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CANADIAN GEOSPATIAL DATA INFRASTRUCTURE
INFORMATION PRODUCT 48e

Value study findings report

GeoConnections

2016

Canada

Value study findings report

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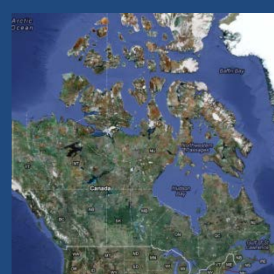


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Executive Summary

This *Value study findings report* provides a description of our analysis of the findings from all lines of enquiry related to the economic and non-economic benefits associated with geomatics technologies and services in Canada.

The content of this report is based upon a review of the literature and the input received during consultations with geospatial information (GI) suppliers in industry and government, users of GI products and services, and providers of GI education and training programs. Selected case studies were also conducted with users of GI. The study methodology precluded the capture of comprehensive information through a survey of stakeholders.

The definition adopted for geospatial information is “any information that identifies the position relative to the Earth of objects, whether natural, built, or cultural.” Geospatial information products and services can be location-centric (i.e., products or services that would not be possible without geographical location or position), location-enabled (i.e., where geographical location or position is an important part of the delivery of products and services), or location-incidental (i.e., where geographical location or position is not required for the delivery of products or services, but would be nice to have).

The definition of the geomatics sector adopted for the purposes of this study is “organizations involved in: geospatial information capture and processing; geospatial information analysis and presentation; integrated information products and services; location-based solutions; and geospatial information technologies".

Geospatial information contributes to economic growth, environmental quality, and social progress. This study considered three groups of socio-economic impacts:

- Geomatics Products and Services – This is the value in the Canadian economy of the provision of geomatics products and services (i.e., supply side).

- Economic Productivity – This is the value in the Canadian economy of the use of geomatics products and services (i.e., demand side). The impact that geospatial information has had on the Canadian economy was estimated using a Computable General Equilibrium (CGE) model.

- Social and Environmental Benefits – These are the social and environmental benefits of the use of geomatics products and services that are difficult to quantify in economic terms.

Geomatics Products and Services

The geomatics sector value chain consists of the following segments:

- Geospatial Information Capture and Processing - encompasses the activities of data collection using surveying, GNSS, hydrographic, 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 - encompasses the activities of data analysis using GIS, 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 - encompasses the integration of geospatial information with other types of information (e.g., resource, demographic, socio-economic, etc.) to develop value-added products and services to help inform decision-making and improve operational performance within organizations.
- Location-based Services - encompasses a growing range of both Internet-based services that employ geospatial information to help users locate destinations and businesses (e.g., Google Earth and Maps, Windows Bing, Mapquest, etc.), sometimes referred to as Mass Market Geomatics, and a variety of services to mobile device users, including advertisements, billing, information, tracking and safety.
- Geospatial Information Technologies - encompasses the production and distribution of software and equipment used for geospatial information capture, processing, analysis, presentation and value-added information production.

The geomatics industry consists of almost 2,500 firms. 83% of the firms have fewer than 100 employees and revenues below $10 million. Almost 70% were formed in the three decades between 1970 and 2000. The bulk of the firms are in Ontario (30%), the Prairies (22%), and Quebec (19%).

Economic Productivity

The bulk of the value of geospatial information comes from its use, rather than its production. This study found that there is widespread use of geospatial information in the Canadian economy, and that use is growing rapidly. In 2013, geospatial information was found to contribute $20.7 billion dollars (1.1%) to Canada's GDP. A sensitivity analysis found that the 90% confidence interval for the result is between $18.9 billion and $22.5 billion. 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.

The bulk of the benefits of geospatial information come from those sectors that are the heaviest users: natural resources, agriculture, and transportation. As a result, the regions that benefit the most are those with a high concentration of those industries.

The regional results are shown in the following table:

	Atlantic	Quebec	Ontario	Prairies	British Columbia	North	Canada
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%)**

Notably, governments are benefiting from the use of geospatial information through improved decision-making and responsiveness. Municipalities are leading the way in infrastructure maintenance, land use planning, and emergency preparedness and response. Those consulted suggested that provincial and federal governments are lagging the municipalities in their use of geomatics.

Social and Environmental Benefits

Benefits from the use of geospatial information that cannot be readily expressed in monetary terms include:

- **Quality of Life Benefits for Canadians –** Quality geospatial information improves the quality of life for Canadians in many ways. New and improved products and services will provide greater functionality and convenience for consumers. Better information leads to better planning and administration within the public sector, to the benefit of all Canadians. Geospatial information, such as road maps and navigational charts, is an important element in many environmental, health, emergency response, and recreational activities.

- **Sovereignty Benefits for Canada –** Quality geospatial information is a vital part of defining Canada and establishing its sovereignty. Our geography plays a major role in defining our national identity. Establishing our borders is fundamental to establishing our sovereignty, especially in the North and the offshore. Geospatial information is a critical ingredient in military operations and the defence of Canada. It is also an important part of Aboriginal land claim negotiations, protection, and development.

- **Health and Safety Benefits for Canadians –** Quality geospatial information helps in protecting the health and safety of Canadians. For example, it is an important component of search and rescue operations. It is used in disaster mitigation, prevention, response, and relief against such disasters as flooding, oil spills on land and water, and forest fires. It is used in emergency response by ambulances, the police, and fire departments – for example, emergency 911 needs are a primary driver of road network and address databases. Geospatial information is also used in epidemiology to monitor and respond to longer-term health issues.

- **Benefits for the Environment –** Quality geospatial information is a vital part of understanding and protecting the environment. It is used in research, regulatory and advocacy activities. It helps in defining, measuring, and monitoring the environment.

Open Data

The government of Canada has made a commitment to make available its large holdings of geospatial information. The study attempted to impute the value of this policy initiative in terms of economic benefits. Open geospatial data, that is data which is accessible and freely available, was found to contribute $695 million (0.04%) to Canadian GDP in 2013. The study notes that economic welfare is maximized if data is made available at marginal cost or free. The one proviso on this condition is the requirement that governments 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 accessibility. Some of those consulted noted that open government data frequently falls short of the currency requirements for their applications.

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1. Introduction

This *Value study findings report* provides a description of our analysis of the findings from all lines of enquiry for this part of the overall *Canadian geomatics environmental scan and value study*. The objectives of the Value study were to:

- Determine the economic value (impact) of geospatial information on the broad Canadian economy as of 2013.
- Determine the economic value of open geospatial information.
- Evaluate geospatial information in the Canadian context, and the provision of geospatial information, as a public good – in terms of both the provision of information and related services.

The content of this report is based upon a review of the literature and the input received during consultations with geospatial information (GI) suppliers in industry and government, users of GI products and services, and providers of GI education and training programs. Selected case studies were also conducted with users of GI. The study methodology precluded the capture of additional information through a survey of stakeholders.

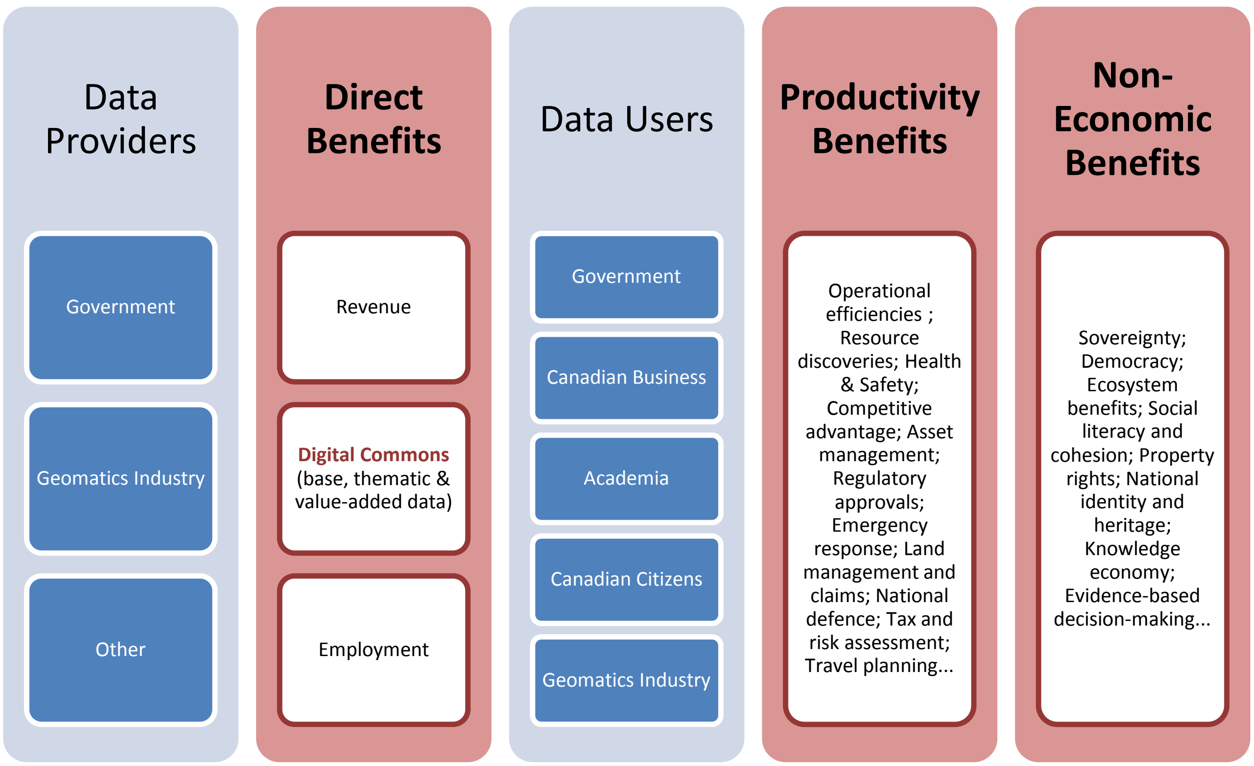
The report is structured to address the study questions posed for the Values study component of the overall study. Chapter 2 introduces the economics of geospatial information – the flow of benefits from providers to users and the particular economic attributions of the information. Chapter 3 discusses the approach and methodology used to measure the benefits in the Canadian context. Chapter 4 describes the Canadian geomatics industry that provides geospatial information. Chapter 5 quantifies the economic impact of the use of geospatial information across the Canadian economy. Chapter 6 describes other benefits to users and the nation that come from the use of geospatial information. Chapter 7 examines the benefits from the provision of open geospatial data. The final chapter examines the prospects for an internationally defined open geospatial data infrastructure.

2. The Economics of Geospatial Information

2.1 Overview

Geospatial information contributes to economic growth, environmental quality, and social progress. Figure 1 shows the participants in realizing those benefits. The following sections introduce the participants and the benefits.

Figure 1: Geospatial Information Benefit Flows



2.1.1 Geospatial Information Providers

The definition of the geomatics sector adopted for the purposes of this study is "organizations involved in: geospatial information capture and processing; geospatial information analysis and presentation; integrated information products and services; location-based solutions; and geospatial information technologies". In addition to organizations that have traditionally specialized in these disciplines, the sector also now includes non-traditional geomatics players (e.g., ICT, engineering and environmental consulting, Internet publishing, etc.). In general, geospatial information providers can be broken into three groups: Canadian governments, the Canadian geomatics industry, and other geospatial information providers:

Canadian Governments – Canadian governments include the federal, provincial, territorial and local 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 provision of geospatial data may be contracted out to the Canadian geomatics industry, government is in a good position to ensure that base data coverage is provided in a complete, cohesive, and current manner. Government also provides a significant amount of thematic data as the result of mandated government responsibilities for activities such as taxation, census taking, and management of resources.

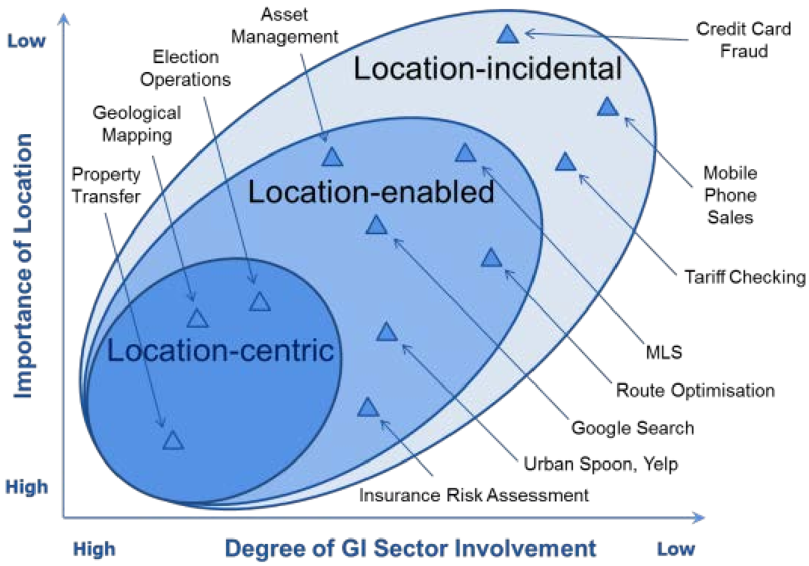
Canadian Geomatics Industry – The Canadian geomatics industry plays a crucial role as a provider of value-added data that builds on base data and other data sources. The Canadian geomatics industry also plays an important role in providing resources and expertise needed by governments responsible for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

Other Geospatial Information Providers – 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, all users of geospatial information are potentially also providers of thematic data. For example, crowd-sourcing is being used to update maps, biodiversity and environmental indicators, weather, and traffic information. One of the most important aspects of the value of a spatial data infrastructure stems from the role it plays in providing a common framework for the exchange of thematic data among geospatial information users.

2.1.2 Geospatial Information

The definition adopted for **geospatial information** is "any information that identifies the position relative to the Earth of objects, whether natural, built, or cultural." The definition being used for the **geospatial information market** is "the demand that exists for geospatial information (GI) products and services, including those that are location-centric (i.e., products or services that would not be possible without geographical location or position) and location-enabled (i.e., where geographical location or position is an important part of the delivery of products and services)". The study scope will not include GI products or services that are location-incidental (i.e., where geographical location or position is not required for the delivery of products or services, but would be nice to have). Figure 2 illustrates examples of the types of products and services in each of these categories.

Figure 2: The Importance of Location



2.1.3 Geospatial Information Users

Geospatial Information Users consist of five groups: the Canadian geomatics industry, other Canadian businesses, academia, Canadian governments, and individual Canadians.

Canadian Geomatics Industry – The Canadian geomatics industry members are obvious users of geospatial information as they add value for resale to other users. In doing so, they improve the products and services available to Canadian business and thus increase their productivity and competitiveness. Through these improved products and services, they also improve the quality of life for Canadians, help maintain the environment, provide health and safety benefits for Canadians, and help maintain the sovereignty of Canada. The Canadian geomatics industry also directly contributes to the economic prosperity of Canada by providing high quality jobs and exporting goods and services.

Other Canadian Business – Canadian business uses geospatial information in many aspects of decision-making. Geospatial information is used 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, and is providing new products and services for Canadians. Ultimately, in all business applications, geospatial information provides benefits by improving productivity and competitiveness, enabling the discovery of new resources, or creating new and improved products and services.

Academia – Academia uses geospatial information for both of 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. Academia also contributes to informed citizens in general that are better able to contribute to social decision-making. Through research, academia contributes to many aspects of our understanding of both our physical and social world. This understanding allows Canadian leaders and citizens to make more informed decisions regarding the environment, the economy, the nation, health and safety, and society.

Canadian Governments – Federal, provincial, territorial and local governments rely on having the necessary 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 which 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 patterns, jurisdictional boundaries and tax collection, etc.), and geographical names.

Individual Canadians – Ultimately, all uses of geospatial information benefit individual Canadians. However, 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 become ubiquitous.

2.1.4 Geospatial Information Benefits

The benefits of data usage are difficult to identify or quantify. This is due to the potentially wide range of data applications and to the breadth of other investments necessary to realize the benefits. In attempting to estimate the benefits stemming from geospatial information, two broad categories are apparent:

Economic Benefits to Canada – Economic benefits come from increased productivity or quality of products and services. Quality geospatial information enables these benefits by permitting better business decisions, making business processes more efficient, allowing natural resources to be discovered and exploited, and creating new business opportunities through new products and services. Some economic benefits come from a Canadian geomatics industry that is more competitive in world markets (see Chapter 4). Most economic benefits come from all of the other Canadian industries that are more competitive as a result of quality geospatial information (see Chapter 5).

Other Benefits to Canada – In addition to direct impacts on the productivity of the Canadian economy, geospatial information provides a multitude of other benefits that are either non-economic or difficult to quantify in economic terms. These benefits include contributions to environmental health, the health and safety of Canadians, national sovereignty, and better decisions by governments, industry, and individuals (see Chapter 6).

2.2 Measuring Geospatial Information Benefits

As an information resource, geospatial information has many of the complex economic characteristics which all information goods and services possess. For example[1]:

- Information is often associated with relatively high collection and custodian costs and relatively low dissemination costs.
- Consumption of information by one user does not reduce the availability of the same information to others (non-rival characteristics).
- Information can often be used for a wide variety of applications and may have very different values in its alternative uses.
- The value of information to a user may depend on the skills of that user.
- The *a priori* knowledge of the value of information to the potential user is incomplete. Determining the value to *that* user at *that* time for *that* purpose is not trivial.
- Information may be have no value unless or until it is combined with other items of information.
- Information can display characteristics of both private and public goods, depending on circumstances, and has the potential for both positive and negative externalities (see Section 7.2).

Although having some intrinsic value in itself, the value of geospatial information flows mainly from its contribution as a necessary input to various purposes, products, and services. At the level of the individual user, the value of geospatial information depends upon and changes with: the application; the external environment; existing knowledge; the time-frame; ability and skills; and information quality. These are not minor economic valuation issues. In this case, the purpose of this exercise is to determine the macro-level impact of GI on the Canadian economy, which means that some of these micro-level valuation difficulties are not encountered.

Figure 3 illustrates three classes of benefits and how they vary as the use of geospatial information increases. The area within the graph represents the amount of benefit as use increases to the right. The three classes are private, public, and network benefits:

- Private Benefits accrue to the user of geospatial information. They include increased productivity and better decisions.

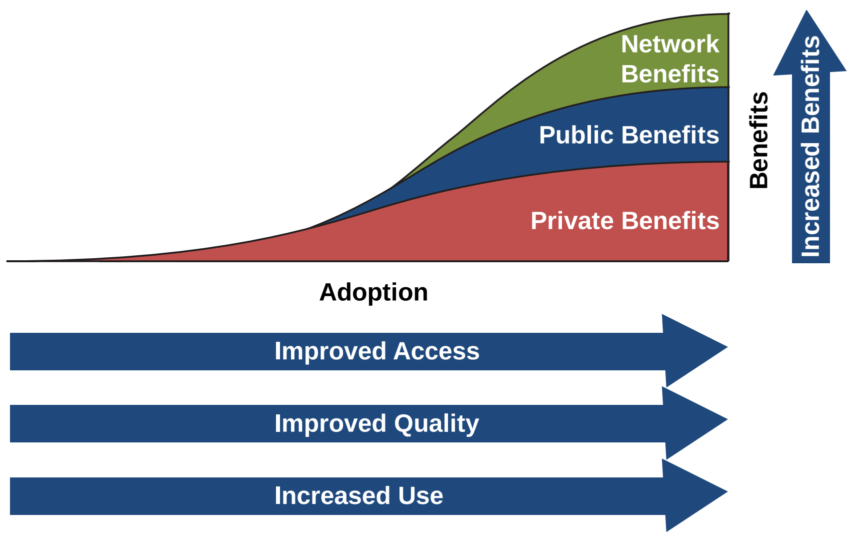
[1] Hoogsteden, Christopher; John Hannah (1999) "Of Capital Importance: Assessing the Value of the New Zealand Geodetic System", prepared for Land Information New Zealand.

- Public Benefits accrue to others as a result of the activities of the users of geospatial information. In economic terms these are known as 'non priced spillovers'. Typical examples include improved understanding of spatial relationships, better use and management of natural resources, and more informed government decisions.

- Network Benefits accrue to private users and the public as a result of the interactions among users of geospatial information. They include easier collaboration, efficiencies from sharing information, and better communications. These benefits are enhanced by the implementation of a spatial data infrastructure (SDI) that enables geospatial information to be openly accessed and shared using consistent standards (see Chapter 8).

As shown in the diagram, the overall level of benefits increases with the amount that geospatial information is used. At the left side of the diagram, benefits are predominately private for which users are willing and able to pay. As use increases, benefits come increasingly from applications that provide more public benefits and fewer private benefits, and for which users are less willing or able to pay. As use increases there are also increasing network benefits, which are discussed next.

Figure 3: Benefit Types



As the volume, use, and demand for geospatial information proliferates, society requires commonly understood reference bases or foundations with which to link and combine information. A significant benefit provided by an SDI lies with its role in ensuring compatibility within a network of datasets. The SDI reduces transaction costs in terms of searching and verifying that the different datasets are actually compatible. It also reduces costs by eliminating or significantly reducing the costs of transforming the various datasets, especially when these datasets are collected by different organizations at different times for different uses and users. A common reference system, and datum, is necessary in order to align or 'fuse' these datasets 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.

The fundamental property, and major economic feature, of networks is that they display positive consumption and production externalities. A positive consumption externality means that the utility derived from use (and the value) of a unit of the good increases with the number of units sold. Good examples are telephones, fax machines, and word processing software, which derive benefit from compatibility with many other similar units.

Added value is created from linking different geospatial data sets together and also by reducing costs for new data gathering by aggregating existing sets. While any two original data sets are useful and have value in themselves, it is the complementarity and compatibility that enables a new good to be created with additional value. The value of this compatibility illustrates the concept of network externalities.

In some networks, the utility of the composite good is not the sum of the respective qualities. The quality may be the minimum of the qualities of the component parts as occurs with voice quality of telecommunications. Thus significant quality coordination problems arise in a network with fragmented ownership. A case can be made that the combined spatial information product will only be as strong as its weakest component and a lack of spatial accuracy in one dataset will affect the composite product.

3. Approach and Methodology

Figure 4 shows the framework for our approach to the economic analysis. At its core are three groups of socio-economic impacts:

- Geomatics Products and Services – This is the value in the Canadian economy of the provision of geomatics products and services (i.e., supply side).
- Social and Environmental Benefits – These are the social and environmental benefits of the use of geomatics products and services that are difficult to quantify in economic terms.
- Economic Productivity – This is the value in the Canadian economy of the use of geomatics products and services (i.e., demand side).

The magnitude of these impacts is driven by the use of new geospatial products and services in sector applications, shown at the sides of the figure 4.

The magnitude of these impacts is also affected by the policies and programs in Canada for the provision of geospatial information, and in particular those shown at the top and bottom of the figure: i) open data and the Canadian Geospatial Data Infrastructure, and ii) the provision of data as a public good and the work of GeoConnections and other federal, provincial, territorial and local organizations.

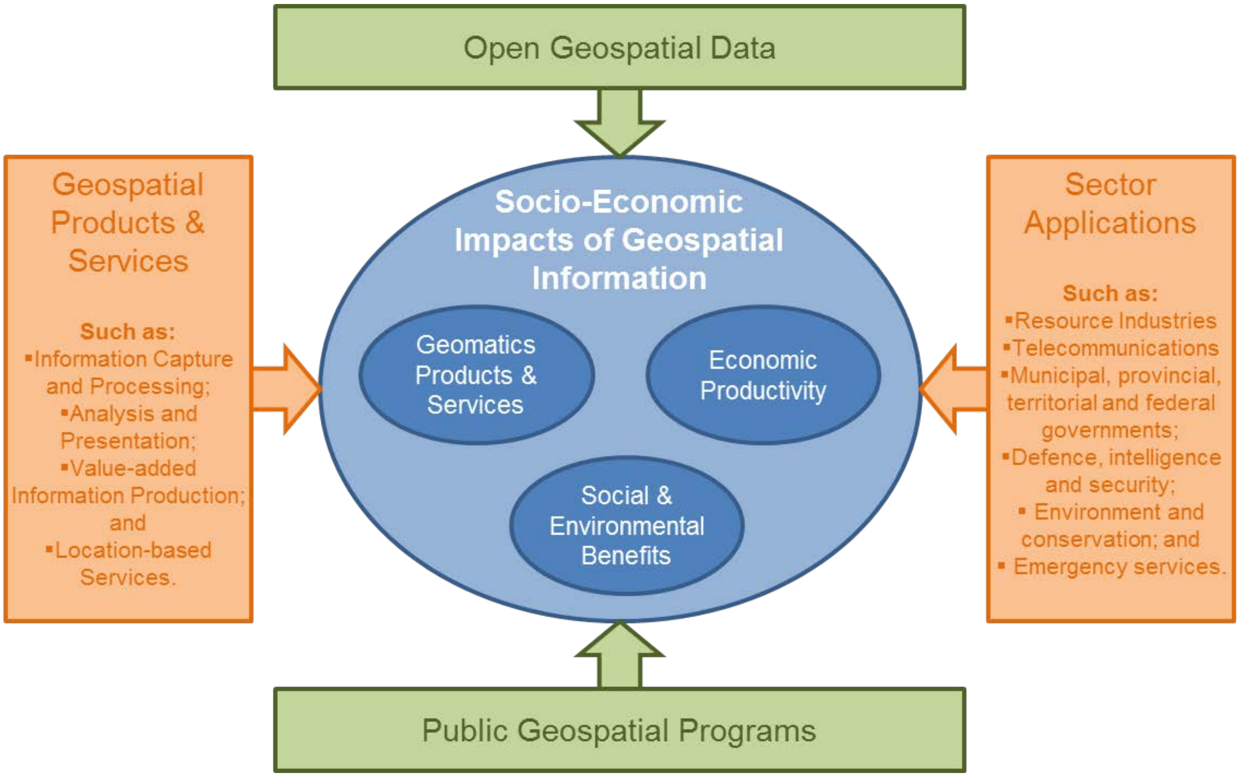
Economic prosperity comes primarily from two sources: i) the value added of geospatial products and services, and ii) increased economic productivity due to the use of geospatial information across the economy. The economic contribution of the production of geospatial information by Canada's geomatics industry is due to the first of these. The economic contribution of the use of geospatial information is due to the second.

Our analysis of the economic value of geospatial information has three components:

1. The value added of the producers of geo-products and services (Chapter 4).
2. The economic benefit to users of geospatial information (Chapter 5).
3. Other benefits to users of geospatial information (Chapter 6).

The methodologies employed to evaluate each of these components are discussed in the following sections.

Figure 4: Economic Analysis Framework



3.1 The Economic Contributions of the Geomatics Industry

Indicators of an active geomatics industry were taken from the industry cluster literature. Measures of industry performance include: significance in terms of the number and size of core firms, the breadth of their responsibilities, and their reach to distant markets; interactions within the sector and with the rest of the world; and the sector's dynamism in terms of innovativeness and growth. [2] Due to the lack of an industry survey in this study, not all of these indicators could be measured. Table 1 list industry indicators and the extent to which they are measured in this study.

In Chapter 4, the direct contribution to the Canadian economy of the geomatics industry have been measured in a number of ways, such as number of organizations, employment, revenues, and ultimately value added (as measured by GDP contribution).

[2] Arthurs, David; Cassidy, Erin; Davis, Charles; Wolfe, David (2009) "Indicators to support innovation cluster policy", International Journal of Technology Management, Vol. 46, Nos. 3-4, pp. 263-279.

Table 1: Geomatics Industry Indicators

Construct	Sub-Construct	Indicator	Chapter 4 Measures
Significance	Critical mass	Number of firms	Section 4.3
		Number of spin-off firms	Not Available
		Size of firms	Section 4.6, Section 4.5
	Responsibility	Firm structure	Not Available
		Firm responsibilities	Not Available
	Reach	Export orientation	Not Available
Interaction	Identity	Internal awareness	Section 4.2
		External recognition	Not Available
	Linkages	Local involvement	Not Available
		Internal linkages	Not Available
Dynamism	Innovation	R&D spending	Not Available
		Relative innovativeness	Not Available
		New product revenue	Not Available
	Growth	Number of new firms	Section 4.8
		Firm growth	Not Available

Estimating the size of the geomatics industry is complicated by difficulties in defining the industry boundaries. For the presentation of economic statistics, Statistics Canada uses the North American Industry Classification System (NAICS). NAICS is a comprehensive system encompassing all economic activities. It has a hierarchical structure; at the highest level, it divides the economy into 20 sectors. Lower levels consist of subsectors (three-digit codes), industry groups (four-digit codes), and industries (five-digit codes) that are common across Canada, US, and Mexico. The sixth digit is used to designate national industries. Canada has 922 categories at the six-digit level.

The criteria used to group establishments into industries in NAICS are similarity of input structures, labour skills and production processes.[3] Unfortunately for our purposes, even at the most detailed level, geomatics activities fall across a wide number of NAICS categories that often also contain non-geomatics activities. For example, aerial photography used for photogrammetry is classified in the same category as wedding photography.

The NAICS categories that best captures a portion of the geomatics community are i) Geophysical surveying and mapping services (NAICS 541360), and ii) Surveying and mapping (except geophysical) services (NAICS 541370). For these categories, economic data is available from Statistics Canada. In particular, the Canadian Business Patterns database provides information on the number of establishments and employment levels by province.

