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CANADIAN GEOSPATIAL DATA INFRASTRUCTURE

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Canadian Geomatics Environmental Scan and Value Study

GeoConnections

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Canada

Summary report

Canadian geomatics environmental scan and value study

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Natural Resources Canada

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INNOVATION POLICY ECONOMICS

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ACIL ALLEN CONSULTING
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Maximising the value of location information

Foreword:
Natural Resources Canada

This report synthesizes the findings from two significant bodies of work that together represent the most comprehensive assessment of geomatics in Canada to date. The first volume, the Canadian geomatics environmental scan, is an independent assessment of the sector, the key players and its operating context; the second, the value study, is a detailed analysis of the economic and non-economic benefits associated with the use of geomatics and Earth observation technologies and services.

Drivers for undertaking such a broad and far-reaching examination of the geomatics sector include several trends and events facing modern societies in general and Canada in particular:

- information as a new form of global currency that can be shared instantaneously to create value;
- the importance of energy and commodities in international markets, and the growing importance of resource literacy and stewardship;
- technological change and innovation linking satellites to handheld devices;
- growing threats to human health and security; and
- impacts of change on the planet – how we understand them and plan for the future.

The ubiquity of geospatial data and information on the Internet or through cloud-based applications accessible on geo-enabled hand-held devices — from specialized business devices to smart phones — is staggering. It is creating opportunities for private and public sectors alike to enhance decisional capability, advance productivity, and manage operations more effectively. But geomatics — although transitioning to general use — is not a panacea.

Fresh approaches, geospatial governance, and government arrangements are required for Canadians to adapt and to capitalize on the economic, environmental, and social potential of the geospatial technologies that our nation helped to globalize. This will require collaboration among the three main actors featured in the report — geospatial

information/geomatics firms, academia, and governments — and a wide variety of new actors.

The value of geospatial information comes from its use, and those organizations that adopt its use and innovate with applications will be the winners. Adoption in Canada has been uneven, which gives rise to opportunities and suggests that rather than being a mature technology, geomatics remains in its early phases of overall contribution. The coming decade will prove to be every bit as exciting as those early days when Canada showed leadership in the field.

The world of geomatics and geospatial information has radically transformed the millennia-old concept of 'the map'. With today's massive volumes of high quality data — available to us in tabular, raster, optical, radar and multi-spectral format — we can see the potential to foster innovative science and technology along multiple vectors of inquiry and in so doing, find new opportunities and derive solutions for societal, economic and environmental challenges.

And so, our need to understand where we should invest has never been greater; how and why we choose to invest in this capability will require deliberation and prudent selection.

Hickling Arthurs Low and its international team of experts conducted the analyses presented in this volume on behalf of Natural Resources Canada. Their effort involved an exhaustive review of literature, analysis of relevant Statistics Canada databases, and the creation of original material through 14 case studies and macroeconomic impact analysis using a computational general equilibrium (CGE) model. One hundred and thirty-seven (137) consultations with industry leaders, educators and government officials supplemented their quantitative analyses.

On behalf of Natural Resources Canada, I would like to thank all of the people who generously contributed their efforts and insights to this work.

Prashant Shukle

Director General, Canada Centre for
Mapping and Earth Observation, Earth Sciences,
Natural Resources Canada

Executive summary

Canada has been at the leading edge of innovation and use of geospatial technologies. With the need to govern so much geography and resource potential juxtaposed against a relatively small population, the question of *where* was and continues as a preoccupation in the national discourse. As we have shaped geospatial technologies, they have shaped us. Over the last decade, the manner in which we create, manage, and especially use location-based information has changed both rapidly and radically. New technologies, business models, the rise of citizen data providers, and social media have all changed how we create and share all forms of geospatial information – even 'maps'.

There are some 2,450 firms making up the geomatics industry that contributed $2.3 billion to Canada's Gross Domestic Product (GDP) in 2013. Companies in the sector are mostly small — nearly 75% having fewer than 50 employees — and employ people disproportionately in two regions: Quebec and the Prairies. In response to the last wave of developments, especially with the advent of Global Positioning Systems (GPS) and Earth observation satellites, there was rapid development of geomatics firms, with over half of existing firms commencing operations between 1970 and 1990. The rate at which new companies entered the sector peaked in the 1980s, but has been in significant decline since 2000.

Table 1. Changes in GDP as a result of geospatial information use and FTE jobs

	GDP		Consumption		Invest-ment	Net trade	FTE jobs
			Private consumption	Gov't			
Region	**$ million**	**% change**	**$ million**	**$ million**	**$ million**	**$ million**	**#**
Atlantic	$995	0.94%	$317	$306	$189	$182	973
Quebec	$2,792	0.77%	$1,179	$668	$550	$395	3,318
Ontario	$5,295	0.76%	$2,396	$1,198	$1,089	$612	5,634
Prairies	$8,985	2.03%	$3,553	$1,051	$2,913	$1,468	7,423
BC	$2,457	1.02%	$1,187	$347	$641	$282	2,174
The North	$174	2.38%	$17	$124	$148	-$115	55
Canada	**$20,700**	**1.10%**	**$8,648**	**$3,695**	**$5,530**	**$2,824**	**19,577**

Canadian academic institutions have worked effectively to support the skills needs of the market and to produce the new knowledge and technology diffusion required to keep the sector vibrant. The Canadian Geomatics Environmental Scan Findings Report (Hickling Arthurs Low, 2015a) includes profiles of 94 of Canada's universities and colleges offering programs in some aspects of geospatial information studies. There are five universities in Canada that offer geomatics engineering degrees: the University of New Brunswick, the University of Calgary, York University, Ryerson University, and Laval University.

The most important findings of the study are the benefits that geospatial information provides to users. In economic terms, geospatial technologies contribute some $21 billion of value to Canada's Gross Domestic Product (1.1%), and generate approximately 19,000 jobs in Canada's economy (Table 1).

The range of social and environmental benefits are even more impressive, although difficult to measure in economic terms, encompassing improved resource stewardship, better response to disease outbreaks, speedier deployment of first responders in emergency situations, and coordinated and timely management of physical infrastructure.

Open geospatial data is also making a difference, and this study estimates that $695 million is added to Canada's GDP as a result of its use. The full potential of open data will be realized through combining foundational geomatics data with other government data holdings such as health, public safety, and climate information.

Significant forces are shaping geomatics in Canada. Here, the fundamental finding is that market demand is shifting emphasis from production of base information to value-added products and services, and in particular, to consumer application-based geospatial information. A wave of disruptive change has enabled non-specialists to take on tasks that were formerly reserved for geomatics specialists, expanding the professional reach of geospatial technologies into engineering and information technology. This is blurring traditional boundaries. The rapidly evolving 'applications solution' market is global and very competitive.

The major actors are adapting: the geomatics sector is consolidating and integrating with other disciplines, firms are remixing offerings to include more value-added services, and academic institutions are adjusting their curricula to broaden the number of disciplines gaining exposure to geomatics and the innovation potential of geospatial data and technologies.

In governments, this cycle of disruptive change, combined with the convergence with other data-driven

technologies, is opening new possibilities for complex decision-making and analysis across jurisdictions, while reducing historical requirements for specialized stand-alone domain investments. It is also challenging governments to stay apace with the demands for up-to-date foundation geospatial-information products that drive industry innovation.

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1. Introduction

Canada's history, economy, and indeed its very identity, have been defined by its geography. Positioned adjacent to the most important market in the world, the United States — and with ready access to both Europe and Asia — our natural endowments have shaped our economy, culture, and identity as a nation. Geography defines the uniqueness of Canadians in every region of the country.

This report is meant to remind Canadians of that reality and to provide a new perspective on the value of geospatial information in Canada, including

- the state of the geomatics sector in Canada,
- global trends involving geospatial information and Canada's position relative to those trends,
- the significance and value of the geomatics sector and of geospatial information to the Canadian economy,
- current and emerging roles of government, industry and academia in supporting and using geospatial information.

The report presents the key findings of a ground-breaking study of the production and use of geospatial information in Canada, which was conducted in two parts: the Canadian geomatics environmental scan and the value study.

Geospatial information (GI)

Any information that identifies the position relative to the Earth of objects, whether natural, constructed, or cultural.

Geomatics sector

Organizations from industry, government, and academia involved in geospatial information capture, processing, analysis, presentation, or services, and in the production of associated technologies.

What has emerged is a picture of a market in a state of transformation and a sector that is rapidly evolving to capture the many opportunities that the significant market changes are presenting.

