadastral, engineering surveys, and positioning.

[20] The precision comes from the Arthur Andersen study. All other numbers here have been rounded.

[21] It is not clear whether or not by geomatics the study assumed that this was part of land surveying. It is broken out here for 2000 in the event that it is determined that this represents a double counting. The figure for 2004 is a combined number. It could be broken out on the same basis.

2.6 Human Resource Implications from the Market and Related Factors

2.6.1 Introduction

In this section, we bring together and analyse the key factors from a market point of view that impinge on the industry and provide an assessment of their implications on human resources. This analysis is based on the factual material obtained during the course of the study as well as informed opinion, in light of the current situation and future trends. The material is presented in bullet form under a number of headings. Each bullet is organised with an observation followed by an impact or a conclusion related to human resources.

2.6.2 International Drivers

- ***Observation:*** There is growing interest from international development and aid agencies in the technologies with which we are associated.

  Conclusion: There will be a requirement for international sensitivity, international marketing skills, and languages.

- ***Observation:*** CIDA Inc.'s interest in supporting geomatics, as well as activities by the development banks is increasing.

  Conclusion: This suggests that more of an international and developmental assistance orientation should be given to geomatics professional education and training in Canada, and geomatics should ensure that its importance is well understood in the international development community, including those providing education in international development.

2.6.3 Policy and Government Activity

- ***Observation:*** There is a growing question as to whether or not geomatics is a useful term under which the profession will gain public recognition and attract employees.

  Conclusion: There should be an analysis of what terminology is most useful to ensure broader acceptance of the field and understanding of its importance.

- ***Observation:*** While the land survey industry is projected to grow less quickly than any other subsector, certain elements of that sub-sector are growing and projected to grow more quickly than others. Those working with GIS, GPS, and land information systems appear to be doing better. These areas of GIS, GPS, and land information are also the sub-sectors in which we project the most future demand.

  Conclusion: This suggests that professional development, in-service training, and modifications in the curriculum of new land surveyors should emphasize these non-traditional areas. By so doing this will help land surveyors to enter higher demand areas with greater export potential. Further, it will reduce the projected shortage (see Chapter 6) for new people in these sub-sectors as land surveyors and survey technicians fill the gap.

- ***Observation:*** Jobs requiring local knowledge for value added and significant field work (forest image interpretation, wetland monitoring, site planning, and the like) will stay in Canada. Those which do not require local knowledge (DEM generation, map conversion, etc) have a greater potential to be exported to low-wage countries.

Conclusion: Human resources planning must take the potential for job export into consideration.

- ***Observation:*** Government purchasing policies will impact the industry – without domestic purchase of products and services it is increasingly unlikely that industry will secure significant export sales, and with the loss of export sales will come a reduction in the ability to employ production workers in particular.

  Conclusion: There must be a coherent plan to purchase Canadian products and services by governments for use within Canada if the governments wish to ensure that exports continue or increase.

- ***Observation:*** Purchase of products and services by government at low prices will lead to a weak industry unable to export. In some cases, competition for large government contracts has been so intense that the price paid has been too low to make a profit. Without a reasonable profit, companies will not be strong enough to export. Without exports, the industry will not be sustainable, and more will have to be purchased off-shore.

  Conclusion: Purchasing policies have to consider more than low prices if the industry is not to be weakened to the point of failure.

- ***Observation:*** Government funding of R&D in-house, in academe and industry will determine if the resources will be developed in academe to train the more highly qualified individuals for high-end technology development positions, as well as those in the user disciplines.

  Conclusion: R&D funding must continue. Recent trends are most encouraging.

- ***Observation:*** There are varying approaches to the requirement for legal surveys upon property purchase in Canada's provinces.

  Conclusion: Policies in this area will determine to a certain extent the demand for traditional land surveying services and the degree to which land surveyors move into other business areas.

- ***Observation:*** International marketing resources are scarce in both government and industry. Marketing support to business by governments can, and in many cases has, positively impacted industry sales, but some government policies and activities eg being competitors have had the reverse effect and reduced employment.

  Conclusion: A review of geomatics trade support activities may lead to better use of scarce human resources in the marketing domain.

- ***Observation:*** Contracting out services and support has been an effective method for industry to gain experience and develop its human resources when the work is done by companies committed to marketing follow-on services. It has not been as successful in terms of generating employment when the major activity of the contractor has been to provide such services to governments and not take the risk to invest in follow-on marketing and sales.

  Conclusion: Contracting out should be done in such a fashion as to encourage development of other business areas rather than contracting to the government.

- ***Observation:*** Data pricing and distribution policies are now being examined. Data pricing, while not alone as a negative factor impacting the industry, is generally seen to have had a negative impact on use of the technology and hence on the competitiveness of industry and access of academe to adequate Canadian examples for teaching.

Conclusion: Pricing policies must be brought in line across Canada with those in competing jurisdictions and more free data should be made available to educational institutions. GeoGratis is highly successful in this regard.

- ***Observation:*** Lack of understanding within industry and government of the impact of policy (both Canadian and foreign) on markets, and lack of understanding of the pressures and realities of the market-place from the point of view of entrepreneurs are shortcomings seen in the sector.

  Conclusion: In-service education and training is indicated for both industry and government staff.

2.6.4 The Economy

- ***Observation:*** There is outside investment entering the sector from (especially) off-shore sources including major aerospace and military contractors. That investment has shown an interest and valuation of geospatial data that goes beyond traditional views. This will give increasing impetus to participation in the sector and visibility of the sector to future potential employees as well as have an impact on the retention of existing employees.

  Conclusion: More attention should be paid to attracting such investment and examining its impacts on human resources.

- ***Observation:*** There will likely be rapid growth in the domestic demand for digital topographic base mapping.

  Conclusion: There will be an increasing demand for technicians to do this mapping work, if it is not contracted off-shore. This "if" is an important consideration.

- ***Observation:*** As a result of this demand, there will be an increase in domestic capacity. To maintain employment, Canadian industry must become/remain competitive with off-shore low-wage suppliers and must win international contracts.

  Conclusion: Innovative approaches to business, product delivery and value-added will be required to prevent a collapse.

- ***Observation:*** Industry is growing more important as the mechanism through which products and services are both built and delivered.

  Conclusion: This suggests more of a need for business education combined with technical fields.

2.6.5 Technology

- ***Observation:*** Internet data delivery will revolutionize the skills needed to distribute, bring together and use geospatial data.

  Conclusion: In service training and new approaches in educational institutions will be required.

- ***Observation:*** There is a growing movement of the technology to the desk-top with some of the more highly skilled technical work being replaced by intelligent software. The skill sets required of those performing tasks will diminish. For example, a number of highly trained photogrammetrists can in many cases be replaced by one photogrammetrist and a number of technicians.

  Conclusion: This change in educational requirements should be monitored and the impacts considered in the number of places devoted to training at these two levels.

- ***Observation:*** As the technology moves to the desk top, there will be a growing schism between those applying the technology, and those developing it. Increasingly, it can be expected that there will be more of a demand for those trained in disciplines like forestry and environmental engineering and planning who can use the technology and perhaps fewer but more highly trained engineers who will develop the technology and models applied by these others.

  Conclusion: There will be a growth in demand for foresters and others with geomatics expertise, as well as growth in the need for advanced degrees in geomatics.

- ***Observation:*** Technology is reducing the need for those trained with high accuracy of data in mind.

  Conclusion: However, there will be a continuing need for such accuracy if the data are to be believed, trusted and ultimately used to their full advantage.

- ***Observation:*** The competitiveness of Canadian technology providers will dictate opportunities for technology development and will drive to a certain extent the technologies that educational institutions will purchase. Canada is competitive in several areas of remote sensing, GPS, photogrammetric mapping software and in certain specialized software such as hydrographic mapping. ESRI has moved into a dominant position in GIS. They and their image analysis partner ERDAS have a significant market advantage over their Canadian competitors.

  Conclusion: Educational institutions should be a focus of Canadian suppliers while the educational institutions will have to be mindful of which technologies are competitive to ensure that their students are trained on technology that will survive the increasingly competitive market place.

- ***Observation:*** As a result of technical innovation there will be a decreasing demand for land survey technicians and field crew.

  Conclusion: Programs in these areas will not produce highly marketable graduates unless there is attention paid to supporting areas (see note above).

2.6.6 Marketing

- ***Observation:*** Marketing is a weakness, especially in reaching international and non-traditional clients.

  Conclusion: Education and training must address these two elements of marketing.

- ***Observation:*** One cause of the lack of marketing expertise is the level of investment and that in turn is related at least in part to managerial capacity and financial experience within the technology dominated industry.

  Conclusion: Specific attention should be paid to business education in finance and management for those in professional schools and for those in the work force whose aspirations include corporate management and entrepreneurial pursuits.

- ***Observation:*** Much has been written on the digital divide – the gulf between those who have access to and use digital spatial information, and those who do not.

  Conclusion: Removing this divide is critical to the development of the sector and suggests a training activity and business opportunity.

- ***Observation:*** The US market is large, accessible and close at hand.

  Conclusion: As such, it is an opportunity in terms of market but is a very real and growing competitor for human resources.

- ***Observation:*** Under NAFTA, Mexico, with a growing and increasingly sophisticated mapping industry, is already a market for Canadian technology and investment, as well as a direct competitive threat to Canadian jobs.

  Conclusion: Mexico should be monitored as both a market and as a potential competitor.

- ***Observation:*** With the move of advanced capabilities to the desk top many smaller companies are entering the business with an increased likelihood that new ideas, new approaches, and new niches will be developed and competed for.

  Conclusion: Incubating these ideas and providing appropriate training and education to ensure that the Canadian fledgling companies take flight will be a significant challenge.

2.6.7 Sub-sector Issues

2.6.7.1 Remote Sensing

- ***Observation:*** GIS will continue to grow and the demand for those who can use GIS in modeling related to decision making and decision support systems will grow dramatically.

  Conclusion: GIS should be a target for increased activity in training and education.

- ***Observation:*** Growth in remote sensing will be significant.

  Conclusion: The impact on human resources is not so much that there will be shortages, but rather that their skill sets and flexibility may not match the demands of the market. (See the two items below.)

- ***Observation:*** Neither radar imagery nor high resolution satellite data have been as well received in the market as some of their respective proponents have suggested was likely.

  Conclusion: This cautionary note should give the educational institutions pause in their assessments of the need for those trained specifically in the application of one or another of the sensors. Those in remote sensing would be better trained to understand and effectively use a broader range of image sources and the tools with which to extract information.

- ***Observation:*** Key people for the services side must be able to integrate different forms of information, "think spatially, but understand client's business areas".

  Conclusion: This suggests interdisciplinary training and education across user disciplines and geomatics.

- ***Observation:*** RADARSAT II with advanced capabilities promises to be more successful, if sufficient users and specialists are made aware of its capabilities.

  Conclusion: For Canada to obtain full benefit for its investment, RADARSAT II will have to be actively promoted.

- ***Observation:*** Those trained in the software side of remote sensing will be competed for by the technology sector. The recent dramatic drop in the stock values in that sector will somewhat reduce the short term threat since stock options are often used as bait, however, salary scales remain higher.

Conclusion: Innovative methods of retaining staff and attention to training in human resources management will be important.

2.6.8 GIS and Decision Support

- ***Observation:*** In playing catch-up in GIS use to the US, growth approaching 20% per year is projected to lead to shortages in the more specialized individuals involved in advanced modeling. This shortage will be compounded by the continuing drain of staff to the US, to certain areas of high technology, and as noted below to decision support.

  Conclusion: Dealing with these issues will be a key activity of human resources planning.

- ***Observation:*** Demand for decision support systems services is projected to grow from a small base by over 30% per year to $45 million in 2004. High-end GIS staff will move into the higher margin decision support, compounding the skilled staff shortages in GIS.

  Conclusion: This will impact human resources and the potential for growth in lower margin GIS work, while higher margin and more value-added decision support will grow. Moving people from one job skill level to the next will be a major challenge given the lack of structure in job classification in the industry.

2.6.9 Mapping and Photogrammetry

- ***Observation:*** Sales are projected to grow by 16% per year with increasing competition from off-shore suppliers being off-set by the aggressive growth of certain Canadian players into the US market.

  Conclusion: Sales can be expected to be somewhat less cyclical than they have been in the past unless there is a major mapping initiative in Canada. This should make human resources planning somewhat easier than it may have been in previous boom-bust cycles.

- ***Observation:*** There is an increasing move to contract staff.

  Conclusion: This alone may lead to the development of an even more entrepreneurial climate in the industry and create a need for additional business training for more junior staff.

- ***Observation:*** Growth and the need for additional staff in more traditional companies will depend to a large degree on new mapping programs in Canada. The less traditional will create their own new markets as GIS will drive some of the growth and the lines between the sub-sectors can be expected to blur.

  Conclusion: There will be an increasing emphasis on adding additional value to increase margins, requiring more innovative business development, marketing, and sales staff than have heretofore been employed in the industry, as well as technical staff with more broadly based training.

2.6.10 Hydrography

- ***Observation:*** The base is small and growth is projected to be small. However, there is a growing interest in integrated coastal zone management.

  Conclusion: The relative lack of importance of hydrography may change, and change dramatically, if hydrographic information is linked to land information in the coastal areas of Canada and elsewhere.

- ***Observation:*** There is a growing interest in integrated coastal zone management in a number of jurisdictions around the world.

Conclusion: If entrepreneurial oriented individuals can be attracted to the business to develop it, there may be a limited need for more technical individuals in the hydrographic sub-sector who can deal with the land-water interface.

2.6.11 GPS, Navigation and Positioning

- ***Observation:*** Significant growth is projected in GPS use and, like GIS, growth will be in areas not typically thought of as "users" of the technology.

  Conclusion: Training will have to be provided to those involved in the technical engineering aspects, as well as to those from user disciplines as diverse as environmental engineering, forestry, geology, transportation, and other fields who do not yet realize that they will be using the technology within the next five years. This presents a tremendous human resources challenge and suggests in-service training.

2.6.12 Land administration, mapping and other geomatics applications in developing countries

- ***Observation:*** The application of geospatial technology in developing countries is projected to be a significant growth area, suggesting, as noted above, special attention to training those involved in international development, as well as those offering project development consulting, technology transfer, and systems integration. This highly competitive market is already populated by aggressive multi-national companies based in Canada.

  Conclusion: There will be a continuing demand for graduates from programs at Laval and UNB for example, with competition from US companies becoming an increasingly important factor.

2.6.13 Geodesy

- ***Observation:*** Geodesy is a small market not likely to grow.

  Conclusion: There will be limited demand for replacement staff for those retiring.

2.6.14 Land Surveying

- ***Observation:*** Land surveying is the area with the largest employment and is an area undergoing what are to some dramatic changes. Traditional land survey firms will see slow or no growth. It would appear that the more successful firms in this business and those projecting significant growth are those branching out into new business areas such as land information and GIS services.

  Conclusion: Land surveying presents a number of human resources challenges. There appears to be a potential demand for business, marketing, and what we refer to as "broadening" courses to allow the already-practicing land surveyor the technical understanding and knowledge to move into these and other new business areas related to land surveying. Survey technicians will need to be re-trained to move into supporting roles in these new business areas.

2.6.15 Consulting

- ***Observation:*** The consulting industry offering advisory services (as opposed to implementations, information, software or technology) across geomatics has grown significantly in the past few years. The sector can be expected to grow significantly over the next five years as growing firms seek to buy the specialized services of consulting firms. Most firms in this area are one to three person companies, although significant informal networks have developed across Canada that can see as many a five or six such firms linked.

Conclusion: This segment will require in-service training to up-date technically as well as in business areas such as financing as more sophisticated deals are structured. The latter are not geomatics specific and can be obtained at most business schools.

- ***Observation:*** The consulting industry will do more and more work overseas in project formulation and design.

  Conclusion: It can be expected that such work will lead to increased demand for other service and technology companies resulting in increased demands for trained staff willing to work overseas.

3. Industry Profile

3. Industry Profile

3.1 Defining the Geomatics Industry

We have drawn attention in Chapter 1 to the fact that geomatics is a generic term covering a wide collection of disciplines. While some firms in the sector are involved in a number of these disciplines, many are narrowly focused on a single niche. This, we have found from our interviews, results in somewhat of an identity crisis within the geomatics industry in that many of its parts do not consider themselves part of a larger whole. For example, only about 8% of 'geomatics' firms in the Industry Canada Canadian Company Capabilities database mention the word geomatics in their descriptions.

This sense of identity is further complicated by the fact that many geomatics professionals are employed by geomatics users, and not by the geomatics industry. In addition, many of the 'new' geomatics firms consider themselves to be part of the information technology industry, rather than geomatics. Finally, geomatics is not an industry that is recognized in the traditional lexicon of statistical data collection agencies such as Statistics Canada, which makes defining and measuring the industry an ongoing challenge. In this chapter, we present data from our surveys that help to better define the scope and composition of the industry.

3.2 Information Sources

This chapter is based primarily on the results from the Industry Survey, which was distributed to 702 companies (see Appendix C, Survey Methodology). Responses were received from 108 firms, for a response rate of 15%. Some statistics are also based on the Industry Canada Canadian Companies Capabilities Database.

The information from the survey was compared to the results of the 1998 Statistics Canada 'Survey of Surveying and Mapping Services', and to the 1996 GIAC 'Study of Impacts of the Changing Market Structure on the Canadian Geomatics Industry'.

3.3 Number of Firms

This study estimates that there are 2,143 geomatics firms in Canada[22]. This compares to 1,526 estimated in the 1996 study. The database developed for the survey in this study identifies 875 of these firms.

---

22 A search of the Industry Canada database resulted in 1,563 firms offering products or services related to geomatics. The Industry Canada database is self reporting, and therefore not exhaustive. The Statistics Canada 'Survey of Surveying and Mapping Services' is more exhaustive, but does not cover all aspects of the geomatics industry. The total number of geomatics firms in Canada was calculated by using both information sources. Of the firms in the Industry Canada database, 1,200 were involved in surveying and mapping. This compares to 1,645 firms in surveying and mapping estimated in the Statistics Canada survey. If the Statistics Canada number is used as a reliable indicator, then the Industry Canada database represents 1,200/1,645 or 73% of the actual number of firms in geomatics. Therefore we estimate that there are 2,143 geomatics firms in Canada.

3.4 Geomatics Areas

For the purposes of this analysis, the geomatics industry has been divided into five areas: surveying, geographic information systems, navigation and positioning, remote sensing, and mapping. The 'other' category represents primarily consulting across the five areas.

The number of firms having some sales in each area is shown in the second column ('Involved Companies') of Table 3-1. About half of companies are involved in 'Other' (primarily consulting), GIS, and Surveying. Survey companies are least diversified, with about 60% of the sales of firms involved in surveying coming from surveying (column four in Table 3-1).

Table 3-1: Geomatics Areas

Geomatics Area	Involved Companies	Involved Count	Avg. % of Sales	Primary Companies	Primary Count
Surveying	48.4%	46	62.4%	33.7%	32
GIS	51.6%	49	39.0%	26.3%	25
Navigation and Positioning	14.7%	14	24.4%	3.2%	3
Remote Sensing	29.5%	28	39.2%	9.5%	9
Mapping	42.1%	40	36.9%	20.0%	19
Other	54.7%	52	36.6%	7.4%	7
Total				**100.0%**	**95**

Companies were categorized into the five areas based on the area that represented the greatest proportion of their sales. About 34% of companies were primarily involved in surveying (column five in Table 3-1). GIS and mapping were also well represented, at 26% and 20% respectively. This compares to the 1996 study that had a higher number of primary survey companies (56%) and other companies (13%), and a lower number of GIS companies (12%), remote sensing (5%), and mapping (8%). The 1996 study did not have a navigation and positioning category. Thus the trends in surveying (decreasing) and GIS (increasing) identified in the 1996 study are continuing.

In the subsequent analyses, firms are identified by their primary area of involvement in the five geomatics areas.

3.5 Regional Distribution

In order to examine the distribution of companies across the provinces, territories, and internationally, respondents were asked the location of their organization's head office. The distribution is shown in Table 3-2. The majority of firms (28%) were in Ontario, followed closely by Quebec and Alberta.

Table 3-2: Provincial Distribution

Head Office Location	Count	%
BC	13	12.0%
AB	22	20.4%
SK	1	0.9%
MB	8	7.4%
ON	30	27.8%
QC	22	20.4%
NB	5	4.6%
NS	2	1.9%
PE	2	1.9%
NF	1	0.9%
USA	1	0.9%
Other Foreign	1	0.9%
Total	**108**	**100.0%**

On a regional basis, this produces the distribution shown in Table 3-3. Note that the information in the IC database matches the results from the 1996 study to within 1.5%. The distribution produced by the survey of this study is a reasonable reflection of these other distributions.

Table 3-3: Regional Distribution

Region	Survey	IC Database	1996 Study
BC	12.0%	14.3%	14.3%
Prairies	28.7%	17.2%	17.8%
Ontario	27.8%	33.8%	34.3%
Quebec	20.4%	17.5%	18.2%
Atlantic	9.3%	16.5%	15.1%
North	0%	0.6%	0.3%

3.6 Size

In order to examine the size of geomatics companies, respondents were asked questions about the number of geomatics staff in the company and the value of geomatics sales for the company. In the subsequent analysis, firms are identified as either small (less than or equal to 10 geomatics employees), medium (greater than 10 and less than or equal to 100 geomatics employees), or large (greater than 100 geomatics employees). The distribution of company sizes is shown in Table 3-4. The majority of companies were small (75%), and only 2% had more than 100 geomatics employees. This is the same result found by the 1996 study and the 1998 study.

Table 3-4: Size

Size	Count	%
Small	74	75.5%
Medium	22	22.4%
Large	2	2.0%
Total	**98**	**100.0%**

3.7 Markets

The markets for the geomatics industry were examined from a number of viewpoints. First, respondents were asked about the proportion of their sales that were within Canada, to the United States, and to the rest of the World. Table 3-5 shows the major markets by size of firm. Canada is the major market for almost 60% of the firms. Not surprisingly, the Canadian market is more important for small firms. The US market is less important that the rest of the world, with just 13% of firms having it as their major market. This is consistent with the findings of the 1996 study.

Table 3-5: Major Markets

	Small	Medium	Large	Total %	Total Count
Canada	88.7%	11.3%		58.9%	53
USA	75.0%	25.0%		13.3%	12
World	56.0%	40.0%	4.0%	27.8%	25

Given the importance of the Canadian geomatics market, it was examined in more detail. Table 3-6 shows the importance of each domestic regional market to firms located in each region. Not surprisingly, each region is its own most important market. However, this effect is strongest in the Quebec, and weakest in Atlantic Canada.

Table 3-6: Domestic Market Importance

Region	Regional Market	Significant	Some	None	Total Count
BC	Atlantic Canada		30.8%	69.2%	13
	British Columbia	61.5%	38.5%		13
	Ontario	7.7%	46.2%	46.2%	13
	Prairies	15.4%	38.5%	46.2%	13
	Quebec		23.1%	76.9%	13
	Territories		30.8%	69.2%	13
Prairies	Atlantic Canada	6.7%	10.0%	83.3%	30
	British Columbia	10.0%	26.7%	63.3%	30
	Ontario	6.7%	10.0%	83.3%	30
	Prairies	80.0%	10.0%	10.0%	30
	Quebec	3.3%		96.7%	30
	Territories		26.7%	73.3%	30
Ontario	Atlantic Canada	10.7%	25.0%	64.3%	28
	British Columbia	10.7%	14.3%	75.0%	28
	Ontario	82.1%	14.3%	3.6%	28
	Prairies	14.3%	21.4%	64.3%	28
	Quebec	10.7%	10.7%	78.6%	28
	Territories	3.6%	25.0%	71.4%	28
Quebec	Atlantic Canada	4.5%	13.6%	81.8%	22
	British Columbia	4.5%	9.1%	86.4%	22
	Ontario	13.6%	22.7%	63.6%	22
	Prairies		9.1%	90.9%	22
	Quebec	86.4%	9.1%	4.5%	22
	Territories		4.5%	95.5%	22
Atlantic	Atlantic Canada	66.7%	22.2%	11.1%	9
	British Columbia		33.3%	66.7%	9
	Ontario	44.4%	33.3%	22.2%	9
	Prairies	11.1%	11.1%	77.8%	9
	Quebec	11.1%	22.2%	66.7%	9
	Territories	11.1%	22.2%	66.7%	9

Respondents were also asked about the importance of various industry markets. Table 3-7 shows the results. The resource industry was overwhelmingly the most important, with property and utilities also strong. Emergency preparedness, defence, and commerce were surprisingly weak.

Table 3-7: Industry Market Importance

Industry Market	Significant	Some	None	Total Count
Agriculture	10.3%	31.8%	57.9%	107
Forestry	20.6%	33.6%	45.8%	107
Fisheries	8.4%	20.6%	71.0%	107
Oil and Gas	24.3%	22.4%	53.3%	107
Geology and Mining	20.6%	24.3%	55.1%	107
Environment	21.5%	37.4%	41.1%	107
Property	27.1%	29.0%	43.9%	107
Engineering and Construction	18.7%	36.4%	44.9%	107
Transportation	17.8%	29.9%	52.3%	107
Utilities	25.2%	31.8%	43.0%	107
Health	2.8%	11.2%	86.0%	107
Emergency Preparedness and Defence	7.5%	23.4%	69.2%	107
Commerce	4.7%	16.8%	78.5%	107
Education	6.5%	19.6%	73.8%	107
Society, Consumer, Entertainment	5.6%	13.1%	81.3%	107
Other	9.3%	4.7%	86.0%	107

Finally, respondents were asked about the relative importance of the public sector, private sector commercial, and individuals as markets. Table 3-8 shows that GIS is most dependent on the public sector, followed by mapping. In contrast, 'Other' (primarily consulting) and surveying are least dependent on the public sector.

Table 3-8: Public / Private Markets

	Public	Private	Individual
Surveying	31.3%	46.9%	21.9%
GIS	60.0%	32.0%	8.0%
Nav. & Pos.	33.3%	66.7%	
Remote Sensing	33.3%	66.7%	
Mapping	44.4%	55.6%	
Other	28.6%	71.4%	

3.8 Growth

The opportunity for growth in the geomatics industry was also examined from a number of viewpoints. Respondents were asked about the prospects for their company's growth in terms of sales and employment for the two-year period from 2001 through to the end of 2002. Table 3-9 shows the results. The highest growth rates are expected in mapping, and navigation and positioning firms. The lowest expectation is for surveying firms, however it is still positive. Employment growth is also high for mapping, but in contrast to the sales growth, is low for navigation and positioning. Employment growth expectations are also low for surveying firms.

Table 3-9: Company Growth Expectations[23]

Company Type	Sales Growth Mean	Employment Growth Mean
Surveying	39%	30%
GIS	89%	63%
Navigation and Positioning	108%	25%
Remote Sensing	56%	54%
Mapping	114%	110%
Other	63%	50%

Respondents were also asked about the prospects in general for growth in a number of geomatics areas. As shown in Table 3-10, the greatest growth is forecasted for GIS (including Decision Support). The lowest growth is forecasted for surveying (including geodesy and hydrography) and mapping (including photogrammetry). This is generally consistent with the 1996 study, but slightly less optimistic overall. For surveying and mapping, in particular, the forecasts are very much less optimistic.

Table 3-10: Geomatics Area Growth

Market Area	Growth	Flat	Decline	No Opinion	Total Count
Mapping	25.2%	37.4%	17.8%	19.6%	107
Navigation and Positioning	62.6%	18.7%	0.9%	17.8%	107
GIS	82.2%	13.1%	0.9%	3.7%	107
Decision Support	69.2%	14.0%	0.9%	15.9%	107
Geodesy	9.3%	44.9%	14.0%	31.8%	107
Land Surveying	24.3%	32.7%	27.1%	15.9%	107
Hydrography	28.0%	29.0%	10.3%	32.7%	107
Remote Sensing	57.9%	18.7%	6.5%	16.8%	107
Photogrammetry	21.5%	43.0%	15.9%	19.6%	107
Consulting	59.8%	27.1%	3.7%	9.3%	107

[23] For the two-year period from 2001 through to the end of 2002.

Respondents were asked about growth prospects by Industry Markets. Table 3-11 shows that the greatest growth is expected in environmental applications, followed by infrastructure such as transportation and utilities. In contrast, the 1996 study forecast that the greatest growth would be in the resource industry and property.

Table 3-11: Application Growth

Applications	Growth	Flat	Decline	No Opinion	Total Count
Agriculture	41.1%	26.2%	3.7%	29.0%	107
Forestry	48.6%	27.1%	6.5%	17.8%	107
Fisheries	29.0%	29.9%	4.7%	36.4%	107
Oil and Gas	52.3%	24.3%	0.9%	22.4%	107
Geology and Mining	40.2%	29.0%	6.5%	24.3%	107
Environment	75.7%	11.2%	1.9%	11.2%	107
Property	55.1%	27.1%	4.7%	13.1%	107
Engineering and Construction	54.2%	27.1%	0.9%	17.8%	107
Transportation	64.5%	21.5%	0.0%	14.0%	107
Utilities	62.6%	19.6%	0.9%	16.8%	107
Health	31.8%	25.2%	2.8%	40.2%	107
Energy Preparedness and Defence	48.6%	21.5%	1.9%	28.0%	107
Commerce	50.5%	12.1%	1.9%	35.5%	107
Education	36.4%	27.1%	4.7%	31.8%	107
Society/Consumer/Entertainment	32.7%	19.6%	3.7%	43.9%	107
Other	1.9%	0.0%	0.0%	98.1%	107

Finally, respondents were asked about the growth prospects in different geographical regions. Table 3-12 shows that the greatest growth is expected in Canada and the United States, followed by Latin America and Western Europe. This is generally consistent with the 1996 study.

Table 3-12: Regional Growth

Regions	Growth	Flat	Decline	No Opinion	Total Count
Domestic	72.4%	20.0%	3.8%	3.8%	105
Austronesia	31.4%	11.4%	1.0%	56.2%	105
Africa and the Middle East	30.5%	15.2%	3.8%	50.5%	105
Asia - Eastern	34.3%	8.6%	1.0%	56.2%	105
Asia - Southeastern	32.4%	12.4%	1.0%	54.3%	105
Asia – Southern	29.5%	14.3%	1.0%	55.2%	105
Asia – Central	28.6%	14.3%	1.0%	56.2%	105
Europe – Eastern	30.5%	18.1%	3.8%	47.6%	105
Europe - Western	41.9%	12.4%	1.9%	43.8%	105
Mexico	38.1%	11.4%	1.9%	48.6%	105
Latin America and Caribbean	46.7%	8.6%	1.9%	42.9%	105
United States	68.6%	11.4%	0.0%	20.0%	105

3.9 Issues

A number of issues affecting the future of the geomatics industry were examined. First, respondents were asked about the significance of factors influencing change in the geomatics sector. Table 3-13 shows that the most importance factors are technology (including the Internet) and the pricing of data, followed by government policies.

Table 3-13: Change Factors

	Significant	Some	None	Total Count
International Environment	26.9%	50.5%	22.6%	93
National Environment	31.6%	56.8%	11.6%	95
Regional Environment	41.8%	44.9%	13.3%	98
Industry Restructuring	21.9%	51.0%	27.1%	96
Commodity Prices	26.6%	47.9%	25.5%	94
Consumer Demand	44.2%	42.1%	13.7%	95
Government Policies	53.5%	41.4%	5.1%	99
Internet	54.0%	37.0%	9.0%	100
Pricing of Data	60.6%	33.3%	6.1%	99
Technology	67.0%	31.1%	1.9%	103

Next, respondents were asked about the barriers to market development. Table 3-14 shows that the most influential barriers were access to data, the ability of the market to absorb new ideas, and, again, the pricing of data. Interestingly, access to capital was rated last in the 1996 study.

Table 3-14: Market Barriers

	Very Influential	Influential	Not Influential	Total Count
Ability of the market to absorb new ideas	45.7%	45.7%	8.7%	92
Access to capital	36.3%	46.2%	17.6%	91
Absence of standards	18.9%	54.4%	26.7%	90
Access to data	45.8%	44.8%	9.4%	96
Cost of doing business internationally	38.9%	38.9%	22.2%	90
Cost of technology	34.0%	51.0%	15.0%	100
Non-tariff barriers – provincial	14.3%	29.7%	56.0%	91
Non-tariff barriers – international	14.8%	34.1%	51.1%	88
Pricing of data	43.6%	42.6%	13.8%	94
Problems with receiving payment	15.8%	38.2%	46.1%	76
Subsidized competition from abroad	28.1%	24.7%	47.2%	89

Respondents were asked about the importance of partnerships and strategic alliances to the success of their business. Table 3-15 shows that by far the most influential partnerships are with clients, followed by government.

Table 3-15: Importance of Partnerships

Partner Organization	Very Influential	Influential	Not Influential	Total Count
Government	39.2%	41.2%	19.6%	102
Clients	64.1%	30.1%	5.8%	103
Suppliers	30.3%	44.4%	25.3%	99
Other geomatics companies	33.7%	54.1%	12.2%	98
Other non-geomatics companies	28.0%	41.9%	30.1%	93
Research institutes	8.5%	39.4%	52.1%	94
Education institutes	10.5%	48.4%	41.1%	95

Respondents were asked about the importance of the use of the Internet in a number of areas. Table 3-16 shows that the Internet is most important for the delivery of products and services, and least important for sales.

Table 3-16: Importance of the Internet

	Very Important	Important	Not Important	Total Count
Marketing	42.4%	34.3%	23.2%	99
Sales	25.3%	30.3%	44.4%	99
Research	44.6%	34.7%	20.8%	101
Delivery of products and services	45.6%	37.9%	16.5%	103
In-house and outsourced operations	39.4%	37.4%	23.2%	99

3.10 Research and Development

A number of aspects of research and development were examined. Table 3-17 shows the proportion of sales spent on R&D for each geomatics area. GIS is the highest at 20% of sales, while surveying is lowest at 3% of sales.

Table 3-17: R&D spending as a Proportion of Sales

	Mean	Count
Surveying	3%	32
GIS	20%	25
Navigation and Positioning	18%	3
Remote Sensing	19%	9
Mapping	15%	19

Table 3-18 shows the research and development funding sources used by firms. For all areas, internal sources were the most important. Navigation and Positioning made particular use of tax credits and GIS and Remote Sensing made particular use of public sector money.

Table 3-18: R&D Funding Sources

	Internal	Public Sector Contracts	Private Sector Contracts	Tax Credits
Surveying	64.6%	13.6%	11.8%	10.0%
GIS	56.8%	23.1%	3.5%	16.7%
Navigation and Positioning	65.0%	5.0%		30.0%
Remote Sensing	45.0%	24.4%	19.4%	11.3%
Mapping	77.1%	6.4%	5.0%	11.4%

Table shows the involvement of firms in R&D collaboration. The most significant partner was government, followed by clients.

Table 3-19: R&D Collaborative Partners

Partner	Significant	Some	None	Total Count
Government	40.3%	21.0%	38.7%	62
Client Firms	32.3%	41.9%	25.8%	62
Other Geomatics Firms	12.9%	38.7%	48.4%	62
Education/Research Institutes	14.5%	29.0%	56.5%	62

The factors affecting the amount of R&D that a firm performs are shown in Table 3-20. The most important factor is the market demand for new products and services, followed by the availability of capital.

Table 3-20: R&D Performance Factors

	Very Important	Important	Not Important	Total Count
Availability of Capital	59.7%	35.5%	4.8%	62
Availability of Government Support Programs	41.3%	33.3%	25.4%	63
Market Demand for New Products or Services	74.6%	20.6%	4.8%	63
Availability of R&D Resources	39.7%	42.9%	17.5%	63

3.11 Human Resources

Table 3-21 shows the average percentage of female geomatics staff in each of the geomatics areas. The highest percentage is in the 'Other' category (primarily consulting), followed by Navigation and Positioning. The lowest percentage is in Surveying.

Table 3-21: Average Percentage of Female Geomatics Staff

Geomatics Area	Average Female Staff	Total Count
Surveying	20.6%	32
GIS	30.7%	25
Navigation and Positioning	50.0%	3
Remote Sensing	40.8%	9
Mapping	42.1%	19
Other	75.0%	7

Table 3-22 shows the average age in each of the geomatics areas. Navigation and Positioning is the youngest area, followed by mapping. 'Other' (predominately consulting) is the oldest area, followed by Remote Sensing.

Table 3-22: Average Age

	Less than 30 Years Old	30 to Less than 45 Years Old	45 to Less than 60 Years Old	More than 60 Years Old
Surveying	22.6%	48.9%	27.0%	1.5%
GIS	36.1%	57.8%	5.7%	0.4%
Navigation and Positioning	58.3%	8.3%	0.0%	33.3%
Remote Sensing	14.3%	42.6%	43.2%	0.0%
Mapping	42.0%	49.1%	8.9%	0.0%
Other	10.0%	7.1%	68.6%	0.0%

Table 3-23 shows the interest in the certification of human resources in each of the geomatics areas. Interest is highest in Mapping and lowest in Remote Sensing. In most areas, support is below 50%.

Table 3-23: Certification

	Yes	No	Total Count
Surveying	45.2%	54.8%	31
GIS	40.0%	60.0%	25
Navigation and Positioning	33.3%	66.7%	3
Remote Sensing	11.1%	88.9%	9
Mapping	61.1%	38.9%	18
Other		100.0%	7

Table 3-24 shows the reasons for wanting certification. Overwhelmingly, the most important reason is to enhance the credibility of staff.

Table 3-24: Certification Reasons

Reason	Very Important	Important	Not Important	Total Count
To Satisfy a Legal Requirement	27.5%	27.5%	45.0%	40
To Address Health and Safety Concerns	10.8%	13.5%	75.7%	37
To Enhance Credibility of Staff	76.9%	23.1%	.0%	39
To Facilitate More Efficient and Effective Recruitment of Staff	41.0%	43.6%	15.4%	39
To help Geomatics Professionals with Career Building	43.6%	43.6%	12.8%	39
Other	20.0%	.0%	80.0%	5

Table 3-25 shows whether companies perceive that staff turnover is a problem. The majority in all areas do not feel that staff turnover is a problem. The greatest problem is in surveying.

Table 3-25: Staff Turnover Problems

Geomatics Area	Yes	No	Total Count
Surveying	31.0%	69.0%	29
GIS	21.7%	78.3%	23
Navigation and Positioning		100.0%	3
Remote Sensing	11.1%	88.9%	9
Mapping	22.2%	77.8%	18
Other		100.0%	7

Table 3-26 shows the factors that affect staff turnover. The most important (adding the very important and important columns) are salary, advancement opportunities, and interest in work. The 'Other' category includes factors such as seasonal work, travel, overtime, and location.

Table 3-26: Turnover Factors

	Very Important	Important	Not Important	Total Count
Salary	36.6%	45.1%	18.3%	82
Working Environment	30.4%	32.9%	36.7%	79
Advancement Opportunities	37.8%	43.9%	18.3%	82
Interest in Work	43.9%	31.7%	24.4%	82
Other	22.2%	22.2%	55.6%	18

Table 3-27 shows the supporting skills that firms feel they will need in their people to stay competitive in the future. The most important are business skills and entrepreneurship. The 'Other' category includes interpersonal skills.

Table 3-27: Supporting Skills

Supporting Skills	Very Important	Important	Not Important	Total Count
Linguistic	18.9%	43.2%	37.9%	95
Cultural Sensitivity	12.1%	45.1%	42.9%	91
Business	56.6%	35.4%	8.1%	99
Entrepreneurship	53.0%	39.0%	8.0%	100
Other	40.0%	6.7%	53.3%	15

Table 3-28 shows the types of training that firms provide for their staff. The most common training is in-house and mentoring. Some specialized courses are also offered and some support is provided for external programs.

Table 3-28: Training Types

Training Types	Significant	Some	None	Total Count
Mentoring	44.6%	30.7%	24.8%	101
In-House Training	52.5%	37.6%	9.9%	101
Specialized Courses	16.8%	71.3%	11.9%	101
Support for External Degree or Diploma Programs	8.9%	49.5%	41.6%	101

Table 3-29 shows the amount the companies spend on training as a percentage of their geomatics sales. Mapping and GIS companies spend the most at about 2%, while Navigation and Positioning and Surveying companies spend the least at about 0.7%.

Table 3-29: Training Spending

Geomatics Area	Average Spending	Total Count
Surveying	0.7%	32
GIS	2.0%	25
Nav. & Pos.	0.5%	3
Remote Sensing	1.7%	9
Mapping	2.1%	19

3.12 Conclusions

The following sections outline the strengths, challenges, opportunities, and threats for the Canadian geomatics industry, and the human resource implications that follow.

3.12.1 Strengths

Technology

The Canadian geomatics industry is known internationally for their technical capabilities and Canada has led the world in development of technologies such as remote sensing and geographic information systems. This should position Canadian industry well in the future as rapid technological changes drive the future of the sector.

Education

Canadians on the whole are well educated, and this is particularly true in the geomatics industry. Recently, the number of geomatics professionals with university education has increased significantly. The geomatics industry's educated workforce, combined with its technical sophistication mentioned above, is its most important strength as it moves into the future.

3.12.2 Challenges

Firm Size

The most significant characteristic of the Canadian geomatics industry is the small size of the firms; 75% are smaller than 10 people, and 98% are smaller than 100 people. This has a number of important implications, for example:

- Small firms are likely to be under capitalized. Access to capital was identified by the industry as one of the most important barriers to market development. Almost no firms have gone public in order to access capital. This lack of resources is at the root of many of the other threats faced by the industry.
- Small firms may have difficulty competing effectively in international markets. Most international projects require marketing resources, significant working capital, and broad expertise; a combination that is out of reach of most small firms.
- Small firms may have difficulty adapting effectively to technological change. Training and research require time and resources that most small firms cannot afford.
- On the other hand, small firms can be important growth centres if owners/managers are flexible in adapting to change.

The likely outcome of the current structure will be increasing consolidation in the industry. The unanswered question will be whether this occurs through mergers of Canadian firms, acquisitions by foreign firms, or failure of Canadian firms as a result of competition from foreign firms. Obviously, the latter outcome is the least preferable.

Importance of Government

Geomatics is a field that has emerged from the traditionally public sector mandate to map our world, and it continues to be impacted by government actions. Depending on the area, between 30% and 60% of industry markets are with the public sector. This is presumably down from a decade ago as a result of government cutbacks, but is still a significant proportion.

Of the major issues cited by the geomatics industry, many were related to government – for example, public sector geospatial data pricing and access, and government policies. Also government is the second most important partner for the geomatics industry (after clients) and the most important R&D collaborator.

As the markets for geospatial information shift to new applications such as location-based services, it will be important for the geomatics industry to learn how to compete in consumer markets and to wean itself from dependence on government business.

Identity and Awareness

The importance of geospatial information in general, and the geomatics industry in particular, is generally not realized by Canadian citizens, politicians, or investors. Raising awareness about geomatics and its applications is necessary to increase the size of the market and to obtain support for the industry.

This challenge is magnified by the fragmented nature of the industry, which does not have a cohesive sense of identity. The challenge will increase as geomatics technology becomes more integrated with information technology, further diluting the special identity of geomatics. 'New' geomatics firms targeting location based services are more likely to position themselves within the IT industry, rather than the geomatics industry, because access to capital and market image could be enhanced.

3.12.3 Opportunities

The Importance of Geospatial Information

The importance of geospatial information in the economy is increasing significantly, both in the traditional applications such as the resource industry, and more importantly, in new applications such as location based services.

Increasing markets have the potential to cure many of the ills that the geomatics industry faces; larger markets mean more money, more attractive pay, and ultimately more opportunities for geomatics professionals.

3.12.4 Threats

Future Structure

There appears to be a mis-match between the current structure of the Canadian geomatics industry and the opportunities that are developing. For example, the industry is dominated by surveying, but that is the area that will experience the lowest growth in the future. On the other hand, navigation and positioning is currently the smallest segment of the industry, but is predicted to have one of the brightest futures.

This speaks to the need for significant restructuring. One avenue ahead would be for firms to diversify from their traditional areas into new markets. However, there are concerns that this may be difficult to achieve. For example, about 60% of surveying firms are not involved in other geomatics areas. In the case of surveying, governing legislation favours small, narrowly focused firms. In other geomatics areas, the preponderance of small firms could restrict opportunities to diversify without introducing more entrepreneurship into the management.

New Skills

Taking advantage of the opportunities offered by the new applications of geospatial information will require new skill sets, in addition to the core geomatics skills that have distinguished Canadians in the past. Entrepreneurship and business skills will become increasingly important as geomatics moves to a new consumer market orientation. Information technology and Internet skills will become increasingly important, as these technologies become the drivers for new applications and delivery mechanisms.

International and Intra-Industry Competition

Future competition in the geomatics industry will come from without: from outside the country and outside the industry.

The threats from outside the country come from large, well capitalized companies that have the money, resources and connections to displace Canadian firms, either by acquisition or competition. As the Internet reduces the importance of location, Canadian firms will be under increasing competition from foreign companies.

The threat from outside the industry is information technology firms (foreign or domestic) that see the opportunities offered by geospatial information. IT firms are often better positioned to obtain money, resources, and personnel because of the way they are recognized in financial markets.

3.12.5 Human Resource Implications

Future Skill Requirements

The Canadian geomatics industry has historically been very strong technologically. Internationally, Canada's competitive advantage has been the technical skills of its geomatics professionals. However, the result has been a preponderance of small firms started by technologists who do not tend to have the entrepreneurial and business savvy to move their companies to the next level of size and sophistication.

This will not be sufficient in the future as other countries become more technically astute and surpass us in a business sense. Canadian geomatics companies are recognizing this and have identified business and entrepreneurial skills as being very important to their futures. As noted, improved entrepreneurial skills in small companies could turn the current disadvantages of size into an asset allowing these companies to adapt faster to change and to grow.

Similarly, information technology skills will become increasingly important in the future as geospatial information moves on to the Internet for both 'old economy' and 'new economy' applications.

Continuous Learning

There is no sign that change will slow in the geomatics industry. Therefore continuous learning for geomatics professionals is, and will continue to be, vital. Currently, the obligation for continuous learning rests mostly with geomatics professionals, as the small size of most geomatics companies makes it difficult for them to afford extensive skills upgrading for their employees.

4. Technology Profile

4. Technology Profile

4.1 Introduction

Some years ago when surveying and mapping procedures were built upon analogue methods derived from advanced mathematical algorithms, a technology profile, even one in which a great level of detail was investigated, would have been a relatively focused effort with perhaps a heavy emphasis on photogrammetry and remote sensing. Twenty-five or thirty years ago, these were the disciplines that were considered to be cutting edge. Even with the advent of computers and computer-aided mapping the technology of map-making was still relatively traditional without significant fundamental change. Computers were initially used to 'aid' analogue procedures and expedite the creation of manual products. Only as we learned to migrate digital technology into data capture, data manipulation, data display and finally data management and distribution has there been an explosion of creative use of 'geospatial' technologies.

Today, a technology profile must cast a much wider net. Not only has there been a dramatic increase in enabling technologies, some of which are increasingly embedded in geomatics, but we see upwards encroachment along the value added chain of applications which bring with them new and very sophisticated technologies. We now have a situation in which, what we have been used to describing as the single technology of geomatics, must now be treated as an aggregate of numerous technologies which are not necessarily in their entirety part of geomatics.

This technology profile builds upon work undertaken for Industry Canada between 1995 and 1999 in which a Geomatics Technology Roadmap was created and two selective industry overviews were written. More recent sources include, from this current project, the literature review including a broad search of the World-Wide Web, and consolidated results from the interviews and analyses of the survey results. This profile is one of a number of profiles on the sector prepared as part of the study.

While available technologies are of acute interest, they will remain academic unless they can be adopted by the geomatics community at large. It is this community, inclusive of the traditional geomatics industry, geospatial data users and many clients of the industry, which we must take into consideration from a human resource perspective. For this reason, the technologies will be investigated from an industry and user perspective with heavy emphasis placed upon their adaptability and adoptability.

The implications for employment, present and future, will be queried for each significant 'change agent technology' that is identified.

4.2 The Technologies of Geomatics

4.2.1 Surveying

Steady advances in technology have revolutionized the surveying profession over the past twenty years. These advances are quite visible at the annual trade shows such as the American Congress on Surveying and Mapping, or in any of the trade publications, aimed at land surveyors. The future breakthroughs will likely be more in how positional information is applied rather than in how it is acquired. GPS is well documented in a single source – the Big Book on GPS.

Surveying can now be more accurate, faster, and done with far fewer people. Centimetre post processing is now possible and this level of accuracy is improving. One individual consulted concerning this review made the comment that "accuracy is addictive" – the more accurate the positional information people have, the more accurate they want it. Further, it is not the position information itself that has value, but rather what you do with that information. In this way then, surveying and the delivery of accurate position information is enabling other things such as intelligent transport, resource management, emergency service delivery, animal tracking, judicial and policing applications, etc. GPS is an important technology influencing the future direction of surveying.

McDonald (1999) has provided the most concise and clear discussion on GPS technology that we have been able to find. He sees significant improvements being provided. There will be new civil frequencies at L2 and L3c, leading to better signals, less interference, and improved precision. The new civil frequency at L5 is projected to support code rates ten times that of the C/A-code, with significant improvements across a range of important parameters. Perhaps the key change, signalled by McDonald and others writing on GPS, was the end of selective availability (SA), the policy under which the USA has restricted accuracy. The SA policy was suspended in May 2000.

The additional civil frequencies combined with the removal of SA will result in a ten-fold improvement - from 100 metre accuracy with 95% confidence to 10 metres. Improvements in GPS receivers, control segment redundancy and improved statistical estimation techniques will also lead to improved precision. Better spacecraft with more power and longer lifetimes will add to better availability, as would an increase from six to twelve satellites in view at any one time which is being discussed. In addition to all of the technical improvements, there are also significant improvements resulting from new augmentations including the US Coast Guard Differential Network, the Nationwide DGPS, the Federal Aviation Administration Systems, Europe's EGNOS, Japan's MSAS and the other DGPS systems.

While there has been some concern about US military control, GPS has become the de facto standard. It has been recognized that this has been a substantial economic engine for US industry. It is this military control and civilian opportunity that has resulted in the $3.3-4.8 billion Galileo system currently being planned by the European Union.

4.2.2 Navigation and Positioning

One of the market areas that is seeing explosive growth is that served by global positioning systems (GPS). Positioning technology (a phrase that frequently replaces geodetic surveying) generically describes global positioning systems. 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. Today, like computers, the hardware is portable and even hand-held. Units, about the size of a TV remote control, with moving map graphics and accurate to 15 metres, can cost less than three hundred dollars and, due to the size of the 'constellation' of satellites, provide continuous information 24 hours each day anywhere around the globe. We already see them as optional equipment in some luxury cars, boats of all sizes, utility meter reading devices and being developed for inclusion within cellular telephones. Similar but more precise systems are being used in:

- Vehicle navigation (fleet dispatch, tracking, and security);
- Emergency services (police, fire and ambulance);
- Aircraft and marine navigation;
- Aerial photography acquisition;
- Satellite navigation;
- Agricultural applications such as crop spraying (both by aircraft and tractor);
- Mining applications;
- Forestry applications; and
- Municipal and utility applications.

Technically, Canada's industry is well placed to take advantage of GPS. There are a number of suppliers of the technology, software, services, and integrated applications all supported by a strong academic activity, especially at the University of Calgary and UNB. However, many of the same issues that have been faced by remote sensing and GIS are also faced by GPS, including international competition, access to markets, access to trained staff, management and investment.

The Canada-wide Differential GPS (CDGPS) Service is a global positioning system corrections service that will enable all users to derive accuracies of GPS-based positions of between less than one metre to three metres at a confidence level of 95%. This is better than for autonomous GPS-based positions which are currently only accurate to 20 metres.

The CDGPS Service will rely on Natural Resources Canada’s Canadian Active Control System (CACS) data to provide highly accurate, reliable, country-wide real-time GPS correction (GPS·C) data for the service. This service will be described as the Canada-wide Differential GPS (CDGPS) service.

The new service will benefit all users by providing effective access to precise GPS capability across Canada. Through the free and open broadcast of GPS corrections on the mobile communications satellite MSAT-1, GPS manufacturers, systems integrators and value-added service providers will be encouraged to provide effective solutions to Canadians’ needs for various applications requiring precise GPS (sub-metre to 3 metre positioning). Applications include surveying and mapping, all consumer level location technologies, smart agriculture, natural resource management, environmental protection, telecommunications, transportation, fleet and asset management as well as innumerable applications combining positional requirements with business functions.

The Government of Canada, eight Provinces, and the Territory of Nunavut are joint sponsors of this program. As partners, these governments are being committed to:

- provide the free 7 days/week x 24 hours/day broadcast of the GPS corrections over MSAT-1 for four years (expected to begin in early 2001);
- publish an open MSAT-1 broadcast protocol in order to allow industry to build applications and service the Canadian market place;
- seed the engineering and manufacturing of suitable satellite radios (called CDGPS receiver) and supporting satellite network infrastructure;
- nationally standardize and continually improve the GPS corrections in order to improve users' positioning results; and
- incorporate and otherwise promote the use and adoption of the service within their respective jurisdictions.

This service will complement the current Canadian Coast Guard's DGPS service for mariners by extending, for land users, the GPS Corrections inland and to the southern Canadian Arctic. Differential GPS corrections will be available all across Canada, albeit using a different radio frequency band (L-band). This Canadian service will also parallel the United States' program of free provisioning of DGPS under the Nation-wide DGPS program. This service is not intended to serve commercial aviation as served by the Canadian Wide Area Augmentation System (C-WAAS) initiative, nor is it intended to be guaranteed at levels deemed mission critical for public safety (i.e. no fault-tolerant architecture employed). However, the system design will serve as a non-critical or secondary public safety system and may be extensible to meet future primary or "sole means" public safety requirements.

4.2.3 Earth Observation

4.2.3.1 Current Image Sources

The range and number of potential sources for spaceborne imagery changes almost on a daily basis. Some estimates suggest that there will be more than sixty earth observing satellites within the next five to ten years. It is yet to be seen how well the enormous quantities of data will be managed.

Those satellites currently operating that are of most interest to Canada have been primarily government sponsored missions. The systems are RADARSAT (Canada), Landsat VII (USA) launched April 15, 1999, SPOT (France), the Indian Remote Sensing Satellites (India), ERS (Europe), the NOAA AVHRR (USA) and JERS (Japan). Various Russian systems have also been promoted as sources of data, but most of these have been somewhat problematic in terms of routine data delivery. In addition, there is also ADEOS from Japan, and several other missions are either about to be developed or have been recently launched – such as the joint Brazilian-Chinese earth observing mission. Recently IKONOS, the first of the new high resolution commercial systems, began to produce imagery. It provides 1 metre panchromatic imagery and 4 metre multi-spectral imagery. While most of these systems are government sponsored, many do have commercial involvement in the data sales and distribution.

4.2.3.2 High Resolution Sensors/Imagery

With the relaxation by the US government of restrictions on high spatial resolution imagery, a number of new high spatial resolution missions have been planned and launched with one-metre monochrome and four-metre multi-spectral imagery. Only one of those launched, IKONOS, has been successful in returning imagery. Earthwatch planned to provide a new source of high-resolution imagery with its 1-metre panchromatic and 4-metre multi-spectral QuickBird satellite data but the satellite failed to reach orbit after its launch on November 21, 2000. Others such as ORBIMAGE , owned by Orbital Sciences, are in the planning stage.

Just 15 years ago, SPOT imagery with a 10-metre panchromatic band was considered to be of high resolution. Now, one metre pixel imagery is considered to be the standard for high resolution. The one-metre resolution now achieved is, without some very special image processing, the effective limit of satellite sensors. Reading newspapers from space is, we are told by optical scientists, simply not possible. There is a fundamental resolution limit to optical designs, known as the 'diffraction limit', beyond which it is impossible to improve. It happens that, from space, this limit is about one metre. Images will be further degraded by atmospheric scattering, the same problem that ground-based telescopes have looking up through the atmosphere.

To illustrate how far advanced high spatial resolution imaging from space is, Kodak now sells an “off-the-shelf” space-quality camera that will yield one-metre panchromatic imagery and four-metre multi-spectral imagery.

As early as 1984, researchers noted that methods and algorithms developed for use with lower resolution Landsat Multispectral scanner data yielded poorer results when used with higher resolution imagery. This problem is only made worse with the now commercially available, high resolution imagery, some of which can be delivered in stereo, and all of which can be draped over Digital Elevation Models (DEMs). Generalized image analysis methods do not seem to be able to cope with the greater spatial detail, stereo views, and the information on the context of the features being interpreted. It is, therefore, reasonable to predict that there will be a movement towards visual interpretation **(**techniques, tools, etc.). This in turn will have an impact on the type of person required to do interpretation. Many now suggest that some combination of local and discipline knowledge (forestry, agriculture, etc) combined with photo-interpretation skills will be more important than training in image analysis algorithms or systems.

A number of questions remain concerning high spatial resolution imagery:

- Will it be price-competitive with aerial photography or other airborne imagery? Early estimates by some suppliers appear to be higher than the cost of airborne imagery.
- Will it lead to the erosion of the market for aerial photography? The market may be shadowed – leading to a short-term decline in some smaller scale aerial photography sales while users assess what the new imagery can do for them.
- Will delivery be reliable or will it be limited either for political or technical reasons? It is already clear that imagery will not be available for certain countries or for political 'Hot Spots'. Recently several satellites have failed during or shortly after launch. As the systems become more commercial, lower cost, and missions become more routine, it can be expected that technical problems will diminish – or that the number of players in the market will lead to increased reliability.
- Are the tools available to allow users to handle the imagery, or will specialized service providers be required? Tools are

dramatically improving in terms of their ease of use and user friendliness. The nature of the imagery is also making it easier to interpret – this imagery is more like an aerial photograph. New low cost viewers and low cost software can bring imagery to the desktop. (See discussion below.) It can be expected that the role of service providers will diminish as users have access to both better tools and higher resolution imagery.

- What will the key applications be – and have they already been anticipated? Many of the high volume applications will be military and intelligence-related. Others will be for land use planning and thematic mapping. One can expect that with the wider recognition that geo-spatial data are an essential basis for a nation's infrastructure, there will be a broadening of applications. To date every new satellite has seen a serendipitous impact - uses not envisioned becoming important drivers to the success of the program.

4.2.3.3 Hyperspectral Sensors/Imagery

It is only in the past four years that the technology has matured sufficiently to make practical contemplation of a spaceborne hyperspectral sensor. Since then, several spaceborne sensor concepts have been developed (ARIES, SIMSA, PRISM) and several sensors are under construction (NEMO- US Navy; Warfighter – US Air Force; and CHRISS). NASA's Hyperion, the successor to Lewis, is scheduled for launch. From these first generation systems will come the understanding and applications that should make a commercial hyperspectral system a reality within the next five years. The Australian ARIES system may be the first commercial hyperspectral satellite, although that program has been dogged by delays since it was announced with a great deal of fanfare some years ago.

What we currently know in the civilian domain about hyperspectral imagery from space we have learned from airborne data over the past fifteen years. Almost half of the airborne sensors now flying have been built in Canada by Itres (see below.) As with radar imagery, it is difficult to fully simulate what a spaceborne system will yield in the way of imagery.

In addition to spatial resolution limits noted above under 'high resolution sensors', another important limitation is being reached. This is in signal-to-noise ratio (SNR). For technical reasons there is a practical limit to the maximum combined scan rate per number of spatial and spectral pixels without reducing the signal-to-noise ratio. This is an important consideration for hyperspectral sensing from space.

Hyperspectral data involve many (from 64 to over 200) narrow (usually 10 nanometres or less) spectral bands. Understanding the data is difficult, requires significant computational power and a much better developed understanding of the physics of the interaction of light with the objects being sensed than is required in traditional multispectral sensing. To get the maximum information from hyperspectral images it requires that they not simply be regarded as another form of photograph. After a decade of effort, data processing software and information extraction algorithms are available on a research basis. Processing software (for calibration, atmospheric correction, etc.) will become ready for an operational or user environment within the next five years. With this capability as the basis, one can expect that applications products in several areas will be generated on a routine basis.

While no hyperspectral satellite systems exist, there are a number of systems under discussion and a great deal has been learned through the application of the Canadian Itres casi airborne system. Several symposia and journal collections were published in the mid-late 1990s which contained a number of papers on hyperspectral applications (the Australaisian Symposium on Remote Sensing, 1996; Canadian Journal of Remote Sensing), with a great deal of excitement surrounding this technology. A great deal of work has been done on this technology in both the private sector (Itres Research) and at universities (York and Sherbrooke in particular). Recent developments have seen improvements in handling hyperspectral information with more sophisticated software and research such as has been undertaken at CCRS, which have in turn have made its use much easier. These new software tools are now reaching or beginning to reach the market.

The questions that remain with respect to hyperspectral imagery are:

- Will anyone be able to access imagery of any area from commercial systems (such as ARIES and Orbview 4) – or will the investors have some form of priority access, especially if the systems are in part funded by major mining companies?
- Will the data be price-competitive with airborne systems? There is some doubt as to how price competitive a spaceborne system will be where access using an airborne system is feasible.
- Are the tools available to handle the data and extract information? As discussed below, tools are in the research stage now. However, with the increasing use of commercial airborne systems, tools will be developed to solve at least part of the problem.
- Who will foster and pay for technology transfer and commercialization? In the past much of this has been undertaken by government agencies in remote sensing. This technology transfer model would appear to have met with limited success in creating products used by a significant client base.
- Who will create value-added products for clients? The remote sensing industry has had only limited success in creating commercial products for user groups. There would appear to be an opportunity for those serving agriculture, forestry, and the environmental industries to create value-added products.