[3] http://www.statcan.gc.ca/subjects-sujets/standard-norme/naics-scian/2012/introduction-eng.htm

In this study, considerable effort has gone into augmenting the publicly available data that is available for these two NAICS categories by assembling a database of Canadian geomatics companies across all aspects of the sector, including environmental and engineering consulting, information technologies, remote sensing, positioning and navigation, and geospatial information systems.

The database was populated using a number of sources:

- Industry Canada's Canadian Company Capabilities database
- Company lists from professional societies across Canada for surveying and engineering
- Local IDEAs database at the Munk School of Global Affairs Innovation Policy Lab.

Using these sources, data is available concerning the number of companies, their regional distribution, their focus of activity, their age, their employment numbers, and their revenues.

3.2 Economic Benefits from Geospatial Information Use

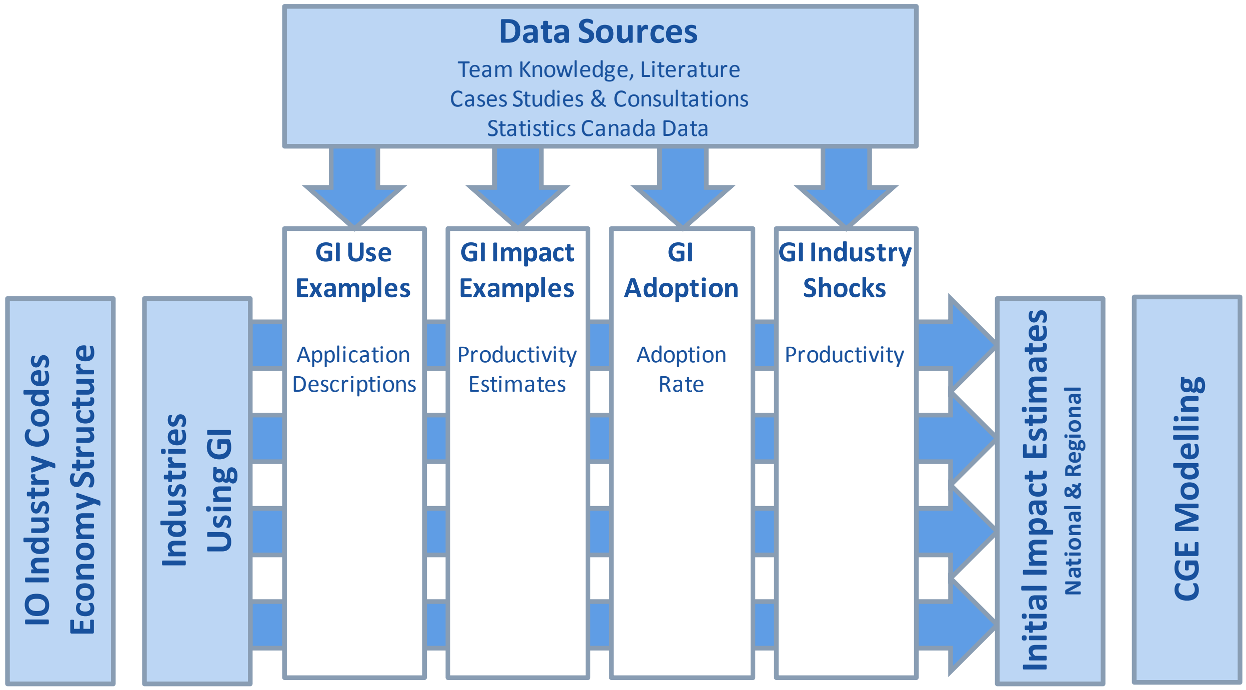
3.2.1 Modelling Approach

The economic benefits from the use of geospatial information were determined using a Computable General Equilibrium (CGE) model of the economy. The approach makes the following assumptions:

- 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 GDP.

Figure 5 provides an overview of the approach.

Figure 5: Geospatial Information Use Modelling Approach



The steps in the approach are as follows:

1. Structure of the Economy – The Canadian economy structure is taken as that used by Statistics Canada for its input-output (IO) tables with the economy broken into 234 industries. This structure is similar to that of the NAICS codes discussed previously (see Section 3.1), and there is a correspondence between the two.

2. Industries Using GI – Not every industry in the economy is an active user of geospatial information. Only those 60 that were found to significantly benefit from geospatial information use were included in the subsequent analysis.

3. GI Use Example – Based on the literature review, consultations, and case studies, examples of how different industries use geospatial information were identified. A listing of these examples is contained in Appendix A, and further descriptions are contained in the CGES Findings Report. Select case study profiles are available in Appendix D.

4. GI Impact Examples – The impact of GI use is assumed to come through productivity improvements. Based on the previous GI use examples and other data from the literature, consultations, and case studies, estimates were made for the productivity improvements experienced by users. This is discussed in Appendix C.

5. GI Adoption – The productivity improvements experienced by users depend on the degree to which they have adopted the relevant technologies and therefore is not

homogeneous across an industry. Therefore productivity impacts were varied across each industry's early adopters, majority, and laggards.[4]

6. GI Industry Shocks – The impact of geospatial information on an industry is then the product of the productivity estimate times the adoption estimate. In some industries, only a portion of the industry, as defined in the industry structure, uses geospatial information. This is accounted for by an 'Industry Applicability' figure. These productivity impacts are termed 'shocks' to the economy in economic modelling. The figures for each industry are shown in Appendix B.

7. Initial Impact Estimates – Using the derived productivity shocks and static information on industry GDP, an initial estimate of the economic impact of the use of geospatial information in the Canadian economy was made.

8. CGE Modelling – Finally, the productivity shocks were entered into the CGE model. The results are reported in Chapters 5 and 7.

The following sections provide more detail on the process for establishing the industry shocks and the CGE model.

3.2.2 Industry Shocks

The industry shocks were derived from three sources:

- Case studies
- Consultations with industry leaders with knowledge of their specific sector
- Analysis of comparable overseas studies, particularly from Australia, New Zealand, Denmark and the UK, the European Union.

Fourteen case studies were completed to provide input to the economic modelling for this Study, as identified in Table 2. They were used primarily to help ascertain the application, quantitative and qualitative benefits, and costs of digital geospatial information in various geospatial information user sectors.

[4] The segmentation of geospatial information adoption is based on the work of Everett Rogers. Rogers estimated the categories of adopters as being innovators (2.5 per cent), early adopters (13.5 per cent), early majority (34 per cent), late majority (34 per cent) and laggards (16 per cent). We have simplified these into three categories. See Rogers (1983) "Diffusion of Innovations", 3rd Edition.

Table 2: Case Studies Sectors

Sector
1. Not for Profit
2. Renewable Resources (two case studies)
3. Non-renewable Resources
4. Architecture, Engineering and Construction
5. Health
6. Utilities
7. Federal Government
8. Municipal Government
9. Safety and Security
10. Land and Property
11. Agriculture
12. Retail and Trade
13. Financial Services

The research examined three scenarios:

1. Reference Case, which represents the current situation.
2. Case 1 – The situation that might have arisen without modern geospatial information technologies.
3. Case 2 – The situation that might have arisen with modern geospatial information systems being developed but without access to open data.

For reference Case 1, modern geospatial information technologies are those that have been developed since about the 1980s, such as GIS, GPS, and remote sensing. Of course geospatial information has been around since time immemorial, for example in the form of paper maps.

For reference Case 2, the case studies and consultations sought comment on what outcomes might have arisen if open data were not available. This proved to be a challenging question for some industries, such as the forestry and water sectors, where geospatial systems have become so embedded in operations that the industry managers often have difficulty envisaging operating without it. Geospatial information is so important to their operations that they would need to either create the data themselves or purchase data from private sector providers.

The results of these consultations and analysis are summarized in Appendix B. The table shows that the direct impact of open data on the productivity shocks ranges between 0 per cent and 10 per cent on the sectors estimated.

These shocks were then fed into ACIL Allen's CGE model (Tasman Global) to estimate the impact on overall economic aggregates such as GDP, incomes and trade. The model is described in the next section and the results are discussed in Chapters 5 and 7.

3.2.3 CGE Model

The impact that geospatial information and Open Data have had on the Canadian economy was estimated using a Computable General Equilibrium (CGE) model, *Tasman Global*. *Tasman Global* is a large scale, dynamic, computable general equilibrium model of the world economy that has been developed in-house by ACIL Allen Consulting. *Tasman Global* is a tool for undertaking economic impact analysis at the regional, state, national and global levels.

CGE models such as *Tasman Global* mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, using a 'bottom-up approach' – starting with individual markets, producers and consumers and building up the system via demands and production from each component. When an economic shock, such as an increase in a sector's productivity, is applied to the model, each of the markets adjusts to a new equilibrium according to the set of behavioural parameters[5] which are underpinned by economic theory.

In addition to recognizing the linkages between industries in an economy, CGE models also recognize economic constraints. For example, increased demand for labour may increase real wages if there is full employment.[6]

A key advantage of CGE models is that they capture both the direct and indirect impacts of economic changes while taking account of economic constraints. For example, *Tasman Global* captures the expansion in economic activity driven by an investment, and at the same time accounts for the constraints faced by an economy in terms of availability of labour, capital and other inputs. Another key advantage of CGE models is that they capture a wide range of economic impacts across a wide range of industries in a single consistent framework that enables rigorous assessment of a range of policy scenarios.

When assessing the impacts of a technology, project or policy on the Canadian economy, there are a range of key macroeconomic variables that are commonly evaluated, these include:

- *Gross Domestic Product (GDP)* — GDP is a measure of Canada's economic activity. GDP is the sum of consumption, government spending, investment and net exports.

[5] An example of a behavioural parameter is the *price elasticity of demand* – the responsiveness of demand for a commodity to a change in the price of that commodity. Each of these markets, for example the market for a commodity or a factor such as labour or land or the market for capital goods, is then linked through trade and investment flows.

[6] By default, *Tasman Global* assumes that the economic changes do not raise unemployment above the so-called natural rate of unemployment in the long term. Any shifts in the demand for labour are assumed to be offset by changes in real wages sufficient to prevent the emergence of unemployment above the natural rate. This is the 'full employment assumption'. This assumption can be relaxed over the short to medium term.

Therefore, changes in GDP largely reflect changes in these economic variables, particularly those of investment and consumption.

- *Real income* — although changes in real economic output (GDP) are useful measures for estimating how much the output of the relevant economies may change, changes in the real income of a region are more important as they provide an indication of the change in economic welfare of the residents of a region. Indeed, it is possible that real economic output can increase with no, or possibly negative, changes in real income. The changes in real income at the national level are synonymous with real gross national disposable income (RGNDI) commonly reported by national statistics organizations.

  In global CGE models, the change in real income is mathematically equivalent to the *equivalent variation* measure of welfare change and provides a monetary measure of the welfare effect of a change in the economy.

- *Employment* — Employment estimates are based on the CGE model standard elasticities and participation/unemployment functions which are only partially flexible in response to changes in economic activity relative to the reference case. Employment growth is constrained by the fact that not all employees are mobile and there is a limit on immigration. A fully flexible labour market would have a much larger impact on employment.

- *Consumption* — consumption is generally the largest component of GDP and measures private consumption expenditure. This variable is an indicator of living standards. An increase in private consumption indicates an increase in welfare of Canadians.

- *Investment* — investment is another component of GDP that measures demand by private firms and individuals for capital, including factories, machinery, computer software, etc. This variable is an indicator of the future productive capacity of the Canadian economy.

- *Balance of trade* — the balance of trade provides insights about the relationship between imports and exports. A positive balance is known as a trade surplus if it consists of exporting more than is imported; a negative balance is referred to as a trade deficit.

- *Terms of trade* — represents the relationship between the average prices of exports and imports. It is a useful measure since changes in the relative prices of Canada’s exports and imports affect the purchasing power of a nation and, hence, real national income. If the price of exports is rising faster than the price of imports, the purchasing power of an economy’s output will increase and enables residents to purchase more imports for the same level of output – thereby increasing the welfare of the population. The terms of trade is an important measure, since the goods and services that make up a country's exports are typically quite different from those that make up its imports.

- *Taxation* — this is a measure of the impact of the industry change on Government revenue.

3.2.4 Database Changes for the Canadian Economy

Underpinning the *Tasman Global* model is a database that contains sectoral and regional detail. It is based on the latest available global economic database produced by GTAP[7] (version 8.1) which has a globally consistent suite of input-output tables and social accounting matrices for 129 regions for 2007. This information is the foundation of the *Tasman Global* database, which has greater sectoral disaggregation, additional international economies and a significant focus on regional economies.

For this analysis, the Canadian database component was disaggregated into six regions:

1. Atlantic (comprising Newfoundland and Labrador, Prince Edward Island, Nova Scotia and New Brunswick)
2. Quebec
3. Ontario
4. Prairies (comprising Manitoba, Saskatchewan and Alberta)
5. British Columbia
6. North (comprising the Yukon, Northwest Territories and Nunavut).

The disaggregation was based on detailed employment and gross value added data by industry and province available from Statistics Canada, along with additional information from Provincial authorities and industry reports. As part of the disaggregation, a range of services sectors was also disaggregated to match the North American Industry Classification System (NAICS) (at the 2-digit level) used by Statistics Canada (see Table 3).

[7] The Global Trade Analysis Project (GTAP) database is fully documented, publicly available, and global. It contains complete bilateral trade information, transport, and protection linkages among regions for all GTAP commodities. The GTAP model was constructed at the Centre for Global Trade Analysis at Purdue University in the United States. It is the most up-to-date, detailed database of its type in the world.

Table 3: North American Industry Classification System (NAICS) Canada 2012

Code	Sector
11	Agriculture, forestry, fishing and hunting
21	Mining, quarrying, and oil and gas extraction
22	Utilities
23	Construction
31-33	Manufacturing
41	Wholesale trade
44-45	Retail trade
48-49	Transportation and warehousing
51	Information and cultural industries
52	Finance and insurance
53	Real estate and rental and leasing
54	Professional, scientific and technical services
55	Management of companies and enterprises
56	Administrative and support, waste management and remediation services
61	Educational services
62	Health care and social assistance
71	Arts, entertainment and recreation
72	Accommodation and food services
81	Other services (except public administration)
91	Public administration

Note: Detailed definitions of each sector are available at:
http://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVDPage1&db=imdb&dis=2&adm=8&TVD=118464

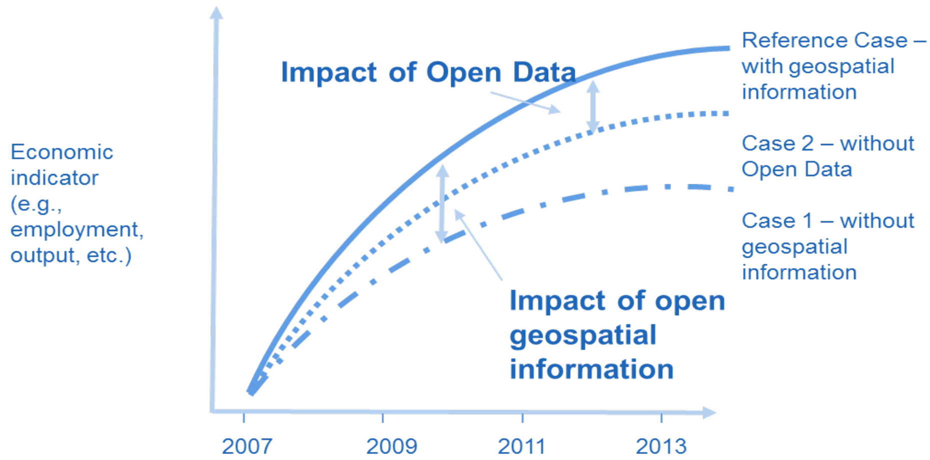
Source: Statistics Canada.

Historical changes in key macroeconomic, industry output, demographic and industry value added have also been incorporated to reflect the historical progress of the Canadian economy to its current state. These updates ensure that the model accurately reflects the Canadian economy at the provincial levels as accurately as possible.

3.2.5 Scenario Description

In CGE analysis the outcomes of a policy simulation are reported as deviations from the business as usual reference case (see Figure). To eliminate the impact of nominal price movements in the results, economic variables such as the change in GDP are reported as deviations from their real rather than nominal values.

Figure 6: Stylised example of estimating the impact of geospatial information and Open Data



For this study, the reference case (*With Geospatial Information*) is the situation where the Canadian economy grew as per historical records (i.e. including the uptake and use of geospatial information). This case is then compared to two alternative cases:

1. Without Geospatial Information (Case 1) — this refers to a scenario where the quantifiable productivity benefits identified from each component of the use of geospatial information were not realized. The difference between this scenario and the reference case scenario provides an estimate of the economic benefits that the geospatial information have had on the Canadian economy to date.
2. Geospatial information without Open Data (Case 2) — this refers to a scenario where the quantifiable productivity benefits identified as a result of Open Data were not realized. The difference between this scenario and the reference case provides an estimate of the economic benefits that Open Data had on the Canadian economy to date.

By comparing the difference between Case 1 and Case 2, the impact of Open Data can be estimated.

3.2.6 Sensitivity Analysis

There is a reasonable degree of uncertainty surrounding the estimates of the input parameters for the economic modelling. In order to assess the impact of that uncertainty, a sensitivity analysis was performed using Monte Carlo analysis[8]. The following steps were taken:

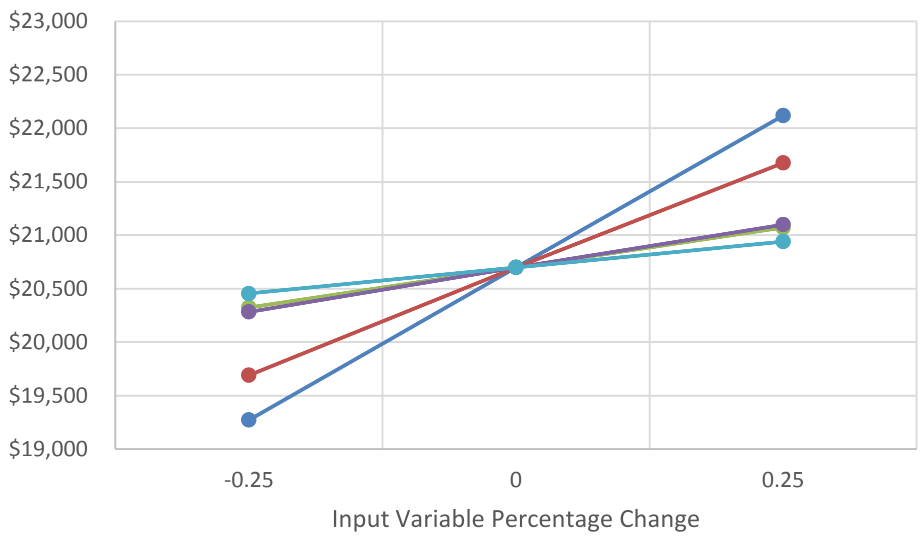
1. The simple spreadsheet version of the model was analyzed to determine the five input variables that had the greatest impact on the results. These were:
   - Conventional and unconventional oil and gas

[8] Monte Carlo simulation is a method of analyzing uncertainty in a model by which input variables are assigned probability distributions and the model is run thousands of times using specific values for each input parameter determined by sampling from the probability distributions each time. The aggregate of the results forms a probability distribution describing the uncertainty in the answer.

- Architectural and related engineering services
- Other municipal Government services
- Mining
- Support services for oil and mining

2. Ten runs of the full CGE model were performed, varying each of the five input variables identified in the previous step by plus and minus 25% individually. The results show that the model is linear; in other words, there is a linear relationship between changes in the input parameters and changes in the output.

Figure 7: Linearity of the CGE Model



3. Normal probability distributions were assigned to the five input parameters such that plus and minus 25% of the value accounted for 90% of the uncertainly.

4. A Monte Carlo simulation was performed using the five input variable probability distributions defined in Step 3 and interpolating/extrapolating from the CGE model results obtained in Step 2. The linearity of the model shown in Step 2 makes this approach valid.

The results from the sensitivity analysis are contained in Section 5.2.1.

3.3 Other Benefits from Geospatial Information Use

Benefits from the use of geospatial information that cannot be readily expressed in monetary terms have been examined through qualitative descriptions. Examples include:

Quality of Life Benefits for Canadians – Quality geospatial information improves the quality of life for Canadians in many ways. New and improved products and services will provide greater functionality and convenience for consumers. Better information leads to better planning and administration within the public sector, to the benefit of all Canadians. Geospatial information, such as road maps and navigational charts, is an important element in many recreational activities such as boating, hiking, and tourism.

Sovereignty Benefits for Canada – Quality geospatial information is a vital part of defining Canada and establishing its sovereignty. Our geography plays a major role in defining our national identity. Establishing our borders is fundamental to establishing our sovereignty, especially in the North and the offshore. Geospatial information is a critical ingredient in military operations and the defence of Canada. It is also an important part of Aboriginal land claim negotiations.

Health and Safety Benefits for Canadians – Quality geospatial information helps in protecting the health and safety of Canadians. For example, it is an important component of search and rescue operations. It is used in disaster mitigation, prevention, response, and relief against such disasters as flooding, oil spills on land and water, and forest fires. It is used in emergency response by ambulances, the police, and fire departments – for example, emergency 911 needs are a primary driver of road network and address databases. Geospatial information is also used in epidemiology to monitor and respond to longer-term health issues.

Benefits for the Environment – Quality geospatial information is a vital part of understanding and protecting the environment. It is used in research, regulatory and advocacy activities. It helps in defining, measuring, and monitoring the environment.

Other benefits from geospatial information use are considered in Chapter 6.

4. Geomatics Industry

This chapter looks at a variety of measures of the Canadian geomatics industry. Section 4.1 begins with a recap of the geospatial information value chain that was introduced in the Canadian Geospatial Environmental Scan (CGES) Findings Report. This is followed by a brief consideration of the term 'geomatics' and its acceptance by the geomatics industry. The subsequent sections examine different metrics for the industry: number of firms, revenue, activities, regional distribution, size, and age and survival rate. These results are summarized in Table 4

Table 4: Canadian Geomatics Industry Summary

Identity	21% of firms providing geomatics products or services identify themselves with the term 'geomatics'					
Number of Firms	2,454					
Regional Establishment Distribution	BC	Prairies	Ontario	Quebec	Atlantic	North
	17%	22%	30%	19%	11%	1%
Regional Employment Distribution	BC	Prairies	Ontario	Quebec	Atlantic	North
	7%	41%	17%	25%	10%	0%
Establishment Revenues	83% below $10 million					
Establishment Employment	83% below 100 employees					
Age	69% were formed in the 1970, 1980 and 1990 decades; 13% before; and 18% after.					

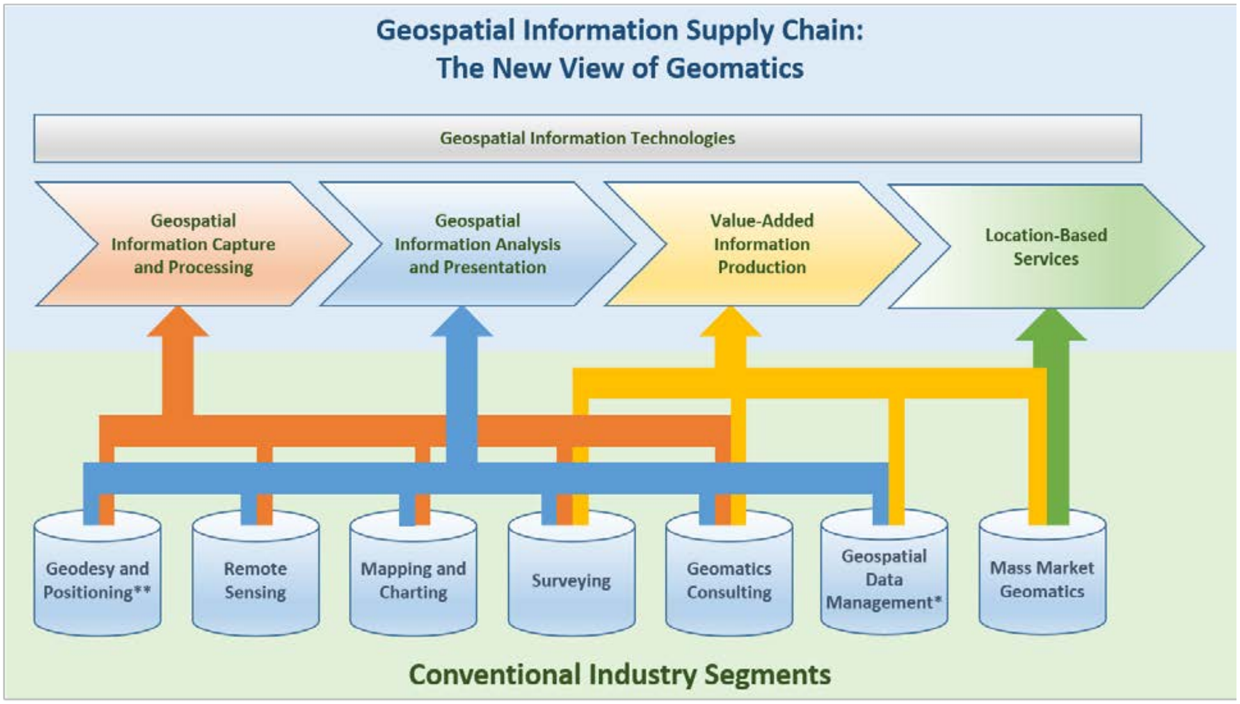
4.1 The Geospatial Information Value Chain

The CGES Findings Report introduced a new segmentation of the geospatial information sector aligned with a modern geospatial information value chain, as defined below and illustrated in Figure 8. The figure also maps the conventional industry segments that have been used in previous geomatics industry studies into this value chain model.

In each subsequent part of the first four components of the chain/segment of the sector, value is added; the fifth component straddles the other components, providing the essential tools for the production of products and services.

- Geospatial Information Capture and Processing - encompasses the activities of data collection using surveying, GNSS, hydrographic, and airborne and satellite imaging technologies, and the processing of such data for entry into data analysis and presentation technologies.

Figure 8: Relation between Contemporary GI Value Chain and Conventional Geomatics Business Segments



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

- Geospatial Information Analysis and Presentation - encompasses the activities of data analysis using GIS, 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 - encompasses the integration of geospatial information with other types of information (e.g., resource, demographic, socio-economic, etc.) to develop value-added products and services to help inform decision-making and improve operational performance within organizations.

- Location-based Services - encompasses a growing range of both Internet-based services that employ geospatial information to help users locate destinations and businesses (e.g., Google Earth and Maps, Windows Bing, Mapquest, etc.), sometimes referred to as Mass Market Geomatics, and a variety of services to mobile device users, including advertisements, billing, information, tracking and safety.

- Geospatial Information Technologies - encompasses the production and distribution of software and equipment used for geospatial information capture, processing, analysis, presentation and value-added information production.

The analysis of the geomatics industry that follows uses both conventional industry segmentation (surveying and mapping, GPS, GIS, remote sensing, and other) and the value chain segmentation (geospatial data capture & processing, geospatial data analysis & presentation, integrated information products & services, location-based solutions, and geospatial information technologies) where appropriate.

It must be noted that this analysis of the Canadian geomatics industry is hampered by two factors:

- As mentioned previously, geomatics is not an industry that is recognized in the breakdown of the economy employed by Statistics Canada, which makes measuring the industry using that source of information an ongoing challenge.
- It was not possible to conduct a survey of the geomatics industry in Canada to obtain industry statistics. As a result, this study relies on third party statistics. In particular, statistics are not available on markets, industry growth, research and development spending, and human resource issues.

4.2 The Geomatics Identity

A 2001 study[9] noted that many parts of the geomatics sector do not consider themselves part of a larger whole. At that time, only about 8% of 'geomatics' firms in the Industry Canada Canadian Company Capabilities database mention the word geomatics in their descriptions. Today, 13 years later, that number has increased to 21%.

Rather, many firms providing geomatics products and services consider themselves to part of other industries such as information technology, engineering consulting, and environmental consulting. For example, Table 5 shows the breakdown of the primary NAICS code reported most frequently by geomatics firms in the Canadian Company Capabilities database.

Table 5: Primary NAICS Code Reported Most Frequently by Geomatics Firms

NAICS Industries	Percentage of Geomatics Firms Reporting as Primary Industry
Surveying and Mapping (except Geophysical) Services	23%
Consulting Services (including environmental)	16%
Computer Systems	12%
Engineering Services	11%
Geophysical Surveying and Mapping Services	9%
Computer Manufacturing	7%

[9] Hickling Arthurs Low (2001) Geomatics Sector Human Resources Study, prepared for Canadian Council of Land Surveyors, Canadian Institute of Geomatics, Geomatics Industry Association of Canada.

4.3 Number of Establishments

This study has identified 2,454 private sector establishments[10] providing geomatics products and service in Canada[11]. It is estimated that the total employment among those establishments is 115,054 people (although not all will be employed in geomatics occupations) and that they contribute $2.3 billion to Canada's GDP (representing 0.15% of the economy).

The number of establishments today is 15% higher than the estimate of 2,143 geomatics establishments in the 2001 study and 11% higher than the estimate of 2,221 establishments in a 2004 study[12]. This represents and annual expansion rate of 1%. Over those years, two conflicting trends have been at play: 1) geomatics as a field has prospered and many new applications for geospatial information have been developed, and 2) the industry has consolidated, especially in the area of land surveying.

4.4 Regional Distribution

Table 6 shows the regional distribution of the geomatics industry by number of establishments and Table 7 shows the distribution by employment. Comparing the two tables indicates that the average firm size is largest in the Prairies, followed by Quebec.