With the need to govern so much geography and resource potential juxtaposed against a relatively small population, Canada has been at the leading edge of innovation and use of geospatial technologies. Building from the need to map the country's vast territories, Canadian governments and industry worked together to create

world-class capabilities in many of the geomatics disciplines, such as surveying, Earth observation, and geographic information systems (GIS).

This study has found that today, the Canadian geomatics industry consists of about 2,450 firms that contribute approximately $2.3 billion to GDP. In addition, the geospatial information that they provide is estimated to result in productivity improvements of $20.7 billion to the rest of the Canadian economy, providing a 1.1% improvement to economic performance.

More important than the economic value of geospatial information are its significant benefits beyond those that can be measured in economic terms, including environmental, health and safety, knowledge, and social benefits.

The market for geospatial information is changing. The greatest growth is occurring in consumer applications for location-based services. Unfortunately, Canada's early dominance in traditional geomatics disciplines has not been translated into strengths in these new areas. Concerted collaborative efforts by Canadian governments and industry will be required to rectify the situation.

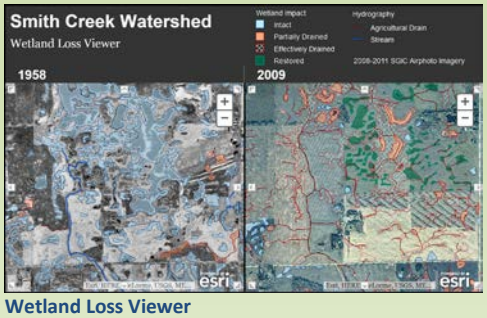
The following chapters provide an overview of the geomatics industry and the value of geospatial information in the economy. Also provided are profiles of Canadian geospatial information users as examples of how geospatial information contributes to Canadian prosperity.

Case study: Ducks Unlimited Canada (DUC)

"Ducks Unlimited Canada has built a strong reputation as a conservation leader because we base our work on the best available information," says Brian Kazmerik, DUC's Director of Information Systems and GIS.

"GIS is all about integrating and synthesizing information to support decisions. And, on top of this, it's also a powerful storyteller. Mapping tools showcase the importance of wetland conservation to supporters, donors, and other members of the public who are interested and concerned about the environment."

DUC is a seasoned user of geospatial information (GI). It adopted remote sensing in 1979 to identify wetlands in Western Canada, and GIS in 1996 to support conservation delivery. The use of desktop GI tools and data has greatly reduced the amount of fieldwork required. According to Kazmerik, *"Staff can now do a quick analysis from their laptops at home or in the office to screen out reconnaissance trips that will have no project potential. Reducing travel and staff costs contributes to an annual savings of approximately $1.7 million."*



Wetland Loss Viewer
(Source: Ducks Unlimited Canada)

2. The Canadian geomatics landscape

2.1 Historical context

The geomatics sector in Canada has a long and proud history, tracing its roots back to the earliest exploration of the country and the development of its natural resources and infrastructure. Famous explorers such as Champlain, Franklin, Fraser, Mackenzie, and Thompson surveyed and mapped the lands that they explored, and mariners like Cook charted Canada's offshore regions.

These pioneer surveyors were followed by pioneers of a different kind and a later era — veteran pilots of the first and second World Wars who, beginning in the late 1920s, conducted aerial survey missions to support the intensive topographic mapping of the country.

The early days

Government surveying and mapping organizations played a leadership role in the early development of the sector. The Geological Survey of Canada, the Earth sciences arm of Natural Resources Canada, was formed in 1842 (and still operates today); the predecessor to the Canadian Hydrographic Service of Fisheries and Oceans Canada was formed in 1867.

Through procurement contracts, public funding was used to survey lands to open up the West ahead of the Canadian Pacific Railway, and to accelerate topographic mapping of the land areas and hydrographic charting of the national waters, promoting development of private sector capability.

Digital developments

The modern digital geospatial information period can be traced to the development in 1962 of the first geographic information system (GIS) by Canadian Dr. Roger Tomlinson, the 'father of GIS'. This was followed by the commercialization of GIS by Esri in the United States in 1969. In the 1980s, availability of Global Positioning Systems (GPS) for civilian use further accelerated the development of a strong consumer and business market for geospatial information.

In 1972, NASA launched the first Earth observation (EO) satellite, Earth Resources Technology Satellite (ERTS), later renamed Landsat. As satellite imagery and a host of other advances transformed the sector, Canada pushed quickly to establish its position as a global leader in EO. The Canada Centre for Remote Sensing was established in

1971. Its responsibilities involved gathering, processing, analyzing, and storing EO data on the Canadian landmass, as well as developing applications and related systems for this new source of data. Canada launched its first EO satellite, RADARSAT-1, in 1995.

With rapid advances in geo-technologies combined with widespread adoption of computing devices during the period from the 1960s to the 1980s, the sector moved from paper to electronic products. The technologies had another important impact: they contributed to a blurring of the lines between the different disciplines and helped to spur the search for a new sector name. The term 'geomatics' was introduced in the mid-1980s by the Quebec geo-community, and, in 1987, the Geomatics Industry Association of Canada became the first organization to adopt the name.

Internet and mobile computing

In the early 2000s, another transformational shift started to occur. Private organizations like MapQuest, Google, and TomTom popularized electronic maps that were easy to access and use. With the advent of smart phones equipped with GPS, a significant consumer market opened, making maps available on these devices at any time.

At the same time, miniaturization and the falling price of hardware spawned significant innovation in developing geospatial hardware and software applications. Professionals and consumers were now entering a domain once dominated by geomatics specialists.

This new environment had a profound impact on the involvement of government in the provision of geospatial information. With the widening demand for data came new expectations and pressures by users for data openness, currency, and authoritativeness. Some of these geospatial information needs could be better met by industry and the users themselves, thus creating further market opportunities for the private sector.

2.2 The geospatial information value chain

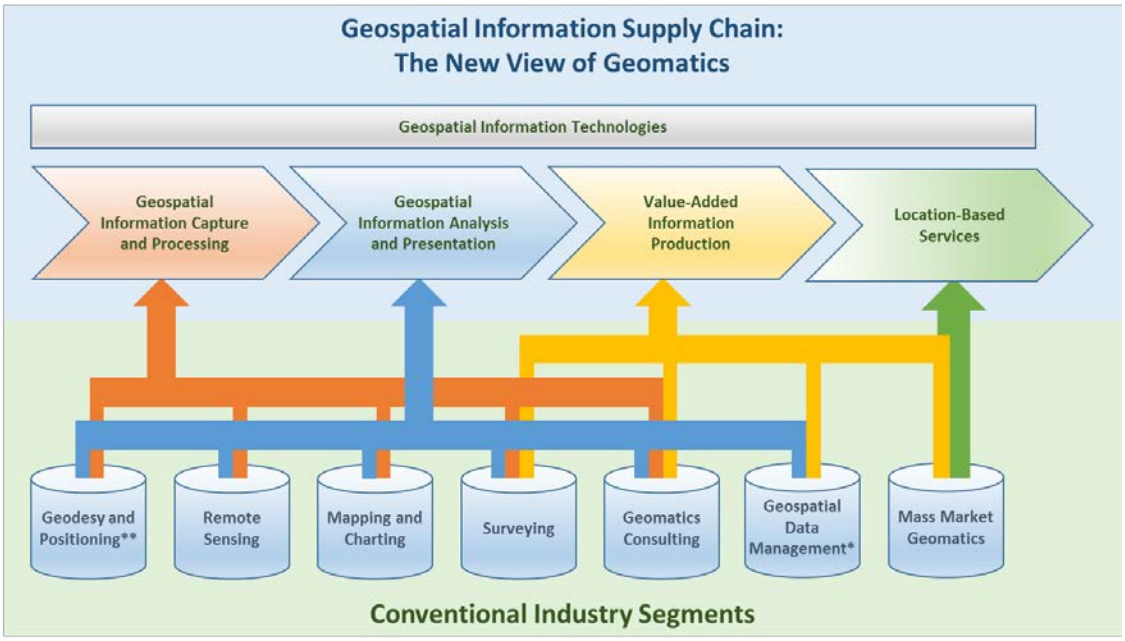
Previous studies (Hickling Arthurs Low, 2001; Statistics Canada, 2007) have segmented the geomatics industry according to the traditional disciplines of surveying, mapping, remote sensing, positioning, and GIS. Due to the blurring of these divisions, and since many businesses no longer categorize

Geospatial information value chain

In the value chain, the production of geospatial information is viewed as a process made up of sub-processes each with inputs, transformation, and outputs that add value to inputs from the preceding stage.

themselves according to these disciplines, an industry segmentation was adopted for this study based on a modern geospatial information value chain (Figure 1).

