Marine User Requirements for Geospatial Data

Summary 2001

Recreation & Tourism

Sovereignty & Defence

Biodiversity

Non-renewable Resources

Disaster Management/Emergency Response

Freshwater Resource Management

Marine Transportation

Integrated Coastal & Ocean Management

Habitat Management

Marine Engineering Works & Service

Ocean Management & Research

Renewable Resources

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Foreword

While we as Canadians stand to reap the benefits of our vast coastal and offshore resources, we must be forever mindful of our stewardship role in protecting and safeguarding these resources for future generations. We have a responsibility to become leaders in addressing the numerous coastal, inland water, and ocean management issues facing our marine environment. These issues can only be addressed and resolved in a timely and forthright manner by having a full understanding of the processes that control this environment and this requires accurate and timely information. The essence of the Marine Geospatial Data Infrastructure (MGDI) initiative is to co-ordinate, manage and disseminate this information through an integrated geospatial infrastructure and make it available to all users in a timely and cost effective manner.

On January 31, 1997, the Canada's Oceans Act became law. The Act positions Canada to move to a more integrated national oceans management approach based on sustainability, the precautionary approach, and the integration of activities occurring in and impacting on our oceans. The Oceans Act also sets the framework for an ecosystem approach to the management of Canada's oceans and ocean resources. Under an integrated management approach, co-management is one of the tools that offer the opportunity to harness the talents and experience of stakeholders in the search for ocean management solutions

Increased public awareness in the last decade has created a demand for knowledge of marine areas. Issues such as the effect of ocean variability on the productivity of fish stocks, the effects of habitat change, and the role of the oceans in the global climate system can only be resolved by an integrated ecosystem approach to ocean management using all the data and information services that are available. Access to databases that currently are inaccessible can only be achieved through having common formats for data exchange and national protocols for the storage, maintenance and updating of information sources. The mission of MGDI is to provide the infrastructure to achieve success in resolving scientific and operational issues through the sharing of geospatial information on the marine environment.

The MGDI Initiative had its beginning in 1999. In that year the Canadian Geospatial Data Initiative (CGDI) was approved as a federally funded five-year $60 million initiative under the leadership of Natural Resources Canada. This federally funded partnership program known as GeoConnections is designed to:

- co-ordinate Canada's numerous databases of geographic information and make them accessible through a common window on the internet; and
- enable partnerships between provincial and federal governments, the private sector and the academic community.

The Program Advisory Network for GeoConnections consists of twelve committees or nodes and one of these nodes is a Marine Advisory Network node. The Marine Advisory Network node is co-led by the Department of Fisheries and Oceans (DFO) and the Canadian Centre for Marine Communications (CCMC).

The Marine Advisory Network node has a Marine Advisory Committee with membership representing the various stakeholders in the sector. These stakeholders are found in the following segments of the marine sector:

- Marine transportation
- Marine habitat management
- Integrated coastal zone management
- Renewable resources and biodiversity
- Non-renewable resources
- Disaster management/emergency response
- Sovereignty and defence
- Ocean research
- Recreation and tourism
- Freshwater resource management
- Marine engineering and works

Under the Marine Advisory Committee, all work related to the implementation of MGDI is coordinated through a Geospatial Projects Integration Office, administered by DFO, and funded jointly by DFO, CCMC and Geoconnections. Dave Pugh (DFO) has been assigned to this office and his contribution has already been significant. The main objective of the Geospatial Projects Integration Office is to ensure that a common integrated infrastructure serving all identified stakeholders in the Marine Sector is developed and integrated.

As Co-Chairs, we would like to acknowledge the support of the Assistant Deputy Minister Science, DFO, and her Departmental Management Committee colleagues. This initiative would not exist without their support as well as the support received from the GeoConnections program of NRCan. Finally, we would also like to acknowledge all government, industry and academic stakeholders for their involvement as we look forward to making the MGDI challenge a reality.

Michel Poulin
Director
Canadian Hydrographic Service
Department of Fisheries and Oceans

Randy Gillespie
Vice President
Canadian Centre for Marine Communications

Executive Summary

Efforts are now underway in many jurisdictions to implement the technological and policy framework required to facilitate access to geospatial data and information. In Canada, government and industry are collaborating in the development of a Canadian Geospatial Data Infrastructure (CGDI) through a national program called GeoConnections. As partners in this initiative, key agencies with an interest in the marine and fresh water areas are leading the development and implementation of a Marine Geospatial Data Infrastructure (MGDI). The essence of the MGDI Initiative is to manage marine databases and disseminate marine data as well as the information obtained from them to all users in a timely and cost effective manner

The marine and freshwater user needs for geospatial data were determined from a series of eight workshops held in various regions of Canada from Clarenville to Victoria. The workshops were focused on the various data collectors, managers, decision makers and users in the marine sector from fishermen to shipbuilders to ocean scientists to habitat managers and included the private, the public and the academic communities. As a result of these workshops, a broad cross-section of the community was given the opportunity to participate in the development of a shared national vision for the MGDI.

