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MGDI: An Information Infrastructure to Support Integrated Coastal Management in Canada

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ABSTRACT: *In order for data or information to be useful for coastal management, or any other application, it must be both comprehensive and accessible. A major challenge for anyone involved in the management of coastal areas is simple access to data and information in a timely fashion. The Marine Geospatial Data Infrastructure (MGDI) initiative is targeted specifically at this challenge. When implemented, MGDI will enable simple, third party access to data and information that, in turn, will facilitate more effective decision-making. However, it is true that the available data are often either not well suited for other applications (incompatibility of scale, projection, etc.), or have been stored in a format that is not easily accessed. Thus, when considering the implementation of an information infrastructure such as MGDI, these issues, along with issues of ownership, data quality, etc. must all be addressed. The concept of data and/or information as a commodity, and policies that will balance the rights of individuals to privacy and the rights of society to information must also be considered.*

Keywords: Coastal Management, MGDI, Decision-Making, Ownership, Data Quality Commodity, Policies, Rights of Society

INTRODUCTION

The coastal zone is a complex environment that includes both terrestrial and marine components. Datasets which describe this environment combine aspects of both spatial and temporal variability. Since these datasets are typically collected and used by different groups for various purposes, they tend to have different data structures, application environments and policies for distribution and use. Furthermore, while some datasets are relatively static (e.g., bathymetry, forest type, physical infrastructure), others are dynamic (e.g., waves, surface currents) and are

often required in 'real time' to be of value. As such, the technologies, methodologies, policies and the processes required to validate, process, store, retrieve, manipulate, disseminate, archive, maintain and visualize (use) coastal datasets all need to be carefully considered when establishing an information infrastructure such as MGDI.

MGDI CONCEPT

The Marine Geospatial Data Infrastructure (MGDI) concept is best described as a 'spatial data infrastructure' comprising a system of data/information products and enabling technologies that are critical to sustainable development and management of coastal, ocean and freshwater areas. According to Coleman and McLaughlin (1998), '(geo)spatial 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.

The MGDI concept is not new. In 1987, the Maritime Resource Management Service (MRMS) in Amherst, Nova Scotia, a former agency of the Council of Maritime Premiers, was contracted by the Canadian Department of Fisheries and Oceans (DFO) to prepare a discussion document on a marine and coastal information infrastructure, subsequently named the Inland waters, Coastal and Ocean Information Network (ICOIN) (Butler et al., 1988). Anderson (1989) pointed out that environmentally sustainable marine resource development, whether for sustainable fisheries, integrated coastal management (ICM), or non-renewable resource development, is an interdisciplinary process that depends on access to data and information from multiple sources. He went on to propose that ICOIN should be based on common standards, networking and simple third party access. Each database would reside with its proprietary agency, which would remain responsible for maintenance and quality control. Users would access these databases using a high speed, wide area network (WAN). This is consistent with the present vision for MGDI.

The basic building blocks for MGDI, particularly data and technology, already exist. However, only recently has it been feasible to consider combining these building blocks into a functioning information infrastructure that will serve the interests of a broad base of users.

THE NEED FOR MGDI

Canada's coastal zone represents an area of both economic and environmental importance. It is one of extremes:

- the World's longest coastline, 243,792 kilometres, contiguous with three oceans, the Atlantic, the Arctic and the Pacific:
- the largest offshore exclusive economic zone of 3.7 million square kilometres, equivalent to 37% of Canada's total landmass;
- the longest inland waterway, 3,700 kilometres from the Gulf of St. Lawrence to Lake Superior;
- the largest archipelago, Canada's Arctic islands covering 1.4 million square kilometres;
- the World's greatest tidal range, 16 metres in the Bay of Fundy; and
- the World's fastest tidal currents, 16 knots in Narwakto Rapids, British Columbia.