Figure 1. Relation between contemporary GI value chain and conventional geomatics business segments



** Includes use of all Global Navigation Satellite Systems
* Includes Geographic Information Systems

In Figure 1, the geospatial data contributions of the conventional industry segments are mapped to a contemporary geospatial information value chain. It is recognized that many parts of the traditional sector contribute to other value chains (e.g. in the land and resource development industries).

In each of the four components of the chain, depicted by the arrows along the top, value is added to the previous stage. The fifth component — geospatial information technologies — straddles the other components, providing the essential tools for the production of products and services at each of the other stages. The stages are as follows.

Geospatial information capture and processing: data collection using surveying, global navigation satellite systems (GNSS), and airborne and satellite imaging technologies, and the processing of such data for entry into data-analysis and -presentation technologies.

***Geospatial information analysis and presentation*:** data analysis using GIS, computer-assisted drafting (CAD), photogrammetric, cartographic, and

image-analysis technologies to produce standardized or customized reports, plans, maps, or charts, and the presentation of such outputs as electronic or hard-copy geospatial products and services.

Value-added information production: integration of geospatial information with other types of information in the value chains of other sectors (e.g. geological, resource, infrastructure, demographic, socio-economic, climate, etc.) to develop value-added products and services to help inform and enhance decision-making and improve operational performance.

***Location-based services*:** a growing range of Internet- and mobile device-based services that employ geospatial information to help users locate destinations and businesses; identify assets by location; track shipments; navigate aircraft, ships and vehicles; and receive consumer information, as examples.

Geospatial information technologies: production and distribution of software and equipment used for geospatial information capture, processing, analysis, presentation, and value-added information production.

2.3 The location market

A series of disruptive forces in the early to mid-2000s combined to transform a relatively specialized geomatics market into a more generalized 'location' market, open to a new community of users with little or no specific geomatics training. Key among these forces were the miniaturization of GPS receivers and their embedding in mobile computing and in-vehicle navigation devices, and the arrival of online mapping services such as MapQuest, Google Maps, and Microsoft Bing — often referred to as 'mass market geomatics' players.

In addition, the emergence of simple, user-friendly open-source applications helped a broader user community to discover and benefit from the use of location information. As the use of business analytics has grown, the use of location analytics has gained more visibility, and understanding of the strategic value of location information to help transform businesses and improve productivity has increased.

The location market can be thought of in terms of three segments:

- ***location-centric*:** where products or services would not be possible without geographical location or position (e.g. property transfer and election operations);
- ***location-enabled*:** where geographical location or position is an important part of the delivery of products and services (e.g. asset

management, insurance risk assessment, banking and government tracking of financial irregularities); and

- ***location-incidental*:** where geographical location or position is not required for the delivery of products or services, but would be beneficial (e.g. pizza delivery and mobile phone sales).

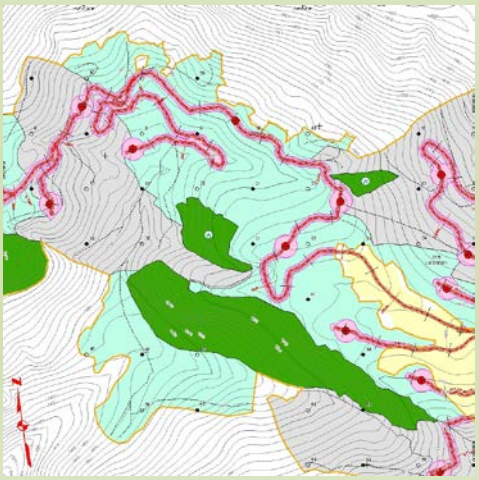
The boundaries between these location market segments are shifting, and applications that are perceived as location-incidental at the time of writing may soon be widely accepted as location-enabled.

Case study: Canfor

According to Jordan Kirk, Canfor's Woodlands Information Management Coordinator, *"Canfor has standardized every geospatial information product and process to work with every operation and automate a lot of tasks, producing major productivity improvements."*

By 2013, this standardization process had reduced the cost of GI use by nearly 60% for estimated annual savings in the range of $3.75M.

Canfor began using geospatial information in a GIS environment in 1996, and today some 200 users in their Woodland Operations Division employ geospatial tools on a daily basis. Foresters use GI as a reference and for inputting data at the block level for managing silviculture activities and writing site plans, among other applications.



Sample of Canfor's Logging Plan Template (Source: Canadian Forest Products Ltd.)

3. The rise of location

3.1 A sector in transition

Recent advances in technologies to generate and access geospatial data have fostered an explosion in the awareness and use of geospatial information.

In addition to the traditional core geomatics firms, the geomatics industry includes mass-market geomatics players predominantly from the ICT (Information and Communications Technology) sector, and others predominantly from the engineering and environment sectors.

This infusion of new players has made it much more difficult to define clear boundaries for the geomatics sector. A 2001 study (Hickling Arthurs Low, 2001) noted that many firms that conducted activities within the geomatics value chain did not consider themselves part of the sector. In fact, only about 8% of 'geomatics' firms in Industry Canada's Canadian Company Capabilities database at that time actually mentioned the word geomatics in their descriptions. As the *Canadian geomatics environmental scan and value study* has found, 13 years later, that number has increased to 21%, but there are still many firms providing geospatial information products and services that do not associate themselves with the field of geomatics. As a consequence, the sector does not have a clearly defined and understood identity.

The global geospatial market

The size of the global market for geospatial products and services has recently been estimated in a variety of studies. The common theme from all is that this is a rapidly evolving market with a high potential for growth.

By far the largest segments are smart routing, location tracking, entertainment and geo-targeted mobile advertising; areas in which Canada is not particularly strong. Even if the estimates are an order of magnitude too large, the potential of these applications in financial terms dwarfs all other parts of the market. Consumer-focused applications are a stronger driver of growth in the geomatics sector than the traditional business and professional applications.

A joint initiative of industry, government, and academia, the Canadian Geomatics Community Round Table (CGCRT; http://cgcrt.ca), is working to address the situation and chart a stronger future for the sector.

3.2 The geomatics industry is adapting to market change

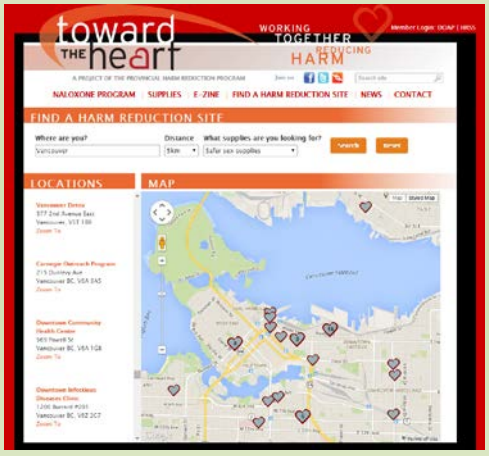
Accelerating technological development is spurring market transformation, and rapid innovation is replacing the predictable change that once characterized the sector. The focus of user demand is shifting from data products and software applications that can be deployed on users' GIS systems, to the provision of integrated location data and software applications, including those found on mobile devices. There is increasing interest in hosted solutions (data, software, and infrastructure as services in the Cloud), and embedded applications (e.g. linking geography with customer-demand information, business intelligence, inventory, etc.). These changes are driving the adoption of new business models and changes in staff skill sets across the traditional geomatics community and the engineering and IT groups that are increasingly incorporating geospatial technologies in their work.

Geomatics organizations are serving these new market demands by changing their offerings and business practices in a number of ways. Some providers are developing the capacity to deliver their own solutions, and others are becoming specialized parts of solutions value chains along with other partners (e.g. contribution of LiDAR data to forestry management solutions). Greater emphasis is being placed on understanding the business environment and processes of target client groups to enable development of fit-for-purpose geospatial information solutions.

Case study: British Columbia Centre for Disease Control

The British Columbia Centre for Disease Control (BCCDC), an agency of the Provincial Health Services Authority (PHSA), is responsible for provincial surveillance of communicable diseases, immunization programs, environmental health services, and public health emergency management.

As the Centre's Medical Geographer, Sunny Mak, says, *"Productivity improvements really depend on the different applications of GIS; it is difficult to quantify the number of lives saved or the impact of reducing the severity of a disease outbreak. However, GIS analysis produces value-added information to support decision making."*



Public Health Unit Finder (Source: http://towardtheheart.com/site-locator)

Providers are adapting their business models from project-related income streams to service-related models suited to medium- to long-term business relationships with clients. This requires new software- and data-management skills combined with foundational geomatics work. Examples include developing apps (applications) for mobile work environments, provisioning and managing Cloud-based services, integrating geospatial information with business information, and providing training and ongoing support for hosted solutions.