Table 6: Regional Distribution of Establishments

Region	Distribution of Establishments
BC	17%
Prairies	22%
Ontario	30%
Quebec	19%
Atlantic	11%
North	1%

[10] Statistics Canada definition of an establishment is: "… the level at which the accounting data required to measure production is available (principal inputs, revenues, salaries and wages). The establishment, as a statistical unit, is defined as the most homogeneous unit of production for which the business maintains accounting records from which it is possible to assemble all the data elements required to compile the full structure of the gross value of production (total sales or shipments, and inventories), the cost of materials and services, and labour and capital used in production." For this exercise, establishments are more or less synonymous with locations. Thus a firm can comprise multiple establishments. However, most geomatics firms have only one location.

[11] Almost 1,800 of these are involved in surveying and mapping, which compares favourably to the Statistics Canada figure of 1,883. See Section 4.6.

[12] Statistics Canada (2006) 2004 Geomatics Industry Census Survey Results

Table 7: Regional Distribution of Employment

Region	Distribution of Employment
BC	7%
Prairies	41%
Ontario	17%
Quebec	25%
Atlantic	10%
North	0%

4.5 Establishment Revenue

Table 8 shows the distribution of revenue by establishment. Most establishments are in the $1 million to $5 million range, with only 18% above $10 million.

Table 8: Revenue Distribution

Revenue Ranges	Distribution
$1 to $99 999	5%
$100 000 to $199 999	6%
$200 000 to $499 999	13%
$500 000 to $999 999	14%
$1 000 000 to $4 999 999	33%
$5 000 000 to $9 999 999	12%
$10 000 000 to $24 999 999	6%
$25 000 000 to $49 999 999	6%
$50 000 000 +	6%

4.6 Establishment Employment

Table 9 shows the distribution of employment by establishment. Most establishments are in the 11 to 50 employees range, with only 17% above 100 employees.

Table 9: Establishment Size Distribution

Size Range	Distribution
1 to 10 Employees	33%
11 to 50 Employees	41%
51 t0 100 Employees	9%
More than 100 Employees	17%

The number and sizes of geomatics establishments were also analyzed in more detail using the Canadian Business Patterns database. However, since the database is broken down by NAICS code, that analysis was restricted to those firms that fall into one of two industries: i) Geophysical surveying and mapping services (NAICS 541360), and ii) Surveying and mapping (except geophysical) services (NAICS 541370). Other aspects of the geomatics industry cannot be extracted from the data.

The database counts two types of locations: i) with employees, and ii) indeterminate employees[13]. Those locations with employees are further divided by size category: 1 to 4 employees, 5 to 9 employees, 10 to 19 employees, 20 to 49 employees, 50 to 99 employees, 100 to 199 employees, 200 to 499 employees, and 500 and plus employees.

In December 2013, there were a total of 3,583 surveying and mapping establishments, 1,883 of which had employees (see Table 10). If assumptions are made about average number of employees within each size category, a rough estimate can be made of the employment within survey and mapping establishments[14]. This totals 22,504 employees[15] in Canada.

Examining previous versions of the database can provide some indication of how survey and mapping industry has changed over time[16] Table 11 shows the data for June 2005. At that time, there were a total of 3,891 surveying and mapping establishments, 2,138 of which had employees. The 2013 numbers are a decrease of 12% from the 2005 numbers. In 2005, the establishments had about 24,420 employees. For employment, the 2013 numbers are a decrease of 8% from the 2005 numbers.

[13] The locations in the "indeterminate" category do not maintain an employee payroll, but may have a workforce which consists of contracted workers, family members, or business owners. However, the Business Register does not have this information available, and has therefore assigned the locations to an "indeterminate" category. This category also includes employers who did not have employees in the last 12 months.

[14] Note, Statistics Canada recommends against doing this: "Please note that the employment size ranges are mostly based on data derived from payroll remittances. As such, it should be viewed solely as a business stratification variable. Its primary purpose is to improve the efficiency of samples selected to conduct statistical surveys. It should not be used in any manner to compile industry employment estimates." (see: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=5510005&pattern=canadian+business+patterns&tabMode=dataTable&srchLan=-1&p1=1&p2=-1)

[15] Statistics Canada notes that: "Employment, grouped in employment size ranges, is more often than not an estimate of the annual maximum number of employees and does not represent a full time equivalent number of employees. For example, a measure of '10 employees' could represent '10 full-time employees', '10 part-time employees' or any combination." (ibid)

[16] Note, Statistics Canada again cautions against doing this: "Changes in business industrial classification strategies used by Statistics Canada's Business Register over the past year have created increases in the number of active businesses shown by the Canadian Business Patterns. As a result, these data do not only represent changes in the business population over time. Statistics Canada advises users to not use these data as a time series." (ibid)

Table 10: Geomatics Establishment Number and Sizes, December 2013

SIZE	Geophysical surveying and mapping services	Surveying and mapping (except geophysical) services	Total Locations	Total Employees
Total, all sizes	1,760	1,823	3,583	
Indeterminate employees	1,028	672	1,700	
Total with employees	732	1,151	**1,883**	
1 to 4 employee size	572	537	1,109	3,327
5 to 9 employee size	55	261	316	2,212
10 to 19 employee size	44	184	228	3,420
20 to 49 employee size	39	133	172	6,020
50 to 99 employee size	12	25	37	2,775
100 to 199 employee size	4	9	13	1,950
200 to 499 employee size	4	2	6	1,800
500 and plus employee size	2	-	2	1,000
Total Employees				**22,504**

Table 11: Geomatics Establishment Number and Sizes, June 2005

SIZE	Geophysical surveying and mapping services	Surveying and mapping (except geophysical) services	Total Locations	Total Employees
Total, all sizes	2,265	1,626	3,891	
Indeterminate employees	1,195	558	1,753	
Total with employees	1,070	1,068	**2,138**	
1 to 4 employee size	766	615	1,381	4,143
5 to 9 employee size	126	215	341	2,387
10 to 19 employee size	69	114	183	2,745
20 to 49 employee size	58	99	157	5,495
50 to 99 employee size	25	17	42	3,150
100 to 199 employee size	19	7	26	3,900
200 to 499 employee size	6	1	7	2,100
500 and plus employee size	1	-	1	500
Total Employees				**24,420**

Figure 9 shows the distribution of establishments by size. As with most industries in Canada, the vast majority are micro or small organizations. In surveying and mapping, this is not surprising given the large number of small, independent, survey firms. Between 2005 and 2013, it is this segment of the population that has decreased the most reflecting the reduction in the number of survey firms due to decreased demand and consolidation.

Figure 10 shows the number of establishments by region. As can be seen, surveying and mapping is focused in the Prairies, and in particular servicing the oil and gas industry in Alberta. It is essentially this region alone that accounts for the decrease in the number of establishments between 2005 and 2013.

It must be remembered that this analysis of establishment number and sizes only applies to survey and mapping industries as defined in the two NAICS codes and is not representative of the wider geomatics sector.

Figure 9: Number of Establishments by Size

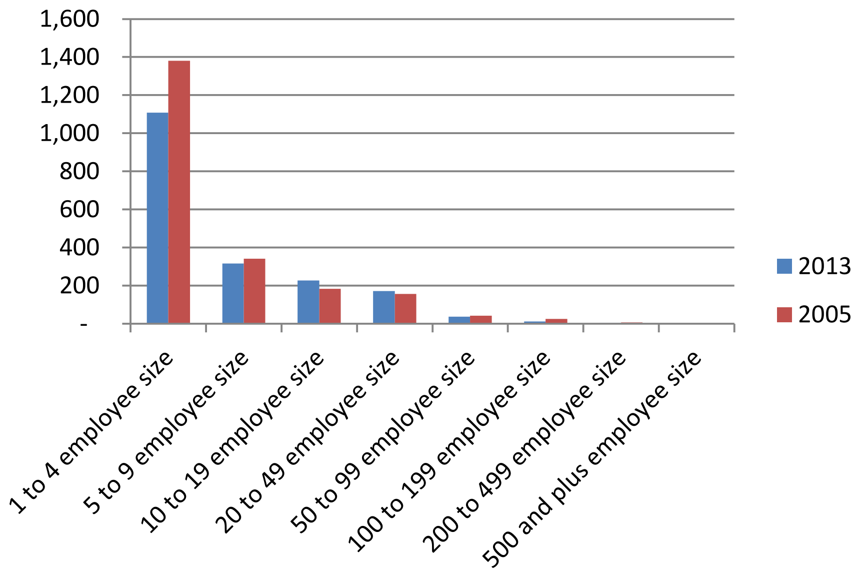
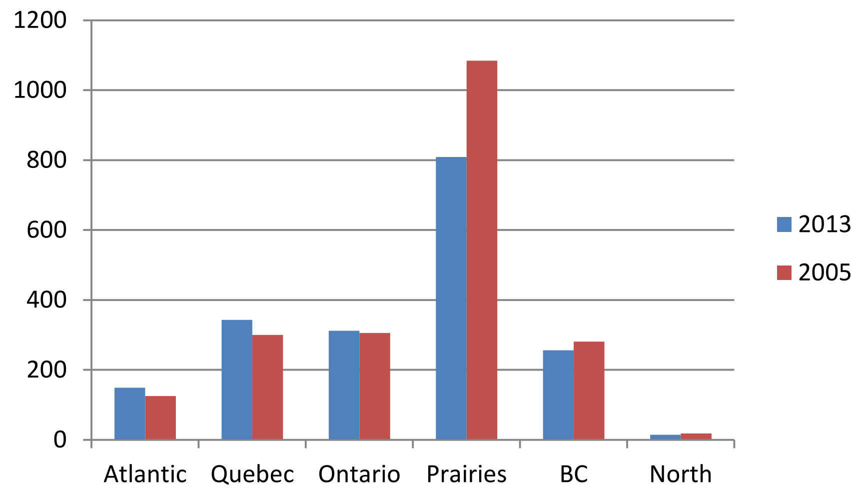


Figure 10: Number of Establishments by Region



4.7 Activities

A number of ways to look at the diversity of activities pursued by geomatics companies are presented here. The Primary NAICS classifications used by geomatics companies were examined above in Section 4.2. The Canadian Company Capabilities database also allows companies to report their secondary activities. Table 12 shows the frequency of NAICS codes for the top alternate activities. The list is not dissimilar to those found in the Primary NAICS classifications.

Table 12: Alternate Industries

NAICS Industries	Percentage of Geomatics Firms Reporting Alternate Industries
541370 - Surveying and Mapping (except Geophysical) Services	12.97%
541690 - Other Scientific and Technical Consulting Services	9.60%
541360 - Geophysical Surveying and Mapping Services	8.64%
541330 - Engineering Services	7.68%
541510 - Computer Systems Design and Related Services	6.96%
541620 - Environmental Consulting Services	5.88%
541990 - All Other Professional Scientific and Technical Services	4.08%
541710 - Research and Development in the Physical Engineering and Life Sciences	3.00%
213119 - Other Support Activities for Mining	2.16%
417320 - Electronic Components Navigational and Communications Equipment and Supplies Wholesaler-Distributors	1.56%

213118 - Services to Oil and Gas Extraction	1.44%
334220 - Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	1.44%
562910 - Remediation Services	1.44%
541619 - Other Management Consulting Services	1.32%
334512 - Measuring Medical and Controlling Devices Manufacturing	1.20%
518210 - Data Processing Hosting and Related Services	1.08%

The Canadian Company Capabilities database allows companies to indicate the type of their primary business activity. As can be seen in Table 13, a full 82% of geomatics companies offer primarily services, with only 18% focusing on producing or distributing products.

Table 13: Primary Business Activity

Primary Business Activity	Percentage
Manufacturer / Processor / Producer	13%
Retail	1%
Services	82%
Trading House / Wholesaler / Agent and Distributor	4%

Table 14 shows the breakdown of products and services offered by geomatics companies according to the traditional sectors of surveying and mapping, GIS, GPS, Remote Sensing, and Other (covering primarily engineering services, environmental services, and information technology). Note that a firm can participate in more than one area.

Table 14: Geomatics Sector Activities

Geomatics Sector Activities	Percentage
Surveying and Mapping	59%
GIS	37%
GPS	28%
Remote Sensing	20%
Other	38%

Table 15 shows the breakdown of products and services offered by geomatics companies according to the value chain stages. Again, note that a firm can participate in more than one stage.

Table 15: Geomatics Value Chain Activities

Geomatics Value Chain Activities	Percentage
Geospatial Data Capture & Processing	62%
Geospatial Data Analysis & Presentation	72%
Integrated Information Products & Services	50%
Location-Based Solutions	2%
Geospatial Technologies	22%

4.8 Firm Age

The vitality of an industry is indicated by the rate at which companies enter and exit the market. A number of metrics of this are presented here. Figure 11 shows the eras in which existing geomatics companies were created, broken down by geomatics sector. It is evident that the prime years for the geomatics industry were the 1980 and 1990 decades. The figure compares interest in remote sensing, which peaked earlier in the 1970s and 1980s, to GPS, which peaked later. The other sectors not shown in the figure tend to follow the average for the industry.

Figure 11: Firm Age by Geomatics Sector

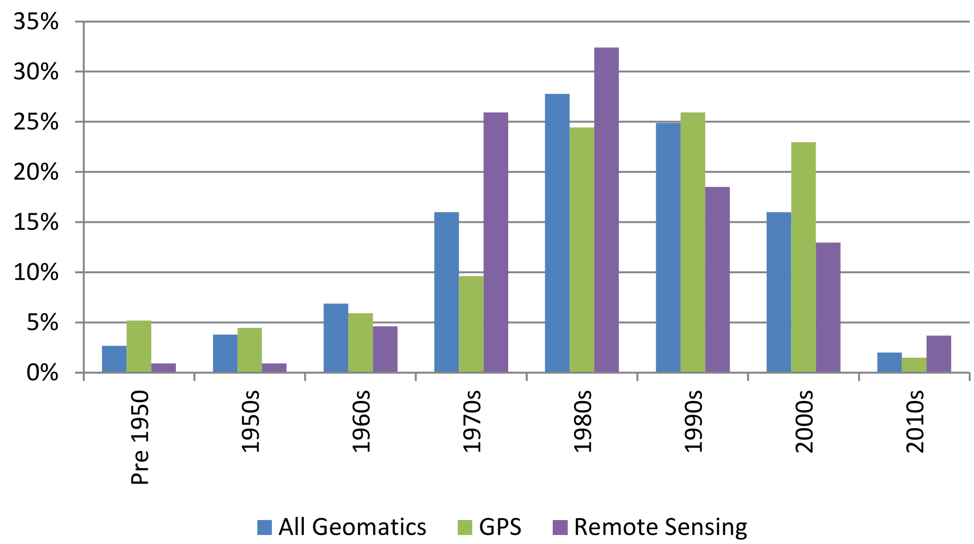
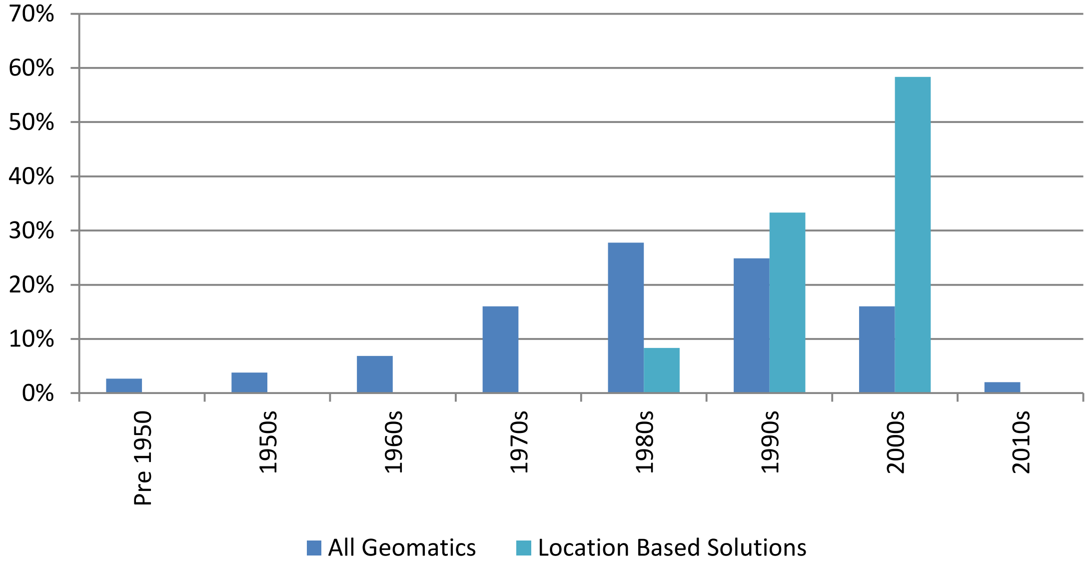


Figure shows the company formation broken down by value chain stage. Only location based solutions is shown explicitly as the other stages follow the average. Not surprisingly, given the recent phenomenon of location based solutions, these types of companies tend to be more recent than the average.

Figure 12: Firm Age by Value Chain Stage



5. Geospatial Information Use Economic Benefits

5.1 The Use of Geospatial Information by Canadians

This analysis of the economic benefits of the use of geospatial information by Canadians was based on a review of the literature and economic statistics databases, and was informed by the results of the consultations and case studies. This section provides a flavour of the responses we obtained in talking to Canadians about their use of geospatial information.

There was agreement among those consulted across all industry sectors[17] that there is widespread use of geospatial information and that the use is growing rapidly. This is due in no small way to mass market geomatics and the role applications such as Google Maps have played in making geospatial information more accessible, less expensive, and much easier to use.

The realization of the benefits of geospatial information is growing and this feeds upon itself, leading to increased interest and uptake. As stated by a respondent in the emergency response sector, "once this information is available, others realize how valuable it can be." As another example, in the security sector "police and military organizations tend to consider what other similar organizations are doing when making procurement decisions." A respondent in the health sector found that articles in health journals about spatial analysis stimulated more senior management interest in support of the technology. And while the use of geospatial information in the retail sector is competitive, "we share experiences – we won't tell each other what our specific plans are, but we do share data and software ideas. We talk about applications and how we can evolve – primarily at a conceptual or theoretical level."

While the use of geospatial information is widespread, it does vary by industry sector. For example, in the transportation sector, "the growth has already occurred and the use is very mature." While in the health sector, a respondent felt that "there is underutilization in the delivery of health care to save costs, create efficiencies, and finding champions is difficult." And, the "forestry industry is behind other sectors generally in the use of some technologies, such as web mapping and mobile applications."

A respondent in the utilities sector observed that "for those just getting into it, the technology and tools are getting better all the time, so they do not have the same learning curve as the early adopters."

[17] Responses were obtained from the following sectors: shipping, emergency response, health, retail, forestry, conservation, security, cities, utilities, transportation, engineering, insurance, mining, and agriculture.

While use of geospatial information is currently growing, growth has been episodic in the past, dependent on the state of the economy and the interests of the day in each sector. A respondent in the health sector stated that “the adoption of geospatial information has gone through waves. For example, the economic downturn and budget reductions limited geospatial information use. This has started to turn around recently.” Similarly in the forestry sector a respondent observed that “there is now growth in the use of geospatial information, following a period of contraction within the industry.” Another respondent noted that “a good disaster opens up windows of opportunity for approvals to implement geospatial technology.

5.2 CGE Modelling Results

The economic impacts of the use of geospatial information from the modelled scenarios are outlined in the following sections. These results are presented as the change in 2013 and are in 2013 Canadian dollars.

In summary, the historical uptake of geospatial information across Canada is estimated to have added:

- $20.7 billion (or 1.1%) to Canadian real GDP in 2013
- $19.0 billion to Canadian real income in 2013.

All regions benefit from the availability of geospatial information, with the Prairies gaining the highest contribution of $9.0 billion, followed by Ontario at $5.3 billion. However smaller population regions also benefit, with the North and the Atlantic region increasing by 2.38 per cent and 0.94 per cent of regional GDP, respectively.

The analysis also shows that the largest beneficiaries in terms of increased industry output are agriculture and forestry, mining and utilities. It also shows that sectors that do not directly benefit from geospatial information or open data benefit nevertheless as a result of rising economic activity boosted by growth in the sectors that benefit from the use and application of geospatial information.

Table shows the changes in a range of macroeconomic sub-components that result in the estimated changes in real GDP and real income by region.

Table 16: Decomposition of changes in real GDP and real income by region as a result of geospatial information use

	Atlantic	Quebec	Ontario	Prairies	British Columbia	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.

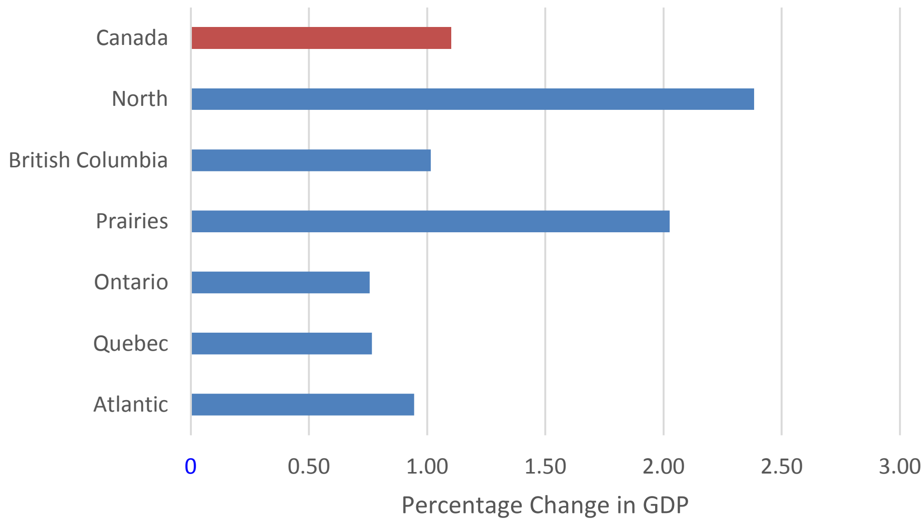
Note: GDP can be calculated either from the expenditure side or from the income side. This table presents the decomposition from the expenditure side. From the income side the change in real GDP would be the sum of the change in real value added, the change in real tax revenues and the change in productivity.

5.2.1 Real GDP

The historical use of geospatial information has delivered productivity improvements across a range of sectors of the Canadian economy. These 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). Indeed, based on the estimated direct productivity improvements stemming from the different components of the geospatial information, the modelling estimates that in 2013:

- Canadian real GDP was 1.10%, or $20.7 billion, higher as a result of geospatial information, with the
  - Atlantic region real GDP 0.94% ($995 million) higher
  - Quebec real GDP 0.77% ($2,792 million) higher
  - Ontario real GDP 0.76% ($5,295 million) higher
  - Prairies region real GDP 2.03% ($8,985 million) higher
  - British Columbia real GDP 1.02% ($2,457 million) higher
  - North region real GDP 2.38% ($174 million) higher

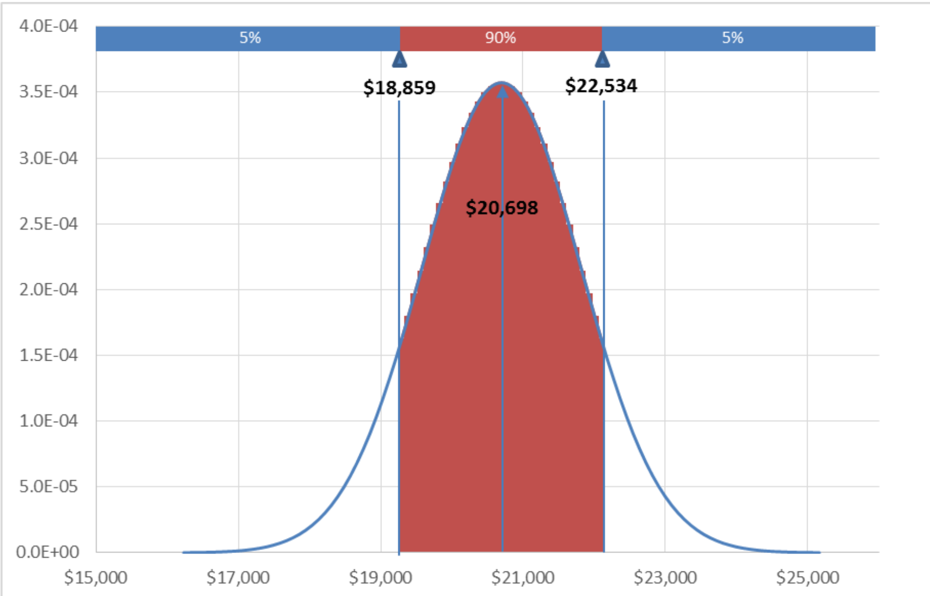
Figure 13: Percentage Change in GDP



Changes in real GDP can be analyzed in more depth by decomposing the changes in value added, tax revenues and productivity effects (i.e. changes in the income side of GDP). Approximately 67 per cent of the increase in real GDP is directly associated with the estimated productivity improvements, and 17 per cent is associated with increased net real tax revenues due to increased economic activity. The remaining 16 per cent 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 was performed on the RDP results using the method described in Section 3.2.6. The results are displayed in Figure 14. The 90% confidence interval for the impact of geospatial information on GDP is between $18.9 billion and $22.5 billion.

Figure 14: GDP Sensitivity Analysis ($million)



5.2.2 Trade

All else equal, the productivity improvements associated with the adoption of geospatial information reduced the real production price, which consequently resulted in higher real exports by an estimated $7.6 billion in 2013. The greater production of goods and services allowed an increase in consumption of imported goods and services by Canadian businesses and individuals by an estimated total of $4.7 billion. In total, therefore, net foreign trade is estimated to have increased by $2.8 billion in 2013 as a result of geospatial information.

5.2.3 Real Income and Terms of Trade

As discussed in Section 3.2.3, although changes in real GDP are a useful measure for estimating how much the output of the Canadian economy would change as a result of the use of geospatial information, changes in the welfare of Canadians are of more importance. In the CGE model, changes in real welfare are measured by real income.

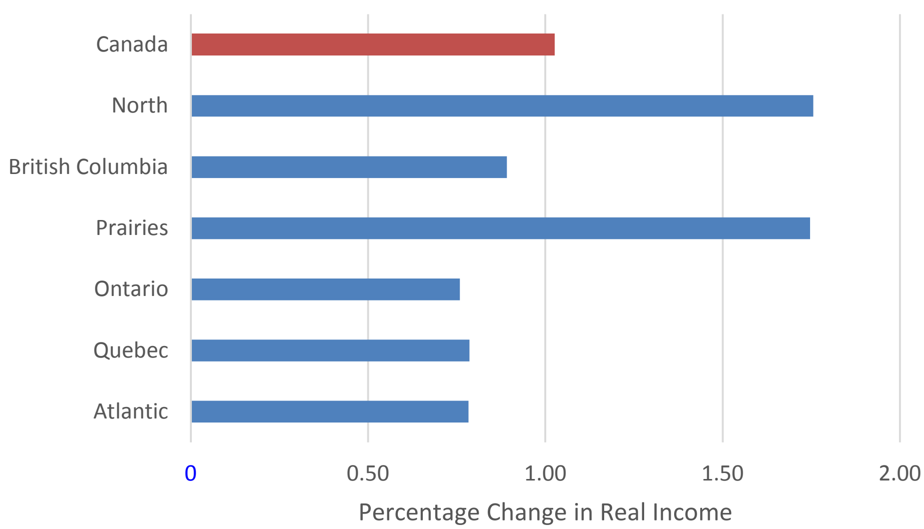
Real income is equivalent to GDP plus net foreign income transfers, while the change in real income is equivalent to the change in real GDP, plus the change in net foreign income, plus the change in terms of trade (which measures changes in the purchasing power of a region's exports).

The productivity improvements associated with geospatial information have the effect of reducing production costs and boosting total production. Most, but not all, of these cost reductions are passed on to final consumers – including foreigners – in the form of lower prices.

This export price decline results in a decline in Canada's term of trade compared to the reference case (see Table). The decline in terms of trade means that Canadians have to export more goods and services to pay for their imports.[18] 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 $19.0 billion, or 1.03%, higher as a result of geospatial information, with the:
  - Atlantic region real income $832 million or 0.78 per cent higher
  - Quebec real income $2,846 million or 0.79 per cent higher
  - Ontario real income $5,234 million or 0.76 per cent higher
  - Prairies region real income $7,858 or 1.75 per cent million higher
  - British Columbia real income $2,139 million or 0.89 per cent higher
  - North region real income $108 million or 1.76 per cent higher.

Figure 15: Percentage Change in Real Income



5.2.4 Private Consumption and Investment

Private consumption is a core component of GDP. A strong increase in consumption indicates an increase in living standards for the Canadian community. Consumption is also estimated to have

[18] Note, however, that total production has also increased, but part of the increased production needs to be used to support demand for foreign products.

risen as a result of geospatial information. The boost in private consumption in 2013 as a result of geospatial information is estimated to have been $8.6 billion.

Under the model structure used for this analysis, a portion of Canadian household income is used to obtain a range of goods and services via government providers. Assuming that the marginal propensity to obtain government versus non-government services remained constant with and without geospatial information[19], then government consumption is also estimated to have increased as a result of geospatial information. More specifically, real government consumption in 2013 is estimated to have been $3.7 billion higher as a result of geospatial information.

Investment, an indicator of the future productive capacity of the Canadian economy, was also estimated to have been boosted by geospatial information. The estimated increase in investment in 2013 is $5.5 billion.

