



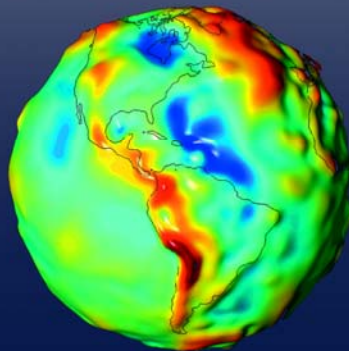
Natural Resources  
Canada

Ressources naturelles  
Canada



# Geodetic Survey Division Strategic Plan

September 2009



*Providing precise measurements of the size, shape and motion of the Earth  
and its gravity field in support of geoscience and geomatics for the benefit of  
Canadians!*

Canada

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## Foreword

In 2009, the Geodetic Survey Division (GSD) celebrates its 100<sup>th</sup> anniversary. For the past 100 years, GSD has contributed significantly to Canada's economic and social development. By continually responding to its clients and the country's priorities, GSD has assisted Canadians to map, chart, navigate, and demarcate Canada's territory.

GSD's mandate today? To provide the national geodetic reference system and keep it consistent with continental and global reference systems. As such, GSD is recognized as Canada's authoritative federal institution for providing positioning standards. In fulfilling its mandate, GSD plays a critical part in building an up-to-date knowledge base of our landmass, waterways and offshore Exclusive Economic Zone. This knowledge base contributes to the economy and improves the quality of life for all Canadians.

During the last decade, Canada—and indeed the world—have witnessed a shift from traditional geodesy to space-based geodesy. Consequently, positioning is relatively easy and affordable today. To continue to add value, GSD must therefore alter its role to keep in step with technology.

Specifically, GSD needs to focus on making unique contributions within its mandate. These contributions involve providing reliable geographic and gravimetric reference frames to support high accuracy positioning and geodetic measurements of the dynamic earth. Such measurements contribute to research on water, climate change, and natural hazards and other issues affecting Canada's citizens.

Described herein, GSD's new strategy capitalizes on its strengths to respond to the changing environment and requirements of its stakeholders. These stakeholders come from other federal government departments and agencies, provinces, territories, academia, industry, and the international geodetic community.

GSD's work has never been more challenging, a clear vision never more important, and a sound strategy never more vital. Driven by a century of proud service to Canadians, GSD intends to use this strategy to embrace a promising future.

### **Mark Corey**

Assistant Deputy Minister  
Earth Sciences Sector  
Natural Resources Canada



## Citizen Concerns

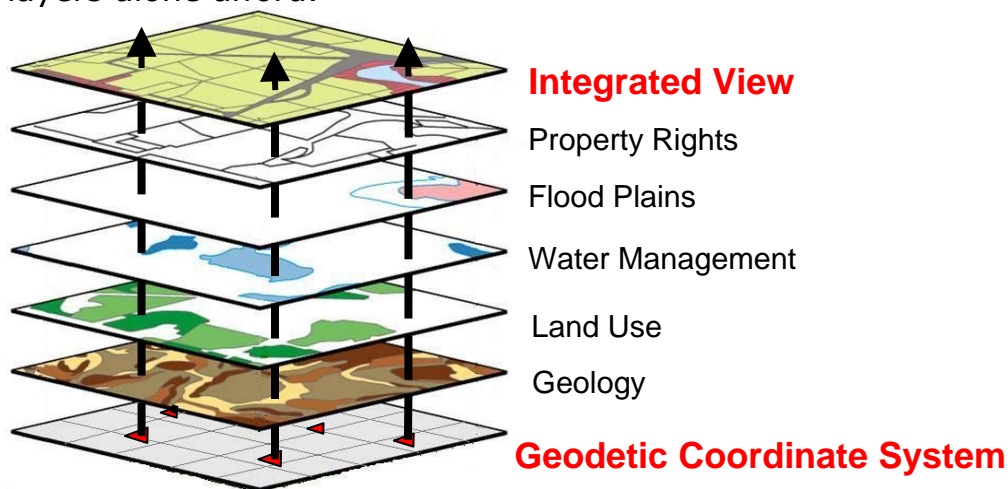
During any year, GSD responds to numerous concerns from Canada's citizens. Here are some examples of the types of concerns that citizens raise and how GSD works to address these concerns.