The initial focus of location-based services on the business-to-consumer (B2C) market is now shifting to business-to-business (B2B), creating growth opportunities for providers that can develop simple mobile apps targeted at organizations hungry for productivity improvements.

New developments in 3D mobile motion-sensing devices (e.g. Google's Project Tango) signal the potential for a new era of data capture and augmented-reality applications in the workplace. For example, utility workers, firefighters, and police officers will be able to navigate through unfamiliar buildings and capture new location-tagged data.

Case study: Golder Associates

According to Robert Murdoch, Golder's GIS & IM Development Group Manager, *"The use of geospatial information and technologies increases our productivity by approximately twenty to thirty percent. We are able to offer more enhanced services to our clients, and do it a lot more efficiently than before."*

Established in 1960, Golder Associates is a global, employee-owned organization. From over 180 offices worldwide, more than 8,000 employees help their clients find sustainable solutions for extraction of finite resources, energy and water supply and management, waste management, urbanization, and climate change.

In most cases, Golder's clients assume or expect that they will be able to provide GIS as a service for their projects. Mr. Murdoch notes that, *"Through the use of GI, Golder is competitive in the market and can offer a wide breadth and depth of services to our clients."*

3D model of the Sea to Sky highway design in British Columbia (Source: Golder Associates)

Another transformative change is the shift from purchasing data under license to accessing open data (available with few or no restrictions on its use). Much of the open data is provided by government, but alternatives are emerging and gaining user acceptance. For example, concerns about available data being outdated, especially in more populated areas, has led to the emergence of online data sources fueled by 'volunteered geographic information' or VGI contributions. The widespread adoption of mobile devices with integrated technologies (e.g. voice, data, GPS, video, etc.) is enabling citizens to become 'human sensors' by collecting and contributing data to the digital commons, and the popularity of contributing to better location data via VGI is growing. Internet giants like Google and navigation data providers like TomTom are exploiting this interest to obtain crowd-sourced updates to their data products.

As more data is opened to use and quality continues to improve through crowd verification, the decreased costs of market entry and data use are spurring increased competition, both within and from outside the sector. For example, major ICT and engineering companies have become dominant players in the geospatial market through acquisitions of geomatics firms and development of strong internal geospatial teams.

Growing recognition of the value of data analytics and the potential for exploiting 'big data' to drive business innovation is particularly relevant in the geospatial market. Many big data sources include a spatial reference, which serves as an essential means to integrate diverse data sets.

Big data

While no consensus appears to have been reached yet on a rigorous definition of big data, there is a common understanding that big data includes three characteristics, as stated in the definition proposed by Gartner: "Big Data are high-volume, high-velocity, and/or high-variety information assets that require new forms of processing to enable enhanced decision-making, insight discovery and process optimization" (Laney, 2012).

However, there are concerns that existing GIS and spatial database technologies are not efficient or robust enough to handle the volumes of data involved in big data analyses, and that there will be an insufficient supply of 'data scientists' with the deep analytical skills to exploit the full potential of big data. Research chairs have already been established in at least three Canadian universities to begin to address these deficiencies.

The changing nature of demand in the geospatial-information market is

prompting a general migration of providers up the value chain. Companies whose primary focus has been on the supply of geospatial data products are focusing more on value-added information products and services. Some companies are adapting by focusing in market niches where they have clear differentiation based on specialized products and services. Since global markets for embedded geospatial applications are expected to provide more growth potential than local-use applications, some Canadian providers see a more promising future in plugging into global value chains to provide integrated geo-enabled information solutions.

Finally, the consumer geospatial market is expanding at an even faster pace than the business geospatial market. While this market is dominated by the online mapping-service providers and the telecom giants, development of geo-enabled mobile apps is much more diversified. Competing in this market will require Canadian geomatics companies to adapt to significantly different business and pricing models.

3.3 Academia is adapting

Canada has a comprehensive geomatics education and training system that is well respected internationally. In addition to the traditional sources of university education in geography and geomatics science and engineering departments, GI-related courses are now routinely offered by most Canadian universities through departments in related disciplines (e.g. forestry, geology, agronomy, environmental sciences, civil engineering, and even health).

Community colleges also offer GI training through specialized geomatics and GIS programs (both diplomas and certificates), and through general technology programs such as engineering and environmental studies. This study identified 94 universities and colleges providing geomatics programs.

There are five universities in Canada that offer geomatics engineering/science degrees. Laval University and the University of Calgary are the biggest in Canada, each with approximately 300 students enrolled in their graduate and undergraduate programs. Enrollment appears to be generally at a level sufficient to meet Canada's needs.

The challenge of funding academic geomatics work that has arisen in the past decade reflects the broader issue of classifying the geomatics sector. As it is a uniquely interdisciplinary field of research, it does not necessarily fit with either the social sciences and humanities or the natural sciences and engineering granting programs with respect to funding. It is sometimes difficult to position proposals so that they meet the

criteria in either of the funding programs. A recent trend has been for universities to work directly with industry to develop market solutions.

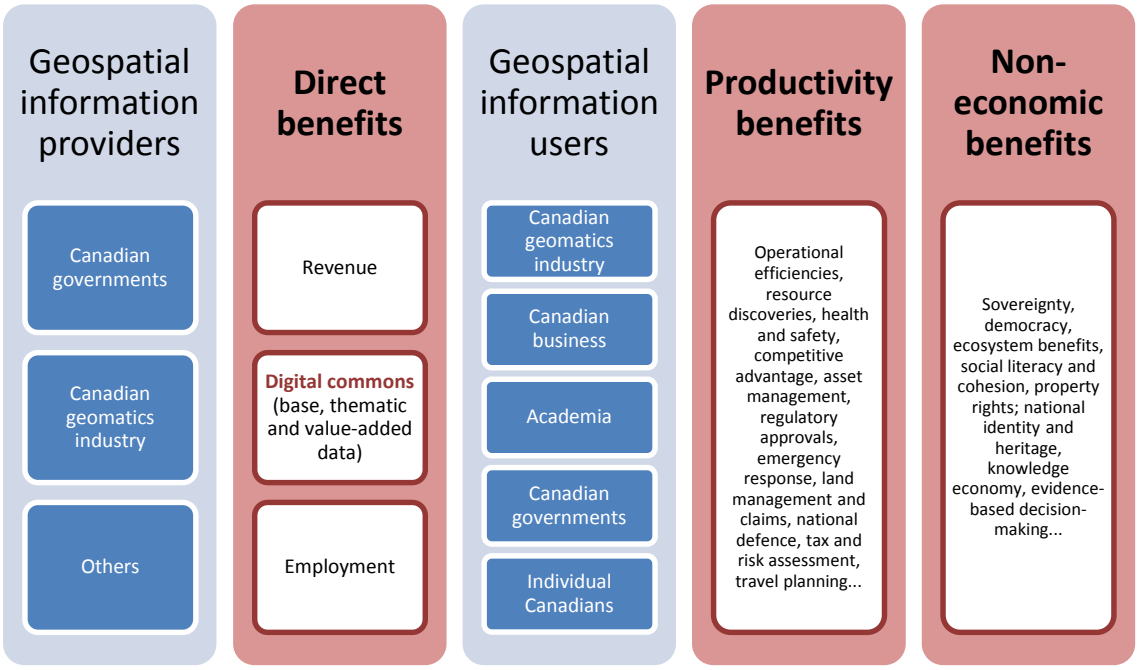
There are currently no established geomatics industry clusters in Canada. In a number of other countries, initiatives exist to promote the development of such clusters.

4. The value of geospatial information to Canada

4.1 The components of economic value

Geospatial information contributes to economic growth, natural-resource stewardship and environmental quality, and social progress. Figure 2 shows the value flow of those benefits; descriptions of the primary GI providers, users and benefits follow.

Figure 1. Geospatial information benefit flows



Geospatial information providers

Canadian governments — including the federal, provincial, territorial, and municipal levels. Governments are active and important providers because a significant amount of geospatial information is created as a result of their activities. While many of the activities involved in the production of geospatial data may be procured from industry sources, governments are in a good

position to ensure that base data coverage is provided in a complete, cohesive, and current manner. Governments also provide a significant amount of thematic data as the result of mandated responsibilities for activities such as taxation, census taking, management of resources, weather, and, forest monitoring.

Canadian geomatics industry — plays a crucial role as a provider of value-added data that builds on base data and other data sources. The Canadian geomatics industry also plays an important role in providing resources and expertise needed by governments responsible for the provision of base and thematic data.