5.2.5 Employment

The following table presents the employment impacts of geospatial information by region. The total for Canada is almost 20,000 full time equivalent (FTE) jobs.

Table 17: Geospatial Information Employment Impacts

Region	FTE jobs
Atlantic	973
Quebec	3,318
Ontario	5,634
Prairies	7,423
British Columbia	2,174
Northern Territories	55
Canada	**19,577**

5.2.6 Industry Impacts

The impacts of geospatial information vary across different sectors. The main points of the industry analysis are as follows (see Table 18).

- Output in industries with the largest productivity changes are the ones to have benefitted the most (including, oil and gas, agriculture, mining, utilities and transportation).
- The relative importance of different sub-sectors within each region can result in noticeable differences between the estimated impacts of the broad industry. For example, according to the case studies, the forestry and logging, fishing, and support services for

[19] Changing this assumption to assume that real government expenditures remain constant (via a reduction in average income tax rates for example) would alter the mix of final goods and services consumed. Although this will have some second order effects on the demand for different commodities, the overall macroeconomic impacts should not be very sensitive to this assumption.

agriculture and forestry sub-sectors are estimated to have benefitted significantly from geospatial information. Regions where these activities are more prevalent are therefore projected to have the largest changes in the output of the aggregate industry.

- Wholesale and retail trade and accommodation and food services also show a significant increase in output despite not having an identified productivity improvement. This is due to increased economic activity fuelled by the boost in productivity in the industries directly affected by geospatial information – as output in these industries increases, their demand for goods and services from other industries (e.g. retail, food and accommodation), increases as well.
- In most regions, manufacturing is projected to be one of the smallest beneficiaries (and is projected to suffer a small loss in the Prairies region) as it is not assumed to have received any direct productivity improvement from geospatial information, and its highly traded nature means that it is more sensitive to the projected exchange rate appreciation.
- 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. For instance, there would be an increase in output in the manufacturing sector, partly due to an increase in the demand for construction materials. The transport sector would also expand due to increased economic activity. Indeed, simulation results show that production increases across almost all industries in all regions.

Table 18: Estimated percentage change in industry output as a result of geospatial information, 2013 (%)

	Atlantic	Quebec	Ontario	Prairies	British Columbia	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

6. Other Benefits of Geospatial Information Use

Geospatial information provides numerous and significant benefits beyond those that we could measure in economic terms. In fact, there are strong arguments that such benefits are significantly more important than the economic ones.

Consultation respondents cited a long list of benefits from the use of geospatial information. Among them, by theme:

- **Environmental:** improved environmental protection, meeting regulatory requirements, better management of resources
- **Health:** saving lives, improved better patient care, lower health risks.
- **Social:** more effective communication, increased user confidence, improved community engagement, higher customer satisfaction.
- **Knowledge:** better decision making, improved access to information, increased information consistency, focus on high risk areas, improved ability to plan, better analyses, improved data integration, increased data confidence.

Table 19 provides examples of such other benefits, by industry, in the following categories:

- Decision Benefits
- Consumer Benefits
- Environmental Benefits
- Health & Safety Benefits

These examples come from the consultations, case studies, and literature. There are many other benefits not cited here.

Table 19: Examples of Other Benefits as a Result of GI Usage

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
Crop production	* Better planning decisions resulting in higher crop yields.		* Less air pollution due to lower fuel consumption. * Less water pollution due to decreased chemical runoff.	
Forestry	* Improved long-term logging operations planning. * Improved decision making on allocation of raw materials to different types of mills. * More effective planning and execution of reforestation projects.		* Reduced damage to sensitive areas and water courses. * Less air pollution due to lower fuel consumption.	* Reduced health and safety risks due to faster navigation of emergency responders to accident sites.
Fishing	* More effective decision making on where to invest.		* Reduced chances of over-fishing.	* Reduced probability of major emergencies with injuries and loss of life.
Oil and Gas	* Improved decision making on lands/leases to acquire.		* Potential prevention of spills or leaks and faster response when they do occur.	
Mining	* More effective decision making on where to invest. * Improved ability to meet stringent monitoring and reporting requirements. * Improved decision making on lands/leases to acquire.		* Less damage to areas of cultural heritage and high environmental value.	
Electric power generation, transmission and distribution	* Improved decision making on investments in new electricity	* Reduced inconvenience to customers due to decreased risk of major	* Reduced risk of environmental damage due to unexpected rupture	* Reduced risk of accidents due to unexpected rupture of

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
	infrastructure and replacement of existing assets. * Improved ability to manage transmission networks and achieve optimal market performance. * Improved decision making on a range of power grid management tasks (e.g., demand response, distribution operations, outage frequency analysis, etc.) * Better decisions on geographical location of renewable energy facilities. Better targeting of energy conservation campaigns.	power outage.	of underground utilities. * Reduced air pollution due to reduced energy consumption.	underground utilities.
Natural gas distribution	* Improved decision making on investments in new natural gas infrastructure and replacement of existing assets.	* Reduced inconvenience to customers due to decreased risk of major gas line break.	* Reduced risk of environmental damage due to unexpected rupture of gas lines.	* Reduced risk of accidents due to unexpected rupture of gas lines.
Water, sewage and other systems	* Improved decision making on investments in new water and sewer infrastructure and replacement of existing assets. * Improved ability to manage water and sewer networks and achieve optimal market performance.		* Reduced risk of environmental damage due to unexpected rupture of sewer lines. * Reduction of air pollution due to less return trips to the field/less fuel consumption.	* Reduced risk of accidents due to unexpected rupture of sewer lines.

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
	* Improved decision making on water and sewer network design. * Better targeting of water conservation campaigns.			
Non-residential building construction	* More effective decisions on design of muti-building complexes.			
Transportation engineering construction	* Better decisions on optimal locations of highways.	* More convenient transportation facilities for the travelling public.	* Less air pollution due to lower fuel consumption with optimal route planning.	
Electric power engineering construction			* Less air pollution due to lower fuel consumption with more efficient earth movement.	
Other engineering construction			* Reduction of air pollution due to less return trips to the field/less fuel consumption.	
Retail	* Better business decisions in all these areas.	* More convenient access to goods and services. * Savings on purchases.		
Air transportation			* Less air pollution due to lower fuel consumption.	
Water transportation			* Less air pollution due to lower fuel consumption.	
Truck transportation	* More effective routing decisions.	* Faster delivery of ordered goods.	* Less air pollution due to lower fuel consumption.	
Urban transit systems	* More effective planning of bus routes.	* Improved service for bus customers.		
Taxi and limousine service		* Faster customer pickups.	* Less air pollution due to lower fuel consumption.	

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
Pipeline transportation	* Improved decision making on investments in new pipelines and replacement of existing assets.		* Reduced risk of environmental damage due to unexpected rupture of pipelines.	* Reduced risk of accidents due to unexpected rupture of pipelines.
Support activities for transportation		* Provides ability to have more aircraft operating, for more customer convenience.	* Reduced risk of pollution from fuel spills due to accidents at sea. * Reduced risk of pollution from fuel spills due to accidents in harbours.	* Reduced risk of accidents due to midair collisions. * Reduced risk of accidents at sea due to collisions. * Reduced risk of accidents in harbours due to collisions.
* Postal service and couriers and messengers	* Better business decisions on optimal locations of outlets. * More effective routing decisions.	* More convenient access to postal services. * Savings on purchases. * Faster delivery of parcels.		
Telecommunications	* Improved decision making on investments in new telecom infrastructure and replacement of existing assets.			
Banking and other depository credit intermediation		* Increased customer convenience.		
Insurance carriers	* Better decision on risks to accept and premium pricing.			* Reduced likelihood of accidents due to better driving habits.
Offices of real estate agents and brokers and activities related to real estate	* Better property valuation decisions.	* Better leasing decisions due to improved information.		

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
Architectural, engineering and related services	* Better decisions on location of major facilities and structures.		* Fewer negative environmental impacts of major construction projects.	
Surveying and mapping (except geophysical) services	* Faster decisions on planning projects in the office.		Less air pollution due to less fuel consumption with fewer return trips to the field.	
Other professional, scientific and technical services (Aerial photography and imaging services)			* Less air pollution due to lower fuel consumption.	
Miscellaneous ambulatory health care services (ambulance services)	* More effective routing decisions.		* Less air pollution due to lower fuel consumption.	* Less risk of more severe consequences of accidents due to quicker arrival.
Hospitality Industry	* Better business decisions on new locations.	* More convenient access to sleeping accommodations and food.		
Defence services	* Better decisions on planning military operations. * Better decisions when responding to situations in theatre. * Better decisions when responding to situations during emergency response operations.			* Less loss of life due to bad decisions. * Improved chance of saving lives or reducing the consequences of injury.
Other federal government services (except defence)				
Agriculture and food		* Better farming decisions due to convenient access to information.		

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
Fisheries			* Improved chance of avoiding species depletion or endangerment.	
Natural resources	* Better mineral development decisions due to convenient access to information. * Improved decision making in forestry management. * Improved decisions on deployment of resources for potential fires. * Improved decisions on crown land management.	* Improved information for citizens and environmental groups. * Higher quality of property surveys and records.	* Contribution to international environmental indicator reporting. * Reduced loss of forest inventory.	* Lower risk of injury or death due to forest fires.
Safety and security	Quicker decision making in SAR situations. * Quicker decision making in responding to calls for assistance * More effective planning and preparing for emergency response. * Better decisions when responding to situations during emergency response operations.	* Improved likelihood of being found in a timely fashion. * Improved likelihood of having assistance provided in a timely fashion. * Higher levels of safety and earlier warnings of emergency situations.	* Reduced air pollution due to reduced fuel consumption.	* Lower risk of more serious consequences of injury or death due to delays in being found. * Lower risk of more serious consequences of crime due to delays in police response. * Improved chance of saving lives or reducing the consequences of injury.
Environment	* Better biodiversity conservation decisions.	* Improved information for citizens and environmental groups.	* Reduced risk of loss of critical habitat and endangered species.	* Improved ability for people with breathing problems to avoid health issues.

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
	* Better water quality protection decisions. * Contributes to daily decision making in many parts of the economy (e.g., agriculture, transportation, tourism, etc.). * Improved decision making on navigation through ice infested waters.	* Facilitates daily planning.	* Improved ability to reduce air pollution. * Improved ability to reduce water pollution. * Reduction of risks of water pollution from spills caused by collisions with sea ice.	* Helps to reduce risk of injury or death from icy roads, hurricanes, tornados, etc. * Helps to reduce risk of injury or death from collisions with sea ice.
Statistics	* Improved decision making in the planning for and conduct of census. * Contributes to improved decisions in activities related to use of census data (e.g., planning health care delivery, siting new retail outlets, etc.)	* Improved information for citizens.		
Parks & protected areas	* Better biodiversity conservation decisions.	* Improved information for citizens and environmental groups. * Improved information for citizens planning park visits.	* Reduced risk of loss of critical habitat and endangered species.	
Aboriginal affairs and northern development	* Quicker and more effective decisions on mineral claim staking. * Improved decisions for potential petroleum development in the North. * Better decision making on planning for future economic development.	* Improved certainty of property ownership. * Improved information for citizens.	* Reduced air pollution due to reduced fuel consumption for on the ground staking.	

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
Health	Better decision making on planning future public health programs.			
Other provincial and territorial government services				
Natural resources	* Facilitates better decisions on choosing sites for renewable energy projects. * Facilitates better decisions on invasive species eradication programs. * Improved decisions on deployment of resources to fight fires. * Better forestry management decisions due to up to date inventory information. * Better water management decisions due to up to date water resources information. * Better fish and wildlife management decisions due to geospatially related information on habitat and species. * Better public lands management decisions due to geospatially related information on boundaries and interests. * Better mineral development decisions due to convenient access to information.	* Improved information for citizens visits to natural heritage areas. * Safer water and improved assurance of long term sustainability of water resources. * Improved information for citizens and environmental groups.	* Potential for reduced pollution if more renewable energy projects are developed. * Improved ability to control the spread of invasive species * Reduced loss of forest inventory. Reduced risk of loss of critical habitat and endangered species.	* Lower risk of injury or death due to forest fires. * Lower risk of injury or death due to flooding.

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
	* Quicker apprehension of violators of crown land use.			
Agriculture and food	* Improved decisions related to response to biosecurity threats. * Improved decisions related to food chain tracking.	* Better farming decisions due to convenient access to information.		* Reduced risk of sickness or death due to contaminated farm produce.
Health	* Better public health program and facilities planning decisions. * More effective planning and preparing for emergency response. * Improved decision making on health care planning and allocation of resource where most needed. * Improved decisions for future handling of outbreaks. * More effective and faster decisions when responding to critical needs.	* More convenient access to health care facilities. * Higher levels of safety and earlier warnings of health emergency situations. * Reduced risk of being impacted by future outbreaks.		* Reduced risk of disease or injury complications because of better access to facilities. * Improved chance of saving lives or reducing the consequences of injury. * Less risk of negative health consequences.
Education and training	* More effective planning of bus routes.	* Convenient access to information on educational resources locations. * Convenient access to information on service provider locations.		
Social services		* Convenient access to information on service provider locations.		

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
Environment	* Better biodiversity conservation decisions. * Better water quality protection decisions.	* Improved information for citizens and environmental groups.	* Reduced risk of loss of critical habitat and endangered species. * Improved ability to reduce air pollution. * Improved ability to reduce water pollution.	* Improved ability for people with breathing problems to avoid health issues.
Transportation	* Better decisions on location of major facilities and structures. * More effective planning of snowplow routes. * Better decisions on planning of future transportation infrastructure. * Better planning of highway safety measures.	* Reduced driver inconvenience due to closure of major thoroughfares. * Improved information for citizens	* Fewer negative environmental impacts of major transportation projects.	* Reduced risks of injury or death from highway accidents.
Municipal affairs	* Better land use planning decisions. * Improved decisions on property transactions.	* More livable spaces in communities, better access to facilities, parks, etc. * Higher quality of property surveys and records.	* Better protection of habitat, ecologically sensitive areas, etc. * Better protection of archeological resources.	
Provincial policing	* Better decisions on planning allocation of policing resources. * Quicker and more effective decisions on interagency responses.	* Faster responses to requests for assistance.		* Less risk of safety problems due to criminal activity.
Other municipal government services	* Better decisions related to planning and design of infrastructure projects.	* More livable spaces in communities, better access to facilities, parks, etc.	* Better protection of habitat, ecologically sensitive areas, etc.	* Reduced risk of disease or injury complications because of better access to facilities.

Industry	Decision Benefits	Consumer Benefits	Environmental Benefits	Health & Safety Benefits
	* Better land use planning decisions.	* Facilitates contributing to faster maintenance actions.		
	* Improved decision making for municipal real property acquisition and management.	* Improved information for citizens planning to use parks and recreational facilities.		
	* Improved decision making for planning of street maintenance projects.	* Faster responses to requests for assistance.		
	* Improved decision making for planning of parks and related maintenance projects.	* More convenient access to health care facilities.		
	* Improved decision making on investments in new water and sewer infrastructure and replacement of existing assets.			
	* Better decision making on planning service improvements.			
	* Better public health program and facilities planning decisions.			
Other Aboriginal government services	* Better land use planning decisions.			

7. The Impact of Open Data

7.1 The Concept of Open Data[20]

The concept of "open data"[21] is linked to both "open source" and "open access", and indeed, the open data movement is situated in the context of these other movements. Open data, open source and open access movements share some common philosophical underpinnings. The open source movement embraces a collaborative and non-proprietary vision for the creation of software. The open access movement grew out of the academic and scholarly community and was geared towards encouraging and facilitating the publication of academic work across all disciplines in a free and publicly accessible manner. The open government data movement focuses primarily on government data. Common themes in all three movements are:

- 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.

One issue that arises in the context of open data initiatives is the difficulty in defining the concept of "data". As noted in one study, "definitions of "open data" do not offer insight into what data are, but rather [focus] on the issue of openness and re-use."[22] In general terms, the open data movement construes the term broadly. While data could be defined to mean bare, unprocessed fact, it is often expansively defined to include *information* – facts that have been interpreted or placed in context.[23] The focus is not on the nature of the information/data but rather on issues of openness, access and possibility for reuse.

[20] GeoConnections, How to share geospatial data primer, p. 2., prepared by Hickling Arthurs Low for Natural Resources Canada.
[21] The Open Data Foundation, http://www.opendatafoundation.org/, describes its mandate as "the adoption of global metadata standards and the development of open-source solutions promoting the use of statistical data." Their work seeks to support "research, policy making, and transparency, in the fields of economics, finance, healthcare, education, labor, social science, technology, agriculture, development, and the environment." This movement is primarily focussed on the standardization of data formats to foster interoperability and accessibility and to enhance quality.
[22] Shellong & Stepanets, note 1, at p. 4.
[23] In Shellong & Stepanets, at p. 4, According to the authors, data is uninterpreted fact, information is fact placed in context; and knowledge is information that is given meaning through interpretation (which can be shaped by various perspectives).

7.2 The Economics of Open Geospatial Information

Information, and in particular geospatial information, has special economic characteristics which mean that governments are often involved with its collection and provision. Information is a form of '*public good*' and is often associated with '*external*' benefits. Because public goods and externalities are, in turn, often associated with '*market failure*' there will be a role for government in these markets. '*National interest*' arguments, which are not purely concerned with economics, often provide an additional stimulus for government involvement. These characteristics highlight why governments throughout the world have become involved in geospatial data provision.

Geospatial information provision has several important economic characteristics:

- High, fixed collection costs and low, variable dissemination costs;
- Non-rivalry in consumption (i.e. multiple users can consume the same information);
- Many different uses and, hence, markets and the same information may have different values in those markets (i.e. the structure of demand is highly complex);
- Additional 'external' benefits from consistent dataset standards;
- A need to invest in regular collection and custodian activities to maintain the value of the dataset.

Furthermore, the first two of these characteristics imply that geospatial information is, in the economic meaning of the term, a public good[24]. It is important to distinguish between the economic concept of '*a public good*', and the policy concept of '*in the public interest*'.

'Externalities' arise where:

- Production of a good by one 'agent' imposes costs on and/or delivers benefits to other producers or consumers; or
- Consumption by one individual imposes costs on and/or delivers benefits to other consumers or users.

It is an important feature of markets where 'externalities' are present that output levels resulting from free market provision will not be optimal. Geospatial information often has important 'external' benefits associated with:

- Ensuring consistency in the collection of data (production externalities);
- Promoting efficiency of decision-making (consumption externalities); and
- Providing users access to the same data (network externalities).

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[24] A 'pure' public good has very specific characteristics:

- The marginal cost of providing an additional unit is zero;
- Use by one individual does not reduce availability to others ('non-rivalry'); and
- Individuals cannot be excluded from using the good or service ('non-excludibility').

A geospatial dataset is a 'weak' public good because the cost of dissemination is low, but not zero, and individuals can be excluded from using it.

In markets with ‘external’ benefits, there is often under-provision and excessive prices because private providers take no account of the wider social benefits when setting prices. These ‘market failures’ would typically lead to under-provision of a public good in a free market. They begin to provide the economic justification for some form of government involvement in the market either in terms of economic regulation or ownership of information providers. A range of policies can be used to address the ‘market failures’ which result, including:

- Regulation of the markets;
- Government provision of the product or service;
- Use of subsidies (or taxes); or
- Specific licensing obligations (e.g. on emission levels).

There is an important distinction between private and public goods. Private goods are efficiently distributed by markets. Public goods generally become a public responsibility, e.g. for financing and regulation, but this does not necessarily imply public provision.

In the context of general debate on information collection and provision by government, arguments are often framed in terms of the public interest. These arguments are usually linked closely to the economic arguments on ‘public goods’ and ‘externalities’. Sometimes additional arguments, less concerned with economics, are also made for collection and provision of information by government. They include:

- Protection of life and property;
- Promotion of democracy;
- Protection of the rights of individuals;
- Support for minority groups in a population;
- Equity;
- The need to maintain confidentiality of data collected; and
- A basic need to meet government functions.

These ‘public interest’ arguments can be very important in determining the overall policy stance to information providers and, in particular, the approach taken to cost recovery.

In summary, economic welfare is maximized if data is made available at marginal cost or free through the internet. The one proviso on this condition is the requirement that governments continue to provide the resources necessary to support the custodians of these data – primarily government agencies that collect and maintain foundation geospatial data[25] – to ensure that the data continues to possess the key characteristics of currency, accuracy, cohesiveness, availability, and accessibility. See Section 7.4 for a review of concerns in this regard.

[25] Foundation spatial data is the authoritative geographic information that underpins other information. Examples include administrative boundaries, hydrographic information, topographic information, road networks, addresses, place names, and property information.

7.3 Open Geospatial Information in the Context of Open Government Data

Since public sector geospatial information initiatives are often situated within the context of government policy focused on public sector information more generally,[26] it is worth looking briefly at geospatial information in the context of open government data.

Open government data is increasingly recognized as an important public policy objective both nationally and internationally.[27] For example, at the June 2013 G8 Summit in Lough Erne, Northern Ireland, all the G8 members agreed to implement a set of open data principles and best practices that will lay the foundation for the release and reuse of government data before December 31, 2015. The recommendation explicitly recognized the economic and social benefits linked to public sector information policies that favoured open government data. Canada's adoption of the G8 Open Data Charter recognizes the contributions it will make to openness, citizen and community engagement, innovation, and the improvement of the economic and social well-being of Canadians.

Spatial data is a subset of government information, which can include many different kinds of information. While in many cases GI initiatives predate broader open government information policies (as is the case in Canada and the U.S., for example), these initiatives will necessarily be shaped and influenced by overarching open government data policies. In the United Kingdom and in New Zealand, for example, such initiatives form part of broader open government data initiatives. This permits the standardization of approaches across departments and sectors, leading to greater accessibility and transparency for users. It also embeds the spatial data infrastructure initiative with a broader set of public policy goals.

One advantage of situating GI policy within a broader government policy on open data may flow from the difficulty in distinguishing, in some cases, between spatial and other forms of government data. For example, The European Union's INSPIRE Directive[28] defines "spatial data" as "any data with a direct or indirect reference to a specific location or geographical area."[29] Such a broad definition could certainly encompass a range of public information that is not typically considered to be primarily spatial. In addition, as more and more public information becomes available and is mixed and matched with different sets of data to create

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[26] Public sector information is a fairly general term. In one report it is described as being "often used as an umbrella term for all content produced by public bodies." (Alexander Schellong and Ekaterina Stepanets, (2011) Unchartered Waters: The State of Open Data in Europe, (CSC Public Sector Study Series, 2011) http://assets1.csc.com/de/downloads/CSC_policy_paper_series_01_2011_unchartered_waters_state_of_open_data_europe_English_2.pdf, at p. 5

[27] For a study on the progress of open government in Europe following the PSI Directive, see: Marco Fioretti, *Open Data Open Society: a research project about openness of public data in EU local administration* (Pisa: Laboratory of Economics and Management, 2010) http://www.lem.sssup.it/WPLem/odos/odos_report.pdf.

[28] Directive 2007/2/EC of The European Parliament and of The Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:108:0001:0014:EN:PDF.

[29] INSPIRE, *ibid.*, art. 3.3.

innovative new applications and services, the lines between spatial data and other government information are bound to blur. In this respect, it makes sense from a public policy point of view to develop an overarching open government data policy, with GI being a key but not exclusive component of this policy.

7.4 Open Geospatial Information Benefits and Concerns

In general, the primary public policy objectives identified in public sector information policies include: government transparency and accountability;[30] the desire to foster innovation and economic growth;[31] the goals of promoting education and advancing knowledge;[32] the need to eliminate market distortions to enhance competition;[33] and improving the efficiency of government.[34] The beneficiaries of open government data policies include the government (which may benefit from increased citizen participation, and increased efficiency),[35] members of the public (who may benefit in a variety of ways, both direct and indirect, from increased participation in government, opportunities to use government data for various commercial and non-commercial purposes, greater transparency and accountability of government, greater efficiency and economic development), private sector companies, and students and researchers.[36]

A common strategy is to use free data where it is available and suitable, and augment this with data acquisition where there are gaps. However, opinions are mixed as to the value of open data, as discussed below.

For the most part, those consulted for this study feel that open geospatial data contributes positively to Canada's productivity, innovation, and economy. The general view is that its use is most suitable in situations that do not demand high quality, often for planning, or by those that are not able or willing to pay for data. One respondent stated that open data is "fantastic for getting people started on understanding geospatial data." Another user of open data explained that "as we currently have no funding for geospatial activity, we are using free Google maps and overlaying our asset locations on top." An engineering company observed that earth observation

[30] See, for example, *UK Framework*, *supra* note 7, at p. 4; Executive Office of the President, *Open Government Directive*, http://www.whitehouse.gov/sites/default/files/omb/assets/memoranda_2010/m10-06.pdf.

[31] See, for example, the *PSI Directive*, *supra* note 13, preliminary paragraph (25); *UK Framework*, *supra* note 7, at p. 2; NZGOAL, *supra* note 7, at p. 3.

[32] *PSI Directive*, *supra* note 13, preliminary paragraph (16).

[33] See, for example: *PSI Directive*, *supra* note 13, at preliminary paragraph (25); OECD *Recommendation*, *supra* note 13,

[34] Shellong & Stepanets, note 1, at p. 2. In the *UK Framework*, *supra* note 7, the importance of public sector information is emphasized along with the public policy goals that are served by open access. The *UK Framework*, *supra* note 7, at p. 2, also notes the importance of public sector information and the goals in liberating it: to promote creative and innovative activities in the public interest; to increase government transparency and better inform public about work of government, and to enable more civic and democratic engagement.

[35] *Open Government Directive*, *ibid*.

[36] See UK Framework, *supra* note 7, at p. 2.

data is increasingly free, and that had resulted in "major contracts that were not possible 10 years ago because of prohibitive data costs."

However, the contribution is being limited by the shortcomings of the open data that is available in Canada: its quality and accessibility. Quality concerns cover data accuracy, currency, and reliability. For example, one respondent feels that "a lot of the open data available from the Ontario government is of very poor quality (the OBM digital base mapping is 20 years old)." Accessibility concerns were often related to the infrastructure available to deliver open geospatial data. In the words of one respondent, "too much emphasis is being put on the data and not enough on the infrastructure that makes it accessible."

As a result, open data has not played a significant role in the businesses of many respondents. For example, the experience with open data of one respondent has been mixed. They have had problems with lack of consistency and gaps in some vector data, while they have found very good quality in a number of imagery datasets they have acquired. Many other respondents do not use open data as part of their business practices because of concerns over accuracy, availability and currency. In the words of one respondent, "open data is being oversold and is typically not authoritative and reliable – you get what you pay for."

One respondent's concern is that open data is being provided by people that have never had to deliver mission-critical data that is heavily relied upon to make decisions. Another respondent predicts that the promises of open data benefits will probably not be realized – "because geospatial information from government does not necessarily have long-term assurance of high quality availability, why would users invest in applications that would depend on it?" The result is "we need to acknowledge it is break even or slightly positive in economic terms but not hugely positive in the manner described in some European Union reports.

At the heart of impediments to the provision of open data is the issue of sustainability. While respondents in the public sector feel that there is increasing pressure to make more data open, and they are willing to do so, they need to find a way to replace the revenue that they rely upon for data updating. In the atmosphere of fiscal constraint that governments operate under today, there is significant concern that open data will lead to the eroding of data quality. "The challenge is to figure out how to continue to produce quality geospatial information products in a form, manner, and representation that users want in a sustainable manner."

A related challenge is convincing partners to share the cost of data collection. A geospatial information provider observed that "if all our data is made freely available, we will not have the financial support to be able to provide as complete a service." One respondent believes that GeoBase is failing because there is no incentive for the partners to maintain it (i.e., no resources from NRCan to convert the input data to the federal data model).

One respondent believes that the end result is when data is free and open, there are no drivers for innovation. "Open data provides the opportunity for lots of small companies to compete in services provision but they do not generate enough business to invest in innovative new applications of interest to large commercial users like oil and gas companies."

Another impediment is the infrastructure necessary to make the data discoverable and accessible. For example, a respondent observed that the infrastructure behind GeoBase needs improvement, "there needs to be better discovery tools and language that addresses market needs – there is too much techno-speak. When dealing with the federal government the vocabulary is almost impenetrable." Another respondent believes that an operational SDI would lead to increased use.

There was wide agreement that increasing access to open geospatial data has a positive impact on private sector geomatics organizations; that improvements in access to data and geospatial information interoperability on the Internet are creating business growth in the geomatics sector; and that opportunities exist for commercial exploitation of open geospatial data provided by government. However, the challenge is how to realize those opportunities given the rapid changes in geospatial information markets.

The general opinion is that "data is not worth much, it is the services derived from the data that have real value." The opportunity lies in translating data into useful information. For example, it was commented that surveyors should not be complaining about their plans potentially becoming open data, they should be figuring out how to use that open data to create new business.

A key challenge is seen to be improving information access. One respondent commented that data availability is not well developed in Canada; "it is trickier to get information here compared to some other countries because of a decentralization data model, with ownership split among federal, provincial, and municipal governments." Another respondent found that their government partners are slow to adopt web services to share data with their partners.