4.2.3.4 Radar Sensors/Imagery

While the Japanese ERS-1, various Russian systems, the shuttle imaging radar missions (SIR), and the short-lived SEASAT have all contributed both data and knowledge on radar applications, the most prominent spaceborne radar system is clearly RADARSAT. The European Space Agency's ERS-1 research system is also widely used because of its capabilities for certain specific applications, because of European Space Agency promotion and because of its low cost data. Canada has long had a focus on radar in terms of government research and commercial capability. The concept for a radar satellite was first advanced in Canada in 1974. RADARSAT II is to be a more commercially oriented system than RADARSAT I and is planned to have better resolution and more closely meet the needs of key target markets.

A recent study by one of our Panel Members has identified more than ten spaceborne radar systems now in various stages of the planning process to be launched by the Japanese, US Military and the US National

Reconnaissance Organization (NRO), Canada, the USA private sector, Italy, Argentina, Germany, Russia and China.

Radar sensors provide an all-weather day or night imaging capability. However, they also provide images that are more difficult to understand and interpret than, for example, high spatial resolution sensors. Interpreting radar is not easy, and will likely not move to the user's desktop as soon as will the interpretation for many other data sources. The factors that contribute to a radar signal are many. They include the texture of the target, the electrical properties of the target, the orientation of the target to the radar, and the nature of the radar system. Radar imagery has been useful in environmental studies, geology, oceanographic work, agriculture, tropical forestry, and disaster mitigation and response. The complexities and applications of radar are well outlined in the 860 page Third Edition of the Manual of Remote Sensing volume titled Principles and Applications of Imaging Radar by Floyd Henderson and Anthony Lewis published in 1998 by the American Society for Photogrammetry and Remote Sensing in association with Wiley. Recognizing the expertise resident in Canada, six of seventeen chapters of this volume were written or edited by Canadians.

RADARSAT II will have more advanced characteristics than any other civilian radar satellite to date. Its capabilities to provide radar interferometry, better spatial resolution, and several other characteristics as outlined at the CSA, MDA, and RSI web sites, leads to a far more complex system delivering far more complex data. As such it will require far more in the way of advanced understanding of the principles of radar imaging, more complex processing, and additional research. A number of those familiar with the system and its demands have suggested that Canada's industry is not yet equipped to understand much less interpret and use the data from RADARSAT II. The questions that remain with respect to spaceborne radar imagery are:

- What impact will the range and number of radar satellites have on future pricing and commercial viability?
- Will military considerations ultimately affect the allowable resolution?
- While there are few airborne radar systems, will they have any impact on lowering the price of satellite radar imagery, as they will for high resolution and hyperspectral data?
- Despite a long period of research in radar imagery, there is some question as to the availability of the tools to handle the data and extract information. Are they really available to the end-users now, and if not when will they be? Will the end-users be ready to use these tools?
- Who will create value-added products for clients? There would appear to be an opportunity for those serving agriculture, forestry, and the environmental industries to create value-added products.
- Will delivery be reliable or will it be limited either for technical or political reasons? As with high resolution sensors, imagery will not be available for certain countries or for politically sensitive areas.
- What will the key new applications be – and have they already been anticipated? Many of the high volume applications will be military and intelligence-related. Others will be for land use planning, environmental monitoring and thematic mapping.

4.2.3.5 Airborne Remote Sensing

Multi-spectral

Multi-spectral aerial photography was first flown in Canada over agricultural targets by a research group at the University of Waterloo in the early 1970s. An airborne multi-spectral scanner from the USA was first flown in Canada over Nova Scotia in the mid-1970s for tests by the Canada Centre for Remote Sensing. However, airborne multi-spectral photography and scanners have not been widely used in Canada outside of a very limited research environment that was, for a long time, dominated by CCRS. This is a function of the high cost compared to both aerial photography and satellite imagery. However, without the early multi-spectral work, Canada would not have been as well positioned with respect to hyperspectral systems (both their development and use), image analysis software development, and analysis of multi-spectral satellite imagery. There are, however, a large number of multi-spectral scanners flying around the world - many flown by government agencies, but a few are commercial.

Replacing some of the multi-spectral scanner market have been digital cameras produced commercially by groups such as Positive Systems in the United States or for research purposes, by Canada's academic community (Carleton University).

Thermal

One of the first instruments purchased and flown by the CCRS airborne program was a thermal scanner. The system was used to assess building heat loss, for water quality studies, for hydrologic studies, and for forest fire monitoring. While attempts were made to develop a commercial service, the applications did not support a commercial activity. Today, thermal imagery is being flown in the United States by one commercial operator for a combination of uses related to facility management – primarily heat loss and related building or facility studies. As noted below, hyperspectral thermal data is also being considered.

Hyperspectral

The major airborne hyperspectral system in use in the world today is the **casi,** designed and built by Itres Research Limited of Calgary. The fact that the system can be used in part as a more precise multi-spectral scanner is one reason that multi-spectral scanners do not have a significant market presence in Canada. The other available systems, built in Australia and the United States, have until recently been built as custom systems. All of these other commercial systems together represent about one-half of the market not captured by Itres.

Itres has already committed to add a short wave infrared capability, making the system more useful for geological prospecting and some vegetation applications. With this and other advances, we see a continued growth of the airborne market. This market will likely be spurred by the increased use of satellite data. Users will want more calibration data, under-flights, and many will realize that airborne imagery offers certain benefits, including higher spatial resolution (60cm) as is required, for example, in forestry applications. One can also expect to see wider swath widths in hyperspectral systems, and data fusion – with either multiple sensors or with multiple capabilities built into systems like the casi. One capability not expected to be seen is a broader spectral resolution – anything beyond 10 nm seems to be overkill, with the possible exception of phytoplankton characterization and mapping. The US military is investigating thermal hyperspectral imaging, and a variety of groups, are investigating hyperspectral use for land mine applications. An expected continuation of increases in airborne data rates as recording/processing technology improves over time means more cost effective mapping of large areas, and when used in conjunction with widespread low cost software and databases, new application areas should develop.

Radar

Airborne radar sensors such as Intera's STAR system, were at one time a major source of imagery in cloudy regions of the world such as Indonesia, northern Canada, and the tropical rainforests of Africa and South America. First the threat and then the availability of spaceborne radar imagery resulted in a great decrease in the market for airborne radar imagery. Now commercial airborne radar, such as Intermap's Star3*i* system, is used primarily for topographic or other mapping requiring all-weather capability. Research systems such as that flown by the Jet Propulsion Laboratory (JPL) are used in support of satellite or other space programs, as well as for more general research on radar parameters. The system owned by the Canadian government is available to meet the mission of the government as well as for commercial work on a cost recovery basis. The system is described on several websites including those of CCRS and Environment Canada.

4.2.4 Geographic Information Systems

In addition to the common GIS applications dealing with land use and natural resource planning and management, GIS technology is changing the way we navigate everything from super tankers to taxi cabs. For example, GIS programs can be used to create electronic maps of road networks, which can improve rush-hour traffic management, delivery routes and road repair and construction projects. A worldwide market exists for integrating GIS and Global Positioning System technology for vehicle guidance systems. In support of marine transportation, Canadian geographic information systems are also being used for electronic charting of coastal zone regions, river beds and marine traffic.

In large cities throughout North America and in other parts of the world, Canadian GIS expertise has been put to work to save lives through 911 systems. By combining data on traffic flow at different times of the day with road network information, GIS applications can be used to give ambulance drivers, firefighters and police the quickest possible route to accidents and other emergency situations.

In developed and developing countries, distribution and access routes is critical to ensuring effective infrastructure management and development. Managers of public utilities and other infrastructure-based organizations are among the most frequent and enthusiastic users of GIS technology. Utility companies have long used Canadian GIS hardware and software to record, monitor and manage information about pipelines and electricity grids, power lines, generating and distribution stations and transformers. In Canada and elsewhere, GIS is being used to support the planning and sustainable development of electricity-generating facilities.

A range of technology innovations are impacting GIS. According to a number of experts the next few years will see more dramatic changes. One of our project's Expert panel members writing in *Geoworld* in February of last year (Levinsohn, 2000) notes that technology is now concentrating on using the information, rather than, as in the past, capturing it, displaying it, and doing so quickly. The major innovations impacting GIS are going to be those advances that allow one to analyze the data, with the likely emphasis being on the underlying data structures. He then identifies a number of advances: object oriented spatial data base design, client-server database architecture, oriented spatial data base structures, and enterprise data administration.

Limp (2000) details many of the same aspects in a wide-ranging assessment of both technology and how it is being used – equally important to the technology itself. He sees the technology making it possible to move geo-spatial data into the core of large (terabyte-sized) enterprise databases. Oracle, IBM, and Sybase are all cited for this. Limp also notes the impact of high level software products that are "geared toward capable software developers". These allow complex software solutions to be embedded in other products, or even in the data themselves as delivered on the Internet or intranet. Limp has also noted that the Open GIS Consortium has played a key role in GIS technology affecting as it has the concept of interoperability to allow information integration and exchange.

While not technology, the fact that MapPoint and other commercial offerings exist has spurred others in the field or on its periphery to both invest in and use the technology. The fact that the client can now buy smaller amounts of information for a selected area is another innovation that has been made possible by the Internet and technology, but this is not strictly a technology-driven change.

Another issue, which is in part related to technology and, in part, to the broader question of what is geomatics, is the observation (or perhaps lament) of Mangold in *EOM Magazine* that the stand-alone GIS conference seems to be dying off. Some, like Mangold suggest that this is a bad thing, while others see it as a sign of maturation and the movement of GIS into the mainstream. Does the world need GIS conferences to discuss the technology, and if not, what does this imply for the field?

4.2.4.1 Data Management

Traditionally the public sector has played the major role in making, distributing, and updating maps such as topographic maps, forestry maps, city planning maps, etc. That has changed in Canada over the past two decades. Not only are many of these traditional maps now made on contract by the private sector, they are distributed and updated by the private sector as well. In addition many more products are being created – from atlases to picture books to detailed street maps. In part this is a result of these private sector firms taking their new expertise and applying it in an entrepreneurial fashion to create other geo-spatial products for the market.

The remaining role for the public sector appears to be in four major areas: ensuring that the data meet a common standard; as a user of the data sets; in doing the research that will lead to continuing improvements in the data products; their use and their integration across a wide spectrum of uses; and lastly in the facilitation of the data's distribution. A major activity in the federal government that spans the last two areas is the GeoConnections initiative. GeoConnections is developing the Canadian Geospatial Data Infrastructure (CGDI), that will co-ordinate and make Canada's geospatial databases accessible on the Internet. It will co-ordinate partnerships between federal, provincial and territorial governments, the private sector and the academic community.

4.2.4.2 Data Distribution

Several factors have come together at the same time to greatly and quickly change how geomatics data are distributed. First, more and more geospatial data are being created as digital files. Secondly, the capacity has been developed to deliver these data to the user's desktop through the Internet. Thirdly, the cost and user-friendliness of the software created to handle geospatial data has made them accessible to almost anyone – and certainly most business people. The final factor and the one most important in many respects is that there has been a growing realization that most economic decisions have a spatial component – from what route one takes to come home to where one buys a product or service, or where one goes on holidays. Some have begun to differentiate this sort of application of the technology from those dealing with, for example land use planning or natural resource management thus creating a new area of endeavour - business geographics.

Regardless of what names are attached to the various uses, the next few years will see dramatic growth in geospatial data use and electronic distribution. A range of issues will become even more important. These include issues related to personal privacy, the ability of smaller firms (in particular, spatially illiterate firms) to compete, the role of multi-nationals in the retail market place, etc. From an industry point of view the ease of distribution suggests that the source of the data may not be known. This opens the door for more offshore competition in data production.

While traditional thinking has maintained that off-shore quality may not be as good as that produced in Canada, increasingly North American companies are finding or creating sources of quality services and products using identical technology to that available here. In many cases the work force is highly educated from a technical standpoint but lacks managerial acumen and the Canadian tradition of developing high technical standards. As with the growth of technical competence this deficiency in offshore business will not be sustained for long.

4.2.5 Cartography

4.2.5.1 Aerial Photography

Conventional

Since 1996 there has been no new major development in the array of optical large format aerial cameras. Major systems in use in North America include those from Zeiss and Leica with motion compensation and integrated with kinematic positioning technology. No more research and development focused on these instruments is anticipated with the fast approach of digital cameras and possibly retrofitted camera backs.

Digital

A concurrent development to softcopy photogrammetry (see under digital 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. Digital images will then 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. New digital camera technology aimed at the mapping market is now at the prototype stage from at least Leica and Zeiss, with others planning the development of such systems, albeit perhaps for niche markets not requiring the resolution and format traditionally obtained by the high-end optical cameras.

Laser Profiling

Lasers have been used in Canada for a variety of mapping and mapping related applications for some years. The first hydrographic charting with lasers was carried out in Canada by the Canada Centre for Remote Sensing working with the Department of Fisheries and Oceans.

Airborne laser mapping (or LIDAR – Light Detection And Ranging) is a fast and reliable method of obtaining 3-dimensional data for the creation of a digital terrain model (DTM). Capable of producing a DTM to an accuracy of ±15 cm, the system is useful for applications where a relatively high degree of accuracy is necessary, but over a narrow swath. In addition, a laser DTM can be produced in a shorter time frame than a similar product using conventional photogrammetric techniques. The LIDAR system is comprised of a high frequency optical laser coupled with GPS and an inertial navigation system (INS). A system used and perfected by GEOSurv of Ottawa can produce two terrain models: one model for the surface of the ground and one for the vegetation cover.

Today laser-based Lidars are used to support a variety of mapping applications as diverse as tree height mapping and corridor mapping in tropical rain forests to digital mapping in northern Ontario for utility line corridor planning or a highly accurate DTM of the flood-prone area south of Winnipeg. Other applications include hydro wire maps and corridor surveys, on pre-construction projects, where towers (or roads, or pipelines) are sited according to the terrain data collected by the LIDAR system while others have been surveys of existing lines to collect both ground information and catenary information of the transmission wires.

4.2.5.2 Imaging and Data Extraction

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.

Simply 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.

Scanning

Image scanning is the digital equivalent of contact printing from aerial negatives. In a scanner the film is placed in front of a charge couple device (CCD) array and high resolution scans of as small as seven microns are performed. The original aerial negative or contact printed 'diapositives' may be scanned. Scanners, available from Leica, Zeiss, I.S.M. of Vancouver and other suppliers in the USA are absolutely necessary to the digital photogrammetric process. They may be found in photogrammetric service companies, specialized service bureaus and increasingly as part of the offering of the aerial photographers.

4.2.5.3 Digital 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 can expect a commensurate decrease in price. As analogue photogrammetric technology was replaced by analytical instruments, the median cost of services started to fall even though the instruments were very much more expensive. More recently the analytical photogrammetry, essentially a hybridization of the mechanically precise analogue technology and computerization, has been superceded by digital photogrammetry, colloquially called 'softcopy.' In the photogrammetric production environment the desktop computer is rapidly replacing the photogrammetric instrument. Instead of viewing the image space in three dimensions through highly precise optical and mechanical trains, the raster image of the aerial photograph, or remotely sensed scene, can be displayed on a single computer screen and viewed stereoscopically. This is accomplished by displaying two images and projecting them through a stereo emitter to stereo eyewear worn by the map technician.

In essence, what was once a cumbersome mechanical technology with either a hardcopy or computer graphics output, is now a completely computerized process, starting at the point of document conversion where a hardcopy aerial film image is scanned into a data file. All that remains is for the original data acquisition (aerial film camera) to become digital for a 'source to user' digital process.

Softcopy photogrammetry is today replacing traditional photogrammetric 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. Being a photographic image it is a very much more pictorial depiction of the earth. With mainstream orthophoto programmes currently being undertaken by more traditional and costly methods one can foresee a dramatic increase in versatility from softcopy systems and once final products becoming byproducts of the softcopy process. This will cause a dramatic decrease in price of the orthophoto and its utility will erode with the acceptance of stereo viewing technology. Clients of the traditional geomatics industry, with the advent of stereo viewer technology can now produce their own thematic map data from viewable file sets generated by softcopy methods.

In the next few 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 and smaller companies because of the lower start-up cost and a lessened requirement for highly qualified technical 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. More and more companies from telecommunications to retail services are beginning to understand the value of three dimensional geospatial information in making better business decisions.

4.2.5.4 Visualization

Visualization is that sphere of the map production process which presents the cartographic images to the user. Traditionally, this has been in the form of a custom-drawn map, plan or chart produced or published for the benefit of many users. What was contained in that product was at the dictate of the producer (photogrammetrist, cartographer, hydrographer etc.) or at best subject to rigid specifications. Even in the nascent years of GIS, with all the computerization of processes and data, images were still presented which were limited by the producer's software or specifications. Recent trends in cartographic philosophy and the subsequent development of increasingly sophisticated software, however, allow the user to take data from much closer to its source and interrogate, manipulate and display with much more autonomy than previously allowed. We are evolving in terms of relationships between producers, maps and users from 'one to many' to 'one to one'. Each dataset made available to the consumer will be able to be displayed in a unique fashion according to the needs of that consumer.

4.3 Issues and Trends

4.3.1 Technology Convergence

Technology has almost always driven at least some parts of the geomatics sector. It can be argued from our findings that this continues to be the case. Our study shows that the Internet has become a commonly cited reason for there to be an exploding demand for geospatial data. Over 92% of the respondents to our industry survey have identified the Internet as a major factor affecting change. Quite simply, the Internet provides a mechanism for low cost dissemination of both data and tools. When one begins to cross reference these – dissemination, tools, data, and the Internet, we come up with most of what is seen as important in technology today.

Penetration of geospatial data is now possible into the home and small business, greatly aided by major software vendors like Microsoft who offer geospatial analysis tools bundled with their office packages. Interest in geomatics is now being shown by those from outside the traditional fields from which geomatics experts come. One of the more complex issues brought on by this interest is that while those of us from within the field understand the need for and value of precision in measurement in certain circumstances, this understanding is not always shared by those from without. Hence standards remain important. Some would say that standards are a way of maintaining hegemony over the field from interlopers. Others would say that it is essential to ensure that our data and decisions based on these data are trusted.

In addition to the Internet, a number of other technologies have become very important. The following table (Table 4-1) summarizes our survey results on this question.

Interpreting the table has to be done very carefully. For example, one could look at this table and see that neither radar nor hyperspectral imaging are seen as important by industry. However, in terms of remote sensing, these may well be key technologies – and they are rated as such by at least 20% of the industry respondents. Further, there is no linkage drawn between size of company and projected growth and the technologies fuelling that growth. For example, we believe it more important to assess not a company that may triple in size by going from 1 to 3 employees, but rather one that may double by going from 100 to 200. Further analysis of those projecting dramatic growth that translates into significant growth in employment shows that the most dramatic growth does appear to be in those areas with the highest importance attached to them – GIS, Internet applications, user application and solutions, followed closely by visualization, and then navigation and positioning, and distribution and communication.

The technologies and or approaches which have been important across more than one sector included things like geospatial data integration, image manipulation, data generalization, positional accuracy, image display, geo-spatial data output, 3-D visualization, etc.

Table 4-1: Importance of Technology Issues as Seen by Industry Respondents

Technology	Very Important	Important	Not Important
Navigation and Positioning	47.6 %	32.0 %	20.4 %
Geoid mapping	15.2 %	38.4 %	46.5 %
Radar imaging	19.2 %	26.3 %	54.5 %
High resolution optical imaging	38.6 %	31.7 %	29.7 %
Hyperspectral imaging	24.2 %	26.3 %	49.5 %
Image analysis	34.3 %	33.3 %	32.3 %
Digital photogrammetry	27.2 %	37.9 %	35 %
Geographic information systems	58.8 %	37.3 %	3.9 %
Data visualization	52.1 %	35.4 %	12.5 %
Digital elevation model generation	41.6 %	38.6 %	19.8 %
Real time mapping	38.0 %	39.0 %	23.0 %
Data fusion and generalization	38.1 %	39.2 %	22.7 %
Communications and distribution	42.1 %	35.8 %	22.1 %
Internet applications	55.6 %	31.3 %	13.1 %
Geospatial data	61.5 %	31.3 %	7.3 %
User applications and solutions	59.4 %	29.2 %	11.6 %
Artificial intelligence & expert systems	23.3 %	31.4 %	45.3 %
Decision support tools	44.8 %	35.6 %	19.5 %
Other[24]			

[24] The “other” category was answered by two people – one suggested hypermedia and the other Internet development.

Other technology issues:

- More and better data access through the web to allow data mining was often noted. This will result in "a total digital environment" removing the need for hard copy and the associated expense. GPS and GIS will improve and be more accessible with a range of new tools. New satellite imagery was cited by a number of users as something that would have a significant impact on their operations.
- A major driver is the availability of precise, low cost, real time positioning (i.e. GNSS). In fact, some are now referring to "l-commerce" (location commerce) as a major subset of e-commerce. Positioning is now imbedded in GIS technology, services, and applications. Positioning is almost invisible, although it forms the backbone of these services.
- What is also emerging are non-traditional geomatics applications in which both positioning and GIS are imbedded and transparent. GIS permits making geo information visible and smart services for decision making (traditional and non-traditional) depend on easy interpretation / effective visualization. Self-help, and interactive mapping via the Web is targeting the consumer and small business markets.

4.3.1.1 Internet

The most dramatic technology development of the late 1990's has been the Internet. It is 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 (hardcopy) 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.

One of the more successful national initiatives in the last few 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 now routinely made to clients via the Internet. This has become a new business area for traditional groups such as the publishers of EOM magazine who now sell geographic data from a wide range of suppliers through their web-based storefront. All of this activity now takes place because of an enabling technology and in spite its lack of high capacity infrastructure. As data handling technologies to distribute larger volumes of information come on line, it can be expected that geomatics data distribution will dramatically increase.

In the future, we can expect an ever increasing use of web technology by the geomatics community for education and training, advertising, business development, sales, commercial transactions and of course product delivery.

4.3.1.2 Enabling Technologies

One of the critical elements in the field is the speed with which changes are being introduced in and by those technologies which we can say are enabling the development of geomatics. Most often mentioned is the tremendous increase in the capabilities of the PC accompanied by a tremendous decrease in their cost. The development of the Internet has also been noted as a major factor facilitating data collection and distribution in a number of studies. Less frequently explicitly mentioned is the fact that the PC is now found in the majority of work-places and millions of homes in the developed world. PCs are almost ubiquitous in the homes of the well-educated and affluent in not only the developed world, but in many of developing countries. This penetration, coupled with Internet access, and wireless data delivery can now place information in the hands of the individual, at the desktop or in the field, changing marketing, data delivery, and data use forever. Computer literacy in the developing world has already begun to change the competitive dynamic as more and more of the routine geomatics tasks are now being done offshore.

Another important enabling technology is telecommunications: one of the leading players in that area, Nortel Networks, has stated that their corporate goal is the "death of distance". They seek to render distance a meaningless factor by using optical technology to improve bandwidth to move vast quantities of information faster and more reliably than was ever dreamt of even a few years ago. Recent demonstrations saw 6.4 terabits per second transferred over optical fibre. It should be clear to anyone involved in geomatics that anything that affects distance and how people react to distance, will have a fundamental impact on the geomatics business.

4.3.2 Operating Systems

An important factor in the development of software used to be the operating system of the computers used. This is now far less the case. Much more can now be accomplished on the desk-top PC operating with Windows 98, its successor – Windows ME (Millenium),Windows NT and NT's consumer successor - Windows 2000, than was the case just a few years ago. 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 and with the continuing convergence of the capabilities of workstation and desktop platforms, it is clear that the pace of development of ever-increasingly sophisticated software will come within the reach of the most modest budgets.

4.3.3 Geomatics on the Desktop

There is some divergence of opinion on what will happen with respect to how data are handled. One view suggests that delivery of information to the desk top, the increasing user-friendliness of information extraction systems, the movement to higher resolution imagery, the development of low cost viewers, will mean that more of the high level (where local knowledge and decision-making/intelligence is needed) value-added work will be done by the end users themselves. They will be working on their own simple systems using highly processed (geometrically and radiometrically) image data sets produced from the "smart sensors" of the future. The "bull work" - that involving repetitive tasks and not much decision making or local knowledge may well be done "off-shore" - i.e. not by value-added companies in developed countries. Lower cost high speed communications links will make such data movement virtually transparent in both time and geographically. In this model, larger consumers of information may still tend to outsource the value adding work.

Another view suggests that users will ask for information ready to make decisions on. This view, found in Europe and among some value-added companies, suggests that viewers are not needed. This is so because users will get information products and not data. In effect, users will, under this model, receive vector instead of simple raster data. Under this approach to information creation the users will be giving the 'addition of value' from their expertise to some third party.

4.3.4 Geospatial Data Infrastructure

A geospatial data infrastructure is the set of continuous and fully integrated geospatial data that provides context and reference information for any jurisdiction. The data is expected to be widely used and generally applicable, either underpinning or enabling most geospatial applications. Canada is in the process of developing a national geospatial data infrastructure along three principal lines:

1. Alignment layers include geometric control required to adequately position geospatial information. This layer has the geodetic control points as well as the active control systems that allow observations to be related to geodetic reference systems.

2. Land feature/Form layers contain well-defined and readily observable natural or man-made physical features that are not subject to interpretation or speculation.

3.Conceptual layers are the frameworks that society develops and uses to describe and administer the country.

Geospatial Data Infrastructure (GSDI) will draw increasing numbers of scientists and technologists with a probable maximum growth rate within about five years which could be maintained for a further five years. During this ten year period, the emphasis on programming skills, web technology and database design and management will dictate the skills requirements. Specialized geospatial knowledge will be secondary to these skills. The typical knowledge worker will have a strong computer science education with supplementary geographic information science training. There will be high demand for GIS skills but the available pool of graduates from computer sciences will outweigh the GIS specialists. The winning formula for academic institutions will involve the hybrid approach, combining strong curricula from both disciplines.

- Export Opportunities
    - Developing countries need packet solutions – they cannot afford to develop customized solutions around core software. This means that there will be increased demand by Canadian exporters for programmers and systems integrators.
    - Standards are key to GSDI. This means that if Canada does not develop or adopt internationally accepted standards there will be no marketplace for our expertise outside of Canada.
    - If robust standards cannot be established jurisdiction-wide, GSDI will not be viable within Canada.
    - Without standardization, there is reduced opportunity to export and therefore reduced demand for a skilled workforce.
- Barriers to GSDI development and exportability
    - No agreements among federal and provincial departments on standards and specifications;
    - Each province has a widely differing approach to GSDI;

- Canadian industry is slow to respond to emerging market opportunities that are divergent from 'tried and true' technologies.

▪ Favouring conditions for GSDI growth and exportability
  - Canadian technology related to e-tools and web-based imagery is the best in the world;
  - Canada has been very pro-active in development of Vmap1 which is accepted world-wide and standardized;
  - There is a large existing market for services related to data integration and fusion through Canada's network with military and civilian agencies;
  - Canada's expertise in wireless telecommunications which will play an increasingly important role in data delivery around the world;
  - Within the US NSDI (National Spatial Data Infrastructure), there is a high demand for delivery of infrastructure components, training and consulting.

4.3.5 Impact of Technological Change on Business Activity

▪ Technological change is helping most companies. Faster servers mean quicker data crunching and interactive, real-time map regeneration; the web has provided an excellent distribution channel not available before. Broad-band deployment via ADSL or Cable Modems is seen as helping to distribute maps and datasets that run in the mB's of size, previously out of range of the general consumer.

▪ Technological competence will be a key competitive edge. Good technology will help establish "trust" and "confidence" with the market and in the information business, this was considered to be paramount. This competence will enable companies to create flexible, tailored, real-time services, allowing data mining to create new datasets.

▪ Many see the technologies moving farther and farther out to less sophisticated users. This would lead to more opportunities for geomatics as geomatics is viewed increasingly as a management tool, leading to more applications. Like any other industry, we will go through a ramp-up period with proprietary solutions, we will then see consolidation + open standards and then true use.

4.4 Human Resource Implications

4.4.1 Summary Implications of Technology

In many instances in the technology development cycle of products with a large software component, there is a mitigating effect on the employment reduction associated with a maturing technology. As an enabling technology matures and becomes routinely accepted in its markets the employment levels associated with its development often decline due to lessened demand for development functions, and even due to transfer of resources to manufacturing and distribution. Furthermore, the embrace of the market for the technology will often lead to growth in the user and client sectors for that technology.

An illustration of this can be found in the evolution of digital photogrammetry, where not only has the technology evolved away from analogue mechanical and optical instrument manufacturing but also there has been a reduction in employment levels of the user community associated with that technology within the geomatics industry. This however has been offset by a growth of the sector as a whole brought about by the increased accessibility of software driven photogrammetric operations, empowering not only geomatics service providers but also their clients. Subsequently, with the maturation of the software, there has come a further reduction in employee levels in the advance technical arena which has been offset by a growth in near entry level technicians in the service providers and their clients.

With rapidly advancing technology and changing skill demands, there is some concern among interviewees that we will not be able to keep pace because we will lack the necessary human resources to write the software to link applications and data bases to users needs. There is strong competition with the information technology sector. Until recently, this was only an issue in places where there are concentrations of technology companies (Ottawa, Toronto, Montreal, and Vancouver, for example). One company interviewed cited the case of one employee leaving for a high tech position and doubling her salary over night. Shortages of staff in high tech were leading to active recruiting across the country but the situation has altered with the current downturn in the ICT sector. There now may be opportunities to attract lay-offs from the ICT industry to geomatics-related software positions.

4.4.1.1 Technology Implications by Geomatics Area

Human resource implications are assessed for each area of geomatics, sub-divided for greater precision, as **low moderate** or **high** regarding:

- **Security** of employment (demand for and maturity of technology);
- **Availability** of new entrants (supply of suitably qualified college and university graduates);
- Degree of **retention** of employees (stability of workforce); and
- Susceptibility to **external demand** from other technologies (higher salaries, better benefits)

Surveying

Cadastral		
Security	High	Legislated demand for services on a provincial basis
Availability	Moderate	Variable across the country with industry partnering with universities to ensure supply of adequately trained graduates
Retention	High	Not much migration from this line of work
External demand	Low	
Geodetic		
Security	Low	Static or declining market predicted by all sectors of survey
Availability	Moderate	
Retention	High	Not much migration from this line of work other than to GPS industry
External demand	Low	

Earth Observation

Satellite Remote Sensing (Services)		
Security	High	Technology advancing fast in public and private sectors. Demand being created because of increased public awareness of applications
Availability	Moderate	
Retention	Moderate	
External demand	High	Competition from high tech and aerospace sectors
Airborne Remote Sensing (Services)		
Security	High	Technology advancing fast in public and private sectors. Demand being created because of increased public awareness of applications
Availability	Moderate	
Retention	Moderate	
External demand	High	Competition from high tech and aerospace sectors
Image Analysis (Services)		
Security	High	Technology advancing fast in public and private sectors. Demand being created because of increased public awareness of applications
Availability	Moderate	
Retention	Moderate	
External demand	High	Competition from high tech and aerospace sectors
Software Suppliers		
Security	High	Technology advancing fast in public and private sectors. Demand being created because of increased public awareness of applications
Availability	Moderate	
Retention	Moderate	
External demand	High	Competition from high tech and communications sectors

Geographic Information Systems

Systems Developers		
Security	High	Very optimistic market growth forecasts predicted from all sectors especially web based delivery of data
Availability	High	Many academic institutions offering GIS science courses
Retention	Moderate	
External demand	High	Competition from information technology sector
Service Providers		
Security	High	Very optimistic market growth forecasts predicted from all sectors
Availability	High	Many academic institutions offering GIS courses at all levels
Retention	Moderate	Not yet seen as a problem
External demand	High	Competition from information technology sector
Large Systems Architecture (GSDI)		
Security	High	Very optimistic long term market growth forecasts predicted from all sectors, many Internet applications
Availability	Low	Many academic institutions offering GIS science courses at all levels
Retention	Moderate	Not yet seen as a problem
External demand	High	Competition from information technology sector

Cartography

Aerial Photography		
Security	Moderate	Markets under attack from satellite R/S
Availability	Low	Very small community of technicians and aircrew with little formal training
Retention	Moderate	Very stable workforce but susceptible to seasonal variations
External demand	Moderate	Competition from other aviation activities
Photogrammetry – Systems Providers		
Security	Moderate	Very small sub-sector, niche technology but stable for the last 5 years
Availability	Moderate	Inductees with generic computer and GIS skills require much on-the-job training
Retention	Moderate	Stable workforce with little movement between firms
External demand	Moderate	Competition from other IT companies
Photogrammetric Services		
Security	Moderate	Technology migrating to users, software keeping employment numbers down, use of Internet for delivery of data growing, thus requiring new skill sets
Availability	Moderate	Inductees with generic computer and GIS skills require much on-the-job training
Retention	Moderate	Stable workforce with little movement between firms
External demand	Low	
Cartographic Software Developers		
Security	Moderate	Technology migrating to users, software keeping employment numbers down
Availability	Moderate	Inductees with generic computer and GIS skills require much on-the-job training
Retention	Moderate	Stable workforce with little movement between firms
External demand	Low	Technology migrating away from pure cartography. Demand will come from database technologies and related software suppliers.
Cartographic Services		
Security	Moderate	Technology migrating to non traditional companies with a web-based orientation
Availability	Moderate	Inductees with generic computer and GIS skills require much on-the-job training
Retention	Moderate	Stable workforce with little movement between firms
External demand	Low	Will increase with growth of web applications
Conversion (AM/FM)		
Security	Low	Traditionally a labour intensive sector with a finite life span as demand lessens and s/w becomes more sophisticated
Availability	Moderate	Inductees with generic computer and GI skills require much on-the-job training
Retention	Moderate	Stable workforce with little movement between firms
External demand	Low	

Navigation and Positioning

Global Positioning Systems (GPS) Component		
Security	High	Although technology fairly mature, demand is outstripping supply
Availability	High	Some academic programs focused on this sector
Retention	Moderate	
External demand	High	Needed skills are congruent with other high tech sectors, esp. communications
GPS Services		
Security	High	Although technology fairly mature, demand is outstripping supply
Availability	High	Some academic programs focussed on this sector
Retention	Moderate	
External demand	High	Needed skills are congruent with other high tech sectors, esp. communications
Kinematic GPS		
Security	High	Although technology fairly mature, demand is outstripping supply
Availability	High	Some academic programs focused on this sector
Retention	Moderate	
External demand	High	Needed skills are congruent with other high tech sectors, esp. communications
Vehicle Navigation		
Security	High	Technology on the threshold of acceptance and demand is outstripping supply
Availability	High	Some academic programs focused on this sector
Retention	Moderate	
External demand	High	Needed skills are congruent with other high tech sectors, esp. communications

5. Education and Training Profile

5. Education and Training Profile

5.1 Introduction

As part of the requirements for this study, an analysis of the education and training segment of the sector was conducted. Chapter 5 provides an overview of the availability of geomatics training and education in Canada and includes the following components:

- An inventory of formal education and training programs;
- An assessment of the effectiveness and validity of available education/training programs;
- An assessment of gaps between skill requirements and education/training programs;
- An assessment of the use of emerging educational technologies;
- Identification of key barriers impacting the sector's ability to access training;
- Examination of the role of sector employers in the provision of formal and "on the job" training and mentoring;
- An assessment of the sector's future training and education requirements.

5.2 Inventory of Education and Training Programs

An inventory of institutions and organizations providing geomatics education and training in Canada was prepared. To our knowledge this is the first such inventory on geomatics. Course information was obtained primarily from websites and from the catalogues/calendars of universities, colleges, and technology institutes. Tables 5-1 to 5-4 list the seventy-eight (78) Canadian universities, colleges and technical institutions found to provide geomatics education or training in their programs.

Courses reviewed were from those academic programs containing any geomatics component, including Civil Engineering, Survey Engineering, Geomatics Engineering, Geography, Business Geographics, and Forestry. Individual courses from other disciplines (e.g. Architecture) were also included as applicable. The inventory also includes courses provided by private organizations and professional associations, including course information on 31 geomatics educational products and/or courses listed under the User Education and Training Initiative (UETI), Canada Centre for Remote Sensing.

We believe that the inventory of institutions is largely complete and provides a sound basis for analysis. As with the inventory, a listing of private sector and professional associations' learning opportunities did not previously exist. There may be gaps in the listing we have generated because of the difficulty in collecting information from a wide range of sources. The inventory has been given to the Canadian Institute of Geomatics as a separate deliverable.

Table 5-1: Universities, Colleges and Technical Institutions Offering Courses in Geomatics (Western/Northern Canada)

Institutions	Website	Geomatics Degree[25]	Geomatics Diploma	Departments with Courses
Universities				
Simon Fraser University	www.sfu.ca	Yes		Geography
University of Alberta	www.ualberta.ca			Forestry
University of B.C.	www.ubc.ca	Yes		Geography
University of Calgary	www.uclalgary.ca	MGIS		Geography, Geomatics Eng.
University of Lethbridge	www.uleth.ca	Yes		Geography
University of Manitoba	www.umanitoba.ca	Yes		Geography
University of Northern B.C.	www.unbc.ca	Yes		Geography
University of Regina	www.uregina.ca	Yes		Geography
University of Saskatchewan	www.usask.ca	Yes		Geography
University of Victoria	www.uvic.ca	Yes		Geography
University of Winnipeg	www.uwinnipig.ca	Yes		Geography
Colleges				
B.C. Institute of Tech.	www.bcit.ca		Yes	Geomatics
Mount Royal College	www.mtroyal.ab.ca		Yes	Geography
N. Alberta Institute of Tech.	www.nait.ab.ca		Geomatics Eng.	
Red River College	www.rrc.mb.ca		Yes	Geography
S. Alberta Institute of Tech.	www.sait.ab.ca	B. Applied GIS		

[25] Although specific geomatics programs do exist, many graduate programs in remote sensing and GIS are offered through Geography or Earth Science department, or in a department of an associated discipline, such as agriculture, forestry or land/natural resources. Some courses are also offered through the Department of Engineering.

Table 5-2: Universities, Colleges and Technical Institutions Offering Courses in Geomatics (Ontario)

Institutions	Website	Geomatics Degree	Geomatics Diploma	Departments with Courses
Universities				
Brock University	www.brocku.ca	Yes		Geography
Carleton University	www.carleton.ca	Geo. Inf. Proc.		Geography
University of Guelph	www.uoguelph.ca	Yes		Eng. Geog
Lakehead University	www.lakehead.ca	Yes		Forestry
Laurentian University	www.laurentian.ca		Cert. App. Geog.	Geography
McMaster University	www.mcmaster.ca	GIS specialist stream		Geography
Nipissing University	www.unipissing.ca		Yes	GIS
Queen's University	www.queensu.ca	Yes		Geography
Ryerson Polytechnical	www.ryerson.ca	Applied Geography		Civil Eng.
Trent University	www.trentu.ca	Yes		
University of Ottawa	www.uottawa.ca	Yes		Geography
University of Toronto	www.utoronto.ca	Ma. Spatial Analysis		Geography
University of Waterloo	www.uwaterloo.ca	Yes		Geography
University of Western Ontario	www.uwo.ca	Yes		Geography
University of Windsor	www.uwindsor.ca	Yes		Geography
Wilfred Laurier University	www.wlu.ca	Yes		Geography
York University	www.yorku.ca	Yes		Geography
Colleges				
Algonquin College	www.algonquinc.on.ca		Yes	GIS, Cart, RS, Survey
Centennial College	www.centennialcollege.ca		Yes	CAD
La Cite Collegiale	www.lacitec.on.ca		Yes	GIS
Durham College	www.durhamc.on.ca		Yes	CAD
Fanshawe College	www.fanshawec.on.ca		Yes	Survey, GIS
Humber College	www.humberc.on.ca		Yes	CAD
Loyalist College	www.loyalistc.on.ca		Yes	Survey
Mohawk College	www.mohawkc.on.ca		Yes	GIS
Niagara College	www.niagarac.on.ca		Yes	GIS,CAD
Royal Military College	www.rmc.ca		Yes	Civil Eng. Survey
Sault Ste. Marie	www.saultc.on.ca		Yes	GIS
Seneca College	www.seneca.on.ca		Civil Eng.	
Sir. Sanford Fleming	www.flemingc.on.ca		Yes	GIS
St. Clair College	www.stclairc.on.ca		Yes	CAD

Table 5-3: Universities, Colleges and Technical Institutions Offering Courses in Geomatics (Quebec)

Institutions	Website	Geomatics Degree	Geomatics Diploma	Departments with Courses
Universities				
Concordia University	www.concordia.ca	Yes		Geography
Laval University	www.ulaval.ca	Geomatics	Geomatics	Geomatics
McGill University	www.mcgill.ca	Yes		Geography
Sherbrooke University	www.usherb.ca	Geomatics		Geography
University of Montreal	www.umontreal.ca	Yes		Geography
Universite du Quebec a Montreal	www.uqam.ca	Geomatics		Civil Engineering
Univesite du Quebec a Hull	www.uqah.ca	Yes		Geography
Universite du Quebec a Chicoutimi	www.uqac.uquebec.ca	Yes		Geology
Universite du Quebec a Trois-Rivieres	www.uqtr.uquebec.ca	Yes		Geography
Colleges				
Cegep de l'Abitibi-Temiscaminque	www.cegepat.qc.ca		Yes	
Cegep de Baie-Comeau	www.cegep-baie-comeau.qc.ca		Yes	
Cegep de Chicoutimi	www.cegep-chicoutimi.qc.ca		Yes	
Cegep d/Outaouais	www.coll-outao.qc.ca		Geomatics	
Cegep de Rimouski	www.cegep-rimouski.qc.ca		Yes	Civil Engineering
Cegep de Sainte-Foy	www.cegep-ste-foy.qc.ca		Yes	Forestry
CERFO	www.cerfo.qc.ca		Yes	Forestry
College Ahuntsic	www.collegeahuntsic.qc.ca		Yes	Info. not available
College de Limoilou	www.climoilou.qc.ca		Yes	Cart., geodesy
Ecole Polytechnique de Montreal	www.polymtl.ca		Yes	

Table 5-4: Universities, Colleges and Technical Institutions Offering Courses in Geomatics (Atlantic Canada)

Institutions	Website	Geomatics Degree	Geomatics Diploma	Departments with Courses
Universities				
Acadia University	www.acadiau.ca			Few courses
Dalhousie University	www.dal.ca	Yes		Geography
Memorial University of Newfoundland	www.mun.ca	Yes		Geography
Mount Allison University	www.mta.ca	Yes		Geography
St. Mary's University	www.stmarys.ca	Yes		GIS, post-grad research
University College of Cape Breton[26]	www.uccb.ns.ca			Courses - GIS/GPS Centre
University of Moncton	www.umoncton.ca	Yes		Geography
University of New Brunswick	www.unb.ca	Yes		Geodesy, Geomatics Eng.
Colleges				
Centre of Geographic Sciences	www.cogs.ns.ca		Geomatics, IT	
College of North Atlantic	www.northatlantic.nf.ca		Geomatics Tech.	
Holland College	www.hollandc.pe.ca		GIS option	
N. B. Community College, Moncton	www.moncton.nbcc.nb.ca		GIS	
University College of Cape Breton	www.uccb.ns.ca			Courses - GIS/GPS Centre

[26] University College of Cape Breton offers both University degrees and College diplomas and therefore has been included in both lists.

5.3 Determination of Skills Requirements

In assessing the effectiveness of the education/training programs, we first determined the accepted base of skills that are the foundation of geomatics-related activities. A candidate skills list for geomatics was developed from National Occupational Categories (NOC) information for geomatics-related information. Further refinement of this list was made as a result of input from the Modules 3 and 4 Sub-Committee and a Skills Panel of 25 experts from across the country, selected with the assistance of the Sub-Committee. The skill sets were developed for each of the five main geomatics areas agreed to by the Steering Committee:

- Surveying
- Earth Observation
- Geographic Information Systems (GIS)
- Cartography
- Navigation and Positioning

The list of skills was further sub-divided into field skills and generic skills. Field skills are specific to each particular geomatics areas, while generic skills, which relate to the individuals capacity to work effectively in a geomatics business environment, are common across the five areas. The generic skills are listed in Table 5-5 and the field skills in Table 5-6.

Table 5-5: Generic Skills for Geomatics

Generic Skills	
Business Skills	**Technical Skills**
Financial statement analysis	Geodesy
Contract negotiation	Geographic Information Systems (GIS)
Proposal, report and science paper writing	Global Positioning Systems (GPS)
Marketing	Computer Aided Drafting systems (CAD)
The ability to secure funding	Computer hardware and software
Leadership and management skills	Data visualization and interpretation
Team skills	Data formats and transfer
Presentation skills	
Project management skills	

Table 5-6: Field Skills for Geomatics

Surveying	Cartography
Survey law	Specialized equipment viz. stereo plotters, airborne survey cameras, sensors and scanners
Legal surveys procedures	Computer graphic systems
Traditional survey equipment	Image processing software
Computerized land information systems	Image interpretation
Global Positioning Systems (GPS)	Geographic Information Systems (GIS)
Geographic Information Systems (GIS)	Computer Aided Design systems (CAD)
Computer Aided Drafting systems (CAD)	Desktop publishing
Computer hardware and software	Computer hardware and software
Construction surveying	File management: meta data and file transfer
Pre-engineering surveying	
Property rights systems	
Land planning and management	
Understanding/interpretation of data	

Earth Observation (Remote Sensing)	Geographic Information Systems (GIS)
Hyperspectral/ultraspectral/radar /lidar techniques	Principles of Geodesy
Algorithm development	Control survey networks
Spectral data exploitation	Spatial referencing systems and positioning
Specialized equipment	Computer Aided drafting systems (CAD)
Large volume data mining	Engineering surveying
Data visualization	Coordinate geometry
Data format conversion and GIS/RS integration	Photogrammetry
Field campaign design and implementation	Computer hardware and software – external databases
In situ remote sensing validation techniques	Surveying, earth observation and cartography
GIS/RS integration	Database/information structures, algorithms, design and systems
Analytical principles and procedures	Geospatial data analysis, modeling and display
Electromagnetic spectrum	Spatial statistics
Image acquisition, processing and interpretation	

Navigation and Positioning
Electronic navigation systems for positioning, navigating, guiding and controlling air, land, and sea vehicles
Custom software to integrate hardware systems
User interfaces for navigation and guidance systems
Position-related information organized in databases
Use of integrated inertial measurement units and GPS
Understanding of ellipsoids, datums, map projections
Application of navigation and positioning into other geomatics areas
Geometrical geodesy

5.4 Effectiveness of Education/ Training Programs

5.4.1 Overall Education/Training Availability

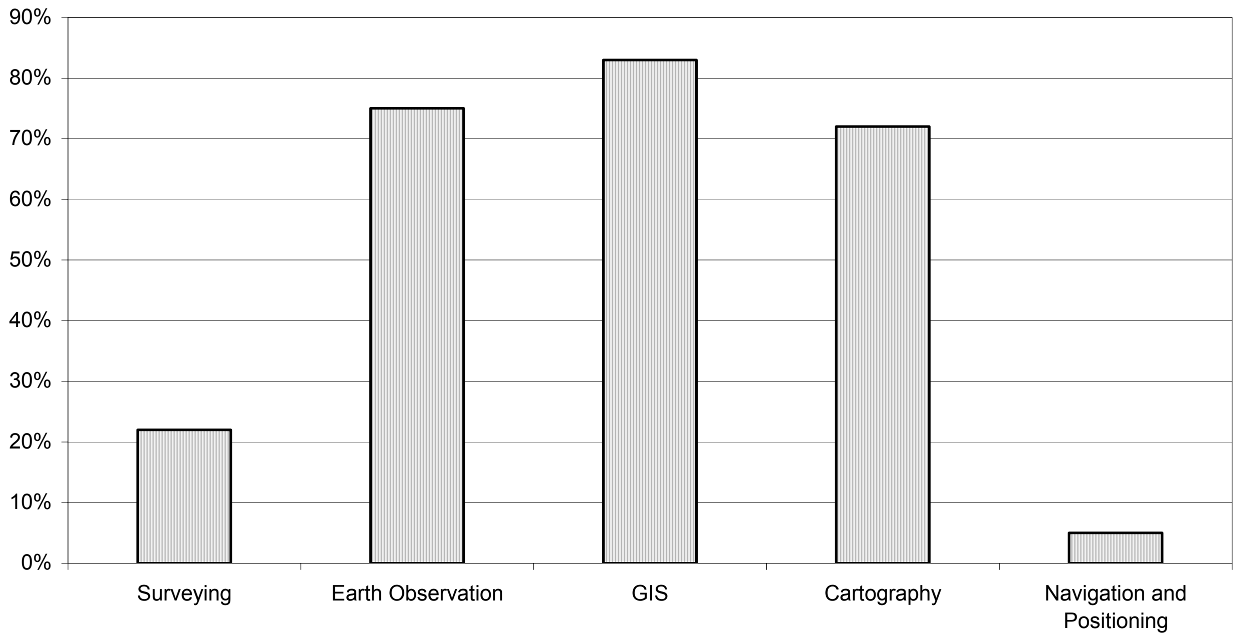
We have examined the geomatics curricula in the universities and colleges in our inventory in light of the above, accepted listing of skills. We have also looked at private sector offerings and the teaching of geomatics in elementary and secondary schools (K-12). The first point to note is that geomatics education and training is predominantly GIS related with over 83% of post-secondary institutions providing significant GIS training. Nearly all universities offer GIS courses, and many allow GIS specializations, in undergraduate and graduate programs. Remote sensing, or earth observation courses, are the next most prevalent (75%), with an emphasis on image interpretation and multispectral analysis. Cartographic courses follow (72%), with map interpretation and map construction/design competencies widespread in introductory geography presentations.

There appear to be more limited course offerings for surveying. Of these, geodesy, GPS, and photogrammetry are the most widely offered. CAD courses in geomatics appear to be rare in the university environment with the exception of Quebec universities but are offered through colleges and technical institutes.

Academic institutions have been responding to the increased need for graduates trained in geomatics; most programs have been updated to reflect changes in the industry, the market and technology, and new programs have been instituted as resources permit. For example, COGS, Limoilou College, and the graduate programs at Laval (Geomatics Sciences Department)[27], bring technically capable people with multidisciplinary backgrounds into the geomatics workforce through a post-graduate diploma or degree program. The availability of courses is summarized in Figure 5-1.

[27] 80 percent of the graduate students in geomatics at Laval come from backgrounds other than geomatics.

Figure 5-1: Education/Training Availability



5.4.2 Education/Training by Geomatics Area

This section reviews the course offerings in each of the five geomatics areas. Additional analysis is being undertaken to determine the impact of broad geographic regions on training availability, for example specific geomatics courses may not be available at all institutions across Canada, however they may well reflect the regional market they serve.

5.4.2.1 Universities

Surveying

Surveying methodology is commonly taught in engineering programs and also in a few geography courses, and provides a practical field component. Traditional surveying instruments are used, as well as more advanced tools, such as total stations. GPS is being integrated into the introductory surveying courses, as is GIS, though to a lesser degree.

Only a few programs address cadastral/legal surveying issues (Laval, Dalhousie, New Brunswick, Calgary), and offer instruction in hydrographic surveying and bathymetric mapping (Laval, New Brunswick). Laval has a large number of courses because of the demanding requirements of the Civil Code. CAD (computer assisted drafting) skills, in the geomatics context, are even more difficult to obtain at a university level. CAD courses in geomatics are found in digital mapping courses as well as in technical drawing courses. Training in this area is more prevalent at colleges and technology institutions.

Earth Observation

Image interpretation, along with image enhancement and analysis using image analysis software, are skills frequently taught at universities across the country. These skills can be obtained through stand-alone remote sensing courses, or as part of a GIS course dealing with data acquisition and sources. Some of the interpretation skills and analysis are taught within the context of a specific application (e.g. forestry). Analogue and digital images are both used for interpretation, and airphoto principles and interpretation remains a staple of introductory earth observation, geography and forestry programs.

There is little opportunity for algorithm development in the undergraduate courses, but perhaps is more likely to be offered in graduate and independent study courses. Very few courses list radar, hyperspectral or ultraspectral imaging in their descriptions, but these technologies are likely discussed in more general courses. Again, graduate courses and independent study courses provide the forum to expand upon these topics. It is difficult to inventory these types of offerings as they are continuously changing to meet current student and faculty interests and requirements. Experience in the use of specialized equipment is absent, with only one university providing skills in direct sensor design and operation. This rarity may be misleading, as course descriptions rarely describe the instruments or equipment used in the course instruction.

No examples of team skill development were found in the earth observation section, although team based projects may be included in some of the courses, particularly those with field components.

GIS

Organization of spatial data, data structure and database management are the most frequently taught skills in the GIS programs. The application of GIS to various problems is also frequently demonstrated, sometimes to a very specific situation (e.g. municipal) but usually with a broader view (e.g. natural resource/environmental applications). Spatial analyses and modelling are skills frequently learned while completing application based projects, and spatial data presentation is covered in many GIS courses.

There is some development of programming/scripting and client application development, mainly in the engineering courses. Business proficiency and project management are useful skills that are covered by few university programs, as are decision support and implementation issues. The MGIS degree program at the University of Calgary (Geography) is an example of a program where these types of skills are developed in conjunction with technical knowledge. Geomatics CAD skills are not usually covered in detail at this level, but rather at the technical colleges and institutions. An exception is Laval where, as noted earlier, CAD is taught in digital mapping, topometry, geospatial data integration, and technical drawing courses and students become familiar with MicroStation, for example.

In terms of soft skills, there a number of courses allowing individual projects which encompass data acquisition, management, analysis, and presentation. The opportunity to build personal and time management, planning, organization, and communication skills is evident more so than in any of the other geomatics areas.

Cartography

In cartography, the three most commonly developed skills are map reading and interpretation, map design and creation, and the use of computers for map generation. In tandem with the production of digital maps, the skill of managing digital files of spatial information is also learned.

CAD skills are not usually developed at this level, with again, Laval being an exception. There is little description of specialized equipment being used, but in data acquisition and map production, there are many opportunities to introduce specialized instruments, and again, the course descriptions may neglect to mention these specifically.

Navigation and Positioning

GPS courses (static and kinematic) are given in the three major geomatics institutions (New Brunswick, Laval, Calgary). Skills in position information are often integrated into surveying and GIS instruction.

5.4.2.2 College and Technology Institutes

In general, the course descriptions from the colleges and institutes are much more detailed than those available from universities. As a result, an assessment of the potential skills learned can be more readily made than is the case with the universities. Generic skills such as planning, organization, teamwork, and communication could be judged more accurately, based on descriptions of course activity and assigned projects.

As in the university environment, training in GIS skills exceeds training in any other area of geomatics. Cartographic skills are second, with an emphasis on map design elements. Earth observation and surveying skills follow, with airphoto principles, image interpretation skills, field surveying techniques and GPS training most predominant. Unlike the university environment, CAD for cartography is also offered.

Many examples of generic skill development are evident, through individual and group projects, and work projects with industry. Business skills are also honed in course work and industry relationships. There is also an emphasis on GIS project management.

Surveying

Surveying methodology using traditional instruments and also more recently developed equipment (total stations) is common. The technologies and applications of GPS and GIS are introduced. There are also courses for CAD for cartographic purposes. Generic skills are developed through major course projects. Computerized land information systems and coordinate systems are offered, although not to the extent of those skills described above. Colleges offering the full range of defined skills include COGS, Limilou, Ahuntsic, and BCIT.

Earth Observation

There is quite a bit of analogue interpretation at this level, but digital systems and imagery are also available. Thus, airphoto principles, image interpretation, and image analysis software are all skills offered quite extensively at this level. Integration of remotely sensed data with GIS is also covered quite well. There is also a program of study dedicated to GISRS integration at the College of Geographic Sciences.

Opportunity for algorithm development and experience with specialized equipment is not evident. There are fewer examples of soft skill development in this area of specialization than in the area of GIS.

GIS

Strengths at this level appear to be data structure, database management, programming and developing custom applications, project management, and presentation of spatial data. Business and municipal application and implementation projects are common. Numerous examples of communication, planning, organization, and team skill development are evident through project-based courses, teamwork, and on-site industry projects.

Geodesy, control network surveys, CAD, and engineering surveying are not typically skills developed through a GIS training environment, although they may be introduced in GIS courses.

Cartography

Digital mapping, including CAD systems, and map design are the commonly developed skills. The use of specialized equipment appears to be more prevalent, but again, that may be due to the detail provided in the course descriptions. Hardware and software knowledge and familiarity are skills found frequently. Some courses demand three versions of software be used and compared for the same application. Geospatial statistics are also examined in depth to better understand spatial analyses in GIS. Map interpretation and information extraction skills are also well represented. Presentation, planning and organization skills are developed in project-based courses.

Image interpretation, image analysis software use, and GIS are used occasionally in the cartographic education at this level.

Navigation and Positioning

In the sample programs reviewed, there was little description of navigation and positioning instruction. Positioning information is often integrated into surveying and GIS instruction.

5.4.2.3 Elementary and Secondary Schools (K-12)

Approximately 20% of Canada's population are enrolled in elementary and secondary school (5.3 million; Statistics Canada, 1997). Geomatics education is emerging at this level, and as such, may have a significant impact on the training and education requirements at the post-graduate level. As a result, it is strongly recommended that activities of this group be taken into consideration.

K-12 education is administered by the provinces through Ministries of Education. The subjects, curriculum content, and outcomes are defined at this level, as are education board structures and funding allocations. Generally, this leads to consistencies within each province, but disparities across the nation in terms of what content is offered and how it is presented. An exception is the framework being developed for the Western Canadian Protocol, an initiative to create commonality between the Manitoba, Saskatchewan, Alberta, and British Columbia curricula, as well as those of the northern territories.

Canadian students are introduced to basic geographic concepts and are familiar with maps, however, even the amount of this fundamental learning varies widely between provinces. Traditionally, there has been no "geomatics" teaching, and there has been no formal initiative to introduce it into the school curriculum. Interest has stemmed from grass-roots initiatives in the early-mid '90's; individual teachers began to offer geomatics (primarily GIS) as optional courses or as a tool to use in their existing courses. News of these activities has sparked interest within the education community, and geomatics is now finding its way into the provincial standards. At this time, GIS is the most frequently addressed geomatics topic, and software licensing to school boards and provinces has recently begun.

The state of geomatics in the K-12 education community is disparate yet invariably growing in popularity and acceptance. Development has always sprung from the grass-roots level where champions have promoted and demonstrated the technology and developed plans to help present existing curriculum. While three provinces (ON, NS, BC) have province-wide software license agreements with one or more companies, other areas are investigating it by board, district, or individual school level (AB, MB, QC, NF, PEI, NB). Vendors have created software appropriate to this level of user and have realized the need of providing data as well. Federal government programs are also supporting data accessibility (GeoGratis, National Atlas of Canada). Between vendors, consultants, and post-secondary institutions, there seems to be adequate support for educators. Lack of awareness of the technology and its appropriateness for the classroom are obstacles that are slowly being overcome.

In an effort to increase awareness of the technology and its uses, the Canada Centre for Remote Sensing has recently developed a Teacher's Guide to Student Research Projects. Intended for students aged 10 to 14 years old, the guide provides a field-tested, ready-made program in the areas of geography, science and other related fields. The guide has been made available online free of charge (http://www.ccrs.nrcan.gc.ca/ccrs/eduref/earthkit/eartkite.html).

It may be of interest that with the inclusion of GIS in the curriculum requirements at this level, small companies and divisions of larger companies are being formed to respond to the potentially explosive demand of teacher-training, in-service development, resources, and software support.

5.4.2.4 Private Industry and Associations

Private industry courses include services and training products. Similar to the difficulty in determining a comprehensive list of university and college level geomatics, private industry and association provided training availability is also difficult to determine. The User Education and Training Initiative (UETI), a funding program within the earth observation component of Canada's Long Term Space Plan, gives a (1999) indication of private sector training services and products developed under that program. UETI was established to provide funding support for Canadian industry and its partners to develop and deliver education and training products and services to meet client needs in priority application sectors and in markets offering maximum potential benefit to Canadian industry and domestic and international learners in the field of earth observation.

A number of Associations provide training, notably the Alberta Land Surveyors' Association (ALSA), the Quebec Association of Land Surveyors, URISA (Ontario Chapter), and the Association of Ontario Land Surveyors (AOLS). These organizations provide training in all aspects of geomatics. The AOLS and the Quebec Association provide a two year apprenticeship training program as part of members' registration.

The Canadian Remote Sensing Society has begun a professional certification program patterned after the non-mandatory certification program offered by the American Society for Photogrammetry and Remote Sensing (ASPRS). To this point, few people have applied. The Canadian Institute of Geomatics has recently circulated a proposal to provide the same sort of service to its members. It should be noted that a number of those certified by the ASPRS are Canadians based in Canada. Most of these are involved in mapping services (in the USA or overseas), or provide consulting services to international organizations such as the United Nations.

