

GEOIDE Thrusts and Themes Research & Developments

Marie-Josée Fortin, GEOIDE Associate Scientific Director

Department of Zoology, University of Toronto, Toronto (Ontario) M5S 3G5, Phone: (416) 946-7886, Fax: (416) 978-3542,

Email: mjfortin@zoo.utoronto.ca

ABSTRACT

Our environment is fundamentally spatial and temporal in nature, Geomatics has come to play an increasingly important role in attempts to better manage our planet. Applications of Geomatics ranges from: providing observations and understanding of large-scale planetary conditions and global change, developing tools for quantifying the elusive concept of environmental quality, supporting ecosystem management by developing spatially explicit models at a range of spatial and temporal scales and to assess, measuring and mapping the impacts of human intervention and pollution on the environment, and forecasting, preventing and evaluating natural risks and disasters. As part of the GEOIDE (Geomatics for Informed Decisions) Network, new research and methods are currently under development to address these issues. This talk presents GEOIDE's research program and structure where "Application Projects" are closely related to applications and involve an active participation of the industrial and governmental sectors, and "Support Projects" are fundamental research projects that apply to a given domain. Furthermore, the projects are classified in application sectors called "Thrust" (Natural and Resources, Environment and Marine, Transportation and Commerce, Health and Social Services) and science and technology domains called "Theme" (Data Acquisition, Data Management, Decision Support). For example, the following research areas are funded by GEOIDE: temporal GIS, more effective use of remote sensing data, modeling for providing better understanding of the systemic aspects of the relationship between humans and the environment and for understanding the limitations of data due to error, spatial analysis, and visualization techniques in support of public participation.

Keyword: GEOIDE (Geomatics for Informed Decisions), Research and Development, natural environment, social issues, technology transfer

1. GEOIDE

The interrelationship between humans and their environment has become an increasingly dominant preoccupation for all sectors of our economy, whether over local and regional scales or for the entire global ecosystem. With the rapid growth of the world's population and the growing impacts of our industrial and post-industrial economies on the natural world, better understanding and better management strategies are sorely needed. A critical part of the management of natural resources is the ability to recognize patterns and trends within a landscape. Because our environment is fundamentally spatial (and temporal) in nature, Geomatics has come to play an increasingly important role in attempts to better manage our planet.

Applications of Geomatics ranges from: providing observations and understanding of large-scale planetary conditions and global change, and to provide tools for quantifying the elusive concept of environmental quality (for example, through the definition and measurement of large-scale indicators), to support ecosystem management by developing spatially explicit models at a range of spatial and temporal scales (e.g., for studying the atmosphere, hydrosphere, biosphere and geosphere) and to assess, measure and map the impacts of human intervention and pollution on the environment; to forecast, prevent and evaluate natural risks and disasters.

New research and methods are currently under development as part of the GEOIDE (Geomatics for Informed Decisions) Network to address these issues such as: temporal GIS, more effective use of remote sensing data, modeling for providing better understanding of the systemic aspects of the relationship between humans and the environment and for understanding the limitations of data due to error, spatial analysis, and visualization techniques in support of public participation.

The GEOIDE projects are classified in application sectors called "**Thrusts**" and three science and technology domains called "**Themes**". Projects belonging to various **thrusts** are closely related to applications and involve an active participation of the industrial and governmental sectors. They are **application projects**. Fundamental research projects that apply to all thrusts within a given **domain** are called **support projects**.

THRUSTS

<i>Themes</i>	Environment and Marine (ENV)	Natural Resources (RES)	Transportand Commerce (TCO)	Health Social Development and Services (HSS)
Data acquisition (ACQ)				
Data management (MNG)				
Decision support (DEC)				

Abbreviations designate projects according to the relevant thrusts and domains. In Phase I (1998-2002) 27 projects were funded and in Phase II (2002-2005) 20 will be funded.

2. Thrusts

2.1 Natural resources thrust (RES)

The exploitation of natural resources is an important part of Canada's economy. Sustained economic growth is fuelled by the following sectors: **agriculture**, the **oil and gas industry**, the **mining industry**, and **forestry**. Furthermore, geomatics is being used to provide the necessary tools for the development and management of natural and renewable resources. The industrial sector along with the federal, provincial and municipal governments need information to facilitate **management** and the **decision-making process**. **Innovative data acquisition and data management solutions** are required because of:

- the diversity of regions in Canada;
- the size of the country;
- the remoteness of the regions where natural resources can be exploited.

