SEAMLESS SDI MODEL TO FACILITATE SPATIALLY ENABLED LAND-SEA INTERFACE

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ABSTRACT

The land-sea interface is one of the most complex areas of management in the world. The population along the coastline is continuously increasing and has done so dramatically in the past decade. This has brought with it an increased need to more effectively and efficiently manage this area to meet the economic, environmental and social outcomes of sustainable development.

In response to this situation, on land, Spatial Data Infrastructure (SDI) have been developed to create an environment that will enable users to access and retrieve complete and consistent spatial datasets in an easy and secure way. Within the marine environment tools such as marine cadastre can provide a means for delineating, managing and administering legally definable offshore boundaries, however there is still the need for an overarching spatial information platform to facilitate the use and administration of these tools in a holistic fashion. Currently, most of the SDI initiatives restrict their attention to the landward or seaward regions with little or no consideration of coastal zones. There is the growing and urgent need to create a seamless SDI model that bridges the gap between the terrestrial and marine environments, creating a spatially enabled land-sea interface to more effectively meet sustainable development objectives.

This paper aims to identify and discuss the main characteristics and criteria for utilisation of a "Seamless SDI model" and to examine the current barriers against implementation of this model. This would help to develop an extended framework to support a spatially enabled jurisdiction covering the land-sea interface. Ideally this extended framework would result in harmonised and universal access, sharing and integrating of coastal, marine and terrestrial spatial datasets across regions and disciplines.

BIOGRAPHY OF PRESENTER

Sheelan Sheikheslami vaez completed a Bachelor of Geomatics Engineering in 2004; she commenced her master degree in GIS at Melbourne University in July 2005 and she is currently a PhD student in the University of Melbourne under the ARC marine cadastre research grant with cooperation from Land Victoria, Geoscience Australia, Department of Land Administration WA, Department of Lands NSW and Land Information New Zealand.

INTRODUCTION

Humanity has always had a close relationship with marine and, especially, coastal environments. The coastal zone is a complex area, consisting of both the marine and terrestrial environments. It is also home to an increasing number of activities, rights and interests. According to the UN Atlas of oceans about two-thirds of the world's population live within 60 kilometres of the coast, and almost half of the world's cities with more than one million people are sited in and around washed river mouths and estuaries (UN 2006). Many nations are 'economically, politically and socially' dependant on the coastal zone. It is a resource provider and gateway to the worlds' oceans which humans rely on for food, raw materials, climate regulation, transportation, disposal of waste and recreation. Coastal economic potential includes shipping, oil and gas mining, fishing, aquaculture, and tourism. It has been suggested that "the coastal zone is not a narrow band. It's the whole country" (U.S. Commission on Ocean Policy 2002).

Despite its overwhelming importance to society, the coastal zone is a difficult geographical area to manage due to temporal issues (tides and seasons) and the overlapping of offshore, near-shore, shoreline and inshore physical geography, hydrography and bathymetry, as well as jurisdictional and organisational overlaps (Longhorn 2004). Typically, many different local, national and regional government agencies are responsible for different aspects of the same physical areas and different uses of the coastal zone, e.g. fisheries, environment, agriculture, transport (inland and marine), urban planning and cadastre, national mapping agency and the hydrographic service.

Clearly appropriate management of these areas is required. In this regard, improvement of models for sustainable coastal development has been the focus of many international governmental organisations over the last decade. Multiple reports internationally have highlighted the need for better coordination and integration between and within levels of government to improve coastal zone management (Hudson & Smith 2002). In this respect, Coastal Zone Management (CZM) initiatives are turning to more integrated strategies worldwide, attempting to harmonise economic, social and environmental objectives, similar to the better-developed land use management frameworks of many urban areas. In coastal areas however, the diversity of interests, some terrestrial and some marine, compounds the issue. Integrated Coastal Zone Management (ICZM) recognises that the coastal resources management situation is unique; that is, it differs greatly from management of either land or water resources, being a combination of both (Bartlett *et al*. 2004).