Others — Geospatial information is a ubiquitous component of our modern economy. The exchange of geospatial information is a growing component of the exchange of information in general in our information society. As a result, the growing list of users of geospatial information—including ICT firms, research and scientific organizations, and vertically integrated resource-extraction firms—are potentially also providers of thematic data.

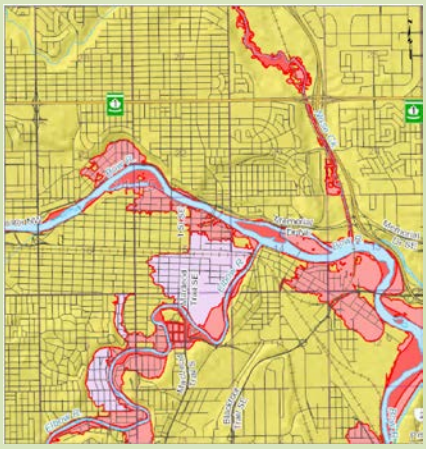
Direct benefits

The Canadian geomatics sector directly contributes to the economic prosperity of Canada by providing high-quality jobs and generating revenue from goods and services.

Case study: RSA Canada

RSA Canada is a leading property and casualty (P&C) insurance company, distributing a broad range of home, auto, business, marine, travel, and pet insurance products across the country. According to Paul Tunney, GeoRisk Consultant with RSA Canada, *"By making geospatially-enabled coverage decisions we have a better understanding of our exposure and can reduce the risk of excessive claim costs."*

Geospatial tools are being widely adopted in the insurance industry and are a source of competitive advantage. Mr. Tunney says, *"With the rapidly increasing use of GIS within the industry, it is imperative that we stay at the forefront and continue to invest in the latest technology. This allows for improved risk selection, pricing and process efficiency and enables us to maintain a competitive position in the market."*



Flood hazard map of the City of Calgary (Source: http://maps.srd.alberta.ca/FloodHazard/viewer.ashx?viewer=Mapping)

An important quality of geospatial information is that once it has been created, it can be employed in many ways beyond its original intended use. Therefore, the broad collection of Canada's geospatial data can be thought of as a digital commons, which when made accessible through common standards can reduce duplication of effort and improve interoperability.

Geospatial information users

Canadian geomatics industry — acquires and processes data and creates geospatial data products for resale to other users. In doing so, it improves the products and services available to Canadian businesses and increases their productivity and competitiveness.

Through these improved products and services, the industry also improves the quality of life for Canadians, helps maintain the environment, provides health and safety benefits, and helps maintain the sovereignty of Canada.

Canadian businesses — use geospatial information in many aspects of decision-making in diverse applications such as resource development, land development, transportation, and environmental management. The application of geospatial information has also transformed the way business is conducted. Ultimately, in the majority of business applications, geospatial information provides benefits by improving productivity and competitiveness.

Academia — uses geospatial information for its functions of teaching and research. Through teaching, academia provides skilled professionals with knowledge of geospatial skills and techniques, either as the core of its expertise or as a useful adjunct to core skills in other areas of specialization. Through research, academia contributes to many aspects of our understanding of both our physical and social worlds. This understanding allows Canadian leaders and citizens to make more informed decisions regarding the environment, the economy, the nation, health and safety, and society.

Working closely with enterprises to incorporate the latest advances and acting as an accelerator for new geospatial companies, academia also plays an important role in the diffusion of geospatial technologies.

Canadian governments — federal, provincial, and local governments rely on geospatial information to support a wide range of functions. Quality geospatial information is vital to ensuring high-quality decision-making. The geospatial information required for decision-making includes that of the natural world (e.g. topography, water resources, soils, geology, vegetation, population, climate, etc.); physical features that humankind has added (e.g. transport systems, utilities and services, communication systems, structures, buildings, etc.); administrative constructs required for key functions of managing a modern state (e.g. land ownership, jurisdictional,

administrative and electoral boundaries and tax collection, etc.); and geographical names.

Individual Canadians — Ultimately, all uses of geospatial information by the previous sectors benefit individual Canadians. In addition, individual Canadians are also users themselves of geospatial information, for example in the use of satellite positioning systems and electronic maps for navigation. This use has exploded as location-based services have become ubiquitous.

Productivity and non-economic benefits

There are two classes of benefits arising from the use of geospatial information:

1. the increased productivity of Canadian industries that use geospatial information; and
2. other benefits that are either non-economic or difficult to quantify in economic terms, such as contributions to environmental health, the health and safety of Canadians, national sovereignty, and better decision-making by governments, industry, and individuals.

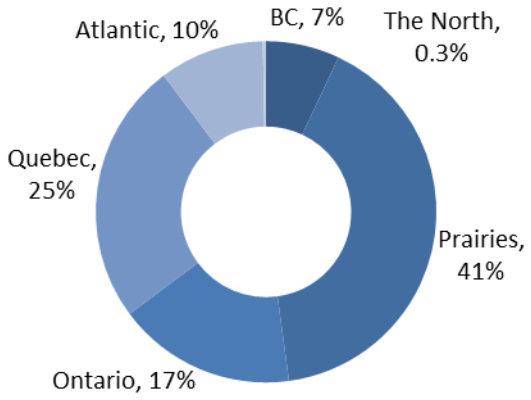
4.2 Profile of the Canadian geomatics industry

This study has identified 2,450 private sector firms providing geomatics products and services in Canada, which in 2013 contributed $2.3 billion to Canada's GDP, or 0.15% of the economy. The number of firms today is 15% higher than found by a 2001 study (Hickling Arthurs Low, 2001). Over the intervening years, two conflicting trends have influenced that growth:

1. Geomatics as a field has grown and many new applications for geospatial information have been developed, generating growth.
2. The industry has consolidated, especially in the area of land administration (land surveying, land-use planning, and engineering), reducing the number of firms.

Figure 3 shows the regional distribution of geomatics employment, with the highest concentration in the Prairies (41%) driven by the resource industries there.

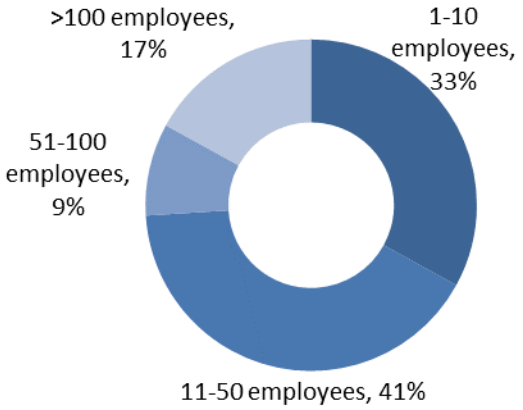
Figure 3. Regional employment distribution



As with most sectors in the Canadian economy, the majority of firms in the

geomatics sector are small, with only 17% having more than 100 employees and 74% having fewer than 50, as shown in Figure 4.

Figure 4. Firm-size distribution

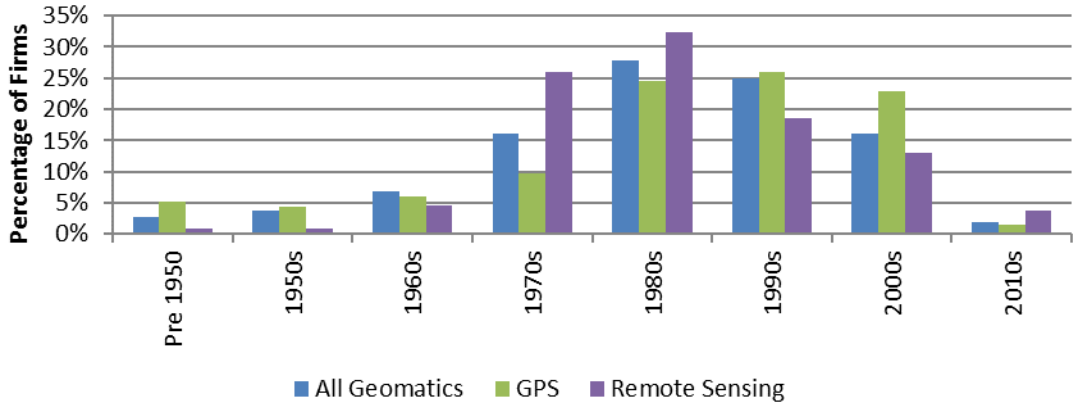


The geomatics sector is overwhelmingly service oriented, with 82% of companies focused on the geospatial information services in the GI value chain.

Almost 60% of the industry has surveying and mapping as their primary activity. Of course, firms can participate in more than one activity across the value chain.

The vitality of an industry is indicated by the rate at which companies enter and exit the market. Figure 5 shows the eras in which existing geomatics firms were created. It is evident that the prime years were the 1980s and 1990s. Remote sensing peaked earlier than GPS.