Considerable learning takes place as a result of on-the-job projects, reading and conference attendance. In most cases, this is not a formalized process, however Natural Resources Canada has a specific program in place in which the organization recruits junior and develops professionals through 2-year Geomatics Professional Development Program (GPDP).

The importance of informal, on-the-job training (in both technical and soft skills) is a very important means of transfer of knowledge in many companies. The small size of many geomatics companies is generally cited as reason for lack of formal in-house programs.

5.5 Assessment of the Skills Gap

We have identified some inconsistencies between the skills required by geomatics industry, researchers, users, and professionals, and those offered through Canadian geomatics training programs and educational institutions. These "gaps" are important to understand in order to recognize how the education community may best support the rest of the sector, and to link projected marketable skills to academic objectives and course planning. If the teaching of these skills is not offered to Canadian students and employees, businesses will be required to look beyond the Canadian workforce and student pool in order to hire adequately trained personnel. This assessment is based on the required skills as identified in the interviews and survey, and the inventory of skills from Canadian training and education institutions and programs.

5.5.1 Skills Gaps

The skills listed as most important vary between geomatics sector communities - that is to say, a skill that is frequently identified as important in industry, may not be identified as such by the user or education community. This difference in perspective is likely responsible for many of the "gaps" that exist. Generally, there is agreement that GIS and computer skills, particularly programming and Internet technology, will have a tremendous demand. Table 5-7 lists the skills identified as most important in the future, by sector segment.

Table 5-7: Important Skills for the Future (by Sector Segment)

Industry	Professionals
GIS	GIS
Programming	Remote sensing
Remote sensing	Computers/Programming
Photogrammetry	GPS
Users	Integration
GIS	Internet
Database management	Information technology
Specific application knowledge	Application development
Internet technology (some)	Database management
Software development	Data integration: some
Education	Decision support
GIS	System architecture: some
Remote sensing	Cartography: some
GPS	Business skills: some
Database management	
Modeling	
Integration	
Need for geomatics education in high school	

The inventory of skills taught in Canadian institutions and in industry is found in the skills matrix presented in section 5.3. The skills education available was compared to the above list of desired skills and the skills requirements defined by geomatics area to assess the relationship between skill demand and supply.

5.5.2 Assessment

GIS skills were universally seen as being in high demand in the future. General GIS and remote sensing knowledge will have a high demand, but there appears to be adequate supply of academic and training courses through private industry, colleges, technical training institutions, and universities (undergraduate and graduate level) throughout the country to meet the current demand.

From the survey results, growth in decision support is the next dominant growth area (69% of industry respondents), followed by navigation and positioning (62%). From the analysis so far, it appears that the availability of decision support and navigation and positioning education is, at present, not representative of future demand for these areas. Without augmentation of course offerings in these areas, industry needs are not likely to be met.

High on all lists, with the exception of the education community, was the necessity of having increased computing literacy and skills, primarily in programming, scripting, and Internet technology. The concern with these skills is that while they may be inherently used in geomatics courses, they are taught in detail elsewhere - namely computer science and IT courses. The same can be said for software development - seen by the user community as an important future skill. This is not to say that all geomatics programs should suddenly concentrate on providing computer programming courses; perhaps the more appropriate message is that geomatics programs should be well rounded and contain options from computer science or IT departments. Students should be encouraged to build their skills in these areas while continuing core geomatics courses.

One concern, however, is whether the high demand for computer science and IT courses would allow students from "outside" the respective departments to access the courses and instructors. It is interesting to note that while these skills are rated most important by industry, they were not even mentioned by the educators as an important future skill. Inconsistencies of perceived skills requirements between the user and the source of learned skills must be addressed to ensure we are providing the most appropriate education to our future workforce.

There appears to be sufficient supply of software usage skills, especially for image analysis and GIS applications. There is still some training in CAD systems, with a low to moderate demand. Database management skill training is also sufficiently addressed.

Gaps appear in the review of soft skills inventory. In the professionals' interviews, most identified the need for training in "professional skills" - business acumen, project management capability, communication and presentation ability, and teamwork. Some programs are beginning to address this issue by focusing on the skills within a general technical geomatics environment. Increasingly, courses specific to project management, effective writing, and leadership are emerging. It appears that the college environment is leading the way, but more opportunities for this type of skill development are required to meet the demands of the geomatics industry. There was no mention of future soft skills required by the research community.

Integration of various geomatics tools and data is viewed as an important future skill by both educators and business, and is becoming more visible in the university programs. This may be considered a gap, although one that is likely recognized and is being addressed. Application development, data modeling, and data management are all considered to be important skills for future geomatics workers to have. Generally, these skills are adequately supplied by university and technical colleges; generally, the application development and modeling through university programs, and database management through technical programs.

There was one mention of required ISO certification/database auditing skills, which ties in with recent quality assurance initiatives in the geomatics sector, and discussions of certification.

5.6 Emerging Educational Technologies

As with many sectors, the Internet is significantly impacting geomatics education. Over 80% of respondents indicated their use of web-based training which surprised us because the interview results identified several barriers to both web-based and distance education. It is possible that the interviews reflected current shortcomings of the kind noted below in attempts to make better use of these technologies whereas the survey gave a view of the longer-term expectations of the respondents. Certainly, interviewees commented on the Internet being used increasingly for communication and for research purposes.

According to the Conference Board of Canada (September 2000 Member Briefing), learning technologies are at the forefront of innovative employee skill development, however three major barriers exist:

- High cost
- Not enough time
- Content shortage

An additional barrier is directly linked to the amount of information that is available through the Internet. There is now so much information that decisions on what to include, in the time available, is becoming increasingly challenging. The rate of technological change makes it increasingly difficult for educational institutions to rapidly integrate newer learning technologies into the curriculum. A recent article[28] concludes, however, that while the Internet certainly allows broader access to more expertise, permitting better geographic education, it does not replace the need for text books.

The workshops noted that some excellent on-line training was available (ESRI and UNIGIS). Two such Canadian examples are: the Canada Centre for Remote Sensing's online Remote Sensing Tutorial (available on their website), and Ryerson University's effective use of web-based education in offering GIS courses to educators. Some commented that effective on-line training required collaboration among stakeholders (universities, industry and government), commitment and resources. The view was that advantage could be taken of existing infrastructure and initiatives to deliver geomatics content. A federal government initiative called Canada's Campus Connection is helping to improve on-line learning and a few on-line geomatics courses[29] are being offered at this site.

5.7 Barriers Impacting Education and Training Accessibility

A number of barriers have been identified to making education and training in geomatics more widely accessible:

- Lack of a comprehensive database of training availability
- Rate of technological change
- Regional and niche education markets
- Professional development faces some barriers - personnel need flexible hours to fit into demanding schedules and many organizations do not appear willing to support external training (40% of survey respondents indicated that their organizations do not support external training).
- Geospatial data accessibility is a problem for universities/colleges (cost, distribution rights – although with pre Landsat-7 data, this issue has been addressed)

5.8 Role of Sector Employers in Education and Training

In house and on-the-job training appears key in the geomatics industry. Mentoring and in-house training comprise over 97% of significant geomatics training provided for staff working in the industry. The need for learning on-the -job is becoming increasingly essential in order to keep pace with rapid technology advances. According to interview data, much of the learning takes place through on-the-job projects, reading, workshops and seminars (often held at

28 Remote Sensing Education and Internet/World Wide Web Technology, J.A. Griffiths and S.L. Egbert, Canadian Journal of Remote Sensing, April, 2001.

29 GPS/GIS Online (University of Alberta), Mapping Using Microstation (BCIT), Maps and Topographic Drawings (BCIT), Fundamentals of Forest Surveying (BCIT), Terrain Mapping (BCIT).

conferences), and conferences. As a result, and as more staff become pseudo educators, there is an increased need for these people to have training skills in addition to their specific technical skills.

The survey suggests that the importance of formal education and continuing professional development/training is consistent and generally evenly distributed between mentoring, in-house training, support for specialized training, self-study, diploma and degree programs.

In fact, in all categories of education, training and professional development, between 44% and 58% of respondents reported that all these types of training/education are very important and it appears that no one type of training is considered more dominant. Rather, a mix of training/education options is seen to be of value. This has implications for the type of training that should be considered for the future. Not only will the content need to be considered but, perhaps more importantly, the delivery mechanism through which learning will take place.

5.9 Future Education and Training Requirements

There is a theme running through the comments in the workshops that there needs to be more collaboration/linkages among universities, colleges and high schools to provide a more cohesive approach to geomatics training/education. The view was that such cooperation could improve awareness and thus recruitment into the sector. These links might also provide a more cohesive approach to professional development and meeting training needs and to life-long learning. The workshops emphasized the value of co-op programs, internships and work terms as an integral part of education (college and university). A further observation from the workshops was the need for more industry participation in the education system, including the use of industry lecturers. Additionally, reciprocal exchanges between industry and academe was suggested as a best practice.

Other points from our analysis of the interviews, workshops and surveys include:

- Professional development is necessary for geomatics personnel, considering the amount and rate of technological change and the increasing requirement for soft skills that historically have not been provided in a traditional academic environment. These soft or business skills include marketing and building a market, client management, creative thinking, and communication skills (presenting, written).
- Business and entrepreneurial skills are seen as increasingly important as reflected both through the interview process and through analysis of the survey results. In all categories of those surveyed (Industry, Professionals and Users), over 80% of respondents reported that business skills are important or very important
- The importance of formal education and continuing professional development/ training is consistent and generally evenly distributed between mentoring, in-house training, support for specialized training, self-study, diploma and degree programs. No one type of education/ training is reported as dominant.
- In all categories of education, training and professional development, between 44% and 58% of respondents reported that these types of training/education are very important. Between 34% and 44%

reported that these modes of training are important.

- GIS, GPS, remote sensing, data management, analysis and integration, application development, computer related skills, especially Internet programming (web-based technology development) are skill areas that will increasingly be in demand.
- The survey indicates that only 36% of industry respondents reported training for managerial succession. This is significant in terms of career development and retention strategies, particularly in view of competition from other sectors.
- Approximately 50% of respondents reported that linguistic and cultural sensitivity skills are important
- Training skills will be in demand.

Some regional differences were apparent in the comments in the workshops on future training. For example, workshop participants in Toronto and Halifax noted that IT skills and IT skills training were lacking, while Quebec participants indicated that this had been a gap in the past, but was being addressed through recent curriculum changes.

6. Human Resources Profile

6. Human Resources Profile

6.1 Human Resources Today

6.1.1 Geomatics Workforce

Estimates from this study (see Section 2.5.5) point to a market in Canada of just over $2 billion[30], with an employment base of about 22,000 in the private sector and about 5,000 in the public sector. These numbers are expected to grow to an income base of $3 billion, employing 32,000 people, by 2004. This suggests the sector will be growing faster in the future than it has in the recent past given that only 1600 employees have come into the private sector of geomatics since 1996 when the figure for industry was estimated to be 20,400[31]. The same report indicated growth from 1990 to 1996, in contrast, was 70%.

The estimated 5,000 people employed in the public and academic sectors includes as many as 300 surveyors, about 400 in remote sensing, over 2000 in various mapping endeavours and at least 2000 in GIS in all levels of government across Canada. The military component of geomatics was not covered in the study. The total non-military employment in geomatics in Canada today, therefore, stands at almost 27,000.

The employment in the private sector is distributed among 2,100 geomatics firms (see Chapter 3) and an unknown number of user firms. We do know from our interviews that user firms tend to employ larger numbers of geomatics professionals per firm than is found in geomatics firms. Considerably fewer than 22,000 employees, therefore, work in geomatics firms which suggests that the employment per firm is less than 10, a figure confirmed in the survey results reported in Chapter 3.

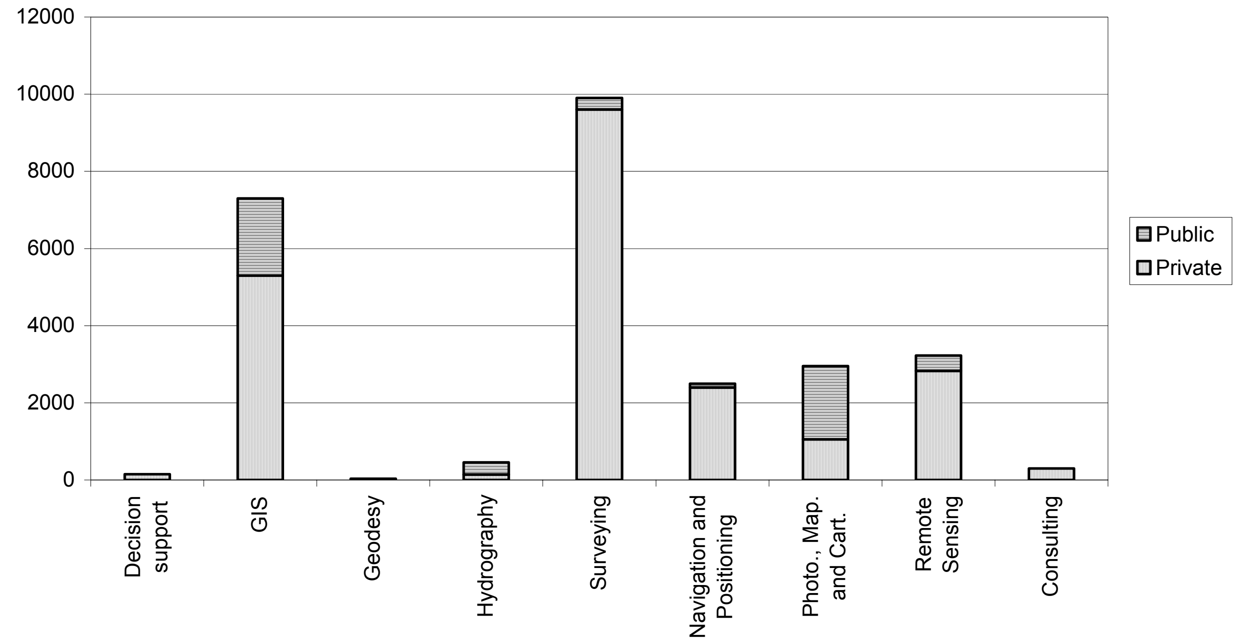
6.1.1.1 Workforce by Geomatics Sub-Sector

Figure 6-1 depicts the number of people working in the geomatics industry by each geomatics sub-sector. Surveying and GIS dominate, and GIS is projected by this study to almost catch up to surveying by 2004. This growth of GIS is mirrored in the relatively high availability of training and education in GIS, both in the primary and secondary levels and at the post-secondary level. GIS has become increasingly available in the marketplace and at the consumer level with the adoption and marketing of the technology by large, traditionally non-geomatics suppliers, such as Microsoft.

[30] The $3 billion market is the business done by Canadian-based companies and includes both domestic sales and exports.

[31] 1996 Study of the Impacts of the Changing Market Structure on the Canadian Geomatics Industry, Industry Canada, 1997

Figure 6-1: Geomatics Workforce by Sub-Sector

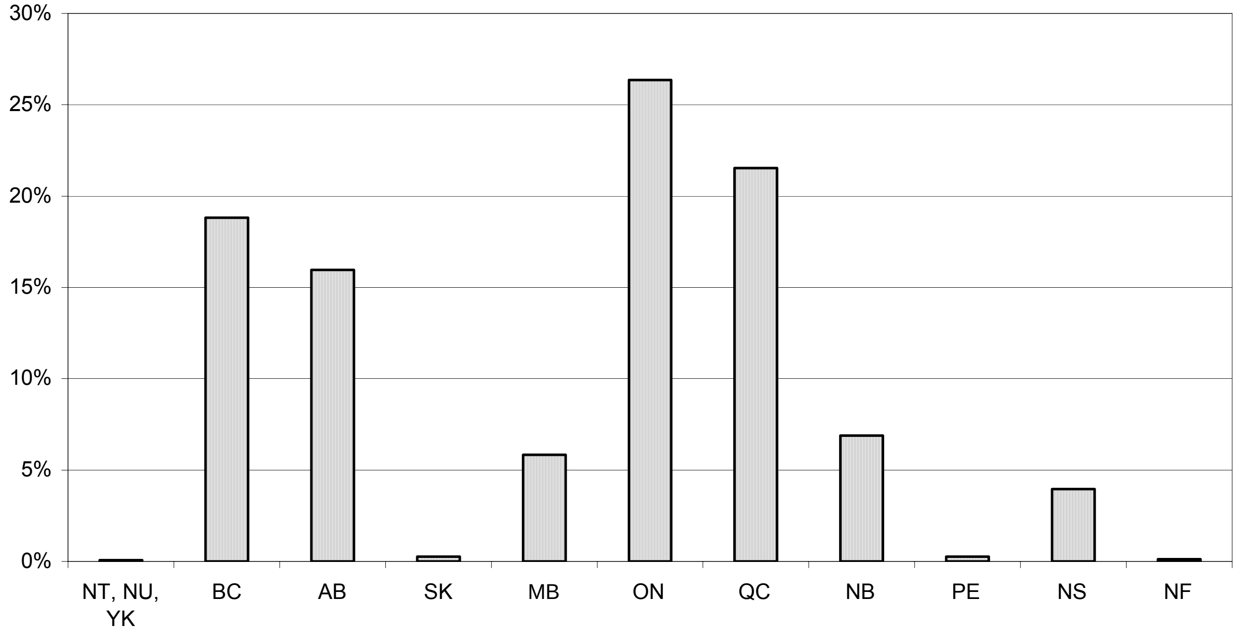


6.1.1.2 Regional Distribution of Workforce

From the companies that identified themselves as being Canadian, only a small number indicated they had staff working outside of Canada. However, almost half of the companies indicated that at least some of their geomatics sales were done outside Canada. From our survey results and interviews, the actual percentage of employees abroad is approximately 3%, which, in real terms, amounts to over 600 individuals. Two thirds of these work in the United States. In some cases these are individuals managing projects, while in others they are engaged in technical support, marketing, or other activities. While we have been unable to determine the number of staff from industry in other countries so engaged, anecdotal evidence and observations by the project team during international assignments suggests that this level is lower in real terms than is found in French and the US industry, and likely lower in relative terms than in the Swedish and Dutch industries.

Figure 6-2, which depicts the workforce distribution in Canada, is a reflection of a combination of factors operating within the geomatics industry in each particular province and the concentration of the industry in a number of urban areas. As other studies have indicated, certain aspects of the industry are tied to applications expertise and interest within the local resource industry, government laboratories, provincial mapping programs, educational institutions, growth in the local economy, etc. It is clear that unlike some other technically based industries, the geomatics industry is truly national in its distribution and is perhaps a harbinger of what is to come in terms of the dispersion of industry based on nodes of expertise and interest.

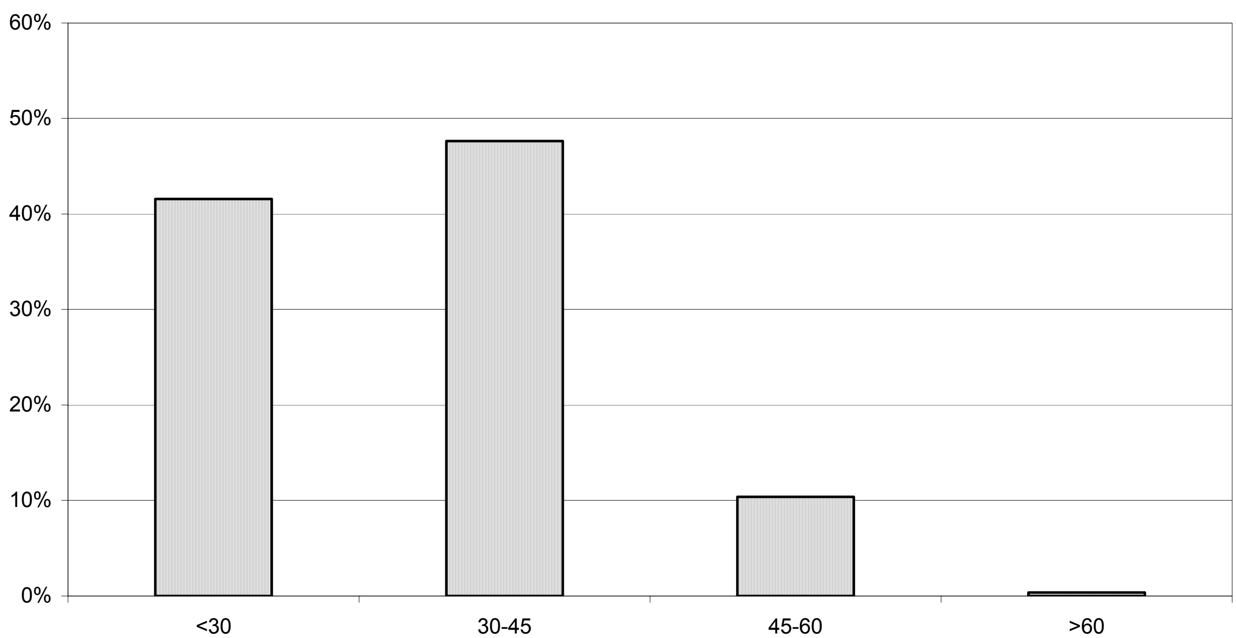
Figure 6-2: Geomatics Workforce by Region



6.1.1.3 Workforce Distribution by Age

As depicted in Figure 6-3, the industry is populated by a relatively young workforce with 42% under 30 years old, and 90% under 45. This figure does not depict the number of individuals working in a management capacity.

Figure 6-3: Workforce Age Distribution



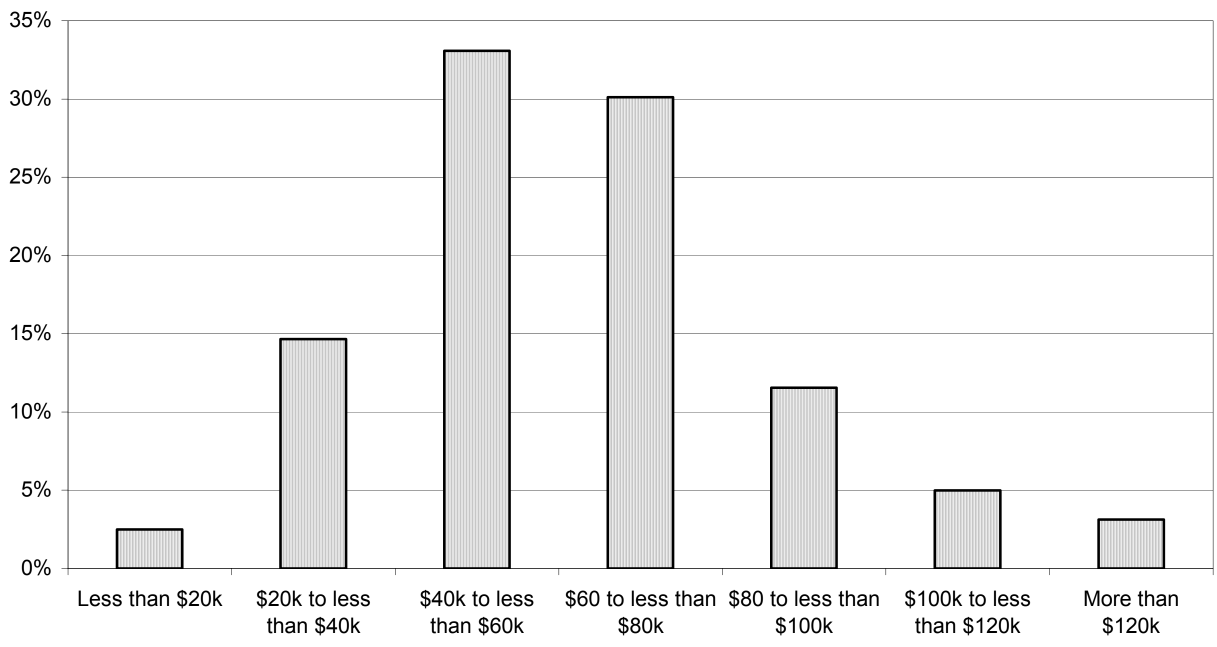
6.1.1.4 Gender Distribution

As with many science and/or technology fields, the geomatics industry is predominantly male. While only 26.4% of the workforce is female, this is a significant increase from 1994 data, when the proportion of females in the industry was between 3% and 10%, depending on the particular sub-sector. Female participation has thus grown in real terms from well under 2,000, to almost 6,000 – an increase that is close to or exceeds the total growth in employment in the sector over the period. While our survey cannot specifically address this factor, it would appear that to have achieved the current level of female participation, many of those replacing retirees and others who have left the industry have been female, and the entry rate of females into the work force must be between 35% and 50% or more. A number of factors have no doubt contributed to this phenomenon but we have not had an opportunity to pursue this finding in our study.

6.1.2 Salaries/Wages

Figure 6-4 indicates that the majority of professional, (63%) working in the geomatics industry currently earn between $40,000 and $80,000 per annum.

Figure 6-4: Salary Distribution



This translates into a fairly high concentration of compensation for the industry. Given that the IT sector is often said to be competing for human resources with the geomatics sector, IT sector compensation distribution is included as Table 6-1 for comparison. There generally appear from this data to be more opportunities for higher salaries in the IT sector.

Table 6-1: 2000 IT Salary Data[32]

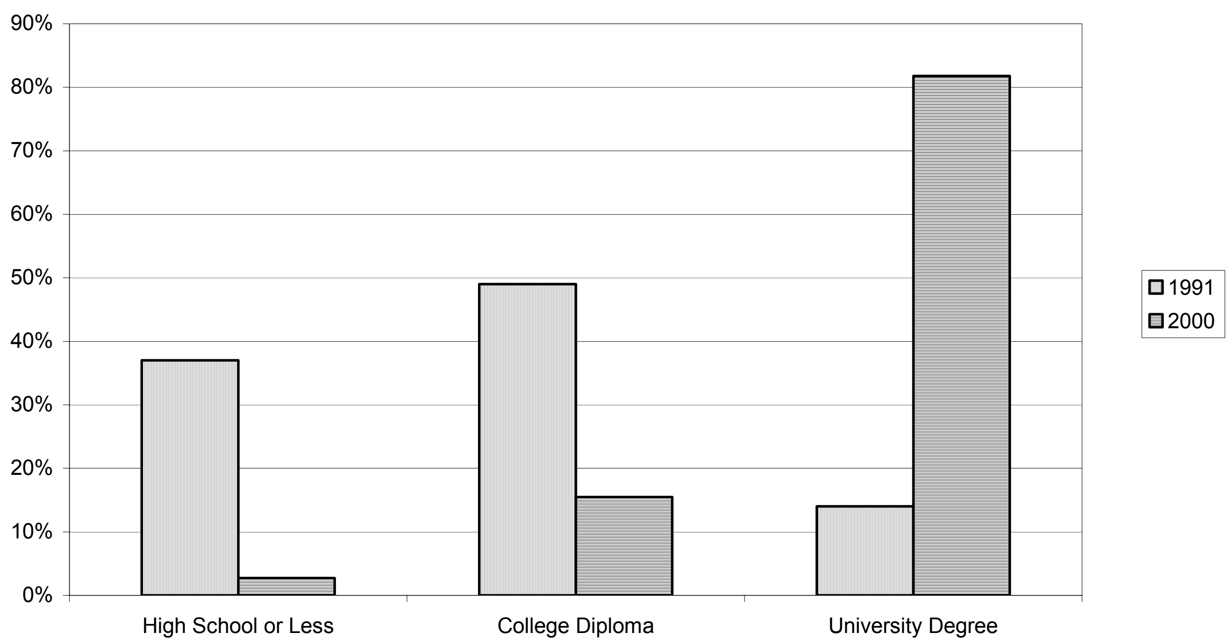
Category	Salary Range
CIO	$115,000 - $185,000
VP - Information Systems	$103,000 - $170,250
IS Director	$85,000 - $125,000
Applications Development	$38,250 - $108,500
Technical Services, Help Desk & Support	$28,000 - $90,000
Data/Database Administration	$60,000 - $94,500
Operations	$29,500 - $88,000
Consulting & Systems Integration	$47,250 - $101,000
Software Development	$47,000 - $100,750
Client Server/Networking	$42,000 - $93,000
Internet & Electronic Mail	$44,000 - $81,750

6.1.2.1 Education and Salary Levels

The geomatics workforce reflects an industry that places significant and increased importance on post secondary education, including industry specific skills, with over 80% of the workforce having a university degree (Figure 6-5). The picture in 2000 is entirely different from the education distribution in 1991, showing a significant increase in the post-secondary (predominantly university) education.

The professionals interviewed all thought their academic background was sufficient, but stressed a requirement to update their skills frequently to match technology advancements and changes in industry (or to better understand new markets – e.g. issues overseas).

Figure 6-5: Levels of Education and Training



[32] RHI Consulting

6.1.3 Employment of New Graduates

Depending on the region, many graduates are leaving Canada - this is particularly true of graduates from Atlantic Canada, where aggressive US recruitment initiatives have been very successful. The Centre of Geographic Sciences (COGS) indicates that, in some years, the numbers have been as high as 36% of the graduates in the geomatics engineering technology program. Although the numbers tend to fluctuate year by year, for some programs, especially surveying and geomatics engineering technology, the proportion of graduates leaving for the US has been increasing The reasons often cited are the higher salaries and the opportunity to pay down student debts that have been incurred over what is often six years of consecutive post-secondary education. It is not known how many of these graduates later return to Canada to take up positions in the Canadian geomatics industry.

From our interviews, we understand the situation in Quebec is different. Geomatics people are migrating from other French-speaking European countries to Quebec because work opportunities are perceived to be better. While no hard evidence was provided, it was thought that immigration into Quebec exceeds the numbers emigrating.

6.1.4 Professional Development Education and Training

In house and on-the-job training appears key in the geomatics industry. Mentoring and in-house training comprise over 97% of significant geomatics training provided for staff working in the industry. The need for learning on-the -job is becoming increasingly essential in order to keep pace with rapid technology advances. According to interview data, much of the learning takes place through on-the-job projects, reading, workshops and seminars (often held at conferences), and conferences.

6.1.5 Certification

Certification is a legal requirement within the surveying profession and professional engineer accreditation (P.Eng.) is necessary in some circumstances. A federal licence and commissioning as a Canada Lands Surveyor permits the conduct of surveys on federal lands. Each province also has its own licensing regime for surveyors which restricts the mobility of surveyors to some extent.

The Canadian Remote Sensing Society has begun a professional certification program patterned after the non-mandatory certification program offered by the American Society for Photogrammetry and Remote Sensing (ASPRS). To this point, few people have applied. The Canadian Institute of Geomatics has recently circulated a proposal to provide the same sort of service to its members. It should be noted that a number of those certified by the ASPRS are Canadians based in Canada. Most of these are involved in mapping services (in the USA or overseas), or provide consulting services to international organizations such as the United Nations. We have been unable to determine any instance where the ASPRS Certification is required to work in Canada.

6.2 Human Resources Implications

6.2.1 Areas of Growth and Decline

There are areas of change that will lead to dramatic growth, and in some other cases areas which will not grow as dramatically. Problems will result in those cases where industry, agencies and their staff are unable to manage or react to change.

6.2.1.1 Areas of Growth

Not surprisingly, this study reflects the tremendous impact that the Internet has had and will have on geomatics and related (and most other) industries. The Internet provides a mechanism for low cost distribution of both data and tools. When one begins to cross tabulate these – dissemination, tools, data, and the Internet – we come up with most of what is seen as important in technology today. Additionally, there will be a proliferation of data available via the Internet and via Intranet. The Internet is the most commonly cited reason for the exploding demand for geospatial data. Over 92% of the respondents to the industry survey have identified the Internet as a major factor affecting change.

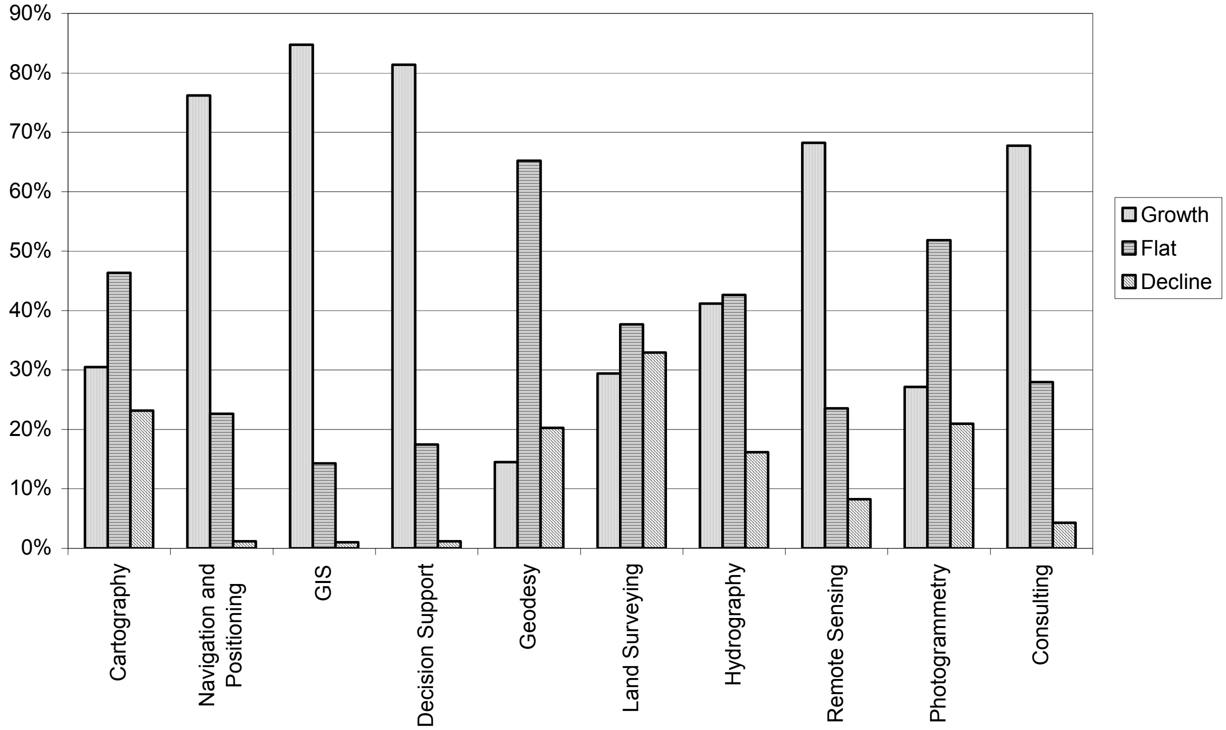
The implications for human resources and education are significant. While there will remain a need for the highly specialized geomatics specialist, interviews and results suggest that there will be a growing demand for those with a solid background in a specific user discipline (forestry, urban planning, etc), with a general understanding of the geomatics field. It is often assumed that an Internet navigability/web application comfort level is a given.

GIS is seen as the predominant growth area, as reported by 85% of survey respondents from industry (Figure 6-6). Growth in decision support follows as the next dominant growth area (81% of industry respondents), followed by navigation and positioning (76%). The majority of those projecting the lowest growth are in the traditional land surveying business. An interesting finding of the industry survey is that land surveying firms involved in GIS, navigation, spatial data bases, and other new business areas are projecting far more business growth than are their counterparts doing only surveying. This supports the contention made in interviews by some land surveyors that the land surveying business can and will grow in certain areas. It should also be noted that projections of the lowest business growth among those in the high growth areas such as GIS and navigation and positioning are also involved in land surveying.

Within these categories, survey respondents reported expected growth in the following technical areas:

- Real-time data acquisition; framework data sets.
- Geospatial data storage in relational data bases; web mapping.
- Integrated, Internet/Web based geomatics including: mapping, high-resolution satellite imagery, digital airborne mapping, knowledge-based systems.
- Web-based data exchange, web based data supply, and commercialization of land information data.
- Seamless linking/integrating of data from all sources, objects, vectors, raster, DEM and databases, data morphing.
- Satellite imagery use.

Figure 6-6: Areas of Growth and Decline



These candidates for technical growth are consistent with the sub-sectors seen as areas of growth in the industry survey. The human resources impact is clear: relatively high levels of computer literacy, combined with a solid foundation in geomatics-specific skills will be required.

6.2.1.2 Areas of Decline

Only one company projected a decline in income. A few others project growth that over time may be lower than the rate of inflation, and hence a real decline. In all but one case these views were found in land surveying.

Some of the traditional disciplines of geomatics, including land surveying, will also change as some of the more routine (and in some cases more complex) tasks are replicated in software, and as technology (especially GPS) becomes more widely used. This has the potential to replace more skilled professionals with less skilled technicians, be they cartographers, photogrammetrists, or those engaged in certain elements of land survey. These new technologies are also lowering the barrier to entry into the field.

Certain aspects of land surveying will decline. One factor affecting land survey has been the growing use of GPS to provide an adequate locational reference for certain applications in forestry and other applications. Another factor has been the growing use of title insurance to replace a land survey and/or title search – which was at one time virtually required by lending institutions in some jurisdictions before a mortgage could be given.

While the sale of desk-top software generates income for Canadian industry, and has made our mapping industry more competitive, it has also resulted in a lowering of entry barriers into the market for lower-wage off-shore competition in some of the more labour intensive mapping operations where local knowledge is not necessary. Some elements of the mapping industry face a competitive threat from overseas. This has resulted in a move to adding higher value by Canadian suppliers – leading to a change in the expected capabilities of Canadian employees. As this software becomes increasingly available (and affordable) data conversion, such as vector digitizing and the pre-processing of imagery, will increasingly be transferred to the suppliers of data, and 'bundled' for easy use by the end user/consumer.

6.2.2 Impact of Technology on Human Resources

As we noted in Chapter 4, with the changes that are rapidly advancing, there is some concern among some of those interviewed that we will not be able to keep pace because we will lack the necessary human resources to write the software to link applications and data bases to users needs. There is strong competition with the information technology (IT) sector for these people. Some interviewees suggested that geographers will do the required software development with a minimum level of software skills using packaged software and their geographic perspective. We believe that such an approach may work in the short term, but as these individuals receive training and more familiarity with software tools, they will migrate to the IT sector where the salaries are higher and rewards greater.

The rapidly reducing cost of software tools coupled with more automation and intelligence built into the software has seen many companies in developing countries become both cost and quality competitive with Canadian firms. In fact, in terms of cost they are considerably less. What kind of geomatics activities can Canada continue to be competitive in and consequently offer employment? The controlling factors here for Canadian firms will be solid management, marketing and strategic planning. What we can say from our investigation is that those tasks requiring local knowledge (much of the thematic mapping to populate data bases, for example) will likely remain in Canada at least for the near term.

6.2.3 Human Resources Demand

Increasingly, industry is looking for a broad range of skills. The ideal people would have a solid technical foundation and an array of professional (soft) skills. That is, individuals employed in geomatics-related work will be expected to have relevant geomatics knowledge as well as having an understanding of the applications and needs of interest to the clients.

Not surprisingly, the skills now in demand reflect the growth areas of the industry identified in the survey and interviews. These include GIS, web-based mapping and data delivery, remote sensing, navigation and positioning, and the intersection of these areas with land information and surveying. A few companies in Quebec and Nova Scotia commented on shortages in photogrammetry. These current demand areas are also seen as the future demand and skills areas. As part of our analysis, we reviewed the job prospects for geomatics professionals on the Job Futures site of HRDC to compare our findings. Geomatics does not exist as an occupational area in the National Occupational Classifications (NOCs) and the only comparison possible was in the area of surveying. Job Futures, in fact, corroborates our survey results that the job prospects for graduates in surveying can only be considered fair currently and over the next five years.

These skills are, however, not sufficient to sustain growth; also needed are skills related to data management, analysis, integration, and Internet programming including web-based technology development. The impact of the Internet cannot be stressed enough. Respondents reported increased need for fluency in Internet technology and the need for skills related to rapidly evolving scripting languages (delivery software). The need for more web-based and computer related skills, including programming skills, is increasing. In fact, the workshops indicated that the market will move beyond database management to data fusion, connectivity, and real-time wide-area distribution, adding to the skill requirements.

Also needed will be project skills, and especially business development skills, to take maximum advantage of proven technologies. Managerial and advisory skills, rather than purely technical skills, will also be required. Specific soft skills identified included managerial, communication, and the ability to see the 'big-picture', to tie technology to many applications. Some of these skills have historically not been covered, in a systematic way, in a traditional academic environment.

Providing the right mix of skills to meet industry demand is a challenge. As one professor pointed out: "One problem is that industry seems to want people with adequate theoretical background to judge the utility of tools, to lay out projects, to manage them, to be able to use disparate data intelligently. On the other hand, they want people to have good technical expertise in many different software and hardware. So, should students be prepared to be project managers or to be technicians, when job ads are often written seeming to require both rolled into one at a beginning level? The balance of theory vs. practical is difficult to perfect."

The sector as a whole is estimated to grow by 10,000 people in the next five years as noted earlier. We also pointed out that demand will be highest for broad geomatics skills, particularly in GIS, decision support, navigation and positioning, and remote sensing, coupled with web-based and project management competencies.

6.2.4 Human Resources Supply

Those entering the geomatics field come from two streams – academic and technical. Based on the interviews, responses to the survey, and a subsequent study of web sites, we have determined that there are a total of approximately 2900 students enrolled in mainstream geomatics-oriented university programs each year in Canada at the Bachelor, Masters, and Doctorate levels.

In addition to highly specialized programs in earth observation and geomatics, there is a growing trend that sees individuals with a focus on forestry, geology, geography, agriculture or other resource area have a specialization in GIS or remote sensing, for example. This last category is providing the bulk of the graduates. We estimate that a total of approximately 700 graduate annually from universities with some claim to a geomatics specialization. However, the vast majority of these have a major specialization linked to another field. In addition to these 700, many more have had at least some courses or training in a geomatics area.

There are some limitations to the survey results. In some universities, we received responses saying that there were no geomatics specializations when we noted that courses were listed in the calendar and were being given this year. In some cases, we received responses from one department, but not another. We therefore carried out supplementary assessments and made (or are making) additional contacts.

Some institutions, including Laval, Calgary and Waterloo, provide work opportunities as part of the academic process. These graduates are highly sought after. One rather disturbing trend noted by one senior faculty member interviewed in Ontario is that many are hired in high demand areas before they graduate. This has, in turn, placed some limits on the ability to attract and hold graduate students, especially in GIS. Entry into some of the geomatics specializations is limited, most often by access to software, and the need for specific prerequisites. Several colleges offer particularly strong programs, including COGS, College Limoilou, Sir Sanford Fleming, SAIT, and BCIT. Many others offer some elements of the basic technical level in GIS or other areas.

The total output of the specialized college programs is estimated to be about 250 per year. Adding this figure to the output of the universities gives a total 950 new graduates each year. Given that some 2000 new entrants are needed each year to match demand projections for the sector, the current shortages of trained people in the sector noted to us in our interviews and workshops can be expected to increase over the next five years and especially in the 2003 and 2004 timeframe.

A possible human resources shortage has also been recognized in the United States. In the on-going multi-million dollar ASPRS/NASA study of the remote sensing industry in the USA, growth in demand in the US is projected to triple in the coming three to five years. That study states that "the biggest issue we face in the USA GIS/RS field is human resources. There is a tremendous growth forecast, but the limit on growth is human resources. That is part of what is driving this study. Who will do the work?"[33] Increased demand in the US could draw more Canadian graduates to the US and exacerbate the shortage issue in Canada.

The consequences of this shortfall in graduates will be felt by Canadian industry as it gears up to meet the increased demand for geomatics goods and services. A number of factors could mitigate the problem such as increased compensation for those in geomatics which would make careers in geomatics more competitive and stepped-up immigration levels. Immigration figures were not available to us and thus we were not in a position to examine the potential of this route as at least a partial solution. The current slowdown in the information technology sector could also be brightening the supply picture for skilled people of interest to the geomatics sector. However, as we note in our conclusions in Chapter 7, the longer term solution to satisfying market demand will be a forceful national strategy that gives high priority to creating a national geomatics infrastructure and making Canada an international leader in this important field.

6.3 Human Resources Issues

6.3.1 Continuing Issues

A number of the human resources issues identified in previous work remain human resources issues today as evidenced in this report. In our literature review, we noted that a number of key points in a 1994 report,

[33] Statement made at the Executive Committee Meeting of the Project Study Team, Rochester, NY. 20/11/00.

"People and Skills in the Canadian Geomatics Sector: Positioning for the Future", are still relevant including:

- **Skills in information technology and systems** - People working in geomatics will work in a digital environment;
- **Adoption of new 'softer skills'** - Technical and professional geomatics skills must be complemented with skills in areas such as marketing, communications and user training;
- **Team skills** - As geomatics specialists adopt a more client-centred vision, they will see their activities as complementing other disciplines;
- **Management skills** - Geomatics managers must become agents of change in their own organizations, exploring innovative ways of delivering geomatics products and services and facilitating the adoption of innovation; and
- **Training skills** - In order to provide support to clients using the technology, not to mention ensuring that the technology is properly applied, training skills will become a necessity.

These are all skill requirements in demand today, over and above technical skills in geomatics. This is not to say that progress has not been made in these areas, in fact these issues may remain key areas that should be addressed and reviewed on a continual basis. A major influence on geomatics now, much greater than it was in 1994, is the Internet whose impact on human resources in this area is immense.

6.3.2 Turnover and Retention

Turnover and retention of employees was identified by 22% of industry respondents in the survey as a significant issue. Our workshop results confirmed that industry has concerns about attracting and keeping its employees because of a pull from the information technology sector and from the United States market. Retention was seen to depend on a number of factors associated with professional development, the business environment, compensation and career paths. The suggestions included:

- Continuous training in the work environment and allow IT and geomatics professionals to cross train.
- Offer opportunities to diversify individual work experiences, keeping the work interesting and challenging.
- Position geomatics as 'the spatial component' of enterprise business solutions creating more opportunities for geomatics professionals.
- Involve employees in some level of ownership of the companies.
- Provide better remuneration.

Table 6-2 provides a useful summary of the inter-related factors that have an impact on the availability and retention of the geomatics workforce. Each technology theme of geomatics that follows is sub-divided for greater precision, with human resource implications assessed as **low, moderate** or **high** regarding:

- **Security** of employment (demand for and maturity of technology);
- **Availability** of new entrants (supply of suitably qualified college and university graduates);
- Degree of **retention** of employees (stability of workforce); and
- Susceptibility to **external demand or competition** from other technologies (higher salaries, better benefits)

Table 6-2: Availability, Retention and Competition Comparison

Disciplines	Security	Availability	Retention	External Competition
Surveying				
Cadastral	High	Moderate	High	Low
Geodetic	Low	Moderate	High	Low
Earth Observation				
Satellite	High	Moderate	Moderate	High (IT - aerospace)
Airborne	High	Moderate	Moderate	High (IT - aerospace)
Image Analysis	High	Moderate	Moderate	High (IT - aerospace)
S/W Suppliers	High	Moderate	Moderate	High (IT - aerospace)
GIS				
Systems Dev.	High	High	Moderate	High (IT sector)
Service	High	High	Moderate	High (IT sector)
GSDI	High	High	Moderate	High (IT sector)
Cartography				
Aerial Photo	Moderate	Low	Moderate	Moderate (aviation)
Photogrammetry - Systems	Moderate	Moderate	Moderate	Moderate (IT companies)
Photgrammetry- Services	Moderate	Moderate	Moderate	Low
Cartographic S/W Dev.	Moderate	Moderate	Moderate	Low
Cartography Services	Moderate	Moderate	Moderate	Low
Data Conversion	Low	Moderate	Moderate	Low
Navigation and Positioning				
GPS Dev.	High	High	Moderate	High (IT - telecomm)
GPS Services	High	High	Moderate	High (IT - telecomm)
Kinematic GPS	High	High	Moderate	High (IT - telecomm)
Vehicle Navigation	High	High	Moderate	High (IT - telecomm)

6.3.3 Attracting New Entrants

The ability of the sector to attract new entrants is dependant on a number of factors including perceived opportunities, remuneration, and public image of the sector. Some years ago in an attempt to encompass the disciplines associated with the gathering and management of geospatial data, the term geomatics was coined. This did much to enhance the image of the industry in Canada as it neatly packaged the constituent disciplines of *inter alia* land surveying, geodetic surveying, remote sensing, photogrammetry, cartography and GIS. At that time, a fence was placed around what is now called the "traditional industry."

Those in the field still find themselves educating not only the rest of the world, but also potential new entrants into the field, as well as new markets on the meaning of the term. Geomatics does not present an image that is understood or very compelling to the general public. It would appear now that the growth of the field has moved beyond the fence erected under the name of geomatics into a far-reaching integration of geospatial information into a wide spectrum of applications involving a plethora of technologies. Another encompassing but more recognizable term 'geospatial' has been increasing in both use and recognition around the world, while geomatics seems to be used primarily in Canada, France, Belgium, Netherlands, Switzerland (French regions), many Spanish-speaking countries in Central and South America, and Australia.

The lack of clear definition of the field is accompanied by a lack of understanding of career paths in geomatics – this begins at the awareness/recruitment level. The workshops suggested a number of important steps to be taken in improving the image of geomatics and making the field more attractive to those making career choices:

- Start at the secondary school level to promote geomatics through information sessions in the schools and on the web, creating a presence at career days, and educating career counsellors on opportunities in geomatics.
- Demonstrate the importance of geomatics to today's society through wide-ranging public awareness campaigns sponsored by leaders in industry and government, highlighting key applications.
- Provide career paths combined with continuing education opportunities.
- Show that geomatics is associated with the information and communications technologies sector and can share in the 'buzz' surrounding that sector.
- Making geomatics data more freely and widely available could open up more career opportunities in the sector.

6.3.4 Occupational Mobility and Career Paths

Because the geomatics sector is broad in nature, it is difficult for those outside the field to see clearly defined career paths. This is both an opportunity and a challenge for the sector in terms of recruitment of new entrants and in terms of professional development for those already in the sector. The opportunity centres on the scope of geomatics which offers a wide range of occupational areas for new entrants to choose from and for existing geomatics professionals to transfer into as their interests and career expectations change. In fact, when promoting careers in geomatics, educational institutions that can demonstrate the breadth of opportunities available through the spectrum of courses provided are increasingly seeing a rise in student enrolment. However, this characteristic of the sector also makes it difficult to define and determine clear career paths and, as a result, creates a challenge for the continuing education of professionals that encompasses all the technical and business skills that employers are looking for.

Various means of improving career paths were suggested in our interviews and workshops. These included employers promoting and supporting continuous learning, keeping staff marketable, identifying geomatics professionals within the organization who have been successful, thereby making career paths more visible, and encouraging management training. Career paths in industry could also be opened up by offering equity ownership to employees.

Mobility among surveyors has been restricted by the requirements for provincial licensing. Each province has specific differences in legislation that has led to differing examinations. Under the Agreement on Internal Trade, the CCLS is seeking to standardize this process from province to province which could facilitate the mobility of surveyors across the country. Mobility of other geomatics professionals is only limited by language. No other barriers were identified.

6.3.5 Education and Training

From the workshops and interviews, it is evident that there needs to be more collaboration/linkages among universities, colleges and high schools to provide a cohesive approach to geomatics training/education. Closer connections to industry by means of co-op programs, internships and work terms as well as reciprocal exchanges between industry and universities/colleges were seen as being beneficial to the education of geomatics graduates.

These linkages have promise for meeting the requirements for soft skills (management, team work, report writing, etc.) that are not provided in traditional academic environments. Industry Canada has noted to us that the need for soft/business skills is also a problem for other technically-oriented industries such as biotechnology. Biotechnology, for example, finds that its workforce lacks project managers and the skills necessary to market new applications. We believe there might then be synergies across the technology disciplines in developing appropriate business skills related curricula at universities and colleges.

6.3.6 Professional Development

Professional development is a necessary component of human resources development in geomatics, especially given the amount of technological change happening in a rapid time period. An uncoordinated approach to professional development within the sector is hindering the sector's ability to cultivate an environment that develops the necessary numbers of senior managers and leaders in the field. Closer linkages among the different educational levels and industry could help to improve an approach which would meet the needs of training and life-long learning.

While a number of associations keep members up to date on issues and provide information seminars, typically most associations do not provide comprehensive accredited training. Rather, workshops are available at industry conferences and through user group meetings. On-line or e-learning, both as part of a degree and/or certificate program and as a component of on-going professional development, offers important opportunities to the geomatics sector for improving the quality and level of geomatics education and training. In particular, this delivery mechanism may help address some of the professional development challenges identified.

A recent report prepared by the Advisory Committee for Online Learning entitled "The E-Learning E-Volution in Colleges and Universities" notes that "For many lifelong learners, especially adults with family and job commitments, online learning may be their only chance to obtain the higher education they need to compete and survive in a labour market driven by rapidly changing demands for new knowledge and skills." It would be worthwhile for this report to be reviewed by university and college faculties providing geomatics education, in order to assess how geomatics curricula could be integrated into a larger e-learning discussion.

Professional development does, however, face a number of barriers in affording opportunities to more geomatics professionals to upgrade their skills. Because the industry is predominantly composed of small and medium sized companies, there seems to be a general lack of in-house formal career development programs. The nature of many projects, in particular international work, tends to require subcontractors hired on a project-by-project basis, many of whom are generally in the field unable to participate in courses.

The following are some of the steps proposed in our consultations to improve professional development:

- More companies and government agencies have to be encouraged to support training including training external to the organization.

- More flexible course hours for training have to be offered to fit into demanding schedules
- A cohesive, coordinated database or source of professional development opportunities has to be created.

6.3.7 Certification

Certification was an issue addressed in the interviews and surveys. First of all, a distinction was made between certification of geomatics people and certification of geomatics products. The latter was generally considered to provide a worthwhile service to the public. The perspectives on the certification of people, on the other hand, were mixed. Those in favour believe certification to be an important requirement in establishing geomatics as a legitimate profession. It was generally accepted that certification may be appropriate for those in geomatics positions that require lesser academic qualifications. Others were of the view that certification could create barriers, restricting opportunities at a time when geomatics is undergoing substantial change and making it difficult for people to move into geomatics from other sectors, in particular the ICT sector.

A number commented that graduates of universities and colleges with degrees and diplomas in geomatics-related disciplines already carry a type of certification that gives assurance to employers of a certain level of skills. The accreditation of courses in geomatics was viewed as desirable to ensure that quality is maintained in the course offerings at these institutions.

Certification was also seen as complicated to put in place because of the multidisciplinary nature of geomatics and the difficulties of defining the sector's scope. A report to ISO[34] on the certification of personnel in Canada points out the challenge in this respect: "The concept of a broader geomatics seems problematic since the definition of its boundaries remain open to debate. The voluntary certification of specialist areas within the broader field is a relatively recent strategy. It remains to be seen whether this new strategy will bring the desired recognition and structure to the broader field."

[34] Type 3 Technical Report, Geographic Information/Geomatics: qualifications and certification of personnel, Robert Maher, Centre of Geographic Sciences, February, 2001

7. Conclusions

7. Conclusions

7.1 Human Resources Challenges

The human resources challenges, as identified in the study and based on the results of the interviews, survey and workshops, have been grouped under four headings: awareness and public image; recruitment and retention; education and training; and, professional development and certification. We present below brief conclusions and optional courses of action to guide the Steering Committee in developing a strategic and tactical plan for human resources. The workshops were particularly helpful in bringing forward suggestions for options.

7.1.1 Awareness and Public Image

Conclusions:

- Some years ago in an attempt to encompass the disciplines associated with the gathering and management of geospatial data, the term geomatics was coined. This did much to enhance the image of the industry in Canada as it neatly packaged the constituent disciplines of *inter alia,* land surveying, geodetic surveying, remote sensing, photogrammetry, cartography and GIS. At that time, a fence was placed around what is now called the "traditional industry." However, because the sector has expanded to include the production and usage of value-added data, it is now so broad in nature that the sector does not have a clearly defined image.
- Those in the field still find themselves educating not only the rest of the world, but also potential new entrants into the field, as well as new markets on the meaning of the term. Geomatics does not present an image that is well understood or very compelling to the general public. It would appear now that the growth of the field has moved beyond the fence erected under the name of geomatics into a far-reaching integration of geospatial information into a wide spectrum of applications involving a plethora of technologies. Another encompassing but more recognizable term 'geospatial' has been increasing in both use and recognition around the world.

Options:

The workshops suggested a number of important steps to be taken in improving the image of geomatics and making the field more attractive to those making career choices:

- Create a "grass roots" awareness of geomatics. Start at the secondary school level to promote geomatics through information sessions in the schools and on the web, creating a presence at career days, and educating career counsellors on opportunities in geomatics.
- Demonstrate the importance of geomatics to today's society through wide-ranging public awareness campaigns sponsored by leaders in industry and government, highlighting

key applications. Have governments proclaim a GIS day.

- Focus on geomatics as a key component of many day-to-day business processes – have industry leaders (CEOs) talk about the importance of geospatial information, making use of business publications like Business Week.
- Spend less time defining what "geomatics" is and more time publicizing the wide variety of applications. Demystify "geomatics". Show that geomatics is part of the new 9and better known) information and communications technologies field.

7.1.2 Recruitment and Retention

Conclusions:

- The geomatics sector is currently facing shortages of people in selected areas eg GIS and, given the projected growth in the geomatics industry, it appears that the demand for geomatics professionals over the coming five years will increasingly exceed the numbers graduating from Canadian universities and colleges.
- Growth in demand in the US is expected to triple in the next five years which will create a further magnet drawing graduates south (significant numbers of graduates from some educational institutions eg COGS are already taking up employment in the US).
- Some view a hindrance to recruitment to be the lack of obvious career paths in geomatics (defined by some as moving on and not moving up) and growing competition for software-related skills in geomatics people from the information technology sector.
- Geomatics faculty members have not been moving but this is changing. There is no clear pattern regarding where they move, some have moved to the US, others have started their own companies in a geomatics or geomatics-related industry. A small number of faculty is now working in the broader IT industry.
- The movement of geomatics staff within users tends to be within the same organization or to other users ie larger multi-national firms or government agencies. Government agencies seem to retain their staff more in certain regions of the country than others (e.g. Quebec). In some regions, it has been noted that there is movement back and forth between government and the private sector (New Brunswick, Ottawa).
- Brain-drain is a serious concern in BC and the Maritimes. Many new graduates are lost to the US where better and more opportunities exist. Also, experienced geomatics professionals sometimes change field to work in software or Internet companies. This is especially so in Vancouver which has become a hotbed of Internet software companies. By comparison, geomatics is seen to lack growth opportunities.
- Growth in GIS and decision support approaching 20% per year is projected to lead to shortages of the more specialized individuals involved in advanced modeling. This shortage will be compounded by the drain to the US and to the IT sector. Also, high end GIS staff are projected to move into the higher margin decision support, compounding the shortages in GIS.
- It is commonly believed that all applications that are associated with the web will grow, as will GPS, business geographics, satellite imagery use, programming and modelling, data base management, process re-engineering, project and knowledge management, and

those areas that add value to the data. To add value, people will have to understand geomatics and the client's needs. The market will move beyond spatial database management to data fusion, connectivity, and real-time wide-area distribution.

- Human resource implications assessed as **low, moderate** or **high** regarding:
  - **Security** of employment (demand for and maturity of technology);
  - **Availability** of new entrants (supply of suitably qualified college and university graduates);
  - Degree of **retention** of employees (stability of workforce); and
  - Susceptibility to **external demand or competition** from other technologies (higher salaries, better benefits)

Table 7-1: Availability, Retention and Competition Comparison

Disciplines	Security	Availability	Retention	External Competition
Surveying				
Cadastral	High	Moderate	High	Low
Geodetic	Low	Moderate	High	Low
Earth Observation				
Satellite	High	Moderate	Moderate	High (IT - aerospace)
Airborne	High	Moderate	Moderate	High (IT - aerospace)
Image Analysis	High	Moderate	Moderate	High (IT - aerospace)
S/W Suppliers	High	Moderate	Moderate	High (IT - aerospace)
GIS				
Systems Dev.	High	High	Moderate	High (IT sector)
Service	High	High	Moderate	High (IT sector)
GSDI	High	High	Moderate	High (IT sector)
Cartography				
Aerial Photo	Moderate	Low	Moderate	Moderate (aviation)
Photogrammetry – Systems	Moderate	Moderate	Moderate	Moderate (IT companies)
Photgrammetry- Services	Moderate	Moderate	Moderate	Low
Cartographic S/W Dev.	Moderate	Moderate	Moderate	Low
Cartography Services	Moderate	Moderate	Moderate	Low
Data Conversion	Low	Moderate	Moderate	Low
Navigation and Positioning				
GPS Dev.	High	High	Moderate	High (IT - telecomm)
GPS Services	High	High	Moderate	High (IT - telecomm)
Kinematic GPS	High	High	Moderate	High (IT - telecomm)
Vehicle Navigation	High	High	Moderate	High (IT - telecomm)

Options:

- Industry needs to reinvent itself to provide better remuneration and career opportunities. The industry needs to attract serious entrepreneurs who can create an attractive vehicle for staff to succeed financially.
- Recruitment and retention require improved opportunities for management training and continuous education at the firm level, offers to employees of equity ownership, identifying role models in an organization of successful geomatics professionals (among users, these may not be readily identifiable).
- Encourage partnerships among organizations to create broader, more attractive business environment, and flexible business networks that allow movement of personnel on a project basis.
- Market geomatics as an IT service, allowing staff to explore, learn and implement new services such as wireless location-based services. Integrate geomatics into mainstream IT organizations (some loss of autonomy but possibly good for the industry in the long run).
- Offer non-salary/non-training perks in the public sector ie incentives for technology upgrades, conferences, research time, paid-deferred leave.