Because of the great diversity of Canada's aquatic areas, the datasets that describe this region are often very large and combine aspects of temporal as well as spatial variability. Furthermore, since groups normally gather data for their own purposes or the purpose of a distinct community, the different datasets tend to have different structures, application environments and policies for distribution. A goal of the MGDI initiative is to provide some order to these data by advocating common standards and policies for acquisition, storage, management, distribution, archiving and maintenance. It is, in fact, an overarching initiative that will provide an information infrastructure, encourage common data, database, and information protocols, and facilitate third party access under controlled conditions.

While the workshops identified distinct user needs for much of the data being collected, it was equally evident that there were many common requirements. One of the main ones is that the majority of users want information rather than raw data. In addition, there are a number of foundation or framework datasets that are needed to support virtually all spatial information needs and applications in the marine and freshwater sector. The most essential of these is water depths. In all the workshops, the need for one-stop-shopping with an intuitive search engine to speed up accessing the infrastructure was viewed as being very important. As well, in virtually all the workshops, a seamless land and water digital elevation model for all Canada's lands was seen as an important need. Other common user needs were on the requirements for standardized formats and workable policies on data, database and information ownership, licensing, access, copyright, pricing, cost recovery, partnerships, capacity building, data quality and timeliness of data. In addition, many of the workshop participants felt that a considerable amount of important data that were not accessible and needed by them existed in public sector databases.

With respect to specific user needs, one of the largest user groups, the Marine Transportation users, were very clear in specifying the requirement for strategic as well as operational information and the need for a visionary shift in the navigation process. This shift would go beyond the use of Electronic Chart Display and Information Systems (ECDIS) and migrate toward the implementation of a full Marine Electronic Highway.

Habitat managers stressed the importance of ensuring that the same information be available to all parties. The Coastal and Ocean Managers were one group who specified the need for real-time to near real-time raw data rather than processed data. For harvesting Non-renewable Resources, fishermen expressed the need for a two-way infrastructure so that data they collected could be used to improve the content of the databases and of the information infrastructure. There were several other unique needs expressed by the various user groups. It is felt, however, that those provided serve to indicate the nature of the specific user needs in terms of data and information and in terms of infrastructure.

While users of geospatial data and information expressed much interest and importance in the MGDI initiative, challenges to the success of MGDI were also noted. These challenges concern the obtaining of satisfactory solutions to many of the user needs as well as developing viable partnership models for prototype projects and developing a level of confidence in the user community to sustain MGDI during its formative years.

Much of the success of the MGDI initiative to date has occurred through the strong support provided by the Geoconnections Program, the support provided by the Department of Fisheries and Oceans, the continuing work of the Marine Advisory Committee and the interest and energy displayed by the user community.

Purpose

The purpose of this report is to provide a summary of the marine user requirements for geospatial data and for a coordinated Marine Geospatial Data Infrastructure[1] (MGDI)[2]. These user requirements have been obtained through a series of workshops held in eight locations across Canada[3] involving stakeholders from industry, government and academia.

Geospatial data are defined as data entries where position is geographically referenced to the earth. In the marine environment, the temporal aspects of geospatial data are also important.

Background

Since the beginning of time, populations have tended to migrate towards coastal areas. The earliest civilization is believed to have started in a coastal area and well over half the world's population now lives within 60 kilometres of the coast. In these areas, the increased demand on aquatic and terrestrial resources and the conflicts among the many users has increased global awareness of the need to preserve and protect coastal as well as offshore marine environments. Concomitantly, populations have continued to harvest the renewable and non-renewable resources in these regions often to the point of depletion or extinction.

A geospatial data infrastructure encompasses all of the data sources, systems, network linkages, standards and institutional policies required to deliver geospatial data and information from many different sources to the widest possible group of potential users. McLaughlin J. and D. Coleman, 1999, Geomatics in the New Millennium: Framing a New Agenda http:/www.geomatics.org/ Report/techreport2/html

Bordered by three oceans, and with its large areas of fresh water, Canada not only has a coastline longer than any other nation but Canadians are stewards to nine percent of the world's renewable freshwater supply[4]. While we as Canadians stand to reap the benefits of our vast coastal and offshore resources, we must be forever mindful of our stewardship role in protecting and safeguarding these resources for future generations. We have a responsibility to become leaders in addressing the numerous coastal, inland water, and ocean management issues facing our aquatic regions. These issues can only be addressed and resolved in a timely and forthright manner by having a full understanding of the processes that control these environments and this requires accurate and timely data. The essence of the MGDI Initiative is to co-ordinate,

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[1] The title Marine Geospatial Data Infrastructure does not clearly define the nature of this report as the user requirements being described include the data and information requirements for both marine and fresh water areas. In reality the report deals with all aquatic users of Geospatial data for all of Canada's submerged landmass.

[2] Appendix B contains a list of the acronyms contained in the report.

[3] Detailed information on workshops provided on website http://www.geoconnections.org

[4] The Green Lane™, Environment Canada's World Wide Web Site, http://www.ec.gc.ca

manage and disseminate these data through an integrated geospatial infrastructure and make the information obtained available to all users in a timely and cost effective manner.