7.5 Open Geospatial Information Economic Benefits

The previous section discussed some of the benefits that Canadian stakeholders are currently obtaining from open geospatial information and some of the impediments that are restricting the realization of the full potential benefit. This section will quantify the current benefits. The general lesson from previous international studies also corresponds to the findings of the Canadian case studies and consultations. These were that the absence of open data would:

- Lower use of fundamental geospatial data across the board; this is not unexpected given the high elasticity of demand that has been observed in other studies around the world for geospatial data.
- Lower levels of productivity in existing applications; this would apply particularly in agriculture, property and services, construction, transport and asset management by

utilities and in certain areas of government such as in emergency services and biosecurity

- Lower levels of innovation, which depends on integration of new developments with existing platforms to build new products and services.

The quantifiable economic benefits from open geospatial information come primarily through:

- Increased use
- Standardization
- Network externalities

The projected economic impacts of the historical use of Open Data from the modelled scenarios have been estimated from the difference between the economic outcomes estimated above and a second case using the shocks estimated for the without Open Data case[37]. As with the previous section, these results are presented as the change in FY2013 and are in FY2013 Canadian dollars.

In summary, Open Data in Canada is estimated to have added:

- $695 million (or 0.04%) to Canadian real GDP in 2013
- $636 million to Canadian real income in 2013.

Table shows the changes in a range of macroeconomic sub-components that result in the estimated changes in real GDP and real income by region.

Table 20: Decomposition of changes in real GDP and real income by provincial region as a result of the impact of Open Data on the outcome

	Atlantic	Quebec	Ontario	Prairies	British Columbia	North	Canada
	2013 $m	2013 $m	2013 $m	2013 $m	2013 $m	2013 $m	2013 $m
Private consumption	9	45	87	61	35	-0	238
Investment	21	42	79	45	16	4	207
Government consumption	8	27	50	58	24	2	170
Net trade **a**	5	23	25	14	16	-3	80
Exports **a**	25	66	92	79	47	2	198
Contribution of imports **a**	-21	-43	-67	-65	-31	-6	-118
Real GDP	**43 (0.04%)**	**138 (0.04%)**	**241 (0.03%)**	**179 (0.04%)**	**91 (0.04%)**	**3 (0.03%)**	**695 (0.04%)**
Terms of trade	-5	-16	-15	-7	-14	2	-55
Net foreign income transfers	-0	-0	-1	-1	-1	-0	-3
Real income	**38**	**122**	**224**	**171**	**77**	**4**	**636**

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.

[37] This is the difference between the results for Reference Case 1 and Reference Case 2.

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 a1dded, the change in real tax revenues and the change in productivity.

7.5.1 Real GDP

The historical uses of Open Data have delivered productivity improvements across a range of sectors of the Canadian economy. Based on the estimated direct productivity improvements stemming from the different components of the Open Data, it is estimated that in 2013:

- Canadian real GDP was 0.04%, or $695 million, higher as a result of Open Data, with the
  - Atlantic region real GDP 0.04% ($43 million) higher
  - Quebec real GDP 0.04% ($138 million) higher
  - Ontario real GDP 0.03% ($241 million) higher
  - Prairies region real GDP 0.04% ($179 million) higher
  - British Columbia real GDP .04% ($91 million) higher
  - North region real GDP 0.03% ($3 million) higher

7.5.2 Trade

All else equal, the productivity improvements associated with Open Data reduced the real production price which consequently resulted in higher real exports by an estimated $198 million in 2013. The greater production of goods and services allowed an increase in consumption of imported goods and services by Canadian businesses and individuals by an estimated total of $118 million. In total, therefore, net foreign trade is estimated to have increased by $80 million in 2013 as a result of open geospatial information.

7.5.3 Real Income

As discussed in Section 3.2.3, although changes in real GDP are a useful measure for estimating how much the output of the Canadian economy would change under as a result of an Open Data policy, changes in the welfare of Canadians are of more importance. Changes in real welfare are measured by real income.

As shown in Table 20, it is estimated that:

- Canadian real income was $636 million, higher as a result of Open Data, with the:
  - Atlantic region real income $38 million higher
  - Quebec real income $122 million higher

- Ontario real income $224 million higher
- Prairies region real income $171 million higher
- British Columbia real income $77 million higher
- Northern Territories region real income $4 million higher.

7.5.4 Private Consumption and Investment

As discussed in Section 3.2.3 an increase in consumption indicates an increase in living standards for the Canadian community. Private consumption is estimated to have risen by $238 million as a result of open geospatial information and government consumption is also estimated to have increased by $170 million.

Investment, an indicator of the future productive capacity of the Canadian economy, was also estimated to have increased by 207 million.

7.5.5 Employment

The following table presents the employment impacts of open data by region. The total for Canada is almost 600 full time equivalent jobs.

Table 21: Open Data Employment Impacts

Region	FTE jobs
Atlantic	26
Quebec	145
Ontario	215
Prairies	141
British Columbia	73
Northern Territories	-2
Canada	**599**

7.5.6 Industry impacts

The projected change in real output by industry by provincial regions associated with Open Data is presented in see Table 22.

Table 22: Estimated percentage change in industry output as a result of Open Data, 2013 (%)

	Atlantic	Quebec	Ontario	Prairies	British Columbia	North	Canada
	%	%	%	%	%	%	%
Agriculture, forestry, fishing and hunting	0.13	0.12	0.15	0.15	0.18	0.40	0.15
Mining, quarrying, and oil and gas extraction	0.01	0.01	0.01	0.01	0.00	0.02	0.01
Utilities	0.08	0.10	0.08	0.07	0.07	-0.06	0.08
Construction	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Manufacturing	0.03	0.04	0.03	0.06	0.08	0.09	0.04
Wholesale trade	0.03	0.03	0.03	0.04	0.04	0.11	0.04
Retail trade	0.02	0.02	0.02	0.02	0.02	0.05	0.02
Transportation and warehousing	0.06	0.04	0.04	0.06	0.04	-0.02	0.04
Information and cultural industries	0.02	0.02	0.02	0.03	0.02	0.05	0.02
Finance and insurance	0.03	0.03	0.03	0.04	0.03	0.08	0.04
Real estate and rental and leasing	0.02	0.02	0.02	0.03	0.02	0.03	0.03
Professional, scientific and technical services	0.02	0.01	-0.00	0.03	0.02	0.04	0.02
Management of companies and enterprises	0.05	0.04	0.04	0.05	0.04	0.06	0.04
Administrative and support, waste management and remediation services	0.04	0.03	0.03	0.04	0.03	0.07	0.03
Educational services	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Health care and social assistance	0.03	0.02	0.03	0.03	0.02	0.04	0.03
Arts, entertainment and recreation	0.01	0.01	0.01	0.02	0.01	0.02	0.01
Accommodation and food services	0.02	0.02	0.02	0.03	0.02	0.04	0.02
Other services (except public administration)	0.02	0.02	0.02	0.03	0.02	0.06	0.02
Public administration	0.12	0.09	0.10	0.11	0.06	0.05	0.10

The industries that benefit most from the Open Data policy are the agriculture, forestry, fishing and hunting; and the utilities sectors with increases in GDP of between 0.15 per cent and 0.08 per cent.

8. Prospects for an Internationally Defined Open Geospatial Data Infrastructure

Considerable effort is being devoted to the development of geospatial data infrastructure (most commonly referred to internationally as 'spatial data infrastructure or SDI') worldwide. Three organizations are playing a particularly important leadership role in supporting the development of an internationally defined open geospatial data infrastructure – Global Spatial Data Infrastructure Association (GSDI)[38], Open Geospatial Consortium (OGC)[39] and International Organization for Standardization (ISO), through its Technical Committee on Geographic Information/Geomatics (ISO/TC 211)[40]. In addition, at the international level, the United Nations is involved through the United Nations initiative on Global Geospatial Information Management (UN-GGIM)[41] and the United Nations Spatial Data Infrastructure (UNSDI)[42], an initiative of the United Nations Geographic Information Working Group (UNGIWG).

The following sections provide brief descriptions of the roles played by these organizations and the implications for an internationally defined open SDI.

8.1 GSDI

The GSDI Association is described as "an inclusive organization of organizations, agencies, firms, and individuals from around the world promoting international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations to better address social, economic, and environmental issues of pressing importance."[43] Formed in 1996, GSDI has conducted regular world conferences every 12-18 months since then. Its goals include:

- Supporting the establishment and expansion of local, national, and regional (multination) spatial data infrastructures that are globally compatible; and

[38] Global Spatial Data Infrastructure Association (GSDI). (See http://www.gsdi.org/)
[39] Open Geospatial Consortium (OGC). (See http://www.opengeospatial.org/)
[40] ISO/TC 211Geographic Information/Geomatics. (See http://www.iso.org/iso/iso_technical_committee?commid=54904)
[41] United Nations Committee of Experts on Global Geospatial Information Management. (See http://ggim.un.org/about.html)
[42] United Nations Geographic Information Working Group. United Nations Spatial Data Infrastructure (UNSDI). (See http://www.ungiwg.org/content/united-nations-spatial-data-infrastructure-unsdi)
[43] GSDI. (2010). *Global Spatial Data Infrastructure Association (GSDI) Profile*. (See https://ggim.un.org/docs/meetings/May2010/papers/GSDI_Association_Profile.pdf)

- Fostering spatial data infrastructure developments in support of important worldwide needs.

In support of the creation of a global SDI, GSDI has created a Technical Committee, whose mandate is to "provide continuous observation and review of technical issues affecting the development of local to global spatial data infrastructures; develop and report on technical topics essential to the creation of compatible spatial data infrastructures; explore technical standards issues; and disseminate technical reports, examples, case studies, and similar learning materials of interest to GSDI Association members."[44]

While not directly responsible for the development of an internationally defined open geospatial data infrastructure, GSDI is making major contributions to SDI development around the world through its activities (i.e., conferences, committees, publications, monthly SDI newsletters covering six regions, etc.). In 2000, it published the Spatial Data Infrastructure Cookbook (later updated in 2004 and 2009), a seminal publication for development of internationally defined SDIs, which contains the most commonly used SDI definition, "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general."[45]

8.2 OGC

The Open Geospatial Consortium (OGC) is "an international industry consortium of 508 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC® Standards support interoperable solutions that 'geo-enable' the Web, wireless and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications."[46] OGC was founded with eight charter members (including one from Canada – PCI Remote Sensing) in 1994 with a vision of diverse geoprocessing systems communicating directly over networks by means of a set of open interfaces.

Since its formation, OGC has developed a broad range of open specifications that have become 'de facto' standards for the development of an internationally defined open geospatial data infrastructure. The majority of the critical standards were subsequently adopted by ISO/TC 211 as formal international standards. Some of these standards have been widely implemented in SDI initiatives worldwide, such as INSPIRE[47], CGDI[48], NSDI[49], etc.

[44] GSDI. (2011). GSDI Standing Committees, Technical Committee. (See http://www.gsdi.org/standingcomm/technical)
[45] GSDI. (2009). The SDI Cookbook. (See http://www.gsdi.org/gsdicookbookindex)
[46] OGC. (2014). About OGC. (See http://www.opengeospatial.org/ogc)
[47] INSPIRE, (2014). Data Specifications. (See http://inspire.ec.europa.eu/index.cfm/pageid/2)

8.3 ISO/TC 211

The goal of the International Organization for Standardization (ISO) Technical Committee 211 is to "establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital / electronic form between different users, systems and locations."[50]

ISO/TC 211 has published 66 ISO standards under its direct responsibility to date. At the time of writing, the committee had an additional 20 standards and/or projects at various stages of development.[51] Given the recognition of the ISO/TC 211 standards and their international credibility, there has been widespread adoption of them in the SDI community as a primary means of facilitating the interoperability of systems and data within infrastructure initiatives.

8.4 UN-GGIM

Formed in 2011, the United Nations initiative on Global Geospatial Information Management (UN-GGIM) was created to "play a leading role in setting the agenda for the development of global geospatial information and to promote its use to address key global challenges. It provides a forum to liaise and coordinate among Member States, and between Member States and international organizations."[52] UN-GGIM`s priorities and work programmes are driven by Member States. Its mandate includes: providing a platform for the development of effective strategies for building and strengthening national capacity on geospatial information; and disseminating best practices and experiences of national, regional and international bodies on geospatial information related to legal instruments, management models and technical standards. Several areas of work that UN-GGIM has underway are specifically related to internationally defined open geospatial data infrastructure:

- Adoption and implementation of standards by the global geospatial information community
- Identification of trends in national institutional arrangements in geospatial information management

[48] Natural Resources Canada. (2014). Geospatial standards and operational policies. (See http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/8902)
[49] Federal Geographic Data Committee. (2014). Standards. (See https://www.fgdc.gov/standards)
[50] *Supra*. Note 3
[51] ISO. (2014). Standards Catalogue. (See http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=54904&development=on)
[52] *Supra*. Note 5

- Legal and policy frameworks, including critical issues related to authoritative data
- Development of shared statement of principles on the management of geospatial information

8.5 UNSDI

In 2005, the UNGIWG initiated the process to establish a UN Spatial Data Infrastructure (UNSDI). In 2010, UNSDI was recognized as a UN System-wide Information and Communications Technology (ICT) harmonization initiative. In 2011, UNGIWG adopted the Centre of Excellence for UNSDI Project proposal developed by the Office of Information and Communications Technology (OICT). In 2012, the UNSDI Steering Committee, in close collaboration with OICT, launched the Centre of Excellence for UNSDI Project funded by voluntary contributions of Member States. The first phase of implementation was planned to take three years to complete by an interagency team from OICT, the UN Office in Geneva Information and Communications Technology Service (UNOG/ICTS) and the Food and Agriculture Organization (FAO) in Rome.[53] However, based on the status report presented at the 14th UNGIWG Plenary Meeting in May 2014, the UNSDI initiative has not unfolded according to plan, prospective partners are no longer engaged and the validity of the project is now in question.[54]

8.6 Prospects

The work of the GSDI and standards groups briefly described above indicates that there is strong momentum towards uniform definitions of SDI internationally. Major SDI projects in individual countries and regions are adopting the international standards that facilitate sharing, discovery of and access to geospatial information. Organizations like GSDI and UN-GGIM are providing valuable fora for the exchange of best practices and lessons learned in SDI implementation. While no organization is presently tasked with integration of national and regional SDIs into a global SDI, the adoption of common SDI models and standards facilitates the discovery and access to data in the separate infrastructures that are being developed. Although the experience of the UNSDI demonstrates the challenges of constructing an infrastructure in a global context, the challenges are primarily institutional rather than technical.

[53] United Nations Geographic Information Working Group. About UNGIWG. (See http://www.ungiwg.org/)
[54] United Nations Geographic Information Working Group. *UNSDI Status*. (See http://www.ungiwg.org/sites/default/files/documents/UNGIWG14_UNSDI_Status.pdf)

A. Example Geospatial Information Applications

The following table provides examples of geospatial information applications by industry. Also provided is the applicable North American Industry Classification System (NAICS) code. Appendix B provides the productivity improvement and industry adoption factors for those applications and Appendix C provides explanations for the derivations of the factors.

Example Geospatial Information Applications

Industry	NAICS	GI Applications
- Crop production (except greenhouse, nursery and floriculture production)	111	- Farm vehicle navigation - Crop yield mapping - Seeding and variable rate chemical application - Agronomic decision-making
- Forestry and logging	113	- Forestry operations planning - Harvesting operations - Materials transportation - Mill operations - Reforestation - Inventory updating - Regulatory compliance reporting
- Fishing, hunting and trapping	114	- Fish finding - Monitoring fishing vessels
- Support activities for crop and animal production - Support activities for forestry	115	- Aerial Crop Dusting; Forest Fire Fighting & Aerial Pest Control: - Aircraft Navigation - Mission Planning
- Oil and gas extraction	21111	- Exploration - Development and production - Reclamation - Regulatory compliance reporting - Land management
- Coal mining - Iron ore mining - Gold and silver ore mining - Copper, nickel, lead and zinc ore mining - Other metal ore mining	2121 2122	- Exploration - Development and production - Reclamation - Regulatory compliance reporting

- Stone mining and quarrying - Sand, gravel, clay, and ceramic and refractory minerals mining and quarrying - Diamond mining - Other non-metallic mineral mining and quarrying (except diamond and potash) - Potash mining	2123	- Land management
- Electric power generation, transmission and distribution	2211	- Planning optimal locations of new generators, dams, powerlines, service delivery lines, etc. - Facilities layout and as-built location - Asset management - Balancing supply and demand and ensuring optimal market performance - Meeting energy conservation targets - Smart grid - Alternative energy planning
- Natural gas distribution	2212	- Planning optimal locations of pipelines - Facilities layout and as-built location - Asset management - Outage management
- Water, sewage and other systems	2213	- Planning optimal locations of pipelines, water and sewage treatment facilities, etc. - Facilities layout and as-built location - Balancing supply and demand and ensuring optimal market performance - Hydraulic Network Modeling - Meeting energy conservation targets - Supporting field staff mobility - Providing real-time operational network awareness
- Non-residential building construction	23B	- Building design/Building information modeling (BIM) - Building layout
- Transportation engineering construction - Oil and gas engineering construction - Electric power engineering construction - Communication engineering construction - Other engineering construction	23X	- Planning and design of transportation facilities - Facilities layout and as-built location - Construction machine control - Planning subdivision of land - Subdivision layout - Surveys of parcels for resale
- Electronics and appliance stores	443	- Planning store openings, closures and

- Building material and garden equipment and supplies dealers - Food and beverage stores - Health and personal care stores - Gasoline stations - Clothing and clothing accessories stores - Sporting goods, hobby, book and music stores - General merchandise stores - Miscellaneous store retailers	444 445 446 447 448 451 452 453	renovation, optimal locations and layouts, and product mix - Location-based services (LBS)
- Air transportation	481	- Aircraft navigation - Route planning
- Water transportation	483	- Route planning - Vessel navigation - Monitoring locations of vessels (AIS)
- Truck transportation	484	- Planning optimal routing of deliveries - In-vehicle navigation - Monitoring locations of trucks
- Urban transit systems	4851	- Planning optimal routing of buses - Monitoring locations of buses
- Taxi and limousine service	4853	- In-vehicle navigation - Monitoring locations of vehicles
- Crude oil and other pipeline transportation - Pipeline transportation of natural gas	486A 4862	- Planning optimal locations of pipelines - Facilities layout and as-built location - Asset management - Balancing supply and demand and ensuring optimal market performance
- Support activities for transportation	488	- Air traffic control - Monitoring locations of vessels (AIS) - Vessel traffic services
- Postal service and couriers and messengers - Postal service and couriers and messengers	49A	- Planning optimal locations of outlets - Planning optimal delivery of mail/parcels
- Motion picture and video industries (except exhibition)	512	- Digital background production
- Telecommunications	517	- Planning optimal locations of facilities - Facilities layout and as-built location - Asset management
- Banking and other depository credit intermediation	52B	- Location-based services (LBS)

- Insurance carriers	5241	- Identifying and managing risk exposure - Reducing auto insurance risk and rates
- Offices of real estate agents and brokers and activities related to real estate	531A	- The cadaster and property rights - Optimizing commercial property selection - Property valuation
- Architectural, engineering and related services	5413	- Engineering applications - Survey and mapping applications
- Management, scientific and technical consulting services	5416	- Environmental Applications
- Other professional, scientific and technical services	5419	- Aerial Photography Mission Planning - Aircraft Navigation
- Miscellaneous ambulatory health care services	621	- Planning optimal routing of ambulances - Ambulance navigation - Monitoring locations of ambulances
- Traveler accommodation - Food services and drinking places	721 722	- Planning optimal locations of new hotels, motels, etc. - Location-based services (LBS)
- Defence services	9111	- Operational planning - Operational support in theatre - Emergency response
- Other federal government services (except defence)	911A	-
- *Agriculture and food*		- *Biomass inventory mapping and analysis* - *Canada land inventory* - *Soils mapping* - *Crop inventorying* - *Agroclimate impact reporting*
- *Fisheries*		- *Habitat mapping and fisheries management*
- *Natural resources*		- *Geological mapping* - *Storing geophysical data* - *Forestry inventorying* - *Wildland fire monitoring* - *Biodiversity monitoring* - *Crown lands administration*
- *Safety and security*		- *Search and rescue operations* - *Policing operations* - *Managing emergencies*

- *Environment*		- *Biodiversity and habitat conservation* - *Air quality reporting* - *Water quality reporting* - *Environmental indicator reporting* - *Greenhouse gas emissions reporting* - *Pollution reporting* - *Weather reporting* - *Sea ice reporting*
- *Statistics*		- *Census planning and conduct* - *Census reporting*
- *Parks and protected areas*		- *Resource conservation* - *Other parks services*
- *Aboriginal affairs and northern development*		- *Mining and minerals* - *Petroleum* - *Land claims and self-government* - *Aboriginal peoples* - *Economic development*
- *Health*		- *Epidemiology*
- Other provincial and territorial government services	912	-
- *Natural Resources*		- *Renewable energy mapping* - *Invasive species tracking* - *Natural heritage areas mapping* - *Forest fire fighting* - *Forest management* - *Water resource management* - *Fish and wildlife management* - *Crown land management* - *Mineral development*
- *Health*		- *Healthcare service planning* - *Health emergency planning* - *Health analytics* - *Outbreak investigation* - *Location allocation analysis*
- *Education and Training*		- *Educational resource mapping* - *Service locations mapping* - *Student transportation*
- *Social Services*		- *Service locations mapping*

- *Environment*		- *Biodiversity and habitat conservation* - *Air quality reporting* - *Water quality reporting* - *Environmental information reporting* - *Pollution reporting*
- *Transportation*		- *Planning and design of transportation facilities* - *Facilities layout and as-built location* - *Snow Clearing* - *Transportation planning and forecasting* - *Road user safety*
- *Agriculture and food*		- *Soils mapping* - *Drainage mapping* - *Land use mapping* - *Emergency planning and response* - *Food chain tracking*
- *Municipal affairs*		- *Land use planning* - *Archeological mapping* - *Tracking municipal changes* - *The cadaster and registry operations*
- *Provincial policing*		- *Planning service delivery* - *Situational awareness* - *Field operations*
- Other municipal government services	913	- Infrastructure design, construction, and management - Urban planning - Realty services - Street operations and maintenance - Parks and recreation - Water and sewer - Fire and police services - Public health
- Other Aboriginal government services	914	- Land management

B. Geospatial Information Adoption and Productivity Impacts

The following table provides the geospatial information use adoption and productivity impact parameters that were used in the CGE modelling. Please refer to Section 3.2 for a description of the methodology used. The columns are as follows:

- Sector – As defined by Statistics Canada. Sectors that are not listed in the table are assumed to not be significantly impacted by geospatial information (for example, manufacturing).

- Productivity Improvement – The impact of modern geospatial information on the total factor productivity of the industry. This represents a combination of the impact in the industry applications that use geospatial information and the importance of those applications within the industry. For example, geospatial information is crucially important for exploration in the oil and gas industry, but not as relevant for oil and gas production. There are three possible values for the productivity improvement to account for variations in adoption rates across the industry. They are distributed as follows: Early Adopters – 16%; Majority – 68%; Laggards – 16%. In cases where an industry is making full use of geospatial information, the productivity improvement values for all three adoption levels are equal.

- Industry Applicability – This factor is used to account for situations where the sector definition is broader than portion that uses geospatial information. For example, geospatial information has an important impact on ambulance services, but ambulance services are only a small part (3%) of the wider medical sector in which their economic statistics are reported.

- Impact Factor – This is the product of the Productivity Improvement and the Industry Applicability.

- Open Data – this is the additional productivity improvement due to the availability of free and accessible geospatial data.

Geospatial Information Adoption and Productivity Impacts

Sector	Productivity Improvement			Industry Applicability	Impact Factor	Open Data
	Early Adopters	Majority	Laggards			
Crop production (except greenhouse, nursery and floriculture production)	0.1	0.06	0.02	32%	0.0189	10%
Forestry and logging	0.07	0.04	0.01	100%	0.0400	10%
Fishing, hunting and trapping	0.1	0.05	0.01	97%	0.0503	3%
Support activities for crop and animal production	0.1	0.08	0.06	83%	0.0666	10%
Support activities for forestry						
Conventional oil and gas extraction	0.06	0.06	0.06	100%	0.0600	0%
Non-conventional oil extraction	0.07	0.07	0.07	100%	0.0700	0%
Coal mining	0.1	0.05	0	100%	0.0500	0%
Iron ore mining						
Gold and silver ore mining						
Copper, nickel, lead and zinc ore mining						
Other metal ore mining						
Stone mining and quarrying						
Sand, gravel, clay, and ceramic and refractory minerals mining and quarrying						
Diamond mining						
Other non-metallic mineral mining and quarrying (except diamond and potash)						
Potash mining						
Support activities for oil and gas	0.06	0.06	0.06	100%	0.06	0%
Support activities for mining						
Electric power generation, transmission and distribution	0.013	0.013	0.013	100%	0.0130	10%
Natural gas distribution	0.013	0.013	0.013	100%	0.0130	10%
Water, sewage and other systems	0.026	0.026	0.026	83%	0.0215	10%
Non-residential building construction	0.01	0.005	0	100%	0.0050	10%
Transportation engineering construction	0.01	0.005	0	100%	0.0050	5%
Oil and gas engineering construction						

Sector	Productivity Improvement			Industry Applicability	Impact Factor	Open Data
	Early Adopters	Majority	Laggards			
Electric power engineering construction Communication engineering construction Other engineering construction						
Electronics and appliance stores Building material and garden equipment and supplies dealers Food and beverage stores Health and personal care stores Gasoline stations Clothing and clothing accessories stores Sporting goods, hobby, book and music stores General merchandise stores Miscellaneous store retailers	0	0	0	100%	0.0000	10%
Air transportation	0.1	0.08	0.06	100%	0.0800	0%
Water transportation	0.05	0.03	0.01	100%	0.0300	3%
Truck transportation	0.03	0.01	0	100%	0.0116	5%
Urban transit systems	0.01	0	0	100%	0.0016	3%
Taxi and limousine service	0.15	0.08	0.01	100%	0.0800	3%
Crude oil and other pipeline transportation Pipeline transportation of natural gas	0.01	0.01	0.01	100%	0.01	5%
Support activities for transportation	0.03	0.03	0.03	12%	0.0036	5%
Postal service and couriers and messengers Postal service and couriers and messengers	0.1	0.05	0.01	100%	0.0516	5%
Motion picture and video industries (except exhibition)	0	0	0	11%	0.0000	0%
Telecommunications	0.0015	0.0015	0.0015	100%	0.0015	5%
Banking and other depository credit intermediation	0	0	0	48%	0.0000	0%

Sector	Productivity Improvement			Industry Applicability	Impact Factor	Open Data
	Early Adopters	Majority	Laggards			
Insurance carriers	0.05	0.03	0	47%	0.0134	5%
Offices of real estate agents and brokers and activities related to real estate	0.1	0.07	0.05	12%	0.0089	5%
Architectural, engineering and related services	0.2	0.12	0.05	76%	0.0924	5%
Management, scientific and technical consulting services	0.2	0.12	0.05	10%	0.0127	5%
Other professional, scientific and technical services	0.2	0.2	0.2	9%	0.0189	0%
Miscellaneous ambulatory health care services	0.02	0.1	0	3%	0.0027	0%
Traveler accommodation Food services and drinking places	0	0	0	97%	0.0000	0%
Defence services	0.05	0.03	0.01	100%	0.0300	5%
Other federal government services (except defence)					0.0041	
Agriculture and food	*0.05*	*0.03*	*0.01*	*1.2%*	*0.0004*	*10%*
Fisheries	*0.05*	*0.03*	*0.01*	*0.9%*	*0.0003*	*10%*
Natural resources	*0.05*	*0.03*	*0.01*	*1.4%*	*0.0004*	*10%*
Safety and security	*0.05*	*0.03*	*0.01*	*2.9%*	*0.0009*	*10%*
Environment	*0.05*	*0.03*	*0.01*	*0.5%*	*0.0001*	*10%*
Statistics	*0.05*	*0.03*	*0.01*	*0.2%*	*0.0001*	*0%*
Parks and protected areas	*0.05*	*0.03*	*0.01*	*0.3%*	*0.0001*	*5%*
Aboriginal affairs and northern development	*0.05*	*0.03*	*0.01*	*4.3%*	*0.0013*	*0%*
Health	*0.05*	*0.03*	*0.01*	*1.8%*	*0.0005*	*0%*
Other provincial and territorial government services					0.0260	
Natural Resources	*0.05*	*0.03*	*0.01*	*1.8%*	*0.0005*	*10%*
Health	*0.05*	*0.03*	*0.01*	*41.9%*	*0.0126*	*10%*

Sector	Productivity Improvement			Industry Applicability	Impact Factor	Open Data
	Early Adopters	Majority	Laggards			
Education and Training	*0.05*	*0.03*	*0.01*	*19.9%*	*0.0060*	*0%*
Social Services	*0.05*	*0.03*	*0.01*	*9.3%*	*0.0028*	*0%*
Environment	*0.05*	*0.03*	*0.01*	*0.7%*	*0.0002*	*10%*
Transportation	*0.05*	*0.03*	*0.01*	*9.3%*	*0.0028*	*3%*
Agriculture and food	*0.05*	*0.03*	*0.01*	*1.2%*	*0.0004*	*10%*
Municipal affairs	*0.05*	*0.03*	*0.01*	*1.7%*	*0.0005*	*5%*
Provincial policing	*0.05*	*0.03*	*0.01*	*1.1%*	*0.0003*	*5%*
Other municipal government services	0.05	0.03	0.01	1	0.0300	10%
Other Aboriginal government services	0.05	0.03	0.01	1	0.0300	0%

C. Sectoral Impacts

C.1 Introduction

This section describes the background to the sectoral impacts that have been adopted as the shocks for the CGE modelling. The shocks can be formulated in terms of

- Improvements in productivity,
- Increases in natural resources (minerals and petroleum),
- Increases in foreign demand or increases in the availability of specific inputs.
- Productivity shocks can be either expressed in terms of
- Improvements in the productivity of labour or capital
- General productivity shocks across the sector.