Approximately 7 million Canadians live in coastal areas. Activities in the coastal zone are not mutually exclusive, and are often in direct conflict with each other (e.g., coastal fisheries, urban development and tourism). Furthermore, coastal areas are regulated and influenced by federal (in Canada there are some 23 different federal departments and agencies), provincial and municipal governments, and are increasingly the focus of international conventions, for example, the United Nations Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. In response, Canada has prepared its National Programme of Action (NPA). Canada has fully one half of all the freshwater area in the world, all of which drains to the oceans (Dick Carson, DFO, pers. comm). Canada has recognized that decisions are required to protect our coastal and marine ecosystems and resources for both ourselves and for future generations. As such, the need for 'shared responsibility and integrated decision-making' has been clearly identified in several documents, including Canada's Oceans Act, and DFO's Strategic Plan, "Moving Forward with Confidence and Credibility" (March 2000). The Oceans Act has, at its heart, the principles of sustainable development, integrated management and precautionary approach.

Informed, integrated decision-making requires ready access to all relevant data and information available. For any given environmental impact assessment (EIA), 50% to 80% of the cost is directly related to gathering and organizing the relevant data and information for the area in question. Furthermore, tools are required to synthesize and correlate data and information from multiple sources into knowledge

regarding particular matters. “Lack of dissemination of knowledge is one of the major factors in the destruction of the coastal zone.” (Barthel and Lehfeldt, 2000). In Canada, governments, community groups, the private sector and universities all collect and maintain valuable databases in support of focused objectives related to social and economic development. However, these databases are invariably discipline specific, widely diverse in structure and location, often unknown outside the particular proprietary agency or group, often incomplete or of uncertain quality, and either unavailable to outside users (due to policies) or unusable (due to incompatible data formats or standards). This is because groups typically collect and maintain data to support their own specific disciplines or programs, with little or no consideration given to collecting, processing or managing data for use by other users. As such, available data are often inadequate for clear, rational decision-making which is both environmentally and economically sound. It has been difficult for the public to obtain a clear picture of the issues or for politicians and bureaucrats to make decisions that are in the best interests of both their constituents and the environment. Today, however, there is increasing recognition by the public at large of the need to support sustainable development of the coastal zone.

Baseline 2000 and the accompanying Canadian Synopsis documents prepared for the Coastal Zone Canada Association in support of the CZC (Coastal Zone Canada) 2000 Conference (17-22 September 2000), summarize the state-of-the-art of ICM globally and within Canada (CZC.

A NEW PROGRAM TO SUPPORT INFORMATION INFRASTRUCTURE

In Canada, the federal government, led by Natural Resources Canada, has launched the GeoConnections Program in response to these needs. The mandate of the GeoConnections Program is to:

- develop the Canadian Geospatial Data Infrastructure (CGDI), which will co-ordinate Canada’s numerous databases of geographic information and make them accessible through a common window on the Internet; and
- enable partnerships between federal, provincial and territorial governments, the private sector and the academic community.

The GeoConnections Program recognizes that many important technologies, standards, protocols and maintenance procedures are required to make geospatial information accessible, and to give Canadians a world-leading information

technology infrastructure. These requirements will be fulfilled through five policy thrusts:

- **Simple Access:** Making geospatial data accessible on the Internet so that businesses, governments and Canadians can find and download geospatial information on demand, 24 hours a day, 365 days a year.
- **Framework Data:** Establishing a framework of data that will make it easier to integrate information to speed decision-making and develop new information products.
- **Geospatial Standards:** Ensuring that information matches international standards, so that Canada can share information with other nations, and Canadian businesses can sell geospatial information technology and services in the global marketplace.
- **Partnerships:** Collaborating in partnership with various levels of government, the private sector and the academic community to capitalize on their collective expertise and to ensure seamless delivery of geospatial information.
- **Supportive Policy:** Developing supportive policy at all levels of government to accelerate private-sector commercialization of geospatial information, and to develop e-commerce, integrated technologies and services.