Earth observation information, satellite data in particular, provide an important data source for the monitoring and management of the previously mentioned sectors. The use of more recent remote sensing technologies such as the **radar**, the **LIDAR** and **hyper-spatial** and **hyperspectral** resolution systems (airborne or commercial satellites), will improve identification and specific monitoring capabilities in the natural resources sector. A more efficient use of these systems requires an integration of additional geospatial data sources. Furthermore, increased spatial referencing is essential for these developments.

Therefore, **high precision GPS data** and an improved characterization of reference surfaces such as the geoid are needed. Finally, **quality and temporal aspects** of data management are critical for the development of renewable natural resources. It is often necessary to collect information on an ongoing basis. For example, forest clear-cut inventory is updated every year. Furthermore, several scenarios require prior data to, during and after exploitation. The mining industry is another typical example.

Research efforts in this thrust are aimed towards:

- More effective use of remote sensing data
- Access to large database
- Temporal and 3D GIS
- Precision positioning by GPS
- Visualization and information dissemination to increase public involvement
- Modelling
- Decision-making tools and the use of geomatics to determine economic and social impacts of natural and renewable resources exploitation

In Phase I the following projects were funded:

- Imaging spectroscopy for the management of the Canadian landscape, with emphasis on the boreal forest and the tundra (RES#6) [Project leaders: Miller, John R. (York University) and Rivard, Benoit (University of Alberta)]
- Three-dimensional digital integration of geological, photogrammetric, remote sensing and geophysical data: application to resource assessment in foreland thrust and fold belts (RES#25) [Project leader: Lebel, Daniel (INRS - Géoressources/Centre Géoscientifique de Québec)]
- Integrated decision support system for watershed management (RES#31) [Project leader: St-Onge, Benoit (Université du Québec à Montréal)]
- Airborne gravity for exploration and mapping (AGEM) (RES#47) [Project leader: Schwarz, Klaus-Peter (University of Calgary)]
- Three-Dimensional Analysis of Forest Structure and Terrain using LIDAR Technology (RES#50) [Project leaders: St-Onge, Benoit (Université du Québec à Montréal) and Treitz, Paul (Queen's University)]
- The Georgia Basin Digital Library: Infrastructure for a Sustainable Future (RES#52) [Project leader: Robinson, John (University of British Columbia)]
- Analysis of Reflectance and Fluorescent Remote Sensing Techniques for Detection of Plant Stresses in Precision Agriculture (RES#54) [Project leader: Viau, Alain (Université Laval)]

In Phase II the following projects are funded:

- Tailored geomatics applications for geohazards and georesource exploration (RES LON) [Project Leader: Long, Bernard (INRS Géoressources)]
- Imaging spectroscopy: Developments for renewable and mineral resources (RES MIL) [Project Leader: Miller, John R. (York University)]
- Automated core logging of lithology by hyperspectral remote sensing (RES RIV) [Project Leader: Rivard, Benoit (University of Alberta)]

2.2 Environment and marine thrust (ENV)

Whether on a local, regional or world scale, the **interrelationship between humans and their environment** has taken a more important place in sectors of our economy. With the rapid growth of the world's population and the growing impacts of our industrial and post-industrial economies on the natural world, a better understanding and improved management strategies are urgently needed. Because our environment is by nature essentially spatial and temporal, geomatics has come to play an essential role in our attempts to better manage our planet. Despite the fact that most geomatics applications are for land use, marine geomatics is becoming more important. The determination of marine boundaries, localizing fish stocks, the monitoring of regeneration and growth of fishing grounds, coastal zone management, determination of current, iceberg formation, heat flows, and wind speed are all aspects that require geomatics data acquisition techniques, decision support and integrated management systems.

Therefore, geomatics is used to:

- Provide **observations** and understanding of large-scale planetary conditions and global change, and to provide tools to quantify the concept of environment quality (for example, defining and measuring of large-scale indicators);
- Support **ecosystem management** by developing spatially explicit models at a range of spatial and temporal scales (to study the atmosphere, hydrosphere, biosphere and geosphere for example);
- Evaluate, measure and map the **impacts of human interventions** and **pollution** on the environment in order to forecast, prevent, and evaluate **risks of natural disasters**;
- Provide support tools for **rapid intervention** during environmental disasters for search and rescue operations;
- Facilitate **coastal zone management** by providing precise and accurate spatial information.