Understanding and proper management of the marine environment is essential for its sustainable use and development. Canadians tend to see their nation only as those areas that are above water. Furthermore, while our knowledge of the terrestrial areas including our forests and agricultural areas is growing exponentially, we probably know as much about the surface of the moon as we do about our submerged landmass. The marine environment, not space, is our last frontier. Better understanding and knowledge of our marine environment will require a quantum leap in our ability to acquire, process and manage data for this region. While the social and economic contributions of the marine sector to modern life are recognized as being significant, one could go further and say with veracity that the health of the oceans is indeed directly related to the very sustainability of human life on our planet. The MGDI initiative is a significant new thrust that will play a large part in the making of informed decisions in this important sector.

Canada's continental shelf covering 3.7 million square kilometres, is the second largest of any country in the world, and its marine ecosystems are host to a remarkable diversity of species, including commercial and non-commercial fishes, marine mammals, invertebrates, seabirds and plants.

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The Marine Advisory Network node has a Marine Advisory Committee[5] with membership representing the various stakeholders in the sector. The mandate or mission of the Marine Advisory Committee is to ensure that the full functionality of the CGDI being implemented under the GeoConnections Program extends to, and serves the interests of all marine stakeholders.

Under the Marine Advisory Committee, all work related to the implementation of MGDI is coordinated through a Geospatial Projects Integration Office administered by DFO. The main objective of this office is to ensure that a common integrated infrastructure serving all identified stakeholders in the Marine Sector is developed and integrated.

The Marine Geospatial Data Infrastructure

Infrastructure Concepts

An integrated view of MGDI is shown as Figure 1. Some of the key characteristics

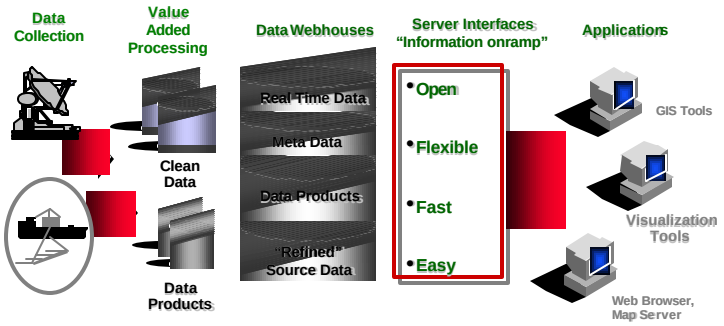

Figure 1 Integrated View of the Marine Geospatial Data Infrastructure (Adapted from Kucera and Keighan, 1998)

of a solid information infrastructure are as follows:

- Good infrastructure is based on common standards. Common standards ensure that component technologies work together. In other words, the technologies are interoperable.
- Wide area networking ensures that the infrastructure reaches a broad audience. Telecommunications and information technology for networking distributed databases is highly evolved (in large part due to recent growth of the Internet and World Wide Web)

MGDI represents a spatial and temporal data infrastructure comprising a system of data and enabling policies and technologies that are critical to sustainable development, management and control of national marine, coastal and freshwater areas.

The MGDI concept is not new. Neil Anderson in 1989 pointed out that environmentally sustainable marine resource development, whether for sustainable fisheries, integrated coastal zone management, or non-renewable resource development, is an interdisciplinary process that depends on access to data from multiple sources. Anderson, N.M.,1989, ICOIN Infrastructure, In ICOIN Forum Proceedings, Fredericton NB, June 13-14, pp.4-17.

[5] *Membership on the Marine Advisory Committee is provided in Appendix A.*

and is relatively well developed for offshore areas in Canada and other parts of the world. It must be recognized that the Internet in particular is a 'transformative' (revolutionary, not evolutionary) technology. As such, one cannot begin to predict its full impact over time.

- Good infrastructure is invisible to the users. If we consider the telecommunications industry as an example, users of telephones do not see, nor do they need to concern themselves with how the infrastructure works. It just does.
- Good infrastructure enables simple, third party access**.** Users require simple access if infrastructure of any kind is to be useful and used. Making existing geospatial databases available on the Internet does not necessarily make them usable for the non-expert. Various application server solutions are required to handle data conversions and datum transformations and to make these complexities transparent to the users. These infrastructure tools must, in particular, make spatial data and information visual. This is how the infrastructure will enable us to move from ecosystem models to economic models to management decisions.
- Good infrastructure is affordable. By serving a broad base of users, infrastructure becomes affordable for each. As such, one of the primary objectives of MGDI will be to break down the present barriers among the various data/information silos. This means that a considerable amount of development work will need to be done in advance of the time when the infrastructure is fully functional and self-sustaining.

Good infrastructure is invisible to the users. They do not see, nor do they need to concern themselves with how the infrastructure works. It just does.

Data and Information Elements

For each sector of the marine community there is a distinct user group, often but not always with unique data and information requirements. Many users and groups of users will have particular requirements with respect to mode of access and the type of information required. Implementation of MGDI must be sensitive to the information needs of the community as a whole as well as to the needs of unique user groups if it is to be a useful and affordable infrastructure. If it is not useful and affordable, then it will not be sustainable.