Figure 5. Year of establishment of Canadian geomatics firms



4.3 The economic benefits of geospatial information use

While it is widely acknowledged that geospatial information provides benefits, estimates of the magnitude of those benefits to the Canadian economy have been lacking. Australia has been a leader in developing the tools to bring greater economic precision to the value of the usage of geospatial information across industries, and in the economy as a whole most specifically, through the use of computable general equilibrium (CGE) modelling. The Australian methodology has been further applied in New Zealand and more recently in the United Kingdom

(ACIL Tasman Pty Ltd., 2008, 2009, 2010; ACIL Tasman Pty Ltd. and Consulting Where, 2010).

In this study, the economic benefits from the use of geospatial information were determined using the computable general equilibrium (CGE) model, detailing both the Canadian and global economies. The following assumptions were made:

- The benefits to be measured are those resulting from the use of modern geospatial technologies.
- The impact of that use is an increase in the productivity of the users.
- The increase in productivity is measured as an increase in gross domestic product (GDP).

Gross domestic product (GDP)

GDP is a measure of Canada's economic activity. It is the sum of consumption, government spending, investment, and net exports.

Real income

Real income provides an indication of the change in the economic welfare of the residents of a region.

Inputs to the model were based on a literature review, consultations with the geomatics industry, and case studies of geospatial information users.

Estimates were made of the geospatial information adoption rate and productivity improvement for each sector of the Canadian economy. The economic impact of geospatial information on an industry is the product of the productivity improvement estimate times the adoption estimate.

The results of the modelling indicated that the historical uptake of geospatial information across Canada is estimated to have added approximately $20.7 billion (or 1.1%) to Canadian real GDP, and $19.0 billion to Canadian real income in 2013.

Table 2 shows the changes in a range of macroeconomic sub-components that produce the estimated changes in real GDP and real income by region as a result of geospatial information use.

The productivity improvements have resulted in more effective use of the country's scarce labour and capital and have provided a stimulus to the Canadian economy compared to what would have otherwise been possible.

Approximately 67% of the increase in real GDP is directly associated with the estimated productivity improvements, and 17% is associated with increased net real tax revenues due to increased economic activity. The remaining 16% of the increase in real GDP is due to increased real returns from factors that result from the higher accumulated capital stocks and allocative efficiency

benefits associated with the reallocation of factors around the economy.

A sensitivity analysis performed on the results showed that the 90% confidence interval for the impact of geospatial information on GDP is between $18.9 billion and $22.5 billion.

Table 2. Decomposition of changes in real GDP and real income by region as a result of geospatial information use

	Atlantic	Quebec	Ontario	Prairies	British Columbia	The North	Canada
	2013 $m	2013 $m	2013 $m	2013 $m	2013 $m	2013 $m	2013 $m
Private consumption	317	1,179	2,396	3,553	1,187	17	8,648
Government consumption	306	668	1,198	1,051	347	124	3,695
Investment	189	550	1,089	2,913	641	148	5,530
Net trade [a]	182	395	612	1,468	282	-115	2,824
Exports [a]	592	1,547	2,263	5,803	1,422	183	7,571
Contribution of imports [a]	-409	-1,153	-1,651	-4,335	-1,140	-298	-4,747
Real GDP	**995 (0.94%)**	**2,792 (0.77%)**	**5,295 (0.76%)**	**8,985 (2.03%)**	**2,457 (1.02%)**	**174 (2.38%)**	**20,698 (1.1%)**
Terms of trade	-159	44	-60	-1,122	-293	-51	-1,642
Net foreign income transfers	-4	10	-1	-4	-25	-15	-38
Real income	**832**	**2,846**	**5,234**	**7,858**	**2,139**	**108**	**19,018**

[a] Trade data for each provincial region includes trade with other Canadian regions. Trade for Canada only includes foreign trade, hence total Canadian exports and imports do not equal the sum of the provincial regions.

Note: GDP can be calculated either from the expenditure side or from the income side. This table presents the decomposition from the expenditure side. From the income side, the change in real GDP would be the sum of the change in real value added, the change in real tax revenues, and the change in productivity.

Although the (small) decline in terms of trade offsets some of the growth in real GDP, total economic welfare of Canadians is still significantly greater as a result of the improved productivity stemming from geospatial information. In particular, Canadian real income was higher by $19.0 billion, or 1.03%, as a result of geospatial information.

Table 3 identifies the differences in impacts of geospatial information across different sectors. The greatest impacts are in the resource, transportation, utilities and agriculture sectors, which involve large geographic areas. Regions where these sectors are most prevalent see the greatest consequence. Conversely, the impact in manufacturing, which occurs primarily in small areas indoors, is relatively small.

Importantly, although geospatial information directly raised productivity in only a subset of the industries modelled, it is estimated that it would also have indirectly benefited almost all other Canadian industries, as the effect of higher productivity in the directly affected industries is passed on to other industries in the form of lower prices for inputs.

Table 3. Estimated percentage change in industry output as a result of geospatial information

	Atlantic	Quebec	Ontario	Prairies	British Columbia	The North	Canada
	%	%	%	%	%	%	%
Agriculture, forestry, fishing and hunting	2.50	1.04	1.33	0.96	1.38	4.47	1.22
Mining, quarrying, and oil and gas extraction	3.32	4.44	4.67	4.55	5.12	4.32	4.54
Utilities	1.60	1.73	1.68	1.19	1.51	2.09	1.58
Construction	1.34	0.94	0.82	1.90	1.17	1.50	1.23
Manufacturing	0.16	0.57	0.30	-0.18	0.86	1.75	0.33
Wholesale trade	0.88	0.85	0.81	1.14	0.93	4.03	0.90
Retail trade	0.51	0.46	0.43	1.11	0.55	1.68	0.60
Transportation and warehousing	1.57	1.65	1.59	1.45	2.16	0.26	1.64
Information and cultural industries	0.47	0.32	0.43	1.01	0.45	1.14	0.51
Finance and insurance	0.74	0.66	0.80	0.97	0.59	2.52	0.78
Real estate and rental and leasing	0.55	0.45	0.49	1.47	0.63	1.65	0.72
Professional, scientific, and technical services	0.72	0.34	0.28	0.94	0.57	1.54	0.57
Management of companies and enterprises	1.06	0.82	0.84	1.75	0.93	2.52	1.08
Administrative and support, waste management, and remediation services	0.87	0.71	1.00	1.13	0.89	3.11	0.95
Educational services	0.28	0.35	0.35	0.66	0.35	0.98	0.40
Health care and social assistance	0.60	0.57	0.55	1.17	0.57	1.48	0.70
Arts, entertainment and recreation	0.40	0.39	0.37	0.72	0.42	0.77	0.45
Accommodation and food services	0.56	0.59	0.64	1.46	0.74	1.59	0.83
Other services (except public administration)	0.38	0.28	0.36	0.92	0.44	1.86	0.48
Public administration	1.59	1.36	1.43	2.03	1.15	1.89	1.51

4.4 Non-economic value of geospatial information use

Geospatial information provides benefits beyond those that can be measured in economic terms. In fact, there are strong arguments that such benefits may be significantly more important than the economic ones. They include, for example,

- ***Environmental benefits*** **—** improved environmental protection, better compliance with regulatory requirements, better management of resources, and reduced impacts of natural disasters.
- ***Health*** **—** saved lives, improved allocation of resources to manage disease outbreaks and emergency situations, better patient care, and lower health risks, as well as better management of health risks.
- ***Social*** **—** more effective communication among governments, business, and citizens; increased confidence in services; improved community engagement; and higher customer satisfaction.
- ***Knowledge*** **—** improved presentation and understanding of complex information, increased information consistency, better focus on areas of risk, improved ability to plan, better analyses, improved data integration, increased data confidence, better evidence-based decision-making, and improved citizen literacy.

The *Value Study Findings Report* (Hickling Arthurs Low, 2015b) provides extensive examples of a wide range of non-quantifiable benefits from the use of geospatial information.

4.5 The value of open geospatial data

Governments throughout the developed world have realized that making their large data holdings available and accessible can spur innovation in both the economic and social spheres. Canada is no exception.

The concept of 'open data' includes the themes of

- removing restrictions on use and dissemination,
- standardizing formats to foster interoperability and accessibility,
- disseminating works at minimal or no cost, and
- improving public use and access in the public interest.

Opening government data is increasingly recognized as an important public-policy objective to engage a broader range of actors in solving problems of interest to the government. Open geospatial data, and the opening up of the data infrastructure that supports the underlying data, were early successes of open government information initiatives in Canada. These initiatives are now increasingly being shaped and influenced by overarching open-government-data policies and the feedback from a new community of open-data users.