Worldwide countries are realising the need to balance development and exploitation of resources in the coastal zone with environmental and social needs. It has been established that access to spatial data aids in decision making for management and administration. Tools and systems such as the cadastre and spatial data infrastructure (SDI) have been developed that allow access and sharing of spatial data. Many countries are implementing these tools at national, state and local levels (Strain *et al*. 2004). Most, if not all of these SDI initiatives have restricted their attention to landward regions. In the ocean environment, many elements of SDI for marine data exchange have been developed by the Intergovernmental Oceanographic Commission (Longhorn 2002, 2003). To achieve the required sharing and integration of coastal databases across regions and disciplines, and with oceanic and land-based spatial data, there is a growing and urgent need for the extension of existing SDIs to fully encompass the information needs of all coastal zone stakeholders. Ideally, this would permit harmonised and universal access to datasets from oceanic, coastal and land-based spatial data providers so that complex issues affecting the coastal zone can be properly and

efficiently addressed in many economic, environmental and policy areas (Bartlett *et al*. 2004).To improve management of the coastal zone, there needs to be access and interoperability of both marine and terrestrial spatial data. Interoperability is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units (OGC 2005).

With this in mind, this paper discusses coastal zone and spatial information management issues and the potential for adding a coastal dimension to an SDI to facilitate coastal zone management. It looks at the complexity and issues regarding management of the land-sea interface. It also examines different coastal/marine SDI worldwide and its required characteristics and finally discusses the need to develop a seamless SDI as an enabling platform to increase the efficiency and effectiveness of management across regions and disciplines.

COSTAL ZONE ISSUES

The coastal zone is one of the world's more hazardous regions in which to live and work. There is still a lack of understanding of the coastal environment. Land management systems deal with an environment that changes with timescales of thousands of years. Comparatively the marine environment is highly dynamic with processes such as tides and shoreline erosion needing much smaller timescales. The marine environment is also fluid and thus natural resources or features are more likely to move with time. These difficulties compound in the coastal zone, as it is both the on and offshore environments combined and interrelated.

Institutional Issues

The coastal zone is difficult to manage due to the fact that it is governed by a complex array of legislative and institutional arrangements from local to global scales. A coastal state may be a party to many international conventions (i.e. RAMSAR, MARPOL, and London Convention) in addition to developing its own national, and even state or local regulations. Activities and resources are usually managed in a sectoral and ad-hoc approach with legislations or policies created when the need arises and specific to only one area of interest (Strain *et al*. 2004). Furthermore, there is currently some confusion about the management of the land-sea interface, an example being in Australia where local governments manage land to High Water Mark (HWM), and state governments manage the marine environment from the Low Water Mark (LWM). This means that there are no overlapping arrangements in place to enable efficient coastal zone management. There is also a strip of land between the two boundaries which is not within a management jurisdiction at all (Binns & Williamson 2003).

There are also a large number of stakeholders with rights, interests, or responsibilities for management in the coastal zone. Binns (2004) states that there is often little cooperation or collaboration between these groups responsible for managing the same area offshore. To add to the complexity these rights and interests can often be overlapping and sometimes conflicting or competing for space. In coastal areas however, the diversity of interests, some terrestrial and some marine, compounds the issue. Integrated Coastal Zone Management (ICZM) recognises that the coastal resources management situation is unique; that is, it differs greatly from management of either land or water resources, being a combination of both.

Other issues also need to be taken into account, including the need for harmonised data access policies and exploitation rights for spatial information, particularly that collected by

public sector agencies across different nations and even within single governments (Bartlett *et al*. 2004). 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 (Gillespie *et al*. 2000). The result is that organisations working in the same country or in the same discipline collect similar data in different ways, engage in much duplication of effort, suffer from insufficient or inappropriate standards, or are insufficiently aware of methods that should be used, or of the availability of existing data. Additionally, concerns over security or other issues may likewise lead to coastal data being withheld from stakeholders and the general public.

Technical Issues

Results of a GIS pilot study undertaken on Port Philip Bay by Loton (2006) in the Department of Geomatics, University of Melbourne, summarised coastal management issues as consisting of: overlapping coastal interests; data gaps between terrestrial and marine environments; resolution differences and scale variations in coastal demarcation, spatial relationship between conflicting interests over the coastal zone; and representation inconsistencies due to data errors. These issues add to the institutional challenges described above, showing that current management strategies are 'fragmented, complex and poorly understood' (Neely *et al*. 1998).