"Almost everything that happens happens somewhere. Knowing where something happens is critically important if we are to associate happenings and establish causal links."
David Pugh, CHS

There are certain databases that can be considered as foundation or framework databases that are needed to support virtually all spatial information needs and applications in the marine sector. Water depths represent one such framework dataset or geospatial foundation upon which other data and information layers can be built. Other marine and fresh water framework data may include navigation aids, administrative data and land ownership boundaries. These framework databases will form the foundation to be combined with various thematic datasets in the formation of a geospatial data infrastructure.

The marine environment is a dynamic environment that demands a constant stream of new data and information. As such, implementation of cost effective data acquisition technologies, methodologies and processes will be required to measure, record and quantify pertinent sea surface, water column, seabed and sub-bottom parameters at scales and resolutions which are appropriate to key marine stakeholders.

The datasets that describe the aquatic environment can be very large and combine aspects of both temporal and spatial variability. In addition, these datasets are typically collected and disseminated by different stakeholders for differing purposes, and therefore tend to be physically disparate with differing data structures, application environments and policies for distribution and use. Advanced data management technologies, methodologies and processes will be required to validate, store, retrieve, manipulate, co-ordinate and up-date multi-dimensional geospatial databases.

In many cases, because of the dynamic nature of the ocean environment, data or information that is more than a few hours old is of limited value, e.g. iceberg drift, current speed and direction or marine weather conditions. This places severe demands on the dissemination of, and access to, these data and the resulting information. Applications of the latest information technologies that capitalize on opportunities for simultaneous, integrated access to data and metadata[6] are paramount to real-time or near real-time access to data and information in the marine environment.

[6] *Metadata are defined as data about data elements including their data descriptions and data about data ownership, access paths, access rights and data volatility.*

Any functioning infrastructure needs to be based on an appropriate set of policies governing its use, and a common set of standards that ensure the interoperability necessary to enable widespread use and simple third party access. It is important that policies and standards implemented for CGDI take into account the user communities represented by MGDI. These include policies governing intellectual property rights, copyright, liability, licensing and pricing.

User training will be required to ensure that all prospective users are aware of, and able to use MGDI. In addition, it is recognized that many marine users will be pressed into service to ensure a high quality data stream for MGDI and that many users will require training in data collection and quality control protocols. While this may represent some initial problems for potential users, the Sentinel Fishery has clearly demonstrated that scientists and fishermen can work together to their mutual benefit.

The Sentinel Fishery initiative on the East Coast of Canada has demonstrated that fishermen can be trained to work alongside scientists to make valuable contributions to the understanding and sustainable management of the resource.

One of the more complex issues will be the implementation of MGDI as a model for cooperation among government, technology (infrastructure) providers, users and others. A public/private partnership approach could be considered as one means of implementing and operating MGDI through a well defined business arrangement between government and the technology industry to produce, market and distribute data through a common information network operated and managed as either a crown corporation or private sector entity. The result would be one or more information utilities providing infrastructure, data and information services not unlike other utilities such as the Telecommunications Utilities.

User Groups

Marine Transportation

MGDI must deliver the right information to the right user at the right time for the right price. Capt. John Pace (per. comm. 2000).

Marine transportation along with shipbuilding and ports and harbours operations is presently one of the world's largest industries. There are more than 46,000 commercial vessels of 100 tonnes or more in the world's cargo fleet and in 1995, foreign trading by sea was valued at more than $US 600 billion[7]. There are 1200 vessels in the Canadian merchant fleet with another 22,000 coastal and inland

[7] *Sea Technology, October 1998*

commercial vessels operating in Canadian waters. Canadians also take to the water in more than two million pleasure craft[8]. Competition from other modes of transport has created a trend towards larger and faster vessels increasing the requirement for greater stress on operational safety and environmental protection. This in turn demands that marine transportation be managed in an integrated manner from planning through to delivery. This integrated approach is much enhanced through the sharing of common datasets that are accurate and are supported by a common data infrastructure. While Electronic Chart Display and Information Systems (ECDIS), Global Positioning Systems (GPS) and Automatic Identification Systems (AIS) have been in use on Canadian merchant vessels for some time, a visionary approach that is being contemplated would see a Marine Electronic Highway (MEH) created to encompass the systems, equipment, information, people and processes required to make all the decisions that have an impact on marine transportation. This includes decisions related to safe, efficient, and environmentally sound navigation of vessels. Decisions related to the efficient management of the vessels themselves include their crews, and decisions required for expeditious and efficient transport and transfer of the ship's cargo and passengers[9].

Marine Habitat Management

The conservation and protection of marine habitat is frequently the object of impact assessments in terms of proposed use for public or private sector interests. Addressing the cumulative loss of marine habitat over time, establishing gain/loss budgets, monitoring, and where necessary restoring critical habitat, are all areas of increased effort. Reviewing developers project proposals and advising proponents on mitigation measures to avoid destruction of habitat are roles that legislators must manage. Sound and balanced decisions on conservation, protection and sustainability require a reliable and credible foundation of scientific knowledge that must be available to decision makers and developers in a meaningful and timely manner and in a format that is compatible to both parties.