### How do we integrate diverse information collected by different people over many years?

Users of the Canadian Spatial Reference System (CSRS) can integrate their information with that of others collected at different periods for a wide variety of purposes. As the national geodetic coordinate system, the CSRS serves as the common foundation for all mapping, charting, navigation, boundary demarcation, crustal deformation, and other georeferencing needs in Canada.

By providing consistent reference coordinates, the CSRS enables users to manage water supplies, harvest forests, and plan urban development, among other georeferencing activities.

The following diagram illustrates how the CSRS enables users to align or integrate a number of data layers to provide an integrated view. These integrated views often provide users with greater insight than single data layers alone afford.





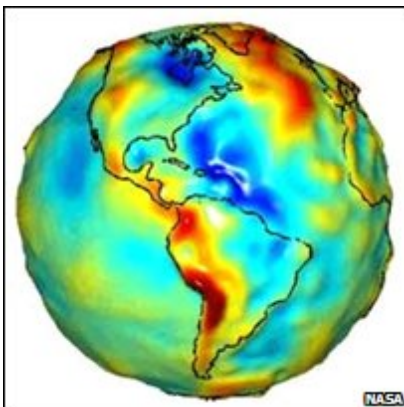
***Can we increase our understanding of the causes of earthquakes and better predict their occurrences?***

In partnership with others, GSD scientists measure subtle deformations of the Earth's surface. These measurements help us understand seismic hazards, particularly in eastern Canada and southwestern British Columbia where these risks are the greatest.

***How can we efficiently chart flood plains?***

In some regions, even moderate rises in water levels can cause big floods—and big economic impacts. So, how do we reliably monitor water levels and mitigate potential damage?

The national Height Reference System is necessary to understand the flow of water. Currently, height reference is provided through a network of monuments limited to highly populated corridors. In addition, heights provided directly by the Global Positioning System (GPS) do not account for gravitational effects and therefore cannot be used to manage water. By modernizing the Height Reference System based on a gravimetric model, GSD will equip users to measure heights above mean sea level<sup>1</sup> anywhere in the country. This modernization will capitalize on GPS and emerging Global Navigation Satellite System (GNSS) technologies.



***A Map of the Earth's Geoid***

*Canada's new height system will be based upon a model of the Earth similar to that in the adjacent diagram. The sweep of colours shows minute variations in the geoid. The geoid is a mathematical representation of the surface coinciding with "mean sea level". Highs are red; lows are blue.*

*Water flow is determined by gravity, and "mean sea level" height is actually height above a surface like that shown in this exaggerated figure.*

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<sup>1</sup> Mean sea level is established by convention on a national, continental, or global scale.



### **How can communities in the eastern Arctic and Hudson Bay plan for a possible ice-free Arctic in the future when their shorelines are continually changing?**

The eastern Arctic and surrounding area of Hudson Bay are rebounding from the weight of massive glaciers that pressed down on the Earth many thousands of years ago. Current measurements indicate that in Canada, this post-glacial rebound is raising the Earth's surface by up to 1.5 cm a year. GSD assesses and monitors these changes across Canada to let communities and stakeholders know what the future holds for shorelines, shipping, flooding hazards, and the natural environment.

### **How do we best understand the overall water budget within the Great Lakes Basin?**

Containing about one fifth of the world's fresh water, the Great Lakes supply drinking water to tens of millions of people. GSD's scientists and researchers are analyzing satellite gravity data to measure changes in the Great Lakes' water volume, contributing to the Earth Science Sector (ESS) groundwater geoscience activities.



## Our Vision

*Our vision is to be the recognized “go-to” national centre in the development, implementation and integration of geodetic science for Canadian needs related to high accuracy positioning and measurement in Earth dynamics.*

## Our Mission

*Our mission is to establish and provide the fundamental reference values used as standards for the measurement of latitude, longitude, elevation and gravity anywhere in Canada and to monitor motions of our continental landmass in support of geoscience and geomatics.*

In fulfilling this mission, GSD ensures that Canadian georeferenced information of various sources or locations can be used together and integrated coherently through a common coordinate reference system consistent with international standards.