Good infrastructure is based on common standards. Recognised common standards ensure that component technologies work together and the infrastructure is transparent to the user. Important standards developments relating to coastal and marine data include the S-57 (Special Publication No. 57) cartographic standard developed and maintained by the International Hydrographic Organisation (IHO) International Hydrographic Bureau (IHB) in Monaco (IHO 1996). This standard is used for collection and exchange of hydrographic data among national Hydrographic offices globally. Within the terrestrial environment, the International Standards Organisation's Technical Committee 211 (TC/211) on Geographic Information/Geomatics creates a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. However, SDI must be based on 'interoperability' (seamless databases and systems). International standards organisations are addressing the development of standards for both land-based and marine-based spatial data and technologies. 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, datum and format (Gillespie *et al*. 2000). Additional CSDI considerations include: metadata creation and related standards; guidance on spatial precision, accuracy and data formats; data access policies; and intellectual property and related legal issues (Longhorn 2004).

Table 1 outlines the current institutional, policy and technical marine/coastal issues and their consequent effect.

Tab. 1**:** Marine/Coastal issues

ISSUES	EFFECTS
Institutional Issues	
Various spatial datasets are collected and stored by different organisations	Finding and obtaining datasets is difficult
Immature institutional arrangements	Reluctance of organisations to share their data
Limited knowledge of marine and coastal environment, boundaries and their associated rights, restrictions and responsibilities	Inefficient and ineffective marine and coastal management and administration

Policy Issues	
Restrictive national security and pricing policy regarding marine and coastal data	Coastal and marine data being withheld from stakeholders and general public
Complex, fragmented regulating framework for marine and coastal management	Inability to adequately handle the pressure of different activities and stakeholders within the coastal zone
Lack of agreed framework of standards, policies and coordination mechanisms	Lack of coordination and sharing of marine and coastal spatial data
Technical Issues	
The dynamic and fuzzy nature of the shoreline as the one of the main fundamental datasets within the coastal zone	Complexity in representation and also barrier to seamless data sharing between disciplines and administrative sectors
Existence of different data formats, reference frames and also lack of metadata and consistency in data	Lack of interoperability of different datasets
Difference in scale, quality , coverage and format of spatial data as well as the lack of, or poor quality metadata	Difficulty in integrating different datasets
S-57 hydrographic data standards is not at the same level of completeness as ISC/TC 211	Difficulty in the interoperability between marine and terrestrial spatial data creates confusion in the coastal zone
Different technology to capture spatial data in marine and coastal environment	Difficulty in achieving the same level of completeness, currency and reliability as terrestrial data

Spatial Nature of Issues

As the interface between marine and terrestrial environments, coasts have diverse and ever increasing conflicting pressures and demands requiring effective administration and management. Most ocean and coastal management problems are of a spatial nature (Williamson *et al*. 2004) and it is now being recognised that the information required to balance competing interests over the coastal zone have an inherent spatial dimension (Rajabifard *et al*. 2005). Spatial information aids decision making by providing a spatial/geographic context to planning, management and resource allocation and is increasingly recognised as essential to emergency response. It enables a better understanding of an area and thus better management (Binns *et al*. 2005). Many coastal management issues could be overcome if a spatial data platform that enables a holistic, integrated and coordinated approach to spatial information for decision-making existed. SDI provides an enabling platform enhancing decision-making and facilitating a holistic approach to management. To improve management of the coastal zone there needs to be access and interoperability of both marine and terrestrial spatial data (Strain *et al*. 2004).

The data requirements of coastal zone managers go beyond those of their more-terrestrially-focussed counterparts, in scale, geographical extent and complexity of definition, leading to the need for specifically coastal-oriented SDI research and implementation (Bartlett *et al*. 2004). In many parts of the world, access to detailed information about the coast is considered a very sensitive issue, primarily due to concerns over national security.

However the need to effectively manage the coastal zone as well as the need for interoperable data between the three environments (land, coast, marine) requires a management system that incorporates them all. This has been recognised through the development of integrated coastal management (ICM) (Gillespie *et al*. 2000), an initiative that aims to combine management of the coastal zone, spatially, institutionally, and ecologically. So applying GIS to coastal issues supports many management tasks, including integration and analysis of larger and conceptually richer databases (Bartlett *et al*. 2004). Figure 1 demonstrates the

conceptual demonstration of issues and challenges of the land, coast, and marine environments.