7.1.3 Education and Training

Conclusions

- A review of the geomatics curricula in the universities and colleges in our inventory, in light of the accepted listing of skills, shows that geomatics education and training is predominantly GIS related with over 83% of post-secondary institutions providing significant GIS training. Nearly all universities offer GIS courses, and many allow GIS specializations, in undergraduate and graduate programs. Remote sensing, or earth observation courses, are the next most prevalent (75%), with an emphasis on image interpretation and multispectral analysis. Cartographic courses follow (72%), with map interpretation and map construction/design competencies widespread in introductory geography presentations.
- There appear to be more limited course offerings for surveying. Of these, geodesy, GPS, and photogrammetry are the most widely offered. CAD courses in geomatics appear to be rare in the university environment with the exception of Quebec universities but are offered through colleges and technical institutes.
- Academic institutions have been responding to the increased need for graduates trained in geomatics; most programs have been updated to reflect changes in the industry, the market and technology, and new programs have been instituted as resources permit. For example, COGS, Limoilou College, and the graduate programs at Laval (Geomatics Sciences Department), bring technically capable people with multidisciplinary backgrounds into the geomatics workforce through a post-graduate diploma program.
- The Canadian geomatics industry has historically been very strong technologically. Internationally, Canada's competitive advantage has been the technical skills of its geomatics professionals. However, the result has been a preponderance of small firms started by technologists who do not tend to have the entrepreneurial and business

savvy to move their companies to the next level of size and sophistication. This will not suffice in the future as other countries become more technically astute and surpass us in a business sense. Industry has recognized this and has identified business and entrepreneurial skills as being very important.

- Land administration, mapping, and other geomatics applications in developing countries is projected to be a significant growth area. There will be a continuing demand for graduates with training in international development, project development consulting, technology transfer and systems integration. This highly competitive market is already populated by aggressive multi-national companies who will be competing for these graduates.

Options:

- A more cohesive approach to education and training in geomatics through collaboration and linkages among universities, colleges and high schools will improve the quality of geomatics education and better prepare students for careers in geomatics. The fact that geomatics tools are being introduced into the educational system at an earlier age is influencing the entry level of knowledge in geomatics. This needs to be taken into account in the design of the overall geomatics educational system
- A cohesive approach would also help to better define the respective roles of universities and colleges in providing education and training in geomatics. Joint graduate degrees with universities focusing on concepts and colleges on tools were seen as a best practice.
- Co-op programs, internships and work terms in industry were recognized as a valuable and integral part of the educational programs in geomatics provided by universities and colleges. Industry participation in the programs through industry lecturers and reciprocal exchanges with university and college professors was also seen to be advantageous.
- Skill gaps have been identified in the mix of skills (specific geomatics technical skills, and broad IT skills) being provided by universities and colleges, on the one hand, and those required by industry (soft/business skills), on the other. Demand for soft skills including skills in management, human resources, team work, languages, cultural sensitivities, entrepreneurship, and report writing and presentations, is increasing.
- The impact of the Internet on human resources skills will be significant. The geomatics worker will, increasingly, have to be fully versed in the workings of a web-based environment, whether it be for applications development, data manipulation and sharing or data integration.
- Costs associated with some equipment can prohibit institutions from teaching leading edge technology. Equipment loans from industry and incentives to encourage the loans would be helpful. Negotiating agreements with technology vendors to make current technology available to all students was also proposed.
- Universities and colleges should research how industry is using or wants to use geomatics products or services and then align training to match on a more timely basis.

7.1.4 Professional Development and Certification

Conclusions:

- Professional development is a necessary component of human resources development in geomatics. The uncoordinated approach to professional development within the sector is hindering the sector's ability to develop necessary numbers of senior managers and leaders in the field. Closer linkages among the different educational levels and industry are needed for training and life-long learning.
- Professional development must not be based entirely on the need to stay current with technology, indeed there is a requirement that relevant business skills be promoted throughout the industry, as a means to grow the sector as a whole. Opportunities for geomatics professionals to increase their skills through on-line business related courses should be promoted as part of becoming a high level geomatics professional.
- Because the profile of the industry is skewed towards SMEs, professional development often happens 'organically' rather than through a planned, strategic approach. It is difficult for small firms, which are focused on sales, delivery and meeting a respectable bottom line, to plan for extensive out-of-office professional development. Indeed, when individuals show potential and skills in an area, they may often find themselves with increased responsibility and time commitments that result in real challenges in terms of time for professional development.
- The more successful firms in land surveying are branching into new business areas such as land information and GIS services. There will be demand for business, marketing, and "broadening" courses to give the practicing land surveyor the technical understanding and knowledge to move into these new business areas.
- Professional associations keep members up to date on issues and provide information seminars, but typically do not provide comprehensive accredited training. Associations have a role if not in providing the training at least in making training opportunities known.
- On-line or e-learning, both as part of a degree and/or certificate program and as a component of on-going professional development, offers important opportunities to the geomatics sector for improving the quality and level of geomatics education and training.
- Professional development faces a number of barriers. The SME composition of the industry has led to a general lack of in-house formal career development programs. The nature of many projects, in particular international work, tends to require subcontractors (SMEs) to spend time in the field unable and adds to the difficulty of accessing training courses.
- On certification, a distinction was made between certification of geomatics people and certification of geomatics products. The latter was generally considered to provide a worthwhile service to the public. The perspectives on the certification of people, on the other hand, were mixed. Those in favour believe certification to be an important requirement in establishing geomatics as a legitimate profession. It was generally accepted that certification may be appropriate for those in geomatics positions that require lesser academic qualifications. Others were of

the view that certification could create barriers, restricting opportunities at a time when geomatics is undergoing substantial change and making it difficult for people to move into geomatics from other sectors, in particular the ICT sector.

- A number commented that graduates of universities and colleges with degrees and diplomas in geomatics-related disciplines already carry a type of certification that gives assurance to employers of a certain level of skills. The accreditation of courses in geomatics was viewed as desirable to ensure that quality is maintained in the course offerings at these institutions.
- Certification was also seen as complicated to put in place because of the multidisciplinary nature of geomatics and the difficulties of defining the sector's scope.

Options:

- Emphasize training opportunities for the individual geomatics professional separate from the firm because of the small size of firms. Offer more flexible hours for training to fit into demanding schedules. Discussion should continue on how to be more creative in training provision and lower the cost.
- The report of the Advisory Committee for Online Learning entitled "The E-Learning E-Volution in Colleges and Universities" should be reviewed by geomatics faculties to assess how geomatics curricula could be integrated into a larger e-learning discussion.
- More formal mechanisms for providing credits for work experience and creating credit databases would be advantageous to the geomatics professional in seeking further training.
- Professional associations may not provide training although some would like to see them do that but can offer objective insights on where the industry is going, identifying the 'hot" demand areas, and focusing on the "branding" of geomatics.
- Arrange for the sharing of site licenses for online learning between firms, associations, and consortia to make it affordable for SMEs.
- Conferences and trade shows offer important training opportunities. A database of these opportunities could usefully be created by professional associations.
- Companies (over ten employees) should commit to a certain level of training (eg 5% of salary/10 days) that employees are entitled to.
- Courses that are the same throughout Canada (eg legal surveys) lend themselves to being made self-sustaining online. There is an unfilled need in the cadastral part of surveying for distance learning.
- Given the proliferation of courses and programs, especially in GIS, some quality control is going to be required. Industry needs some assurance on the quality of courses. Perhaps a voluntary certification would be simplest to put into practice.

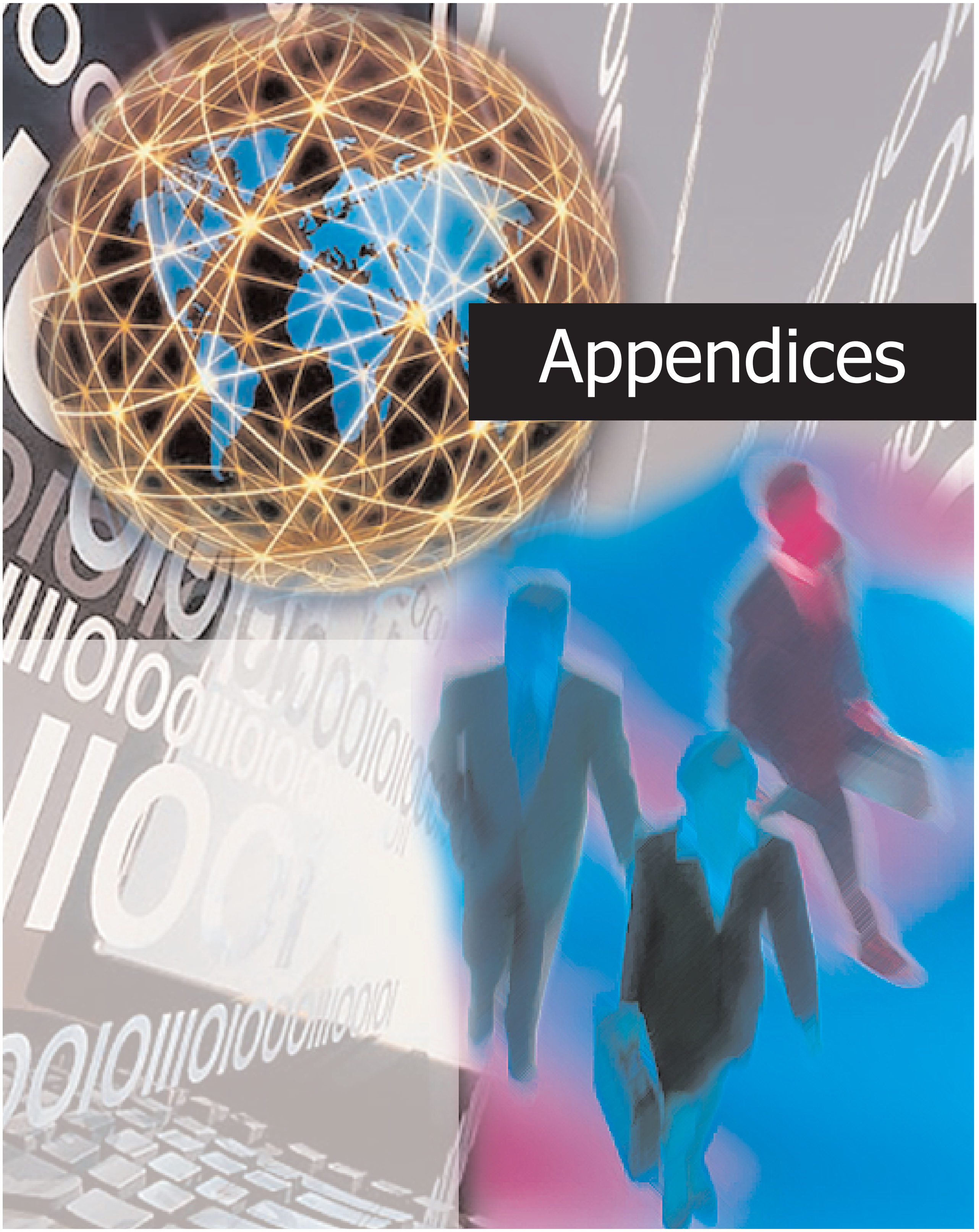
7.2 Strategic and Tactical Plan

The Steering Committee considered this report and produced a strategic and tactical plan for addressing the human resources challenges. The Committee's report is published under separate cover.

Members of the Steering Committee for the Geomatics Sector Human Resources Study

John Appleby	Industry Canada
Brian Ballantyne	University of Calgary
Clark Beattie	GeoSolutions Consulting Inc.
Yvan Bédard	Université Laval
David Coleman	University of New Brunswick
Diane Coleman	Alberta Geomatics Group
Jean Claude Croteau	Canadian Institute of Geomatics
Marc D'Iorio	Natural Resources Canada
S. Andy DeCoste	C.J. McLellan & Associates
Bryan Ferguson	Applied Management
Randy Gillespie	Canadian Centre for Marine Communications
Patricia Glenn	Proactive Technology Trading Ltd.
Joan Harvey	Canadian Space Agency
G.A. (Bert) Hol	Hol and Associates Surveying Inc.
Jeff Labonte	Natural Resources Canada
Michael Pearson	Champlain Institute
Gilbert Pouliot	Centre de développement de la géomatique
Michael Strutt	GPS Training and Consulting
Keith Thompson	GEOIDE Network of Centres of Excellence
Wayne Walsh	Government of New Brunswick
David Woolnough	Centre of Geographic Sciences
Sarah Cornett	Canadian Council of Land Surveyors
Tom Herbert	Canadian Institute of Geomatics
Ed Kennedy	Geomatics Industry Association of Canada
Doug Simmonds	Canadian Council of Land Surveyors
Warren Duthie	Human Resources Development Canada
Phil Mickle	Human Resources Development Canada

Geomatics Sector • Human Resources Study



Appendices

Prepared by:

Canadian Council of Land Surveyors
Canadian Institute of Geomatics
Geomatics Industry Association of Canada

Table of Contents - Appendices

Appendix A

A. Workshop Reports

A.1 Agenda

Workshop Agenda
Human Resource Challenges in Geomatics in Canada:
Strategic Directions

08:30 Coffee

09:00 Introductions .... HAL

09:10 Presentation on Human Resource Challenges .... HAL

09:30 Discussion of Topic 1 .... Plenary

"The geomatics sector is expected to experience a shortfall of people over the next five years."

- What actions/initiatives/conditions are needed to attract new entrants and experienced people in (i) the private sector, and (ii) the public sector?
- Does geomatics as a sector present an attractive image?

10:45 Break

11:00 Discussion of Topic 2 .... Plenary

"Turnover and retention of staff is not at present a major issue in the geomatics sector. The increasing overlap of the sector's reach with the Information Communications Technologies (ICT) sector suggests that the issue will become more pressing in the future, reducing the ability of the sector to meet growing market demand for geomatics products and services."

- What can be done to avoid serious people losses in the sector?

- How can geomatics align its human resource strategies with the ICT sector to take advantage of the migration of geospatial disciplines into the ICT sector?

12:15 Lunch

13:00 Discussion of Topic 3 .... Plenary

"Universities and colleges have been responding well to the changing skills demands of the geomatics sector. Keeping course content up-to-date, however, continues to be a challenge because of technology advances and new market requirements. Knowledge of application areas is in demand together with a base of geomatics skills."

- What are best practices for universities and colleges to follow in ensuring that geomatics-related courses are meeting these sector requirements?
- How can these institutions be at the leading edge of industry's needs?

14:15 Break

14:30 Discussion of Topic 4 .... Plenary

"The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances."

- What training gaps exist in the geomatics sector and how should they be filled?
- What is the role of employers in providing on-the-job training?
- What are best practices in making use of online training opportunities?

15:45 Wrap-up .... HAL

16:00 Conclusion

A.2 Halifax

A.2.1 Executive Summary and Notes

The workshop was attended by nine participants and two observers representing the university and college community, the federal, provincial and municipal governments, and a private institute involved in marketing for the geomatics industry in Atlantic Canada. Many good ideas on human resources were expressed. The general view was that the structure and culture of the industry had to change in order that geomatics be seen as an attractive place to build a career. Until that happened many of the HR issues could not be effectively addressed. To grow the sector, an emphasis was placed on the applications of geomatics rather than on the development of geomatics tools. The university/college system was considered to be doing a good job in producing skilled graduates. More public/private partnerships could help in promoting geomatics in the educational system and in the public domain.

Editor's Notes:

- The symbol // indicates that two similar ideas have been merged together.
- This document contains the meeting proceedings.
- In some cases, comments are appended with a # such as "rapid changes in IT {#59}". The system attaches a sequential # to every item for reference purposes only.

A.2.2 Topic One: Shortfall of People

"The geomatics sector is expected to experience a shortfall of people over the next five years."

A.2.2.1 What actions/initiatives/conditions are needed to attract new entrants and experienced people in (i) the private sector, and (ii) the public sector?

Note: the group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Schools

1. Geography in the class room
2. Public / private partnerships to promote industry within education system
3. Promotion in High schools , beginning at grade nine
4. Move into the Elementary schools to spread the message as well
5. Meet the Junior and Senior High Students in the classrooms
6. Introduce the technology and industry at the career councilor level so that they CAN promote the industry

Education Curricula

1. Closer links between private sector and the educational institutions as in the IT sector where companies have designed courses for colleges to meet their short term needs.
2. Geography in the class room
3. Development of sponsorship programs / scholarships for full educational development
4. Role of combined degrees as a means of not limiting opportunities
5. Have GIS as optional courses for IT students
6. Include "soft skills" development (business, managerial, communications, etc.) INSIDE the geomatics education programs - i.e., nurture the visionaries, bridge the techie - manager gap

Certification

1. National certification at professional levels

Career Path

1. Role of combined degrees as a means of not limiting opportunities
2. Mentoring programs in private sector
3. Better methods of on-campus recruiting by private and public sector firms.
4. Recognize diversity within Geomatics i.e. Spatial data management very different from surveying
5. Proper career structure i.e. Transition from technical to management
6. Design a set of clear career paths which will allow one to change direction or go on to a professional level without loss of effort
7. Work on the career path problem so that the message being delivered will be more enticing
8. Do a series of talks at each Computer Science Faculty/Community College - almost every campus has a regular "speakers series".
9. Fast-track programs...student debts can be related to a desire to move where higher salaries can be gained at a faster rate.

Industry Structure

1. Fast-track programs...student debts can be related to a desire to move where higher salaries can be gained at a faster rate.
2. Recognize diversity within Geomatics i.e. Spatial data management very different from surveying
3. The challenge is not so much "image" as salaries, nature of the marketplace, how industry is structured, etc.
4. $$$
5. Increase business opportunities in Maritimes
6. Entrepreneurial financing programs
7. Bring to the attention of a variety of policy makers, CEO's, Administrators, the issues and realities of salary differentials.
8. Create fewer , larger companies
9. Reduce involvement of 'big government'
10. Create more opportunities to link research, teaching and public/private sector initiatives. Much is talked about in Canada, but the reality of a smaller business sector in Geomatics means it is difficult to foster lasting action.
11. Develop a few more trans-border opportunities (US-Canada or Canada-EC).

PR/Image/Awareness/Profile

1. Develop a few more trans-border opportunities (US-Canada or Canada-EC).
2. Fast-track programs...student debts can be related to a desire to move where higher salaries can be gained at a faster rate.
3. Do a series of talks at each Computer Science Faculty/Community College - almost every campus has a regular "speakers series".
4. Introduce the technology and industry at the career councilor level so that they CAN promote the industry
5. Public / private partnerships to promote industry within education system

6. Higher level of "formalized" integration of professional and scholarly societies within the "geomatics" sector targeting not just HR issues, but a variety.
7. Make the field known to the general public
8. Do more studies like the present one and publicize them in the schools
9. Find some friends in the media who can spell-out what GIS and GPS are (I have read so many varied definitions!).

Miscellaneous

1. We must not base our predictions of future brain drain to the US without taking into account the recent instability in the economy there. What effect will it have on the current predictions, based on the last five years growth, if that growth disappears.

A.2.2.2 Does geomatics as a sector present an attractive image?

Note: the group was asked to vote on the six best ideas to improve the geomatics sector's image.

Total	
9	1. Get Canadian companies to offer more realistic salaries and attractive career paths
7	2. More emphasis on the application of geomatics, less on the tools
6	3. Public / private partnerships to promote industry within education system
5	4. Spend less time defining what "geomatics" is, and more time on the wide variety of applications that are possible for many different fields of work, and disciplines of study.
5	5. Do not try to constrain the field of endeavor by the term geomatics. It refers primarily to the industry not the marketplace.
4	6. Find a champion who can do a regular series of media pieces (a regular newspaper column?; radio show once a week or once a month on hot topics?)
4	7. Make transition between university/college/industry more cost effective i.e. Pay off those student loans
3	8. Make the field known to the general public
3	9. Introduce the technology and industry at the career councilor level so that they CAN promote the industry
3	10. Industry associations need to lobby public sector in supporting K - 12 Geomatics Initiatives
3	11. Need to identify the "contractual" nature of many geomatics fields and show the successes in how a person can still make a living - reduce the negative perspective.
2	12. Broadening career opportunities
1	13. Develop a few more trans-border opportunities (US-Canada or Canada-EC).
1	14. Fast-track programs...student debts can be related to a desire to move where higher salaries can be gained at a faster rate.
1	15. Do a series of talks at each Computer Science Faculty/Community College - almost every campus has a regular "speakers series".
1	16. Develop video clip extolling the virtues of Geomatics and promote it vigorously

0	18. Do more studies like the present one and publicize them in the schools
0	19. Higher level of "formalized" integration of professional and scholarly societies within the "geomatics" sector targeting not just HR issues, but a variety.
0	20. Find some friends in the media who can spell-out what GIS and GPS are (I have read so many varied definitions!).
0	21. Find a minister(s) in gov't (not suggesting "big government") who can really explain/speak to the issues and do a good job of giving a "moonshot" ...
0	22. Geomatics is a wonderful field that combines interaction in the landscape and some neat technologies e.g. GIS, RS, GPS etc
1	23. "2001 a Spatial Odyssey"

A.2.3 Topic Two: Turnover and Retention

"Turnover and retention of staff is not at present a major issue in the geomatics sector. The increasing overlap of the sector's reach with the Information Communications Technologies (ICT) sector suggests that the issue will become more pressing in the future, reducing the ability of the sector to meet growing market demand for geomatics products and services."

A.2.3.1 What can be done to avoid serious people losses in the sector?

Both questions (section A.2.3.1 and section A.2.3.2) were addressed at the same time. The discussion notes for both questions can be found under: "How can geomatics align its human resource strategies with the ICT sector to take advantage of the migration of geospatial disciplines into the ICT sector?"(section A.2.3.2.)

A.2.3.2 How can geomatics align its human resource strategies with the ICT sector to take advantage of the migration of geospatial disciplines into the ICT sector?

Note: the group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Miscellaneous

1. If there is a sufficient "pool" of trained persons then retention is not an issue.
2. Promote the "sex - appeal " of a career in geomatics!

Professional Development

1. Greater movement between industry/government/academia. Easy to say; hard to do
2. Adaptable degree/certificate programs (unigis)
3. Small industry may in fact be the problem as we do not offer the incentives for career pathing - except to say career pathing is defined as moving on and not moving up.
4. Opportunities for staff retooling whether technical or management
5. Sell education and training internationally and generate business opportunities in tandem
6. Invest (recognizing the risks) in continuous training

7. Offer ongoing professional development opportunities
8. Loss of people is not a problem in firms where continuing education is rewarded as well as supported
9. Provide a lot of employee training and challenges to retain the inquisitive mind

Better HRM

1. Offer non-salary/non-training perks in public sector....incentives for technology upgrades, conferences, research time, paid-deferred leaves
2. Treat HRM more seriously within industry
3. Educate the HR personnel in the geomatics needs so as to help in job searches.

Industry Structure

1. Problem resides in the structure and philosophy of the traditional industry. It has been sufficient to make a living (albeit decent) not make money. We lack serious entrepreneurs to create an attractive vehicle for staff to succeed financially.
2. Owners have not been willing to share ownership of companies. They must be prepared to share the spoils to attract and keep good staff.
3. Restructure our individual businesses - integrate into larger entities
4. Creation of employee-owned companies - generate more commitment to growth
5. Expand the high end Geomatics consulting industry and look for consortiums to deliver solutions
6. Develop alliances with firms in complementary sectors
7. Small industry may in fact be the problem as we do not offer the incentives for career pathing - except to say career pathing is defined as moving on and not moving up.
8. Find ways to mirror successes in private sector in the public sector - otherwise, good and sustainable public-private efforts will meet a barrier because all the skilled employees will be in one and not the other.
9. More emphasis on building intellectual property
10. Greater movement between industry/government/academia. Easy to say; hard to do

Curricula Changes

1. Foster and support entrepreneurship (e.g. Encourage risk taking)
2. Adaptable degree/certificate programs (unigis)
3. More business courses during college/university years
4. MBAs in Geomatics or some new equivalent
5. More combined degree/certificate programs (Maryland has a msc in Geog combined with a MLS in Library Science)

Culture Changes (e.g. Compensation Mechanisms, Entrepeneurial etc)

1. Sell education and training internationally and generate business opportunities in tandem
2. Small industry may in fact be the problem as we do not offer the incentives for career pathing - except to say career pathing is defined as moving on and not moving up.
3. Have a well formulated plan, developed by a consortium/alliance of private/academic/public "associations" that can be targeted and sold to the key decision makers both inside and outside

the geomatics sector. Those decision makers are the ones who can/should be able to break the log-jam/culture.

4. Promote new approaches to rewarding talent
5. Offer equity incentives to staff
6. Introducing equity involvement within smaller firms
7. Owners have not been willing to share ownership of companies. They must be prepared to share the spoils to attract and keep good staff.
8. Problem resides in the structure and philosophy of the traditional industry. It has been sufficient to make a living (albeit decent) not make money. We lack serious entrepreneurs to create an attractive vehicle for staff to succeed financially.
9. Offer newer types of employee benefits - e.g., daycare, "well days", shares in the firm
10. Foster and support entrepreneurship (e.g. Encourage risk taking)
11. Offer non-salary/non-training perks in public sector....incentives for technology upgrades, conferences, research time, paid-deferred leaves
12. We should give serious consideration to not fighting the IT/Geomatics pull and push and instead seek ways of noting the similarities and find their mutual growth potentials.
13. All business processes in the companies must be addressed in a professional and commercial manner not just the technological aspects. We need managers capable of marketing, selling. Strategizing, managing people, managing finances etc. Etc.

A.2.4 Topic Three: Best Practices at Universities and Colleges

"Universities and colleges have been responding well to the changing skills demands of the geomatics sector. Keeping course content up-to-date, however, continues to be a challenge because of technology advances and new market requirements. Knowledge of application areas is in demand together with a base of geomatics skills."

A.2.4.1 What are best practices for universities and colleges to follow in ensuring that geomatics-related courses are meeting these sector requirements?

Note: the group was asked to vote for the seven most important best practices.

Total	
6	1. Reciprocal secondments between private sector and academia
5	2. Co-op education
5	3. Work experience component in every program
4	4. Colleges and universities must shorten timeframe between technology developments and teaching curriculum
4	5. Co-operative projects with industry and government
4	6. Joint graduate degrees between university and community college
4	7. Applied research in collaboration with industry and government
3	8. Faculty hired directly from industry
3	9. Regional approach to programs (credit-card example...) Flexible, mix of clicks and mortar...intensive summer institutes...etc
3	10. Allow COGS to incubate Geomatics companies

3	11. Adding new courses quickly in application-specific areas (health, business, law)
3	12. Ensure good communication of emerging markets to educational program decision-makers
3	13. Instructors coming from industry (current experience)
2	14. Continued research within universities and less emphasis on consulting.
2	15. Experiential credit system
2	16. Data partnerships with academia and private sector, thereby providing students with "real life" situational learning
2	17. Industry advisory groups for curriculum development
2	18. Strengthening interaction between core geomatics and application disciplines (CRISP example at UNB)
2	19. Need provincial and private sector research $$$$
2	20. Using business and academic associations (perhaps Champlain Institute) to act as conduits for market intelligence and collaboration in raising profile and dollars
2	21. Realistic credit transfer
2	22. Geomatics advisory boards or committees to act as sounding boards
2	23. UNB-COGS relationship (unique in the country)
1	24. Research group doing some consulting (non R&D).
1	25. Industry involvement in advisory capacity
1	26. There may be a need for 1 or 2 specialized courses in a given field(e.g. Photogrammetry)
1	27. Academic-industry research networks (there is a small group of successful examples, including a couple from the Maritimes)
1	28. Closer ties within regions to focus on the expansions in traditional markets (New England; Atlantic Rim as key areas for Maritimes)?
1	29. Close liaison between private sector and academia
0	30. Academia involvement in industry developments (e.g. Standards)
0	31. Work with IT industry on distributed spatial databases
0	32. Allowing student transfers mid-program to add in practical education with theory
0	33. New mix of clicks and bricks

A.2.4.2 How can these institutions be at the leading edge of industry's needs?

Note: the Halifax group modified this sub-topic. They discussed instead: "How can these ideas be implemented?" and later discussed "Are there regional differences (specific to the Maritimes)? National commonalities?"

How can these ideas be implemented?

1. Reciprocal secondments between private sector and academia //faculty hired directly from industry

    - I think we are forgetting how small the average geomatics company is and little financial cushion it has. {#51}

- We have placed grads in industry then brought back as instructors. Is time limited i.e. Rapid changes in IT {#59}
- Post-secondary sabbatical or professional development process, or third party funding for small geomatics company. {#62}
- Secondments can even be valuable at a lower level of implementation (job shadows/job sharing/sabbaticals) {#72}

2. Co-op education //work experience component in every program // co-operative projects with industry and government (e.g. Student projects within regular curriculum)

- COGS would have a summer work term - students would be given the option of gaining real experience in private/public sector {#47}
- COGS (NSCC) must maintain roster of alumni placements and co-op placements {#49}
- Private sector and government (dept.of ed) must communicate to academia the real need and value for co-op; and convince program directors (academics and administrators) that support should be enhanced ...as well as broadening out to other areas (non-traditional...e.g. Placements in health departments) {#57}

3. Colleges and universities must shorten timeframe between technology developments and teaching curriculum

- Faculty seconded to private partner to develop, or work, in new technological area. {#43}
- Equipment dealers are available to demonstrate latest developments and applications. Often able to lend new instruments for short term student use. {#61}
- COGS can benchmark and test bed new technologies {#71}
- Rather than always striving to have latest equipment in-house, give more thought to working out arrangements to have access to state of the art facilities in industry - and to best practices {#76}
- Give customized, full cost program to well-heeled industry or government player that can later be turned into new curriculum for broader geomatics sector needs. {#77}

4. Joint graduate degrees between university and community college

- This could be applied regionally through mou's between the institutions. {#40}
- Initially it would be easier in the region but there should be no impediments to more global view {#44}
- We in the Maritimes are probably best positioned to do this (given history, personal relationships, MPHEC, etc.) {#58}
- Do not wait for big initiatives; institution-to-institution agreements {#67}
- Credit transfer and accreditation are important parts of the process. {#69}
- This is a vital link in the answers to topic 1 {#73}

- At regional level we have few real barriers....we should remember that at a national level, standards in geographic education are being developed whereby GIS will be a standard outcome of secondary students {#78}

5. Applied research in collaboration with industry and government

- International. Joint agreements between partners {#38}
- Expand the CCRS model {#39}
- Pro-active research networks (i.e. Formed to advance consortium research agenda, not merely to respond to external RFPs) {#42}
- Just do it! {#68}
- Ibid {#70}

6. Regional approach to programs (credit-card example...) Flexible, mix of clicks and mortar...intensive summer institutes...etc

- Unigis - Mix of online University and Community College courses with on-site education, co-op training etc. {#41}
- Take advantage of the strong e-learning industry in the region {#53}

7. Allow COGS to incubate Geomatics companies

- Such arrangements must be structured carefully to avoid private sector backlash {#64}
- Needs proactive NSCC policy {#65}
- What are the limitations currently? {#66}
- OFFER A BUSINESS DEVELOPMENT ASPECT WITHIN THE COGS STRUCTURE - ALLOWING FOR STUDENTS TO CREATE THEIR OWN FIRM - BE NUDGED INTO THE ENTREPRENEURIAL WORLD {#75}

8. Adding new courses quickly in application-specific areas (health, business, law)

- Local application of this effort - perhaps even working with the Private IT schools and other similar institutions. This would also expand the exposure of the geomatics fields in specialty areas. {#46}
- Invite relevant past graduate from the application-specific area to teach GIS {#52}
- Must be careful with diversity of specialism and balance the core curriculum e.g. Business Geographics and Marine Geomatics at COGS {#54}
- Need regular input from client industries {#56}
- Create incentives for fast-tracked dollars to be applied to areas "recognized" as in need/"hot"...not just from traditional sources of funding (which tend to be hard to get...already earmarked for "previously recognized" areas) {#63}

9. Ensure good communication of emerging markets to educational program decision-makers

- Representation from academic institutions at industry meetings and vice-versa {#45}
- Web-based newsletters and email "hot items"; industry and academia forums at local level and regional level; major "recognized" thrust in a national conference bringing together THE key players and the ideas/issues from the grassroots levels (that have previously met)... {#48}
- Arrangement between organization SUCH AS Champlain institute, FOR INSTANCE {#50}
- Ideally offer courses in "hot" applications - two-way street required for academia to stay current with private sector apps. (through GANS, CI or similar type of entity which facilitates monthly communication of industry status) {#60}

A.2.4.3 Supplemental Question

Are there regional differences?

1. Language (Quebec)
2. Photogrammetry: COGS/UNB example can be exported.
3. Credit structure... Recognition of college courses
4. Unique geography of Atlantic Canada (e.g. Marine geography, hydographic)

A.2.5 Topic Four: Skills Upgrading

"The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances."

A.2.5.1 What training gaps exist in the geomatics sector and how should they be filled?

1. Photogrammetry
2. Writing/Communications skills (e.g. Resumes)
3. Business development skills / marketing
4. Licensed land surveyor (ongoing education) ...Continuing Education for our members
5. Computers .. Recent stuff: www, wireless, object oriented programming etc
6. Meta data
7. High level executive overview
8. New developments and what they mean re: direction of the industry
9. Business & long range planning (ability to fit all the pieces in the big picture)
10. Behavioral-based screening/interview processes
11. More formal credit mechanisms (e.g. Credit databases)
12. The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances.

A.2.5.2 What is the role of employers in providing on-the-job training?

14. Employers' Role: yes. But tough with smaller companies
15. Prof Associations: maybe not providing training... But sober objective insights on where industry is going... Identifying where are the "hot" demand areas... Community requirements & future environment... Branding advantage of prof associations.

16. The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances.

A.2.5.3 What are best practices in making use of online training opportunities?

17. Unigis - global in reach?
18. ESRI Virtual Campus
19. E-learning business sector have some great experiences with online coaching and mentoring
20. Best uses are those that mix clicks and mortar
21. Long distance education
22. We have tried many IT related online training and no experience worth repeating.
23. Good for conceptual material; less successful for practical problem solving
24. Prior-learning assessment/credit data bases
25. Online materials do not cover bad data, apps with bugs etc
26. Linked to customized resource discovery and delivery (myncsu)
27. There is an unfilled need in the cadastral part of surveying for distance learning. UNB may well fill that need across Canada.
28. Make it affordable to SMEs through sharing of site licenses between firms/assoc/other consortia.

A.2.6 Workshop Participants

A.2.6.1 Participants

Sylvan Latour, NRCan (Slatour@nrcan.gc.ca)

Brad Fay, Nova Scotia Government (Bfay@gov.ns.ca)

John McLaughlin, UNB (Jdm@unb.ca)

Philip Milo, CCLS (Phil.milo@ns.sympatico.ca)

Colin Maclean, COGS (Macleacj@nscc.ns.ca)

James Boxall, Dalhousie University (James.boxall@dal.ca)

Laura Beazley, Champlain Institute (Lbeazley@champins.ns.ca)

Edward Light, Regional Municiplality of Halifax (Lighte@region.halifax.ns.ca)

Bob Maher, COGS (Maherrv@cogs.ns.ca)

A.2.6.2 Observers

David Arthurs, HAL Corporation (darthurs@hal.ca)

Bob Batterham, HAL Corporation (rbat@fox.nstn.ca)

A.2.6.3 Facilitators

David Low, HAL Corporation (dlow@hal.ca)

Erik Lockhart, Queen's University Executive Decision Centre (lockhare@qsilver.queensu.ca)

A.2.7 Meeting Evaluation

A.2.7.1 Your most significant "takeaway" or learning from today?

- Lack of private sector participation {#10}
- The level of agreement on the importance of changing the industry culture - with out that a lot of the specific HRM issues will not be effectively addressed. {#11}
- Great to, once again, find out that there is more which joins us than divides.
- Still, it was fun to find out that there are several innovative ideas floating around out there which need to get a wider audience (hope that this provides that forum). {#12}
- Interesting use of the technology {#13}
- "geomatics" as a field is too ill-defined for people outside the industry. The focus should be on sub-categories of the discipline in order to build the industry. {#14}
- A "culture change" and enhancing skills is required for increased growth {#16}
- Update on status of Geomatics HR {#17}
- There is a role for professional associations, but limited time to define and act {#19}
- FOCUS on applications development {#24}
- The process/technology is a good way of getting ideas out of a group. {#27}
- I have enjoy the use of this new technology to obtain input from the field. {#31}

- Prof. Associations need to revamp their models perhaps merge - i.e., paid boards {#34}
- Cultural changes are long in the making and in some cases we may not have been making a lot of progress in the last several years. - too bad ! {#35}
- I intend on making this study material to our HR department so that they might better understand the industry we represent. {#42}

A.2.7.2 Next Steps: what do you see as the key points and priorities from today's discussion?

- Our schools are doing a great job but industry is not doing its share. Not helping the universities, not training the employees. {#18}
- Must be a feedback loop. Really interested in whether we have a regional view cf with Quebec and elsewhere {#20}
- Continuing education agenda. Bringing the entrepreneurial issues (equity participation, etc.) to the table. {#22}
- Must get the decision makers together. Need replicate our good works into more regions and more often. Have to get the message out; we are the converted, we need to find those who can affect us, but do not know us. {#26}
- Get some industry feedback on the same topics, if at all possible. {#33}
- Priorities: 1) GIS training in non-traditional application. 2) executive overview of domain evolution and relevance to their sector {#37}
- Entrepreneurial support required for visions to become realities... {#41}

A.2.7.3 Anything you would like to say that did NOT get said...

- Because there was little or no representation from industry, I would not want the discussion surrounding academia entering into industry business to be mis-interpreted. I believe industry has and continues to NOT want academia to be in direct competition. Call it "applied research", "embryo industries" "incubation" or whatever, it still spells academia competing with industry ! And if you want to stagnate an industry, snuff it out with unfair competition ! {#25}
- On the certification issue, this remains a political hot potato. It is interesting to see the variation in the region. It is even more contentious internationally. {#36}
- The report should present the results for the different sub-field of geomatics and not simply as a whole. I feel this could lead to some confusion. {#43}

A.3 Montreal

Note: The Montreal workshop was held in French. The following is a translation of the proceedings.

A.3.1 Executive Summary and Notes

The workshop in Montreal had eight participants and two observers. The participants were drawn from industry, federal government and the universities and colleges; representatives of the user community and the provincial and municipal governments were invited but, unfortunately, were unable to attend. A key point was the recognition that a shortfall in skilled geomatics personnel exists today and is not just a problem for the future. At the same time, industry does not yet see the shortage as a serious issue. HR questions need to be looked at by subsector and by region. A stronger link is needed between universities, colleges, research centers, industry and government to increase the visibility of geomatics and improve training. A national strategy and infrastructure for geomatics is a prerequisite to Canada benefiting from the expected growth of the field. Some consolidation of professional associations would be an advantage to the sector.

Editor's Notes:

- The symbol // indicates that two similar ideas have been merged together.
- This document contains the meeting proceedings.
- In some cases, comments are appended with a # such as "rapid changes in IT {#59}". The system attaches a sequential # to every item for reference purposes only.

A.3.2 Topic One: Shortfall of People

"The geomatics sector is expected to experience a shortfall of people over the next five years."

A.3.2.1 What actions/initiatives/conditions are needed to attract new entrants and experienced people in (i) the private sector, and (ii) the public sector?

Discussion Notes

- Why make a projection if we already have one? We already have things to fix. The problem is only going to get worse.
- Too many job offers in comparison with the number of graduates. Schools use shortfalls as an excuse for receiving grants from the government. The report can help if there is evidence of a shortfall.

- Today's shortfall was not as apparent in the study as it is in the ICT sector. Because of the size of the companies, survival is more important than recruiting personnel. Perhaps turnover, where keeping people is becoming difficult and therefore replacing those people might be the problem.
- Can we adjust today's shortfall by sector? Not only by sector, but also by region.
- It would demonstrate that some regions are in demand while others seem to be exporting to other regions. Although there is anecdotal evidence, but no concrete observations, it does not appear to be the main problem.
- For five years we have had a shortage of graduates. The solution: a shorter program (2 years rather than 3 years), new programs to meet specific needs (photogrammetry, specific programs for one or two companies in the region of Quebec...)
- Photogrammetry: seen as one of the best sectors to begin studying. Traditional companies must not believe that the industry is growing. But the new photogrammetry companies, that do not necessarily see themselves as photogrammetry companies, see the growth in industry.
- Presently, there is a shortfall of people with a base knowledge in multiple geomatics disciplines. A search for versatile individuals…a basic degree is as valuable as it was in the past, we are training people to meet the demands.
- Good comprehension will allow us to easily find what we need. Who has been hired…general or specialized? We are looking for generalists who are not specialized. But the basic skills and potential of each individual (soft skills, learning capabilities) may as well be used to chose the first round of candidates.
- Someone who is good is good…the person's background is not important…what matters is that he or she can learn.
- An attractive image: no, there is not an image…In high school, geomatics is taught as surveying or geography…no recognition of the word/field of geomatics…must improve the perception and transmission of the geomatics sector.

Computer Input

Note: the group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Training

1. Develop a marketing approach for training in geomatics
2. Update training programs
3. New specialized training in universities
4. Scholarships
5. Coordination of training between various training institutions have an option for joint training between various schools
6. Paid work experience in the enterprise
7. Increase the information given to secondary and college students

Awareness…Publicity

1. Demonstrate the potential for an international career
2. Mass publicity for young people and the general public: no one will come if they are not aware that a field such as geomatics exists
3. Establish introductory geomatics courses in secondary school programs (ex. ON), demystify geomatics for young people
4. Information sessions on relief and careers in schools
5. Increase the visibility of geomatics by participating in job fairs, and so on
6. Make guidance counsellors aware of geomatics
7. Publicity for students in other engineering programs to encourage them to specialize in geomatics
8. Make simple, yet interesting GIS tools that are used daily (Ex: Mapquest, GIS software), available for everyone.
9. Develop a marketing approach for training in geomatics
10. Popularize geomatics applications more often in the media
11. Demonstrate the efficiency of geomatic methods and tools to answer popular concerns. Ex: Emergency measures/ make people aware that geomatics is omnipresent in many aspects of their lives (transportation, city planning, environment, and so on.)
12. Show that geomatics is part of new information and communications technology
13. Make the job market recognized as being excellent and lucrative
14. Relate geomatics with well-known applications among the public
15. Effective mass publicity that is noticed right away (through Videotron: "des tonnes d'applications, pis ça c'est l'fun!…des tonnes d'applications, pis ça c'est l'fun!…)

Woking Conditions (salary, environment, and so on)

1. Pleasant working conditions
2. Pleasant work environment
3. Enterprises offer higher salaries
4. Job stability.

Industry profile

1. Scholarships
2. Show that geomatics is a part of new information and communications technology
3. Make simple, yet interesting GIS tools that are used daily (Ex. Mapquest, GIS software, and so on), available for everyone.
4. Promote the decision-making aspect and not limit the vision of the technical aspect
5. Demonstrate that there is not only a technological component, but that there is also a lot of team and multidisciplinary work
6. Demonstrate the potential for an international career
7. Aim for the diversity of geomatics applications and therefore the versatility needed in this sector
8. Make governments and International Agencies (Ex. Spatial agencies) aware of the timely dispersion of free (or nearly free) information

A.3.2.2 Supplemental Question

Note: Another question was also discussed within this sub-topic: “Which "sub sectors/disciplines" within geomatics have a shortfall?” The group was asked to vote for the seven sub-sectors for which the shortfall was the most critical.

Total	
4	1. GIS
4	2. Spatial analysis
4	3. Integrators
4	4. Project management
3	5. Development of new markets and applications
3	6. Spatial data banks
2	7. Production of digital images
2	8. Geomatic engineering + computer science training
2	9. Training to integrate the disciplines
2	10. Complete and comprehensive training, covering the complete cycle of production/usage/diffusion of spatial dada
2	11. Training
2	12. Internet and distribution of data
2	13. Electronic commerce
1	14. Staff who are able to speak French, English, Spanish, XML, Java, C++, UML, GPS, GML, pixel, ArcInfo, Mapinfo, VMap, management, web, MTM, UTM, and so on.
1	15. Cartography
1	16. Innovation and creativity
1	17. Data base management
1	18. Development of marketing products
1	19. Legal surveying (professional training) (very recent shortfall, but is increasing)
1	20. Surveying
1	21. Image processing
1	22. Communication
1	23. GPS applications
1	24. Management
1	25. Interoperability of information
1	26. Distributed data banks
0	27. All the sub sectors that are adopting Web technology
0	28. Interpersonal relationships
0	29. Softcopy photogrammetry
0	30. Cartographic representation on the Internet
0	31. Strategists

A.3.2.3 Does geomatics as a sector present an attractive image?

This topic was not discussed as such within the Montreal workshop. It was discussed as a part of the previous sub-topic (section A.3.2.2).

A.3.3 Topic Two: Turnover and Retention

"Turnover and retention of staff is not at present a major issue in the geomatics sector. The increasing overlap of the sector's reach with the Information Communications Technologies (ICT) sector suggests that the issue will become more pressing in the future, reducing the ability of the sector to meet growing market demand for geomatics products and services."

A.3.3.1 What can be done to avoid serious people losses in the sector?

Discussion Notes

- Retention can be a problem for the industry, but not necessarily for the field…it is more of a positive factor since it allows an infiltration of geomatics within other industries.
- Only when an individual leaves to work in a field other than geomatics does it become problematic.
- The problem is not retention, that is secondary to having a national strategy to tackle the idea of geomatics and its role in Canada as well as outside of Canada (United States). Geomatics is going to soar…Canada must have a national infrastructure and strategy worth millions of dollars.
- The countries that support Geomatics will be the beneficiaries of huge gain, if not, the industry will remain small potatoes.
- The organization of the industry…it is currently not organized. They are very small enterprises. GEOintegra, a grouping of industries in Quebec, has a united front on the outside…with approval from the government…
- And those who are not in GEOintegra…
- They pay and then they enter…there is no market in Quebec and in Canada, therefore the strategy is to use all our energy to build infrastructure for geomatics in Quebec.
- A realization must be made: geomatics is already important and is pushing products that are already available, but it is not known for being a driving force… Like when we buy a car we "drive" the aluminium industry. Geomatics must distinguish itself so it can become a visible part of everyday life and the products that we use. If geomatics allows us to do something, why do we not have any recognition?

Computer Input

1. Have a strategy integrated with development.

2. Facilitate the exchange between all types of organizations in the field of geomatics for better synergy: teaching, research, private industry, and government
3. Facilitate the exchange of information
4. Make data banks available.
5. Interoperability
6. Demolish professional barriers that prevent the entry of competent personnel of every discipline in the world of geomatics.
7. The development of the supply is closely linked to governmental strategies related to the development of national infrastructure in geospatial information. Without speculation on these policies, we cannot correctly evaluate the level or characteristics of the supply to develop.
8. We must be aware of the decision-makers (especially the governments) who are already large consumers of geomatic products and that their investments could improve in this sector by recognizing this fact specifically and by investing directly in its structuring. This will stimulate the sector in a major way and the benefits will depend on this.
9. One of the largest restraints in industry development is the absence of an adequate communication of enterprises. We must find and quickly establish discussion methods. In Quebec, GeoIntegra is a good example of discussion between industries, public administration and schools for the development of export markets.
10. Have a vision of geomatics infiltration beyond traditional geomatics.
11. Define the national and international geomatic vision and establish strategies, objectives and policies that will facilitate attaining these objectives and the development of geomatics in Canada.
12. Facilitate the access of information and have a working knowledge of the necessary tools.
13. Develop new management skill, market development, and international market within the field of geomatics.
14. Develop a marketing approach for the use of product and services and so on.
15. Examine the make-up of Canadian geomatics enterprises and regarding their characteristics, make facilitating measures available for them to surpass their abilities.
16. Development of international cooperation programs.
17. Demolish barriers that prevent access to information.
18. Governments must invest in a major way in the information base that they must manage, i.e. information about the territory. It is the definition itself of a government: people who share the same territory and want to use it to its fullest.
19. There is not a factor of determination of the demand more important than the liberalization of a market by a free access to public geospatial information. Not taking this factor into consideration greatly reduces the value that we can give to the evaluation of the demand, and consequently, to the evaluation of the level supply to respond to it.
20. More lobbying to government authorities in order to make them aware of the potential and capabilities of the Canadian industry and of the position that it can occupy in the world for the benefit of the country.
21. The Governments must establish a strong and clear policy (with the necessary investments) in order to build the base of our economy: information about the territory (they invest in other infrastructures: roads, telecommunications, and so on).
22. Greater national cohesion in the field (varies from province to province)

23. Geomatics is "technology driven". It must become "market driven". We must increase our abilities in the fields related to knowledge of the market and its translation into products and services to be developed.

A.3.3.2 How can geomatics align its human resource strategies with the ICT sector to take advantage of the migration of geospatial disciplines into the ICT sector?

24. Skills required: knowledge of what is happening in the ICT, understanding the phenomenon of technological convergence and the ability of building a vision based on this knowledge and the knowledge of the potential of geomatics
25. Skills required: visionary
26. Skills linked to geomatics must be integrated in the fields of application where the markets will develop. We must therefore stimulate interdisciplinary training programs where a link can be established between geomatics and these high potential applications.
27. Skills required: knowledge of the technology (potential and limitations + anticipated evolution)
28. Skills required: knowledge of certain fields of application in order to see how geomatics can assist them in an innovative way.
29. Skills required: ability to collaborate with specialists in other fields (fields of application)
30. Develop information systems and “intelligent” server.
31. Have a good knowledge of the tools
32. Create products for the general public; make the products well-known by every means of communication possible.
33. Increase the research and development in information transfer techniques and methods (compression, shared access, Internet…)

A.3.4 Topic Three: Best Practices at Universities and Colleges

“Universities and colleges have been responding well to the changing skills demands of the geomatics sector. Keeping course content up-to-date, however, continues to be a challenge because of technology advances and new market requirements. Knowledge of application areas is in demand together with a base of geomatics skills.”

A.3.4.1 What are best practices for universities and colleges to follow in ensuring that geomatics-related courses are meeting these sector requirements?

Discussion Notes

- At first, students lack maturity; they enter into the high tech aspect, but they do not see the importance of having a vision. Therefore, it is in 3rd and 4th year that they understand the importance of the vision and the need for a variety of skills. We cannot always lead them by the hand…they need more maturity, even with the best programs on paper, once they enter the working world, they seem to be lacking since they have forgotten their first years of study from either a lack of interest or maturity.

- Proper technological training, but for t hose who want to lean towards the computer science, they should havemore difficult computer courses.
- MBA centred on the needs of the industry, therefore we must duplicate this program. 1. Work Experience, build bridges with the industry. 2. Case studies of the industry. 3. Infrastructure in Canada that will help to understand the process between an idea and seeing this idea enter the market…the use of tele-learning.
- Should have students coming from high school, but in fact a large portion are coming from college or university to receive technical training…they are more likely to do well, since they are more mature. Geomatics seems to be easier to teach to people who have already gone through school.
- Predicts that there will soon be paid work experience, because of this, they are presently conducting case studies to be able to envision possible situations that will be presented in the work environment.
- Would like to see the grouping of all groups in the industry in one environment (school, company, government), but would this be possible?
- No, because of competition and commerce that is not loyal.
- We can make contracts that are too large. Companies are already opposed because they think as if they were competing against a subsidized vehicle.
- A new program such as environmental geomatics and earth sciences with biology (ecology). Keeping ties with the private sector (cooperative), and integrate the approach through a case study. And through the fine-tuning of the program, they have realized the need for a new educational module dealing with business geomatics.
- The possibility of a vision is more necessary that the concrete tools for the management of the project.
- Leave the marketing for marketing, and geomatics should learn to sell its industry.
- But we must know what we are selling.
- An element to add to Guy's comment, people who work in the industry and teach about the industry must continue/begin to speak and listen to one another…to move forward together.

Computer Input

Note: the group was asked to vote for the seven most important best practices.

Total	
5	1. Work terms
5	2. Support a research environment in order to have an education that is not only at the forefront but that is ahead of its time.
5	3. Encourage the collaboration between professors and the environment (ex. people from the industry who act as lecturers, professors for industrial training, industrial research contracts to universities and colleges)
4	4. Case study // to make case studies, analyse existing applications, gather industrial speakers.
4	5. Include solid scientific training (math, physics, computer science) with geomatic training as well as knowledge of potential applications.
3	6. Synergy between the needs of the geomatics industry and the schools

3 7. Improvement of teachers by training them in the industry
2 8. To base training on versatility since it will lead to flexibility, innovation, and the creativity that organizations look for. Specialization is not highly sought after and can be developed at any time.
2 9. Case based teaching with projects having been defined by the industry.
2 10. Training must not only be based on the acquisition of knowledge, but on the development of capabilities and of personal qualities. Geomatics changes too rapidly. We are not only looking for people who have knowledge, but especially for people who can learn quickly and who are anxious to keep themselves up-to-date.
2 11. Encourage the renewal, growth and diversity of the teaching profession.
2 12. Prepare the students to work in an international environment.
1 13. First, the participants of the sector must identify their needs and make them known in specific and not too general terms.
1 14. Use meetings and discussion groups between them.
1 15. Provide a solid training foundation that does not become obsolete too rapidly (as opposed to training that is too oriented on learning the technology).
1 16. Make adequate resources available to support teaching (ex. technicians who assist the professors with their courses).
1 17. We need to increase the range of the notion of property and teach them where it falls under the Civil Code and the Common Law.
1 18. Exchange of knowledge
1 19. Invite speakers from the industry.
1 20. Industrial visit
1 21. Solid foundation in basic sciences: math, physics, computer science
1 22. More interaction between schools, private industries and the government. Centres of excellence.
0 24. Ensure that courses are up-to-date (concepts are evolving, new concepts are developing rapidly [for example, web mapping], and technology is evolving even more rapidly).

Other Computer Input

2. Work terms (students)//Improving professors by providing them with experience in the industry
The industry must be prepared and up-to-date in order to give something to the student. It must ensure that the companies do not take away from or "unteach" the training taken at school. {#33}.

3. Encourage the collaboration of professors and the environment (ex. managers who act as lecturers, professors receiving experience in the industry, industrial research contracts for universities and colleges).
Communication with infrastructure, exchange of information, pooling issues (cases) together, Internet tools, data banks, list of enterprises {#35}.

4. Encourage the improvement, growth and diversity of the teaching profession

Alain: Graduates with master's degrees are better models (in order for the industry to teach) since the courses are less administrative and they can therefore see that their time is better spent {#38}.

5. Prepare students to work in an international environment
Scholarships for students {#36}

A.3.4.2 How can these institutions be at the leading edge of industry's needs?

1. Case study // Conduct case studies, analyze existing applications, welcome industrial speakers
2. Make adequate resources available to support teaching (ex. technicians who assist professors with their courses)
3. Support a strong research environment in order to provide not only education at the forefront, but education that is ahead of its time.
4. Improvement of professors by providing them experience in the industry (vice versa)//encourage the collaboration between professors and the environment (ex. industrialists who act as a lecturer, professors in industrial training, industrial research contracts for universities and colleges).
5. Include a solid scientific training (math, physics, computer science) to geomatic training, as well as knowledge of potential applications.
   Solid foundation of basic sciences: math, physics, computer science {#26}.

6. More interaction between schools, private industry and the government. Centres of excellence.
   An example of the centre of this kind is the CCRS (Canada Centre for Remote Sensing). This method of acting as an incubator facilitates the technological transfer and also benefits the teaching environment and the industry {#48}.

   With the creation of incubator projects where the industry, schools and centres of excellence and the government all share the same environment (physical, of knowledge, and so on) to produce output {#52}.

7. Encourage the renewal, growth and diversity of the teaching profession.
8. Prepare students to work in an international work environment.

A.3.4.3 Supplemental Question

Better methods for the interaction between students, professors and the industry.

1. Money used for applied research should go towards: the government, the industry, universities and colleges (with paperwork in the industry; ex. GeoInnovation)
2. Money used for fundamental and exploratory research should go towards: the government and industry, universities with a high level of flexibility.
3. Research centres or institutes: encourage the transfer of technology, joint project between the university, industry and the government.
4. Holding conferences on specific topics.

5. NSERC and other granting agencies should give more credit to researchers having strong ties to industry (they presently put too much emphasis on publications and not enough on technology transfer)
6. A scholarship program specifically in geomatics
7. Promotion of a post-doctoral work term (to attract foreigners)

Comments about Certification:

- Certification is useless and even a hindrance. Why create barriers when we've been able to avoid them until now? By doing so, we eliminate the possibility of getting IT (and other people) into the geomatics sector since they will not be able to participate in the industry [without being certified].
- We are looking to be recognized as an engineering school so that our students can receive another piece of paper to add to their collection and that another avenue [that of an engineer] will be open to them.
- But in a way we already have certification. We have a set of skills and we try to match them with whatever [geomatics] skills the applicants have.
- But what we should look for is someone who can learn, adapt and who has good "soft skills", and the rest can be taught (with certification, we exclude those types of people, even if they have useful IT skills and/or basic geomatic skills). We might also end up using certification as a crutch and rely on it to make our decisions and protect the 'traditional' people within the geomatics industry.

A.3.5 Topic Four: Skills Upgrading

"The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances."

A.3.5.1 What training gaps exist in the geomatics sector and how should they be filled?

Note: the group was asked to vote on the top five training gaps that exist within the geomatics sector.

Total	
4	1. Grants for industries that participate in research projects and development, including the update of knowledge.
4	2. Knowledge in the development of the market and marketing
4	3. From the industry, there exist certain misconceptions about the training programs offered. This can be filled by more frequent exchanges between the industry and education.
3	4. The creation of an "MBG" based on the MBA model, or a "certificate" in geomatics.
3	5. Base training on versatility since it will lead to flexibility, innovation and creativity that organizations are looking for. Specialization is in very little demand and can be developed at any time.

3 6. Training, meeting, exposition and research workshops
3 7. Develop and improve learning tools for heavy and complicated software (especially relating to discontinued and irregular use of this software: how to learn to use them again!).
3 8. Training does not only need to have the acquisition of knowledge as an objective, but especially the development of personal qualities and capabilities that are more essential than knowledge. The evolution of geomatic science is too rapid, therefore it is more important to be able to acquire new knowledge and to be updated than to have acquired knowledge that quickly becomes obsolete.
2 9. Web literacy
2 10. A perfect command of languages = clearly insufficient (this limits their comprehension abilities.
1 11. Case study to stimulate the students' imaginations with regard to the many possible applications (ex. GPS receivers embedded in Celestron telescopes).
1 12. Until recently, employers regretted the lack of training in computer science and in programming. The new geomatics program in colleges will contribute to fill these gaps.
1 13. Impact of the program for the cadastral reform on the future notion geomatics property.
1 14. Include one or two geomatics courses in the second language (ex. an English GIS course in a French college or university and vice versa).
0 15. Large-scale management. Give the basics in training.
0 16. Remove parking lots from university campuses and students will not buy cars. They will cease from working while they are in school and they will be able to devote themselves more to their studies.
0 17. A perfect command of French and working knowledge of English. Requires a certain work performance.

A.3.5.2 What is the role of employers in providing on-the-job training?

1. Accept to invest to receive students (who become potential employees by the end of their studies, employees who are already trained in the culture of the enterprise).
2. Accept to temporarily lose some efficiency because of the student. Or compensate this loss of efficiency with any benefit.
3. Facilitate the on-going training of their personnel.
4. Flexible working hours and tasks for the training and participation in workshops and conferences
5. Invest in the preparation of quality work terms that will help in the student's development.
6. Actively participate in the establishment of work terms.
7. Give contracts to universities and colleges to update training in their enterprise (when the demand becomes strong enough, then this will be profitable for universities and colleges).
8. Accept the fact that they can benefit in the long run from the presence of an observer who can help them to innovate and create.
9. Openness allows for the participation in research projects and for the establishment regular links with the research and development centres.
10. Develop learning tools via Internet with training institutions.
11. Be able to modify the internal structure of the organization in order to students.

12. Update of skills in the work environment

A.3.5.3 What are best practices in making use of online training opportunities?

1. Promotion for targeted clientele - marketing
2. Financial and human resources that have the skills to develop and to make this information tool available
3. Commit to a major investment from the government and the industry in the building of a complete series of high-quality, international-level courses (ex. through GEOIDE). An excellent international showcase.
4. To pool the knowledge and the resources of the industries and institutions in order to reduce the costs of creating online courses.
5. Integrate certain aspects of the course on the Internet.
6. Have tools that are good and easy to use.
7. A major RFP!
8. Infrastructure with an "intelligent" server for connection and questioning on multi-source databases.
9. Facilitate the contact and exchange between organizations that have training needs and organizations that have the skills to develop these programs.
10. Put the organizations that have computer science methods in contact with those that have less to carry out this training.