"Canada is currently slowly losing fish habitat. The MGDI initiative is timely and needed not only as a means to gather data but to do the necessary monitoring to assess progress in redressing the situation. Patrice LeBlanc." Director Habitat Programs, DFO

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[8] *Fisheries and Oceans Canada. Canadian Hydrographic Service 2000-2001 Annual Report, p.2. web site www.charts.gc.ca*

[9] *Rick Bryant, Michael Casey and Antony Kasprzak. Maritime Magazine, October 2000, Vision for Electronic Navigation Technology and Proposed Plan. pp.34-40.*

Integrated Coastal Zone Management

Integrated coastal zone management requires an understanding of the interdependencies of a set of natural and human interactions. These interactions are complex and not easy for regulators and stakeholders to understand or incorporate into existing regulatory frameworks. The diversity of conflicts, some terrestrial and some marine, compounds the issue.

"Geospatial data and associated information technologies represent the technological nexus of the biophysical and social sciences applied to integrated coastal management." Bruce Hatcher, Halifax MGDI Workshop, April 2000.

An integrated approach to coastal management would attempt to harmonize economic, social and environmental objectives, similar to the better-developed land use management frameworks in urban areas. Data and information, coupled with a strong infrastructure, is key to integrated planning and to build the necessary consensus on sustainability of coastal environments. Increases in sea level and changes in the intensity and pattern of storms related to global warming are likely to increase the risk and pattern of coastal flooding. As such, integrated scientific (prognostic and predictive) and socio-economic models are needed as a basis for planning future coastal zone developments.

Renewable Resources and Biodiversity

Ocean based activities now generate nearly $20 billion in annual economic activity, which is important to the national income and even more to the approximately seven million Canadians living in coastal communities. Where once, Canada's oceans were the exclusive domain of commercial fishing and marine transportation industries, there is now a wide array of new ocean activities including offshore oil and gas, aquaculture, ecotourism, recreational fishing, cruise shipping and recreational boating[10].

Marine life is governed by complex biological, chemical and physical interactions in the oceans and fresh water. The exploitation of living marine resources is placing stresses on biodiversity and habitat that must be managed in order to ensure availability for generations to come. Measuring and understanding the environmental parameters, the size and characteristics of the biomass and the interactions between natural and human activities, allocating resources and monitoring harvesting activities and capacities are challenges facing fishermen and resource managers alike.

[10] *Fisheries and Oceans Canada, 2001-2002 Estimates, Part III, p. 12.*

The size of our oceans, the dynamics of ocean phenomena, trans-boundary impacts and the simple fact that the resources are not easily seen or touched make geospatial data and infrastructure the essential drivers to support better decision making by both regulators and those who harvest the resources.

Non-renewable Resources

Offshore oil and gas provides 25% of the world's oil and gas production, and accounts for about the same proportion of known reserves[11] and the value of crude oil and gas produced from offshore wells exceeds $US 9 billion annually[12]. The present trend in offshore oil and gas exploitation is towards development of reserves in deeper water, and at greater depths below the seabed. On Canada's East Coast, ice and icebergs present particular problems both in terms of offshore operations and in the placement and protection of seabed structures.

Operational oceanographic information is needed to satisfy the need for improved marine environmental management in support of offshore exploration and production. This includes improved ocean models and ocean-atmosphere models for climate forecasting. High-resolution seabed mapping is required to support exploration and site development planning. Improved understanding of geotechnical characteristics of the seabed is critical to optimally position offshore production facilities.

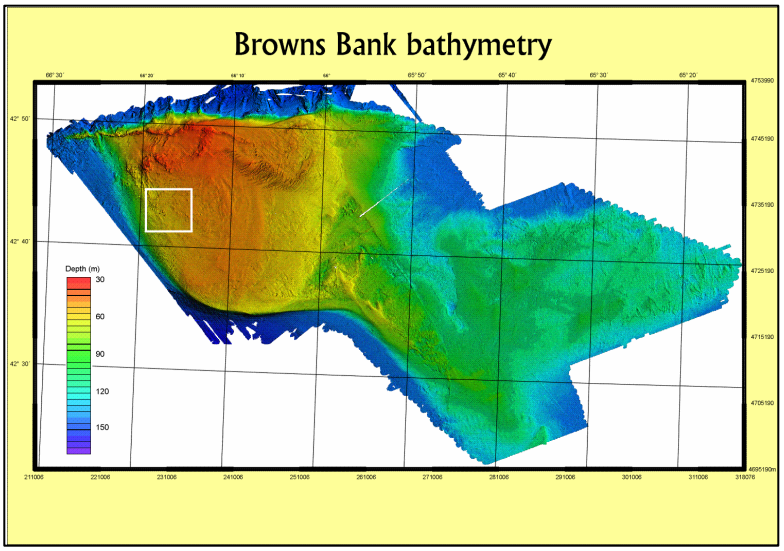

Figure 2 Multibeam Image

[11] *Marine Foresight Panel, UK, 1997.*
[12] *Sea Technology Magazine, October 1998.*

In addition to offshore oil and gas, sand and gravel and many strategic minerals (gold, diamonds, platinum, copper, zinc, silver deposited as placers or around hydrothermal vents) are gaining in importance and commercial viability.