An associated result is an improved understanding of Earth processes such as global changes and geo-hazards from the knowledge of variations in the Earth’s geometry and gravity field over time.

## The Strategy

The Geodetic Survey Division’s strategy is built on four pillars:

### **1. Provide the fundamental geodetic systems and infrastructure needed to strengthen the safety and security of Canadians and the stewardship of Canada's natural resources and territory.**

- Make available the geodetic information, data products, and tools that enable users to precisely establish the coordinates of geographic features, infrastructures, or assets with respect to a common reference system (standard) over Canadian lands.
- Maintain the fundamental infrastructure that enables users to precisely measure the geometry and gravity field of the Canadian territory measurements essential for advancing Earth sciences.



## 2. Align scientific efforts with the following three issues:

- ***Geographic foundation***
  - ***Water and climate change***
  - ***Natural hazards***
- Further exploit precise geodetic information for scientific work by developing partnerships and integrating external expertise (academia).
  - Develop a core geodetic capability internally to better contribute to multidisciplinary scientific projects.
  - Focus R&D activities on the following areas:
    - Wide area GNSS solutions
    - Motion of the Canadian landmass
    - Gravimetry and geoid modeling

## 3. Lead standards development and priority setting.

- Strengthen the development and application of georeferencing standards with industry, academia, other federal government departments and agencies, and the international community.
- Work with provinces and territories to address today's challenges. These challenges include the emergence of inconsistent spatial reference frames resulting from the growing number of satellite constellations and providers of augmented positioning services.

## 4. Champion change and mobilize partners.

- Initiate a national Geodetic Science collaboration to better align geodesy efforts with issues and priorities of concern to citizens.
- Increase synergy with other federal departments that use GNSS and formalize resulting collaborations.



## Key Activities

<b>Geographic Foundation</b>	<b>Geosciences</b>	<b>Policy</b>
<ul style="list-style-type: none"> <li>• Provide the national geodetic coordinate system</li> <li>• Maintain the national gravity standardization network</li> <li>• GF includes:               <ul style="list-style-type: none"> <li>- GNSS satellite monitoring</li> <li>- GNSS data products</li> <li>- On-line tools for accurate positioning</li> <li>- Geodetic points coordinate updates</li> <li>- Client Services and outreach</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Align GSD program with three scientific priorities:               <ul style="list-style-type: none"> <li>- Water</li> <li>- Climate Change</li> <li>- Natural Hazards</li> </ul> </li> <li>• Provide authoritative information about the dynamic Earth to scientific users</li> <li>• Create a new national scientific collaboration relating geodesy efforts to issues and priorities of concern to citizens</li> </ul>	<ul style="list-style-type: none"> <li>• Contribute to the development and application of standards for high accuracy measurement, satellite positioning, and gravimetry in collaboration with:               <ul style="list-style-type: none"> <li>○ Federal departments</li> <li>○ Provinces and territories</li> <li>○ Academia</li> <li>○ Industry</li> <li>○ International organizations and governments</li> </ul> </li> </ul>
<b>Measurable Results</b>		
<ul style="list-style-type: none"> <li>• Recognition as the national “go-to” centre in geodesy</li> <li>• Increased usage of satellite navigation and gravity information</li> <li>• Improved client satisfaction</li> <li>• GPS•C distribution service transferred to private sector by April 2011</li> </ul>	<ul style="list-style-type: none"> <li>• GSD science and technology efforts better aligned with key issues</li> <li>• New partnerships addressing key issues</li> <li>• New users within government and scientific community</li> <li>• Access to competitive scientific funding</li> </ul>	<ul style="list-style-type: none"> <li>• Recognition of GSD geodetic reference products as standards for high accuracy positioning and measurement of gravity anywhere in Canada</li> <li>• New engagements established with partners on policy issues</li> </ul>



## Outcomes

(Note: the theme or area relevant to each of the following outcomes is specified in brackets after each outcome.)