A.3.6 Workshop Participants

A.3.6.1 Participants

Guy Rochon, Envirosat (rochon@envirosat.ca)

Yvan Bedard, Universite Laval (yvan.bedard@scg.ulaval.ca)

Alain Royer, Universite Sherbrooke (aroyer@courrier.usherb.ca)

J. P. Lemieux, NRCan (Sherbrooke) (jlemieux@nrcan.gc.ca)

Andre Cloutier, Limoilou College (acoutier@climoilou.qc.ca)

Gilbert Pouliot, CDG (gilbert.pouliot@cdg.qc.ca)

Michel Brunet, CCLS

Claire Gosselin, Geomatics Consultant (Claire@gosselin.com)

A.3.6.2 Observers

Mathieu Pinard, HAL Corporation (mpinard@hal.ca)

Bob Batterham, HAL Corporation (rbat@fox.nstn.ca)

A.3.6.3 Facilitators

David Low, HAL Corporation (dlow@hal.ca)

Erik Lockhart, Queen's University Executive Decision Centre (lockhare@qsilver.queensu.ca)

A.3.7 Meeting Evaluation

A.3.7.1 Your most significant "takeaway" or learning from today? What is the most important thing today?

- The problem of the evolution of knowledge in the industrial sector of geomatics
- The problem of training-industry relations {#10}
- The shortage of labour is not an event to come, but is a problem today. {#11}
- It is difficult to generalize for the whole country and all the geomatic disciplines. The identification of the specialist covering the complete lifecycle of geospatial information is missing, i.e. every analyses are separated by sectors, but no one has been identified as being the specialist. The labour problem is not important enough for the industry to deign participate in. It is a very important exercise to do since the results have a direct impact on the training programs. {#13}
- Better integration and discussion between the various types of geomatics organizations (private and public teaching) will give good results. Communication, common comprehensive action plan, common vision, Proof = this exercise. {#14}

A.3.7.2 Next Steps: What do you see as the key points and priorities from today's discussion?

- The willingness of the institutions and the industry to collaborate to improve training even if there were very few representatives from the industry. {#12}
- To distribute the results of the current survey
- Encourage the initiatives taken for discussion as was undertaken by the CDG for example.
- Encourage training meetings (universities-colleges) - industry
- Promote geomatic research and development (scholarships, joint projects) {#15}
- Promote an open policy for the dispersion of databases {#16}

- Create a strong link between schools, research centres, private enterprises and the government to increase the visibility of geomatics and to improve the training of students. {#18}

- Identify a few Champions who will sell Guy Rochon's vision to the proper forum, i.e. politics! Mass publicity for young people in order to meet the demand in 4 to 5 years. More students in the programs mean more budgets per department and normally better teaching (more professors, equipment, and technicians for support and so on). {#19}

- Need for training: Geospatial databases, integration of information, Internet {#20}

- Better develop the user markets of geomatics products {#21}

- Create a common vision (industry, government and teaching) and a positioning of geomatics in relation to the world market in order to give themselves objectives and to quantify their expectations {#23}

- Personal qualities and skills are more important than knowledge {#24}

- The versatility and flexibility of individuals (and by extension of the organization) is in demand and not the specialization. {#25}

- Demolish the barriers at the entrance of the geomatic field for the people of all the domains {#28}

A.3.7.3 Anything you would like to say that did NOT get said...

- Congratulations on a job well done. {#17}

- I would have like to talk about the future of professional geomatics organizations (provincial and national) in Canada and the possibility of merging or consolidations of views and resources. I see this as a must for the sector and the industry. With the addition of the Association of Canada Land Surveyors two years ago, the Provincial Land Surveyors Associations should look towards pooling their visions and admission criteria. {#22}

- How does the situation compare itself with the situation of related fields? For example, the number of students in computer science has decreased while the number of students has increased, also for sciences in general. Another example, more students are registering for programs that do not lead to a profession recognized by a corporation (they are often new hybrid programs, ex. bio-economy, agro-environment), and it would seem that it is often because the requirements are not as high as in basic sciences ex. (math). Why do a large number of students register for programs that will lead them directly to unemployment while it is difficult to get most students interested in "difficult" programs that will certainly lead to a job? {#26}

- It is important that the report explain the results of the questionnaire and workshops by region. This segmentation of the territory will allow for the better understanding of the dynamics of geomatics in Canada, to better target discussion efforts and to define a strategy that corresponds to the forces of each region. {#27}

- Is there a federal-provincial collaboration in the geomatics domain? {#29}

A.4 Toronto

A.4.1 Executive Summary and Notes

The workshop had nine participants and one observer. A theme repeated throughout the discussion was that IT forms the foundation of Geomatics today and therefore the basics of IT have to be incorporated into all educational and training programs associated with geomatics. Another point was that to be competitive for talent with other sectors especially the IT sector, geomatics has to increase the value it brings to the business environment, thereby increasing revenues and compensation. Geomatics should align itself with the IT sector to keep pace and be seen as a related service warranting the same level of recognition. The educational institutions were considered to be doing a good job of meeting the needs of employers but emphasis was placed on access to continual training and development to ensure Canada remains a leader in geomatics.

Editor's Notes:

- The symbol // indicates that two similar ideas have been merged together.
- This document contains the meeting proceedings.
- In some cases, comments are appended with a # such as "rapid changes in IT {#59}". The system attaches a sequential # to every item for reference purposes only.

A.4.2 Topic One: Shortfall of People

"The geomatics sector is expected to experience a shortfall of people over the next five years."

A.4.2.1 What actions/initiatives/conditions are needed to attract new entrants and experienced people in (i) the private sector, and (ii) the public sector?

Note: the group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Education (curriculum)

1. Provide a career path combined and continuing education opportunities
2. Provide appropriate educational programs

3. Introduce IT/Geo component in university studies
4. Introduce in university programs the concept of data base
5. Geomatics education which covers the broad range of activities from data collection through to spatial-based decision support system
6. Broad education standards that allow people to change course
7. Geomatics and the definition thereof needs to be injected into most university and college curriculum
8. Let industry have more direct influence on academic programs
9. Increase IT system development education in university programs

Career path (certification etc)

1. A professional designation (i.e. Like OLS, P.Eng etc) should be associated with field so prospective employers and public at large will become aware of profession
2. Broad education standards that allow people to change course
3. Offer career opportunities and keep people marketable
4. Attractive careers with clear expanding futures
5. Challenging work environment that includes variety
6. Provide a career path combined and continuing education opportunities
7. Certification can tend to build barriers, especially if companies and agencies are looking for employees with a range of versatile backgrounds
8. A career path that demonstrates how people evolve through various levels (i.e. Technical and management)
9. Need to broadcast widely that there is a shortfall in potential employees. Give examples of companies that are needing people - what sorts of things they would be doing with the company, what sort of salaries they would attract. Basically a need to be proactive and sell the need to university students. They are looking for interesting and rewarding jobs.

Public Image

1. The 'geomatics' field, is an unknown, what would the rewards be in the field?
2. A professional designation (i.e. Like OLS, P.Eng etc) should be associated with field so prospective employers and public at large will become aware of profession
3. Recognition as a profession rather than a part of another profession
4. Industry needs to better market its capabilities to clients, particularly the general public
5. Make the image more attractive (get rid of the "tripod on the shoulder" stereotype)
6. Understanding of geomatics as a profession by the public
7. Need to give Geomatics a higher profile in the population at large. Perhaps we can discuss how this can be done?
8. Define geomatics so term is recognizable to public
9. Prof. Associations and future employers (government and industry) participate in job fairs and other forums to market Geomatics to secondary students
10. Get more geospatial content and tools on the Web. Make the connection between "Mapquest" and others with Geomatics
11. Promote through conferences and conventions (even not directly associated with geomatics)
12. Promote through other professional organizations such as Professional Engineers, Architects etc.

13. "grass roots" awareness of geomatics discipline at the high school level including the use and application of this technology in everyday business and life situations

Industry Structure / Business Model

1. Certification can tend to build barriers, especially if companies and agencies are looking for employees with a range of versatile backgrounds
2. Better link Geomatics to high growth areas (e.g. IT) in Academia and in Industry
3. Continue talking to the universities - plus the professional organizations that represent the different disciplines
4. We must come to terms with the potential for 'geomatics' as a much broader field than it currently represents to us. It really defines the industry more than the marketplace.
5. Move beyond proprietary geomatics architectures thereby increasing attractiveness to more pure IT professionals
6. Build applications (specifically Internet) with spatial component
7. Let the market demand define the structure of the geomatics industry and do not try to constrain the industry in an old business model.

Compensation (salaries, working conditions etc)

1. Be competitive in work conditions
2. Competitive compensation
3. Often adjust salary range to industry level

A.4.2.2 Does geomatics as a sector present an attractive image?

Note: the group was asked to vote on the six best ideas to improve the geomatics sector's image.

Total	
7	1. Focus on the results (applications) rather than the discipline of Geomatics
5	2. Position geomatics as a key component of many day-to-day business processes.
5	3. Awareness = demand; therefore should it be possible to have industry leaders (i.e. Ceos of AT&T, CN Rail, Petro Canada, General Motors etc. And Gov't officials (PM, Premiers, Deputy Ministers etc.) Talk about use of Geographical related data in making business decisions -- use periodicals like Business Week, Canadian Business, Harvard Business Review etc.
4	4. "grass roots" awareness of geomatics discipline at the high school level including the use and application of this technology in everyday business and life situations
4	5. Define geomatics so term is recognizable to public
4	6. Get more geospatial content and tools on the Web. Make the connection between "Mapquest" and others with Geomatics
3	7. Promote through conferences and conventions (even not directly associated with geomatics)
3	8. Sell the benefits of geomatics solutions to IT departments - get beyond the pure CAD/GIS audience.
3	9. Demonstrate the value of products produced by the industry

2 10. A professional designation (i.e. Like OLS, P.Eng etc) should be associated with field so prospective employers and public at large will become aware of profession

2 11. Build Internet applications with spatial component

2 12. Get successful companies in high tech area to recognize the importance of Geomatics

2 13. Publicize use of geomatics in news events such as floods, environmental issues, accidents etc. (all good news!)

1 14. Prof. Associations and future employers (government and industry) participate in job fairs and other forums to market Geomatics to secondary students

1 15. For web-mapping sites advertise "made possible by Geomatics"

1 16. Need to tie the work of the industry to the 'geomatics profession'

1 17. Strengthen physical geography programs with an emphasis on map creation and reading in the high schools

1 18. Associate Geomatics to IT and not to the traditional sciences (mapping, surveying, etc)

1 19. Spatial-enable government web-sites

1 20. Link with media publications such as Canadian Geographic to promote Geomatics

1 21. Establish spatial data exchange and distribution standards

0 23. Promote through other professional organizations such as Professional Engineers, Architects etc.

0 24. Advertising in the media - but an expensive proposition

0 25. Create technology standards with geomatics component (programming languages, data modeling)

A.4.3 Topic Two: Turnover and Retention

"Turnover and retention of staff is not at present a major issue in the geomatics sector. The increasing overlap of the sector's reach with the Information Communications Technologies (ICT) sector suggests that the issue will become more pressing in the future, reducing the ability of the sector to meet growing market demand for geomatics products and services."

A.4.3.1 What can be done to avoid serious people losses in the sector?

1. The industry will have to reinvent itself to provide better remuneration and opportunities / how does industry become more profitable?? How do we raise the demand for geo services? -> that would translate into higher salaries... How do we elevate the perceived value of geomatics products & services to the general public??

- Standardize on technology tools {#25}
- Continue to build awareness - general public needs to understand how Geomatics play a role in everyday life and how the application of geo-data is used {#27}
- Industry can best reinvent itself by answering market demand for products and services and looking beyond the current psychological constraints {#28}

- Governments should recognize the strategic aspect of the industry and the fact that benefits are both long term and often far downstream. This should translate to strategic disposition of contracts as in the geoconnections model. {#33}
- Geomatics solution providers have to sell the benefits to a larger audience. Only when a return on investment is seen by the user community will the value of geomatics products and services elevate. Prove that Geomatics in IT saves time, money and improves service. {#34}

2. Market Geomatics as IT services (e.g. Location IT)

- Integrate Geomatics into mainstream IT organization with specific projects {#16}
- Allow staff to explore, learn, and implement new GIS based services, e.g. Wireless location-based services. The 'newness' of technology such as this is attractive and will aid retention. {#23}
- Promote geomatics within organization {#37}
- Geomatics companies should market themselves to IT companies. It may lead to lack of autonomy or the potential for a take over - but that might be good for industry in the long run. {#44}

3. Partnership programs between industry / academia and government on specific projects / programs where each identifies a benefit and funds internally

- NRCan has the "Geomatics Professional Development Program" where new University graduates work on projects in government and in Industry getting practical skills and creating closer links between government. And Industry. Access to government labs and researchers by Industry can also be arranged. {#20}
- Industry / association projects through ITAC, URISA, GITA, AOLS, etc. {#31}
- Sounds like the Ontario "centres of excellence" model. Core funding is provided for projects submitted by university researchers, but the researchers have to be linked directly to industry and/or government. This is best done through cash, but in-kind contributions are also important. The centre that links most closely to Geomatics is the Centre for Research in Earth and Space Technologies (crestech). Another university/industry grouping is Geomatics for Informed Decision-Making (GEOIDE). This is one of the federal government-sponsored Networks of Centres of Excellence. {#35}

4. Provide links with progressive areas of organization

- Educate people in these progressive areas about geomatics.
- Ask where is the business problem and find how (if) geomatics can help {#38}

5. Integrate geomatics in business processes

- Illustrate how knowing spatial information can solve business problems or integrate diversified information by geography {#17}

- Within each business project team involve IT professional as a full member {#18}
- Standardize spatial data
- Create meta-data environment
- Use industry standard technologies when building business applications (Oracle Spatial)
- Make sure that data modelers and application architects understand Geomatics {#19}
- Identify and quantify the potential for geospatial applications in the business processes {#22}
- Provide web-mapping of business data {#24}
- Promote the advantages of geomatics to other professional associations who in turn can carry the messages to their members {#36}

6. Provide through an industry association a medium to encourage standards for education, compensation,etc

7. Define where or to what sectors people are being lost

   - Follow-up interviews with those people leaving business to determine type of employment, salary and reasons behind move {#21}
   - Exit questionnaire, follow-ups a year later to determine what real advantages there are, formal surveys {#30}

8. Accept certain movement as 'good for the industry'

   - Accept movement within an organization (move geomatics people to business units) {#29}
   - Compare turnaround to other high tech areas. Study the positive effect of getting "new blood". Establish a target (which is not 0%) and monitor. {#40}

9. Position geomatics as "the spatial component" of enterprise business solution. Make the sandbox within which geomatics professionals can play bigger.

   - "top down" involvement and support from the CEO office to illustrate importance of "spatial" information to the enterprise {#39}

10. Attempt to partner with other institutions to create broader, more attractive, business environment

    - Create flexible business networks that allow movement of personnel on a project basis {#15}
    - Large projects can be done in cooperation between companies rather then trying to attract people from other companies {#32}
    - Variety in assignments through association with other groups, industries, etc. Will improve the level of exposure and experience of geomatics staff. Learning and new experiences will lead to higher retention. {#41}

11. Market geomatics as a area open to migration with other business units.

  - The ability to provide/aid other business groups the data, or means to display their data to benefit their unit e.g. Marketing. {#26}

12. Industry needs to expose its IT professionals to the broader view of IT through association with their internal business units and how these groups use information to make decisions and support customers

  - Let the people go to business units {#42}

  - Marketing and sales organizations must involve and embrace the IT professionals of their business to help in the decision making process {#43}

A.4.3.2 How can geomatics align its human resource strategies with the ICT sector to take advantage of the migration of geospatial disciplines into the ICT sector?

Note: the group instead looked at approaches and strategies related to turnover and retention. The group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Professional Development & Training

1. Continuous training in the work environment - allowing IT and Geomatics professionals to cross train
2. Keep up with technology and offer training programs
3. Provide career path options and growth.
4. Offer training perks (non salary): incentives for skills upgrades etc.
5. Focus on in-house training so that the staff feel that they are continuing to work at the leading edge of Geomatics
6. Diverse employment opportunities-stimulating tasks.
7. Promote and support continuous learning. Keep staff marketable.
8. Identify geomatics professionals within an organization so that career paths becomes more visible
9. Continually train staff on IT technologies that complement geomatics.
10. Get people involved in the business, this will create a very interesting work environment
11. Offer opportunities to diversify. Keep the work interesting and challenging.
12. Provide educational opportunities that meet industry needs
13. Baby boomers on the way out. Provide management training and opportunities for on-the-job learning to the younger staff
14. Challenge staff to take more responsibility, e.g. Project management, technical architecture.

Business Environment / Industry Structure

1. Promote team work as the new generation is more loyal to their colleagues than to the organization.
2. The industry will have to reinvent itself to provide better remuneration and opportunities / how does industry become more profitable?? How do we raise the demand for geo services? -> that would translate into higher salaries... How do we elevate the perceived value of geomatics products & services to the general public??
3. Market Geomatics as IT services (e.g. Location IT)
4. Partnership programs between industry / academia and government on specific projects / programs where each identifies a benefit and funds internally
5. Provide links with progressive areas of organization
6. Integrate geomatics in business processes
7. Provide through an industry association a medium to encourage standards for education, compensation,etc
8. Define where or to what sectors people are being lost
9. Accept certain movement as 'good for the industry'
10. Position geomatics as "the spatial component" of enterprise business solution. Make the sandbox within which geomatics professionals can play bigger.
11. Attempt to partner with other institutions to create broader, more attractive, business environment
12. Market geomatics as a area open to migration with other business units.
13. Industry needs to expose its IT professionals to the broader view of IT through association with their internal business units and how these groups use information to make decisions and support customers

Formal Education Opportunities

1. MBA in Geomatics

Compensation / Career Paths

1. The industry will have to reinvent itself to provide better remuneration and opportunities
2. Keep salaries in sink with IT industry
3. Offer more ownership situations (employee owned "dot.com" type of arrangements)
4. Equity incentives to employees
5. Involve employees in some level of ownership of the companies. Provides both motivation to perform and stay.

Cultural Changes

1. Provide clear career growth paths within the sector
2. Promote the image of Geomatics
3. Promote team work as the new generation is more loyal to their colleagues than to the organization.

4. Develop a team approach to tasks so that staff learn from each other and feel part of a team with commitment to the company. This is likely to promote more loyalty than if staff tend to work in isolation.

A.4.4 Topic Three: Best Practices at Universities and Colleges

"Universities and colleges have been responding well to the changing skills demands of the geomatics sector. Keeping course content up-to-date, however, continues to be a challenge because of technology advances and new market requirements. Knowledge of application areas is in demand together with a base of geomatics skills."

A.4.4.1 What are best practices for universities and colleges to follow in ensuring that geomatics-related courses are meeting these sector requirements?

Note: the group was asked to vote for the seven most important best practices.

Total	
8	1. Coop/Internship programs // More and longer co-op programs
6	2. Innovative distance learning and other modern media mechanisms
4	3. The professions and the educational institutes need to design geomatics courses and degrees jointly
4	4. Greater Linkages between colleges & universities
4	5. Linkages between universities and high schools
3	6. More practical university programs with large load of practical projects sponsored by large organizations
3	7. Incorporate more industry specific knowledge into curriculum by somehow involving the private sector (more).
3	8. Need for networking between faculties (Informatics, engineering, geography) to offer degrees that are specialized
3	9. Through distant learning (video conferencing) and use of lecturers / graduates, visiting scholars from other geographical locations teach about regional differences
3	10. Greater private industry involvement. Specifically big vendors.
3	11. It is important to cover not only the technical aspects of GIS but also the management as well. University students will not want to be pushing buttons and programming for the rest of their lives. They will want to move into managerial positions.
3	12. Continuing education courses for industry
3	13. One Geomatics program with various specializations
2	14. Make it easier/appealing to hire faculty directly from industry (with leading edge industry knowledge)
2	15. Dividing university courses up into "1/4 or 1/2" weekend courses
2	16. Collaboration among educational institutions to teach smaller enrollment specialized courses
2	17. Industry must make commitments to coop programs which themselves must be designed for the specific industry

2	18. Get Industry and government leaders on faculty management boards to help design the curriculum
2	19. Associations working with universities (e.g. Survey law)
2	20. Schools and professions must be willing to eliminate out-of-date subjects to help make room for new programs
1	21. Identify market/labour niches "out there" and fill the gap
1	22. Consider specialization in the final years of a bachelor degree as well as at the post-grad level
1	23. Underlying foundation of core geomatics knowledge (i.e. Across all geomatics fields) is key to specialization and future growth opportunities for the individual
1	24. Geomatics information manager (Queens?)
1	25. Establish a stronger link between departments of geomatics and computer science.
1	26. Certificate programs for other non-Geomatics areas who use technology/applications
0	27. Greater linkages are OK p but as long as they are appropriate and not forced
0	28. GIS Certificate of Excellence (waterloo)
0	29. University and industry/professional association collaboration in practical education of students
0	30. We haven't talked about finances, but keeping hardware and software up-to-date is expensive. Perhaps linkages with universities and industry could help with this.
0	31. A restricted market in a vast country needs ways to get students into local university to get their training
0	32. Grant programs
0	33. Involve graduates on a regular basis in delivering course content to make information relevant

A.4.4.2 How can these institutions be at the leading edge of industry's needs?

Note: the Toronto group modified this sub-topic. They discussed instead: "How can these ideas be implemented?"

1. Coop/Internship programs // More and longer co-op programs

- 8 month co-op term required in order to obtain value for employer and student {#45}
- How about secondment from a business / government to a university for a 3-6 month term to share knowledge / work on project {#50}
- This is a win-win situation for the student and for industry. The student gets not only the theoretical aspects in university, but also the practical aspects when working with industry. For industry, it is a great opportunity to see how good a student is from a practical point of view and whether or not the student has ideas that can be of benefit to the company. {#51}
- Before anything can be accomplished nationally we need to provide a forum for debate that includes all interested universities and colleges, industry and a government champion. {#52}

- Provides student the feeling of actually gaining useful experience, the student can decide early on where they can direct their education {#58}

2. Innovative distance learning and other modern media mechanisms

- There are enough examples of distance learning that we can learn from. {#57}
- Distance learning is only suitable for a minority of students. Would need to work in processes that will allow the necessary socialization that facilitates training. If not, the drop-out rate will be high. {#68}
- The Canadian Council of Land Surveyors will soon issue a EOI to identify interest in providing such courses as survey law which are common to all Cdn jurisdictions by distance learning media {#82}

3. Greater private industry involvement. Specifically big vendors. // the professions and the educational institutes need to design geomatics courses and degrees jointly

- Industry gathering input from {#47}
- Why specifically vendors? Big - yes. {#63}

4. Greater Linkages between colleges & universities

- Minimize programs overlap {#43}
- Universities to prepare instructors for other institutions {#48}
- Look at the UNB/COGS model. {#65}
- Allows most of the practical training with the colleges while the universities can focus on the more academic and research side {#85}

5. Linkages between universities and high schools

- Establish pilot projects with selected high schools. Participate at high school career fairs. Conduct an industry mentor program. {#60}
- The earlier done the better - start in grade nine and continue - visiting lecturers can be university students who share their knowledge and make more relevant for the high school student (since age is not so great - pick 3rd, 4th year undergrads, tas) {#77}

6. More practical university programs with large load of practical projects sponsored by large organizations

- Environmental studies, data collection etc. Can be conducted as a summer job activities. {#54}
- If industry is willing to do this, that's great! {#56}
- Mentoring programs {#64}

7. Incorporate more industry specific knowledge into curriculum by somehow involving the private sector (more).

- Communicate the need through associations, conferences or other means of contact. Invite guest speakers/lecturers/instructors. Encourage realistic labs and assignments that involve and work with industry. {#53}
- Industry people to gave lectures to students. {#80}

8. Need for networking between faculties (Informatics, engineering, geography) to offer degrees that are specialized

- Computer courses should be mandatory for geography students, geography courses for computer science, engineering courses should include geography and computers as well {#66}
- Is it possible to reduce the element of competition between universities enough to get them to co-operate or even talking? {#70}
- Create a "virtual" faculty that will adapt to changing requirements. The program get built on existing courses and new specific ones. {#83}
- Educational programs can fill a niche market and collaborate to broaden the educational opportunities for students. Collaboration among educational institutes allow Universities to improve research opportunities and target larger research projects. {#86}

9. Through distant learning (video conferencing) and use of lecturers / graduates, visiting scholars from other geographical locations teach about regional differences

- Solicitation of past graduates with evaluation criteria; and what course content / business experience that needs to be shared, graduates would sign up at their expense to share their successes {#67}

10. It is important to cover not only the technical aspects of GIS but also the management as well. University students will not want to be pushing buttons and programming for the rest of their lives. They will want to move into managerial positions.

- It may be appropriate to screen students based on other factors than high school grades to determine that they have the required skills including the leadership that is necessary in management. Employers should work at defining a "statement of qualification" from which Universities could design the program and set their screening process. {#62}
- Management skills are needed in the industry but be careful of encouraging graduates that they will quickly occupy management positions. {#75}
- Provide some basic management and business course as part of the curriculum or offer continuing education courses designed for industry to students as well, perhaps at a reduced cost {#76}
- Provide some very high calibre advanced GI-specialized management programs. {#79}

11. Continuing education courses for industry

- Distance learning, on-line or video learning, weekend courses {#69}
- Companies should offer 1 day presentations to other companies to show what and how {#72}
- Universities must become more proactive in this - but it is difficult to do everything. Innovative ways of involving graduate students and hands-on approaches would be good. But what types of courses is industry wanting? Would it not be better for industry to provide in-house courses that are more limited in scope and geared towards their specific needs? {#73}
- Most surveying associations have some level of professional development, mandatory and voluntary. There is a market here if such courses can be made available nationally {#74}
- Visiting lecturers {#78}

12. One Geomatics program with various specializations

- Common and more general program initially, followed by more specialized courses which may be offered by other educational institutes. Offer many streams in the program to cover the broad Geomatics field. {#49}

A.4.4.3 Supplemental Question

Is certification a good idea?

1. Beyond satisfying regulatory and legal requirements certification is of little value. {#44}
2. Only if it is required by the employer and used as a pre-qualification process {#46}
3. As long as a standard is set and everyone understands and supports it - then okay {#55}
4. Certification provides a focus/sponsor/supporter for the field {#59}
5. Certification is mandatory for professions(engineers, surveyors) additional certification would benefit both employers as well as clients in providing a level of confidence. The Cdn Institute of Geomatics is proposing to provide some certification but in any case certification must be seen as independent and reliable {#61}
6. Certification as what???Will that certification provide an entry level person, the salary and advancement they may be seeking. {#71}
7. For GIS solution delivery, skills and experience outweigh certification. Although the most senior technical people in organizations tend to carry certification or advanced degrees these alone are not the prime characteristic for potential hires. {#81}
8. Certification formalizes knowledge in the particular topic {#84}
9. Certification of individuals or courses or programs? The Province evaluates all graduate programs every seven years and universities are now undertaking in-house "Self-Study" reviews to demonstrate to government that they are being accountable.

Given the proliferation of courses and programs, especially in GIS, some sort of quality control is perhaps going to be required in the near future. Industry cannot afford to find out that they made the wrong choice several months down the line. Perhaps a voluntary certification, as being offered by the Canadian Remote Sensing Society would be simplest to put into practice. {#87}

A.4.5 Topic Four: Skills Upgrading

"The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances."

A.4.5.1 What training gaps exist in the geomatics sector and how should they be filled?

Discussion Notes

- Core IT skills: relational db, internet development, systems eng'g methodology, project management
- Data modeling .... Oracle skills
- Microsoft development
- Systems development skills
- Business skills (we do this in house) interview savvy, communications stuff, etc.
- Career development ...career path counseling
- Client management
  People skills ... Creative thinking

Computer Input

1. Conferences and conventions should also be considered as training opportunity. Big vendors should organize more in heavy populated areas
2. Project life cycle (needs analysis to maintenance and everything in between)
3. Skills upgrade and training should be provided by the employer to align with business goals. Support by formal class training, CBT, on-line training.
4. Probably more important than employees realize. Where are you heading? Where do you want to be in five years? In 10 years?
5. Gaps evolve and each University is good in some areas and not so in others. Soft skills are often overlooked by employers when hiring but all agree that team skills, communication and leadership are essential. These are difficult to learn as they are not theoretical concepts.
6. Establish mentoring mechanism for junior staff.

A.4.5.2 What is the role of employers in providing on-the-job training?

Discussion Notes

- X-training opportunities, post-training internal presentations to colleagues, continuous learning, allocations in lieu of salaries, GPDP geomatics prof development programme, professional associations code of ethics make it mandatory to continue training, PA: mandatory payment as part of fees.

- Focus on shorter term courses.
- Formal programmes with leave of absence...
- On-site training rooms (autocad, etc) ...
- Private sector needs to train in core IT skills. ...
- Intense 1-2 week courses...night courses (but quite tough)...... Provide opportunities to immediately apply training (when employees return from training)...
- Encourage trainees to make contacts on courses (for future user networks, etc) ...
- Link training plan into annual performance planning process...
- Provide incentives...

Computer Input

1. The best company commit to a certain level of training (5% of salary / 10 days) that employees are entitled to.
2. Must provide training where legally required - health and safety issues, operation of equipment
3. Where a program or job changes in scope, then responsibility of employer to insure incumbent is trained to complete the task at hand
4. Employee training is a win-win situation. The work place becomes more attractive and the employees more skilled.
5. Should assist in professional development to ensure it's senior staff are meeting requirements
6. Employer is responsible to support, maintain and grow the skill base of all geomatics staff
7. Employers are usually kept abreast of industry trends, etc.. Through memberships, conferences, documentation. They must help keep employees aware of changes or opportunities for training; this would only benefit their depts.
8. Makes good business sense to ensure that services are up-to-date and at optimum efficiency
9. Conferences and conventions should also be considered as training opportunity. Big vendors should organize more in heavy populated areas
10. Cross-training and work in teams are important ways for employees to get on-the-job training.
11. Ensure staff have the time to commit to training. Emphasize importance.
12. In-house training the most efficient and cost-effective
13. Managers must be consistent with corporate goals and employee career aspirations. Not all employees need or want to move up ladder. Many are satisfied doing routine tasks which a corporation may need as well.

A.4.5.3 What are best practices in making use of online training opportunities?

Discussion Notes

- Canada lands is looking at this..
- Video conferencing, ...
- Courses that are the same throughout Canada (e.g. Legal surveys) lend themselves to be self sustaining online.

Computer Input

1. On line training has some limits and can only introduce to the topic. However, things like legal surveys, economics etc. Should be available on line
2. On-line training provides some opportunities to enhance technical skills but is hampered by a lack of structure, deadlines and interactions with other people.
3. This technology allows employees to maintain upgrading on their own schedule
4. Distance learning provides the same opportunities regardless of geographic location
5. On-line must include a process to get a discussion going, the sharing of experiences and team work. Teaching can't be one-way only. See-You-See-Me technology needs to be used so that the student does not feel isolated.
6. Cannot be done entirely in isolation. Need a mechanism for questions and feedback.

A.4.6 Workshop Participants

A.4.6.1 Participants

Laura Kingston, Ontario Ministry of Transport (Laura.Kingston@mto.gov.on.ca)

Jim Statham, Marshall Macklin Monaghan (Stathamj@mmm.ca)

Brian Cowan, Teranet (Bcowan@teranet.ca)

Phil Howarth, University of Waterloo (Howarth@watleo.uwaterloo.ca)

Francois Faucher, NRCan (Ffaucher@nrcan.gc.ca)

Andrew Lyszkiewicz, City of Toronto (Alyszkie@city.toronto.on.ca)

David Armstrong, Intergraph (Dharms@ingr.com)

Fay Patterson, AT&T (Fay.patterson@attcanada.com)

Bob Batterham, Management Consulting in Geomatics Inc. (rbat@fox.nstn.ca)

A.4.6.2 Observer

David Arthurs, HAL Corporation (darthurs@hal.ca)

Bob Batterham, HAL Corporation (rbat@fox.nstn.ca)

A.4.6.3 Facilitators

David Low, HAL Corporation (dlow@hal.ca)

Erik Lockhart, Queen's University Executive Decision Centre (lockhare@qsilver.queensu.ca)

A.4.7 Meeting Evaluation

A.4.7.1 What do you see as the key points and priorities in HR from today's discussion?

- Geomatics evolves at the same rate and in the same direction as IT. Must align very closely to it to keep pace and be seen as a related service warranting the same level of recognition. {#5}
- We must fill the IT skills gap that exists with geomatics professionals. {#6}
- There is a need for universities and colleges to be more responsive to the needs of the geomatics community. {#7}
- We need to provide a stimulating and continuous learning environment to attract and retain top geomatics talent. {#8}
- There is a dedicated group of people who would like to improve the situation within the Geomatics industry and get ready for a new challenges in the future. Training is available, but discussion should continue how to be more creative in training provision and lower the cost {#9}
- I think this study will provide a wealth of information on the industry. The industry (steering committee) must use this study to move forward with very specific programs to 'formalize geomatics as an industry. {#10}
- Geomatics is a broad interesting field of study. The technology used in Geomatics and skills sets are evolving. There is a need to develop University and other educational programs to meet these evolving needs. {#12}
- The Geomatics industry is relatively young in Canada and since many of the sciences have been amalgamated under this term "Geomatics", it is difficult for the general populous to know what it is and what it does. The image of the science or rather the business must continue to be improved. Continual training and development for those people in this profession is critical to insure Canada remains a leader in this discipline. {#13}
- Determining what geomatics is and where/how to certify and maintain knowledge base. {#14}
- The ideal Geomatics professional must be capable not only in an applications area, but also in IT.
- To-date the universities are doing a fairly good job of meeting the needs of employers within the Geomatics industry. Things are going to get tougher, however, in the next three to four years as the demand for Geomatics professionals increases. {#15}

- Much of the learning will occur after graduation. The employer and the associations have to be very supportive of this if they want to support growth of this discipline. {#17}
- Delivery and adoption of distance learning has to become second nature to academic institutions and the geomatics community. {#18}
- To compete for the best talent and minimize loss to non-geomatics sectors we must elevate the value that geomatics brings to the business environment. More value yields more revenue and correspondingly higher compensation. {#25}
- Each of us, industry, academic institutions and government all play a role in making Geomatics a mainstream profession. {#34}
- IT forms the foundation of Geomatics today with most applications of Geomatics employs some component of IT. Therefore insure that the basics of IT is incorporated into all educational programs associated with Geomatics. {#41}

A.4.7.2 Your most significant "takeaway" or learning from today for your organization?

- I'd like to keep communication lines open and hope that our professional organizations will follow with further discussion {#16}
- There is a lot of consensus among the participants in where Geomatics is heading. {#19}
- Their are exciting and rewarding jobs for the committed Geomatics student {#21}
- We must continue to share our ideas on how to develop this sector such that a spatial identity is linked to everything we do in business, at home and in the community. {#23}
- There is lots of opportunity in this expanding field of study.... And to see this new knowledge being applied throughout both the public and private sectors. {#26}
- This is a problem that concerns us all and we all deal with it in our own way. There are good practices out there and there is benefit in sharing them. However, we all believe that there is still major problems because it is a discipline that is not well defined and that is not understood (or recognized) by outsiders. {#29}
- Our experiences in hiring and retention (challenges) are not uncommon compared to other private and public agencies. {#31}
- There is almost full consensus on the issues dealt with. Hopefully it will be relatively easy to better define and organize the industry into 'creating itself' . {#35}
- Organizations must emphasize that strong management is necessary to take care of top performing geomatics professionals that are key to the business. {#37}
- The Canadian geomatics field is large, but will require the input of both industry and the education sector to keep participants educated and motivated. {#39}

A.4.7.3 Anything you would like to say that did NOT get said...

- Geomatics is multi-disciplinary. It requires the coming together of teams of specialists. From this perspective, being a generic Geomatics professional may be unrealistic and being good at it is unlikely. {#11}

- It would have been good to have more educators in the group today. A couple of students would also have been good. They have a unique perspective and frequently will express different opinions from the ones that others are putting forward. {#28}

- It would be very beneficial to obtain a copy of the report. Hopefully this report will be passed to higher levels of government and relevant private companies.

- Thanks for invitation, it is heart worming to know that geomatics is getting proper attention {#32}

- Geomatics experts need not be IT specialists but must be able to work in a team environment with the IT area. They need to become knowledgeable enough in the IT area to communicate with these resources. Geomatics is becoming part of IT of organizations but still requires its own specialized set of skills. {#38}

- Could you distribute a list of all participants in all workshops to help us all know who are comrades are across the country. {#40}

A.5 Calgary

A.5.1 Executive Summary and Notes

Ten participants and two observers attended the Calgary workshop. A focus of discussion was the benefit of increased collaboration at the university, college and post secondary levels in designing curricula that will provide a seamless transition through the educational process. Resources need to be dedicated to promoting geomatics in high schools through means such as a CD and brochures that could be used by guidance councilors in articulating career paths in geomatics. Best practices for universities and colleges include delivering bundled packages of skill sets, coop internship programs with the right amount of time in industry (eight months), and increased opportunities in distance learning. Jurisdiction-wide agreements with technology vendors could make current technology available to all students. Attracting and retaining employees was regarded as a challenge. Many suggestions were made for improving retention including sharing of ownership, flexible hours of work, and making new employees feel part of a team.

<u>Editor's Notes:</u>

- The symbol // indicates that two similar ideas have been merged together.

- This document contains the meeting proceedings.
- In some cases, comments are appended with a # such as "rapid changes in IT {#59}". The system attaches a sequential # to every item for reference purposes only.

A.5.2 Topic One: Shortfall of People

"The geomatics sector is expected to experience a shortfall of people over the next five years."

A.5.2.1 What actions/initiatives/conditions are needed to attract new entrants and experienced people in (i) the private sector, and (ii) the public sector?

Note: the group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Miscellaneous

1. I'm not sure I agree with the predicted shortfall; nature abhors a vacuum and new demand will be filled with new supply; this may not mean a resupply of people for diminishing disciplines

Education Curricula

1. When the post-secondary institutions are buying software investigate expanding some of the licensing rights to the K-12 system
2. Provide best in class training & education
3. Recognize that geomatics skills are frequently most valuable when combined with those of other disciplines. Therefore, both geomatics education and promotion of it should be in the context of the end results and the significance to employers or society generally. Results orientation.
4. Increase collaboration at the University and post-secondary level in designing curriculum that will provide a seamless transition through the educational process
5. Design curriculum and programs with a work placement component, partner with industry to accomplish this
6. Use the OOST program offered by U of C's Continuing Ed Faculty as a model in re-training university graduates in a new career direction in Geomatics.
7. Differentiate between the science of geomatics (i.e. Contribution to the core subjects comprising geomatics) and the application/use of the tools that apply geomatics.

Career Path

1. Use the OOST program offered by U of C's Continuing Ed Faculty as a model in re-training university graduates in a new career direction in Geomatics.
2. Help organizations advertise/recruit students from Laval and Nova Scotia University Geomatics Engineering programs.

3. Promotion of career paths in K-12 (secondary) education, through presentations, interactive CD's, career days, teacher education
4. Develop a event that target young women in high school to attend SAIT and Uof C and explore careers in the Geomatics /GIS
5. Sell the geomatics area of expertise to high schools and early years of post secondary education by planned outreach strategies.
6. Promote geomatics skills development as continuation education for related disciplines. Some of this is already occurring with the teaching of GIS to natural resource and planning disciplines.
7. Promote the availability of opportunities at all levels (technician, manager, professors) as part of career path

Public Image/Awareness

1. Beef and bun for students at universities etc
2. Issue with promotion: general public doesn't recognize the term "geomatics" - what do we use? Geographic information?
3. Develop a CD that could be distributed to High Schools to promote the industry
4. Improve relationship/interactions between prof associations and colleges/universities
5. Find some friends in the media who call clearly/simply articulate what GIS/Geomatics is and write about potential career paths
6. Introduce GIS and geomatics industry to career councilors so they can promote the industry
7. Geomatics or geography in general will become more attractive to people and is becoming so, largely because of the Internet and the affect that it is having on people. People see more geographical solutions connected to more day to day solutions.

Schools

1. Develop a CD that could be distributed to High Schools to promote the industry
2. Promotion of career paths in K-12 (secondary) education, through presentations, interactive CD's, career days, teacher education
3. Industry needs to promote Geomatics more in K to12, colleges etc
4. Move into elementary schools to promote also
5. Need to increase career path opportunities that school kids K-12 can relate to and see themselves being involved with over time; more along the line of information management and Internet Interoperability relating to geography.
6. Develop a CTS strand at the High school level in GIS or Geomatics
7. Build links and sense of community between K-12 and post-secondary, easy access to data, industry participation

Workplace/Industry

1. Find some friends in the media who call clearly/simply articulate what GIS/Geomatics is and write about potential career paths
2. Design curriculum and programs with a work placement component, partner with industry to accomplish this
3. Help organizations advertise/recruit students from Laval and Nova Scotia University Geomatics Engineering programs.

4. More job sharing / research /development opportunities as partnerships between educational institutions and the workplace
5. Mentoring programs in private sector
6. Demonstrations of post-secondary research and projects to industry, done here through a breakfast seminar and poster session sponsored by Alberta Geomatics Group (AGG)
7. The public sector in Alberta tends not to actively recruit in the geomatics area on campus. Hiring is more typically done thru bringing in geographers, foresters, biologists who also have GIS skills. They join teams of survey engineers and computing science grads. Contractors round out the teams.

A.5.2.2 Does geomatics as a sector present an attractive image?

Note: the group was asked to vote on the five best ideas to improve the geomatics sector's image.

Total	
4	1. Develop a CD that could be distributed to High Schools to promote the industry
4	2. Introduce GIS and geomatics industry to career councilors so they can promote the industry
4	3. On a provincial basis, work with education depts and schools toward actions in every school on days like ESRI's GIS day in Nov each year. Have ministers proclaim a GIS day.
4	4. Develop a easy to read graphic brochure that clearly articulates the career journey through a career in geomatics
3	5. Get involved in Great Canadian Geography challenge (gr 6-8)
3	6. Promote using technology such as internet which already has high profile and public appeal
3	7. More public information dissemination on valued geomatics applications like on-line 911 mapping.
2	8. Issue with promotion: general public doesn't recognize the term "geomatics" - what do we use? Geographic information?
2	9. Find some friends in the media who call clearly/simply articulate what GIS/Geomatics is and write about potential career paths
2	10. Use young people as the spokespersons to present a younger image
2	11. VARIOUS BROCHURES OUT TO PUBLIC
2	12. Articles about geomatics applications in mainstream media vehicles (Time/ Reader's Digest? The ENQUIRER?)
2	13. More emphasis on geomatics applications NOT the tools
2	14. HIGH SCHOOL CAREER DAY PARTICIPATION
2	15. Introduce a Geomatics project as one of the events at Skill Canada Competitions
1	16. Radio shows like CBC - interview people in the industry... How people can benefit from GIS
1	17. Find a dynamic champion who will do regular series of media pieces (radio, newspaper, TV etc)
1	18. There seems to a number of separate interests or groups all trying in their individual efforts to achieve the same goal in increasing public awareness about

the Geomatics sector Why not unite as one group (an Alliance Group) to further this effort?

1 19. Targeted marketing to people at decision points of their careers e.g. Grade 12, first year engineering, career days for associated educational areas ie. Forestry, biology, geography, computing science.

0 21. Beef and bun (and beer!) For students at universities etc

0 22. Improve relationship/interactions between prof associations and colleges/universities

0 23. Geomatics or geography in general will become more attractive to people and is becoming so, largely because of the Internet and the affect that it is having on people. People see more geographical solutions connected to more day to day solutions.

0 24. Need to offer more realistic, attractive salaries and career paths

0 25. Promote desirable career perks - travel,

0 26. Get interest of a political Champion to get geomatics in the news. I.e. John Manley in Ottawa

0 27. Find a geomatics "extreme sport"

A.5.3 Topic Two: Turnover and Retention

"Turnover and retention of staff is not at present a major issue in the geomatics sector. The increasing overlap of the sector's reach with the Information Communications Technologies (ICT) sector suggests that the issue will become more pressing in the future, reducing the ability of the sector to meet growing market demand for geomatics products and services."

A.5.3.1 What can be done to avoid serious people losses in the sector?

1. Creating a fun place to work, select new employees that fit the organization from personal prospective as well as functional.

    - Young people like to relate to others of their generation. Employ several young people if possible {#32}
    - Hire new staff on a contract or with a 3 to 4 month probation period to have the time to determine fit between the organization and person. {#33}
    - MAKE EMPLOYEES FEEL THAT THEY ARE PART OF THE TEAM {#34}
    - Give employees the opportunity to share their work with other employees by setting up info sessions. Provides peer satisfaction and breeds new thoughts. {#36}

2. Until recently sharing in ownership was a perk, now it is almost a given, especially for more senior staff who directly contribute to the bottom line of the company. All private enterprise needs to find ways to make employees feel that they both contribute to and are rewarded by the success of the firm.

- Don't "force" monetary ownership for junior employees. Allow feelings of ownership by letting junior employees represent the company at events/ talks/ think-tanks {#27}
- Advertise accomplishments of employees throughout the company (whether work related or not) {#30}

3. Setting up tools & systems to permit flex hours/arrangements to work at home

- Provide and pay for home access to office systems, let staff work at their own pace. Still has to me managed, setting and measuring of objectives {#21}

4. Cool environment (pizza days, flex dress etc)

- Join a softball league, company picnics {#19}
- "cool environments' are most often created by motivated employees and are most successful {#29}
- Have regular staff events at work "4pm wine tasting", "soup and slides" to allow a lunch-time "vacation" {#37}
- Dump out-of-date dress codes. Allow employees to wear comfortable clothing instead of suits if they are not involved in corporate contact (sales or external customers) etc. {#39}
- Bring guest speakers in for casual seminars {#40}

5. Promote Work/life balance through flex hours, time off for volunteer efforts, telecommuting, part time work arrangements, job-sharing.

- Promote a learning environment by encouraging time for training or time away from work to pursue other interests {#38}

6. Flexible benefits programs that recognize the differences in age demographics. What appeals to the 40+ may not be as appealing to the under 30 and vice versa.

- Develop an employee recognition or reward system where the employee can choose their gift or reward from a catalog or menu of gifts/prizes {#20}
- Institute a Health Spending Account to increase flexibility and choice in covering medical and dental costs. (This is done with pre-tax $$'s, another advantage). {#24}

7. Create strategies to meet psychological needs of affiliation, belonging, part of something...

- Events such as team sports, outdoor challenges, wilderness trips, etc that allow employees to interact as a team outside of the workplace. Employees should have major say in selecting the events. {#23}
- Allow mistakes. Reward risk-taking or innovative idea generation as well as results. {#28}

- Discourage managers from tearing down employees for their ideas, especially in front of others. {#31}

8. Job security

- No such thing {#15}
- Avoid downsizing if possible, or if it can't be avoided understand there may be residual effects for years to come. {#17}
- Ensure that employees understand that the ultimate responsibility for job security rests with them. {#22}

9. A shared and desirable company Vision & Values

10. Create a prized Teamwork environment where your skilled employees are challenged by each other

- Reward / celebrate team accomplishments {#26}

11. In all areas (gov/ind/academia) provide flexibility (work form home/flex hours)

- End the practice of time-sheets, and implement "accomplishment sheets" instead {#16}
- Home computers and high-speed connections for home {#18}
- Compressed work week, work slightly longer days in order to get a day off every 2 weeks or so {#25}
- Encourage education days off as part of multi year degree programs or adding a specialist course to a first degree. Work out on a case by case basis. Announce to the staff that this is organization policy. Tell them how many opportunities will be open each year. {#35}
- Allow sabbatical year to be built up e.g. Instead of overtime or stored vacation. May prevent someone leaving. {#41}

12. Encourage involvement in corporate sponsored events such as the Calgary Corporate Challenge or United Way campaigns, which foster team-work and friendly competition.

- Unless you are a very large firm this can involve a lot of time {#42}

A.5.3.2 How can geomatics align its human resource strategies with the ICT sector to take advantage of the migration of geospatial disciplines into the ICT sector?

Note: the group instead looked at approaches and strategies related to turnover and retention. The group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

HRM Practices

1. Where staff do have pension plans as opposed to RRSP accounts ensure that pension portability laws do not discourage movement.
2. Creating a fun place to work, select new employees that fit the organization from personal prospective as well as functional.
3. Beware of "one size fits all" solutions and fads. Most important is to understand the requirements of specific employees and then find mechanisms to satisfy those requirements.
4. Providing opportunities for staff to have input into the establishment of business plans, objectives and company direction.
5. Make an effort to demonstrate a career path which people can identify with that will make them consider staying with the employer for more than the next year or two. This may be difficult to do in smaller companies
6. Discourage restrictions to moving into different positions in the company, such as labeling employees as "too valuable at present position" or forcing employees to leave in order to advance.
7. Formal regular tracking of employees to ensure expectations of employee/employer are met
8. Invest strongly in employee development with sound HR strategies
9. Listen to exit interviews.
10. Some turnover isn't a bad thing -> new skills, new blood

Prof Development/Training

1. Lots of internal training opportunities
2. Provide the necessary training opportunities to develop management skills whereby the employee can expand their career beyond the technical occupations.
3. Provide our employees with secondments/exchange opportunities
4. Strongly promote MBA or other programs and have return to service agreements
5. To improve the business environment, provide managers with management training and skills
6. Paid education / life long learning
7. Develop university/workplace sharing by trading workplace mentoring opportunities in return for upgrade placements for existing employees
8. Promote and support professional development opportunities
9. Professional associations should work on building memberships and providing perceived benefits to members

Corp Culture/Environment

1. Creating a fun place to work, select new employees that fit the organization from personal prospective as well as functional.
2. Until recently sharing in ownership was a perk, now it is almost a given, especially for more senior staff who directly contribute to the bottom line of the company. All private enterprise needs to find ways to make employees feel that they both contribute to and are rewarded by the success of the firm.
3. Setting up tools & systems to permit flex hours/arrangements to work at home
4. Cool environment (pizza days, flex dress etc)

5. Promote Work/life balance through flex hours, time off for volunteer efforts, telecommuting, part time work arrangements, job-sharing.
6. Flexible benefits programs that recognize the differences in age demographics. What appeals to the 40+ may not be as appealing to the under 30 and vice versa.
7. Create strategies to meet psychological needs of affiliation, belonging, part of something...
8. Job security
9. A shared and desirable company Vision & Values
10. Create a prized Teamwork environment where your skilled employees are challenged by each other
11. In all areas (gov/ind/academia) provide flexibility (work form home/flex hours)
12. Encourage involvement in corporate sponsored events such as the Calgary Corporate Challenge or United Way campaigns, which foster team-work and friendly competition.

Compensation/Ownership

1. Until recently sharing in ownership was a perk, now it is almost a given, especially for more senior staff who directly contribute to the bottom line of the company. All private enterprise needs to find ways to make employees feel that they both contribute to and are rewarded by the success of the firm.
2. Ownership opportunities / Participate in equity
3. Monetary strategies: Higher salaries!
4. Provide stock options
5. Creation of employee owned companies (a la dot.com) where we attract and retain entrepreneurs who are committed to growth and like a little risk
6. Vesting schedules integrated into methods of compensation: stock option plans, bonuses, retirement funding plans etc.
7. Provide better related perks; scholarships for kids for valued employees
8. Universities and colleges have a problem attracting instructors/ professors. Academia can not provide the salaries for highly educated people that are a "given" in industry
9. Offer reward and recognition programs

Meaningful Work / Challenges

1. Constantly create challenging opportunities for new employees
2. Continue to provide variety, interesting, career changing work
3. Provide changing opportunities within the org on challenging projects
4. Provide supportive international opportunities for employees to grow new offshoots from the parent organization using and building on corporate IP

Public Policy

1. Reposition govt role to be a vehicle to develop specific technical skills and then place in private sector
2. Find ways for people to seamlessly move between private/public/academia without huge $/career risks. Easier said than done!
3. More funds from government to make academia an attractive career option

4. Reject the idea that ICT is a competitor. It is an alternative delivery mechanism to meet market demand. Then make sure you produce enough staff to meet the full Canadian requirement. Give the staff enough interesting work to stay.
5. Where staff do have pension plans as opposed to RRSP accounts ensure that pension portability laws do not discourage movement.

A.5.4 Topic Three: Best Practices at Universities and Colleges

"Universities and colleges have been responding well to the changing skills demands of the geomatics sector. Keeping course content up-to-date, however, continues to be a challenge because of technology advances and new market requirements. Knowledge of application areas is in demand together with a base of geomatics skills."

A.5.4.1 What are best practices for universities and colleges to follow in ensuring that geomatics-related courses are meeting these sector requirements?

Note: the group was asked to vote for the seven most important best practices.

Total	
8	1. Colleges & Universities deliver bundled packages of skill sets. What about specialty programs that last 1-3 weeks where people can update geomatics-related skills (e.g. A 5 day GIS course)
6	2. Coop Internship programs
5	3. Increase offerings of distance learning courses - e.g. Specific geomatics skills
4	4. Need an incentive for industry folks to come to teach at universities & colleges (e.g. Secondments)
4	5. On the job ongoing training relates to life long training, but educational institutions should give some thought to how they can provide ongoing life long learning. Something like subscription access to regular technical information updates, regular theses and research reports, etc.
4	6. Encourage industry to assist in providing subject matter experts for curriculum development or curriculum validation
4	7. Encourage student projects/theses to involve industry data or partnership
3	8. Better communications about courses/talks/etc. Across provincial geomatics associations (web site geomaticsgroup.ab.ca)
2	9. The costs associated with some of the equipment sometimes prohibits institutions from teaching leading edge technology. Equipment loans from industry would be helpful. Incentives to encourage industry to loan their equipment need to be developed
2	10. Refresher courses (life long learning)
2	11. Continue/increase dialogue between industry and colleges & universities re: gaps, needs
2	12. Weave soft skills into courses (e.g. Presentation skills, proposal writing etc)

2 13. From industry perspective, need to use a variety of approaches that best meet the specific need - one size doesn't fit all (e.g. Bring a prof in for a day to lecture... Send an employee on course... It depends!)

2 14. Negotiate jurisdiction-wide (all educational institutions) agreements with technology vendors to make current technology available to all students

2 15. Soft skill courses are plentiful and easy for an employer to send employee on. Apart from a need to be able to write a readable project report before applying for the first post-graduation job, there is no time in a degree course to push in extra courses and employers should recognize this reality.

2 16. Colleges & Universities should hire a person to research how industry sectors are using or want to use Geomatics products or service and then align training to match on a more timely basis. Two recent examples have the software vendors hiring someone to work specifically with clients and potential clients to determine where the business need and direction is to help them focus on the development of future enhancements or products.

2 17. Make Internship/Co-op programs more compatible (usable) for industry. It is simply too long a time to commit to an internship placement for 16 months for a company. Operationally, that too long for companies to commit too. Why not offer 8 month terms instead of 16 month or 12 month terms?

2 18. Easy access to/ communication about alternative educational sources (e.g. Most suitable course might be in Denver)

1 19. Exchange program (employee goes to teach and faculty goes to work in company)

1 20. Industry vendor training

1 21. Bring practitioners/advisory committee in and go thru and exercise to go through all key skill sets to do job. Have them identify objectives within each skill set. Develop curriculum based on this.

1 22. Need to streamline how colleges/universities respond to industry demands. Lots of bureaucracy/lag time in developing curriculum

1 23. Industry actively providing data, financial support in exchange for student labour on projects

1 24. Professional Associations can also provide supplementary soft skills courses...

1 25. Joint geomatics degree programs between SAIT & uofc (a la Bach of Communications)

1 26. Increase partnerships with industry for placements and work experiences.

1 27. Industry more active in academic projects / student advisors, mentors

1 28. Need more on-line technical skill specific courses

1 29. ITDO: Innovation technology development office at SAIT. X-dept office

0 30. Ditto 28 (costs of equipment) software maintenance and keeping up with new versions / upgrades also prohibits "leading edge technology" teaching

0 31. It is possible for industry to provide input into such classification coding systems such as NOCS (National Occupational Classification System) where new skills and education requirements are reflected. This is at the occupational level however and not all Geomatics occupations fall neatly into this coding system.

0 32. Build Entrepreneurship courses into geomatics curriculum

0 33. Academic staff offering "short-courses"

0	34. How to attract more Research contracts $ -> grad students get experience -> job creation etc.
0	35. Topic 3: Best Practices at Universities & Colleges (Categorizer)
0	36. Need to improve interaction between Saskatchewan industry and educational institutions outside of Saskatchewan
0	37. SAIT offers weekend certificate programs (offered in GIS skill sets)
0	38. Niche courses that may not "fit" within academic curricula (e.g. Proposal writing, how to respond to rfps etc)
0	39. Schools offer free courses to come in and teach (quid pro quo and tax break for company??)

A.5.4.2 How can these institutions be at the leading edge of industry's needs?

Note: the Calgary group modified this sub-topic. They discussed instead: "How can these ideas be implemented?"

1. Colleges & Universities deliver bundled packages of skill sets. What about specialty programs that last 1-3 weeks where people can update geomatics-related skills (e.g. A 5 day GIS course)

   - The university is offering more "block week" classes - classes held in the week prior to the start of each semester, which is equivalent of a semester long course. Industry members can register as an unclassified student. E.g. Environmental decision support course held the first week of January U of C {#58}
   - Industry can contact the educational institutions who can take their courses and customize sessions specifically designed to meet industries needs {#67}
   - Things like theoretical concepts of GIS to help improve the skill level of GIS operators who may have already become adept at using vendor software. Same goes for remote sensing. Courses could be set up in various levels of from 2-4 weeks each ; on-line preferred with perhaps a 3 day on site follow-up. {#69}

2. Coop Internship programs

   - Make Internship/Co-op programs more compatible (usable) for industry. It is simply too long a time to commit to an internship placement for 16 months for a company. Operationally, that too long for companies to commit too. Why not offer 8 month terms instead of 16 month or 12 month terms? {#36}
   - Have internship included as a requirement or at least an option in government procurements to provide incentives for companies to seek out interns. Government contracts that include interns should likewise allow provisions that did not penalize the company for including the intern. {#48}
   - Great idea, have to be supported by industry with meaningful experiences that enhances the learning objectives {#68}

3. Increase offerings of distance learning courses - e.g. Specific geomatics skills

- On line development is very expensive. Institutions, government, and industry need to collaborate on this development. Business cases can be made for significant savings in not having individuals attend on site training sessions. This becomes a business proposition. {#49}
- There are already several well established distance learning programs for geomatics/GIS e.g. UNIGIS. Better to support these than to create new competing program. {#53}
- Try and find institutions where the infrastructure is in place already and add geomatics training to that delivery method. This requires a coordinated approach by industry stakeholders. {#54}
- Alberta is enhancing high speed networks to rural communities. This means distance learning using relatively heavy spatial data sets for student GIS projects will be made practical. Are the centres of learning in the two big cities planning to take advantage of this? {#59}
- Webct is a good vehicle to conduct these courses. Will be used as a communication tool for the GIS community at U of C {#61}

4. Need an incentive for industry folks to come to teach at universities & colleges (e.g. Secondments) // Encourage industry to assist in providing subject matter experts for curriculum development or curriculum validation

- Need a government policy to support and encourage industry to get involved in this. At present industry specialists have no incentive for doing this. They are in some cases penalized by having to receive less pay, step down from their current position. This practice should also encourage international exchanges with other institutions. {#55}
- It can be expensive and difficult for private industry to offer an employee to an educational institution for the purposes of adding another dimension to post-secondary training. The company may not be entirely too altruistic in this regard, so you may have to think about how to compensate companies for this actual time and opportunity cost. {#62}
- F the leading expertise is often developed in the workplace. Encourage industry to assist institutions in developing new curriculum by providing subject matter experts. Technical writers at the institutions can take the expertise and develop curriculum. On line curriculum can then be developed {#63}

5. Encourage student projects/theses to involve industry data or partnership

- This would work best in connection with a co-op session or internship program where a student can start on something at the industry location and then complete as a thesis upon his return to university; both win. {#57}
- Some of this is already occurring with employees completing their master's degrees where their thesis is based on a current work project. Once again, both the company and employee/student benefit. {#70}

6. Better communications about courses/talks/etc. Across provincial geomatics associations (web site geomaticsgroup.ab.ca)

    - It is critical to allow employees access to their own development, so access should be offered at the individual level, not just to the organizations or institutions. {#51}
    - Share best practices so that organizations are not re-inventing the same materials and ideas {#64}

7. The costs associated with some of the equipment sometimes prohibits institutions from teaching leading edge technology. Equipment loans from industry would be helpful. Incentives to encourage industry to loan their equipment need to be developed

    - Even when non-useful (non-useful for universities. Or business) equipment is donated, it often supports obtaining matching funds through granting agencies (i.e. The agency will match what the university has been able to bring in on its own). {#50}
    - Incentives should be allowed for companies to lend equipment to institutions. Technical expertise and support should also be encouraged {#60}

8. Continue/increase dialogue between industry and colleges & universities re: gaps, needs, what courses etc // Colleges & Universities should hire a person to research how industry sectors are using or want to use Geomatics products or service and then align training to match on a more timely basis. Two recent examples have the software vendors hiring someone to work specifically with clients and potential clients to determine where the business need and direction is to help them focus on the development of future enhancements or products.