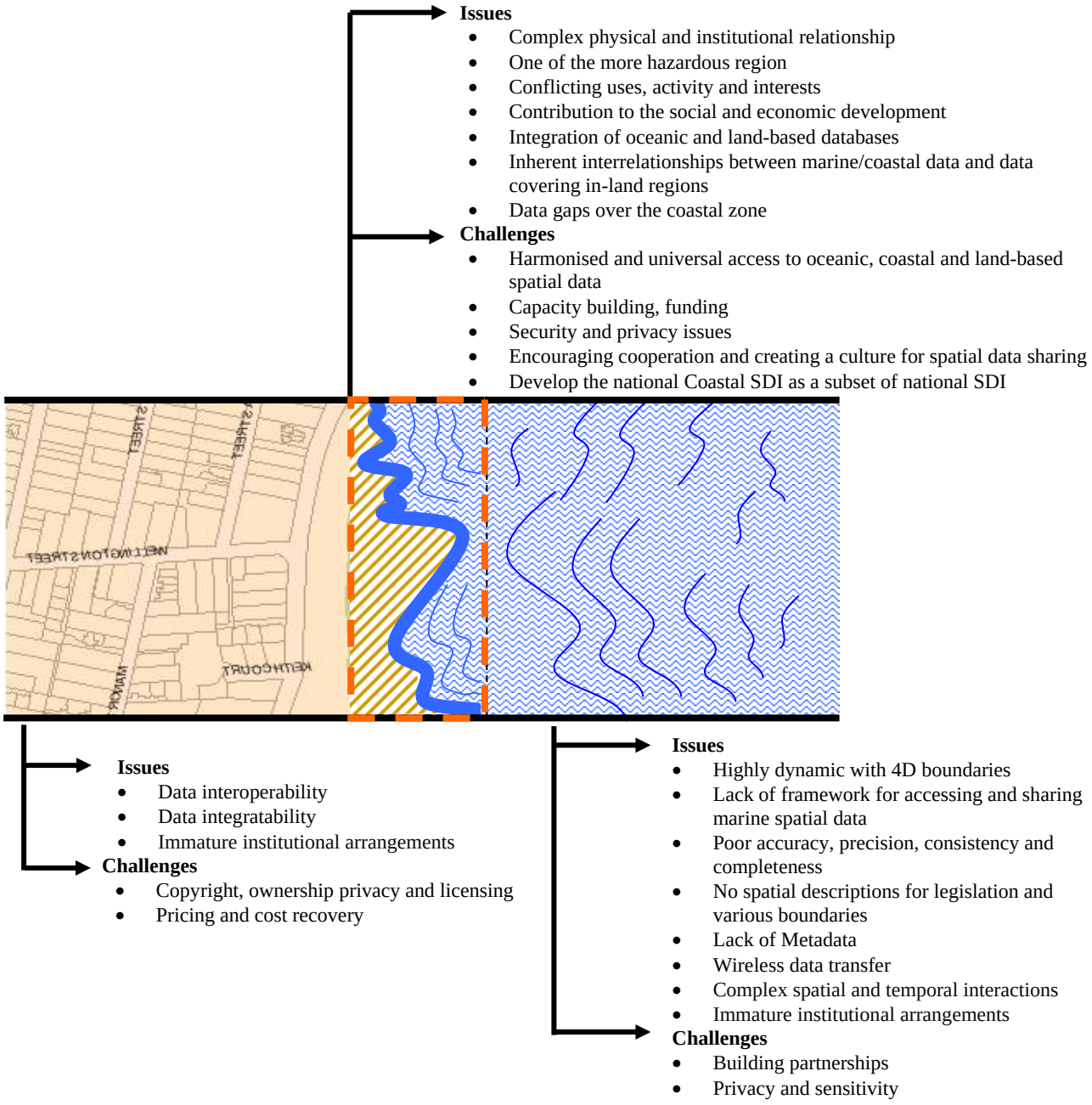

Fig. 1: Issues and challenges of the terrestrial, marine and coastal environments

MARINE/COASTAL SDI CONCEPTS AND DEFINTIONS

Until recently spatial information management and administration tools have focussed on the terrestrial environment. Initiatives such as the 3rd United Nations Convention on the Law of the Sea (UNCLOS) and the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA) have bought to attention the importance of sustainable development of the coastal and marine environment. The concepts of marine SDI, marine cadastre and marine spatial planning have all emerged recently in response to a global realisation of the need to improve management and administration of the marine environment and help overcome some

of the issues discussed above. The underlying theme of these initiatives is the importance of including a spatial dimension to marine administration (Strain *et al*. 2006).