Research efforts in this thrust are aimed towards:

- Temporal GIS
- More effective use of remote sensing
- Use of modelling to provide better comprehension of systemic aspects of relationship between humans and the environment and to understand the limitations of data due to error
- Tools to help the decision-making process, particularly in cases where time is an issue
- Simulation of scenarios, archiving and access to geospatial data
- Spatial analysis

- Visualizing techniques to promote public involvement

In Phase I the following projects were funded:

- Quantitative Spatial Descriptors for Improved Natural Resources Decision-Making (ENV#4) [Project leader: Fortin, Marie-Josée (University of Toronto)]
- The synergistic use of multi-sensor remote sensing for monitoring of the earth's surface and atmospheric parameters (ENV#13) [Project leaders: Collins, Michael J. (University of Calgary) and Rubinstein, Irene G. (York University)]
- Natural hazards and disaster monitoring (ENV#17) [Project leaders: Cannon, Wayne H. (York University) and Merriam, James B. (University of Saskatchewan)]
- Extraction of features from remote-sensed imagery for a search and rescue synthetic vision database (ENV#19) [Project leader: Elder, James H. (York University)]
- Marine Activity Geomatics and Risk Analysis in the Coastal Zone (ENV#60) [Project leader: Pelot, Ronald (Dalhousie University)]

In Phase II the following projects are funded:

- Modelling of Atlantic salmon smolt production using remote sensing and GIS-based methods (ENV DOD) [Project Leader: Dodson, Julian (Université Laval)]
- Marine Activity Geomatics and Risk Analysis in the Coastal Zone (ENV PEL) [Project leader: [Pelot, Ronald](#) (Dalhousie University)]

2.3 Transportation and commerce thrust (TCO)

Commerce, including retail, restaurants and entertainment services, is among the last sectors to undergo rapid globalization and restructuring. Strategic decision-making in such a sector requires the development and analysis of spatially distributed data for outlet distribution, rapid distribution and fluctuation of consumer patterns. An important aspect of this thrust is the application of geographic information systems to retail planning and to the analysis changing competitive retail environments. Transportation is an aspect that is tied to retail sales activities, but is not restricted to it. Transportation on land, water or by air, is one of the most important supporting sectors of Canadian economy. Intelligent transportation systems (ITS) require accurate positioning, route planning, conventional cartography and decision support systems with a strong spatial component in order to make traffic safer and smoother. Other applications of geomatics for land transportation include highways and smart bridges, monitoring the movements of goods, corridors and related land use planning, and data gathering for onboard navigational systems. Furthermore, a precise determination of the geoid and vertical position with GPS calculations is important for maritime transportation in order to evaluate the maximum load of cargo.

Research efforts in this thrust are aimed towards:

- Collection of small area data from new sources and new forms
- The estimation of error and uncertainty
- Analysis study of temporal series of spatial data
- Adoption GIS and spatial information for strategic planning of retail sales
- Development of normative, probabilistic multivariate and programming models which are spatially explicit
- Intelligent Transportation Systems and automated vehicle systems for route planning and estimation of time of arrival
- Precise geoid determination and GPS positioning with long baselines
- On-line decision-making tools for management of bus fleets

In Phase I the following projects were funded:

- A cartographic interface for the multidimensional exploration of environmental health indicators on the World Wide Web (W3) (SOC#1) [Project leaders: Bédard, Yvan (Université Laval) and Gosselin, Pierre (Université Laval)]
- Human behaviour and GIS-based environmentally sustainable land use and transportation modelling (SOC#8) [Project leader: Lee-Gosselin, Martin E.H. (Université Laval)]
- Geomatics for strategic planning in the business/commercial sector (SOC#12) [Project leader: Jones, Ken (Ryerson Polytechnic University)]

- Biometrology (SOC#23) [Project leaders: Chapman, Michael A. (Ryerson Polytechnic University) and Ronsky, Janet L. (University of Calgary)]
- Real-time bus location, passenger information and scheduling for public transportation (TCO#51) [Project leader: Shalaby, Amer (University of Toronto)]
- Development of a Real-time Mobile Information Management Technology in Support of Energy and Resources Operations (TCO#53) [Project leaders: Gao, Yang (University of Calgary) and Tao, Chuang (York University)]

In Phase II the following projects are funded:

- Next Generation MEMS-Based Navigation System for Vehicles and Personal Location and Navigation (TOC ELS) [Project Leader: El-Sheimy, Naser (University of Calgary)]
- Perception-based Modelling and Business Geomatics (TOC JON) [Project Leader: Jones, Ken (Ryerson Polytechnic University)]
- An integrated GPS-GIS system for collecting spatio-temporal microdata on personal travel in urban areas (TOC LEE) [Project Leader: Lee-Gosselin, Martin (Université Laval)]

2.4 Health and social services thrust (HSS)

Health Canada has defined a set of research priorities for the coming decade. These priorities include population health, the renewal and a restructuring of the health system, research into new methodologies and research on the transfer and integration of knowledge. It is expected that geomatics will play an essential role in many of these areas.