The rationale for the open data movement is that economic welfare is maximized if data is made available at

marginal cost or for free. There are further arguments for the role of governments in not only providing, but also setting, standards for open data. Government involvement is 'in the public interest' because of the need to

- protect life and property,
- promote democracy,
- protect the rights of individuals,
- support minority groups,
- ensure the confidentiality of some forms of data collected, and
- encourage the innovative potential of scientific knowledge.

Beyond these are internal benefits to government operations of sharing data sets and infrastructure among the three levels of government and among various government ministries. The guiding principle for these inter- and intra-governmental collaborations is 'build once, use many times' to make the best use of tax dollars.

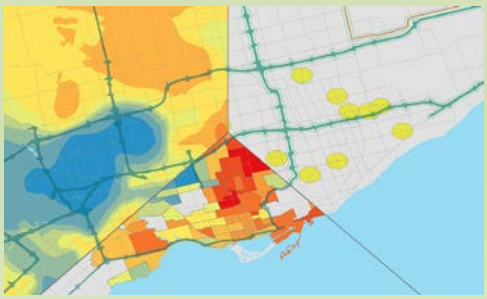
While open data is free at the point of use, it is not costless to produce and maintain. Governments must continue to provide the resources necessary to support the custodians of these data — primarily government agencies that collect and maintain foundation geospatial data — to ensure that the data continues to possess the key characteristics of currency, accuracy, cohesiveness, availability, and usability.

There are quantifiable economic benefits from open geospatial information that come primarily through

Case study: Altus Group

The Altus Group provides a comprehensive offering that encompasses all phases and aspects of real estate for individuals, businesses, governments and municipalities.

Robert Dorion, President of Knowledge Management at Altus, is a strong advocate of the use of tools like MLS® HPI for urban development and other governance/public policy/ infrastructure support systems. He claims, *"Using better tools for planning and financing the development of a community based on accurate historical data and defendable future models can greatly enhance the design of cities and municipal areas thereby enhancing their livability as well as their financial sustainability."*



Altus GIS Tool for market monitoring (Source: Altus)

- ***Increased use*** — all of the benefits of geospatial information are magnified by increased use.
- ***Standardization*** — open data standards improve data interoperability and reuse.

- ***Network externalities*** — sharing data leads to efficiencies and common understandings.
- ***Novel applications*** — those in areas not directly connected to geospatial data creation may see uses not previously imagined.

This study estimates that the historical uptake of open geospatial data across Canada has added at least $695 million (or 0.04%) to Canadian real GDP and $636 million to Canadian real income in 2013.

As the volume, use, and demand for geospatial information proliferates, society requires commonly understood reference foundations with which to link and combine information. A significant benefit provided by a spatial data infrastructure (SDI) lies with its role in ensuring compatibility within a network of data sets. The SDI reduces transaction costs by searching and verifying that the different data sets are actually compatible. It also reduces costs by eliminating or significantly reducing the costs of transforming the various data sets, especially when these data sets are collected by different organizations at different times for different uses and users.

A common reference system and datum are necessary to align or 'fuse' these data sets into a network. The potential cost savings from compatibility are likely to increase as users add ever more data layers to improve their spatial analysis.

Spatial data infrastructure (SDI)

An SDI is "the framework of fundamental spatial datasets, metadata, and interoperability standards that enable integration, the distribution networks and technologies that provide access and services, the policies and administrative principles that ensure compatibility, and the people including users, providers, and value adders, at each level; local through to state, national, regional and global, that use and maintain the infrastructure to support decision-making." *(Source: Global Spatial Data Infrastructure Association, 2015)*

An example is the Canadian Geospatial Data Infrastructure (CGDI). More information can be found at http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/10783.

5. Geomatics outlook in Canada

Geomatics has been an active subject of technological development for 50 years, and the coming decade will see an acceleration of change. As a result of a new wave of innovation, geospatial technologies have become cheaper, more user friendly, and more broadly available. The evidence compiled for this study suggests that there is a bright future for those geomatics organizations that recognize and seize opportunities presented by modern geospatial tools and the growing geospatial market, and that are prepared to make the transition necessary to integrate and use this technology.

5.1 Private sector prospects

The most significant potential for growth in the geospatial market lies in consumer applications. However, there is also considerable room for growth and diversification in professional and business applications of geospatial information.

For geomatics businesses — traditional and emerging — professional and business markets for geospatial information products, services, and technologies provide opportunities. In sectors where the deployment of geospatial tools and services is more widespread (e.g. oil and gas, mining, forestry, and infrastructure), the opportunities lie in more sophisticated use of location as a means of reducing costs, improving worker productivity, and increasing the quality of management planning and decision-making outputs.

Examples of applications that are at an early stage of the adoption life cycle across these sectors and that represent considerable growth potential include

- mobile field-data collection and real-time database updating,
- route optimization and robotics for transportation of resource raw materials,
- positioning of underground utilities with unknown locations using ground-penetrating radar,
- inventory tracking in milling and retail operations,
- embedded geospatial information within business-information tools for management decision-making,
- geo-positioning data and remote communications for more effective management of field assets (e.g. oil company field installations, hydro

poles, fire hydrants and vehicles), and
- Use of geospatial tools and data for resource and environmental literacy.

The prospects of geospatial market growth in sectors that are less exposed to the use of geospatial tools and services (e.g. agriculture, finance and insurance, ground transportation, and property assessment) are also promising. In these sectors, examples of application areas that represent important opportunities for further development and future growth include

- spatial epidemiological analysis (e.g. tracking disease outbreaks and deciding where to locate resources, calculating catchment areas and patient travel times, and forecasting populations at risk);
- pesticide-application planning (e.g. for mosquitoes carrying West Nile virus) to minimize negative environmental impacts;
- geo-enabled insurance underwriting risk assessment;
- geo-enabled farm planning and operations management;
- geo-enabled desktop evaluation of property; and
- long-term, full-life-cycle cost of real estate ownership analysis.

Entering the consumer geospatial-applications market requires a significantly different business model focused on generating high-volume, low-margin revenue streams. Although the evidence from this study indicates that established Canadian geomatics companies have limited interest in this market, start-up activity suggests that a new generation of geospatial market entrants see this market as their primary focus.

The export market, while representing tremendous potential, is competitive and dominated by global suppliers. For Canadian geospatial providers, the potential for success will depend upon their ability to

- enter and integrate effectively within global value chains — geospatial information and others,
- supply clearly recognizable and differentiated products and services within niche markets,
- form effective public-private partnerships in developing markets, and
- develop innovative geo-enabled business solutions in the domestic market that can be applied abroad.

5.2 Public sector prospects

The level of maturity in adoption of geospatial products, services, and technologies within different spheres of government activity mirrors the private

sector to a large extent. While some specific organizations are at the edge of innovating and using the technologies, governments are generally seen to have adopted geospatial technologies more slowly. Large masses of government data are not geotagged, and so cannot be layered on geospatial foundation data.

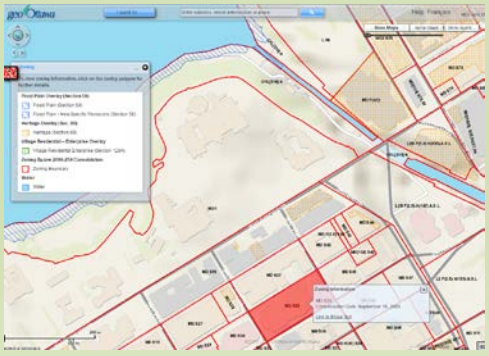
Government programs in natural resources management, water and oceans management, land administration, environment, defence, public safety, agriculture, statistics, elections, and aboriginal affairs and northern development exhibit advanced applications of geospatial information. However, even in these organizations, there is room for expanded use of geospatial information in new application areas such as

- automated updating of forest-inventory databases with near real-time digital updates from forestry companies,
- monitoring the impacts of climate change in coastal zones (e.g. sea-level rise, increased erosion and flooding),
- monitoring the impacts of resource extraction on groundwater quantity and quality,
- building rapid and effective response capability to disasters and emergencies with real-time updating and interactive management features,
- expediting northern-development project evaluation and approval

Case study: City of Ottawa

The City of Ottawa is among Canada's leaders in GI use at the municipal level. When municipal amalgamation occurred in 2001, Ottawa integrated all the GI of the amalgamated municipalities and developed a solid common base as a foundation for multiple GIS applications.