    - Steering committees have been created to "hear' what industry wants. Funds would not be available for hiring a specific "industry watch" person, although that can be part of the mandate of manager...again, a problem with academia. Having said that, programs do have a more "client-based" approach, with a more professional approach and responsiveness than in the past. {#66}

9. Negotiate jurisdiction-wide (all educational institutions) agreements with technology vendors to make current technology available to all students

    - Include educational institutions in government procurement to lessen cost impact on education and standardize technology. Ensure that program includes basis for supporting educational technology. {#56}
    - Government often negotiates provincial site license for technology to reduce unit costs and make technology available to all government agencies. However, such site licenses rarely if ever, include educational institutions. {#65}
    - Cost of software is a huge issue, {#71}

A.5.4.3 Supplemental Question

Is certification a good idea?

- good source is Bob Mahyer.
- No. There are enough prof designations out there already (eng'g, survey, forester, planner etc)...
- No. Geomatics has such a broad definition that have difficult to articulate boundaries. Too many "sub-disciplines" within
- Geomatics ... Smorgasbord of disciplines
- it has created problems in colleges also - to meet some national accreditation program sometimes conflict with what
- Industry advisory council is telling us to create.
- need to distinguish between certification (individual) vs. Accreditation (institutions) vs. Quality standards (ISO)
- could certify people within the quality standards
- being a graduate of accredited program becomes a certification in itself.
- accounting analogy. Cga, cma, etc. {#52}

A.5.5 Topic Four: Skills Upgrading

"The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances."

A.5.5.1 What training gaps exist in the geomatics sector and how should they be filled?

- Ongoing requirement for new skills... Persistent problem.
- Usually training is to fill a very specific skill (e.g. A new hire needs training in some software) e.g. SME software
- On each job, we build in time for tools-specific training
- General understanding of land information systems... Legislative & procedural framework re: lands. Cadaster, titling, planning legislation, permits etc.
- We tend to hire the people with the hard skills (get the programmer and teach them the other skills)
- Specialist systems design training in Canada (e.g. DEC, geomatics software, etc.)
- Online training courses
- Partnerships between educators and vendors... Beta product development participation
- Train the trainer situations
- Tools-specific training is a dangerous area for educators to get into... Teaching someone WORD doesn't make them an author.... We should be teaching people how to become novelists and let employer teach them how to use tools.
- Business analysis skills: e.g. Experience in oil & gas sector
- Very difficult to find someone who has "all" the skills ...
- SKILLS gaps: communications skills, writing, speaking etc.

- Recent emphasis has been on hard skills (at the expense of softer skills)

A.5.5.2 What is the role of employers in providing on-the-job training?

- Tools-specific training
- Surveyor Association: Getting it right
- Need to drive home to employees the need for on the job training so they will look for opportunities
- Need to create the appropriate corporate culture so that training is seen as a win-win
- Corporate & individual interests need to be aligned so that employee is enthusiastic and training meets goals of corporation
- Lots of $ spent on training. ... Retention issue
- Accountability and performance plans partly based on written learning plans
- Training budget 4-5% in industry and 3% in govt
- Land surveyor: change in govt legislation causes necessity of reach land surveyor to communicate down the chain

A.5.5.3 What are best practices in making use of online training opportunities?

- Discrepancy between demand for greater online training vs. More soft skills
- One way on-line tutorials don't work
- There are some excellent online courses: UNIGIS (SFU) and ESRI
- Online courses take a lot of concentration and focus
- Motivation & time: a problem with online
- Difficulty in evaluation with online courses
- Surveyors: we did an interactive video conference with uofc. Worked very well.
- Technology constraints...
- Credibility of content issue: accreditation problem with online training.
- On line development is very expensive. Institutions, government, and industry need to collaborate on this development. Business cases can be made for significant savings in not having individuals attend on site training sessions. This becomes a business proposition. {#49}
- There are already several well established distance learning programs for geomatics/GIS e.g. UNIGIS. Better to support these than to create new competing program. {#53}
- Try and find institutions where the infrastructure is in place already and add geomatics training to that delivery method. This requires a coordinated approach by industry stakeholders. {#54}
- Alberta is enhancing high speed networks to rural communities. This means distance learning using relatively heavy spatial data sets for student GIS projects will be made practical. Are the centres of learning in the two big cities planning to take advantage of this? {#59}
- Webct is a good vehicle to conduct these courses. Will be used as a communication tool for the GIS community at U of C {#61}

A.5.6 Workshop Participants

A.5.6.1 Participants

Larry Rosia, Southern Alberta Institute of Technology (Larry.rosia@sait.ab.ca)

John Potter, Saskatchewan Government (John.potter@isc-online.ca)

Sharon Ogilvie, Novatel Inc. (Sogilvie@novatel.ca)

Don Jaques, ALSA (Djaques@umagroup.com)

Mike Toomey, Alberta Government (Mike.toomey@gov.ab.ca)

Jim Huff, Telus (jim.huff@telus.com)

Lynn Moorman, University of Calgary (Lmoorman@ucalgary.ca)

Allan Levinsohn, AG Levinsohn Consulting (A_g_levinsohn@agt.net)

Phil Mickle, HRDC (phil.mickle@spg.org)

Paul Lepper, Cquay (paul.lepper@cquay.com)

A.5.6.2 Observers

David Arthurs, HAL Corporation (darthurs@hal.ca)

Bob Batterham, HAL Corporation (rbat@fox.nstn.ca)

A.5.6.3 Facilitators

David Low, HAL Corporation (dlow@hal.ca)

Erik Lockhart, Queen's University Executive Decision Centre (lockhare@qsilver.queensu.ca)

A.5.7 Meeting Evaluation

A.5.7.1 What do you see as the key points and priorities in HR from today's discussion?

- Retention
- Partnership between education and industry {#45}
- Reinforced some of my concepts in geomatics training and ongoing development {#46}

- See increase need for partnerships between universities and industry on training and joint research {#47}
- Important to dedicate resources to promoting geomatics in the school systems across the country {#48}
- EDUCATION WHERE ARE WE HEADED IN THE FUTURE? {#50}
- Building and retention of excellent teaching staff in the subject area is a continuing challenge. Canada has done well here. {#52}
- Partnerships among the educational institutions, industry and government
- Promotion and education increased awareness of the geomatics sector and the opportunities that exist for new entrants
- Opportunity to provide life-long learning
- Seamless design in career paths and educational paths from K-12 to colleges, post-secondary technical institutions and university {#54}
- Need more interaction with industry / academia , partner on projects, develop curriculum {#55}
- Have academia provide more learning opportunities for industry {#56}

A.5.7.2 Your most significant "takeaway" or learning from today for your organization?

- FANTASTIC EXCHANGE OF INFORMATION {#53}
- Good counterpoint to the day job. Contributed to the continuous learning. {#58}
- Look at more industry involvement in program {#59}
- Look for opportunities to provide "short course" training {#60}
- I was impressed by the apparent willingness by all parties from all sectors to collaborate on human resource development issues. I am more optimistic now for the results and impact of this study. {#66}

A.5.7.3 Anything you would like to say that did NOT get said...

- No. Good facilitation & methodology. {#61}
- Was said, but not recorded - the idea of having significantly reduced fees for educators/students for conferences to promote interaction and networking with industry {#63}

- Increased scholarships would promote geomatics! {#64}

A.6 Vancouver

A.6.1 Executive Summary and Notes

The workshop in Vancouver was attended by six participants and two observers. A major concern was the difficulty of obtaining continuing education in geomatics. Professional associations have a role in providing such opportunities but have not so far responded. Much could be learned from developments in distance learning in the universities and colleges; for example, BCIT is changing from a physical campus to a virtual campus. The problem of upgrading skills was compounded by the generally small size of the companies in geomatics and the fact that small companies do not have the resources for training. Another key concern was that until geomatics could be better defined as a profession, there was little likelihood of the industry or professional associations being able to focus on substantial internal development. A public awareness initiative is needed by industry and government to inform Canadians of how geomatics improves our world.

Editor's Notes:

- The symbol // indicates that two similar ideas have been merged together.
- This document contains the meeting proceedings.
- In some cases, comments are appended with a # such as "rapid changes in IT {#59}". The system attaches a sequential # to every item for reference purposes only.

A.6.2 Topic One: Shortfall of People

"The geomatics sector is expected to experience a shortfall of people over the next five years."

A.6.2.1 What actions/initiatives/conditions are needed to attract new entrants and experienced people in (i) the private sector, and (ii) the public sector?

Discussion Notes

- An increase of 10,000 people in geomatics over the next five years is optimistic.
- There is a need to clearly distinguish between data collectors who disseminate information vs those people who add value to existing data vs users.
- The use of geomatics tools will increase but the number of employees in geomatics will not.
- "Spatial isn't special - another couple of columns in Oracle database."

Computer Input

Note: the group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Schools ...K-12

1. Promote in high schools - beginning in eighth grade geography courses
2. Make some relevant, really easy to administer geographics projects available on the WWW, using Canadian data, for students in elementary or high schools. The critical point here is that the teacher would not have to install or administer any software or data to their school's computer systems.
3. Introduce geomatics and related technology to career counselors in schools
4. Bring more computers and IT into high school geography courses, to show the power of using computers to 'manage spatial entitlement' - good phrase, Hans - in a way that's important to society. Show how it can be used to address unfairness, or settle disputes.

Education Curricula

1. Create an undergrad Computing Science course in geospatial concepts, equivalent to an 'Introduction to Databases' course.
2. Develop a relationship with Universities/Colleges that have the courses/programs where your company would want to hire graduates.
3. This would introduce IT professionals to the field of geomatics.
4. Think outside of the box in the recruitment process. I.e. Soft skills, attitude
5. Create faculties at educational institutions that are not subservient to a more formal discipline i.e.: engineering , but rather are focused on producing the perfect HR. For this emerging industry
6. Be prepared to help education ministries teach the fundamentals at an early stage. Until now, geography has not been an important part of system and has been quickly reduced due to budget cuts. Bring it into the main stream

Image/Awareness

1. Government can be an educator. This should be added to its mandate of as a long term support to the industry.
2. Introduce geomatics and related technology to career counselors in schools
3. Communicating to 5 year olds thru Barney the meaning & importance of Geomatics!
4. Career Days at Universities - presentation by professional on what is a ...
5. Find some media friends who can spell out what geomatics is all about
6. The sector must show the importance and practicality of geomatics to other domains. How it touches many facets of our world.
7. Conduct talks at computer science depts/community colleges - speakers series etc.
8. Support 'GIS Day' (www.gisday.comm I believe, or check the ESRI website) in November. This is an opportunity for people from across society, but especially high school and University students, to be introduced to GIS and spatial information. There was a good one in Victoria in 1999, put together by volunteers in the business. No-one picked up the idea in 2000.
9. Use the internet as a tool to attract new applicants i.e. The features and benefits to working for

your company.
10. Drop the name 'geomatics'.. To a high school student, it sounds like something from the 60's. How about 'geography', a good Greek word with roots in our culture.
11. Public awareness initiative by industry and by governments in order to improve the apparent value to society of the workers in this industry

Access to data

1. Make some relevant, really easy to administer geographics projects available on the WWW, using Canadian data, for students in elementary or high schools. The critical point here is that the teacher would not have to install or administer any software or data to their school's computer systems.
2. Reduce the difficulty...cost in getting access to what is thought to be public domain geospatial data ...this will increase the apparent need for participants as users invent new applications
3. I fully support #14 ("reduce the difficulty...").. It is a huge barrier for Canadian teachers to get at detailed data (the neighborhood around the school) useful in a grade school class. "Professional" identification

Industry Structure

1. Determine what the individual needs of each sector are in order to identify a separate strategy for each
2. Government can be an educator. This should be added to its mandate of as a long term support to the industry.

A.6.2.2 Does geomatics as a sector present an attractive image?

Note: the group was asked to vote on the five best ideas to improve the geomatics sector's image.

Total	
3	1. Come up with a clear definition/message of what we do and how it is used in all walks of life
3	2. Introduce geomatics and related technology to career counselors in schools
2	3. Career Days at Universities - presentation by professional on what is a ...
2	4. Get out there and tell people why our professionals are important to society - go look in other countries to see how they have done it
2	5. Bring more computers and IT into high school geography courses, to show the power of using computers to 'manage spatial entitlement' - good phrase, Hans - in a way that's important to society. Show how it can be used to address unfairness, or settle disputes.
2	6. Look at what other professions have done (docs, lawyers etc) to improve their image...
2	7. Public awareness initiative by industry and by governments in order to improve the apparent value to society of the workers in this industry
2	8. The sector must show the importance and practicality of geomatics to other domains. How it touches many facets of our world.
1	9. Communicating to 5 year olds thru Barney the meaning & importance of

Geomatics!

1 10. Conduct talks at computer science depts/community colleges - speakers series etc.

1 11. Find some media friends who can spell out what geomatics is all about

1 12. Is this really such a problem ? If people contribute a lot to society or business, generally their pay levels will reflect it. Perhaps when AT&T's business really requires spatial awareness, the people managing it will become important and well paid.

1 13. Look at other international examples. I.e. OS etc.

1 14. Make some relevant, really easy to administer geographics projects available on the WWW, using Canadian data, for students in elementary or high schools. The critical point here is that the teacher would not have to install or administer any software or data to their school's computer systems.

1 15. Promote in high schools - beginning in eighth grade geography courses

1 16. Prove that what we do is important to society through education, increased public profile and lobbying for government leadership

1 17. Start spatial awareness in schools at the earliest levels

1 18. Support 'GIS Day' (www.gisday.comm I believe, or check the ESRI website) in November. This is an opportunity for people from across society, but especially high school and University students, to be introduced to GIS and spatial information. There was a good one in Victoria in 1999, put together by volunteers in the business. No-one picked up the idea in 2000.

1 19. Use the internet as a tool to attract new applicants i.e. The features and benefits to working for your company.

0 21. Drop the name 'geomatics'.. To a high school student, it sounds like something from the 60's. How about 'geography', a good Greek word with roots in our culture.

0 22. Emphasize the 'high tech' component of the geomatics business.. This is currently in favour within society. However, this is a risky thing to do, because 'high tech' may not be in fashion in a decade or two.

0 23. Government can be an educator. This should be added to its mandate of as a long term support to the industry.

0 24. Seriously think about a more understandable name for the industry

A.6.3 Topic Two: Turnover and Retention

"Turnover and retention of staff is not at present a major issue in the geomatics sector. The increasing overlap of the sector's reach with the Information Communications Technologies (ICT) sector suggests that the issue will become more pressing in the future, reducing the ability of the sector to meet growing market demand for geomatics products and services."

A.6.3.1 What can be done to avoid serious people losses in the sector?

Note: the group instead looked at approaches and strategies related to turnover and retention. The group brainstormed ideas and then categorized the ideas into several themes (appearing in bold)

Miscellaneous

1. Comes back to definition - geomatics is undefined. There is no geomatics box
2. We need to establish why people are coming to our industry ...if it was just because they had no particular place to go and chose us as a last resort ...then its not surprising that they might leave when they found out what we do....keep in mind that geomatics has traditionally been a transient occupation ...perhaps the turn over is the same as it has always been
3. I'm not yet convinced that this is really a problem.

Prof Development/Training

1. We need to teach people to be "technology managers". Exporting our expertise - we can only sell our "managers"
2. Introduce technology management courses in post secondary institutions
3. Government could set up exchange programs with industry. This will offer workers new challenges and better cooperation. Employees will be given a broader experience.

Compensation/Ownership

1. Salary problems in geomatics relative to IT careers
2. Use alternative ways to incent people other than straight salary
3. Offer equity ownership to employees so they have a reason to stay
4. Where justified by the work they are doing, recognize geomatics workers with the benefits and status currently given to IT workers.
5. An increase in international work will keep a certain percentage of workers in the sector.
6. Ensure that compensation strategies are in line or above industry. This will depend on budget constraints.

HRM Practices

1. As geomatics becomes more integrated with other IT work, exchange of people between the two will increase.
2. Exit Interviews to get better data on reasons for leaving
3. Maintain long term connections with former employees - after a while, respect & cultural things become more important than $
4. Keep track of where your employees are going and what they will be doing.
5. Company's should develop policy/strategy aimed at retention i.e. Training and development, flexible work weeks.
6. Invest in your employee's. Create a "happy" work environment.
7. Co-op programs give University students a realistic way to determine whether they like the field. This should reduce the loss rate in the first couple of years after graduation, of students who move on because they don't get what they expect.

Cultural Changes

1. Need to work on improving respect of geomatics professionals
2. Geomatics industry is concentrated in large centres - big cities (some people are looking for quality of life -- in smaller communities) ... Are clusters important?

3. Give research and development a larger percentage of budgets to keep the brightest interested in staying home

Career Paths

1. We need to teach people to be "technology managers". Exporting our expertise - we can only sell our "managers"
2. All professions have turnover - expected career span in years is longer but people are making more choices/changes/career switches
3. As geomatics becomes more integrated with other IT work, exchange of people between the two will increase.

A.6.3.2 How can geomatics align its human resource strategies with the ICT sector to take advantage of the migration of geospatial disciplines into the ICT sector?

Note: the group did not discuss this topic as such. See previous section (section A.6.3.1) to view their comments on the retention issue.

A.6.4 Topic Three: Best Practices at Universities and Colleges

"Universities and colleges have been responding well to the changing skills demands of the geomatics sector. Keeping course content up-to-date, however, continues to be a challenge because of technology advances and new market requirements. Knowledge of application areas is in demand together with a base of geomatics skills."

A.6.4.1 What are best practices for universities and colleges to follow in ensuring that geomatics-related courses are meeting these sector requirements?

Note: the group was asked to vote for the seven most important best practices.

Total	
5	1. Ensure that tech colleges & universities are talking to each other so that most effective transition can occur (e.g. Btwn sait and uof calgary or COGS and UNB)
4	2. Coop Programmes
4	3. Need more training in communications skills (written & oral) - few people have both technical & soft skills
4	4. Better utilization of industry resources as sessional instructors, guest speakers etc
3	5. Need more business content in geomatics program (finance, capital costing etc)
3	6. Encourage universities to create more of a geomatics identity rather than simply include in program streams in science (geography, statistics, etc) programs
2	7. Encourage universities to attract additional funds from, for example, NSERC, industry etc to provide scholarships, research grants etc. More focused on the Canadian "geomatics industry" needs, particularly those centres on the more traditional practice of professional land surveying.
2	8. Universities should focus on what exactly the Canadian geomatics field needs

so that we are not producing geomatics grads who leave the country

2 9. All sectors must work together to keep programmes relevant. (gov't, academia, private sector)

2 10. Better background in computing science (db design, programming course etc)

2 11. Don't lose sight of a University as a place to teach citizenship, history, and a sense of culture. Don't confuse it with a technical school.

2 12. Need to revisit funding mechanisms in universities - r&d funds drive universities. Education goes where $ is (researcher who attracts big R&D funds is most important)

1 13. Universities need to stay in touch with prof. Associations

1 14. Industry needs to lobby the universities on opportunities in the Canadian geomatics industry

1 15. Provide students with GIS capability with a broader outlook as well... How geomatics can be used for land use decisions, resource stewardship, allocating scarce land. T

1 16. Use Advisory Boards (to get industry input on curricula content)

0 17. Educational institutions need to be more realistic in the promotion of professional designation to their graduates

0 18. Joint degrees between colleges and universities

0 19. Reciprocal agreements between academic community and private sector

0 20. In the second or third year work with companies so that students know what jobs are out there and what the possibilities are of their degree are. This will help in the planning for the soft skills that go with that job.

0 21. Need to determine the needs of small geomatics companies. Don't know how!

0 22. Universal language capabilities (French, Spanish, Italian etc)

0 23. Need to expand curriculum so that it is attract to import geomatics workers

0 24. Make whole faculties based on geomatics (rather than a sub category of engineering) - see Laval example.

0 26. Case studies that reflect real world situations

0 27. Universities need to find a way to convince people to stay in Canada once they have graduated

0 28. Uof C changed name of Programme to something more appealing (Geomatics)

A.6.4.2 How can these institutions be at the leading edge of industry's needs?

Note: the Calgary group modified this sub-topic. They discussed instead: "How can these ideas be implemented?"

1. Ensure that tech colleges & universities are talking to each other so that most effective transition can occur (e.g. Btwn sait and uof calgary or COGS and UNB)

2. Coop Programmes

- Simply provide more funding for Co-Op coordinators at the Universities. {#40}
- As a company you have to keep the lines of communication open with the University programs where you wish to have students. Target the Institutions and then work with them to "market" your organization. {#43}

- Assist Co-Op coordinators to coordinate efforts between them, so that students from different Universities can be hired through a central 'pool' of jobs, advertised across multiple institutions. {#44}
- Educate first-year students about the Co-Op program and its benefits. Some don't hear about it until third year. {#46}

3. Need more training in Complementary Skills
   - communications skills (written & oral) - few people have both technical & soft skills
   - Business skills

- Need more business content in geomatics program (finance, capital costing etc) {#12}
- Would be a good idea to talk with students in their 3rd or 4th year of study in geomatics to see what direction they would like their career to move. This will help prepare for the study of some of the soft skills required if they are not already there. {#55}
- The education system must respond to communications skills upgrading as it requires action from the earlier grades. {#60}

4. Better utilization of industry resources as sessional instructors, guest speakers etc

- Establish working protocols with land surveyors organizations, industry associations and all levels of government to address getting the broader message out to students about careers in geomatics. Establish a formal roster and publicize the events well. {#45}
- Assist University professors in coordinating these talks.. They must be a lot of work to set up. {#49}
- This is great because it gives students (and therefore potential employees) an idea as to what it will be like to work in geomatics. Also may help give students an idea as to what they really want to do. {#50}
- Gov't could also participate with resources as sessional instructors/guest speakers {#54}

5. Encourage universities to create more of a geomatics identity rather than simply include in program streams in science (geography, statistics, etc) programs

- Easier said than done. Make presentations to the university administration on the skyrocketing demands for geomatics expertise in the domestically and internationally. {#48}

6. Need to revisit funding mechanisms in universities - r&d funds drive universities. Education goes where $ is (researcher who attracts big R&D funds is most important) // Encourage universities to attract additional funds from, for example, NSERC, industry etc to provide scholarships, research grants etc. More focused on the Canadian "geomatics industry" needs, particularly those centres on the more traditional practice of professional land surveying.

- The geoconnections initiative is a good starting point since all the players have been brought together. This could be a natural progression. {#42}

- Get a better dialogue going with those who have money! {#51}

7. Universities should focus on what exactly the Canadian geomatics field needs so that we are not producing geomatics grads who leave the country //all sectors must work together to keep programmes relevant. (gov't, academia, private sector)

   - Again use geoconnections as a starting point from which to progress. {#47}

8. Better background in computing science (db design, programming course etc)

   - Intended for Computer Science majors who may be working with spatial data for a cell-phone network or other business application... Like a statistics course for Biology students. {#52}
   - Maybe the root problem is that there is too much material to be covered in too short a time. Students resist an extra year and universities like to stay competitive but maybe it just won't fit without one. {#58}

9. Don't lose sight of a University as a place to teach citizenship, history, and a sense of culture. Don't confuse it with a technical school.

   - One of the other points asks for 'soft skills' like presentation or composition. These traditionally are taught from a basis in philosophy, English, or history. {#56}
   - In an ideal world we would all have a better grounding in many of these topics when we arrived at university. Are we trying to fix a systemic problem in the pre-university education system by focusing all the fix in the final two years of a university program? {#64}

10. External Input: Universities need to stay in touch with prof. Associations ... Use advisory boards

    - Use Advisory Boards (to get industry input on curricula content) {#25}
    - One of the ways professional associations could get a direct link to geomatics students while they are in the formal educative process is to offer "articles" time as an adjunct to the coop process... That way the student would get credit for the time spent in a professional environment ....it would link the student ...master relationship as something to be continued after the formal education process was complete {#53}
    - Advisory boards are often driven by the agendas of the appointees to them. Appointees should only be coming to them with a very clear and singular mandate from the constituencies they represent. {#65}

11. Industry needs to lobby the universities on opportunities in the Canadian geomatics industry

- Careers Days are still alive and well. Industry associations and individual large employers are regularly courted to attend, display their wares and recruit. {#66}

12. Provide students with GIS capability with a broader outlook as well... How geomatics can be used for land use decisions, resource stewardship, allocating scarce land.

A.6.4.3 Supplemental Question

Is certification a good idea?

- The public is likely more interested in certified products rather than certified people. {#57}
- Certification would allow for standards to be created in the industry that are more formalized. {#59}
- Would create awareness of the industry and interest at all levels of education. {#61}
- Certification provides a "home "where the professional can practice his or her craft ....that is an important requirement in being considered a legitimate profession in Canadian society {#62}
- Certification of personnel is more relevant to those with lesser educational qualifications. Certified photogrammetrists are certified because they have no academic qualifications. {#63}
- I distinguish between certification and commissioning or registering simply because of the latter's more rigorous academic testing and prescribed period of training or experience (e.g. Articles) {#67}

A.6.5 Topic Four: Skills Upgrading

“The need for skills upgrading in the workplace is becoming increasingly essential in order to keep pace with rapid technology advances.”

A.6.5.1 What training gaps exist in the geomatics sector and how should they be filled?

- Very reactive industry: we don't have a proactive, disciplined approach to meeting training needs.
- Poor long range planning because so many changes in industry.
- No strong industry organizations/associations because there is so much diversity-> to identify gaps.
- Larger employers train their people on their own methodologies.
- In a study on training, found that smaller firms generally don't have enough resources to train their people.
- Technology management will be critical.
- Question is whether we train people on software or on managing the data?
- The geomatics industry has a history of creating consortia and then letting them fall apart.
- We need to have a mechanism to determine "what's next?" -- where is the next strategic

direction of the industry? Only large companies have the resources to identify these new strategic directions - e.g. Focus Intech - most rapidly growing geomatics firm in Canada.

- In hiring practices, geomatics firms need to focus more on social/people skills rather than just technical capabilities.
- All education has geospatial significance. How do we engrain this in the institutions in the early stages?

A.6.5.2 What is the role of employers in providing on-the-job training?

- All successful companies will require that HR depts organize continuing education for their employees.
- The only way these organizations will survive is if they become multi-disciplinary organizations. Small niche companies probably won't be able to compete. Some felt the opposite was true. As technology gets more specialized, people will focus on niches and more outsourcing to individuals and smaller firms will take place.

A.6.5.3 What are best practices in making use of online training opportunities?

- BCIT: changing from a physical to a laptop campus.
- All of the technical documentation in BC Environment is on the web (helps out with new hires in orientation).
- First Nations Experience: have done a lot of training in survey services. CLS has tailored courses (e.g. field assistance). All 14 first nations have GIS sections in their Lands departments. Secondary non-geomatics industry has benefited through trickle down effects... Improved cohesion between aboriginal community and survey community.
- Professional associations are currently debating whether Continuing professional education should be mandatory. However, there are very few Internet training opportunities in surveying... Professional associations have not responded. They have not included this in their strategic plan. It is clear that these associations must take advantage of distance learning opportunities. This need will be filled by outside professional education organizations... They have the knowledge on how to create a learning environment.
- ESRI has a lot of online opportunities on their website (some are related to geomatics concepts).
- In the BC government, the demographics are such that there is a huge gap in the middle (lots of older, and lots of younger) -> there will be a huge training need in the near future.... There will be lots of online training opportunities

A.6.6 Workshop Participants

A.6.6.1 Participants

Tracy Brown, Radarsat International Inc (Tbrown@rsi.ca)

William Voller, NRCan (Wvoller@nrcan.gc.ca)

Bruce Mackenzie, British Columbia Environment Department (Bruce.Mackenzie@gems7.gov.bc.ca)

Tim Koepke, DIAND, Yukon (koepket@inac.gc.ca)

Hans Troelsen, BCLS (troel@mpt.bc.ca)

Phil Mickle, HRDC (phil.mickle@spg.org)

A.6.6.2 Observers

David Arthurs, HAL Corporation (darthurs@hal.ca)

Bob Batterham, HAL Corporation (rbat@fox.nstn.ca)

A.6.6.3 Facilitators

David Low, HAL Corporation (dlow@hal.ca)

Erik Lockhart, Queen's University Executive Decision Centre (lockhare@qsilver.queensu.ca)

A.6.7 Meeting Evaluation

A.6.7.1 What do you see as the key points and priorities in HR from today's discussion?

- Training and Development is an issue. No succession plan for geomatics professionals. {#5}
- Professional association for Geomatics ? {#6}
- Skills upgrading in the near term. A long term plan developed by all stakeholders {#7}
- What is the definition of Geomatics ? Mapping, Surveying, Remote Sensing, IT, or data management ? {#9}
- The industry needs well educated individuals but their passion and ability to adapt is probably more important than their formal education {#10}
- Importance of a professional designation in geomatics {#11}
- If the end objective is to build a world class geomatics industry in Canada, it is essential that the educators and their institutions partner with industry associations, professional associations and individual employers to work in more harmony. This might need to be done on a regional basis to reflect populations, demographics and regional economies. {#14}
- Competition with other countries "taking our geomatics professionals". {#15}

A.6.7.2 Your most significant "takeaway" or learning from today for your organization?

- Have to think creatively where to find geomatics professionals. And when you find them there is still a lot for them to learn/for company's to teach/train. {#8}
- Who says it rains all the time in Vancouver! The realization that we are no closer to defining the "geomatics industry" {#12}
- Whether it is time to create a professional association/accreditation like lawyers/engineers for geomatics professionals. {#13}
- It has reinforced my long held suspicion that the fix is not easy. There a re a lot of positions across the geomatics spectrum being defended with vigour. {#18}
- The field of geomatics is not well defined and until it is there is not much likelihood that industry or professional rep. groups will be able to focus on substantial internal development of character or substance.... as a result companies and individuals are pretty much on their own {#24}
- I don't have a clear picture of whether there is a 'problem' which needs to be fixed. I heard lots of solutions, but am not sure I understand the problem. {#25}

A.6.7.3 Anything you would like to say that did NOT get said...

- Such a high proportion of younger people in this business seem to indicate that there is not a big problem with staffing. Professions with a higher average/median age have more of a problem. {#17}
- Find a way to overcome the apparent barriers to the younger "hot shots" providing some upgrade training to the dinosaurs. {#22}
- The most important thing that this process will generate is a confluence of ideas.... what we do with them is a separate issue {#26}

Appendix B

B. Interview List and Guides

B.1 Interviewees

B.1.1 Education

- Beck, Dr. James; Univeristy of Alberta; Renewable Resources Department (Calgary, AB)
- Coleman, David; University of New Brunswick (NB)
- Delorme, Paul;
- Gwyn, Hugh; University of Sherbrooke (QC)
- Hall, Beyer; University of Calgary; Geography (AB)
- Klinkenberg, Brian; University of BC; Dept. of Geography (BC)
- Lachapelle, Gérard; University of Calgary; Department of Geomatics Engineering (AB)
- LeDrew, Ellsworth; University of Waterloo; Environmental Studies (Waterloo, ON)
- Lodwick, Graham; School of Spatial Sciences, Curtin University of Technology (Australia)
- Maher, Bob; COGS (Lawrencetown, NS)
- Miller, Ross; British Columbia Institute of Technology (Vancouver, BC)
- North, Chris; ESRI (Don Mills, ON)
- Poiker, Tom; Simon Fraser University (BC)
- Simms, Elizabeth; Memorial University of Newfoundland; Dept. of Geography (NF)
- Thomson, Keith; University of Laval (Laval, QC)
- Woolnough, David; COGS (Lawrencetown, NS)

B.1.2 Industry

- Anderson, Neil; Canada Centre for Marine (Ottawa, ON, company in NF)
- Baker, Terry; Nautical Data International Inc. (Ottawa, ON, company in NF)
- Beattie, Clark; Linnet (Winnipeg, MB)

- Béliveau, Guy; Lasermap-Image Plus (Saint Foy, QC)
- Blair, John; McElhanney Consulting (Vancouver, BC)
- Clark, Bernie; Macdonald Dettwiler (Richmond BC)
- Croteau, Jean-Claude; Tecsult (Laval, QC)
- Ferguson, Bryan; Applied Management (Toronto, ON)
- Giroux, Christian; DMR Conseil (Ottawa, ON)
- Grenier, Paul; Group Hauts-Monts (Beauport, QC)
- Hasham, Ali; The Focus Corporation (Edmonton, AB)
- Knight, Roland; RSI (Richmond BC)
- Lamarre, Louis; Le Bureau Géo-Info (LBGI) (Montreal, QC)
- Lawrence, Garth; Intermap (Ottawa, ON)
- Maffini, Giulio; Autodesk (Ottawa, ON)
- Marlon, Lewis; Satlantic (Halifax, NS)
- Maynard, Jim; Facet Design System
- Milbrath, James; Terra Surveys (Ottawa, ON)
- Miller, Emery; Worldsat International (Mississauga, ON)
- Peyton, Derrick; CARIS: Universal Systems Limited (Fredericton, NB)
- Power, Andy; Jacques Whitford (Fredericton, NB)
- Reid, Doug; Novatel (Calgary, AB)
- Sarkar, Dr. Kit; Develtech (Saskatoon, SK)
- Schober, Mark; Bell ActiMedia GeoSolutions (Barrie, ON)
- Van Wyngarten, Robert; Golder Associates (Calgary, AB)
- Vincent, Pierre; Viasat (Montréal, QC)

B.1.3 Policy

- Auger, Denis; Commercialization Office CSA (Québec, QC)
- Chance, Jimmy; C&C Technologies
- DeBow, Sam; Coast Survey
- Faucher, Francois; Mapping Services Branch, NRCan (Ottawa, ON)
- Hissong, Frank; Bureau of Land Management, US Govt.(Washington, US)
- Holland, Peter; Australian Surveying and Land Information Group (Australia)
- Hollinger, Allan; CSA; Sensor and Signal Processing, Spacecraft Eng.
- Kerwin, Terry; CSA; International Marketing

- Logan, Bryan; EarthData Holdings (Washington)
- Mangold, Roland; Earth Observation Magazine (Colorado, US)
- Ottaway, Elizabeth; MGP Information Systems Ltd. (Woodstock, ON)
- Parashar, Surendra; CSA; Satellite Operations
- Plasker, James; ASPRS
- Schell, David; Open GIS Consortium (Maine, US)
- Spinrad, Richard; Oceanographer of the US Navy
- Walker, Stewart; LH Systems (USA)

B.1.4 Professionals

- Boudreault, Dan; Veritas (Calgary, AB)
- Calderbank, Bruce; Hydrographic Survey Consultants Infl. Ltd. (Calgary, AB)
- Dams, Bob; Isosceles (Manotick, ON)
- Daniels, Bob; Servant, Dunbrack, McKenzie & MacDonald (Halifax, NS)
- Giffen, Barry; LandLink Consulting/Geographics Inc. (Edmonton, AB)
- Kena-Cohen, Serge; Intélec Géomatique (St-Laurent, QC)
- Kucera, Henry; Holonics Data Management Group(Victoria, BC)
- MacCallum, Fin; Norteck (Calgary, AB)
- Mackenzie, Bruce; Ministry of Environment, Lands & Parks, BC (Victoria, BC)
- McEwen, Dr. Alec; Land Administration Consulting (Calgary, AB)
- O'Neill, Kevin; RSI (Richmond, BC)
- Patterson, Scott; Dendron Resource Surveys (Ottawa, ON)
- Unger, Peter; Digital Planimetrics (Saskatoon, SK)
- Wagner, Carol; Geological Survey of Canada (Vancouver, BC)
- Wirzba, Carl; Mike Spencer Geomatics (Lethbridge, AB)

B.1.5 Research Facilities

- Edwards, Geoffrey; Centre for Informed Decisions (GEOIDE) (Laval, QC)
- McNabb, Dave; Forest Resources; Alberta Research Council (AB)
- Shaw, Ed; CCRS (Ottawa, ON)
- Worsfold, Richard; CRESTECH (Toronto, ON)
- Zwick, Harold; MacDonald Dettwiler (MDA) (Richmond, BC)

B.1.6 Users

- Belair, Marc; Gaz Métropolitain (Montréal, QC)
- Brown, Carl; Environment Canada (Ottawa, ON)
- Brown, Michel; Hydro-Québec (Montreal, QC)
- Costello, Barry; Cuestor Systems (Burlington, ON)
- D'Aoust-Martin, Carole; IT Dept. CN
- Gamble, Robert; Service New Brunswick (NB)
- Gray, Bob; BC Forest Service (BC)
- Hoffmeyer, Hally; Gov't of BC, Aboriginal Affairs (Victoria, BC)
- Huff, Jim; Telus Geomatics (Edmonton, AB)
- Johnston, David; RMOC (Ottawa, ON)
- Koepke, Tim; Indian & Northern Affairs Canada (Whitehorse, YK)
- Ladha, Nargis; Ontario Hydro (Toronto, ON)
- Lessard, Pierre; Ministère des Transports (Montréal, QC)
- Maloney, Brian; Ontario Min. of Natural Resources (Fraserville, ON)
- Monahan, Dave; Canadian Hydrographic Service (Ottawa, ON)
- Purpur, Gary; Weyerhauser
- Ritchie, Glenn; City of Edmonton; GBIS (Edmonton, AB)
- Roux, Jean-Philippe; RAAQ (QC)
- Sax, Herschell; Elections Canada (Ottawa, ON)
- Solomonson, Eric; Alberta Infrastructure (Edmonton, AB)

B.2 Interview Guide: Educational Institutions

B.2.1 Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in the industry, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated this study to address the sector's human resource issues. The study will be used by the sector to devise a cohesive national plan on how to develop its workforce. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The first part of the study is a series of interviews with members of the geomatics community representing industry, users, geomatics professionals, research facilities, educational institutions, public policy, and international experts. The interviews are crucial to the success of the study in identifying issues affecting the sector related to the business environment, technology, and human resources. These issues will be validated later in comprehensive surveys of the geomatics community.

The following questions are intended to help stimulate and guide our discussions. We very much appreciate your time and effort in responding and we look forward to our interview with you.

B.2.2 Interview Questions

B.2.2.1 Organization Background

1. What courses, certificates, diplomas and degrees are offered by your organization in geomatics? Which do you consider to be areas of special strength for your organization? What has been the enrollment in these courses over the last five years? Has enrollment been increasing or decreasing?
2. Has the content of the courses changed in the last five years? If so, what have been the changes and the reasons for the changes? Are any of these courses offered as part of a distance education program at your institution? In what form are they offered? Have external bodies (e.g. accreditation boards, professional associations), reviewed any of the courses?

B.2.2.2 Business and Market Issues

3. How does your institution keep abreast of market and technological changes in the geomatics area that could impact course content? What formal and informal links exist with industry (e.g. industry advisory board, sabbaticals for professors)? What barriers are there to keeping courses up to date? Which other institutions in Canada or abroad, if any, do you monitor to determine what courses others are offering?
4. How willing is your organization to make use of emerging educational technologies in the geomatics area? Are you planning on offering web-based training in any geomatics area?
5. What kinds of employment have graduates of your organization in the geomatics area obtained in the last five years? Have your graduates had difficulty in finding suitable employment in the geomatics sector? How many have gone to the US?
6. What, in your opinion, are the major educational issues facing your organization and other similar organizations in the geomatics area?

B.2.2.3 Human Resource Issues

7. What issues does your organization face in the turnover and retention of geomatics professional? How mobile are your organization’s geomatics employees? Where do your geomatics employees tend to move to (e.g. US, another geomatics organization, start their own firm, another sector)?

8. Is your organization able to attract new entrants and experienced staff in the geomatics areas of interest to your organization? Which areas are difficult to fill and why? What is the major competition for staff (e.g. US, or other sectors such as information technology)?
9. Which areas of geomatics employment will be growing and emerging and which will be in decline over the next five years? What skills, knowledge and competencies will be required in these emerging areas? What particular skills will be needed to be effective abroad (i.e. technical and soft skills, such as dealing in different cultural and economic environments, language etc.)? What requirements are there for certification of geomatics professionals?

B.2.2.4 General

10. Are there any other aspects of geomatics business, human resources or government policy issues that you would like to comment on?
11. Would you please recommend some recent graduates we could interview for this study. Is there anyone else (industry, universities or government) we should interview during the course of this study?
12. We will also be conducting a survey as part of this study. To whom in your organization should we send the survey?

B.3 Interview Guide: Geomatics Industry

B.3.1 Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in the industry, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated this study to address the sector's human resource issues. The study will be used by the sector to devise a cohesive national plan on how to develop its workforce. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The first part of the study is a series of interviews with members of the geomatics community representing industry, users, geomatics professionals, research facilities, educational institutions, public policy, and international experts. The interviews are crucial to the success of the study in identifying issues affecting the sector related to the business environment, technology, and human resources. These issues will be validated later in comprehensive surveys of the geomatics community.

The following questions are intended to help stimulate and guide our discussions. We very much appreciate your time and effort in responding and we look forward to our interview with you.

B.3.2 Interview Questions

B.3.2.1 Organization Background

1. What is the location of your organization's head office and regional offices?

2. How many geomatics professionals does your organization employ?

3. What geomatics products and services does your organization provide? What other products and services does your organization provide? What portion is exported?

B.3.2.2 Business and Market Issues

4. What have been the domestic and international factors (e.g. public policy, technology) influencing change in the geomatics sector? What do you see as the major factors influencing geomatics in the future?
5. What are the major geomatics market drivers (e.g. competition, technological change)? What are the barriers to domestic and international market access for your organization?
6. Will there be significant restructuring in the Canadian geomatics industry? Will companies be getting bigger or smaller or both? What role do you see for new business models such as networks, partnerships and strategic alliances?
7. Does your organization sell or market over the Internet? Do you plan to do so? What geomatics products?

B.3.2.3 Technology Issues

8. What has been the impact of technological change on your organization's business activity? What barriers have your organization experienced in adopting or adapting new technologies? How important has technological competence been to your organization's competitiveness?
9. What are the leading-edge geomatics technologies today? What geomatics technologies do you see emerging? What will be the impact of these new geomatics technologies on your organization and on the geomatics industry in general? What impediments do you see to getting these technologies to market in new products and services?

B.3.2.4 Human Resource Issues

10. What issues does your organization face in the turnover and retention of geomatics employees? How mobile are your organization's geomatics employees? Where do your organization's geomatics employees tend to move to (e.g. US, another geomatics organization, start their own firm, another sector)?
11. Is your organization able to attract new entrants and experienced staff in the geomatics areas of interest to your organization? Which areas are difficult to fill and why? What is the major competition for staff (e.g. US, or other sectors such as information technology)?
12. Which areas of geomatics employment will be growing and emerging and which will be in decline over the next five years? What skills, knowledge and competencies will be required in these emerging areas? What particular skills will be needed by your organization's staff to

be effective abroad (i.e. technical and soft skills, such as dealing in different cultural and economic environments, language, etc.)? What requirements does your organization have for certification of its geomatics employees?

13. What sources (e.g. universities, colleges, other employers) will your organization draw on to meet current and future geomatics employee requirements? Does your organization have preferred sources? Why?

B.3.2.5 Training Issues

14. What formal and 'on the job' training and mentoring of geomatics employees is provided by your organization? What factors affect your organization's ability to train geomatics employees (e.g. access to needed training, high turnover, willingness of employees to train)? Is your organization considering the use of innovative training solutions, such as web-based training, to meet your organization's requirements?

B.3.2.6 General

15. Are there any other aspects of geomatics business, human resources, or government policy issues that you would like to comment on?
16. Would you please recommend some geomatics professional we could interview for this study. Is there anyone else (industry, universities, or government) we should interview during the course of this study?
17. We will also be conducting a survey as part of this study. To whom in your organization should we send the survey?

B.4 Interview Guide: Geomatics Professionals

B.4.1 Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in the industry, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated this study to address the sector's human resource issues. The study will be used by the sector to devise a cohesive national plan on how to develop its workforce. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The first part of the study is a series of interviews with members of the geomatics community representing industry, users, geomatics professionals, research facilities, educational institutions, public policy, and international experts. The interviews are crucial to the success of the study in identifying issues affecting the sector related to the business environment, technology, and human resources. These issues will be validated later in comprehensive surveys of the geomatics community.

The following questions are intended to help stimulate and guide our discussions. We very much appreciate your time and effort in responding and we look forward to our interview with you.

B.4.2 Interview Questions

B.4.2.1 Organization Background

1. What is the location of your organization's head office and regional offices?
2. How many geomatics professionals does your organization employ (full-time, part-time)?
3. What geomatics products and services does your organization provide?

B.4.2.2 Skills Requirements

4. What is the broad area of geomatics activity of your current position? Is your area of competency subject to certification? What are the main geomatics related technologies, applications, and tools that you use?
5. Many people believe that successful geomatics professionals require not only technical skills, but also generic skills (e.g. communication, working in teams, problem-solving). To what extent do you need such skills in your job?
6. Have you performed geomatics-related work abroad? If so, are there special skills that are required in a foreign environment?

B.4.2.3 Skills Acquisition

7. What academic and technical training do you have (e.g. university, college, on-the-job, self-study, continuing education, other)? How adequate do you consider the sources of your skill acquisition to be to meet the requirements of your job? What changes would you consider desirable to improve the adequacy of skill acquisition? Would you be interested in web-based training for skills acquisition?
8. What length of service do you have in the geomatics sector and what is your age group (e.g. 30-40, 40-50)?
9. What formal and on-the-job training and mentoring of employees is provided by your organization? What factors affect your organization's ability to train employees (e.g. access to needed training, high turnover, willingness of employees to train)?

B.4.2.4 Future Skills Requirements

10. Which areas of geomatics employment will be growing and emerging and which will be in decline over the next five years? What skills, knowledge and competencies will be required in these emerging areas?
11. Some industry professionals are concerned about the brain-drain to other industries or countries. To what extent is that a problem in your area of work? If it is a problem, which factors help keep you in Canada?

B.4.2.5 General

12. Are there any other aspects of geomatics business, human resources or government policy issues that you would like to comment on?
13. Could you recommend anyone else (industry, universities or government) we should interview during the course of this study?
14. We will also be conducting a survey as part of this study. To whom in your organization should we send the survey?

B.5 Interview Guide: Geomatics Research Facilities

B.5.1 Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in the industry, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated this study to address the sector's human resource issues. The study will be used by the sector to devise a cohesive national plan on how to develop its workforce. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The first part of the study is a series of interviews with members of the geomatics community representing industry, users, geomatics professionals, research facilities, educational institutions, public policy, and international experts. The interviews are crucial to the success of the study in identifying issues affecting the sector related to the business environment, technology, and human resources. These issues will be validated later in comprehensive surveys of the geomatics community.

The following questions are intended to help stimulate and guide our discussions. We very much appreciate your time and effort in responding and we look forward to our interview with you.

B.5.2 Interview Questions

B.5.2.1 Organization Background

1. What areas of geomatics research does your organization pursue?
2. How many geomatics professionals does your organization employ?

B.5.2.2 Business and Market Issues

3. What have been the domestic and international factors (e.g. public policy, technology) influencing change in the geomatics sector? What do you see as the major factors influencing geomatics in the future?
4. What role do you see for new business models such as networks, partnerships and strategic alliances between your organization and the geomatics industry or users?

B.5.2.3 Technology Issues

5. What are the leading-edge geomatics technologies today? What geomatics technologies do you see emerging? What will be the impact of these new geomatics technologies on your organization and on the geomatics industry in general? What impediments do you see to getting these technologies to market in new products and services?

B.5.2.4 Human Resource Issues

6. What issues does your organization face in the turnover and retention of geomatics employees? How mobile are your organization's geomatics employees? Where do your geomatics employees tend to move to (e.g. US, another geomatics organization, start their own firm, another sector)?
7. Is your organization able to attract new entrants and experienced staff in the geomatics areas of interest to your organization? Which areas are difficult to fill and why? What is the major competition for staff (e.g. US, or other sectors such as information technology)?
8. Which areas of geomatics employment will be growing and emerging and which will be in decline over the next five years? What skills, knowledge and competencies will be required in these emerging areas? What particular skills will be needed by geomatics professionals to be effective abroad (i.e. technical and soft skills, such as dealing in different cultural and economic environments, language, etc.)? What requirements does your organization have for certification of its employees?
9. What sources (e.g. universities, colleges, other employers) will your organization draw on to meet current and future geomatics employee requirements? Does your organization have preferred sources? Why?

B.5.2.5 Training Issues

10. What formal and 'on the job' training and mentoring of geomatics employees is provided by your organization? What factors affect your organization's ability to train geomatics employees (e.g. access to needed training, high turnover, willingness of employees to train)? Is your organization considering the use of innovative training solutions, such as web-based training, to meet your organization's requirements?

B.5.2.6 General

11. Are there any other aspects of geomatics business, human resources or government policy issues that you would like to comment on?

12. Would you please recommend some geomatics professional we could interview for this study. Is there anyone else (industry, universities or government) we should interview during the course of this study?
13. We will also be conducting a survey as part of this study. To whom in your organization should we send the survey?

B.6 Interview Guide: Geomatics Users

B.6.1 Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in the industry, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated this study to address the sector's human resource issues. The study will be used by the sector to devise a cohesive national plan on how to develop its workforce. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The first part of the study is a series of interviews with members of the geomatics community representing industry, users, geomatics professionals, research facilities, educational institutions, public policy, and international experts. The interviews are crucial to the success of the study in identifying issues affecting the sector related to the business environment, technology, and human resources. These issues will be validated later in comprehensive surveys of the geomatics community.

The following questions are intended to help stimulate and guide our discussions. We very much appreciate your time and effort in responding and we look forward to our interview with you.

B.6.2 Interview Questions

B.6.2.1 Organization Background

1. What is the location of your organization's head office and regional offices?
2. How many geomatics professionals does your organization employ?
3. What geomatics products and services does your organization use?

B.6.2.2 Business and Market Issues

4. Does the use of geomatics increase your organization's competitiveness? How? What drivers underlie your organization's current and future use of geomatics? What barriers exist?

5. What have been the domestic and international factors (e.g. public policy, technology) influencing change in the geomatics sector? What do you see as the major factors influencing geomatics in the future?

B.6.2.3 Technology Issues

6. What are the leading-edge geomatics technologies today? What geomatics technologies do you see emerging? What will be the impact of these new geomatics technologies on your organization and on your industry in general? What impediments do you see to the acceptance by users of these technologies in new products and services?

B.6.2.4 Human Resource Issues

7. What issues does your organization face in the turnover and retention of geomatics employees? How mobile are your organization's geomatics employees? Where do your geomatics employees tend to move to (e.g. US, another geomatics organization, start their own firm, another sector)?
8. Is your organization able to attract new entrants and experienced staff in the geomatics areas of interest to your organization? Which areas are difficult to fill and why? What is the major competition for staff (e.g. US, or other sectors such as information technology)?
9. Which areas of geomatics employment will be growing and emerging and which will be in decline over the next five years? What skills, knowledge and competencies will be required in these emerging areas? What particular skills will be needed by your organization's staff to be effective abroad (i.e. technical and soft skills, such as dealing in different cultural and economic environments, language, etc.)? What requirements does your organization have for certification of its geomatics employees?
10. What sources (e.g. universities, colleges, other employers) will your organization draw on to meet current and future geomatics employee requirements? Does your organization have preferred sources? Why?

B.6.2.5 Training Issues

11. What formal and 'on the job' training and mentoring of geomatics employees is provided by your organization? What barriers affect your organization's ability to train geomatics employees (e.g. access to needed training, high turnover, willingness of employees to train)? Is your organization considering the use of innovative training solutions, such as web-based training, to meet your organization's requirements?

B.6.2.6 General

12. Are there any other aspects of geomatics business, human resources or government policy issues that you would like to comment on?
13. Would you please recommend some geomatics professional we could interview for this study. Is there anyone else (industry, universities or government) we should interview during the course of this study?
14. We will also be conducting a survey as part of this study. To whom in your organization should we send the survey?

B.7 Interview Guide: Policy and Strategy

B.7.1 Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in the industry, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated this study to address the sector's human resource issues. The study will be used by the sector to devise a cohesive national plan on how to develop its workforce. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study, which is under the overall direction of a Steering Committee composed of key stakeholders in the geomatics sector.

The first part of the study is a series of interviews with members of the geomatics community representing industry, users, geomatics professionals, research facilities, educational institutions, public policy, and international experts. The interviews are crucial to the success of the study in identifying issues affecting the sector related to the business environment, technology, and human resources. These issues will be validated later in comprehensive surveys of the geomatics community.

The following questions are intended to help stimulate and guide our discussions. We very much appreciate your time and effort in responding and we look forward to our interview with you.

B.7.2 Interview Questions

B.7.2.1 Business and Market Issues

1. What have been the domestic and international factors (e.g. public policy, technology) influencing change in the geomatics sector? What do you see as the major factors influencing geomatics in the future?
2. What are the major geomatics market drivers (e.g. competition, technological change)? What are the barriers to domestic and international market access for the Canadian geomatics industry?
3. Will there be significant restructuring in the Canadian geomatics industry? Will companies be getting bigger or smaller or both? What role do you see for new business models such as networks, partnerships and strategic alliances?

B.7.2.2 Technology Issues

4. What has been the impact of technological change on Canadian geomatics business activity? What barriers has the industry experienced in adopting or adapting new technologies? How important has technological competence been to Canadian industry's competitiveness?

5. What are the leading-edge geomatics technologies today? What geomatics technologies do you see emerging? What will be the impact of these new geomatics technologies on the geomatics industry in general? What impediments do you see to getting these technologies to market in new products and services?
6. How does Canada's current R&D capacity in geomatics compare to other countries?

B.7.2.3 Human Resource Issues

7. Which areas of geomatics employment will be growing and emerging and which will be in decline over the next five years? What skills, knowledge and competencies will be required in these emerging areas?
8. How well prepared are Canadian educational institutions to meet future skill requirements in the geomatics sector?

B.7.2.4 Training Issues

9. What innovative training solutions, such as web-based training, are available to meet Canadian geomatics requirements?

B.7.2.5 General

10. Are there any other aspects of geomatics business, human resources, or government policy issues that you would like to comment on?
11. Do you have suggestions for geomatics professionals or others we should interview for this study?

Appendix C

C. Survey Methodology

C.1 Survey Questionnaires

Five surveys were developed in response to the five different identified groups (Geomatics Education and Training Institutions, Geomatics Industry, Geomatics Professionals, Geomatics Research Facilities and Geomatics Users). Questionnaire length varied between 29 and 46 questions, touching upon six[1] major areas: About your Organization, Education and Training, Business and Market Issues, Technology Issues, Research and Development and Human Resources. When possible, the same questions were used to facilitate future analysis of the responses at a survey wide level.

The surveys were made available in both French and English.

C.2 Survey Administration

The survey was launched on August 24th 2000 and closed on September 25th 2000. In all, almost 4,500 invitations to participate in the survey were sent out. From that number, slightly over 800 were returned as having been sent to invalid email addressees. The remaining 3,645 emails were assumed to have reached the intended recipient.

During the life of the survey, someone was available to help/assist those who encountered problems while filling out the survey to ensure the highest possible return rate. In some cases, surveys were faxed to the respondent and their answered were then entered by hand into the survey database. In addition, a number of emails were sent out during the survey to remind potential respondents of the survey and to inform them about prize winners and other news regarding the survey.

Table 2-1 shows the breakdown of response rate by different survey. Overall, 875 valid[2] responses were received, a return rate of 24%.

[1] The Geomatics Professionals survey also included an 'About You' section.

[2] Some responses were either submissions that contained no information or double submissions from the same respondent.

Table 2-1: Summary Statistics

	Total Sent	Returned	Adjusted Number[3]	Responses Received	Response Rate[4]
Educational Institutions	117	21	96	27	28.13%
Industry	892	190	702	105	14.96%
Geomatics Professionals	3099	547	2552	666	26.10%
Research Facilities	27	6	21	6	28.57%
Users	314	40	274	71	25.91%
Total	**4449**	**804**	**3645**	**875**	**24.01%**

C.3 Giveaway

In an effort to increase the response rate of the survey, prizes were raffled off. To be eligible, a respondent had to include his or her email address with their survey response.

The prizes were Garmin eTrex hand-held GPS receivers provided by Prairie Geomatics. In all five draws were made. The winners are listed below:

- Carolyn Bakelaar, Fisheries & Oceans Canada
- Kevin Ives, NU-TECH
- Suzette Giles, Ryerson Polytechnical University
- C. Peter Keller, University of Victoria
- Derek Davidson, Department of Transportation (NB)

C.4 Data Collection

During the survey, responses were collected on our own server and the data files were periodically imported into Perseus. From there, data was exported in SPSS to facilitate and allow for more in-depth analysis.

C.4.1 Perseus

Perseus is a development tool to create online surveys. The software enables the creation of the needed HTML code to administer a survey online. The software also defines the format and type of the files that will be collected from the surveys and creates a database of information from those files.

[3] Adjusted number is equal to the number of emails sent minus the number of returned emails.
[4] Received surveys as a percentage of the Adjusted Number. Returned emails were not counted as either being sent or received.

C.4.2 SPSS

SPSS is a statistical analysis and data management system. It facilitates the manipulation and analysis of data. It allows for the tabulation of responses and the generation of both tables and graphs.

Appendix D

D. Literature Review

D.1 Introduction

D.1.1 Context

This literature review concerns the field of geomatics, for which a number of definitions exist. To avoid restricting our study and thinking, we take here a more inclusive view based on Batterham (1997), but updated to reflect recent changes and developments. Geomatics includes the disciplines of Surveying (geodetic, cadastral, engineering, and marine, embracing technologies such as GPS), Mapping (photogrammetry, cartography, and charting, including image mapping and the application of LIDARS), Remote Sensing (data acquisition and applications, including hardware and software development), and GIS as well as related land and ocean information systems. The Internet is universally regarded as an enabling technology facilitating data delivery.

Our investigation is made complex for a number of reasons. First the fields with which we are concerned involve a number of complex technologies. In addition there is rapid change within the range of tools and technologies and high variability in how new tools are adopted and accepted across the sector. Furthermore, the application of these tools is no longer within the strict purview of those employed in geomatics firms, or even by professionals in geomatics. The rapid advances in the field have seen lower-cost user-friendly systems applied within the user community. Indeed, we are seeing the blurring of lines between traditional geomatics firms and their clients, some of whom are now offering their derived geomatics products for sale to third parties.

As well, we are seeing technology being developed that can replace the geomatics professional's expertise that once had to be applied to the collection or use of data. Lastly, we are seeing investments made by those from outside the traditional field, including companies like Microsoft and major players in the aerospace industry such as Boeing and Lockheed-Martin as the value of geospatial data is recognized by the general business and investment community. A recent case in point was the sale of Mapquest for $1.1 billion. Even two years ago such a valuation on a "mapping company" would have been scoffed at. While the price may well have been inflated by the frenzy over the so-called "dot.com" stocks, map information is being recognised as having definite value.

It is within this rapidly changing environment that we are performing a literature review. Past history in geomatics means little unless it can be examined within the context of the changing environment in which we find ourselves. For this reason, we have skimmed over some of the past's major studies, while concentrating on others that seem better able to help us understand the present and how we will get to the future.

D.1.2 Considerations

This review is meant to be neither a static document nor a comprehensive one-time review. It is being done as a living document, as a well-integrated part of a major study of the sector. As such it is meant to help formulate further questions, identify areas in which we will wish to drill down for further information, and areas to which particular attention should be paid during the analysis.

An issue in a literature review is source material. In an academic review, usually only refereed journals would be consulted and used,and only those authors with a substantial track record or clearly reviewed work would be included. However, while there are review articles written at key junctures, the long lead time before publication results in materials that were often written as long as a year or more earlier. Further, assessments of industry trends, markets, and general technology trends are rarely found in learned journals. For that reason we have placed much more reliance on alternative sources, including commercial contract reports, trade journals and newsletters. By so doing, we do run the risk of using materials that have not been subjected to peer review and which may not be as objective as we would like. However, in that the overall goal is to define what we should look at in terms of future human resources issues, the resulting material should provide useful signposts.

Furthermore, in the classical literature review each reference and statement would be meticulously documented with extensive footnotes and references throughout the text. Such reviews may be useful in an academic sense, and are certainly part of the McGrath and Sebert volume (1999) as well as being evident in a number of the documents consulted for this, but here we believe that such meticulous attention to a broad selection of references will be neither helpful in the present context, nor easy to read. For example, where a number of authorities have made a statement such as “the growth in capability of PCs accompanied by a continual reduction in their cost has been an important enabler for the development of geomatics”, we have not cited every source that has made that statement. We have cited sources for numbers used and opinions expressed on technology, although in some cases we have used the existence of a body of technical literature as an indication of the growing (or waning) interest in a particular technology.

The review is organized using the same outline as the rest of the study. We have reviewed documents under the basic headings of Industry, Market, Technology, Education and Human Resources. The whole has been made somewhat more difficult for the very reasons that this study has been called for at this time.

- The entire field of geomatics and the industry that both serves it and the clients that use it are all changing rapidly - both in Canada and around the world.

- While it is recognized that the industry is changing, there is little agreement as to where it is heading, why, and when it will get there. Part of our task is to collect appropriate information to conduct research on this topic to place our study on a firm foundation of fact and informed opinion.
- Technology is changing almost daily and at a variable rate from sub-sector to sub-sector.
- The field is broad – there is no one individual who understands all aspects in the necessary breadth and depth to do a critical and accurate review. We have opted therefore for a series of technically accurate vignettes accompanied by a more general approach as the foundation on which we build.
- Much of the available information and studies have been done for groups advancing one cause or another within the field of geomatics and as such must be questioned as to their inherent biases.
- Many of the studies with which the consultants are familiar are proprietary in nature and are not available for this study. The study team has, however, brought a number of proprietary studies to the table where the consultants own the background material or were able to secure releases from the owners of the information.
- The age of materials being reviewed is a concern. In general, in a rapidly changing field, older work is less useful. However, we have found that some of the older studies being reviewed here have been accurate in terms of what they have predicted (see the cited reviews by Ryerson) and as such provide a valuable anchor for the current work.