A Marine Advisory Committee was established in August 1999 with a mandate to: "ensure that the full functionality of the Canadian Geospatial Data Infrastructure (CGDI) being implemented under the GeoConnections Program extends to, and serves the interests of, all marine stakeholders." Reporting to the GeoConnections Management Board, the Marine Advisory Committee acts as the primary point of contact for input and feedback concerning the Canadian Geospatial Data Infrastructure (CGDI) and its relevance to the marine (including coastal) user communities. That component of CGDI which serves the marine and coastal communities has been termed the Marine Geospatial Data Infrastructure (MGDI). The reader is referred to the GeoConnections web site for more information about this program, CGDI and MGDI (http://www.geoconnections.org).

MGDI AS INFRASTRUCTURE

All good infrastructure possesses certain key characteristics:

Good infrastructure is based on common standards Recognized common standards ensure that component technologies work together and the infrastructure is transparent to the user. Spatial data infrastructure must be based on 'interoperability' (seamless databases and systems). International standards organizations are addressing the development of standards for both land-based and

marine-based spatial data and technologies. Probably the most advanced in this work in the marine sector is the International Hydrographic Organization (IHO) which has now adopted a global standard for electronic charts and chart systems that support safe navigation and operation in the marine environment. Electronic chart databases also provide the geospatial foundation for other marine environmental and operational data. However, at this point in time, not all of the questions relating to data standards, communication protocols, etc. required to implement MGDI have been addressed, and in many cases they have not even been asked. For coastal zone users, a big issue is the difference in standards between land and ocean data products. In many instances, these data products are incompatible in terms of scale, projection, datums and format.

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) and relatively well developed for offshore areas in Canada and other parts of the world. Proximity (VHF, UHF) and wide area (cellular, satcom) communication systems ensure moderate to broad band access by a wide range of marine users, extending the concept of the 'information highway' seaward to an 'information seaway', and thereby completing a truly global digital network. This is transforming how we see the world and provides the backbone for virtually instantaneous access to data and information.

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 will be required to handle data conversions, datum transformations, conflation, etc. 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. A paradox common to all infrastructure is that 'increasingly simple access demands increasingly complex infrastructure'. To understand this concept, one need only consider the present telecommunications infrastructure. It is relatively simple for anyone with a telephone to place a call to someone half way around the world. However, the infrastructure to support this is extremely complex.

Good infrastructure is 'invisible' to the user Or, at the very least, a part of the landscape that goes unnoticed. If we again consider the telecommunications example, users of the infrastructure do not see, nor do they need to concern themselves with how the infrastructure works. It just does.

Good infrastructure is affordable By serving a broad base of users, infrastructure becomes affordable. While MGDI will serve the needs of users in the coastal zone, it will also serve the needs of a wide range of other marine and terrestrial users. In order to accomplish this, MGDI will be a 'horizontal' initiative that will help to break down the barriers between data silos and vertically integrated management systems. In the beginning, data pricing and policy (and the related issues around copyright and intellectual property (IP) rights) will all be major issues. However, they are not insurmountable and have been resolved in other areas (e.g., telecom industry).

MGDI ARCHITECTURE

The delivery of digital geospatial information in an integrated network environment requires much more than just storage of the data itself. It requires careful definition and application of the following:

- a common spatial data model to ensure communication between software components;
- an integrated process and data modeling environment to ensure quick and clear communication between the stakeholders;
- a common spatial language and data exchange format to ensure open access to data;
- mechanisms for managing, querying, and delivering data to safeguard data integrity and guaranteed delivery; and
- open productivity tools to ensure access at all levels of public and government.

Some of these tools have been developed in Canada by the Mercator Alliance, a diverse group of researchers, businesses, and government agencies, formed to stimulate and coordinate the creation of a common spatio-temporal information management environment. Companies participating in the Mercator Alliance have also participated in the development of a suite of spatio-temporal information standards (International Standards Organization (ISO) SQLMM, and TC211), distributed database and warehousing technologies, spatial application servers, and application software. These technologies now represent the foundation of the

evolving integrated Canadian Geospatial Data Infrastructure (CGDI) and have been adopted by the Open GIS Consortium as well. In keeping with a philosophy of adapting existing technology and leveraging previous developments, these technologies can now be adapted to form the backbone of MGDI as shown in Figure 1.