Disaster Management/Emergency Response

Heavy precipitation, icing, gale to hurricane force winds, waves, storm surges and flooding are among the extreme events that can result in injury or death and significant damage to property in coastal and offshore environments. When such disasters strike, there is no more hostile or lonely environment on earth. Furthermore, damage to ships at sea (particularly those transporting bulk hydrocarbons, drill rigs or production facilities) can result in significant and widespread detrimental impacts on the environment. Preventive measures and timely response is critical to mitigating such impacts. Various geomatics technologies offer the potential to provide early signals and improve emergency response to lessen the impact of such events through rapid identification of potentially impacted areas and preparation of appropriate planning, protection and response measures. High resolution, seamless coastal digital elevation models, advanced drift prediction models and decision support systems are all key components to effectively anticipate, respond to and mitigate coastal and ocean emergencies.

Sovereignty and Defence

Canada is a maritime nation that owes much of its security and prosperity to its use of the oceans for commerce and national security. Canada spends in excess of $2.2 billion annually on Maritime Command operations by the Department of National Defence alone. In addition, Fisheries and Oceans Canada spends several million each year on maritime surveillance.

The United Nations Convention on the Law of the Sea (UNCLOS) created a framework of international agreements that are designed to protect ocean access, maintain the environmental quality of the oceans and guard against inappropriate exploitation of marine resources. As Canada implements its new Oceans Act, pressure will increase to prepare a submission to the Commission on the Limits of the Continental Shelf (CLCS) of UNCLOS to claim oceanic territories beyond the 200 nautical miles Exclusive Economic Zone. Declaration and implementation

of sovereign rights over this territory is spurred not only by the need to exploit economic opportunities but also by the need to manage and protect marine resources for future generations.

Conservation and protection of Canada's offshore areas will depend in large part on the use of geomatics tools and technologies to map and monitor this vast area. Satellite, airborne, land based and shipboard sensors, many of them new, will be required to feed an advanced, multi-jurisdictional information management and decision support system.

Ocean Research

In addition to being a significant source of protein, the oceans act as a natural sink for carbon dioxide and play a significant role in influencing global climate. As such, reducing the uncertainty in understanding and monitoring the state of the oceans can assist in preventing both social and economic impacts and devising adaptive strategies to cope with the impacts of climate change. Increases in sea level and changes in the intensity and pattern of storms related to global warming will increase the risk and pattern of coastal erosion and flooding, and adversely impact the operation of ships and other structures at sea. Other ocean phenomena, such as El Nino, have also been demonstrated to have a profound effect on weather patterns impacting the livelihood of coastal communities and the health of many fish stocks.

It is estimated that only 5% of the oceans' volume has been examined in spite of the fact that the oceans provide 95% of the habitat available to biological communities on this planet. Sage, L.E. and C. Levi. Beaming Studies of Ocean Frontiers to a Technological Audience. MTS Journal, Vol. 35, No. 1, pp. 10-17.

Changes in ocean circulation, sea level and the pattern of weather systems are some of the areas requiring scientific investigation and technological innovation. Enhancing ocean observation capabilities, refining ocean components of coupled ocean/atmosphere circulation models, strengthening regional climate models and developing better operational ocean forecast methods are challenges to be addressed in understanding the impact of the world's oceans on climate, and vice versa.

Recreation and Tourism

Of all of the activities that take place in coastal and ocean areas, none is increasing in volume and diversity more than tourism and recreation. Clean water, healthy coastal habitats, bountiful living resources and a safe, secure and enjoyable environment are all fundamental to marine

tourism. Security from risks associated with natural hazards such as wind, waves and strong currents created by storms is required if coastal tourism is to be safe. Geospatial data and information can contribute to the sustainable development of coastal tourism by assisting with proper siting of coastal and marine structures and public access, habitat management and coastal monitoring

Freshwater Resource Management

Water management is a social, political and trade issue. What is missing at present is the knowledge of how to best use information technologies to derive and shape community policy and assist water resource management decision makers in balancing resource management against the social and economic needs of a sustainable community. A key issue in this regard is related to information management and access. The perception in this field, as in others, is that there are a lot of data and information in public sector databases that should be more readily available to the general public. This is one of the primary drivers behind the GeoConnections Program and the MGDI initiative.

"Fresh water is the oil of the future, with one important exception – it can be used and reused." Statement by a workshop participant.

Marine Engineering Works and Services

Marine engineering works and service is an important part of the marine transportation network in any maritime nation. On 19 June 2001, the Minister of Industry unveiled the new Shipbuilding and Industrial Marine Industries Policy[13], and the Policy framework. The policy framework focuses on opportunities, growth and innovation in niche markets where Canada can compete with emphasis on capturing domestic markets, looking globally, innovation as key to competitiveness, financing and stronger partnerships. In addition to shipbuilding and port infrastructure, this user group includes buoy technology, marine materials, marine towing and salvage, diving technology and coastal and offshore structures including the mechanical properties of seafloor materials.