This task is also made somewhat more complex as a result of the assumed use of the Internet. While the Internet is a rich and valuable resource of often up-to-the-minute opinion and information, what is found on the Internet is not always as carefully researched or free of bias as are journal-published articles.

In summary, we have tried to apply a combination of logic, experience, and a critical eye to arrive at a review that makes sense in the context of what we see unfolding in the field of geomatics.

D.2 Industry

The Canadian industry in the global or continental context has been the topic of a number of studies. (Canadian Institute of Surveying, 1985; Batterham, 1997; Ryerson, 1999; Ryerson et al 1999, 2000). Older studies such as that cited done in the 1980s are of less relevance and are useful only as a point of departure. The industry areas that have been studied recently with specific reference to Canada have had as their focus remote sensing and to a lesser extent mapping and GIS. While there recently has been a study on GPS, it is not available yet for use in this study.

Returning to historical assessments, the 1985 Task Force estimated (not backed up by truly quantitative surveys) that 9000 people were employed in the industry in 1983. Based on analysis of a questionnaire, 53% of these were involved in land survey, 6% in geodetic survey, 9% in photogrammetry, 3% in hydrography, 5% in cartography, 1% in spatial information, 8% in engineering survey, 1% in mining survey, 5% in remote sensing, 3% in geophysical, and 6% in other areas. At that time virtually 100% of the firms were Canadian owned, with the greatest number of firms and employees (as could be expected) in Ontario and Quebec. There were more firms in British Columbia than population and size might lead one to expect. The fact is that all figures in this early study are skewed by the large number of land survey companies spread across the country. This trend appears to be continuing. Gross revenues in 1983 were estimated to be $380 million. Sales dropped 24% from 1981 to 1983. This was just before the period when the remote sensing sub-sector began a steady increase that was to last into the mid-late 1990s.

The fact that the 1985 study concluded that much of the domestic surveying and mapping industry depends on "various forms of exploration and development (meaning land development)" and on the "federal and provincial governments" shows how far the industry has moved in reaching its current position of serving a much broader client base. In terms of the foreign market assessment, foreign competition was identified as increasing, and specific recommendations were made to increase or at least maintain the international market presence. While some of these recommendations appear to have been acted upon, many of the identified issues remain today (Ryerson, 1999).

The single most important aspect of the 1985 study was found in the section entitled "New Horizons". It was recognized that massive changes in technology and the market were on the horizon. Digital data, data integration, flexibility, provision of dynamic data for monitoring, new thematic maps, and changing market demands were all cited as being important. While none of the specific new markets were identified (nor were they in any other study we have reviewed), some signposts were erected. It would appear, however, that few of the signposts were then followed.

The next relevant report of interest specifically to Canada is that by Batterham (1997). This "report is by no means meant to be an exhaustive inventory of products and services." The report covers the early history of the industry – being based on the capacity in aerial surveys that came back to Canada at the end of World War II, augmented by immigration from Great Britain and Europe, coupled with a government policy to make Canada a leader in this field. That history is very well documented in the McGrath and Sebert book, Mapping a Northern Land (1999).

Batterham noted the dramatic changes that came with remote sensing, GPS, computer aided mapping, off-the-shelf software, etc. He was among the first to mark the trend in the industry "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."

Under the title "New Players" Batterham cites the 1996 Canadian GIS Source Book, to note that in 1996 there were 253 companies in this field in Canada. In 1991-92, there were only 1000 world-wide – although most of those were in North America. The Geomatics Industry

Association has grown from eleven companies when the industry was made up of aerial surveying firms to over 100 today.

He states "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, Monenco, Tecsult, SPAR Aerospace (formerly), MacDonald Dettwiler and Hughes Aircraft of Canada have divisions generally devoted to geomatics and sometimes specifically to GIS Management consulting firms, such as Pricewaterhousecoopers and the systems oriented DMR Group, routinely provide GIS 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 GIS 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…" A further analysis of Batterham's comments is quite instructive. Of the two dynamic new companies identified as entering the industry, one was sold to a multi-national Canadian-based engineering company, while the other has gone out of business, with several of the original key people forming another company. Another of the major players is no longer in the business, and one of the successful models for cooperation has ceased to operate. Change is truly the only constant. Change is found in the technology, the business models, the market, and the structure of the industry to serve that changing market.

One of the more useful elements of the Batterham report is the characterization of the economic environment in which the industry operates. He noted that the recent attention to the development of infrastructure in the USA has resulted in more technology and capacity building in the USA industry. Similarly, Ryerson (1999) has suggested that the US retail, banking and insurance industry have used their leading edge geo-spatial data use expertise to dominate markets in Canada and around the world, with adverse consequences for the local industry.

Batterham also makes the very useful point, "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."

The results of a study by Ryerson (1999) of Kim Geomatics on the industry structure are reported in a key-note paper at the Second International Symposium on the Operationalization of Remote Sensing in the Netherlands, and in an invited contribution to the January 2000 issue of Geo-Asia Pacific. While the study had as its focus remote sensing, many of the companies interviewed were also active in mapping, GIS, and related areas suggesting that the results were probably valid across a significant part of the geomatics sector. Some of the study conclusions were:

On fragmentation: Both consolidation and fragmentation in the industry can and will occur at the same time – and for different reasons. When done for the right reasons with good corporate citizens, either model can lead to success; when done for the wrong ones, both will certainly lead to failure

More work will be done at the desktop: This will lead to more intense competition, even more fragmentation, as almost anyone will be able to set up a business. Standards, quality control, and personal relationships will become more important than ever.

On productivity: Many of the companies selling services from the developing world cannot match Canadian productivity because of lack of technology. Canada, on the other hand, comes close to matching the productivity of the US, with far lower wages. Continuing increases in productivity will be needed by Canadian companies to stay in the market.

On the capacity to grow jobs and exports and international competitiveness: Canada will become less and less competitive with some of the developing countries and will lose low-end and some (but very few) high-end jobs to them. However, there is also the capacity to create more jobs with the huge US market literally at our doorstep. An inhibiting factor is wages. Wages paid to Canadian GIS and EO staff lag far behind those of the USA. We can expect to see a significant brain drain by those working in large companies where there is an unsettled environment. Fragmentation may mean more of a feeling of ownership (or real ownership) and may result in more of a willingness to stay put.

Government policy: Despite fewer resources being available, government can still have a profound impact on the market. How government reads and reacts to the messages of the market and recent events will go a long way towards deciding whether or not the country "built for remote sensing" will have a dynamic, export oriented remote sensing industry by 2005. Certain policy changes are suggested in the study as being essential to ensure that the industry is resuscitated, does not become too concentrated in the hands of, especially, foreign controlled entities, and develops the capacity to grow.

GPS: No Canadian studies were identified for GPS. However, the study by Kim Geomatics concluded that the threats and opportunities identified for other technology intensive areas of geomatics could also be expected to be facing GPS such as international competition, access to markets, access to trained staff, management and investment. A point of difference is that GPS has been raised into the public's mind. This is very important from an investment and business development point of view. Simply because of media visibility, far more people are likely to be thinking of ways to make money from GPS than from GIS, for example. Technically Canada's industry is well placed to take advantage of GPS. There are a number of suppliers of the technology, software, services, and integrated applications all supported by a strong academic activity, especially at the University of Calgary and UNB.

The above reviewed studies have been useful in guiding the current study's approach to the industry and the questions we are asking in our interviews and our surveys of the industry and those working in the geomatics sector.

D.3 Markets

D.3.1 Introduction

The markets for geomatics have been the focus of a large number of studies that are referred to throughout this section. Much of the market in remote sensing and GIS has already been reviewed in a proprietary study by Kim Geomatics and we draw on that study in this review with the permission of the author. We believe that much of the logic in the more detailed remote sensing analysis is also applicable to the broader geomatics sector. In terms of GIS, the material we have examined is somewhat dated since we have not accessed, for cost reasons, the most recent versions of the major commercial studies by Daratech, for example[5].

Section D.3.3 reviews the mapping market (which is not well documented in publicly available studies) as well as the rapidly growing and robust market in GPS, while section D.3.4 draws some general conclusions about the future markets across the broad range of geomatics based on the material reviewed.

D.3.2 Remote Sensing and GIS Markets

D.3.2.1 Limitations to Market Assessments

In the study by Batterham (1997), sources cited state that "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." These numbers provide an excellent lead into the discussion of these markets. Taken at face value, these assessments seem reasonable and seem to be from reputable sources – such as the US Department of Commerce. However, as with many market assessments in this field, one should take a great deal of care in using them. The balance of this section explains this, and the market in GIS and remote sensing, in some detail.

The size of the global remote sensing market as projected by a variety of studies (Frost and Sullivan, KRS (Kodak Remote Sensing), May and Bossler, Industry Canada/GIAC, etc) varies considerably. The fact that there are many different numbers cited as the "market" may appear confusing to one just entering or beginning to study the field. The variability in the projected

[5] These studies cost approximately $3000 (US) each. In the context of the present study, access to these dated studies at this stage of the study should suffice.

market is accounted for by the fact that the studies are counting and comparing not only the product but the tools used to produce the product.

Some studies include just satellite data sales – the value of remotely sensed data sold. Others include the fees charged to ground station operators plus the data value. Still others include both airborne and space-borne data sales and call it all remote sensing. Some include the value added to these data – usually taken to be between four and ten times the value of the data sold - depending upon the nature and use of the raw data. Other studies include the total value of the sensors, ground stations, satellites, etc. In some studies one can find double counting: they total the income of the system integrators plus the income of all of the sub-assembly suppliers.

The larger numbers tend to include the value of the satellites, sensors, launch, all data sales, ground station fees, ground stations, processing software, image interpretation, and integration of image data into a GIS. The biggest question in all of this is where one should draw the line between value added and GIS. The studies citing the remote sensing field as being in the $10 billion dollar range typically count more of the GIS activity than would normally be accepted in an accounting sense.

Some studies total the market for a given country. Some take into consideration changes in exchange rates, while others don't. Some count the assigned costs to government activities in economies dominated by central government spending – where there is almost no real cash expenditure on remote sensing. How does one compute the value of the input of an engineer in a developing country compared to that of a worker in Canada? For example, there may be twenty people doing image interpretation in a given agency in a developing country. They receive housing, schooling for their children, access to health care, and are paid wages far below what they would make in Canada. How does one assign a value to their work to arrive at the "value of remote sensing market" in their country? Is this really a market or an activity to which someone has arbitrarily assigned a market value?

In such cases, the concept of realizable market is useful**.** How much of the market is accessible to off-shore suppliers? Of that market, how much is accessible to Canada? While Canada has been very successful in winning open bids in the remote sensing market, the fact (and problem) is that not many bids are really open, and not much activity is part of a true market.

In hindsight, general market assessments often seem to miss some of the key trends. Some have significantly underestimated the market (see the KRS study analyzed and referenced in May and Bossler), while others may have been overly optimistic. Some are looking at benefits not markets, while others seem to confuse the two terms. As can be expected, the market assessments that are done by those without some grounding in the field seem to be less accurate in projecting beyond current trends.

With each new major advance in satellite remote sensing, there is an increase in market size. In part this is a function of technology driving demand. (See Asker, 1992) Furthermore, the ease with which market size or increase has been predicted appears to be directly proportional to the ease with which users have been able to understand and use the new data. This is in turn related to the similarity of the new data source to existing sources of information. For this reason, Landsat Thematic Mapper and SPOT imagery were both relatively easy to use for those experienced with colour aerial photography. RADARSAT imagery was less easily adapted to existing systems, and the literature suggests that hyperspectral will fall between these two "extremes."

In previous commercial market assessments reviewers have generally been unable to look beyond the next major shift in technology or capability. It is as if anything beyond the next major product advance has been lost in the shadow of what is just over the horizon. To date, the major advances have been the introduction of Landsat TM, the introduction of SPOT, and the introduction of RADARSAT. It will be noted that Landsat MSS has not been cited here as a "major advance". We argue that this is so because there was little commercial or operational market in any but a few cases.

The next major advance that is being touted is the introduction of high spatial resolution imagery. That market has been projected to be huge – pushing sales of imagery toward the billion dollar range. The study by Kim Geomatics was of the view that these projected market numbers for high spatial resolution imagery which is, after all, a replacement for aerial photography and some digital airborne imagery, are exaggerated. (This is especially so given that, in some cases, the prices cited for the high resolution satellite imagery are, in fact, greater than that of aerial photography!)

D.3.2.2 Remote Sensing Market Projections

Frost and Sullivan and May and Bossler (Mapsat) provide what seem to be both unbiased and realistic assessments of what is likely to happen in the space imaging market. Frost and Sullivan state that the satellite image market is expected to be $ (US)139.8 million in 1998, up 17.5% from $ (US)120 million in 1997. This is taken to be the total image product sales including enhanced products, ground station fees, and products sold by Value Added Resellers (VARs) of SPOT, Landsat and IRS and RADARSAT. This number is considered to be accurate. It is expected that this market will grow by 28.6% through 2004 (assumed to be three years after launch of a hyperspectral system) when it will be $ (US)698.3 million. Interestingly, May and Bossler projected growth in data sales of 29% from 1995 to 2000, also based on high resolution data. (As noted below, both groups have been used as sources in a third projection.) Compounded growth is projected to be closer to 40% over the next few years. It is not clear if the one report used the other as a source.

Frost and Sullivan suggest that commercial remote sensing revenues were $(US)2.1 billion in 1997. This number includes all airborne and space-borne data sales, but no additional services or technology. The airborne market is projected to rise by a more modest 12.0%. While they note that the airborne market is mature, they suggest (and we agree) that there are many specialized applications that will use airborne imagery combined with other data sources, integrated in a GIS. Some (See Spacevest) have even begun to use the term "Space GIS" to refer to the integration of space-acquired imagery and geographic information derived from other sources. As noted elsewhere in this report, where one draws the line between these two fields creates a definitional problem. The value of hyperspectral airborne imagery is not specifically included in this projection, but it too will add to the overall value.

MacDonald (1999) suggests that there is a gap in knowledge between the users and the suppliers of satellite imagery – the users don't know much about the satellite imagery (and don't care so long as their needs for information are being met), while on the technology side there is limited knowledge of users needs and how to convert satellite imagery to information that will meet the users needs. This gap accounts for the lower use of satellite data than one might expect. It is incumbent upon the remote sensing industry to bridge this gap to make satellite imagery truly operational – i.e. cost-effective and self-financing.

May and Bossler projected total sales of raw and value-added products of $ (US)800 million by 2000, compared to Frost and Sullivan's $ (US)218 million. Asker (1992) citing a KPMG Peat Marwick study which gives a range of $ (US) 560-730 million by 2000, "(and) it could hit $ (US) 1.3 billion." Contributors to the May and Bossler study include NASA, KPMG Peat Marwick, and a number of others. Its completeness stems in part from the fact that it built upon a number of other studies, as well as its attention to explaining the methods used.

The estimate of $ (US) 800 million for value-added products (i.e. for interpretation and data integration services) for 2000 is now considered to be a reasonable number. This is in addition to the $ (US) 218 million for products and access fees. A few years ago this estimate may have been higher. An earlier set of studies done in industry and reported by Ryerson (1994/95) suggested that Canada would achieve applications services sales on the order of $ (US) 200 million including sales related to GIS/space data and airborne data integration. These sales were to be driven by environmental applications.

Kim Geomatics and other studies indicate that these applications sales are not on target to achieve this result for a number of reasons. Globally, the market is smaller and growing somewhat slower than expected because of the failures of high resolution and hyperspectral satellites, and the Asian economic troubles. In Canada, which has an export driven industry, these global factors have been exacerbated by the level of investment in the private sector, some re-structuring in the domestic industry, delays in R&D caused by government cut-backs and, until recently, the over-riding and understandable emphasis on RADARSAT.

A more reasonable number for Canada would now likely be on the order of $ (US)100 million for the year 2000 – between 10 and 20% of the world market. The really interesting numbers come from the year 2004 (assumed to be three years after launch of a hyperspectral system) and beyond when the market is projected by many to dramatically increase. The assessment that the market will increase dramatically after 2004 (assumed to be three years after launch of a hyperspectral system) seems reasonable.

It is again worth underlining that the market for optical remote sensing imagery, and products and services derived from it, has consistently been underestimated around the world. Projections of growth in sales by the marketing staff at CCRS through the early-mid 1980s were consistently running at 80% per year, and were often criticized as being too optimistic. But these targets were met five years in a row, including during a recession. The projections for CCRS were based on estimates of market penetration, current use, and probable conversions among new users. A similar approach was used in the Kim Geomatics hyperspectral market assessment from which much of this section is drawn. We expect that the same will happen with hyperspectral as has happened with other optical sensors – sales will exceed what traditional market surveys tell us.

Two studies have dealt with the impact of hyperspectral data specifically: one by Dornier and another by Kim Geomatics – both are proprietary. That by Dornier of Germany was done in support of their own hyperspectral program. The Dornier study interviewed over 300 people world-wide. Dornier projects the total market to be about $393 million for agriculture, about $18 million for forestry, $36 million for the environment, $81 million for geology, and $161 million for cartography (which includes land use mapping and some other thematic mapping. At the time of the review, these numbers had yet to be validated. Their un-validated total is $689 million. In the Kim Geomatics study, the value for applications and data on a global basis totals $546 million. Given that the Dornier numbers are not validated, we assume that these numbers – about 25% apart, seem reasonable. Were it not for problems associated with obtaining cloud free data in areas of rain-fed agriculture, the market associated with agriculture would be even be higher.

Euroconsult (1991) listed a number of factors causing blockages in growth: supply and demand, the lack of a commercial approach by leading suppliers, lack of information and training, the conservative nature of users, the difficulty of integrating remote sensing with other information, the dominance of public sector supply, inadequacy of human, financial and technical resources, data costs, data delivery, and weaknesses in data processing and interpretation methods. In addition to some of the above, other limiting factors identified in a 1996 geomatics study (IACG) but also relevant to remote sensing, include cost, lack of suitable format, encumbrances on data use, data dissemination, and lack of consistent standards. However, more recent studies (Ryerson, 1999) indicate that many of these blockages are disappearing or have disappeared.

According to Frost and Sullivan, the major growth is projected to come in "high resolution panchromatic and multispectral imaging" at one metre resolution used for surveillance and base mapping. They see demand varying over this period based on "armed conflicts, economic situation, border incursions, natural disasters, and infrastructure crises." These are all areas in which we see the useful application of hyperspectral imagery.

The number of countries that can use space imagery is projected by Frost and Sullivan to double from 25 to 50 by 2004. This is very important for the hyperspectral market as will be seen below. Hyperspectral data, because of its volume, "shelf-life," and the nature of applications will generally have to be delivered closer to the area being imaged than is often the case with Thematic Mapper imagery where a small service bureau in Vancouver can supply enhanced products of exploration areas in South America for a client elsewhere.

The Frost and Sullivan conclusions on market size and market penetration fall within limits that we suggest range from reasonable to optimistic, given the fact that they have not included hyperspectral data in the mix.

There has also been a recent fundamental change in market conditions that has not been mentioned in the literature. With the successful launch of Landsat 7, data is being offered at the cost of filling the user request (COFUR). The price for a Landsat scene (up to the precision geocoded level) is now around $600 as opposed to around $4,000 as it was for Landsat 5. The net effect of this will be dependent on the elasticity of the market. It will take about six times the volume of sales to achieve the same total sales figure at the data level. This may not be achieved, but the availability of lower cost data may lead to larger sales of information products. This may well have a ripple impact across the entire geomatics area.

D.3.2.3 GIS Market Projections

To date few studies in the public domain have directly assessed the GIS market. Daratech does provide an assessment of the GIS market in which they review the performance and activities of many of the key players in remote sensing, including PCI, ERDAS, and even the satellite image suppliers. The GIS market is said to be over $(US) 6 Billion in 1995, although Daratech suggests that this may include some double counting. In 1993, the base year for a number of studies, according to GIS World (1994) the total GIS market was $ (US) 2.2 billion, with software sales of $ (US) 474 million. Daratech placed software sales at $ (US) 495 million in 1994, a year later.

The "core business" as Daratech calls the direct software and hardware sales and services in GIS is relatively easy to estimate. The real difficulty is apparent looking at the two numbers given by the two groups for the GIS market just one year apart: $ (US) 2.2 billion vs $ (US) 6 billion (It should be noted too that these are not projections but after the fact statements of market size).

It is obvious that there is no clear definition of what falls in the GIS market – or the one study with the higher number that admitted to "some double counting" had much more than double counting! Quite simply, the numbers are not consistent. Since many of the benefits of remote sensing are said to begin after the results of information extraction enter the GIS environment, one must be very careful in how numbers are used, expanded, and analyzed from the GIS market.

What of this GIS software market (the $ (US) 474 – 495 million referred to above) is remote sensing image processing software is open to some discussion. Looking at the sales today of the major players: PCI, ERDAS, ENVI, and ER Mapper suggests that current civilian sales are in the vicinity of $ (US) 30 million based on assessments made by Kim Geomatics. We have been unable to find independent estimates of sales related to satellites, satellite components, sensors, ground stations, image processing software, or much detail on applications areas of the market, although a variety of indicators do exist.

While we have not been able to find independent and citable sources of information on the technology market, another study does exist that may not be considered to be independent. A set of estimates was prepared for the year 2000 at the Canada Centre for Remote Sensing (CCRS) by Ryerson (1994/95) in support of planning related to the Space Plan and the future focus of CCRS. The cut-off projection date of that study, 2000, makes it of limited use for this projection, although the approach to market projections may be useful to consider in the development of our study's market profile.

D.3.3 The Mapping and GPS Markets

Surveying and mapping have often been linked in their analysis, much as remote sensing and GIS have been. In a review of market studies, Batterham (1997) cites a number of estimates for this market area. "A 1996 feasibility study 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 the previously cited 1994 Daratech study, 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."

While these numbers are large and quite impressive in and of themselves, they all pale beside the recent acquisition of MapQuest by America Online (AOL) for $1.1 billion. AOL has seen the value of spatial data applied in a different non-traditional context. Market assessments for mapping and more traditional geomatics are, for the most part, based on straight line projections from the past to the future. They tend to look at what areas have been mapped and what areas have yet to be mapped. They tend not to take into consideration major shifts in demand, new markets, new applications and new requirements. They certainly have failed to take into consideration shifts in technology and the Internet and all of the ramifications. The value placed on mapping and the acquisition of mapping companies by non-traditional players (such as MDA, for example) is an indication that the mapping market has changed. We suggest here that the value that will be put on the future market is likely far larger than what has been stated in the studies referenced above.

GPS is another market area that has undergone explosive growth. According to Gibbons in the Big Book on GPS**,** the consensus of the industry places annual growth in GPS markets in the 25 to 40% range. The most aggressive forecast, cited by Allied Business Intelligence - ABI, places compound growth at 84% per year through 2004. The more aggressive projections assume "strong penetration into the wireless handset market and other embedded application-specific integrated circuit markets". A 1998 US Department of Commerce estimates worldwide sales at $6 billion in 1999, and at $16 billion by 2003. The ABI study suggests the 2005 sales will only be $14 Billion. A 1997 survey by Booze Allen and Hamilton projected a cumulative market in Europe from 1998 to 2007 for satellite positioning equipment and services as $38.5 billion. Frost and Sullivan project world wide cumulative sales from 2005 to 2023 (including both GPS and the European Galileo) to be about $250 billion.

In other words, dollar estimates are highly variable, as are growth projections. This leads Gibbons to note that quantifying and qualifying GPS markets is "a much more complicated undertaking than many of the reports will admit." This is in part a function of the size and nature of what is sold – everything from a $20 chip in another item, to a receiver that can cost $10,000. One study puts the number of chips at 7.6 million in 1999 (worth $148 million), increasing to over 162 million (worth $2.2 billion) in 2004. Gibbons concludes that what is needed is a GPS score-keeper.

To provide an indication of relevant market share by GPS segment, we refer to the US Department of Commerce study as cited by Gibbons. In it, sales by 2003 are projected to be as follows: car navigation - $4.7 billion; consumer – $3.8 billion; OEM - $.690 billion; surveying, mapping and GIS - $3.120 billion; aviation $0.71 billion; marine - $0.21 billion; military - $0.185 billion. Gibbons notes two trends: a 30% annual decrease in hardware costs and an increase in embedded software in commercial solutions.

There are also government policy factors that influence the market. The effect of Selective Availability (SA)[6], now removed, was critical. At present, the government must provide six years notice before changing free access to GPS. Europe has planned its own GPS system (Galileo) to ensure that control over such a critical tool is not subject to outside political pressures. Without SA, sales are expected to increase as much as 60%.

Other government policy decisions could also have a profound impact. One could envision a situation in which the government may require wireless communications service providers to have an emergency location capability. It is not hard to imagine the impact if every cell-phone in the USA was mandated to contain a GPS chip. The range of low-per-unit cost (but high total value) services could be immense. A number of these have been noted by Gibbons – from road-side assistance and traffic reports to emergency response.

Another area in which there is significant projected growth market is in land administration, mapping and other geomatics applications in developing countries. Ryerson and Batterham (2000) argue that geomatics is a fundamental part of a nation's infrastructure, a position supported by the 1999 UN Conference on Space held in Vienna. Williamson et all (2000) also argue that land administration is a key component of sustainable development. McGrath and Metcalfe (1999) have also outlined how important cadastral information is in development. Adding this together suggests that this area represents a market that goes far beyond what one normally associates with mapping. The fact that much of the market helps countries derive tax income (from land) and provides an asset (land) to assist poor rural residents in developing countries further suggests that modernization of records will be a growth area. While we have been unable to identify a quantitative source for this markets estimation, it can be supposed that it will be significant, albeit much of the labour provided will be local.

D.3.4 Summary and Conclusions

If we look at the numbers cited in the two previous sections, we can ask, as did Batterham, "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." For the 2003 to 2004 time frame the world's total geomatics annual market may be as high as $30 to 40 billion (US) dollars. This number excludes the cost of the space segment.

[6] Selective availability is the intentional degradation of the SPS signals by the Department of Defence. Without SA the potential accuracy is on the order of 10-30 meters vs. 100 meters with it.

D.4 Technology

D.4.1 Introduction

The geomatics market is driven in part by technology – technology resident in geomatics, as well as enabling technologies used by geomatics. Indeed, the argument can be made that geomatics has long been an enabling technology for other fields such as resource management and civil engineering. Now, however, that recognition is spreading to other fields such as retailing, banking, disaster response, and many other areas of human economic endeavour.

It is not surprising then to find that there are well over 40,000 technical articles on remote sensing, thousands of papers on GPS (and over 100 books), several mammoth volumes summarizing GIS, and a score of technical journals and trade magazines on surveying, mapping, and business geographics. We have not attempted to provide a comprehensive all-embracing technical review of this body of information with the time and resources allocated to this task. What we have done, based on the knowledge resident in the project team, is to review and summarize many of the key issues facing the field in order to help us perform our analysis of the sector.

There are a number of elements that make up technology. There are the enabling technologies – the Internet, telecommunications, software development tools, hardware, etc. These are discussed but only in general terms below insofar as they impact geomatics. Of prime importance to us here are the core technologies in geomatics – sensors, image analysis and display tools, spatial data integration, digital mapping tools, spatial decision engines, GPS receivers and related tools, etc.

D.4.2 Enabling Technologies

One of the critical elements in the field is the speed with which changes are being introduced in and by those technologies which we can say are enabling the development of geomatics. Most often mentioned is the tremendous increase in the capabilities of the PC accompanied by a tremendous decrease in their cost. The development of the Internet has also been noted as a major factor facilitating data collection and distribution in a number of studies, including the recently completed (in draft form) up-date of the Industry Canada report on Geomatics by Batterham. Less frequently mentioned is the fact that the PC is now found in the majority of work places and millions of homes in the developed world and to an increasing extent in many developing countries. This penetration, coupled with Internet access and wireless data delivery, can now place information in the hands of the individual, at the desk top or in the field, changing marketing, data delivery, and data use forever. Computer literacy in the developing world has already begun to change the competitive dynamic as more and more of the routine geomatics tasks are now being done offshore.

Another important enabling technology is telecommunications: one of the leading players in that area, Nortel Networks, has stated that their corporate goal is the “death of distance”. (Ottawa

Citizen, March 7, 2000) They seek to render distance a meaningless factor by using optical technology to improve bandwidth to move vast quantities of information faster and more reliably than was ever dreamt of even a few years ago. Recent demonstrations saw 6.4 terabits per second transferred over optical fibre. It should be clear to anyone involved in geomatics that anything that affects distance and how people react to distance, will have a fundamental impact on the geomatics business.

D.4.3 Core Technologies

D.4.3.1 An Overview

Geomatics, which some call the Geo-spatial technologies (EOM Magazine), has evolved out of surveying, mapping, GIS, and remote sensing. That evolution and the evolution of the technology as it relates to Canada is well documented in McGrath and Sebert (1999)[7]. Even before it was regarded as a single field (or single technology), there was a great deal of technical cross-fertilization. It is perhaps for this reason that many remote sensing and GIS organizations were started in mapping agencies. As more and more of the technologies developed in each sub-sector were seen as important to the other sub-sectors, a coming together was inevitable. The technologies and or approaches which have been important across more than one sector included things like geospatial data integration, image manipulation, data generalization, positional accuracy, image display, geo-spatial data output, 3-D visualization, etc.

While there has been this integration, much of the technical literature and information is still put forward in scientific and technical journals devoted to but one or two of the sub-sectors. Only Photogrammetric Engineering and Remote Sensing can be said to cover the entire field, although some others like Geomatica attempt to do so. For a comprehensive list of relevant scientific journals consult the various compendia such as the GIS Sourcebook, the Big Book on GPS, and the various web sites such as that operated by CCRS, ASPRS, ACSM, etc.

One of the interesting dilemmas in assembling this technology overview is in deciding which sub-sector to deal with first. Virtually every sub-sector has a symbiotic relationship in terms of technology with another of the sub-sectors. Surveying, which prepares the base for everything else, was selected as the first – and it is in surveying that we have covered GPS, which is also arguably the hottest and best known of the “new” geomatics technologies.

D.4.3.2 Surveying and GPS

Steady advances in technology have revolutionized the surveying profession over the past twenty years. These advances are quite visible at the annual trade shows such as the American Congress on Surveying and Mapping, or in any of the trade publications aimed at land surveyors. The future breakthroughs will likely be more in how positional information is applied rather than in how it is acquired. GPS is well documented in a single source – the Big Book on GPS.

---

[7] While it may be tempting to regard this book as up-to-date because of its 1999 publication date, much of the material in it was actually written in or prior to 1996.

Surveying can now be more accurate, faster, and done with far fewer people. Centimetre post processing is now possible and this level of accuracy is improving. One individual consulted concerning this review made the comment that "accuracy is addictive" – the more accurate the positional information people have, the more accurate they want it. Further, it is not the position information itself that has value, but rather what you do with that information. In this way then, surveying and the delivery of accurate position information is enabling other things such as intelligent transport, resource management, emergency service delivery, animal tracking, judicial and policing applications, etc.

McDonald (1999) has provided the most concise and clear discussion on GPS technology (especially for neophytes) that we have been able to find. He sees significant improvements. There will be new civil frequencies at L2 and L3c, leading to better signals, less interference, and improved precision. The new civil frequency at L5 is projected to support code rates ten times that of the C/A-code, with significant improvements across a range of important parameters. Military improvements will see more accurate and better power distribution, among other features.

Perhaps the key change noted by McDonald and others writing on GPS is the end of selective availability (SA), the policy under which the USA has restricted GPS accuracy. It was earlier announced that SA would be removed no later than 2006, and perhaps as early as this year or next. In fact, President Clinton announced the removal in May, 2000. The additional civil frequencies combined with the removal of SA will result in a ten-fold improvement - from 50 metre accuracy with 95% confidence to five metres. Improvements in GPS receivers, control segment redundancy and improved statistical estimation techniques will also lead to improved precision. Better spacecraft with more power and longer lifetimes will add to better availability, as would the fact that an increase from six to twelve satellites in view at any one time (up from the present four to six depending on topography) is being discussed.

In addition to all of the technical improvements detailed above, there are also, notes McDonald, significant improvements resulting from new augmentations including the US Coast Guard Differential Network, the Nationwide DGPS, the Federal Aviation Administration Systems, Europe's EGNOS, Japan's MSAS and the other DGPS systems. While there has been some concern about US military control, GPS has become the *de facto* global standard. It has been recognized that this has been a substantial economic engine for US industry – a lesson that may be applicable to some for the geomatics sub-sectors being examined here. It is to counter this military control and to gain the civilian opportunity that has resulted in the European $3.3 – 4.8 billion (Can $) Galileo system. A study has been done for Geomatics Canada (Natural Resources Canada) on the impact of enhanced GPS technology but it has yet to be released. We have also been told that Geomatics Canada has plans to develop a wide area differential service based on CACS. The Department has solicited funds from the provinces and has issued an RFP. Consideration is being given to the provision of a free service after the purchase of the decoder.

D.4.3.3 Mapping

The single most important advance within the field of mapping has been digital photogrammetry, sometimes referred to as soft-copy photogrammetry. This development has had a profound impact on mapping and that impact will, if anything accelerate over time as there is more of a need for baseline information on which to sit other geospatial data for the myriad applications now being identified.

The only guide or total source with which we are familiar is a small book titled The Fundamentals of Digital Photogrammetry (ISM, 1996 & 1999). A number of short articles explaining where this field is going have also been published by Pat Wong, the President of Vancouver-based ISM in trade publications (GIM, Photogrammetric Engineering and Remote Sensing), as well as by researchers and technical people at Leica. Recent advances (which have first been taken to market by Canadian industry) include the automation of certain photogrammetric operations, with the prospect of more such developments in the future. Automation of labour intensive activities obviously will have an impact on human resources.

The impacts cannot be overstated: the knowledge and skill of experienced technicians are now being replaced by software, costs of entering the business have dropped dramatically, costs of equipment maintenance have dropped to almost zero, costs of delivering product have dropped dramatically, products are far better than they have ever been before, and entry for developing countries is now a straightforward task almost as simple as buying Microsoft Office and a computer. One cost comparison is useful: it costs less to outfit a company with new software and computers than to maintain traditional precision optical equipment.

Another related recent development has been the release of a low cost stereo viewer on which one can do interpretations for direct linkage into a digital map environment. As more digital elevation model data become available, the need for and utility of such systems will become broader. Through these relatively low cost systems, digital map information will truly be available at the desk-top for users. This will spur the need for more digital map information, but may well see a transfer of some mapping activities from today's value added companies to the desks of the users – much as Power Point has allowed us all to make our own presentations without the need to go to a graphics artist.

Two other developments that have also had an impact come from the data acquisition side. The first of these is mapping using airborne radars (see the Intermap web site), and Interferometric SAR whereby digital elevation models can be made directly from radar and advanced processing based on the properties of the radar signal. These techniques have been covered (and advertised) in recent issues of EOM Magazine. Both of these techniques have already delivered mapping information in cloudy environments where traditional aerial photography has been unable to even "see" the ground, much less map it. The second tool is LIDAR – the use of lasers for terrain profiling and the creation of elevation information (Limp 2000). LIDARs are being used by a number of Canadian companies who have been in a pioneering position with this technology (Batterham and Ryerson (2000)).

Another data acquisition advance now in the prototype stage is the digital camera. While a variety of sensing devices and array-based cameras are on the market, none has the geometric fidelity required of an aerial mapping camera. Leica has presented papers on this development at a number of recent international conferences (e.g. Second International Conference on the Operationalization of Remote Sensing, 1999*)*, while ZI has issued press releases promising a similar development. The advantage of such a camera is that it will allow one to do away with aerial film and the scanning of aerial images, both of which are laborious, expensive elements of the mapping activity. Needless to say, the accuracy of positioning of the aircraft using tools developed elsewhere in geomatics has been significant in making this development possible.

D.4.3.4 GIS

A range of technology innovations are impacting GIS. According to a number of experts, the next few years will see more dramatic changes. Levinsohn, one of our project's Expert panel members writing in Geoworld in February of this year (Levinsohn, 2000) notes that technology is now concentrating on using the information, rather than, as in the past, capturing it, displaying it, and doing so quickly. The major innovations impacting GIS are going to be those advances that allow one to analyze the data, with the likely emphasis being on the underlying data structures. A number of advances are identified: object oriented spatial data base design, client-server data base architecture, oriented spatial data base structures, and enterprise data administration.

Limp (2000) details many of the same aspects in a wide-ranging assessment of both technology and how it is being used – equally important to the technology itself. Limp sees the technology making it possible to move geo-spatial data into the core of large (terabyte-sized) enterprise data bases. Oracle, IBM, and Sybase are all cited for this. Limp also notes the impact of high level software products that are "geared toward capable software developers". These allow complex software solutions to be embedded in other products, or even in the data themselves as delivered on the Internet or intranet. Limp has also noted that the Open GIS Consortium has played a key role in GIS technology affecting as it has the concept of interoperability to allow information integration and exchange. While not technology, the fact that MapPoint and other commercial offerings exist has spurred others in the field or on its periphery to both invest in and use the technology. This has been remarked on by Ryerson (1999) and Limp (2000). The fact that the client can now buy smaller amounts of information for a selected area is another innovation that has been made possible by the Internet and technology, but this is not strictly a technology-driven change.

Another issue, which is in part related to technology and in part to the broader question of what is geomatics, is the observation (or perhaps lament) of Mangold in EOM Magazine that the stand-alone GIS conference seems to be dying off. Some, like Mangold suggest that this is a bad thing, while others see it as a sign of maturation and the movement of GIS into the mainstream. Does the world need GIS conferences to discuss the technology, and if not, what does this imply for the field?

D.4.3.5 Remote Sensing

Remote sensing went through a remarkable growth from the early 1970s to the late 1980s. By then, however, most of the easy problems had been solved. Those remaining were technically and politically more challenging, and, in certain cases, simply awaited more powerful computers, better processing or better data. As might therefore be expected, many of the recent key developments in remote sensing are related to data acquisition (some noted above under mapping - interferometric SAR, LIDARS, etc). Others under data acquisition include high resolution satellite imagery, and hyperspectral remote sensing (from aircraft now and in the future from spacecraft). A recent proprietary study by Kirby, one of our Expert Panel, has identified a total of more than ten planned SAR EO space missions in the future.

MacDonald (1999), another of our expert panel, has reviewed a number of issues in making remote sensing technology operational, as well as a number of new missions using different sensors. This paper is a useful departure for those wanting a fundamental understanding of some of the current issues facing remote sensing. A key factor is the way in which information is extracted. MacDonald and others suggest that it is important to adopt a more quantitative approach to information extraction. Without a quantitative approach, information extraction will be less rigorous and results will certainly be far less repeatable.

Recent developments in remote sensing include:

Radar Imagery: A great deal of effort has gone into developing radar image processing capability, especially in Canada. The result has been a suite of processing software and capabilities that make complex radar imagery accessible to those who lack a complete understanding of how an image is formed. However, the availability of such software tends to mask a fundamental problem that exists: few people truly understand radar imagery. Interpreting radar is not easy, and will likely not move to the user's desk top as soon as will the interpretation for many other data sources.

High Spatial Resolution Imagery: As early as 1984 researchers noted that methods and algorithms developed for use with lower resolution Landsat Multispectral scanner data yielded poorer results when used with higher resolution imagery. This problem is only made worse with the now commercially available, high-resolution imagery, some of which can be delivered in stereo, and all of which can be draped over Digital Elevation Models (DEMs). Generalized image analysis methods do not seem to be able to cope with the greater spatial detail, stereo views, and the information on the context of the features being interpreted. It is, therefore, reasonable to predict that there will be a movement towards visual interpretation (techniques, tools, etc.). This, in turn, will have an impact on the type of person required to do interpretation. Many now suggest that some combination of local and discipline knowledge (forestry, agriculture, etc) combined with photo-interpretation skills will be more important than training in image analysis algorithms or systems.

Hyperspectral Imagery: Hyperspectral data involve many (from 64 to over 200) narrow (usually 10 nanometres or less) spectral bands. Understanding the data is difficult, requires significant computational power, and a much better developed understanding of the physics of the interaction of light with the objects being sensed than is required in traditional multispectral sensing. To get the maximum information from hyperspectral images requires that they not simply be regarded as another form of "photograph". After a decade of effort, data processing software and information extraction algorithms are available on a research basis. Processing software (for calibration, atmospheric correction, etc.) will become ready for an operational or user environment within the next five years. With this capability as the basis, one can expect that applications products in several areas will be generated on a routine basis.

While no hyperspectral satellite systems exist, there are a number of systems under discussion and a great deal has been learned through the application of the Canadian Itres *casi* airborne system. Several symposia and journal collections were published in the mid-late 1990s which contained a number of papers on hyperspectral applications (the Australiasian Symposium on Remote Sensing, 1996; Canadian Journal of Remote Sensing), with a great deal of excitement surrounding this technology. A great deal of work has been done on this technology in both the private sector (Itres Research) and at universities (See the work at York and Sherbrooke in particular). Recent developments have seen improvements in handling hyperspectral information which have in turn made its use much easier. New software tools are now reaching the market.

Implications for Applications: A number of interesting general observations can be made related to the application of remote sensing technology. The number of applications of remote sensing is growing. A recent study in India (Radhakrishnan, 2000) catalogued almost 200 separate uses of earth observation in that country. As well, far more sectors of the economy are now using the technology. Where it was once limited to government agencies and researchers, there is now a much wider user community – ranging from Non Governmental Organizations (from groups preserving wildlife habitat to those dealing with refugees) to a variety of private sector groups.

There is some divergence of opinion on what will happen with respect to how data are handled. One view suggests that delivery of information to the desk top, the increasing user-friendliness of information extraction systems, the movement to higher resolution imagery, the development of low cost viewers, will mean that more of the high level (where local knowledge and decision-making/intelligence is needed) value-added work will be done by the end users themselves. They will be working on their own simple systems using highly processed (geometrically and radiometrically) image data sets produced from the "smart sensors" of the future. The "bull work" - that involving repetitive tasks and not much decision making or local knowledge may well be done "off-shore" - i.e. not by value-added companies in developed countries. Lower cost high speed communications links will make such data movement virtually transparent in both time and geographically.

In this model, larger consumers of information may still tend to outsource the value adding work. Another view suggests that users will ask for information ready to make decisions on. This view, found in Europe and among some value-added companies, suggests that viewers are not needed. This is so because users will get information products and not data. In effect, users will, under this model, receive vector instead of simple raster data. Under this approach to information creation, the users will be giving the addition of value from their expertise to some third party.

D.5 Education

Canada has a long history in and strong reputation for its education and training in geomatics. Canada's offerings in this area run the gamut from traditional universities and college degrees and diplomas to courses offered on a for-profit basis by service and technology vendors. All groups are developing newer programs for delivery through the Internet. Like everything else in geomatics, education and training are changing at a dramatic rate. Entire courses in remote sensing and GIS are available at various web sites from Australia to the United States, and many places in-between, with many more expected to come. In Canada several well known institutions are looking at web-based training as an adjunct to their more traditional training, and in one case with which we are familiar, as a whole new offering.

A recent review of education and training in geomatics in Canada (Batterham and Ryerson, 2000) discusses what is offered in three distinct groupings: degree-granting institutions, diploma granting technical institutions, and commercial training.

D.5.1 Universities

As noted elsewhere, geomatics includes surveying, mapping, remote sensing, and GIS. Recognizing the underlying importance of geomatics, virtually every university in Canada offers some courses in one or more of these constituent fields. Indeed, several of the sub-fields of geomatics have been among the few to have grown in Canadian universities through the universities' near zero-growth period in the 1980s. The review points out that geomatics courses are often found in engineering, geography, forestry, environmental studies, earth sciences, space sciences, and the like making it difficult to comment on all the universities offering programs. What was done was to identify those that offer post-graduate programs or significant specialization in the field.

There are three universities that offer Bachelors, Masters and Doctorate level programs in surveying and mapping: University of New Brunswick, Laval University, and University of Calgary. The University of New Brunswick, (http://www.unb.ca/GGE/) was the first university in Canada to offer graduate and post-graduate programs in survey engineering (since 1994 called 'geodesy and geomatics engineering'). Graduates from this program can be found throughout industry and government across Canada, the United States and around the world. Since 1962 over 600 people have received undergraduate degrees – 18 in the most recent year for which we obtained information. Total graduate student enrolment exceeds 60 students, taught by a total of ten faculty members. Graduate students specialize in the fields of advanced engineering surveying; cadastral, land information, GIS and digital mapping; geodesy and precise navigation; hydrography and ocean mapping; mapping, charting and geodesy; and photogrammetry and remote sensing.

Laval University's surveying program was started in 1907 and was the first applied sciences program to be offered in Canada. Laval was also probably the first university in the world to offer a post-graduate degree in geomatics, an initiative that has contributed to geomatics becoming more prevalent in education. A major review was conducted in the mid-1980's that reflected the evolution of surveying and mapping sciences into a modern systemic field of study, integrating the fundamental disciplines involved in producing, analysing and managing spatial data and geographic information. Two options are offered: Geomatics Engineering and Land Geomatics, satisfying the respective requirements of the Canadian Engineering Accreditation Board (CEAB) and the Canadian Council of Land Surveyors (CCLS) as well as those of the Ordre des Arpenteurs-Géomètres du Québec (OAGQ).

Education in geomatics is primarily provided by the Department of Geomatics Sciences (http://geomatique.scg.ulaval.ca) which has the largest enrolment in geomatics among the G7 countries. Laval also has a well known geomatics research centre (Centre for Research in Geomatics, CRG) (http://www.crg.ulaval.ca) and is home to GEOIDE, (http://www.geoide.ulaval.ca) a Canadian Network of Excellence, along with other leaders in the field including the University of new Brunswick and the University of Calgary.

At the graduate level, M.Sc. and Ph.D. programs in geomatics sciences are offered covering cartography and geographic information systems; geodesy; hydrography; land legislation; metrology and microgeodesy; photogrammetry and remote sensing. The international flavour of the program can be seen from the web site – which is presented not only in French and English, but also in Spanish. The Centre comprise 12 Researchers, 8 Associate Researchers, 8 Collaborative Researchers, 7 Postdoctoral Fellows, 62 M.Sc. and Ph.D. Students and 13 Employees. Since 1990, the Laval has produced 106 M.Sc. and Ph.D. graduates.

The University of Calgary's geomatics engineering program, while not as long established as those of the University of New Brunswick and University of Laval, is an important component in research and the education of geomatics professionals in Canada. With growth to eighteen or nineteen faculty members expected in the near term, it will be the largest program in Canada, and one of the fastest growing in the world. It has 120 students in Years 2 to 4, 61 graduate students from 12 countries, and $2.3 million in research funding. The program has four major areas of research: positioning and navigation (which receives the majority of funding); the study of the gravity field; photogrammetry, remote sensing, geographic information systems and land studies; and precise engineering surveys. With the emphasis on positioning and navigation, it is rapidly becoming the focal point of an emerging western centre of high technology that has, as a primary focus, the development and application of GPS.

Relative newcomers in education have been the fields of GIS and remote sensing, both of which are also covered by the three university programs cited above. GPS, also a "new" field has, for historical reasons, been more closely linked with programs in surveying, such as that found at Calgary.

The web site at CCRS has a comprehensive listing of the institutions involved in remote sensing and GIS. Offering the Ph.D. degree are the University of Waterloo which granted the first Ph.D. with specialization in remote sensing in 1975 (http://watleo.uwaterloo.ca/), Laval, Sherbrooke University (http://www.callisto.si.usherb.ca/~cartel/), and the University of British Columbia (http://www.interchg.ubc.ca/firms/firms.html). A more recent addition to this list is York (http://www.eol.ists.ca/), which has a particular strength in the physics of remote sensing. Sherbrooke, with 12 faculty members with Doctorate degrees, has one of the world's largest educational programs dedicated to remote sensing.

As noted in the CCRS web site, Ph.D. degrees are often granted between remote sensing and some other field. This has been done at McGill (http://www.geog.mcgill.ca/) and Calgary in geography (http://www.ucalgary.ca/UofC/faculties/SS/GEOG/), and in agriculture at the University of Alberta (http://web.cs.ualberta.ca/Ualberta.html). Like many schools, Alberta has programs in remote sensing and GIS in several different departments.

Other university programs with geomatics activities include Memorial (http://www.mun.ca/) in geography and engineering, University of Québec at Chicoutimi (http://www.uqac.uquebec.ca/), University of Québec at Montréal (UQAM) (http://www.uqam.ca/), Carleton (http:// www.carleton.ca/ geography/ geography/ geo_info.html), Guelph (http:// www.uoguelph.ca/ lrs/), Western Ontario (http:// www.uwo.ca/ geog/ grad_pgm/ graduate.htm), Winnipeg (http:// www.coned.uwinnipeg.ca/ remote/ remote.htm), University of Manitoba (http:// www.umanitoba.ca/ faculties/ arts/ geography/ ceos/ index.html), Regina (http:// www.uregina.ca/ arts/ geog), University of Lethbridge (http:// home.uleth.ca/ geo/), Simon Fraser (http:// www.sfu.ca/ geography), and Victoria (http:// office.geog.uvic.ca/ index.shtml)

D.5.2 Colleges

There are a number of colleges involved in geomatics – including GIS, mapping, and remote sensing. Those best known and covered by the review are the College of Geographic Sciences (COGS) in Nova Scotia (http://www.cogs.ns.ca/), and the British Columbia Institute of Technology in British Columbia. (http://www.gis.bcit.bc.ca/). Other programs include those at the South Alberta Institute of Technology, Northern Alberta Institute of Technology, College de Limoilou in Quebec, and Sir Sanford Fleming College in Ontario. Most technical colleges in Canada do offer courses in one or more of the sub-fields of GIS, remote sensing, mapping, etc.

D.5.3 Commercial Programs

Virtually all of the commercial entities involved in geomatics in Canada offer courses that support the use of the technology which they have developed or sell. This includes companies such as PCI Geomatics in Ontario, ISM Systemap in British Columbia, ESRI Canada in Ontario, Intermap of Calgary, and the many providers of GPS technology. Others offer specialized training in their specific areas of expertise. This includes groups like Aerde in Nova Scotia, Hauts Monts in Quebec, Noetix in Ontario, and Linnet Geomatics in Manitoba. Many of these companies can be accessed through the GIS Source book from GIAC (http://www.giac.ca) or from the CCRS web site.

D.6 Human Resources

The most recent study directly applicable to human resources and the geomatics sector was that entitled People and Skills in the Canadian Geomatics Sector: **Positioning for the Future (1994)**. The introductory sentences in that study are useful to recall in terms of the objective of the current study to produce an HR strategy for geomatics:

> *"Changing markets, coupled with the growing adoption of new technologies have profound implications for the people working in the geomatics sector. Geomatics is a knowledge industry. Highly skilled people are a key factor in the competitiveness of geomatics firms worldwide. However, geomatics skills are perishable."*

It is clear that some of the key trends identified in that study (continuing technological change, greater involvement of users, "traditional boundaries are no longer relevant", and low cost customization of highly specialized products) are still being discussed by those erecting today's signposts to the future.

It was stated that "the industry is in flux and consequently there is confusion in geomatics." The literature surveyed in this review suggests that this is still the case. The role of the information highway was noted, and this is one of the few general studies to note its importance. This too is to be commended, although the importance of the information highway to HR issues has, we would suggest, gone far beyond what most would have projected for geomatics.

The section on "*Future Requirements for People, Skills, and Working Relationships*" seems to have hit the mark in a number of areas, but not all. The keys topics noted in this section are ones that may serve as a useful point of departure in the current study. These topics are: employment growth in larger private sector firms and small niche firms, growth in non-standard work and employment relationships, fewer and fewer jobs requiring no formal post-secondary education, more complementarity of skills, skills in information and technology and systems, adoption of new softer skills, team skills, workforce diversity, management skills, training skills, and flexibility.

With the luxury of hindsight, the 1994 study can be seen to have missed several marks. While it was noted that the users' role would change, the importance of that change and the implications were not well identified. The degree to which "users" would become important players was not foreseen. The report assumed that geomatics firms would be delivering large amounts of data or information to users through projects. It is not clear that this will be the prevalent model. Similarly, it was not envisioned that major outside players would be as important to the market or technology. Companies like Microsoft, Boeing, Lockheed Martin, etc. have all played key roles in the past few years – roles that seem destined to increase. Further, it was not anticipated that as more and more geomatics employees gain skills in information and technology and systems, they leave for competing sectors. However, the uncertainty and chance of error in predictions was recognized in one of the concluding sentences: "The new requirements are not readily predictable … we cannot easily map out the terrain ahead and define a specific curriculum."

Another paper related to the subject is that by McGrath and Metcalfe (1999). This paper discusses human resources and training in the context of the development and management of land registration and cadastral services. Detailed needs and analysis of human resources and training issues are provided. Given the size of this market, the potential roles for Canadian industry to do the work, and the potential role for Canadian educators and trainers to help build the in-country human resources, this assessment is one that should be commended in terms of developing a human resources strategy for Canada.

In addition to the papers with a geomatics focus, we have had the opportunity to review papers on HR in the advanced technology sector for indications of future trends. While these reports are somewhat dated, they do contain some useful insights and an historical perspective. These reports are from 1991 (Software and National Competitiveness), 1994 (From Potential to Prosperity: Human Resources in the Canadian Consulting Engineering Industry), and 1996

(Human Resources Study of the Canadian Telecommunications Industry). As a group, they are instructive for geomatics.

The software report deals with a tool used within geomatics. The study of civil engineering deals with a service industry, not unlike the geomatics service industry. Indeed, one of the ways some consulting engineering firms have tried to reinvent themselves is by offering geomatics services as part of their offerings to differentiate themselves from their competitors and add more value for their clients. The telecommunications study covers an industry that is like geomatics – it is both an enabling technology and one that is a part of a nation's infrastructure. The telecommunications industry has experienced profound changes even in the short time since the study was published in 1996. Several key trends and their impact seem to have been either missed or underestimated, and changes in the industry were not predicted. The weaknesses and their cause provide an interesting point of comparison with results being generated by the present study.

While the 1991 software study is dated, there are some interesting parallels that can be drawn with today's geomatics industry. Like the software industry then, geomatics is not well understood as a source for and driver of a broader sector of the economy. This study and its recommendations provide some useful insights into how that situation may be corrected.

The 1994 study of the consulting engineering profession is in several key respects relevant to geomatics industry. The report identifies the following broad trends: "continuing re-structuring; opportunities for innovation and value-added in services … driven by new technologies, downsizing of in-house…groups, and cost-reduction pressures; international markets are becoming increasingly important as domestic demands remain static; the role … as independent providers … to final clients is diminishing; new organizational and ownership structures are emerging; changing demand structures are giving rise to needs for new services and service delivery mechanisms". These are all consistent with comments noted in this literature review about the geomatics industry. Consequently, the issues, challenges and recommendations are also potentially germane.

D.7 References

1. Asker, J.R. (1992) "Remote Sensing Sales Grow with Expanding Data Needs" ***Aviation Week and Space Technology*** July 13. Pp46-59
2. Aubrey, M.C. (1986) ***Australian Users and Usage of Remote Sensing: A National Survey*** Technical Field Surveys Pty Ltd. Contract Report for Department of Resources and Industry and CSIRO. North Ryde, NSW. Australia.
3. Batterham et al (1993) ***Report of the Geomatics Competitiveness Working Group***, GIAC, Ottawa.
4. Batterham, R. (1997) ***Geomatics in Canada: An Industry Overview*** Contract Report for Industry Canada. Ottawa. February 1997.
5. Batterham, R. and R.A. Ryerson (2000 in press) ***Geomatics in Canada to the Year 2000 A Technology and Industry Structure Overview*** A Report for Industry Canada. Management Consulting in Geomatics.

6. Booz Allen and Hamilton (1995) "North American GPS Markets: Analysis of SA and other Policy Alternatives" in ***GPS – A Shared National Asset*** Washington, D.C.

7. Brisco, B. et al (1998) Precision Agriculture and the Role of Remote Sensing ***C. J. Remote Sensing*** 24 (3) 315-27.
8. Canadian Space Agency (1999) ***Global Space Sector market Trends and Drivers*** (Satellite Communications, Remote Sensing, and Space Robotics)
9. Canadian Consulate General (1998) ***US Geomatics Update.*** Canadian Consulate, Chicago, Illinois. February.
10. Canadian Institute of Surveying (1985) ***Report on the Task Force on the Surveying and Mapping Industry in Canada*** Report for the Dept. of Regional Economic Expansion, Ottawa.
11. Canadian Institute of Geomatics. (1994) ***Geomatics Human Resources: Final Report.*** August 1994. 21 pp plus appendices.
12. Canadian Institute of Geomatics and Geomatics Industry Association of Canada. (1998) ***Geomatics Technology Roadmap***. Prepared for Industry Canada and Natural Resources Canada.
13. Canadian Institute of Surveying. (1985***) Report of the Task force on the Surveying and Mapping Industry in Canada***. Prepared for the Department of Regional Industrial Expansion.
14. DARATECH, Inc. (1996) ***Geographic Information Systems Markets and Opportunities*** Daratech, Inc. Cambridge, Mass. USA.
15. Employment and Immigration Canada (1991) ***Software and National Competitiveness: Human Resource Issues and Opportuntiies*** Report IM-180/2/92. Ottawa.
16. ESYS Ltd. (1998) ***European EO Industry and Market: 1998 SnapShot – Fiinal Report***
17. Euroconsult (1991) ***EO Data Processing and Interpretation Services: Analysis of the Sector and the Conditions for its Development***. Study for the European Communities DG XII. Paris. June 1991.
18. Frost and Sullivan (1998) ***From Imagery to Information: The Commercial Remote Sensing Industry on the Threshold of Space-Based High Resolution Era.*** San Jose, CA, USA.
19. Geomatics Industry Association of Canada. 1997***. 1996 Study of the Impacts of the Changing Market Structure on the Canadian Geomatics Industry***. Prepared for Industry Canada, Ottawa. 32p.
20. Gibbon, G. (ed.) (1999) ***GPS World's Big Book of GPS*** Advanstar Communications, Eugene, Oregon. USA.
21. GIS World Inc. (1994) ***GIS Strategies: A Quarterly Analysis of the Worldwide GIS Market***. 3 (1)
22. ***GIS World Source Book*** 1996
23. Group Secor (1994) ***Les Competences reliees a l'espace des entreprises et des organismes de recherche au Quebec*** Montreal, Quebec
24. Human Resources Development Canada (1996) ***From Potential to Prosperity: Human Resources Study in the Canadian Consulting Engineering Industry*** Ottawa.
25. Human Resources Development Canada (1996) ***Human Resources Study of the Canadian Telecommunications Industry*** Ottawa.
26. IACG (1996) ***Barriers to the Use of Geomatics Data*** Interagency Committee on Geomatics, Working Group on Coordination and Cooperation. Geomatics Canada, Natural Resources Canada. 21 pp

27. Industry Canada (1989) ***B.O.S.S. Directory of Canadian Surveyors and Mappers***
28. Industry Canada (1991) ***Report on the Status of the Geomatics Industry in Canada***
29. ISM (1996 & 1999) ***The Fundamentals of Digital Photogrammetry*** International Systemap, Vancouver B.C. (84 pp)
30. Jenkins, B and A. Shaw (1998) ***European EO Industry and Market: 1998 Snapshot - Final Report***, ESYS Contract Report Contract 14093-1998-06 F1ED ISP GB. Project Number 98196. For the Space Applications Institute of the Joint Research Centre. Reference Number ESYS-98196-RPT-02. December.
31. KPMG (1998) ***The Satellite Remote Sensing Industry: A Global Review*** KPMG Peat Marwick.
32. Levinsohn, A. (2000) "GIS Moves from Computer Aided Mapping to Spatial Knowledge Representation" ***Geoworld*** 02/2000, p. 28.
33. Limp, F. (2000) "Ride the Waves of Innovation" ***Geoworld***. March 2000. pp 30-33.
34. MacDonald, J. S. (1999) "the New Generation of EO Spacecraft and It's Impacts on Operationalization" Keynote Paper ***Second International Symposium on Operationalization of Remote Sensing***, Enschede, The Netherlands. August 1999.
35. Maritime Geomatics Board (1992) ***Maritime Geomatics Strategy.*** 32 pp + appendices
36. May, G.A. and J.D. Bossler (1991) ***Mapsat Market Review*** Ohio State University ITD/Space Technology Center and Center for Mapping (on a contract to NASA Office of Commercial Programs).
37. McDonald, K. (1999) "Modernization in a Nutshell" In Gibbon, G. (ed.) (1999) ***GPS World's Big Book of GPS*** Advanstar Communications, Eugene, Oregon. USA.. p.29.
38. McGrath, G. and L. Sebert (eds.) (1999) ***Mapping a Northern Land*** McGill and Queens University Press. Montreal and Kingston.
39. McGrath, G. and W. S. Metcalf (1999) ***Aspects of Cadastral Modernisation: the Private Sector, Human Resources and Training*** Theme 2: Delivering effective cadastral and land registration services to the public. United Nations Economic Commission For Europe Meeting Of Officials On Land Administration (Mola), Workshop On Managing And Developing Effective Land Registration And Cadastral Services. London. September 1999.
40. Merrill Lynch (1998) ***Global Satellite Marketplace***
41. NASA (1994) ***Commercial Remote Sensing National Workshop: Notes*** Denver, CO, USA. John C. Stennis Space Centre.
42. National Academy of Public Administration (1998) ***Geographic Information for the 21st Century: Building a Strategy for the Nation*** Report for the BLM, USGS, and NOC. Washington.
43. 1998 ***National County Spatial Information Technology Survey Results***
44. National Science Foundation ***Human Resources for Science and Technology: the Asia Region*** (And others in the Surveys of Science Resource series 93-303. (Jean M. Johnson: Principal Author)
45. Radhakrishnan, K. (2000) ***Some Strategies for the Management of the Indian Earth Observation System.*** Ph.D. Thesis, Dept. of Industrial Engineering and Management. Indian Institute of Technology. Kharagpur. India.
46. Rochon, G. (1999) ***Réflexion sur la diffusion des DRS au Québec.*** Softmap, Montreal, Quebec.