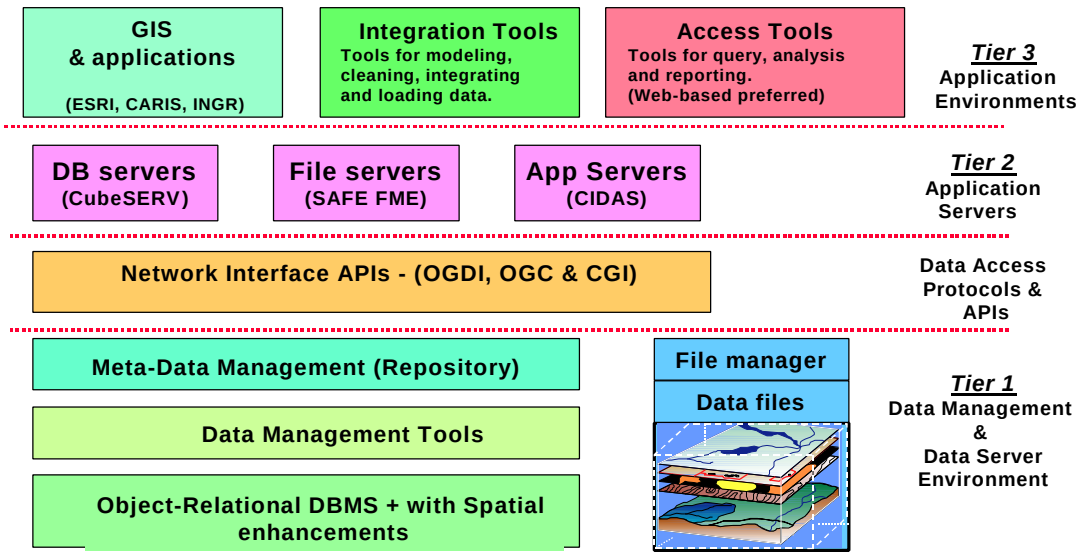

Figure 1. N-tier technology architecture for MGDI, including data servers (Tier 1), application servers (Tier 2) and applications (Tier 3) (from Kucera and Keighan, 1998)

The components of this n-tier architecture include:

- object-relational database management systems to manage the data warehouses. These systems must be flexible and extensible, and adhere to the international standards for managing geospatial information;
- data repository tools to manage meta-content holdings;
- Web interfaces and client tools as needed to test, browse, query and visualize data and information. Each system or tool must be capable of connectivity to other client agencies;
- application servers to manage and control, security, transactions, commercial access and input from remote real-time sensors;
- translation software for loading data from files into the DBMS, and for converting warehouse data into user formats;
- components to allow query access to diverse data holdings independent of hardware platform and data format; and
- spatial application development environments to facilitate the generation of new databases and client applications.

THE WAY FORWARD

“Data and information management are the ‘circulatory system’ in ICM” (J. Truscott, British Columbia Ministry of Fisheries, pers comm, 2000).

Sparse data leads to management by crisis. Managing commons, such as wild fish stocks or complex environments such as the coastal zone, means managing by partnership and consensus, which in turn requires comprehensive, conclusive, irrefutable and visual data and information.

Under current management regimes, coastal zone managers tend to get bogged down in mediation of short term conflicts. They are ill equipped to deal with the demands of diverse user groups and decision-making tends to be fragmented between government agencies, NGOs and others. Further compounding these matters is the tendency towards 'intergenerational amnesia' (M. Dunn, Wildlife Habitat Canada, pers. comm, 2000) which results in changing baselines over time and loss of knowledge that may reside only in the minds of key individuals. MGDI will help to resolve these issues. This infrastructure will enable a powerful information resource for managers in fields as varied as fisheries habitat management, pollution monitoring and control, shoreline erosion, weather forecasting and tourism development, etc. The information that can be derived from such a fully integrated information infrastructure will facilitate improved decision-making at all levels.

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