The proposed study methodology included online surveys of stakeholders. During the information collection phase of the study, it was learned that such surveys would not be permitted. The shocks were estimated using evidence from selected case studies, information gathered during wide ranging consultations and published studies undertaken in comparable operating environments.

C.2 Agriculture and Forestry

C.2.1 Crops

This application involves the use of self-steering tractors and harvesters to automate broad acre crop sowing, fertilizing and harvesting. It is based on the agriculture case study. Self-steering technology uses augmented GPS receivers integrated with the farm vehicle's steering system to automatically navigate the vehicle over a field. Typically configured with a touch screen computer in the vehicle cab, the application allows the use of map displays to show the location of the vehicle in the field. The farmer maps the boundary of the field insitu or virtually, and after the first turn the computer establishes the location of the machine and its intended path to complete the field. The operator only needs to monitor the display and check that turns happen in the proper direction.

The technology leads to improved fertiliser and seed application and better agronomic decision making and operations.

In the US, the adoption rate for GPS based precision agriculture technologies has been estimated to be 60%, producing an average GPS-induced yield gain of 10 % and an average input savings of 15 %. Based on an average crop production value of US $170B and average input costs of US $110B, the estimated annual yield gains were US $10.1B and the average input savings were US $9.8B."

Estimated productivity shocks

It was assumed that the level of adoption in cropping in Canada was lower than in the US and an adoption factor of 0.32 was applied. The general productivity impact was estimated to be 0.06 applying to 32 per cent of the crop sectors output which results in a general productivity shock of 0.0189 for the sector.

C.2.2 Forestry

Forestry companies use GIS in all phases of their forestry operations planning. They typically prepare management plans that outline cutting blocks for extended periods (e.g., 25 years, in five-year increments). The planning forester takes the five year "open blocks" and groups them into an annual operating plan. Field staff then go into the field with GPS data collectors and map out all the features that affect cutting in each block (e.g., stream buffers, protected habitat, etc.).

Harvesting operations

Harvesting machinery operators typically use onboard maps with block boundaries shown and GPS navigation that allows them to easily and efficiently discern harvest block boundaries and within-block critical features (e.g., wet areas, brooks, eagle's nests, steep slopes, etc.) that factor into harvesting operations. The operator uses the system as his harvesting specs (e.g., when he reaches a stream buffer, it will flash on the system so that he knows not to harvest within that buffer zone). The system can also track the location of all machinery and the track logs can be used to update forest inventory and for operational quality control.

Materials transportation

GIS can be used to plan and design roads, track maintenance equipment, optimize wait times, keep track of shift change locations, harvesting machine operators, tree planting contractors, trucking contractors, etc. Logging trucks can be equipped with GPS to allow dispatch centres to monitor truck speeds so that contract trucking rates can be adjusted as necessary. If rolling speeds on routes are slower than average, grader operators can be dispatched to grade that stretch of road.

Mill operations

GIS and GPS can be used to support loading and delivering lumber and other wood products from warehouses and routing to customers. GIS is also used to help minimize wood costs to mills by optimizing which cut trees should go to each specialized mill (e.g., hardwood, softwood, etc.).

Reforestation

Plans for all the tree planting work orders can be made in the office using GIS. Quality control of planting can be expedited with mobile GIS applications and GPS data collection in the field. Similarly, data can be gathered for regeneration surveys, plantation survival surveys, permanent sample plots to measure individual tree growth, or inventory cruising.

Inventory updating

The inventory of felled wood can be compiled and tracked in GIS so that the people managing transportation of material know what kinds and volumes of wood are cut in each block. Dispatchers can provide truck drivers with instructions on how to get to a particular block to pick up a load, and the drivers can use in-vehicle navigation with GPS to optimize their routing.

Regulatory compliance reporting

Forestry companies have to submit geospatial data to the government at the block level (inside block boundaries they have to manage silviculture activities, writing site plans, etc.) as part of their business process to obtain harvesting approvals and update provincial forest cover data. They do different kinds of analyses with GIS to see how they are doing against regulatory targets (e.g., ungulate range, forestry impacts on stream flow, and directions on calculating equivalent clearcut area, etc.).

Estimated productivity shocks

From this evidence and general consultations with industry and government forestry experts it has been estimated that a productivity impact of 0.04 with an applicability factor of 100 per cent was reasonable.

C.3 Fishing, Hunting and Trapping

Fish finding

Commercial fishers are using sonars and echo sounders for fish detection, definition, and size distribution. There is typically a high degree of integration between the fishfinder system, marine radar, compass and GPS navigation systems.

Monitoring fishing vessels

Fishing fleet operators use vessel tracking systems linked to major global satellite networks (Satellite AIS or Automatic Identification System technology) to accurately locate vessels and track their movements.

Research and other evidence

Estimated maximum Canadian improvement of 10%

Estimated productivity shocks

From this evidence and estimates of adoption it has been estimated that a productivity improvement of 0.0516 with an applicability factor of 97 per cent is reasonable, giving a sector shock of 0.0503.

C.4 Support Activities for Crop and Animal Production

These activities include aerial crop dusting and pest control, aircraft navigation and mission planning.

Estimated productivity shocks

The general productivity impact was estimated to be 0.08 with an applicability factor of 83 per cent, giving a sector productivity shock of 0.0666.

C.5 Conventional Oil and Gas Extraction

Exploration

Exploration work undertaken by petroleum geologists and geophysicists for conventional oil and gas extraction involves the use of a range of GI technologies. Areas considered to have potential are initially subjected to gravity, magnetic, passive seismic or regional seismic reflection surveys, where aerial or ground based platforms are navigated/positioned using GPS. Features of interest are subjected to more detailed seismic surveys, also involving positioning of measurement instruments. Mapping outputs are generated from the data collected in all cases and GIS is used to visualize data as digital terrain models of the surface and 3D models of the subsurface.

Development and production

Once a prospect has been evaluated and passes selection criteria, an exploration well is drilled to conclusively determine the presence or absence of oil or gas. Surveys of the well site location are required to produce the well site survey plans needed by regulatory authorities to process the application to drill. If the well is successful and a production well is established, surveys and plans are required for access roads and pipeline right-of-ways. GIS is applied by petroleum companies for many production purposes, including well and lease management, pipeline inspection and leak detection, directional drilling zone calculations, automating workflow processes using mobile technologies, managing production data, environmental monitoring, major incident management, etc.

Reclamation

Once a well has been abandoned, the company must return the land to its original state, which involves capping the well and removing equipment, cleaning up any chemicals, replacing soil and replanting native vegetation. There are often regulatory requirements to provide maps or plans of the reclaimed areas.

Regulatory compliance reporting

Under government regulation of the oil and gas sector, companies are required to undertake and report on environmental impact assessments, vegetation mapping, monitoring of sites and facilities, and major incidents such as gas leaks or oil spills. GIS is applied in integrating and analyzing the data and presenting the results of analyses for these purposes.

Land management

Geospatial tools are used to record and manage land inventory details and ownership history of land parcels (including mineral and surface ownership details). Use of GIS allows companies to see who owns the interest of various properties and monitor data about who owns what, who's acquiring what, and what and where they're drilling.

Research and other evidence

Productivity improvements gained from the use of GPS for positioning of airborne and ground-based gravity, magnetic, etc. measuring equipment are estimated to be 5 per cent.

Productivity improvements in the interpretation of data through the use of GIS are also estimated to be 5 per cent.

Productivity improvements gained from the use of GPS for surveys related to well sites, access roads, etc. are estimated to be 30 per cent.

Use of GIS in oil and gas development and production, regulatory compliance reporting, and land management is estimated to produce productivity gains of 10 per cent.

Estimated productivity shocks

It was estimated that these productivity improvements when taken together had delivered an average productivity improvement for conventional oil and gas of 0.06, with an applicability factor of 100 per cent.

C.6 Non-Conventional Oil Extraction

Non-conventional oil extraction relates to tar sand and shale extraction and retorting to product petroleum products. Similar impacts as described in conventional oil extraction were considered to apply.

However the productivity impact is considered to be slightly higher than in conventional oil and gas extraction given the disbursed nature of extraction activities, the higher level of capital intensity associated with non-conventional extraction, and the higher demands for vegetation monitoring and remediation.

Estimated productivity shocks

A productivity improvement of 0.07, with an applicability factor of 100 per cent, was estimated for non-conventional oil extraction, slightly higher than for conventional oil and gas.

C.7 Metallic and Non-metallic Minerals Mining

Exploration

Mineral exploration geoscientists use diverse types of datasets, ranging from geophysical and geochemical data to hyperspectral airborne and multispectral satellite imagery, to search for mineral deposits. GIS integrated with other specialized programs for image processing and CAD allows geoscientists to bring these datasets together and accurately calculate economic potential. Raster images, such as satellite or geophysical imagery, can be integrated and overlaid with vector data such as geology, faults, and sample information.

Development and production

Mining companies use GIS to analyze mine data for engineering design and production management tasks such as seeing mines as 2D or 3D visualizations, generating reports and maps on site and keeping the corporate database current, and performing simple or complex analyses that helps stretch production dollars. GPS is also widely used for such functions as: mine site surveying; autonomous mining and operations control; remote control of vehicles and machines, including haul tracks and drilling equipment; vehicle tracking and dispatch; loading systems; material tracking along the supply chain; preserving areas of cultural heritage and high environmental value.

Reclamation

Proposals for a new mine typically include a mine closure and reclamation plan to return mine sites and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities. Once a mine has been abandoned, the company must return the land to its original state, which involves removal or stabilization of any structures and workings remaining at the site after closure, and decommissioning tailings disposal facilities, quarries and open pits, pipelines and electrical transmission lines, etc. With the availability of satellite imagery, mining companies can use GIS to show the size of tailing ponds, replanted areas, and how they are being monitored over months or years. There are often regulatory requirements to provide maps or plans of the reclaimed areas.

Regulatory compliance reporting

Under government regulation of the mining sector, companies are required to undertake and report on environmental impact assessments, monitoring of sites and facilities, etc. GIS is applied in integrating and analyzing the data and presenting the results of analyses for these purposes.

Land management

Geospatial tools are used to record and manage land inventory details and ownership history of land parcels (including mineral and surface ownership details). A spatially enabled approach enables: accurate plotting of land and mineral title data from corporate or government sources; visualization of competitor activity and potential stakeholder conflicts, tracking of regulations and obligations on active leases.

Research and other evidence

Use of GIS in mining development and production, regulatory compliance reporting, and land management is estimated to produce productivity gains of 10%.

Productivity improvements gained from the use of GPS for mining development and operations are estimated to be 15%.

Assumed productivity shocks

Taken together these impacts were estimated to result in productivity improvements of 0.05 over 100 per cent of the exploration phase of coal mining, 0.05 with an applicability factor of 100 per cent for development, production and remediation for iron ore mining and 0.05 with an applicability factor of 100 per cent for stone mining and quarrying.

C.8 Support activities for oil and gas and mining

Support activities for oil and gas extraction include airborne and transport activities related to managing workforce and materials delivery in remote locations.

Estimated productivity shocks

The productivity impact was estimated to be 0.06 with an applicability factor of 100 per cent for the activities.

C.9 Electric power generation, transmission and distribution

Planning optimal locations of new generators, dams, power lines, service delivery lines, etc.

To support long term planning, a combination of asset data, performance data and GIS analysis is used to help utilities understand how their utility networks are performing. It can then be used to identify the best location for new generators, dams and power lines and to estimate project costs to support project evaluation, management and budgeting. For example, electrical power utilities use repeatable geoprocessing models that take into account many weighted factors to rate their assets on condition, reliability, criticality, performance, etc. This information is then used to help guide where to best spend capital dollars to maximize the value of investments in a utility's assets.

Facilities layout and as-built location

The spatial analysis capabilities of GIS are used to assist in the design and operation of utility's facilities from a single authoritative database and it can also be used to build or enhance overall facilities technology systems. The ability of GIS to do analysis and apply models based on different scenarios allows facility managers to create efficient building and other structure layouts that provide the best space usage and energy efficiency possible. Creating geographically aware facilities means managers are equipped to effectively manage everything from maintenance to emergency response. Viewing facilities in 2D, 3D, and even 4D means facilities are more functional and layout is optimized. Geospatial tools like GPS and electronic total stations are used in positioning structures, power lines, etc. and recording their final as-built locations following construction.

Asset management

GIS supports the asset management process as an authoritative system to store, manage and maintain accurate asset records that can be shared utility wide. Ideally there is integration among all of the systems that store information about an asset and an ability for staff to access data stored across multiple systems enabling a comprehensive view of the location, connectivity, status, history and description of an asset. Additionally, data visualization tools available within the GIS are used to isolate power lines in emergencies thereby reducing the impact to customers. As such, GIS tools help reduce power outages over an annual cycle and provide high service standards.

Balancing supply and demand and ensuring optimal market performance

GIS can assist power companies intelligently monitor and manage their transmission networks. A geodatabase is a key component for maintaining and managing accurate transmission asset data such as sub-stations, lines, and associated structures. GIS can assess grid reliability levels and formulate plans for compliance requirements, as well as mange transmission corridors, schedule right of way maintenance and analyze load growth or changes in load shape or strain on substation capabilities to ensure optimal market performance.

Smart grid

A smart grid is a modernized electrical grid that uses analog or digital information and communications technology to gather and act on information. Smart grid is all about situation awareness and effective anticipation of and response to events that might disrupt the performance of the power grid. There are a number of areas where spatial analytics are beginning to be applied including reducing non-technical losses, targeting demand response, distribution operations planning, transformer load management, assessing data quality, voltage correlation (linking meters to transformers), energy modeling, voltage deviation monitoring, geographicl outage frequency analysis, and predictive analytics for electric vehicle adoption to name just a few.

Alternative energy planning

Geospatial information plays an important role in planning and optimisation of renewable energy systems for power production. Data on cloud cover, solar irradiance, and on wind/wave speed and direction (combined with other environmental parameters such as land elevation and land cover models) are vital elements in developing a strategy for the location and operation of solar, wind, and wave power facilities.

Meeting energy conservation targets

GIS tools can be used to develop different series of thematic grid maps showing the electric power distribution across a city/region. The maps can be color coded to denote areas of low; average and high power consumption levels. The commercial/industrial consumption analysis can be developed through a combination of GIS mapping and the addition of the North American Industry Classification System (NAIC) code assigned to each customer record. This analysis provides a detailed overview of the mix of businesses/residential customers within the area and their total consumption in millions of liters per year thus supporting targeted power conservation communications and social marketing campaigns.

Research and other evidence

Productivity improvements for planning applications with GIS are estimated to be 5%.

Productivity improvements for layout and as-built surveys with GPS are estimated to be 20%.

Productivity improvements for asset management with GIS are estimated to be 15%.

Productivity improvements for helping to meet energy conservation targets with GIS are estimated to be 25%.

Productivity improvements for use of satellite data for facilitating renewable energy project site selection are estimated to be 5%.

Estimated productivity shocks

It was estimated that the overall productivity impact of these effects was 0.013 per cent with an applicability factor of 100 per cent for the sector.

C.10 Natural gas distribution

Planning optimal locations of pipelines

Gas utilities rely on GIS for planning, maintaining, and reporting on utility infrastructure and millions of miles of pipes. GIS-based planning and analysis allows gas utilities to assess and prioritize construction and maintenance activities, ensure regulatory compliance, complete risk and integrity analyses, and better understand customer needs. Through GIS, utility asset data links directly to other key information providing situational awareness to proactively monitor work orders and emergency shutdowns, and to ensure public safety.

Facilities layout and as-built location

Similar to Electric power generation, transmission and distribution.

Asset management

Gas utilities must know the status of their assets at any time. With GIS, managers can make updates to keep your records current. Once a complete system inventory is in place, informed decisions about operations and maintenance can be made. As such, a GIS-based asset and facility management system optimizes workflows so operation of the distribution system can be done more efficiently. With GIS, analysts can monitor asset conditions to assist in infrastructure life cycle planning and replacement; field crews can capture inspection information and quickly update centrally stored as-built construction data and engineers can monitor cathodic protection systems to view information in relation to the distribution system, diagnose problems, and ensure corrosion protection.

Outage Management

With GIS, analysts can identify, isolate, and map areas of concern during a leak or outage. Managers can also trace the network to identify customers who are downstream of a main break, complete valve isolation traces, create leak reports, and reroute resources in an outage. For inspections or surveys, GIS can quickly produce professional maps or map books. Through GIS, managers can also communicate leak or outage information to customers and related agencies such as public works and water companies.

Research and other evidence

Productivity improvements for planning applications with GIS are estimated to be 5%.

Productivity improvements for layout and as-built surveys with GPS are estimated to be 20%.

Productivity improvements for asset management with GIS are estimated to be 15%.

Productivity improvements for outage management with GIS are estimated to be 15%.

Estimated productivity shocks

Taking into account the contribution of each of the above activities to the overall sector, It was estimated that these combined impacts amounted to e general productivity impact of 0.013 with an applicability factor of 100 per cent.

C.11 Water, sewerage and other systems

Planning optimal locations of pipelines, water/sewage treatment facilities

To support long term planning, a combination of asset data, performance data and GIS analysis is used to help utilities understand how their utility networks are performing. It can then be used to identify the best location for new pipelines, and treatment facilities and to estimate project costs to support project evaluation, management and budgeting. For example, water utilities use repeatable geo-processing models that take into account many weighted factors to rate their assets on condition, reliability, criticality, performance, etc. This information is then used to help guide where to best spend capital dollars to maximize the value of investments in a utility's assets. For main pipeline extensions; land records, demographic projections and proposed development plans are often used to help guide long-term system expansion plans.

Facilities layout and as-built location

The impacts in facilities layout and as built are estimated to be similar to Electric power generation, transmission and distribution

Balancing supply and demand and ensuring optimal market performance

GIS can assist water and sewer utilities intelligently plan, build, monitor and manage their water mains as well as treatment and distribution networks. A geodatabase is a key component for maintaining and managing accurate asset data on pumping stations, water mains, treatments facilities, sewage lines, and associated structures. GIS can assess pipeline reliability levels and formulate plans for compliance requirements, as well as mange capital infrastructure upgrades, schedule right of way maintenance and analyze water testing results to ensure reliable, plentiful, and safe supply of water for customers while at the same time exceeding market performance.

Hydraulic Network Modelling

GIS and Geospatial data forms the basis for the development of the Hydraulic Network Model. Water mains, valves, hydrants and their related attributes are loaded in the GIS model and once built this data can then be used for (i) water demand analysis and forecasting; (ii) network design and optimization (iii) fire flow and network resilience analysis (iv) optimization of operating scenarios and capital improvements (v) redesigning the network for pipe routing and pipe sizing for new development or land use rezoning; and (vi) operational efficiency studies such as the identification of areas for energy efficiency.

Meeting water conservation targets

GIS tools can be used to develop different series of thematic grid maps showing the distribution of water consumption across a city/region. The maps can be color coded to denote areas of low; average and high water consumption levels. The commercial/industrial consumption analysis can be developed through a combination of GIS mapping and the addition of the North American Industry Classification System (NAIC) code assigned to each customer record. This analysis provides a detailed overview of the mix of businesses/residential customers within the area and their total consumption in millions of litres per year thus supporting targeted water conservation communications and social marketing campaigns.

Supporting field staff mobility

Mobile field workers at water utilities need information that is current, delivered in any easy to use format and optimized for their needs to assist them to carry out their work in an effective manner. They also generate information that needs to be relayed to the office and managed in enterprise business systems. GIS tools support the field crews by providing interactive/real-time maps and map centric applications that can be rapidly updated and are easy to use. GIS also supports the field mobility business pattern by enabling field crews to capture GIS data in the field and efficiently pass it back into the office. Some utilities are deploying mobile GIS applications for field crews that act as an interactive version of the traditional utility map book and also provide decision support and data capture tools (GPS) while in the field.

Providing Real-time Operational Network Awareness

GIS supports utility operational awareness by enabling management to have a web map based view into the current state of network operations so they are aware of how their assets and personnel are performing and how they are affecting each other. An interactive map is also an effective way for utilities to take information from multiple business systems and present it through a common application. The interactive maps support decision-making by showing the utility networks overlaid with locations of recent callers, new service requests, open work orders, out of service customers, crew locations, recent sewer over flows, planned capital projects, etc. The maps can also show historic operational data on demand and be able to zoom far enough in to see all of their utility assets in detail as necessary.

Research and other evidence

Productivity improvements for planning applications with GIS are estimated to be 5%.

Productivity improvements for layout and as-built surveys with GPS are estimated to be 20%.

Productivity improvements for Hydraulic Network Modelling with GIS are estimated to be 5%.

Productivity improvements for Real-time Operational Network Awareness with GIS are estimated to be 15%.

Productivity improvements for helping to meet water conservation targets with GIS are estimated to be 25%.

Productivity improvements for supporting field staff mobility are estimated to be 5%.

Estimated productivity shocks

A general productivity impact of 0.0253 with an applicability factor of 85 per cent was estimated for the modelling giving a sector shock of 0.0215.

C.12 Non-Residential Building Construction

Building design/Building information modelling (BIM)

Building Information Modelling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. Building owners use BIM to manage data particular to individual buildings. Challenges such as querying information in multiple buildings, such as across a campus, or performing geographic analyses, like a best path analysis from one building to another, can be overcome by integrating BIM data with GIS.

Building layout

Typical building layout services include accurately defining the building location relative to property limits, confirming by-law conformance, providing horizontal and vertical references for construction purposes, and issuing various certificates required. The layout is often preceded by a property boundary survey, a topographic survey illustrating the location of natural and man-made features, and contours and spot heights required for designing the location of the proposed structure. The layout may involve: stakeout for excavation; placement of caissons, pilings, or footings; perimeter column grid layouts; precision alignment of pads for heavy machinery; and control of vertical datum for structure and grading.

Research and other evidence

Productivity improvements for use of GIS in building design are estimated to be 5%.

Productivity improvements for building layout surveys with GPS and electronic theodolites are estimated to be 20%.

Estimated productivity shocks

Take up of BIM technologies is still in the early stages. Use of GIS and positioning in engineering surveying and building layout is becoming universal but a conservative approach to the productivity shock was considered appropriate given the uncertainty as to the nature of the applications being applied. A total productivity shock of 0.005 was estimated with an applicability factor of 100 per cent.

C.13 Transportation engineering and construction

Planning and design of transportation facilities

Transportation planning is the field involved with the siting of transportation facilities (generally streets, highways, sidewalks, bike lanes and public transport lines). Geospatial information has a critical role to play in planning for the development of new transportation facilities. Transportation planners use mapping data and GIS to identify and analyze alternative routes for new highways, locations of bridges, etc., to pick the best route to minimize life cycle costs and negative environmental impacts and maximize traveller convenience. High resolution geospatial data collected from aerial or ground surveys are incorporated into the design process using CAD or other design software.

Facilities layout and as-built location

Surveying services are required to layout the locations of all highways, streets, bridges, sidewalks, berms, etc. during the construction phase. Once these transportation facilities are built, surveys of their as-built locations are conducted, and the resulting data is captured and managed in transportation GIS applications.

Construction machine control

Machine control involves the integration of positioning tools into construction machinery. The term 'machine guidance' refers to systems that purely display the design difference to the operator. The term 'machine automation' refers to those systems that not only show the operator the design difference but are also able to directly control the machine hydraulics to maintain a desired position. This technology incorporates GPS, Motion Measuring Units and other devices to provide on-board systems on construction equipment with information about the movement of the machine in either 3, 5 or 7 axis of rotation. Feedback to the operator is provided through audio and visual displays which allows improved control of the machine in relation to the intended or designed direction of travel.

Research and other evidence

Research evidence is based on precise positioning services in the construction sector:

- Productivity improvements for use of GIS in planning and design of transportation facilities are estimated to be 5%.
- Productivity improvements for facilities layout surveys with GPS and electronic theodolites are estimated to be 20%.
- Productivity improvements for construction machine control with GPS are estimated to be 10%.

Research evidence is based on precise positioning services in the surveying and land management sector:

- Productivity improvements for use of digital mapping and GIS in planning and design of subdivisions are estimated to be 5%.
- Productivity improvements for subdivision layout surveys and real property reports with GPS and electronic theodolites are estimated to be 20%.

Estimated productivity shocks

A conservative total productivity shock of 0.005 was estimated with an applicability factor of 100 per cent for the sector given the variability of applications across the nation.

C.14 Air transportation

Aircraft navigation

Aircraft navigation is the process of piloting aircraft from one place to another that includes determining position, orientation, and velocity, establishing course and distance to the desired destination, and determining deviation from the desired track. GPS-equipped avionics that are certified for IFR flight meet en- route, terminal area and non-precision approach requirements, but approaches with vertical guidance require augmentation of GPS with either a Satellite-Based or Ground-Based Augmentation System.

Route planning

Prior to departure on a flight, pilots must plan and submit to the local aviation authorities a flight plan. Official air navigation charts are the primary tool required to plot the intended route that is submitted as part of this plan.

Research and other evidence

Supporting documentation for shocks contained in ACIL Tasman reports – Value of Spatial Information in Australia (2008) and Value of Precise Positioning (2012) - adjusted for Canadian aviation environment.

Estimated productivity shocks

Productivity shock estimated to be 0.08 with an applicability factor of 100 per cent.

C.15 Water transportation

Vessel navigation

Most navigation on water involves the use of GPS either wholly or in part. The most common marine navigational technology is the Electronic Chart and Display Information System (ECDIS), which displays the information from electronic navigational charts (ENCs) and integrates position information from GPS and other navigational sensors, such as radar and automatic identification systems (AIS).

Research and other evidence

Productivity improvements for use of ECDIS and GPS are estimated to be 5%.

Estimated productivity shocks

A general productivity shock of 0.03 with an applicability factor of 100 per cent was estimated. ECDIS is not universally installed on smaller vessels. However GPS is now integrated into navigation and pilotage in most water transport vessels.

C.16 Truck transportation

Planning optimal routing of deliveries

Trucking company dispatch centres use geospatial information along with other information (e.g., traffic flow, road conditions, weather, etc.) to optimize delivery efficiencies. Either in advance of truck dispatch or en route in real time, dispatchers provide drivers with instructions on which route to take from warehouses to destinations.

In-vehicle navigation

Automotive navigation systems use a GPS navigation device to acquire position data to locate the user on a road in the unit's map database. Using the road database, the unit can give directions to other locations along roads also in its database. As a supplement to GPS, when the signal is lost or multipath occurs due to urban canyons or tunnels, dead reckoning can be employed using distance data from sensors attached to the drivetrain, a gyroscope and an accelerometer.

Monitoring locations of trucks

Automatic vehicle location (AVL) is a means for automatically identifying and transmitting the geographic location of a vehicle, which is normally determined using GPS. Location data is periodically polled from each vehicle in a fleet by a central controller or computer and, in simpler systems, displayed on a map allowing humans to determine the location of each vehicle. More complex AVL systems feed the data into a computer assisted dispatch system which automates the process.

Research and other evidence

Research evidence is based on precise positioning services in the road transport sector.

Productivity improvements for use of electronic map based dispatch systems and GPS are estimated to be 20%.

Estimated productivity shocks

The productivity shock was estimated to be 0.0116 with an applicability factor of 100 per cent for the trucking sector.

C.17 Urban transit systems

Planning optimal routing of buses

GIS is being used as a framework to create predictive models, such as those used to forecast travel demand and plan capital improvements. Typical GIS applications include: helping to understand travel demand characteristics in community, residential, and employment locations; segmenting ridership populations to deliver the most appropriate and effective transit service; and studying current ridership patterns and monitoring the effectiveness of existing service levels.

Monitoring locations of buses

Many transit authorities use automatic vehicle location for automated dispatch, vehicle re-routing, schedule adherence, and traffic signal pre-emption. AVL systems are becoming integrated into multifunctional systems such as Urban Traffic Management and Control (UTMC) Systems. By integrating the technology, a wide range of traffic management options become possible, including: route prioritization; traffic density monitoring; real-time public transport messaging; parking information; and general road conditions monitoring.

Research and other evidence

Estimates were drawn from reports.

Estimated productivity shocks

The productivity shock was estimated to be 0.0116 with an applicability factor of 100 per cent for the sector.

C.18 Taxi and limousine services

In-vehicle navigation

Similar to Truck transportation

Monitoring locations of vehicles

Similar to Truck transportation.

Research and other evidence

Research evidence is based on precise positioning services in the road transport sector.

Productivity improvements for use of electronic map based dispatch systems and GPS are estimated to be 20%.

Estimated productivity shocks

The productivity shock was estimated to be 0.08 with an applicability factor of 100 per cent for the sector.

C.19 Crude oil and other pipelines

The productivity benefits relate to planning, design, construction and maintenance of petroleum pipelines. The productivity benefits are similar to those in water sewerage and other pipeline systems.

Research and other evidence

Productivity improvements for planning applications with GIS are estimated to be 5%.

Productivity improvements for layout and as-built surveys with GPS are estimated to be 20%.

Productivity improvements for asset management with GIS are estimated to be 15%.