Many countries are beginning to consider extending their land management systems to include the marine environment, while others are examining developing a different system to manage their marine area separately (Strain *et al*. 2004). The term SDI has numerous definitions across countries, regions and disciplines. Far fewer nations - perhaps fewer than ten - are engaged in formally developing specific coastal SDI (CSDI) components either separate to or contained within their national SDI plans. In some nations the term marine geospatial data infrastructure (MGDI) is used versus CSDI. While the data interchange collaboration work of IOC's IODE (Intergovernmental Oceanographic Commission Committee on International Oceanographic Data and Information Exchange) has been ongoing for several decades, specification of Coastal SDI/Marine GDI at national level only started at the beginning of the new millennium (Longhorn 2004). These different definitions of SDI can be expected due to the dynamic concept of SDI which can include a broad variety of information, can be updated with changing technology, human attitudes, or to include new environments. Table 2 shows different perceptions and definitions of spatial information management initiatives in the marine environment around the world.

Tab. 2: Marine/Coastal initiatives

Jurisdiction	Title	Definitions/Understandings
Canada	Marine Governance	The governance of marine spaces is the management of stakeholder activities in these spaces. To optimise this management and to address stakeholder issues requires that effective governance frameworks be in place. Collaborative, cooperative, and integrative governance are improved frameworks for dealing with stakeholder issues (Sutherland & Nichols 2002).
	Marine Geospatial Data Infrastructure	A Marine Geospatial Data Infrastructure (MGDI) is being developed within the framework of the CGDI, "to enable simple, third party access to data and information that will facilitate more effective decision making" for anyone involved in coastal zone management. MGDI is described as comprising data and information products, enabling technologies as well as network linkages, standards and institutional policies (Gillespie *et al*. 2000).
Europe	Coastal SDI	A coastal SDI (CSDI) must accommodate the widely varying information needs of highly diverse disciplines and sectors of society, business and government. Because of such complex physical and institutional relationships, it is not possible to develop a coastal SDI in isolation from the broader national or regional SDI (NSDI) because the coastal zone covers multiple physical and institutional spaces included in the generic NSDI (Bartlett *et al*. 2004).
	MGDI	The MGDI should provide a "thematic hub with information about water depths, currents, tides, channel widths, seabed texture, sediment characteristics, temperature, wrecks, pipelines, cables, seabed obstructions, fish stocks, coastal terrestrial data etc.; allow people to make better decisions (such as planning and protecting vital resources); (and) allow extraction of data from diverse sources, blend it and come up with original perspectives and innovative solutions." (Pepper 2003).
	Marine Spatial Planning	Marine Spatial Planning is a strategic plan for regulating, managing, and protecting the marine environment that addresses the multiple, cumulative and potentially conflicting uses of the sea (Tyldesley

		2004).
Australia	Marine Cadastre	Marine cadastre aims to administer the spatial dimension of marine boundaries. Marine cadastre aims to define, visualise and realise legally defined maritime boundaries and the rights, restrictions and responsibilities attached to them (Binns 2004).
	Marine Administration	Marine administration is management and administration of rights restrictions and responsibilities in the marine and coastal environments. Marine administration encompasses different activities such as marine industries, resource management, marine protected areas and conflict resolution. There is a need to create a framework for marine administration in order to provide a foundation from which management issues, including the global focus on sustainable development, can be addressed (Rajabifard *et al*. 2005).
	Marine SDI	The spatial component of marine administration has evolved over the past 5 years as many coastal countries are developing different ways to facilitate sustainable management of their marine jurisdictions. As part of this evolution Marine SDI has emerged to facilitate marine administration. Its components are: a marine portal, a marine catalogue and a network of interoperable service and content providers (Strain *et al*, 2006).
United States	Marine/Coastal SDI	Coastal SDI is technologies to facilitate discovery, collection, description, access and preservation of spatial data that should be widely available to the coastal zone management community. The mission of Marine and Coastal NSDI is current and accurate geospatial coastal and ocean data will be readily available to contribute locally, nationally, and globally to economic grow the environmental quality and stability, and social progress" (NOAA 2003).
	Marine Cadastre	Marine cadastre is being examined within the FGDC Marine Boundary Working Group (MBWG), in order to address issues relating to the legal and technical aspects of marine boundaries, with the goal to alleviate cross-agency problems concerning marine boundaries, plus provide outreach, standards development, partnerships, and other data development critical to the NSDI (FGDC 1998).
Asia-pacific	Marine Cadastre	Marine cadastre is defined as a management tool which spatially describes, visualises and realises formally and informally defined boundaries and associated rights, restrictions and responsibilities in the marine environment as a data layer in a marine SDI, allowing them to be more effectively identified, administered and accessed (UN-PCGIAP 2004).