Summary of User Needs

Eight workshops were held throughout Canada to obtain the user requirements. The workshops were held in Clarenville, Dartmouth, Halifax, Montreal, Ottawa, Toronto, Vancouver

[13] http://www.info.ic.gc.ca

and Victoria. All workshops were facilitated by representatives of the Marine Advisory Committee and had three main objectives. The first objective was to provide the user community in each market segment with background information concerning CGDI, MGDI and the GeoConnections Program. The second objective was to identify the similarities in user needs and the third objective was to gain a better understanding of ongoing information access/management needs and to solicit user feedback on how to proceed with the development and implementation of a data infrastructure. Because of the manner in which the workshops were structured, these needs not only reflect needs from the various sectors but also reflect the different requirements in the different geographic areas.

Participants in the workshops had various backgrounds from commercial mariners to fishermen to consultants in the marine field to industry leaders to government and university marine scientists to hydrographers to hardware and software suppliers. Some of the **common themes**[14] that emerged from the workshops are as follows:

- Users for the most part want information not data.
- There is a need for One Stop Shopping or single portal availability to satisfy data needs in each marine sector. This should incorporate an intuitive search engine for finding data and data sources and metadata to indicate quality and coverage as well as the source of the data.
- Many marine users want a two-way infrastructure whereby they can contribute valuable data and need the infrastructure to aggregate data from various sources and feed information back to them.
- In all sectors, strategic as well as operational information is required.
- Data requirements are global. Users felt that if the MGDI initiative deals only with data in the Canadian context, it will not likely be sustained in the longer term.
- Users at virtually all the workshops listed access to water depth information as a basic foundation database requirement.
- Users stressed the need to be able to access collected data and information. There was a general feeling

MGDI should not only facilitate access to data, but should also enable the conversion of data into information and information into knowledge. This is where the real value of MGDI will be realized.

[14] *Detailed information on specific user needs may be obtained by consulting the website at www.mgdi.ca*

that a considerable amount of data has been collected in various formats and these data reside in government laboratories and are not accessible to potential users.

- Data ownership, licensing, policy and cost recovery issues were recognized as issues that need to be resolved. These issues, not technology, are the more difficult barriers to the success of MGDI.
- Standardized formats in terms of databases, data transfer and data query are needed. Interoperability is critical and users should be able to use their own hardware and software to access and use the infrastructure.
- All datasets should carry date stamps, as users indicated that times of collection are an important factor.
- Users need to know if there are data quality issues in the information being accessed. If there are, then the infrastructure should deal with these issues.
- In virtually all the workshops, the need was identified for a seamless land and water digital elevation model for all of Canada's lands.
- The real value of the MGDI initiative will be in providing access to useful information for making decisions.

Some of the **specific user needs** and comments from the various workshops are as follows:

For efficient **Marine Transportation,** strategic information is required about the global marine environment as well as operational information on what a Ship Master may expect to encounter in minutes, hours and days. The more immediate information concerns issues such as vessel traffic, weather, and hydrographic data including chart and tidal information. Users felt that MGDI holds the potential to enable a fundamental shift in the navigation process. In the early stages, MGDI could open up the mariner to more complete information about the operational environment. As an example, often the mariner must stay within fairly restricted navigation channels because the necessary information does not exist to navigate outside these channels. Additional information such as total bottom coverage would give the mariner a choice, most important when operating in inclement weather and in restricted waters where there may be heavy traffic.

Many mariners felt the electronic chart systems are rapidly becoming the nerve centre of the modern ship at sea. Their vision is that it should be possible to view everything from the status of ship's systems to the location of neighbouring vessels in real-time through a single portal. They stressed the importance of MGDI linking with ongoing projects such as the Integrated Navigation Information System (INNAV), the Integrated Marine Information Infrastructure (IMII) and the Ocean Portal and the Marine Services Portal. Cooperative and coordinate ventures with these agencies could lead the way to the adoption of a more aggressive role in supporting the Marine Electronic Highway concept.

A portal is defined as an enabling agent to facilitate the inclusion of geospatial content and geospatial services to a community.

The **Habitat Management** Program deals with the conservation and protection of fish habitat in Canada's fresh and marine areas and the carrying out of environmental assessment of development proposals requiring regulatory decisions. The most important data requirements include data on sediment characteristics, floral and faunal assemblages, water temperatures, nutrient and pollution distributions, watershed and catchment basin boundaries, water column chemistry and traditional ecological knowledge. Effective habitat management requires considerable information on the environment and one important criterion is that the same information is available to the developer as to the assessor.

Aquatic species in North America are estimated to be disappearing at a rate five times faster than their land-based counterparts. Already in this century, 123 freshwater species have become extinct and the Committee on the Status of Endangered Species (COSEWIC) has listed 65 different fish species as either being endangered, threatened, or vulnerable.

The workshops clearly identified that the needs for **Integrated Coastal and Ocean Management** include metadata availability (online, searchable, hierarchical meta databases). In this instance, the need was expressed for comprehensiveness and flexibility versus focus and simplicity in spatial data (unprocessed vs. processed satellite images; hyperspectral versus multispectral; numerical tables versus text summaries). Users also requested real-time to near real-time access to satellite imagery fast enough to predict changes in the marine community function. Furthermore, the need was expressed for hierarchical datasets derived from multiple sensors and sources

To harvest the **Renewable Resources** and to manage **Biodiversity**, fishermen and fisheries managers need real-time spatiotemporal data and information. In many cases, data that are more than a couple of hours old are useless for anything other than trend analyses. More data from more

collection points are required and these data must provide timely information as the fishery unfolds. The infrastructure should be two-way, as fishermen want to be both collectors and users of data. It should also be concise, broad-band, easy to understand and able to aggregate data into information products.