Estimated productivity shocks

The productivity shock was estimated to be 0.01 with an applicability factor of 100 per cent for the sector.

C.20 Natural gas transmission pipelines

This sector applies to planning, design, construction and maintenance of natural gas transmission pipelines. Similar impacts arise as with water and petroleum pipelines.

Estimated productivity shocks

The productivity shock was estimated to be 0.01 with an applicability factor of 100 per cent for the sector.

C.21 Support activities for transportation

This sector includes air traffic control, automated information systems for maritime vessel location (AIS) and vessel traffic services (VTS) in ports, coastal waters and the Great Lakes.

Air traffic control

Air traffic control (ATC) is a service provided by ground-based controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace. The primary purpose of ATC worldwide is to prevent collisions, organize and expedite the flow of traffic, and provide information and other support for pilots. Air traffic controllers use Automatic Dependent Surveillance – Broadcast (ADS-B) technology for tracking aircraft. ADS-B uses GPS-supplied target information from aircraft as the basis for air traffic controllers to determine aircraft locations.

Monitoring locations of vessels (AIS)

An Automatic Identification System (AIS) is an automated tracking system used on ships and by Vessel Traffic Services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships and VTS stations. AIS uses a transponder system that transmits information relating to ship identification, embedded GPS-derived location, vessel type, and cargo.

Vessel traffic services

Most harbour and port authorities have established vessel traffic services (VTS), which use radar, closed-circuit television (CCTV), VHF radiotelephony and automatic identification systems (AIS) to keep track of vessel movements. Because the ship's GPS position is embedded in these transmissions, all essential information about vessel movements and contents can be uploaded automatically to electronic charts.

Estimated productivity shocks

The productivity shock was estimated to be 0.03 with an applicability factor of 12 per cent for the sector giving an overall general productivity shock of 0.0036 for the sector.

C.22 Postal Services, Couriers and Messengers

Research and other evidence

Research evidence is based on precise positioning services in the road transport sector.

Productivity improvements for use of electronic map based dispatch systems and GPS are estimated to be 20%.

Estimated productivity shocks

The productivity shock was estimated to be 0.0516 with an applicability factor of 100 per cent for the sector.

C.23 Telecommunications

This case involves planning and location of facilities, facilities layout and asset management. The productivity effects are similar to those in water utilities and energy networks.

Research and other evidence

Productivity improvements for planning applications with GIS are estimated to be 5%.

Productivity improvements for layout and as-built surveys with GPS are estimated to be 20%.

Productivity improvements for asset management with GIS are estimated to be 15%.

Estimated productivity shocks

The productivity shock was estimated to be 0.0015 with an applicability factor of 100 per cent for the sector. This is considered a highly conservative estimate made in recognition of the lack of survey data to confirm the estimate.

C.24 Insurance Carriers

Identifying and managing risk exposure

Geospatial information and GIS are being used primarily by insurance underwriters for accumulation management (i.e., helping to manage risk exposure by not insuring too many properties in one concentrated area). By bringing together the location of assets and hazards, insurers are better able to provide fair and competitive premium quotations, and at the same time evaluate the exposure to risk posed by their own insurance portfolios. Using spatial analysis, insurance underwriters can correlate natural hazard areas with historical claims to better determine an equitable pricing model.

Reducing auto insurance risk and rates

Telematics technology is being introduced with usage-based auto insurance plans by Canadian insurers as a means of more accurately assessing risk, and ideally, improving driver behaviour by providing an incentive for good driving. The technology involves some form of GPS tracking device that records driver behaviour, including such things as acceleration, braking and speed. In exchange for good habits, drivers get a discount, and accidents decrease and insurers have fewer claims to pay out.

Research and other evidence

Productivity improvements for use of GIS for risk management are estimated to be 5%.

Estimated productivity shocks

The productivity shock was estimated to be 0.0248 with an applicability factor of 48 per cent for the sector. This produced an estimate of a total productivity shock of 0.0134.

C.25 Offices of Real Estate Agents and Brokers and Activities Related to Real Estate

Geospatial data is increasingly being used in real estate for property selection and valuation purposes.

Optimizing commercial property selection

Commercial real estate companies are using GIS to help them service clients' needs for leasing commercial space. Applications combine information from a variety of sources (e.g., mapping data, customer demographics, tax information, zoning, tax incentives, floodplains, nearby businesses, and traffic counts) to allow brokers to help their clients make more informed and timely lease decisions. GIS use also enables agents to give clients virtual tours of potential sites, and to prospect on behalf of landlords for prospective tenants or buyers.

Property valuation

Property assessment organizations are using GIS to map valuation and appraisal information and integrate it with a variety of other data (e.g., parcel boundaries and ownership, structure type, improvement square footage, structure information, recent sales, tax history information, and year built). GI-ebabled systems can be used to partially analyze real estate transactions data coupled with other data layers and statistics to not only provide more rigorous valuation but also to consider a wider range of data [larger geographic area] and comparisons with other similar communities.

Research and other evidence

Productivity improvements for use of GIS for property leasing are estimated to be 5%.

Productivity improvements for use of GIS for property valuation are estimated to be 15%.

Estimated productivity shocks

The productivity shock was estimated to be 0.0716 with an applicability factor of 12 per cent for the sector. This produced an estimate of a total productivity shock of 0.0089.

C.26 Architectural, Engineering and Related Services

Engineering applications

GIS can support architectural and engineering services in numerous ways including identifying the best location of infrastructure projects, supporting geotechnical investigations, environmental impact assessments and other field studies. GIS helps manage the social, environmental and economic implications of different infrastructure projects (e.g., where best to locate wind turbines in a popular tourist destination in order to minimize undue visual impact; most suitable location for a power transmission corridor taking into account geography, environmental factors, towns etc.) GIS assists in determining the most suitable location to build supported by 3D map analysis and soil samples. GIS also assists in developing an inventory of environmental flora and fauna to support regulatory requirements of environmental assessment. Base map data is overlaid with different data sets, related to the local habitat, and a visual representation of the area is then available to support informed decision making. GIS can also assist with reporting on environmental phenomena, and modeling the environment's response to natural and man-made factors.

Surveying and mapping applications

Modern geospatial technologies are being applied routinely in survey practices to improve productivity and save costs. The use of GPS and electronic total station systems has dramatically reduced the amount of time for field data capture, and the use of mobile devices for storing and transmitting this information to the office has reduced the time necessary for data analysis and quality control checking, eliminating the possible necessity of returning to the field. GIS/CAD is used to speed up and improve the quality of plan preparation processes, and facilitates the submission of electronic plans where this is required. Planning of projects is also facilitated with the common use of open source data and tools like Google Maps/Earth.

Mapping practices have also benefitted from modernization, with routine use of digital imagery (satellite, airborne, LiDAR, etc.) and photogrammetry for map production, reducing production time and increasing quality of outputs.

Geomatics consultancy practices routinely use GIS and image analysis tools to produce a plethora of geospatial products and services, and sophisticated integrated information products and services that would not be possible without the availability of these tools and digital geospatial information.

Research and other evidence

Productivity improvements for use of GIS for engineering services are estimated to be 20%.

Precise positioning services in the surveying and land management sector:

Productivity improvements from technology transformation in surveying and mapping services are estimated to be 100%.

Estimated productivity shocks

The productivity shock was estimated to be 0.1216 with an applicability factor of 76 per cent for the sector. This produced an estimate of a total productivity shock of 0.0924.

C.27 Management, Scientific and Technical Consulting Services

This relates principally to environmental consulting services. The productivity impacts are considered to be similar to architectural and engineering services.

Research and other evidence

Productivity improvements for use of GIS for environmental consulting services are estimated to be 20%.

Estimated productivity shocks

The productivity shock was estimated to be 0.1216 with an applicability factor of 10 per cent for the sector. This produced an estimate of a total productivity shock of 0.01217.

C.28 Other Professional, Scientific and Technical Services

Aerial Photography Mission Planning

Similar to Air transportation

Aircraft Navigation

Similar to Air transportation

Aerial imagery processing

With the replacement of analog aerial cameras with digital imaging systems for collection of optical, infrared, multispectral, hyperspectral, LiDAR, etc., production of hard copy aerial survey products has been virtually eliminated

Estimated productivity shocks

The productivity shock was estimated to be 0.2 with an applicability factor of 9 per cent for the sector. This produced an estimate of a total productivity shock of 0.0189.

C.29 Miscellaneous Ambulatory Health Care Services

Planning optimal routing of ambulances

Similar to Truck transportation

Ambulance navigation

Onboard GPS transmit vehicle location and status information to a centralized ambulance dispatch centre. Incident locations are determined by geo-enabling the 911 address of the caller by matching the address to the street network GIS layer. Shortest path calculations are automatically calculated to all emergency vehicles within a minimum specific radius of the incident and the appropriate vehicle is automatically identified as the most suitable to dispatch.

Monitoring location of ambulances

Shocks are likely to be similar to those for truck transportation.

Research and other evidence

Research evidence is based on precise positioning services in the road transport sector.

Productivity improvements for use of electronic map based dispatch systems and GPS are estimated to be 20%.

Estimated productivity shocks

The productivity shock was estimated to be 0.1 with an applicability factor of 27 per cent for the sector. This produced an estimate of a total productivity shock of 0.0027.

C.30 Other Federal Government Services

C.30.1 Agriculture and Food

Biomass Inventory Mapping and Analysis

This is an interactive mapping application that provides Internet-based GIS functionality to query and visualize biomass inventory data. Biomass supply and location information is made available through a collection of thematic maps and interactive queries of the herbaceous and woody databases.

Canada Land Inventory

The Land Capability for Agriculture dataset illustrates the varying potential of a specific area for agricultural production. Classes of land capability for agriculture are based on mineral soils grouped according to their potential and limitations for agricultural use.

Soils Mapping

This national scale web map displays the distribution and areal extent of soil attributes such as drainage, kind of material and classification of soils. The information is mainly derived from the 1:1M scale Soil Landscape of Canada database.

Crop Inventorying (2009-2013)

The process of generating annual crop type digital maps used a Decision Tree based methodology applied with optical (Landsat-5, AWiFS, DMC) and radar (Radarsat-2) based satellite images. This approach consistently delivered a crop inventory that meets the overall target accuracy of at least 85% at a final spatial resolution of 30m (56m in 2009 and 2010).

Agroclimate Impact Reporting

This is an online spatial tool to view an ongoing dataset of weather impacts, which provides monthly snapshots of current and historic individual impacts, as reported by registered volunteer reporters.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 1.2 per cent for the sector. This produced an estimate of a total productivity shock of 0.0004.

C.30.2 Fisheries

Fisheries management

Protection and conservation of fisheries resources are a key component of fisheries management. DFO is coordinating multi-year stock assessments and advice with multi-year fisheries management planning in more fisheries. Annual stock assessment advice and fisheries management planning will continue to take place where fish stock biology requires this approach, such as Pacific salmon fisheries.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 0.9 per cent for the sector. This produced an estimate of a total productivity shock of 0.0003.

C.30.3 Natural Resources

Geological mapping

A major activity at the federal level to support the mining sector is the production and publication of geological mapping information. Geospatial information is used in the capture of geological features in the field so that it can later be mapped, and the geological map is normally produced by superimposing the geological data over topographic data. The Geo-mapping for Energy and Minerals (GEM) program is developing modern geological maps and data sets that will completely cover Canada's North by 2020.

Storing geophysical data

The Geoscience Data Repository for Geophysical Data provides facilities to discover, view and download the following information: airborne and marine geophysics, gravity data, borehole geophysics, and seismic and magnetotelluric data.

Forestry inventorying

The National Forest Inventory, a collaborative effort between the federal, provincial and territorial governments, compiles detailed information for each of Canada's forested ecozones. The Canadian Forest Service maintains a national database and leads data analysis and reporting. The provinces and territories collect the data, including tree ages, volume of wood, dominant species and land use.

Wildland fire monitoring

The Canadian Wildland Fire Information System (CWFIS) includes daily maps that display fire danger and fire occurrence nation-wide. Data used to create CWFIS map products includes: weather observations from federal and provincial/territorial networks' weather forecasts; satellite imagery; fire statistics and reports; geographical features; and vegetation classes. The Fire Monitoring, Accounting and Reporting System (FireMARS) provides burned area polygons mapped nationally on an annual basis through the integration of data from fine and coarse spatial resolution satellite data with provincial/territorial agencies.

Biodiversity monitoring

BioSpace—Biodiversity monitoring with earth observation data—uses remote sensing technology to observe the landscape, gather data on biodiversity and monitor changes—all from space. BioSpace gathers data on four landscape characteristics: topography, productivity, land cover, and disturbance.

Crown lands administration

The Canada Lands Survey System (CLSS) provides the framework and infrastructure for defining, demarcating and describing boundaries of Canada Lands and of private lands in the North. Crown lands administration involves: setting standards that ensure a level of quality for legal surveys and survey products; maintaining a ground-based parcel fabric that provides the basis upon which additional surveys can be built and from which cadastral mapping and land information systems can be derived; safekeeping of and access to legal survey documents for Canada Lands; and support of some 20 land registry systems.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 1.4 per cent for the sector. This produced an estimate of a total productivity shock of 0.0004.

C.30.4 Safety and security

Search and rescue operations

Search and rescue (SAR) can be divided into three categories: marine, aviation and ground operations. In all cases, Emergency responders use maps and GPS to help locate and navigate to the persons in distress. The COSPAS-SARSAT provides accurate, timely, and reliable distress alert and location information. Canadian SAR Planning (CANSARP), a computerized search and rescue program developed to establish the drift of SAR targets, also uses GPS to determine the search and rescue patterns required to locate people/ships in distress. GPS and GIS are also used for asset tracking, monitoring and planning, reporting, and documentation purposes.

Policing operations

National, provincial and municipal police services in Canada use GPS for positioning assets, navigation purposes, border integrity and to assist in search and rescue operations. Some police force vehicles have been equipped with a GPS and computer with an electronic map to facilitate quicker response to calls. This allows the police dispatch system to know the precise location of each vehicle at all times and can then determine the most appropriate resource and closest vehicle to a particular incident. The police are using GIS for tactical mapping, situational awareness mapping, security exercises, crime analysis, incident reporting etc.

Managing emergencies

Geospatial information and tools are critical in all phases of the emergency management cycle. To prepare for and mitigate emergencies, GIS can map and model potential disasters to help visualize critical vulnerabilities and damage consequences. Preparedness involves developing plans of action for when disaster strikes and GIS is used for selecting sites for adequate evacuation shelters, selecting and modeling evacuation routes, and identifying and mapping key tactical and strategic facilities. During the response phase GIS is used in providing warnings to people, determining appropriate shelter activations based on the incident location and optimum routing for affected populations, and providing common operating pictures for all agencies involved. GIS is used during recovery for assessing damage, prioritizing recovery efforts, obtaining funding and monitoring progress. GPS is also heavily used during response and recovery efforts to collect data on rapidly changing situations in the field and navigating response vehicles.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 2.9 per cent for the sector. This produced an estimate of a total productivity shock of 0.0009.

C.30.5 Environment

Biodiversity and habitat conservation

Geospatial information and tools are used for inventorying habitats, studying endangered species, correlating species and geographic relationships, analyzing change over time, and evaluating the effectiveness of conservation practices and policies. Environment Canada is mandated to protect habitat by conserving and protecting migratory birds, species at risk, and other species of national interest, thereby preserving biodiversity at regional, national and even international scales. They use geospatial information to provide access to information on Canada's protected areas via the web map application "Interactive Indicator Maps", which can be used to search geographically, and this information can also be displayed on Google Earth.

Air quality reporting

The Air Quality Health Index or "AQHI" is a scale designed to help people understand what the air quality around them means to their health. EC uses geospatial information to provide access to air quality information at specific locations across Canada, updated daily, with the Web application "Your Local Air Quality Health Index Conditions".

Water quality reporting

While water quality is primarily the responsibility of provinces and territories in Canada, Environment Canada plays a leading role in scientific research, monitoring and leadership on the development of guidelines for water quality. EC uses geospatial information to provide access to information on Canada's fresh water quality (and quantity) via the web map application "Interactive Indicator Maps". The Canadian Aquatic Biomonitoring Network (CABIN) is an aquatic biological monitoring program for assessing the health of freshwater ecosystems in Canada. EC uses geospatial information to provide access to information on the sampling locations where data has been collected in support of the CABIN program with the web map application "Current Activities of sampling locations Map".

Environmental indicator reporting

Canadian Environmental Sustainability Indicators (CESI) measure the progress of the Federal Sustainable Development Strategy, report to Canadians on the state of the environment, and describe Canada’s progress on key environmental sustainability issues. EC uses geospatial information to provide access to information on a range of indicators via the web map application "Interactive Indicator Maps", which can be used to search geographically for this information, and the information can also be displayed on Google Earth.

Greenhouse gas emissions reporting

The Greenhouse Gas Emissions Reporting Program (GHGRP) is Canada's legislated, publicly accessible inventory of facility-reported greenhouse gas (GHG) data and information. EC uses geospatial information to provide access to information on greenhouse gas emissions from large facilities in kilotonnes of carbon dioxide equivalents with the web map application "Interactive Indicator Maps", which can be used to search geographically, and this information can also be displayed on Google Earth.

Pollution reporting

Environment Canada's National Pollutant Release Inventory (NPRI) is Canada's legislated, publicly accessible inventory of pollutant releases (to air, water and land), disposals and transfers for recycling. EC uses geospatial information to provide access to NPRI data .KMZ format for use with Google Earth™ and other "virtual globe" software. Information for facilities reporting to the NPRI is plotted on a series of eight static maps on the web according to facility latitude and longitude coordinates, while emissions from area, mobile and open sources (e.g. agriculture, construction, road dust, waste and prescribed burning) are distributed using spatially resolved surrogates from Statistics Canada, Natural Resources Canada and other sources.

Weather reporting

Environment Canada's Meteorological Service provides information about weather, air quality, climate, ice and other environmental issues. The weather.gc.ca website offers up-to-the-minute information on current weather conditions, forecasts and warnings for over 800 locations across the country and uses a map interface to allow users to navigate to the geographical location where they want to retrieve this information. Their GeoMet service provides access to the Environment Canada's Meteorological Service of Canada (MSC) raw numerical weather prediction (NWP) model data layers and the weather radar mosaic via Web Map Service (WMS) and Keyhole Markup Language (KML).

Sea Ice reporting

The Canadian Ice Service (CIS) provides accurate and timely information about ice in Canada's navigable waters. This information is derived from analysis of RADARSAT imagery. The CIS uses geospatial information to display the latest ice cover in Canadian waters on Online Maps, updated on a daily basis from the most recent regional and daily ice charts.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 0.5 per cent for the sector. This produced an estimate of a total productivity shock of 0.0001.

C.30.6 Statistics

Census planning and conduct

Geospatial information is critical for all phases of a census. GIS applications are used for pre-enumeration (data design, collection and preparation), enumeration (conducting the census), and post-enumeration (data analysis).

Census reporting

Statistics Canada provides census geography covering a wide range of geographic areas – from provinces and territories down to city blocks. These geographic areas have boundaries, names, and other information that make it possible to locate them on the ground and relate census data to them. Mapping data available includes: interactive maps (census and non-census boundaries, patterns, and distribution based on interaction with the user and the map); thematic maps by subject (population distribution, earnings of Canadians, etc.); and reference maps by geographic area (boundaries of geographic areas, such as provinces, cities, health regions, or watersheds)

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 0.2 per cent for the sector. This produced an estimate of a total productivity shock of 0.0001.

C.30.7 Parks and Protected Areas

Resource conservation

Parks Canada's Resource Conservation (Res Con) program uses GIS for wildlife monitoring to provide location analysis of collared animals and species at risk; for monitoring glaciers in national parks via monitoring protocols; and for the collection and storage of available Landsat and Radarsat images used to assist in fire mapping.

Other parks services

There is an increasing demand for GIS services in other areas (e.g., realty, digital images and coordination of assets, maps and information for law enforcement officers, internet maps and on-line campground reservations for visitors). For example their ‘Planning Your Visit’ website has a map interface for linking to information on visitor experiences by geographic region.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 100 per cent for the sector. This produced an estimate of a total productivity shock of 0.03.

C.30.8 Aboriginal Affairs and Northern Development

Mining and minerals

In the northern territories the rights to sub-surface lands including hard-rock minerals, precious gems and coal are administered through the Nunavut Mining Regulations and the Northwest Territories Mining Regulations and the Territorial Coal Regulations. NORMIN, a database of mineral showings, and a database of references to geology and mineral exploration in the Northwest Territories and Nunavut, stores geographical location and geological information about showings, as well as information on the content of references. AANDC publishes a map on Major Mineral Projects North of 60th Parallel in Canada.

AANDC is modernizing the way that mineral claims are acquired in Nunavut, which will allow licence holders to acquire mineral rights using a web-based system which includes an interactive map.

Petroleum

AANDC works in partnership with Northern and Aboriginal governments and people to: govern the allocation of Crown lands to the private sector for oil and gas exploration; develop the regulatory environment; set and collect royalties; and approve benefit plans before development takes place in a given area. Northern Oil and Gas disposition and Call maps are available for various regions within the jurisdiction of the department. In addition, digital boundaries for existing exploration licences, significant discovery licences, production licences, former permits, former leases and the Norman Wells Proven Area are available for download.

Land claims and self-government

The Government of Canada negotiates Comprehensive Land Claim Agreements (modern treaties) and Self-Government Agreements with Aboriginal groups and provincial/territorial governments across Canada. AANDC produces an interactive map that shows the location of Aboriginal communities negotiating agreements, including specific information on all negotiations in progress. Surveys have been required to confirm/establish the boundaries of the settlement areas and boundary maps are produced for inclusion in the agreements.

Aboriginal peoples

AANDC is one of the federal government departments responsible for meeting the Government of Canada's obligations and commitments to First Nations, Inuit and Métis. A variety of geospatial information tools and products have been developed in relation to this mandate. The GeoViewer is a full-fledged "Web GIS" application that provides searching, viewing, measuring, emailing and printing capabilities for some departmental geographic data on Aboriginal communities and lands. The First Nation Profiles interactive map is a collection of information that describes individual First Nation communities across Canada. The Inuit Community Profiles interactive map provides information about their location, traditional name, population and other statistics. The Urban Aboriginal Strategy interactive map provides information on the 2006 census demographic characteristics for Aboriginal people living in urban areas.

Economic development

The Government of Canada, through Canada's Economic Action Plan initiated in 2009, is continuing to deliver on its commitments to Aboriginal people through investments in economic development, skills development and community infrastructure. The Aboriginal and Northern Investment Announcements Map shows the locations of where these initiatives are taking place across the country. The Interactive Map of Aboriginal Mining Agreements shows where mine development agreements are taking place across the country and provides specific information on exploration projects and mines, Aboriginal communities, and the types of agreements signed between communities and mining companies. The Northern Oil and Gas Disposition static maps display all current dispositions of oil and gas rights. The Petroleum and Environmental Management Tool (PEMT) displays generalized environmental and socio-economic information for selected Arctic regions to inform decisions about oil and gas exploration and land management.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 4.3 per cent for the sector. This produced an estimate of a total productivity shock of 0.0013.

C.30.9 Health

Epidemiology

Epidemiology involves the study of patterns, causes, and effects of health and disease conditions in defined populations, which informs policy decisions and evidence-based practice by identifying risk factors for disease and targets for preventive healthcare. Geospatial information is used in epidemiology for the description and examination of disease and its geographic variations. Results of these efforts are used to guide resource allocation decisions, target outreach efforts, assess program outcomes, and guide public health policy and program enhancement decisions.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 1.8 per cent for the sector. This produced an estimate of a total productivity shock of 0.0005.

C.30.10 Defence Services

Operational planning

Defence organizations are heavily dependent on geospatial information for planning military operations. Mapping and charting products are primary tools for planning operations on land and sea and in the air. GIS is used to quickly identify patterns, trends and threats to help military personnel make better decisions, then share their knowledge. Typical operational planning applications are: creating maps for military operations, analyzing the impact of terrain and weather conditions on operations, defining an engagement area plan, sketching a plan for a beach landing operation, creating a lodgment plan, creating a vehicle checkpoint for stability operations, and creating range cards for known firing positions.

Operational support in theatre

During military operations in the field of conflict, access to high quality geospatial information and tools is equally important. Situational awareness requirements include such things as troop movements, locations of enemy personnel and assets, etc. and mobile units are often deployed to collect, analyze and present this information in mapping formats. GIS is used in such applications as: in-vehicle and mobile situational awareness analysis, creating patrol tracks on maps, and customizing common operational pictures to monitor significant activities and events, track friendly and enemy units, and assess the status and performance of daily operations.

Emergency response

Defence organizations are often called upon to assist local, provincial and national governments in responding to disasters and emergencies in Canada and abroad. In addition to current geospatial information on the local environment (e.g., transportation routes, major buildings like hospitals, schools and government offices, flood mapping, etc.), real time updates on the emergency situation are critical to response and recovery efforts. GIS emergency response applications include: creating Common Operational Pictures, incident analysis to discover spatial patterns and trends, viewing and analyzing real-time video streams or digital images, and efficiently and effectively releasing information to the public and sharing information with other response organizations.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 100 per cent for the sector. This produced an estimate of a total productivity shock of 0.03.

C.31 Other Provincial/Territorial Services

C.31.1 Natural Resources

Renewable energy mapping

Geospatial information is used to map a jurisdiction's potential for renewable wind and water energy production. For example, Ontario's Renewable Energy Atlas is a web mapping application that illustrates Ontario's renewable energy potential and provides information to assist with identifying a potential renewable energy site. The Atlas is an interactive web tool that allows users to create and view maps of wind and water energy resources in the Province.

Invasive species tracking

Geospatial information is used to position and map locations where invasive species have been reported. The Ontario Invasives Tracking System is an interactive web mapping application that allows users to enter information on their sightings and also to identify where invasive species have been sighted in the past by geographical area.

Natural heritage areas mapping

Geospatial information is used to record and make available the locations and extents of natural heritage areas such as provincial parks, conservation reserves, wetlands and woodlands. For example, The Make a Map: Natural Heritage Areas application enables users to interactively view the available natural heritage information for the province, which is also available digitally for those with GIS capabilities.

Forest fire fighting

Geospatial information is important for both fire response planning and daily fire operations support. For example, GIS is used to forecast problems (moisture, weather, lightning strikes) to plan deployment of resources and monitor for fires, in advance of actually fighting fires. The Fire Management Information Systems and Daily Fire Operations Support System at OMNR make use of GIS and a wide variety of spatial data including Ontario Base Maps (OBM), Forest and Land Cover inventories, and the Natural Resources Values Information System (NRVIS). In addition, GPS receivers, used either on the ground or in the air, capture the location and size of ongoing wildfires, and document other features and facilities. The Ontario Fire program uses the collected information to carry out spatial analysis and to develop decision support tools that will enhance tactical and strategic planning and decision-making.

Forestry management

Provincial ministries responsible for forestry management typically develop and periodically revise comprehensive inventories of forestry assets, using a combination of aerial imagery and interpretation of that imagery to provide mapped attributes for forest and non-forest land and water features, and ground surveys to provide volume estimates of forest stand types, typically using GPS. Forest inventories are being called upon to answer increasingly complex forest management questions, and GIS is helping to address this need.

Water resource management

Management of Canada's water resources is typically a provincial responsibility and involves the use of geospatial information for: protecting human life, property and natural resources through forecasting and warning about flood / drought / erosion hazards; ensuring sustainable use of water resources; and ensuring integrated management of water resources through water budgeting, river management and watershed planning. For example, Ontario`s Water Resources Information Program: uses airborne and satellite imagery to identify and measure the size of features on the ground, locate objects (like wells), etc.; produces a provincial digital elevation model to be used in flow analysis as well as producing standardized river and stream databases; and uses GIS to produce a variety of maps to support different projects in WRIP as well as other water-related programs.

Fish and wildlife management

Management of these resources involves such things as protecting and restoring aquatic ecosystems and wildlife habitat, ensuring resource sustainability through monitoring and enforcing regulations, setting catch and kill quotas, monitoring of harvest levels and population trends, protecting species at risk, etc. Web applications allow users to spatially explore fish and stocking related data. GIS technology is an effective tool for managing, analyzing, and mapping fish and wildlife data such as population size and distribution, habitat use and preference, changes in habitats, and regional biodiversity. GIS and GPS offer an indispensable means of tracking threatened animals to help prevent further harm or even extinction. GIS is also well suited to monitoring habitats. Once an area is found to be suffering from human disruption, weather, forest fires, or other interferences, it can be targeted as an area for conservation practices to be implemented.

Managing crown land

Geospatial information is indispensable for crown land acquisition, disposal, and land use planning. This land management role has two important components. First, ministries must maintain careful records about who has rights to use or occupy Crown land, typically using automated land index systems to track title and survey records. Second, when individuals illegally use Crown land, ministry staff may take enforcement action to resolve those situations before public ownership of the land is jeopardized, and GIS is used for risk assessment, operations planning, vehicle navigation, and recording offenses. GIS applications are used to allow users to view the boundaries of Crown land use areas as well as associated land use policies via Internet web mapping portals.