### Primary

Canadian georeferenced information of various source or location can be used together and integrated coherently through a common coordinate reference system consistent with international standards. **(mandated role)**

### Associated

Improved understanding of Earth processes such as global changes and geo-hazards from the knowledge of variations in the Earth's geometry and gravity field over time. **(geoscience support)**

### Intermediate outcomes :

- Scientific responses involving several government agencies are coordinated, decision making is enhanced, and collaboration is both improved and focused on issues of importance. **(effective governance)**
- Scientific studies linked to sea-level heights, water flow, and hydrological balance are enhanced from the knowledge of variations in the Earth's geometry and gravity field. **(water and climate change)**
- Improved Earth dynamics information and geodetic tools help Canadians better understand natural hazard risks. **(natural hazards)**
- Positions on the Canadian territory or in space can be determined with sub-centimetre accuracy with respect to a common national reference system. **(geographic foundation)**
- The Canadian spatial reference system is consistent with international standards and integrated into continental and global coordinate reference systems. **(geographic foundation)**



## Science at Work for Canada

Scientific organizations use geodetic data, products, and services to investigate a broad range of Earth and atmospheric processes. The following represent the types of geodetic activities that support these investigations.

### Providing the spatial reference frame

- Support precise positioning in Canada by operating a fundamental network of approximately 20 GNSS<sup>2</sup> continuous tracking stations. This positioning support will also come from providing related data products that offer space-based access to the national reference frame.
- Work with other organizations to share tracking stations.
- Maintain and update geodetic procedures and standards and related software tools.
- Coordinate and collaborate in developing national and international standards.

### Monitoring the dynamic Earth

- Monitor Earth dynamics from a network of approximately 100 GNSS continuous tracking stations (operated by GSD or partners).
- Adapt to emerging GNSS developments through international and national partnerships.
- Integrate and test emerging technologies, solutions, and processes.
- Compute and analyze global and regional reference frames.
- Contribute geodetic information to natural hazard research.

### Measuring and interpreting the Earth's gravity field

- Support gravity standardization by operating the Canadian absolute gravity site.
- Provide national standards and contribute to validating international satellite missions by maintaining the national primary gravity reference network (approximately 70 stations) and complementary control

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<sup>2</sup> The Global Positioning System (GPS) is the only fully operational GNSS today. The Russian GLONASS is a GNSS now being restored to full operation. The European Union's Galileo positioning system is a GNSS in initial deployment, scheduled to be operational in 2013.



network.

- Support Earth Sciences Sector's activities related to the definition of Canadian offshore boundaries and to the discovery and development of new energy and mineral resources.

### **Integrating the gravity satellite mission data and modernizing the Height Reference System**

- Integrate data from multiple sources and collaborating agencies to modernize the Height Reference System.
- Model the gravimetric geoid in Canada (mathematical representation of the surface coinciding with "mean sea level").
- Contribute to Earth Sciences Sector's activities related to groundwater geoscience, securing Canadian energy supplies, and enhancing resilience to climate changes.
- Let stakeholders know about the initiative to modernize the Height Reference System; promote the initiative and educate stakeholders in partnership with provincial and territorial geodetic agencies.

### **Leadership and policy coordination**

- Chair Federal-Provincial Geodesy committee.
- Chair a National Geodetic Science Network.
- Proactively support GNSS coordination among federal departments.
- Conduct outreach with industry.

### **Information and client services**

- Research and respond to requests for positioning and geodetic information.
- Maintain and provide access to real-time and archived data products, information, and solutions from the Canadian Spatial Reference System holdings.
- Provide client technical support and outreach.
- Provide access to precise positioning applications and solutions for industry to develop commercial value-added products and services.



## Our Strengths

### Our people

Our people, their knowledge, and their expertise are our greatest strength and the key to our success.

To achieve this success, GSD will need to both manage its existing employees in a new way and attract qualified newcomers. We will better manage our employees by using technology and automation to improve efficiency. These efficiency gains will allow us to re-deploy employees to priorities as noted above. We will also establish projects and scientific teams to address essential issues.

But we also need to attract new people. Demographics indicate that attrition could cost GSD more than 40 percent of its workforce over the next five years and more than 70 percent over the next ten years. Recruiting highly qualified personnel and scientific staff will be a priority for GSD's renewal. Our strategy involves increasing GSD's scientific leadership, and this strategy will be reflected in the skills and expertise of our future employees.