47. Ryerson, R.A. and R. Batterham (2000) "An Approach to the Development of a Sustainable National Geomatics Infrastructure" ***Photogrammetric Engineering and Remote Sensing*** 66 (1) Jan. 2000. Pp. 17-28.
48. Ryerson, R.A., E. Jurkevics, M. D. Thompson, and T. Cary (1999) A New Industrial Paradigm for Remote Sensing: 2000 and Beyond. Keynote Paper ***Second International Symposium on Operationalization of Remote Sensing***, Enschede, The Netherlands. August 1999. A shortened version was published in ***GeoAsiaPacific*** Feb/March 2000.
49. Ryerson, R.A. (1999) ***Recent Changes in the Canadian Value -Added Remote Sensing Industry, its Access to the US Market, and an Assessment of Future Industry Structure*** A Contract Report for: Dr. Marc D'Iorio, Chief, Industrial Cooperation, Canada Centre for Remote Sensing, Natural Resources Canada. Contract Serial Number 99-0656 File Number 23413-8-B077. Contains Proprietary Information: Expurgated version Published by Ryerson et al (1999)
50. Ryerson, R.A. (1999) ***A Market Study On Hyperspectral Data Use and Value Added Services for Canada and its Industry*** A Proprietary Contract Report. Canadian Space Agency.
51. Ryerson, R.A. (1994/95) ***Past Present and Future Markets for Remote Sensing*** Canada Centre for Remote Sensing, Natural Resources Canada. Ottawa. Restricted Circulation
52. SAR Corporation (1998) ***Disaster Management User Requirement's Study*** Space Technologies Contract Report for the Canadian Space Agency, March 1998.Contract 9F025-7-1024
53. SpaceVest et al (1997) ***State of the Space Industry*** SpaceVest, Reston, VA, USA.
54. Tkach, S. (1992) ***Slip Sliding Away: Is the US Losing its Lead in the Commercial RS Industry: A Case for a US Industrial Policy*** Graduate Research Paper. University of Denver. Prof. Richard Lee, Supervisor.
55. UN/ESCAP, (1994) ***Ministerial Conference on Space Applications for Development in Asia and the Pacific: Beijing Declaration on Space Technology Applications for Environmentally Sound and Sustainable Development in Asia and the Pacific. Strategy for Regional Cooperation and Action Plan.*** September 19-24, 1994. Beijing, China. United Nations, New York.
56. UN/ESCAP (1997) ***Proceedings of the Meetings of the Regional Working Groups on Space Application for Sustainable Development*** UN New York.
57. UN/ESCAP, (1999) ***Ministerial Conference on Space Applications for Development in Asia and the Pacific*** November 1999. New Delhi.. United Nations, New York.
58. US Congress Office of Technology Assessment (1993) ***The Future of Remote Sensing from Space: Civilian Satellites and Systems***. OTA-ISC-558. US Government Printing Office. Washington, DC.
59. Williamson, I. Et al (1999) "The Evolving Role of Land Administration in Support of Sustainable Development" ***The Australian Surveyor*** 44 (2)
60. Wilson, J.D. (2000) "The Internet Dominates – Even in GIS" ***Geoworld*** 02/2000, p. 66

D.8 Conferences and Continuing Series

1. ASPRS/ACSM Annual Meetings
2. Asian Connerence on Remote Sensing
3. Canadian Symposia on Remote Sensing

4. ERIM Symposia
5. Commonwealth Surveyors
6. ICA
7. ISPRS
8. Photogrametric Engineering and Remote Sensing
9. Geomatica
10. ITC Journal
11. UN Cartographic Conferences
12. Asian Journal of Remote Sensing
13. EOM Magazine (USA)
14. GIS World (USA)
15. GIS Asia Pacific (Asia)
16. GIS User (Australia)
17. Proceedings of various ESCAP meetings

D.9 Web Pages

1. GIAC
2. Industry Canada
3. Geomatics Canada (and various constituent Directorates)
4. Provincial agencies
5. US National Science Foundation
6. Universities and Colleges (Canada, USA, Australia, France, Germany, etc.)
7. UNESCO
8. ITC
9. UN
10. CIG, CASI, ASPRS, ACSM.
11. Industry links from above

Appendix E

Survey Forms

Geomatics Sector • Human Resources Study

Prepared by:

Canadian Council of Land Surveyors
Canadian Institute of Geomatics
Geomatics Industry Association of Canada

Education Survey

A. Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in geomatics, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated a strategic study of the sector. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study.

An important part of the study is this survey of the geomatics educational institutions. Other surveys are being initated for users, professionals, research organizations and industry. The survey results will be used to develop profiles of the geomatics industry, markets, technology trends, education capabilities, and human resource outlook.

Your survey response is crucial to the success of the study. In appreciation for your efforts in completing the survey, we are pleased to be able to enter you in draws for eTrex hand-held GPS receivers. Five draws will be held over the period of the survey. The earlier your response is received, the more draws you will be eligible for. If you would like to be entered into the draws, please provide us with your Email address.

Email address (only required for entry into the draw): ____________________

Please be assured that your responses will be held in the strictest confidence. You may choose not to answer any question with which you feel uncomfortable. Responses will only be released in aggregate, and will not be attributable to any individual or organization.

Note: In the following questions, additional explanations and definitions can be obtained by clicking on the highlighted words.

B. About Your Organization

What is the name of your organization?

1. Where is your organization located?

(Click here to choose) ▼

2. Does your organization have a web page where we can obtain more information?

Web page:

3. At which levels does your organization provide geomatics education and training?

	Significant	**Some**	**None**
Courses	○	○	○
Certificates	○	○	○
Diplomas	○	○	○
Degrees	○	○	○
Graduate Degrees	○	○	○

4. In what geomatics areas does your organization provide education and training?

	Significant	Some	None
Cartography:	○	○	○
Navigation and positioning:	○	○	○
GIS:	○	○	○
Decision support:	○	○	○
Geodesy:	○	○	○
Land surveying:	○	○	○
Hydrography:	○	○	○
Remote sensing:	○	○	○
Photogrammetry:	○	○	○
Other:	○	○	○

If other, please specify:

5. In your opinion, what types of geomatics skills will be in demand in the future?

6. What supporting skill does your organization provide with its geomatics education and training?

	Significant	Some	None
Linguistic	○	○	○
Cultural sensitivity	○	○	○
Business	○	○	○
Entrepreneurship	○	○	○
Other	○	○	○

If other, please specify:

7. For which geomatics markets does your organization provide education and training?

	Significant	Some	None
Natural Resources - Agriculture	○	○	○
Natural Resources - Forestry	○	○	○
Natural Resources - Fisheries	○	○	○
Natural Resources - Oil and gas	○	○	○
Natural Resources - Geology and mining	○	○	○
Environment	○	○	○
Property	○	○	○
Infrastructure - Engineering and construction	○	○	○
Infrastructure - Transportation	○	○	○
Infrastructure - Utilities	○	○	○
Health	○	○	○
Emergency preparedness and defence	○	○	○
Commerce	○	○	○
Education	○	○	○
Society/consumer/entertainment	○	○	○
Other	○	○	○

If other, please specify:

8. What is the total enrolment in your geomatics programs this year?

Total enrolment:

9. From 2001 through to the end of 2002, by what percentage does your organization expect to see enrolment in geomatics programs and courses change?

% Change in enrolment:

C. Education and Training

10. How does your institution keep abreast of market and technological changes in geomatics that could impact course content?

	Very Important	Important	Not Important
Monitor other educational and training institutions	○	○	○
Formal and informal links with industry	○	○	○
Accreditation process	○	○	○
Other	○	○	○

If other, please specify:

11. What barriers are there to keeping courses up to date?

- ☐ Personnel
- ☐ Information on needs
- ☐ Costs
- ☐ Other

If other, please specify:

12. What emerging educational technologies is your institution using to deliver geomatics education and training?

- ☐ Distance education
- ☐ Web-based training
- ☐ Video conferencing
- ☐ Other

If other, please specify:

13a. Is there a need for certification of geomatics professionals?

○ Yes ○ No

13b. If so, for what types of skills or occupations?

13c. If so, for what reasons?

	Very Important	Important	Not Important
To satisfy a legal requirement	○	○	○
To address health and safety concerns	○	○	○
To enhance the credibility of staff	○	○	○
To facilitate more efficient and effective recruitment of staff	○	○	○
To help geomatics professionals with career building	○	○	○
Other	○	○	○

If other, please specify:

14. What types of jobs have your graduates obtained?

15. Where have your graduates gone?

	Many	Some	Few
Regional	○	○	○
National	○	○	○
USA	○	○	○
Other International	○	○	○

16. In your opinion, what are the major issues facing geomatics educational and training institutions?

D. Business and Market Issues

17. In your opinion, what are the main factors influencing change in the geomatics sector?

	Very influential	Influential	Not influential
Business environment - international	○	○	○
Business environment - national	○	○	○
Business environment - regional	○	○	○
Industry restructuring	○	○	○
Commodity prices	○	○	○
Consumer demand	○	○	○
Government policies	○	○	○
Internet	○	○	○
Pricing of data	○	○	○
Technology	○	○	○
Other	○	○	○

If other, please comment:

18. How important to the success of your organization are partnerships and strategic alliances with the following types of organizatic

	Very important	Important	Not important
Government	○	○	○
Clients	○	○	○
Suppliers	○	○	○
Geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Research institutes	○	○	○
Education institutes	○	○	○
Other	○	○	○

If other, please specify:

19. How important is your organization's use of the Internet in the following areas?

	Very important	Important	Not important
Marketing	○	○	○
Sales	○	○	○
Research	○	○	○
Delivery of education and training	○	○	○

20. In your opinion, what are the growth prospects for the following geomatics areas?

	Growth	Flat	Decline	No opinion
Cartography	○	○	○	○
Navigation and Positioning	○	○	○	○
GIS	○	○	○	○
Decision support	○	○	○	○
Geodesy	○	○	○	○
Land surveying	○	○	○	○
Hydrography	○	○	○	○
Remote sensing	○	○	○	○
Photogrammetry	○	○	○	○
Consulting	○	○	○	○
Other	○	○	○	○

If other, please specify:

21. In your opinion, what are the growth prospects for the following geomatics client markets?

	Growth	Flat	Decline	No opinion
Natural Resources - Agriculture	○	○	○	○
Natural Resources - Forestry	○	○	○	○
Natural Resources - Fisheries	○	○	○	○
Natural Resources - Oil and gas	○	○	○	○
Natural Resources - Geology and mining	○	○	○	○
Environment	○	○	○	○
Property	○	○	○	○
Infrastructure - Engineering and construction	○	○	○	○
Infrastructure - Transportation	○	○	○	○
Infrastructure - Utilities	○	○	○	○
Health	○	○	○	○
Emergency preparedness and defence	○	○	○	○
Commerce	○	○	○	○
Education	○	○	○	○
Society/consumer/entertainment	○	○	○	○
Other	○	○	○	○

If other, please specify:

22. In your opinion, what are the geomatics growth prospects for the following regions?

	Growth	Flat	Decline	No opinion
Domestic	○	○	○	○
Australia / New Zealand	○	○	○	○
Africa and the Middle East	○	○	○	○
Asia - Eastern	○	○	○	○
Asia - Southeastern	○	○	○	○
Asia - Southern	○	○	○	○
Commonwealth of Independent States	○	○	○	○
Europe - Eastern	○	○	○	○
Europe - Western	○	○	○	○
Mexico	○	○	○	○
Latin America and Caribbean	○	○	○	○
United States	○	○	○	○

E. Technology Issues

23. How important are the following technologies for the future of geomatics?

	Very Important	Important	Not Important
Navigation and Positioning	○	○	○
Geoid mapping	○	○	○
Radar imaging	○	○	○
High resolution optical imaging	○	○	○
Hyperspectral imaging	○	○	○
Image analysis	○	○	○
Digital photogrammetry	○	○	○
Geographic information systems	○	○	○
Data visualization	○	○	○
Digital elevation model generatio	○	○	○
Real time mapping	○	○	○
Data fusion and generalization	○	○	○
Communications and distribution	○	○	○
Internet applications	○	○	○
Geospatial data	○	○	○
User applications and solutions	○	○	○
Artificial intelligence & expert sy stems	○	○	○
Decision support tools	○	○	○
Other	○	○	○

If other, please specify:

F. Human Resources

24. Of your organization's geomatics staff, what percentage are female?

Female: %

25. What is the percentage of your organization's geomatics staff in the following geomatics areas?

Cartography %: [ ]

Navigation and Positioning %: [ ]

GIS %: [ ]

Decision support %: [ ]

Geodesy %: [ ]

Land surveying %: [ ]

Hydrography%: [ ]

Remote sensing %: [ ]

Photogrammetry %: [ ]

Consulting %: [ ]

Other %: [ ]

If other, please specify:

[ ]

26. What percentage of your organization's geomatics staff is in the following age groups?

Less than 30 years old %: [ ]

30 to less than 45 years old %: [ ]

45 to less than 60 years old %: [ ]

More than 60 years old %: [ ]

27. What percentage of your organization's geomatics staff has attained the following levels of education?

High school : % [ ]

College diploma : % [ ]

College diploma in geomatics : % [ ]

University degree : % [ ]

University degree with diploma in geomatics : % [ ]

University degree in geomatics: % [ ]

28. Is the rate of turnover of your organization's geomatics staff a problem?

○ Yes ○ No

29. What are the factors affecting turnover of your geomatics staff?

	Very Important	Important	Not Important
Salary levels	○	○	○
Workplace environment	○	○	○
Advancement opportunities	○	○	○
Interest in work	○	○	○
Other	○	○	○

If other, please specify:

30. How difficult is it for your organization to hire geomatics staff with the following types of capabilities?

	Very difficult	Difficult	Not difficult	Not Applicable
Operational/Research	○	○	○	○
Management	○	○	○	○
Sales	○	○	○	○
Information Technology	○	○	○	○
Teaching	○	○	○	○

31. From which groups do you tend to hire your geomatics staff?

	Often	Sometimes	Rarely
Universities	○	○	○
Colleges	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Government	○	○	○
Other	○	○	○

If other, please specify:

32. To which groups do you tend to lose your geomatics staff?

	Often	Sometimes	Rarely
Universities	○	○	○
Colleges	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Government	○	○	○
Other	○	○	○

If other, please specify:

33. From which regions do you tend to obtain geomatics staff?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

34. To which regions do your geomatics staff tend to move?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

35. What is the distribution of the employment status of your organization's geomatics staff?

Independent Contractors: %

Casual: %

Term: %

Permanent part-time: %

Permanent full-time: %

G. General

36. We would like to send a survey to a selection of geomatics professionals. Would you please provide us with the Email addresses of a number of your graduates and geomatics staff?

37. Please provide any comments that you would like to make here.

Thank you for taking the time to complete this survey. Remember to enter your Email address at the top of this survey if you would like to be entered in the draw for a hand-held GPS receiver. Select Submit Survey now to send your responses to us.

Review

A. Background

B. About Your Organization

C. Education and Training

D. Business and Market Issues

E. Technology Issues

F. Human Resources

G. General

Geomatics Sector • Human Resources Study

Prepared by:

Canadian Council of Land Surveyors
Canadian Institute of Geomatics
Geomatics Industry Association of Canada

Industry Survey

A. Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in geomatics, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated a strategic study of the sector. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study.

An important part of the study is this survey of the geomatics industry. Other surveys are being initated for users, professionals, research organizations and educational institutions. The survey results will be used to develop profiles of the geomatics industry, markets, technology trends, education capabilities, and human resource outlook.

Your survey response is crucial to the success of the study. In appreciation for your efforts in completing the survey, we are pleased to be able to enter you in draws for eTrex hand-held GPS receivers. Five draws will be held over the period of the survey. The earlier your response is received, the more draws you will be eligible for. If you would like to be entered into the draws, please provide us with your Email address.

Email address: ____________________

Please be assured that your responses will be held in the strictest confidence. You may choose not to answer any question with which you feel uncomfortable. Responses will only be released in aggregate, and will not be attributable to any individual or organization.

Note: In the following questions, additional explanations and definitions can be obtained by clicking on the highlighted words.

B. About Your Organization

What is the name of your organization?

1. Where is your organization's head office located?

(Click here to choose) ▼

2. Does your organization have a web page where we can obtain more information?

Web page:

3. What is the number of staff in your organization?

Total staff:

Geomatics staff:

4. Please enter the distribution of your organization's geomatics staff by region:

Alberta %:

British Columbia %:

Manitoba %:

New Brunswick %:

Newfoundland %:

Nova Scotia %:

Ontario %:

P.E.I %:

Quebec %:

Saskatchewan %:

Territories %:

Foreign - United States %:

Foreign - Non United States %:

5. Please indicate in which geomatics business areas your organization is involved.

	Significant	Some	None
Data	○	○	○
Hardware	○	○	○
Software	○	○	○
Services	○	○	○

6. Please enter the value of your organization's sales for 1999.

Total sales: $m

Geomatics sales: $m

7. Please enter the distribution of your organization's geomatics sales for 1999 in the following geomatics areas:

Cartography %:

Navigation and Positioning %:

GIS %:

Decision support %:

Geodesy %:

Land surveying %:

Hydrography%:

Remote sensing %:

Photogrammetry %:

Consulting %:

Other %:

If other, please specify:

8. Please enter the distribution of your organization's geomatics sales for 1999 in the following regions:

Domestic %: [ ]

Austronesia %: [ ]

Africa and the Middle East %: [ ]

Asia - Eastern %: [ ]

Asia - Southeastern %: [ ]

Asia - Southern %: [ ]

Asia - Central %: [ ]

Europe - Eastern %: [ ]

Europe - Western %: [ ]

Mexico %: [ ]

Latin America and Caribbean %: [ ]

United States %: [ ]

9. In which domestic regions are your organization's clients?

	Significant	Some	None
Atlantic Canada	○	○	○
British Columbia	○	○	○
Ontario	○	○	○
Prairies	○	○	○
Quebec	○	○	○
Territories	○	○	○

10. In which markets are your organization's clients?

	Significant	Some	None
Natural Resources - Agriculture	○	○	○
Natural Resources - Forestry	○	○	○
Natural Resources - Fisheries	○	○	○
Natural Resources - Oil and gas	○	○	○
Natural Resources - Geology and mining	○	○	○
Environment	○	○	○
Property	○	○	○
Infrastructure - Engineering and construction	○	○	○
Infrastructure - Transportation	○	○	○
Infrastructure - Utilities	○	○	○
Health	○	○	○
Emergency preparedness and defence	○	○	○
Commerce	○	○	○
Education	○	○	○
Society/consumer/entertainment	○	○	○
Other	○	○	○

If other, please specify:

11. Please enter the distribution of your organization's geomatics clients between the public and private sectors?

Public sector: %

Private sector - Companies: %

Private sector - Individuals: %

12. From 2001 through to the end of 2002, by what percentage does your organization expect to grow?

% Growth in sales:

% Growth in employment:

C. Business and Market Issues

13. In your opinion, what are the main factors influencing change in the geomatics sector?

	Very influential	Influential	Not influential
Business environment - international	○	○	○
Business environment - national	○	○	○
Business environment - regional	○	○	○
Industry restructuring	○	○	○
Commodity prices	○	○	○
Consumer demand	○	○	○
Government policies	○	○	○
Internet	○	○	○
Pricing of data	○	○	○
Technology	○	○	○
Other	○	○	○

If other, please comment.

14. How influential to your organization's domestic and international market development are the following barriers?

	Very influential	Influential	Not influential
Ability of the market to absorb new ideas	○	○	○
Access to capital	○	○	○
Absence of standards	○	○	○
Access to data	○	○	○
Cost of doing business internationally	○	○	○
Cost of technology	○	○	○
Non-tariff barriers - provincial	○	○	○
Non-tariff barriers - international	○	○	○
Pricing of data	○	○	○
Problems with receiving payment	○	○	○
Subsidized competition from abroad	○	○	○
Other	○	○	○

If other, please comment

15. How important to the success of your business activities are partnerships and strategic alliances with the following types of organizations?

	Very important	Important	Not important
Government	○	○	○
Clients	○	○	○
Suppliers	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Research institutes	○	○	○
Education institutes	○	○	○
Other	○	○	○

If other, please specify:

16. How important is your organization's use of the Internet in the following areas?

	Very important	Important	Not important
Marketing	○	○	○
Sales	○	○	○
Research	○	○	○
Delivery of products and services	○	○	○
In-house and outsourced operations	○	○	○

17. In your opinion, what are the growth prospects for the following geomatics areas?

	Growth	Flat	Decline	No opinion
Cartography	○	○	○	○
Navigation and Positioning	○	○	○	○
GIS	○	○	○	○
Decision support	○	○	○	○
Geodesy	○	○	○	○
Land surveying	○	○	○	○
Hydrography	○	○	○	○
Remote sensing	○	○	○	○
Photogrammetry	○	○	○	○
Consulting	○	○	○	○
Other	○	○	○	○

If other, please specify:

18. In your opinion, what are the growth prospects for the following geomatics client markets?

	Growth	Flat	Decline	No opinion
Natural Resources - Agriculture	○	○	○	○
Natural Resources - Forestry	○	○	○	○
Natural Resources - Fisheries	○	○	○	○
Natural Resources - Oil and gas	○	○	○	○
Natural Resources - Geology and mining	○	○	○	○
Environment	○	○	○	○
Property	○	○	○	○
Infrastructure - Engineering and construction	○	○	○	○
Infrastructure - Transportation	○	○	○	○
Infrastructure - Utilities	○	○	○	○
Health	○	○	○	○
Emergency preparedness and defence	○	○	○	○
Commerce	○	○	○	○
Education	○	○	○	○
Society/consumer/entertainment	○	○	○	○
Other	○	○	○	○

If other, please specify:

19. In your opinion, what are the geomatics growth prospects for the following regions?

	Growth	Flat	Decline	No opinion
Domestic	○	○	○	○
Austronesia	○	○	○	○
Africa and the Middle East	○	○	○	○
Asia - Eastern	○	○	○	○
Asia - Southeastern	○	○	○	○
Asia - Southern	○	○	○	○
Asia - Central	○	○	○	○
Europe - Eastern	○	○	○	○
Europe - Western	○	○	○	○
Mexico	○	○	○	○
Latin America and Caribbean	○	○	○	○
United States	○	○	○	○

D. Technology Issues

20. How important are the following technologies for your organization's future business activity?

	Very Important	Important	Not Important
Navigation and Positioning	○	○	○
Geoid mapping	○	○	○
Radar imaging	○	○	○
High resolution optical imaging	○	○	○
Hyperspectral imaging	○	○	○
Image analysis	○	○	○
Digital photogrammetry	○	○	○
Geographic information systems	○	○	○
Data visualization	○	○	○
Digital elevation model generatio	○	○	○
Real time mapping	○	○	○
Data fusion and generalization	○	○	○
Communications and distribution	○	○	○
Internet applications	○	○	○
Geospatial data	○	○	○
User applications and solutions	○	○	○
Artificial intelligence & expert systems	○	○	○
Decision support tools	○	○	○
Other	○	○	○

If other, please specify:

E. Research and Development

21. How much did your organization spend on geomatics R&D for 1999? If none, please go to Section F

Total geomatics R&D spending: $

22. In what geomatics areas does your organization carry out R&D?

	Significant	Some	None
Data	○	○	○
Hardware	○	○	○
Software	○	○	○
Services	○	○	○

23. How is your organization's geomatics R&D funded?

Internal: %

Public sector contracts : %

Private sector contracts : %

Tax credits : %

Other: %

If other, please specify:

24. With whom does your organization perform collaborative geomatics R&D?

	Significant	Some	None
Government	○	○	○
Client firms	○	○	○
Other geomatics firms	○	○	○
Education/Research Institutes	○	○	○
Other	○	○	○

If other, please specify:

25. How important are the following factors to the amount of geomatics R&D your company performs?

	Very Important	Important	Not Important
Availability of capital	○	○	○
Availability of government support programs	○	○	○
Market demand for new products or services	○	○	○
Availability of R&D personnel	○	○	○
Other	○	○	○

25b. If other, please specify:

F. Human Resources

26. Of your organization's geomatics staff, what percentage are female?

Female: %

27. What is the percentage of your organization's geomatics staff in the following geomatics areas?

Cartography %:

Navigation and Positioning %:

GIS %:

Decision support %:

Geodesy %:

Land surveying %:

Hydrography%:

Remote sensing %:

Photogrammetry %:

Consulting %:

Other %:

If other, please specify:

[ ]

28. What percentage of your organization's geomatics staff is in the following age groups?

Less than 30 years old %: [ ]

30 to less than 45 years old %: [ ]

45 to less than 60 years old %: [ ]

More than 60 years old %: [ ]

29a. Would certification of geomatics staff be of value in your business?

○ Yes ○ No

29b. If so, for what types of staff?

[ ]

29c. If so, for what reasons?

	Very Important	Important	Not Important
To satisfy a legal requirement	○	○	○
To address health and safety concerns	○	○	○
To enhance the credibility of staff	○	○	○
To facilitate more efficient and effective recruitment of staff	○	○	○
To help geomatics professionals with career building	○	○	○
Other	○	○	○

If other, please specify:

[ ]

30. What percentage of your organization's geomatics staff has attained the following levels of education?

High school : % [ ]
College diploma : % [ ]
College diploma in geomatics : % [ ]
University degree : % [ ]
University degree with diploma in geomatics : % [ ]
University degree in geomatics: % [ ]

31. Is the rate of turnover of your organization's geomatics staff a problem?

○ Yes ○ No

32. What are the factors affecting turnover of your geomatics staff?

	Very Important	Important	Not Important
Salary levels	○	○	○
Workplace environment	○	○	○
Advancement opportunities	○	○	○
Interest in work	○	○	○
Other	○	○	○

If other, please specify:

[ ]

33. What types of geomatics skills will be in particular demand by your organization in the future?

[ ]

34. What types of supporting skills will be important to your organization in the future?

	Very Important	Important	Not Important
Linguistic	○	○	○
Cultural sensitivity	○	○	○
Business	○	○	○
Entrepreneurship	○	○	○
Other	○	○	○

If other, please specify:

35. How difficult is it for your organization to hire geomatics staff with the following types of capabilities?

	Very difficult	Difficult	Not difficult	N/A
Operational/Research	○	○	○	○
Management	○	○	○	○
Sales	○	○	○	○
Information Technology	○	○	○	○
Teaching	○	○	○	○

36. From which groups do you tend to hire your geomatics staff?

	Often	Sometimes	Rarely
Universities	○	○	○
Colleges	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Government	○	○	○
Other	○	○	○

If other, please specify:

37. To which groups do you tend to lose your geomatics staff?

	Often	Sometimes	Rarely
Universities	○	○	○
Colleges	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Government	○	○	○
Other	○	○	○

If other, please specify:

38. From which regions do you tend to obtain geomatics staff?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

39. To which regions do your geomatics staff tend to move?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

40. What is the distribution of the employment status of your organization's geomatics staff?

Independent Contractors: %

Casual: %

Term: %

Permanent part-time: %

Permanent full-time: %

G. Education and Training

41. What type of training, education or mentoring does your organization provide for its geomatics staff?

	Significant	Some	None
Mentoring	○	○	○
In-house training	○	○	○
Specialized courses	○	○	○
Support for external degree or diploma programs	○	○	○
Other	○	○	○

If other, please specify:

42. How much did your organization spend on training and education in 1999?

43. To what extent does your organization train for managerial succession?

	Significant	Some	None
In-house training	○	○	○
Specialised courses	○	○	○
Support for external degree programs	○	○	○
Other	○	○	○

43b. If other, please specify:

44. We would like to send a survey to a selection of geomatics staff. Would you please provide us with the Email addresses of a number of your geomatics st

45. We would like to send a survey to a selection of geomatics users. Would you please provide us with the names and Email addresses of a number of your clients for geomatics products services?

46. Please provide any comments that you would like to make here.

Thank you for taking the time to complete this survey. Remember to enter your Email address at the top of this survey if you would like to be entered in the draw for a hand-held GPS receiver. Select Submit Survey now to send your responses to us.

Review

A. Background

B. About Your Organization

C. Business and Market Issues

D. Technology Issues

E. Research and Development

F. Human Resources

G. Education and Training

Geomatics Sector • Human Resources Study

Prepared by:

Canadian Council of Land Surveyors
Canadian Institute of Geomatics
Geomatics Industry Association of Canada

Professionals Survey

A. Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in geomatics, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated a strategic study of the sector. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study.

An important part of the study is this survey of the geomatics professionals. Other surveys are being initated for industry, users, research organizations and educational institutions. The survey results will be used to develop profiles of the geomatics industry, markets, technology trends, education capabilities, and human resource outlook.

Your survey response is crucial to the success of the study. In appreciation for your efforts in completing the survey, we are pleased to be able to enter you in draws for eTrex hand-held GPS receivers. Five draws will be held over the period of the survey. The earlier your response is received, the more draws you will be eligible for. If you would like to be entered into the draws, please provide us with your Email address.

Email address: ____________________

Please be assured that your responses will be held in the strictest confidence. You may choose not to answer any question with which you feel uncomfortable. Responses will only be released in aggregate, and will not be attributable to any individual or organization.

Note: In the following questions, additional explanations and definitions can be obtained by clicking on the highlighted words.

B. About Your Organization

What is the name of your organization?

1. In which province or territory do you conduct the majority of your business?

(Click here to choose) ▼

2. Does your organization have a web page where we can obtain more information?

Web page:

3. What is the number of staff in your organization?

Total staff:

Geomatics staff:

4. Please indicate your organization's sector?

Public sector %

Private sector %

Academic sector %

5. Which best describes yours organization?

- ○ Geomatics user
- ○ Geomatics products and services provider
- ○ Research organization
- ○ Education and training organization

C. Business and Market Issues

6. In your opinion, what are the main factors influencing change in the geomatics sector?

	Very influential	Influential	Not influential
Business environment - international	○	○	○
Business environment - national	○	○	○
Business environment - regional	○	○	○
Industry restructuring	○	○	○
Commodity prices	○	○	○
Consumer demand	○	○	○
Government policies	○	○	○
Internet	○	○	○
Pricing of data	○	○	○
Technology	○	○	○
Other	○	○	○

If other, please comment.

7. In your opinion, what are the growth prospects for the following geomatics areas?

	Growth	Flat	Decline	No opinion
Cartography	○	○	○	○
Navigation and Positioning	○	○	○	○
GIS	○	○	○	○
Decision support	○	○	○	○
Geodesy	○	○	○	○
Land surveying	○	○	○	○
Hydrography	○	○	○	○
Remote sensing	○	○	○	○
Photogrammetry	○	○	○	○
Consulting	○	○	○	○
Other	○	○	○	○

If other, please comment.

8. In your opinion, what are the growth prospects for the following geomatics markets?

	Growth	Flat	Decline	No opinion
Natural Resources - Agriculture	○	○	○	○
Natural Resources - Forestry	○	○	○	○
Natural Resources - Fisheries	○	○	○	○
Natural Resources - Oil and gas	○	○	○	○
Natural Resources - Geology and mining	○	○	○	○
Environment	○	○	○	○
Property	○	○	○	○
Infrastructure - Engineering and construction	○	○	○	○
Infrastructure - Transportation	○	○	○	○
Infrastructure - Utilities	○	○	○	○
Health	○	○	○	○
Emergency preparedness and defence	○	○	○	○
Commerce	○	○	○	○
Education	○	○	○	○
Society/consumer/entertainment	○	○	○	○
Other	○	○	○	○

If other, please comment:

9. In your opinion, what are the geomatics growth prospects for the following regions?

	Growth	Flat	Decline	No opinion
Domestic	○	○	○	○
Austronesia	○	○	○	○
Africa and the Middle East	○	○	○	○
Asia - Eastern	○	○	○	○
Asia - Southeastern	○	○	○	○
Asia - Southern	○	○	○	○
Asia - Central	○	○	○	○
Europe - Eastern	○	○	○	○
Europe - Western	○	○	○	○
Mexico	○	○	○	○
Latin America and Caribbean	○	○	○	○
United States	○	○	○	○

10. In your opinion, what types of geomatics skills will be in demand in the future?

11. What types of supporting skills will be important in the future?

	Very Important	Important	Not Important
Linguistic	○	○	○
Cultural sensitivity	○	○	○
Business	○	○	○
Entrepreneurship	○	○	○
Other	○	○	○

If other, please comment:

D. About You

12. What is your gender?

○ Male ○ Female

13. In which age group are you?

○ Less than 30 years old
○ 30 to less than 45 years old
○ 45 to less than 60 years old
○ More than 60 years old

14. What level of education have you attained?

○ High school
○ College diploma
○ College diploma in geomatics
○ University degree
○ University degree with diploma in geomatics
○ University degree in geomatics

15. In which range is your salary?

○ Less than $20k
○ $20k to less than $40k
○ $40k to less than $60k
○ $60k to less than $80k
○ $80k to less than $100k
○ $100k to less than $120k
○ More than $120k

16. How long have you worked as a geomatics professional?

Length of service: [ ]

17. In which geomatics business areas are you involved.

	Significant	Some	None
Data	○	○	○
Hardware	○	○	○
Software	○	○	○
Services	○	○	○

18. In which markets are you involved?

	Significant	Some	None
Natural Resources - Agriculture	○	○	◉
Natural Resources - Forestry	○	○	◉
Natural Resources - Fisheries	○	○	◉
Natural Resources - Oil and gas	○	○	◉
Natural Resources - Geology and mining	○	○	◉
Environment	○	○	◉
Property	○	○	◉
Infrastructure - Engineering and construction	○	○	◉
Infrastructure - Transportation	○	○	◉
Infrastructure - Utilities	○	○	◉
Health	○	○	◉
Emergency preparedness and defence	○	○	◉
Commerce	○	○	◉
Education	○	○	◉
Society/consumer/entertainment	○	○	◉
Other	○	○	◉

If other, please comment:

19. In which geomatics areas do you work?

- ☐ Cartography:
- ☐ Navigation and positioning
- ☐ GIS:
- ☐ Decision support:
- ☐ Geodesy:
- ☐ Land surveying:
- ☐ Hydrography
- ☐ Remote sensing:
- ☐ Photogrammetry:
- ☐ Consulting:

20. In which technologies do you have expertise?

	Significant	Some	None
Navigation and Positioning	○	○	◉
Geoid mapping	○	○	◉
Radar imaging	○	○	◉
High resolution optical imaging	○	○	◉
Hyperspectral imaging	○	○	◉
Image analysis	○	○	◉
Digital photogrammetry (softcopy)	○	○	◉
Geographic information systems	○	○	◉
Data visualization	○	○	◉
Digital elevation model generation	○	○	◉
Real time mapping	○	○	◉
Data fusion and generalization	○	○	◉
Communications and distribution	○	○	◉
Internet applications	○	○	◉
Geospatial data	○	○	◉
User applications and solutions	○	○	◉
Artificial intelligence & expert systems	○	○	◉
Decision support tools	○	○	◉
Other	○	○	◉

If other, please comment:

21. How many organizations have you worked for in your professional career?

Number:

22. What are the factors that would tend to make you move between organizations?

	Very Important	Important	Not Important
Salary levels	○	○	○
Workplace environment	○	○	○
Advancement opportunities	○	○	○
Interest in work	○	○	○
Other	○	○	○

If other, please comment:

23. In which regions have you worked?

- ☐ BC and Territories
- ☐ Prairies
- ☐ Ontario
- ☐ Quebec
- ☐ Atlantic
- ☐ United States
- ☐ Other international

24. What is your employment status?

Independent Contractors %:

Casual %

Term %

Permanent part-time %

Permanent full-time %

E. Education and Training

25. Please rate the adequacy of the geomatics education and training that you have received.

	Very Good	Good	Poor
Mentoring	○	○	○
In-house training	○	○	○
Specialized courses	○	○	○
Self-study	○	○	○
Diploma programs	○	○	○
Degree programs	○	○	○
Other	○	○	○

If other, please comment:

26. Please rate the importance of these different modes of education and training delivery to the field of geomatics?

	Very Good	Good	Poor
Mentoring	○	○	○
In-house training	○	○	○
Specialized courses	○	○	○
Self-study	○	○	○
Diploma programs	○	○	○
Degree programs	○	○	○
Other	○	○	○

If other, please comment:

27. Would certification of geomatics professionals be of interest to you?

○ Yes ○ No

27a. If so, for what types of skills or occupations?

27b. If so, for what reasons?

	Very Important	Important	Not Important
To satisfy a legal requirement	○	○	○
To address health and safety concerns	○	○	○
To enhance the credibility of staff	○	○	○
To facilitate more efficient and effective recruitment of staff	○	○	○
To help geomatics professionals with career building	○	○	○
Other	○	○	○

If other, please comment:

F. General

28. We would like to send a survey to a selection of geomatics professionals. Would you please provide us with the Email addresses of some of your geomatics colleagues?

29. Please provide any additional comments that you would like to make here.

Thank you for taking the time to complete this survey. Remember to enter your Email address at the top of this survey if you would like to be entered in the draw for a GPS receiver. Select Submit Survey now to send your responses to us.

Review

Geomatics Sector • Human Resources Study

Prepared by:
Canadian Council of Land Surveyors
Canadian Institute of Geomatics
Geomatics Industry Association of Canada

Research Survey

A. Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in geomatics, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated a strategic study of the sector. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study.

An important part of the study is this survey of geomatics research organizations . Other surveys are being initated for users, professionals, industry and educational institutions. The survey results will be used to develop profiles of the geomatics industry, markets, technology trends, education capabilities, and human resource outlook.

Your survey response is crucial to the success of the study. In appreciation for your efforts in completing the survey, we are pleased to be able to enter you in draws for eTrex hand-held GPS receivers. Five draws will be held over the period of the survey. The earlier your response is received, the more draws you will be eligible for. If you would like to be entered into the draws, please provide us with your Email address.

Email address: ____________________

Please be assured that your responses will be held in the strictest confidence. You may choose not to answer any question with which you feel uncomfortable. Responses will only be released in aggregate, and will not be attributable to any individual or organization.

Note: In the following questions, additional explanations and definitions can be obtained by clicking on the highlighted words.

B. About Your Organization

What is the name of your organization?

1. Where is your main research facility located?

(Click here to choose) ▼

2. Does your organization have a web page where we can obtain more information?

Web page:

3. What is the number of geomatics staff in your organization?

Geomatics staff:

4. Please enter the distribution of your organization's geomatics staff by region:

Alberta %:
British Columbia %:
Manitoba %:
New Brunswick %:
Newfoundland %:
Nova Scotia %:
Ontario %:
P.E.I %:
Quebec %:
Saskatchewan %:
Territories %:
Foreign - United States %:
Foreign - Non United States %

5. Please enter the distribution of your organization's geomatics research for 1999 in the following geomatics areas:

Cartography %:

Navigation and positioning %:

GIS %:

Decision support %:

Geodesy %:

Land surveying %:

Hydrography %:

Remote sensing %:

Photogrammetry %:

Consulting %:

Other %:

If other, please specify:

6. For which markets does your organization do research?

	Significant	Some	None
Natural Resources - Agriculture	○	○	○
Natural Resources - Forestry	○	○	○
Natural Resources - Fisheries	○	○	○
Natural Resources - Oil and gas	○	○	○
Natural Resources - Geology and mining	○	○	○
Environment	○	○	○
Property	○	○	○
Infrastructure - Engineering and construction	○	○	○
Infrastructure - Transportation	○	○	○
Infrastructure - Utilities	○	○	○
Health	○	○	○
Emergency preparedness and defence	○	○	○
Commerce	○	○	○
Education	○	○	○
Society/consumer/entertainment	○	○	○
Other	○	○	○

If other, please specify:

7. Please indicate your organization's sector?

Public sector %:

Private sector %:

Academic sector %:

8. From 2001 through to the end of 2002, by what percentage does your organization expect to grow?

% Growth in research value:

C. Business and Market Issues

9. In your opinion, what are the main factors influencing change in the geomatics sector?

	Very influential	Influential	Not influential
Business environment - international	○	○	○
Business environment - national	○	○	○
Business environment - regional	○	○	○
Industry Restructuring	○	○	○
Commodity prices	○	○	○
Consumer demand	○	○	○
Government policies	○	○	○
Internet	○	○	○
Pricing of data	○	○	○
Technology	○	○	○
Other	○	○	○

If other, please specify:

10. How important to the success of your research activities are partnerships and strategic alliances with the following types of organizations?

	Very important	Important	Not important
Government	○	○	○
Clients	○	○	○
Suppliers	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Research institutes	○	○	○
Education institutes	○	○	○
Other	○	○	○

If other, please specify:

11. How important is your organization's use of the Internet?

- ◯ Very important
- ◯ Important
- ◯ Not important

12. In your opinion, what are the growth prospects for the following geomatics areas?

	Growth	Flat	Decline	No opinion
Cartography	◯	◯	◯	◯
Navigation and positioning	◯	◯	◯	◯
GIS	◯	◯	◯	◯
Decision support	◯	◯	◯	◯
Geodesy	◯	◯	◯	◯
Land surveying	◯	◯	◯	◯
Hydrography	◯	◯	◯	◯
Remote sensing	◯	◯	◯	◯
Photogrammetry	◯	◯	◯	◯
Consulting	◯	◯	◯	◯
Other	◯	◯	◯	◯

If other, please specify:

13. In your opinion, what are the growth prospects for the following geomatics client markets?

	Growth	Flat	Decline	No opinion
Natural Resources - Agriculture	○	○	○	○
Natural Resources - Forestry	○	○	○	○
Natural Resources - Fisheries	○	○	○	○
Natural Resources - Oil and gas	○	○	○	○
Natural Resources - Geology and mining	○	○	○	○
Environment	○	○	○	○
Property	○	○	○	○
Infrastructure - Engineering and construction	○	○	○	○
Infrastructure - Transportation	○	○	○	○
Infrastructure - Utilities	○	○	○	○
Health	○	○	○	○
Emergency preparedness and defence	○	○	○	○
Commerce	○	○	○	○
Education	○	○	○	○
Society/consumer/entertainment	○	○	○	○
Other	○	○	○	○

If other, please specify:

14. In your opinion, what are the geomatics growth prospects for the following regions?

	Growth	Flat	Decline	No opinion
Domestic	○	○	○	○
Austronesia	○	○	○	○
Africa and the Middle East	○	○	○	○
Asia - Eastern	○	○	○	○
Asia - Southeastern	○	○	○	○
Asia - Southern	○	○	○	○
Asia - Central	○	○	○	○
Europe - Eastern	○	○	○	○
Europe - Western	○	○	○	○
Mexico	○	○	○	○
Latin America and Caribbean	○	○	○	○
United States	○	○	○	○

D. Technology Issues

15. How important are the following technologies for the geomatics industry?

	Very Important	Important	Not Important
Navigation and Positioning	○	○	○
Geoid mapping	○	○	○
Radar imaging	○	○	○
High resolution optical imaging	○	○	○
Hyperspectral imaging	○	○	○
Image analysis	○	○	○
Digital photogrammetry	○	○	○
Geographic information systems	○	○	○
Data visualization	○	○	○
Digital elevation model generation	○	○	○
Real time mapping	○	○	○
Data fusion and generalization	○	○	○
Communications and distribution	○	○	○
Internet applications	○	○	○
Geospatial data	○	○	○
User applications and solutions	○	○	○
Artificial intelligence & expert systems	○	○	○
Decision support tools	○	○	○
Embedded technologies	○	○	○
Other	○	○	○

If other, please specify:

E. Research and Development

16. How much did your organization spend on geomatics R&D for 1999?

Geomatics R&D spending: $

17. In what geomatics business areas does your organization carry out R&D?

	Significant	Some	None
Data	○	○	○
Hardware	○	○	○
Software	○	○	○
Services	○	○	○

18. How is your organization's geomatics R&D funded?

Internal % [ ]

Public sector contract % [ ]

Private sector contract % [ ]

Tax credits % [ ]

Other % [ ]

If other, please specify:

[ ]

19. With whom does your organization perform collaborative geomatics R&D?

	Significant	Some	None
Government	○	○	○
Client firms	○	○	○
Other geomatics firms	○	○	○
Education/Research Institutes	○	○	○
Other	○	○	○

If other, please specify:

[ ]

20. How important are the following factors to the amount of geomatics R&D your company performs?

	Very Important	Important	Not Important
Availability of capital	○	○	○
Availability of government support programs	○	○	○
Market demand for new products or services	○	○	○
Availability of R&D personnel	○	○	○
Other	○	○	○

If other, please specify:

F. Human Resources

22. Of your organization's geomatics staff, what percentage are female?

Female: %

23. What is the percentage of your organization's geomatics staff in the following geomatics areas?

Cartography %:

Navigation and positioning %:

GIS %:

Decision support %:

Geodesy %:

Land surveying %:

Hydrography %:

Remote sensing %:

Photogrammetry %:

Consulting %:

24. What percentage of your organization's geomatics staff is in the following age groups?

Less than 30 years old %:

30 to less than 45 years old %:

45 to less than 60 years old %:

More than 60 years old %:

25. Would certification of geomatics staff be of value in your business?

○ Yes ○ No

25a. If so, for what types of staff?

25b. If so, for what reasons?

	Very Important	Important	Not Important
To satisfy a legal requirement	○	○	○
To address health and safety concerns	○	○	○
To enhance the credibility of staff	○	○	○
To facilitate more efficient and effective recruitment of staff	○	○	○
To help geomatics professionals with career building	○	○	○
Other	○	○	○

If other, please specify:

26. What percentage of your organization's geomatics staff has attained the following levels of education?

High school % [ ]
College diploma % [ ]
College diploma in geomatics % [ ]
University degree % [ ]
University degree with diploma in geomatics % [ ]
University degree in geomatics % [ ]

27. Is the rate of turnover of your organization's geomatics staff a problem?

○ Yes ○ No

28. What are the factors affecting turnover of your geomatics staff?

	Very Important	**Important**	**Not Important**
Salary levels	○	○	○
Workplace environment	○	○	○
Advancement opportunities	○	○	○
Interest in work	○	○	○
Other	○	○	○

If other, please specify:

[ ]

29. What types of geomatics skills will be in particular demand by your organization in the future?

[ ]

30. What types of supporting skills will be important to your organization in the future?

	Very Important	Important	Not Important
Linguistic			
Cultural sensitivity			
Business			
Entrepreneurship			
Other			

30b. If other, please specify:

31. How difficult is it for your organization to hire geomatics staff with the following types of capabilities?

	Very difficult	Difficult	Not difficult	Not Applicable
Operational/Research				
Management				
Sales				
Information Technology				
Teaching				

32. From which groups do you tend to hire your geomatics staff?

	Often	Sometimes	Rarely
Universities			
Colleges			
Geomatics companies			
Non-geomatics companies			
Government			
Other			

If other, please specify:

33. To which groups do you tend to lose your geomatics staff?

	Often	Sometimes	Rarely
Universities	○	○	○
Colleges	○	○	○
Geomatics companies	○	○	○
Non-geomatics companies	○	○	○
Government	○	○	○
Other	○	○	○

If other, please specify:

34. From which regions do you tend to obtain geomatics staff?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

35. To which regions do your geomatics staff tend to move?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

36. What is the distribution of the employment status of your organization's geomatics staff?

Independent Contractors %: [ ]

Casual % [ ]

Term % [ ]

Permanent part-time % [ ]

Permanent full-time % [ ]

G. Education and Training

37. What type of training, education or mentoring does your organization provide for its geomatics staff?

	Significant	Some	None
Mentoring	○	○	○
In-house training	○	○	○
Specialized courses	○	○	○
Support for external degree or diploma programs	○	○	○
Other	○	○	○

If other, please specify:

[ ]

H. General

38. We would like to send a survey to a selection of geomatics staff. Would you please provide us with the Email addresses of a number of your geomatics st

[ ]

39. Please provide any comments that you would like to make here.

[ ]

Thank you for taking the time to complete this survey. Remember to enter your Email address at the top of this survey if you would like to be entered in the draw for a GPS receiver. Select Submit Survey now to send your responses to us.

Review

A. Background

B. About Your Organization

C. Business and Market Issues

D. Technology Issues

E. Research and Development

F. Human Resources

G. Education and Training

H. General

Geomatics Sector • Human Resources Study

Prepared by:

Canadian Council of Land Surveyors
Canadian Institute of Geomatics
Geomatics Industry Association of Canada

Users Survey

A. Background

Geomatics is an important and rapidly changing sector in the Canadian economy that is facing challenges to its markets, structure, and human resources. To assist Canada in remaining a strong player in geomatics, the Canadian Council of Land Surveyors (CCLS), the Canadian Institute of Geomatics (CIG), and the Geomatics Industry Association of Canada (GIAC), in cooperation with Human Resources Development Canada, have initiated a strategic study of the sector. Hickling Arthurs Low (HAL) Corporation has been commissioned to undertake the study.

An important part of the study is this survey of geomatics users. Other surveys are being initated for industry, professionals, research organizations and educational institutions. The survey results will be used to develop profiles of the geomatics industry, markets, technology trends, education capabilities, and human resource outlook.

Your survey response is crucial to the success of the study. In appreciation for your efforts in completing the survey, we are pleased to be able to enter you in draws for eTrex hand-held GPS receivers. Five draws will be held over the period of the survey. The earlier your response is received, the more draws you will be eligible for. If you would like to be entered into the draws, please provide us with your Email address.

Email address: [ ]

Please be assured that your responses will be held in the strictest confidence. You may choose not to answer any question with which you feel uncomfortable. Responses will only be released in aggregate, and will not be attributable to any individual or organization.

Note: In the following questions, additional explanations and definitions can be obtained by clicking on the highlighted words.

B. About Your Organization

What is the name of your organization?

1. Where is your organization's head office located?

(Click here to choose) ▼

2. Does your organization have a web page where we can obtain more information?

Web page:

3. What is the number of staff in your organization?

Total staff:

Geomatics staff:

4. Please enter the distribution of your organization's geomatics staff by region:

Alberta %:

British Columbia %:

Manitoba %:

New Brunswick %:

Newfoundland %:

Nova Scotia %:

Ontario %:

P.E.I %:

Quebec %:

Saskatchewan %:

Territories %:

Foreign - United States %:

Foreign - Non United States %:

5. Please indicate in which geomatics areas your organization is involved.

	Significant	Some	None
Data	○	○	○
Hardware	○	○	○
Software	○	○	○
Services	○	○	○

6. Please enter the value of the geomatics data, hardware, software, and services that your organization purchased in 1999.

Geomatics purchases: $ [ ]

7. Please enter the distribution of your organization's geomatics purchases for 1999 in the following geomatics areas

Cartography %: [ ]

Navigation and Positioning %: [ ]

GIS %: [ ]

Decision support %: [ ]

Geodesy %: [ ]

Land surveying %: [ ]

Hydrography%: [ ]

Remote sensing %: [ ]

Photogrammetry %: [ ]

Consulting %: [ ]

Other %: [ ]

If other, please comment.

[ ]

8. In which markets does your organization operate?

	Significant	Some	None
Natural Resources - Agriculture	○	○	○
Natural Resources - Forestry	○	○	○
Natural Resources - Fisheries	○	○	○
Natural Resources - Oil and gas	○	○	○
Natural Resources - Geology and mining	○	○	○
Environment	○	○	○
Property	○	○	○
Infrastructure - Engineering and construction	○	○	○
Infrastructure - Transportation	○	○	○
Infrastructure - Utilities	○	○	○
Health	○	○	○
Emergency preparedness and defence	○	○	○
Commerce	○	○	○
Education	○	○	○
Society/consumer/entertainment	○	○	○
Other	○	○	○

If other, please comment.

9. Please indicate your organization's sector:

- ○ Public sector
- ○ Private sector
- ○ Academic sector

10. From 2001 through to the end of 2002, by what percentage does your organization expect its use of geomatics to grow?

% Growth in geomatics purchases:

C. Business and Market Issues

11. In your opinion, what are the main factors influencing change in the geomatics sector?

	Very influential	Influential	Not influential
Business environment - international	○	○	○
Business environment - national	○	○	○
Business environment - regional	○	○	○
Industry restructuring	○	○	○
Commodity prices	○	○	○
Consumer demand	○	○	○
Government policies	○	○	○
Internet	○	○	○
Pricing of data	○	○	○
Technology	○	○	○
Other	○	○	○

If other, please comment.

12. How important is geomatics to your company's success?

- ○ Very important
- ○ Important
- ○ Not Important

13. In your opinion, what are the growth prospects for the following geomatics areas?

	Growth	Flat	Decline	No opinion
Cartography	○	○	○	○
Navigation and Positioning	○	○	○	○
GIS	○	○	○	○
Decision support	○	○	○	○
Geodesy	○	○	○	○
Land surveying	○	○	○	○
Hydrography	○	○	○	○
Remote sensing	○	○	○	○
Photogrammetry	○	○	○	○
Consulting	○	○	○	○
Other	○	○	○	○

If other, please specify:

14. In your opinion, what are the growth prospects for the following geomatics client markets?

	Growth	Flat	Decline	No opinion
Natural Resources - Agriculture	○	○	○	○
Natural Resources - Forestry	○	○	○	○
Natural Resources - Fisheries	○	○	○	○
Natural Resources - Oil and gas	○	○	○	○
Natural Resources - Geology and mining	○	○	○	○
Environment	○	○	○	○
Property	○	○	○	○
Infrastructure - Engineering and construction	○	○	○	○
Infrastructure - Transportation	○	○	○	○
Infrastructure - Utilities	○	○	○	○
Health	○	○	○	○
Emergency preparedness and defence	○	○	○	○
Commerce	○	○	○	○
Education	○	○	○	○
Society/consumer/entertainment	○	○	○	○
Other	○	○	○	○

If other, please specify:

15. In your opinion, what are the geomatics growth prospects for the following regions?

	Growth	Flat	Decline	No opinion
Domestic	○	○	○	○
Austronesia	○	○	○	○
Africa and the Middle East	○	○	○	○
Asia - Eastern	○	○	○	○
Asia - Southeastern	○	○	○	○
Asia - Southern	○	○	○	○
Asia - Central	○	○	○	○
Europe - Eastern	○	○	○	○
Europe - Western	○	○	○	○
Mexico	○	○	○	○
Latin America and Caribbean	○	○	○	○
United States	○	○	○	○

D. Technology Issues

16. How important are the following technologies for your organization's future business activity?

	Very Important	Important	Not Important
Navigation and Positioning	○	○	○
Geoid mapping	○	○	○
Radar imaging	○	○	○
High resolution optical imaging	○	○	○
Hyperspectral imaging	○	○	○
Image analysis	○	○	○
Digital photogrammetry	○	○	○
Geographic information systems	○	○	○
Data visualization	○	○	○
Digital elevation model generatio	○	○	○
Real time mapping	○	○	○
Data fusion and generalization	○	○	○
Communications and distribution	○	○	○
Internet applications	○	○	○
Geospatial data	○	○	○
User applications and solutions	○	○	○
Artificial intelligence & expert systems	○	○	○
Decision support tools	○	○	○
Other	○	○	○

If other, please specify:

E. Research and Development

17. How much did your organization spend on geomatics R&D for 1999? If none, please move to Section F.

Total R&D spending: $

18. In what geomatics business areas does your organization carry out R&D?

	Significant	Some	None
Data	○	○	○
Hardware	○	○	○
Software	○	○	○
Services	○	○	○

19. How is your organization's geomatics R&D funded?

Internal: % [ ]

Public sector contracts : % [ ]

Private sector contracts : % [ ]

Tax credits : % [ ]

Other: % [ ]

If other, please specify:

[ ]

20. With whom does your organization perform collaborative geomatics R&D?

	Significant	Some	None
Government	○	○	○
Client firms	○	○	○
Other geomatics firms	○	○	○
Education/Research Institutes	○	○	○
Other	○	○	○

If other, please specify:

[ ]

21. How important are the following factors to the amount of geomatics R&D your company performs?

	Very Important	Important	Not Important
Availability of capital	○	○	○
Availability of government support programs	○	○	○
Market demand for new products or services	○	○	○
Availability of R&D personnel	○	○	○
Other	○	○	○

If other, please specify:

F. Human Resources

22. Does your organization employ geomatics staff? If not, please move to Section G - Question 38

○ Yes
○ No

23. Of your organization's geomatics staff, what percentage are female?

Female: %

24. What is the percentage of your organization's geomatics staff in the following geomatics areas?

Cartography %: [ ]

Navigation and Positioning %: [ ]

GIS %: [ ]

Decision support %: [ ]

Geodesy %: [ ]

Land surveying %: [ ]

Hydrography%: [ ]

Remote sensing %: [ ]

Photogrammetry %: [ ]

Consulting %: [ ]

Other %: [ ]

If other, please specify:

[ ]

25. What percentage of your organization's geomatics staff is in the following age groups?

Less than 30 years old %: [ ]

30 to less than 45 years old %: [ ]

45 to less than 60 years old %: [ ]

More than 60 years old %: [ ]

26. Would certification of geomatics staff be of value in your business?

- ○ Yes
- ○ No

26b. If so, for what types of staff?

[ ]

26c. If so, for what reasons?

	Very Important	Important	Not Important
To satisfy a legal requirement	○	○	○
To address health and safety concerns	○	○	○
To enhance the credibility of staff	○	○	○
To facilitate more efficient and effective recruitment of staff	○	○	○
To help geomatics professionals with career building	○	○	○
Other	○	○	○

If other, please specify:

27. What percentage of your organization's geomatics staff has attained the following levels of education?

High school : %

College diploma : %

College diploma in geomatics : %

University degree : %

University degree with diploma in geomatics : %

University degree in geomatics: %

28. Is the rate of turnover of your organization's geomatics staff a problem?

○ Yes
○ No

29. What are the factors affecting turnover of your geomatics staff?

	Very Important	Important	Not Important
Salary levels	○	○	○
Workplace environment	○	○	○
Advancement opportunities	○	○	○
Interest in work	○	○	○
Other	○	○	○

If other, please specify:

30. What types of geomatics skills will be in particular demand by your organization in the future?

31. What types of supporting skills will be important to your organization in the future?

	Very Important	Important	Not Important
Linguistic	○	○	○
Cultural sensitivity	○	○	○
Business	○	○	○
Entrepreneurship	○	○	○
Other	○	○	○

If other, please specify:

32. How difficult is it for your organization to hire geomatics staff with the following types of capabilities?

	Very difficult	Difficult	Not difficult	Not Applicable
Operational/Research	○	○	○	○
Management	○	○	○	○
Sales	○	○	○	○
Information Technology	○	○	○	○
Teaching	○	○	○	○

33. From which groups do you tend to hire your geomatics staff?

	Often	Sometimes	Rarely
Universities	○	○	○
Colleges	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Government	○	○	○
Other	○	○	○

If other, please specify:

34. To which groups do you tend to lose your geomatics staff?

	Often	Sometimes	Rarely
Universities	○	○	○
Colleges	○	○	○
Other geomatics companies	○	○	○
Other non-geomatics companies	○	○	○
Government	○	○	○
Other	○	○	○

34b. If other, please specify:

35. From which regions do you tend to obtain geomatics staff?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

36. To which regions do your geomatics staff tend to move?

	Often	Sometimes	Rarely
Regional	○	○	○
National	○	○	○
United States	○	○	○
Other international	○	○	○

37. What is the distribution of the employment status of your organization's geomatics staff?

Independent Contractors: %

Casual: %

Term: %

Permanent part-time: %

Permanent full-time: %

G. Education and Training

38. What type of training, education or mentoring does your organization provide for its geomatics staff?

	Significant	Some	None
Mentoring	○	○	○
In-house training	○	○	○
Specialized courses	○	○	○
Support for external degree or diploma programs	○	○	○
Other	○	○	○

38b. If other, please specify:

39. We would like to send a survey to a selection of geomatics staff. Would you please provide us with the Email addresses of a number of your geomatics staff?

40. Please provide any additional comments that you would like to make here.

Thank you for taking the time to complete this survey. Remember to enter your Email address at the top of this survey if you would like to be entered in the draw for a hand-held GPS receiver. Select Submit Survey now to send your responses to us.

Review

A. Background

B. About Your Organization

C. Business and Market Issues

D. Technology Issues

E. Research and Development

F. Human Resources

G. Education and Training