Mineral development

Ministries responsible for minerals use geospatial information in a variety of ways. For example, most provinces have mine claim management systems to handle mineral land tenure, and some have adopted electronic mine staking processes. Provincial Geological Surveys usually work closely with the Geological Survey of Canada on the preparation of geological mapping products that are accessible to the mining industry. GeologyOntario is an example of provincial online warehouses that contain all of the publically available digital data collected on geology, geochemistry and geophysics, which is available for download and can be discovered using spatial and attribute-based search. Some provinces (e.g., Ontario) develop annual recommendations for mineral exploration based on the wealth of available geological and exploration data and any new information or concepts derivative from the current year's activities.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 1.8 per cent for the sector. This produced an estimate of a total productivity shock of 0.0005.

C.31.2 Health

Healthcare service planning

Given the important relationship between location and health, geospatial information can be used in public health tasks such as planning to improve healthcare service delivery. By visualizing this information in a geographic format, planners are able to identify how well their current service locations are situated to accomodate target populations. Taking advantage of the network analysis capabilities in GIS, planners can determine the optimal path for delivery of medical supplies and execute what-if scenarios to measure the catchment areas of hospitals.

Health Emergency Planning

Spatial analysis can be used to forecast disease outbreaks and track them wherever they spread. As cases are recorded, statistical analysis can reveal trends that can then be used to identify at-risk groups in the population. Increased capacity for spatial epidemiological analysis enables generation of new information to inform decision making. Using demographic and socio-economic census data, maps can be created in a GIS that depict where the at-risk groups are concentrated, and by superimposing known cases onto at-risk groups, emergency health planners can mobilize their resources more effectively. For example, Vancouver Island Health Authority's Emergency Management GIS (VEMGIS) is an interactive, web based GIS tool that allows users to access detailed information related to planning for emergencies such as a tsunami, explosion, gas leak, etc.

Health analytics

Ministries of health use geospatial information and GIS to provide information, analyses, and methodological support to enhance evidence-based decision making in the health system. For example, under the Geographic Information System (GIS) Strategy adopted in 2010, the Health Analytics Branch of the Ontario Ministry of Health and Long-Term Care has significantly increased their breadth of geospatial data and GIS use. Data holdings include: administrative boundaries for Local Health Integration Networks (LHINs) and subLHIN planning areas; number of beds available, and physical locations of a number of health service providers (e.g., hospitals, long-term care homes, community health centres, family health teams), etc. BC Ministry of Health is using GIS for operational review of immunization program – using GIS to visualize coverage rates that were previously reported only in tables, drilling down into smaller and smaller coverage areas in the province.

Outbreak investigations

GI applications are being used for investigations such as E-coli and salmonella outbreak geocoding and mapping to determine if there are any patterns. With E-coli, environmental factors may come in, so data like agricultural lands, water bodies and topography are integrated with the outbreak locations.

Location allocation analyses

GIS allows health agencies to send out harm reduction supplies across the province to fill gaps in communities where there are no services, identify clinics that would be best able to serve as hubs for services, etc. By using demographics on susceptible populations, they can identify the best clinic if there is a large vaccination campaign required for disease outbreaks like measles or mumps.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 100 per cent for the sector. This produced an estimate of a total productivity shock of 0.03.

C.31.3 Education and Training

Educational resources mapping

Education and training ministries are using GIS to provide information to the public about educational and child care resources available within their jurisdictions. For example the BC Ministry of Education has an online interactive mapping tool that provides locations and contact information for StrongStart BC programs, public schools and board of education offices in British Columbia. BC Ministry of Ministry of Children and Family Development provides the locations and contact information for a variety of early childhood development programs and services (Early Years Services Map) and child care services (Child Care Programs Map) in their province.

Service locations mapping

Similarly, Ministries are using GIS to provide information to the public about employment assistance service providers. For example, the ON Ministry of Training, Colleges and Universities provides a mapping tool to help users find information about service providers in their geographic region.

Student transportation

Ministries of Education typically provide funding to school boards for student transportation. Geospatial information is critical in student transportation management software that is used for such functions as: automated student data upload, creation of transportation eligibility boundaries; and performing school bus run and route optimizations.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 19.9 per cent for the sector. This produced an estimate of a total productivity shock of 0.006.

C.31.4 Social Services

Service locations mapping

Social services ministries are using GIS to provide information to the public about social program resources available within their jurisdictions. For example, the BC Ministry of Social Development and Social Innovation has an online interactive mapping tool that provides locations and contact information for WorkBC Services Centres, which provide resources and support to assist people in their search for work.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 9.3 per cent for the sector. This produced an estimate of a total productivity shock of 0.0028.

C.31.5 Environment

Biodiversity and habitat conservation

Geospatial information and tools are used for inventorying habitats, studying endangered species, correlating species and geographic relationships, analyzing change over time, and evaluating the effectiveness of conservation practices and policies. GIS is being used for targeting and planning habitat protection and restoration projects by focusing on habitats that are at highest risk and where they can have the biggest impact, and remote sensing is being used for identification of wetlands.

Air quality

The Air Quality Index or "AQI" is a scale designed to help people understand what the air quality around them means to their health. Provincial environment ministries use geospatial information to manage and provide access to air quality information at specific locations, updated regularly, with Web applications.

Water quality

Water quality is primarily the responsibility of provinces and territories in Canada, and environment ministries use geospatial information to provide access to information on Canada's fresh water quality (and quantity) and drinking water quality via web map applications.

Environmental information reporting

Provincial ministries provide web-based GIS applications to access authoritative environmental datasets. Users can choose between viewing the raw data, locating features on a map, querying datasets, performing GIS analysis and generating reports.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 0.7 per cent for the sector. This produced an estimate of a total productivity shock of 0.0002.

C.31.6 Transportation

Planning and design of transportation facilities

GIS provides a framework to inform models, such as those used to forecast travel demand and plan capital improvements, and to support strategic decision making. In addition, GIS applications for making environmental evaluations can shed light on the consequences of various transportation alternatives. GIS-based planning and analysis allows transportation ministries to assess and prioritize construction and maintenance activities, ensure regulatory compliance, complete risk and integrity analyses, and better understand customer needs. GIS tools that can integrate CAD files and support surface and hydraulic models and soil and geotechnical analyses provide capabilities for designing context-sensitive projects.

Facilities layout and as-built location

Geospatial tools like GPS and electronic total stations are used in laying out roads, bridges, overpasses, sidewalks, etc. and recording their final as-built locations following construction. For maintenance projects, precise geospatial information is essential, for example, in replacing overpasses on busy highways, where the new structures are built closeby and the replacement takes place overnight to reduce driver inconvenience (e.g., Hwy overpass replacements at given avenue).

Snow Clearing

GIS and GPS are being used to plan snow clearing routes, monitor clearing operations and report post-clearing road conditions to the public in near real time.

Transportation planning and forecasting

Geospatial information is used for long term transportation systems planning and forecasting purposes, in helping to find the right balance between the need to accommodate demand on public infrastructure and the responsibility to preserve quality of life and environmental sustainability in communities. An appreciation of existing transports hubs and networks in relation to expected population growth trends can identify areas of future bottlenecks in the absence of any forward planning. Spatial information is integral to transport modelling and managing congestion and freight

Road user safety

Engineers are using GIS to perform safety analyses and identify root causes of dangerous highway segments.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 100 per cent for the sector. This produced an estimate of a total productivity shock of 0.03.

C.31.7 Agriculture and food

Soils Mapping

Geospatial information is used to map and display the distribution and areal extent of soil attributes such as drainage, kind of material and classification of soils. Existing soil maps, and their classifications of soil and land attributes, are digitized and electronically "stitched" together to produce a single digital soils coverage. For example, the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFMRA), in cooperation with the Ministry of Natural Resources and Agriculture and Agri-Food Canada, are compiling a high quality, detailed, geospatial soils database for Ontario.

Drainage mapping

"Constructed Drains" are watercourses in the form of ditches or natural watercourses that have been modified to improve drainage, or they are in the form of buried tile systems. Provincial agriculture agencies are creating mappable layers of constructed drains that can be easily updated and then integrated with watercourse data from other agencies. For example OMAFMRA is making enhanced drainage data available to users so that they can make more knowledgeable observations and decisions about current drainage conditions, future drainage plans, and environmental conditions.

Land use mapping

Detailed land use information such as fields, farmsteads, fencerows and ditches is often provided by provincial agriculture ministries. For example, OMAFMRA's Agriculture Operations Inventory contains detailed information such as crop type, row direction, ditch and farmstead locations, livestock raised, irrigation and tillage method use, which assists with environmental modelling and agricultural land use decisions.

Emergency planning and response

Geospatial information is used in planning for potential agriculture emergencies and their response and to support biosecurity initiatives. For example, when there is an outbreak of annimal disease, GIS is used to identify the locations of the outbreak, and establish the boundaries of quarantine areas. Biosecurity at the farm level means preventing the movement of disease-causing agents onto and off of agricultural operations.

Food chain tracking

Agriculture ministries are being challenged increasingly by the public to track food production problems (e.g., disease, etc.) directly to farms. A traceability system captures, stores and shares information about products received, internal production and operational processes, all the way to finished goods that are shipped and sold to the customer.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 1.2 per cent for the sector. This produced an estimate of a total productivity shock of 0.0004.

C.31.8 Municipal affairs

Land use planning

Provincial land use planning systems typically give municipalities the major role in planning decisions. Provincial ministries have such roles as: identifying and protecting provincial interests, and promoting sound infrastructure planning, environmental protection, economic development and safe communities GIS applications primarily designed for land use planners provide visualization of GIS layers from many sources. GIS-based planning support systems can measure and compare performances of different planning scenarios according to planner- or citizen-defined indicators for land use, transportation, natural resources, and employment, to name a few.

Archeological mapping

GIS-based, user-friendly planning tools are used to enable municipal planners from various departments (e.g., public works, engineering, parks and recreation, and planning) to screen development proposals and identify areas for which a detailed archaeological assessment by a licensed archaeologist would be required. The goal is to inventory, classify and map significant archaeological resources and provide direction for their appropriate assessment and protection, as required.

Tracking municipal changes

Provincial municipal affairs ministries need to keep track of land use changes in municipalities to ensure that they are in alignment with provincial planning guidelines for growth (e.g., sustainability of robust economies; complete and strong communities that use land, resources and existing infrastructure efficiently, with amenities and community infrastructure to support a good quality of life; healthy environments and cultures of conservation)

Registry operations

Land titles/registry organizations examine applications to register interests in land, including transfers of ownership and the registration of charges against title, register survey plans that define the boundaries of parcels of titled land, such as subdivision and strata plans, and provide access to those records to lawyers, notaries, land surveyors and other stakeholders.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 1.7 per cent for the sector. This produced an estimate of a total productivity shock of 0.0005.

C.31.9 Provincial policing

Planning service delivery

Geospatial information is extremely important in developing strategies for deterring and preventing crime as well as developing tactical plans for dealing with today's issues. Data-driven policing through GIS enables police forces to leverage their analysis of crime and intelligence information to proactively focus scarce resources in solving community problems, preventing crime and apprehending criminals.

Situational awareness

GIS provides command staff with the most up to date information by integrating the police force's high-value static data (crime hazards, gang territories, critical infrastructure, imagery, etc.) with dynamic event data (crimes, traffic, incidents, cameras, and other sensors, etc.) and analysis through a map. A map provides the comprehensive situational awareness needed to make better decisions as well as the ability to share this information with other involved agencies.

Field operations

Law enforcement agencies want to put the best available information in the hands of their first responders to improve their effectiveness and ensure their safety. Equally important is the ability of these officers to provide a timely and accurate picture of what is actually occurring in the field. A mobile GIS provides the capability for this rapid data exchange in a manner that is easy to understand and that can be integrated, visualized and shared through a map-based common operating picture.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 1.1 per cent for the sector. This produced an estimate of a total productivity shock of 0.0003.

C.31.10 Other municipal government services

Infrastructure design, construction and management

Geospatial information supports a broad range of infrastructure related activities, including: planning and design of new infrastructure facilities; assessment of right-of-way infrastructure condition and needs; annual infrastructure rehabilitation; environmental assessments of rehabilitation projects; and maintenance of infrastructure records (i.e., asset management application).

Urban planning

Urban planners deal with a wide range of spatial information: parcel, zoning and land use data, addresses, transportation networks, housing stock, etc. Planners also study and keep track of multiple urban and regional indicators, forecast future community needs, and plan accordingly to guarantee the quality of life for everyone in livable communities. Some jurisdictions have incorporated automation into their planning approvals process, allowing submission of proposed development plans electronically, producing efficiency gains for both the municipalities and developers.

Realty services

Cities acquire and manage real property rights as required, for municipal needs consistent with city-mandated programs. Geospatial information supports the responsibilities of realty services organizations for: departmental acquisition needs assessments; and legal surveys, appraisals, negotiations, expropriations, legal and other activities related to the real property acquisitions.

Street operations and maintenance

Geospatial information is invaluable for the ongoing management of city streets and roads and for planning and executing maintenance activities. Some major cities are using web mapping and mobile applications to facilitate the reporting and viewing of maintenance issues such as potholes, malfunctioning traffic signals, dead animals, etc.

Parks and recreation

City departments responsible for parks and recreation use geospatial information and tools for planning parks and recreation facilities, maintenance activities, and providing services to the public (e.g., identifying recreation facilities locations and information in web mapping applications).

Water and sewer

Similar to Water, sewage and other systems

Fire and police services

Similar to Ambulance services and Provincial policing. Some fire departments are using GIS to plan performance improvements much better (i.e., having very accurate time data on when calls received and dispatched, when crews arrived on scene, how long they were there, activities undertaken, etc.).

Public health

Municipalities typically have public health organizations and Boards of Health, which are responsible for approving policies developed by a Medical Officer of Health and staff of the public health organizations, who together identify the health needs of the community. These needs are addressed by a range of programs and services in areas such as health protection, health promotion, disease and risk factor surveillance (population health assessment), and injury and disease prevention. Geospatial information is being used to help facilitate citizen access to health care information and facilities (e.g., hospital locations, restaurant inspection reports, etc.) with web mapping applications.

Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 100 per cent for the sector.

C.32 Other Aboriginal Government Services

Land management

As Aboriginal communities move to self-government, they are making increasing use of geospatial information for management of their lands.

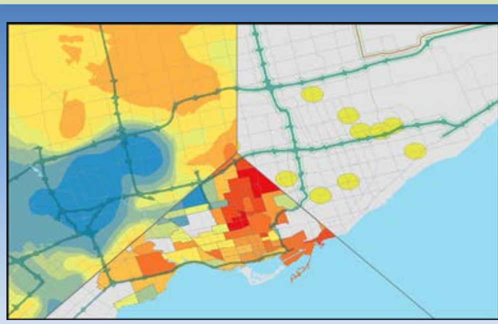
Estimated productivity shocks

The productivity shock was conservatively estimated to be 0.03 with an applicability factor of 100 per cent for the sector.

D. Case Studies

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. Altus's Cost Consulting & Project Management services include costing, project monitoring, and infrastructure advisory services. Their Property Tax team employs a customized database that accommodates differences in local tax regimes, and assesses property tax impacts at the individual property or portfolio level. The Research, Valuation & Advisory group (RVA) offers the following services: valuation and appraisal, legal support, decision-making support, financial due diligence, targeted research, and market information and perspective, tenant satisfaction studies, and industry benchmark reporting. The Altus Geomatics Service Areas include: Legal/Municipal Land Surveys, Construction Surveys, Geographic Information Systems (GIS) and Internet GIS, Mapping, 3D Scanning, and LiDAR. Altus developed MLS® HPI (Home Price Index) under agreements with The Canadian Real Estate Association, Greater Vancouver Real Estate Board, Fraser Valley Real Estate Board, Calgary Real Estate Board, Toronto Real Estate Board and Greater Montreal Real Estate Board.



Altus GIS Tool for Market Monitoring (Source: Altus)

MLS® HPI includes transactional data for home sales via MLS® Systems at participating Canadian Real Estate Boards and Associations. These data include sale price and information from a GIS to capture additional neighbourhood characteristics relating to schools, main streets, water, and others.

Using the spatially enabled HPI tool provides analytical capabilities that previously were either not possible or very labour intensive. A similar technology can be used to appraise the value of properties, and appraisal reports that used to cost $250-$400 each to produce can now be done for $15-$25 in most cases. Robert Dorion, President, 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, and 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."*

Although the use of geospatial information in the real estate sector is widespread, Altus believes that a barrier to even more productivity improvements is that access to cadastral/assessment/property data is not standard across the country. According to Mr. Dorion, *"There is also a need to increase the GIS competencies of the appraisal/ assessment/ land-use planner communities, which will not only help satisfy the demand for these services but also enhance and extend the current systems to provide even better models and results."*

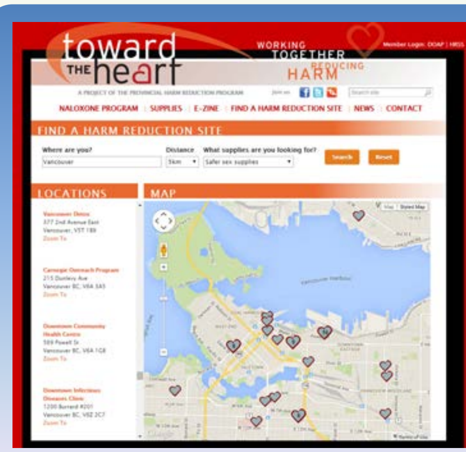
Case study: British Columbia Centre for Disease Control

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. The Centre provides both direct diagnostic and treatment services for people with diseases of public health importance, and analytical and policy support to all levels of government and health authorities.

The BCCDC has 15 geospatial information (GI) users (i.e., geographic information systems (GIS) specialists, epidemiologists, data analysts, etc.) who have access to an internal spatial data warehouse. A number of internal facing GI applications have been developed for outbreak investigations, disease surveillance, location-based funding allocation, business continuity planning and risk mapping, as well as external facing Internet applications such as the Harm Reduction Site Locator illustrated on the right (http://towardtheheart.com/site-locator).

Place is a foundational component of the epidemiological triad of person, place and time. GI is critical in disease surveillance and outbreak investigations to determine where exposure to a pathogen has occurred, and where resources should be allocated to prevent or reduce the burden of disease. Location allocation type analyses enable efficient distribution of harm reduction supplies across the province, identification of clinics that would be best able to serve as hubs for services, and use of demographics on susceptible populations to identify the best clinic if a large vaccination campaign is required during a disease outbreak.

The use of geospatial information produces a number of benefits for BCCDC. For example, use of GIS analysis informs the most effective method to apply mosquito controlling pesticides to prevent West Nile Virus disease, to protect



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

vulnerable water bodies and sensitive habitat, food production and other sites of agriculture activities. It also helps them meet mandatory disease outbreak reporting requirements while ensuring a balance between public responsibility and the privacy of individuals.

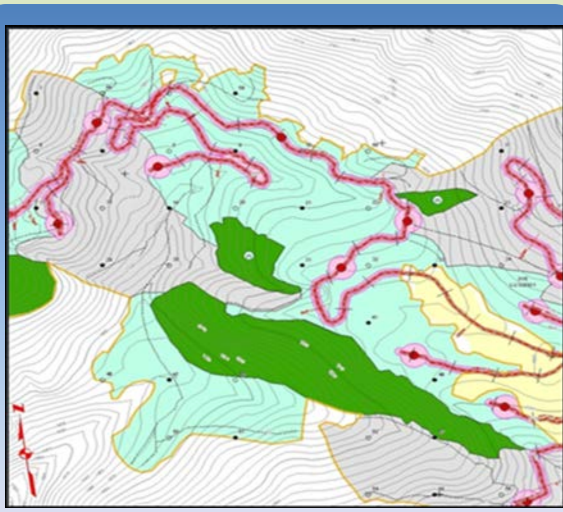
As the Centre's Medical Geographer, Sunny Mak says, "*Productivity improvements really depend on the different applications of GIS; it is difficult to quantify the number of lives saved or the impact of reducing the severity of a disease outbreak. However, GIS analysis produces value-added information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

BCCDC is considered a leader in health geomatics. Other agencies within the PHSA and regional health authorities consult with Mr. Mak on a regular basis, and he trains the Public Health Agency of Canada's team of field epidemiologists and public health field staff on the topic of spatial epidemiology.

Case study: Canfor

Canadian Forest Products Ltd. (Canfor) is a forest products company involved in the lumber and pulp and paper businesses with 23 sawmills, 4 pulp mills, a nursery and distribution centres. Canfor lumber manufacturing facilities produce dimension lumber, value-added finishing products, wood pellets and green energy. Their pulp manufacturing facilities produce market northern bleached softwood kraft (NBSK) pulp, fully bleached high-performance kraft paper, and bleached chemi-thermo-mechanical pulp. Canfor sales in 2013 totaled approximately $3.2B.

Canfor began using geospatial information (GI) in a geographic information systems (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, writing site plans, etc.



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

This information is submitted to the provincial government as part of Canfor's business process to obtain harvesting approvals and to update the province's forest cover data. GIS is also used for different kinds of analyses (e.g., ungulate range, forestry impacts on stream flow and directions on calculating equivalent clear-cut areas, etc.) to determine how well they are meeting regulatory targets.

The use of GI and geospatial technologies has produced a number of benefits for Canfor. By using the information available in the GIS in the office before going to the field, foresters can be much more productive. They can do basic block designs and planning using the data and then simply verify this work in the field. GIS is used to automate a lot of the entry of tabular data into the Cengea forest resource planning, reporting and management system, saving considerable time.

Canfor also uses GIS to support third party environmental certification of their woodland practices, which is important for protection of market share (e.g., their two biggest customers require certified logging practices).

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.

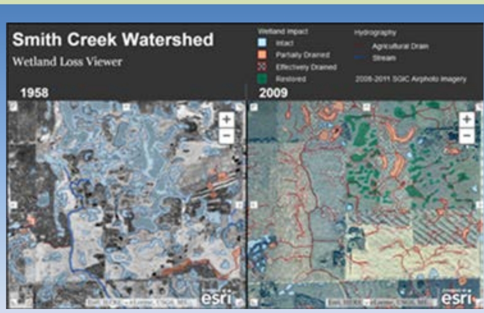
Case study: Ducks Unlimited Canada

Geographic information plays a role in nearly every decision made at Ducks Unlimited Canada (DUC). Choosing project locations, targeting marketing strategies, studying waterfowl movements, tracking landscape changes – all of these activities involve questions of geography.

DUC has 76 years of experience delivering wetland conservation. During this time, its conservation programs have strengthened and evolved thanks to ongoing advancements in geospatial knowledge. With the integration of digital mapping, Global Positioning Systems (GPS), remote sensing, geographic analysis and location-based applications, Geographic Information Systems (GIS) has helped deliver significant on-the-ground results.

"*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."*

The map below shows the dramatic impacts that have occurred on the Smith Creek watershed in Saskatchewan. Not only do they serve as a compelling communications tools, maps provide valuable information that allows DUC to identify key threatened landscapes across the country.



Wetland Loss Viewer
(Source: Ducks Unlimited Canada)

DUC is a seasoned user of geospatial information (GI). It adopted remote sensing to identify wetlands in Western Canada in 1979, 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."*

The use of GI to better target conservation work produces a range of social and environmental benefits as well. By using spatially explicit decision support tools, the quality of wetland habitat projects is higher. Wetland protection and restoration can also be targeted to reduce nutrient loading, pollution, sedimentation and flooding within watersheds.

"Targeted wetland protection helps prevent flooding, filters and purifies water, replenishes and stores groundwater, reduces erosion and protects shorelines," said Kazmerik. "Wetlands provide exceptional biodiversity, affecting one-third of Canada's species at risk."

By sharing and exchanging GI with its partners, DUC is equipped with the tools to monitor habitat change, track waterfowl demographics and predict future land and resource use. All of these are essential to achieving its long-term conservation goals.

Case study: Golder Associates

Established in 1960, Golder 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.

Golder's Spatial Information Management service team provides innovative solutions to the various disciplines within Golder, as well as external clients. The primary geospatial information (GI) applications at Golder are:

- **Location Determination for Infrastructure Projects**: Using Geographic Information Systems (GIS) and spatial data to best determine the most suitable location based on key factors such as environmental, social, technical and economic factors.
- **Geotechnical Investigations**: Determining suitable locations to locate or build (i.e., will the environment support this infrastructure) using mapping, spatial analysis, 3D modelling, etc.
- **Environmental Assessments**: Developing an inventory of environmental flora, fauna, and physical attributes to support regulatory requirements for environmental assessments.

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

Using geospatial information and technologies provides considerable benefit. 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."*

Project planning and data collection is much more efficient since Golder can do desktop studies using GIS, as well as using readily available, often free, geospatial information. Consultants perform a preliminary site analysis in the office identifying only those areas that need to be confirmed on site, prior to sending field crews out to collect additional information. Knowing what to expect when in the field also improves the overall safety of staff and decreases risk.

For Environmental Assessment studies, GIS allows Golder to model and perform more complex analysis over larger areas using more input variables, based on the datasets available. This analysis allows them to draw more informed decisions and conclusions. Some projects require their GIS team to produce large reports with hundreds of maps showing layers of data in many different scenarios. Advancements in GIS, such as 3D analysis and rendering, help clients visualize the impact of their projects before they are built.

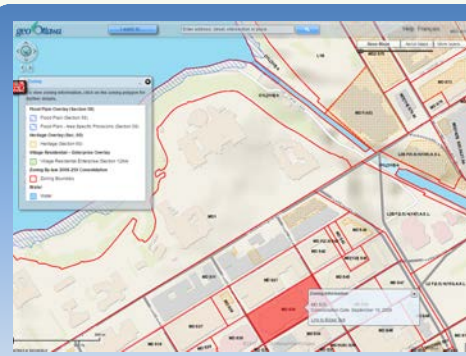
In most cases Golder's clients assume or expect that they will be able to provide GIS as a service for their projects. Mr. Murdoch notes that, *"Through the use of GI, Golder is competitive in the market and can offer a wide breadth and depth of services to our clients."*

Case study: The City of Ottawa

The City of Ottawa is the fourth largest city in Canada in terms of population and the largest in terms of geography with an area of 2,760 square kilometres. The Infrastructure Services Department is responsible for delivering effective and efficient survey, mapping, utility coordination, design, construction, and asset management services to help ensure safe, accessible and sustainable municipal infrastructure. The Asset Management and Business Technical Services group in the department manages over $30B worth of City assets (e.g., buildings, parks, roads, underground infrastructure, utilities, etc.) and maintains all the information about these assets in a Geographic Information Systems (GIS) database. They have some 100 geospatial information (GI) users of which 80 are very dependent on GIS use.

The asset management applications of GI in the City of Ottawa are wide-ranging. For example, GI is used to establish the condition of assets to decide replacement priority (e.g., combining age with geographical considerations such as proximity to watercourses, bridges, railways, etc.). They also use GIS for information sharing with other groups who may influence when maintenance activities take place. They create specialized GI products for major events such as severe floods, winds, ice storms, etc., to identify assets that may have been damaged or failed to perform, and make recommendations for repair.

Other geospatial information applications include: preparing capital forecasting on a monthly basis; positioning closed circuit television system (CCTV) information on the interior condition of pipes; capturing GI with mobile devices when field crews are inspecting bridges, culverts, etc.; and using GIS-enabled dispatch technology and GPS navigation of salt trucks. The City of Ottawa is among Canada's leaders in GI use at the municipal level.



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

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.

GIS is supported by regularly updated core GI. Every three years the City collects aerial imagery for the entire municipal area and makes derived orthophoto mapping available to the Corporate GIS. They also produce 1:1,000 vector mapping, about 1/3 of the City per year, with a resolution of 6 cm in urban and 20 cm in rural areas.

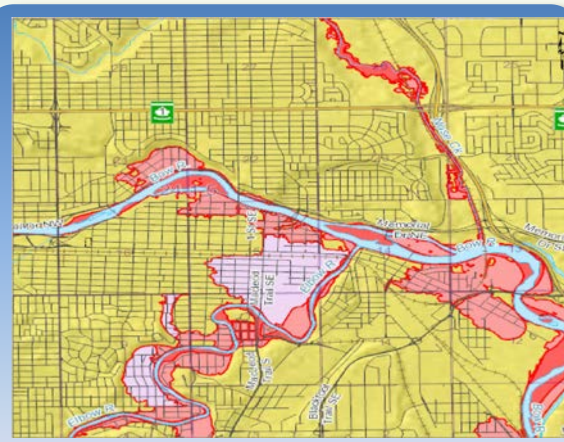
Kelly Martin, the City's Manager of Asset Management says, "Geospatial information helps reduce asset management costs and citizen inconvenience. It is used to maintain records of all maintenance activities (e.g., water main break repairs, etc.) and planned works so that decisions on future replacement of asphalt and pipes can be done more effectively. Also, since the accurate 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.

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. In its headquarters in the United Kingdom, RSA has been using geospatial information and GIS technology for risk modelling and accumulation management since 2001. RSA Canada introduced the technology in 2012, and there are now some 200 GIS users across their Canadian operations. The primary users are underwriters, who are better able to assess the insurability of a property based on its location and risk factors in the area.

Using the geospatial tools developed for RSA Canada, underwriters are receiving the analysis needed to develop insurance premium quotes significantly faster. For large commercial insurance business, the analysis now performed using automated GIS tools was previously done manually by underwriters, with a significant time cost, and in some cases this meant it simply wasn't possible to complete full assessments before quoting. 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."*

A critically important example of the value of GIS use in insurance underwriting is flood risk modelling. RSA Canada recently implemented a brand new river flood model which, for the first time, gives a consistent view of flood risk across the whole country. This enables underwriters to make more informed decisions and ensure that pricing accurately reflects the risk.



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

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."*

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