However, social services have gone through major transformations over the last few years. Land-use planning, property management, management of public parks, travel services, telecommunications and public participation in policy-making are all services that rely heavily on geomatics. The determination of the social impact of decisions and spatial changes is a major area in which social sciences and geomatics share common ground. Applications in the fields of health, development and social services all require access to information (by the internet for example), user-friendly interfaces to complex databases, dissemination of decisions and better visualizing tools that can provide access to data to laypersons.

Analysis of social and health sector data are based on the tracking of geographic variation patterns of occurrence of relevant variables (diseases, sanitary conditions, population demographics, etc.), the definition of legal and social meanings of boundaries (ontology) and the access to spatio-temporal databases (historical databases). The acquisition of data represents also a major obstacle for these areas, just as it was the case for the natural resources sector a decade ago. Data archiving and management are also important, especially across distributed and heterogeneous networks. Public participation in the elaboration of policies and decisions requires that these networks be accessible. However, the confidentiality of the data must be kept.

Research efforts in this thrust are aimed towards:

- User-friendly data interfaces incorporating data browsing techniques such as OLAP
- Access problems for geospatial information and decision strategies
- Links between data, evidence and policies
- Management and integration of historical databases supporting analysis and spatio-temporal algorithms
- Links between population and decision policies
- Integration of human behaviour and cognitive models into geospatial tools

In Phase I the following projects were funded:

- Good Governance of Canada's Oceans: Determining the Use, Value and Potential of Marine Boundary Information (HSS#55) [Project leader: Nichols, Susan (University of New Brunswick)]
- Sharing Geodatabases in Historical Dynamics / MAP: Montréal, l'Avenir dur Passé (HSS#56) [Project leader: Olson, Sherry (McGill University)]
- Spatial Variation in Health and Human Development (HSS#57) [Project leader: Willms, J.Douglas (University of New Brunswick)]

In Phase II the following projects are funded:

- Biometrology for Informed Decisions in Medical Diagnoses, Procedures and Treatment Evaluations (HSS RON) [Project Leader: Ronsky, Janet (University of Calgary)]

- Système d'Information Spatio-Temporel sur l'Infarctus du Myocarde (SIST-IM) (HSS VAN) [Project Leader: Vanasse, Alain (Université de Sherbrooke)]

3. Themes

3.1 Data acquisition theme (ACQ)

Geomatics Canada is implementing a new compound-counter positioning infrastructure which will have a significant impact on data acquisition and fusion research (the Canadian Spatial Reference System). Industries relying on real time information regarding vehicles or other mobile services will also benefit. Real time cartography is a recent field of research and represents a new geopositioning application.

Furthermore, GIS data sources have shifted away from field sampling towards the widespread use of satellite and airborne imagery. Canada has a strong industrial presence in terms of remote sensing equipment and applications, as demonstrated its RADARSAT program. The extraction of significant information from multi-resolution and multispectral image data (for example, artificial vision, artificial intelligence drawings, computer sciences) requires new approaches along with the more traditional methods (pattern recognition, model inversion, classification). Data gathering from non-image sources is also necessary. This requires the collaboration of geomatics scientists in geodesy, photogrammetry and remote sensing, and researchers in non-geomatics fields such as computer sciences, mathematics and physics, and in application domains such as agriculture, forestry, oceanography, geology and hydrography.

Two essential elements of the current technical revolution are:

- Precise positioning with geodetic tools such as GPS;
- image acquisition and analysis.

In Phase I the following projects were funded:

- Precise Geoid determination for geo-referencing and oceanography (ACQ#10) [Project leader: Sideris, Michael G. (University of Calgary)]

In Phase II the following projects are funded:

- Precise Geoid Determination for Geo-referencing and Oceanography (ACQ VAN) [Project Leader: Vanicek, Petr (University of New-Brunswick)]
- Development of a Dynamic Seamless Vertical Reference System for Environmental, Climatic, Geodynamical, Oceanographic, Hydrographic and GIS Applications (ACQ SID) [Project Leader: Sideris, Michael (University of Calgary)]

3.2 Data management theme (MNG)

Work regarding the integration, fusion and management of heterogeneous data from a variety of sources is very significant. Furthermore, the conversion and update of this data is of increasing importance. Therefore, remote sensing data can be integrated and combined in an interactive manner in a way to enhance the existing databases. The data is manipulated, undergoes a change in scale and is updated in order to create "new" data sources. These two types of data, "new" and original, are stored in spatial data warehouses and digital spatial libraries. These can be accessed from numerous sites, which leads to questions regarding interoperability.