### Innovation

Maintaining the national reference system for one of the world's largest landmasses has been and will continue to be a challenge. This challenge is amplified by the fact that GSD works with a budget modest in comparison to those of other advanced countries.

Despite these constraints, GSD has harnessed its unique and highly specialized expertise to become a world-class innovator. Our accomplishments have positively impacted Canadian citizens and businesses both at home and abroad. GSD succeeds because it harnesses global technological change and collaboration, fertile ground for innovation.

GSD's innovations include the following:

- Developed and implemented wide-area GPS correction capability
- Enhanced absolute gravimetry measurements and instrumentation
- Established autonomous GPS precise point positioning algorithms
- Developed processes to validate data from satellite gravity missions



GSD is also enabling and delivering innovations that benefit other sectors. Examples include high accuracy time transfer, space weather, atmospheric sensing, and ground water mapping. These are topics of leading-edge research and development internationally and will significantly enhance the world's future geodetic capabilities.

### **Collaboration**

At the heart of the GSD strategic plan is the need to refocus research and development. Where is our new focus? It is on those elements of our mandate where GSD contributes uniquely to high accuracy positioning and measurement. This refocusing requires revitalizing our collaboration with other organizations actively involved in science and research and development.

GSD is already networking with Canadian academia and other government departments and agencies. In addition, GSD is collaborating internationally with the United States Department of Commerce, National Geodetic Survey of the National Oceanic and Atmospheric Administration (NOAA) and services under the auspices of International Association of Geodesy. Benefiting GSD and Canadians for many years, our proactive participation with other organizations will continue in key areas. These areas will be determined by priorities of government, such as good governance, economic opportunity, safety, and security of Canadians.

Collaboration becomes all the more important when one considers the funding pressures that affect public science and technology initiatives today. As new public funding mechanisms encourage multi-sector collaboration, GSD will have to rely more on new partnerships with universities and other organizations to harness geodetic expertise as well as to earn competitive funding in the future.

GSD must be more relevant to Canadians and be recognized as such. To meet—and maintain—this goal, GSD must partner with scientists who have a broad range of expertise. These partnerships will equip GSD to deal with increasingly complex important public issues.



## A Proud Past and a Promising Future

Since confederation, the Government of Canada has provided a fabric of monumented survey control points as the basis for surveys and mapping. From the days of the Dominion Lands Surveyors opening up the West to the present, Canada has relied on this reference frame as an integral part of the national infrastructure. In 1909, the Geodetic Survey of Canada was formally created by an order-in-council and mandated to determine the positions (and elevations) of points throughout the country with the highest attainable accuracy.

While improving the way GSD responds to ongoing requirements for survey control, technological advances have also enabled the division to precisely monitor large scale deformations of the continent and gravity changes due to mass redistribution. Many issues of importance to Canadians now rely on this capacity to monitor changes, whether it be understanding the impacts of climate change, the likelihood of earthquakes, or the management of water by a hydroelectric company. Along with rapid and continuing technological advances, the potential for using high accuracy geodetic information and solutions to address issues of these types is growing. Realizing this potential will determine GSD's relevance to Canadians in the coming decade.



## Summary

As the Geodetic Survey Division (GSD) celebrates its 100th anniversary, the organization must concentrate not on its eventful past, but on its promising future.

For much of its existence, GSD has provided positioning data to surveyors, map makers, and others. The recent advent of Global Positioning System technology has made such positioning relatively simple and inexpensive. This technological change is calling for GSD to respond to the unique requirements of geoscience while catering to a much broader base of users in positioning.

At the same time, the division stands to lose up to 70 percent of its employees to attrition over the next 10 years. To remain relevant, GSD needs to both attract new qualified employees and focus on four key areas, all within its mandate:

1. Provide the fundamental geodetic systems and infrastructure needed to strengthen the safety and security of Canadians and the stewardship of Canada's natural resources and territory.
2. Align scientific efforts with the following three issues:
  - Geographic foundation
  - Water and climate change
  - Natural hazards
3. Lead standards development and priority setting.
4. Champion change and mobilize partners.

By focusing on these areas and collaborating with universities, scientists, and other organizations, GSD intends to maintain its relevance to Canadians. GSD will achieve this relevance by continuing to provide services that contribute to the country's economic and social well being.