Kelly Martin, the City's Manager of Asset Management, says, *"Geospatial information helps reduce asset management costs and citizen inconvenience. It is used to maintain records of asset inventories, topographical information, planning data and planned works so that decisions on future replacement of asphalt and pipes can be done more effectively. Also, since the locations of underground facilities like pipes, water valves, underground utilities etc. are in the GIS database, when works are proposed there is informed collaboration and better planning and issue mitigation opportunities both within the City and with external agencies."*



Land use zoning mapping (Source: geoOttawa, City of Ottawa Website. Parcel data is owned by Teranet Enterprises Inc. and its suppliers. All rights reserved.)

processes with geo-enabled decision support systems,
- supporting aboriginal self-government and land-reform initiatives,
- pipeline and infrastructure monitoring, and
- change detection at a centimetre level, at any point on Earth.

Growth potential also exists in programs that do not have such a long history of geospatial information use (e.g. health, social services, employment, education and training). Early adopters in these sectors have recognized the power of geo-enabled tools to more effectively engage with their clients and facilitate access to their services with public-facing Web applications. Other emerging applications include healthcare service planning such as disease-outbreak investigations and health services location allocation analytics.

The widespread availability of simple-use, open-source applications, open data and geo-enabled mobile devices provides opportunities for new users in government at both operational and management levels to benefit from regular geospatial information use. The federal government's renewed science, technology and innovation strategy released in December 2014 contains a number of research priorities in which geospatial information can play a substantive role (Government of Canada, 2014). Significant growth is expected in the emerging demand for mobile applications to support the work of field personnel.

Government plays a crucial role in the geospatial market by providing the underlying spatial data infrastructure (SDI) that facilitates easy access to and integration of geospatial data resources. The ongoing development and maintenance of not only the physical and logical infrastructure but also the essential regulatory, policy, and standards resources that underpin SDI will help industry to develop and expand location business.

At the local level (i.e. municipalities and aboriginal communities), geospatial applications are embedded in many kinds of program delivery. Where use is more advanced (e.g. infrastructure, development planning, and real property management), demand is growing for simple geospatial analysis and visualization capabilities well beyond the traditional 'power user' base of engineering and urban-planning professionals. In particular, there is significant growth potential in self-governing aboriginal communities that manage their lands, resources, and infrastructure.

An increased focus on innovation within government will produce results both in productivity improvements and in increased potential for commercialization. One area in which government can make a significant contribution is in maximizing the value of its own 'big data', by strategically

investing in high-value data and in technology to open their data for public consumption.

Finally, geospatial information has enormous potential to improve services to taxpayers. Important progress on this front has been made across the three levels of government in Canada, with a steadily expanding number of services that facilitate access to and visualization of all kinds of information available to the public.

For the citizen, effective combination of geospatial with other information translates into understanding what regulations or policies impact them, knowing where local services are, avoiding traffic congestion, and being able to manage daily activities better by having access to better and more easily comprehended information. Expansion of geo-enabled citizen-facing web applications provides the means of further improving government's interface with its constituents and citizen involvement in governance.

New science, technology and innovation (STI) strategy announced

The federal government's updated science, technology and innovation (STI) strategy identifies new areas in which support of innovation will be focused. GI products, services, and technologies can play a substantial role in many of the research priorities that are considered to be of strategic importance to Canada (e.g. water health, energy and security; climate-change research and technology; disaster mitigation; responsible development and monitoring of the environment; pipeline safety; advanced data management and analysis; and advanced manufacturing automation, including robotics).

6. Conclusion

This report shows that geospatial technologies in their many forms are essential to Canada's economy and its citizens' well-being. Geospatial information drives business and government decisions that result in the more effective stewardship of our natural resources, ensures the efficient and safe movement of goods and travellers, and helps manage risks that affect property and human lives.

In the future, geospatial-information use will be an even greater factor in our daily lives and drive a next generation of productivity improvements in the private and public sectors.

Canada had an advantage from the 1950s to the early 2000s with a responsive geomatics industry that worked effectively with government and academia. Technological advances were propelled by large government investments that were focused on using new technologies to strengthen Canada's sovereignty, push the boundaries of scientific knowledge, and generate efficiencies in its operations.

Over the last decade, that situation has changed; a broader field of international players now compete aggressively with Canadian companies.

While government remains a significant source of infrastructure investment, it spends less, and this has had effects on industry, including reductions in research and development spending. The industry is adapting, but will need to continue to transition from government to business and consumer markets.

Equally important is the shift occurring on the market/demand side, with consumers playing a new and significant role. Consumers and businesses have differing needs for the currency, accessibility, and authoritativeness of their data, and as a result a new class of geospatial information is becoming available that relies less on government sources.

Governments will continue to have a vital role in the development of standards and in enabling the governance structures and new institutional arrangements necessary to support the provision of open geospatial information from their own holdings and other sources.

The future view can be optimistic if Canadian actors continue to work together to adapt to this changing environment.

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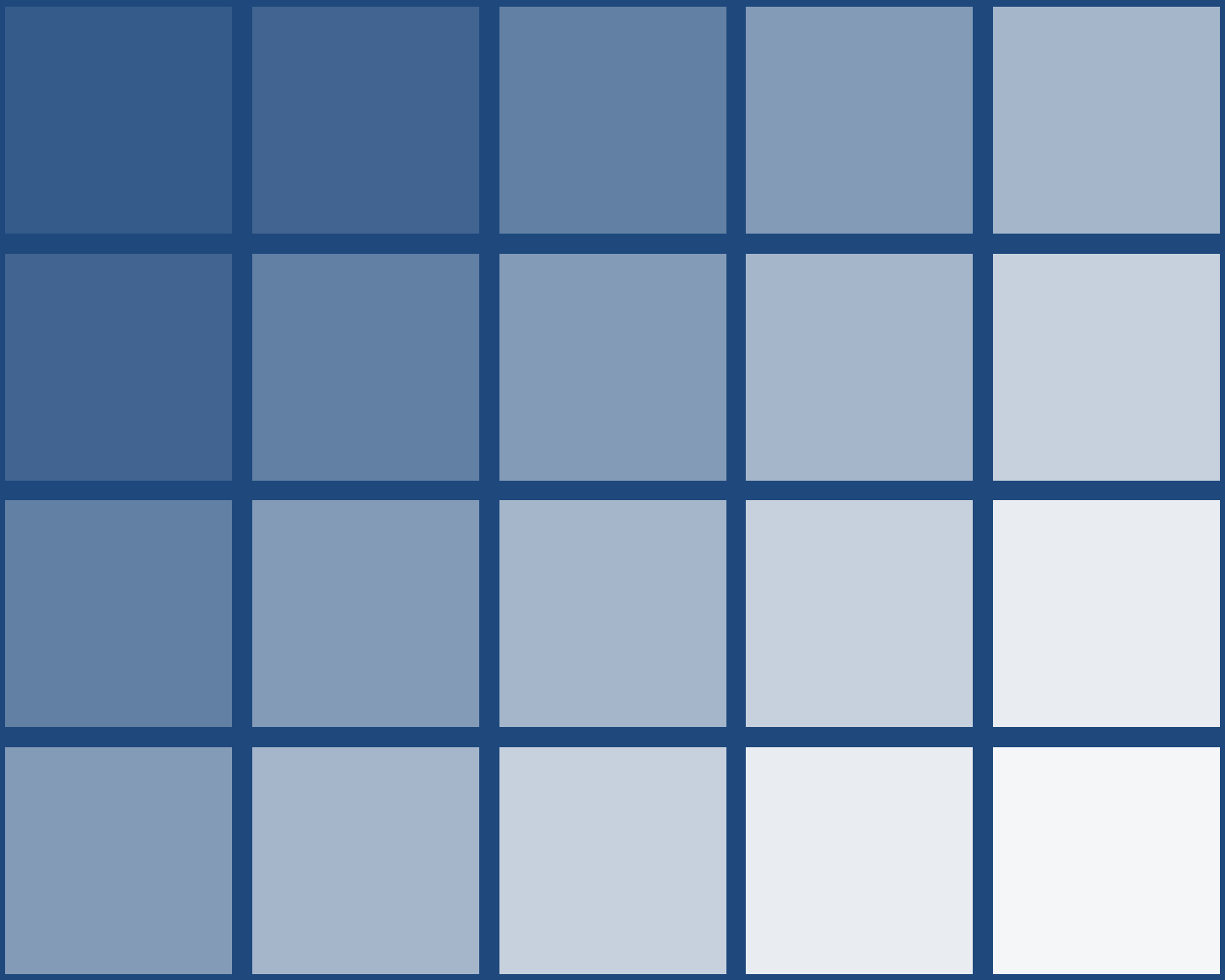

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