The use of equipment and parallel or distributed material for performance considerations is also an important factor. These issues must be addressed in order to ensure the long-term viability of spatial databanks, which are costly to build and maintain. These databanks must also incorporate tree dimensional and temporally referenced data. This process requires the collaboration of geomatics experts, computer scientists and professionals. We expect that new alliances in the fields of artificial intelligence, algorithmic sciences, and cognitive sciences will play a major role.

In Phase I the following projects were funded:

- Parallel and Distributed Geomatics (MNG#26) [Project leaders: Maheshwari, Anil (Carleton University) and Sack, Jörg-Rüdiger (Carleton University)]

In Phase II the following projects are funded:

- Multi-scale generalization and multiple representation techniques for efficient production and delivery of cartographic data (Project Gemure). (MNG BED) [Project Leader: Bédard, Yvan (Université Laval)]

- Automating Photogrammetric Processing and Data Fusion of Very High Resolution Satellite Imagery with Lidar, IfSAR, and Maps for Fast, Low-cost and Precise 3D Urban Mapping (MNG TAO) [Project Leader: Tao, Vincent (York University)]

3.3 Decision support theme (DEC)

New technologies must not only be appropriate for a given task, but must also be customized to the practices and constraints of existing organizations and must simplify the user's work instead of increasing the difficulty of the task at hand. The development of integrated approaches for characterizing the social, institutional, and cognitive dimensions of the workplace, by means of formal studies and the development of methodological tools, is also necessary in order to integrate these aspects in the development of tools.

Furthermore, within such a framework, data extracted from central databases must be restructured into intermediate, higher levels to support decision-making, as is the case with the Internet. This structure could include interactive visualization or animated environments, online data processing and extraction techniques, sophisticated models, and new analysis tools. Furthermore, appropriate interactive environments designed to support the decision-making process must be developed. Decision-makers work with a mental representation of both the territory and the decision context. The tools developed must help decision-makers build and maintain more efficient mental models that will enhance their capability to make informed decisions.

Finally, information must be accessible to an increasingly broad and heterogeneous public. This will require modern and efficient communications tools. Furthermore, studies of the impacts of access to geospatial information and spatial data infrastructures on various social and institutional environments may also offer guidelines to policy makers on what dissemination mechanisms are effective and how information should be used. Also, geospatial information is increasingly used when conflicts of interest arise among participants. Studies regarding the integration of geospatial information into conflict resolution and assistance to the decision-making process are also part of this domain. These interests require the coordinated efforts of cognitive sciences and geomatics researchers. The involvement of these disciplines is also needed: algorithmic geometry, administrative and informational sciences, political science and economics, as well as application fields such as ecology, commerce and geology.

In Phase I the following projects were funded:

- Designing the technological foundations of geospatial decision-making with the World Wide Web (DEC#2) [Project leader: Bédard, Yvan (Université Laval)]
- Development of automated techniques to extract, generalize, and access geospatial information from hyperspatial remotely sensed data (DEC#9) [Project leader: Niemann, K. Olaf (University of Victoria)]
- Simulations of memory, mental imagery and mental models – applications to spatial planning and electronic map use (DEC#30) [Project leader: Edwards, Geoffrey (Université Laval)]

In Phase II the following projects are funded:

- Intelligent Data Fusion for Aircraft Navigation and Disaster Management (DEC ELD) [Project Leader: Elder, James (York, University)]

4. Concluding remarks

R&D developed within the scope of GEOIDE aim to fill gap in key **R&D geomatics sectors**. This is facilitated by targeting both users and potential markets for geomatics solutions as well as science and technology research areas deemed as essential for the development of geomatics.

We believe that this strategy will increase the use of geomatics technologies in key sectors and demonstrate the active presence of geomatics in Canada. The key sectors include the social development and health sectors which could benefit tremendously from geomatics. Furthermore, we expect that this strategy will bring geomatics technologies to more traditional sectors such as environment and natural resources

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