Fishermen at the Clarenville workshop were of the opinion that there are a lot of data being collected by DFO that are not being made available. The clear message was: "We need to use the data we already have."

Fishermen stressed the importance of obtaining high-resolution bathymetric data as well as the standard datasets that include water temperature and salinity, weather information on the fishery being harvested as well as on other fisheries in the area.

For **Non-renewable Resources**, there is an increasing awareness that a spatial database infrastructure such as MGDI would be useful in accessing data and information on a wider range of operational issues such as iceberg management, wind and wave regimes, and other data that are time sensitive. Barriers to access because data are proprietary, lack of clear public policy on data, cost of satellite data and lack of accepted standards were cited as issues that need to be addressed.

"The objective of any good management strategy should be to increase the quality and accessibility of data while decreasing data volumes and management costs." E.Togood, Norwegian Petroleum Directorate.

Disaster Management/Emergency Response needs include ready access to information on extreme precipitation, icing, gale to hurricane force winds, waves, storm surges and flooding.

Sovereignty and Defence needs are for standard oceanographic and hydrographic data as well as weather information. In addition, for tactical reasons, there is often the requirement for specialized acoustic datasets and total seafloor surveys especially on main vessel routes, in turning basins and in mooring areas.

Ocean Management and Research workers are collectors and users of data. These data are often for specific research projects and the databases are normally made available either at no cost or at the cost of processing. The data needs are varied with the requirement normally for large datasets.

Recreation and Tourism interests need many standard datasets at large scales. With the use of over two million pleasure craft, mainly operating in shallow water, accurate hydrographic data are essential. Environmental and cultural information is also necessary. For both the operators of

facilities and for who are users or potential users, a sound infrastructure is a necessary ingredient for management and access.

Freshwater Resource Management requires up to date information on topography, hydrology, soils, vegetation cover, administrative boundaries, and civic infrastructure. It was the opinion of participants at the water resource management workshop that it is the responsibility of the private sector to develop and implement data standards.

"The MGDI infrastructure needs to stress the requirement for policies to manage water as a resource and as a commodity." Comment by a workshop participant.

The data and information needs for **Marine Engineering Works and Services** consist of the standard datasets such as bathymetry and navigation aids, environmental information and detailed information on the foreshore and tidal zone. In addition, information on the geotechnical properties of the material on which structures are to be installed is essential.

Challenges

The following are seen as some of the challenges to the success of MGDI:

- Copyright, ownership, entitlement, intellectual property rights, proprietary formats and licensing are policy issues that need to be resolved.
- There are currently levels of diversity in the data collection process and in the existing databases in terms of data quality. Whilst these issues cannot readily be resolved, they should be understood.
- Pricing and cost recovery need to be addressed.
- Telecommunications facilities will have to be improved in order to provide sufficient bandwidth to transmit and download the large amounts of data in a reasonable time as well as ensuring the security of databases and of the infrastructure.
- Capacity building (training) will be needed to create demand for MGDI and to create the capacity to use MGDI to the fullest. A level of confidence will have to be built to ensure that potential users are not dissatisfied. This will require clear communications and resounding success with pilot projects.
- It will be necessary to carry out prototype projects under strict guidelines to test the MGDI initiative.
- Partnerships will need to be put in place during the pilot projects to demonstrate the effectiveness and

efficiency of the MGDI concept. Effective partnerships will require clear partnership guidelines, sources of leveraged funding, champions and implementation on a project-by-project basis.

Appendix A

Membership Marine Advisory Committee

Randy Gillespie, Canadian Centre for Marine Communications (CCMC) (Co-Chair)
Michel Poulin, Canadian Hydrographic Service (CHS) (Co-Chair)
Paul Bellemare, CHS Québec Region
Mike Butler, Atlantic Coastal Zone Information Steering Committee (ACZISC)
Andy Sherin, Natural Resources Canada (NRCan)
Anne O'Toole, Integrated Business Management Directorate, CCG/DFO
Dave Coleman, Geomatics for Informed Decisions (GEOIDE)
Ed Kennedy, Geomatics Industry Association of Canada (GIAC)
Ian Robertson, Institute for Pacific Ocean Science and Technology (IPOST)
Michel Mellinger, Information Interoperability Institute (III)
Lcdr. Ken Polson, Department of National Defence (DND)
Richard Worsfold, Centre for Research in Earth and Space Technology (CRESTech)
Tim Evangelatos, GeoConnections Secretariat

Appendix B
Listing of Acronyms

AIS	Automated Information System
CGDI	Canadian Geospatial Data Infrastructure
CCMC	Canadian Centre for Marine Communications
CHS	Canadian Hydrographic Service
COSEWIC	Committee on the Status of Endangered Species
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Nautical Chart
IMII	Integrated Marine Information Infrastructure
INNAV	Integrated Navigation Information System
MGDI	Marine Geospatial Data Infrastructure