Many Coastal SDI initiatives are driven by mandates derived from environmental programme goals, often involving water management. Other important drivers for implementing a comprehensive CSDI within the framework of a national or regional SDI include legal requirements and economic issues surrounding boundary definitions, such as the shoreline. However, a major driving force behind the CSDI/MGDI initiatives is the need for better management of coastal/marine environments and concerns over a range of climate change issues that both impact on the coastal zone and marine environment and for which these environments (especially oceanic) may effect climate change (Longhorn 2004).

SDI is described as the underlying infrastructure, often in the form of policies, standards and access networks that allows data to be shared between and within organisations, states or countries. Some of the benefits of developing SDI are: improved access to data and reduced duplication of effort in collecting and maintaining data and interoperability between datasets

(Strain *et al*. 2004) All of the SDI components have their relevance and applications in the marine and coastal domains (Bartlett *et al*. 2004).

Between different coastal SDI initiatives there are many commonalities in specifying the common components for a typical CSDI. Commonalities are also shared regarding non-technical issues and barriers that need to be resolved and for specific goals to be reached. From examination of the comparatively sparse discussions of coastal SDI to be found in the literature to date, it appears that the main recognised ingredients of a CSDI comprise data sources, standards, enabling technologies and institutional policies. Work in relation to the first two needs to be carried out with a specific marine or coastal focus. Such a focus is generally missing from more generic SDI initiatives. The most commonly occurring data components that current CSDI/MGDI initiatives include are bathymetry, shoreline, boundary data, marine cadastre, coastal imagery, marine navigation, tidal benchmarks and benthic habitats. Only some of these are supported by the basic 'framework' data appearing in most national SDI programmes and even that level of data is not yet harmonised across national boundaries (Longhorn 2004).

Datasets which describe the coastal 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. 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 (Gillespie *et al*. 2000). Provision and inclusion of appropriate coastal data is essential if SDIs are to be extended off-shore. A coastal SDI (CSDI) must accommodate the widely varying information needs of highly diverse disciplines and sectors of society, business and government.

As suggested by Bartlett *et al,* (2004) due to the high economic value of coastal and marine activities, and to the social value of coastal zones for quality of life, managing the coastal zone is a key component of the socio-economic framework in most nations with coastlines. These complex physical and institutional relationships require that CSDI/MGDI be developed in close cooperation with the more generic SDI initiatives of countries and regions, within which CSDI will typically be an important thematic subset of the more comprehensive NSDI, as the coastal zone covers multiple physical and institutional spaces included in the generic NSDI. There are also inherent interrelationships between marine/coastal data and data covering inland regions which directly impact the coast and near-shore waters. This provides yet further evidence that coastal SDI should be an integral part of national and regional SDI specifications. However, legal and institutional barriers require greater awareness and stronger support at the highest levels of government amongst those agencies responsible for national information infrastructure (NII) implementation. SDI is only one component of NII and CSDI/MGDI is typically a sub-component of SDI.

SEAMLESS SDI

A more integrated and holistic approach to management of coastal and marine environments would be facilitated by the extension of the SDI on a seamless platform. This would promote data sharing and communication between organisations thus facilitating better decision-making involving marine and coastal spatial information.

The ability to access and integrate data has been identified as a problem by people involved in coastal zone management, as can be seen from the development of ICM initiatives. Incorporation of marine and coastal regions within global, national and regional SDIs will bring substantial additional benefits of integration, standardisation and interoperability of technologies, enabling better policy formulation, monitoring and enforcement, often reaching beyond the coastal zone itself (Bartlett *et al*. 2004).

For modelling the coastal zone, there is likely to be one source for the land, another for the sea and potentially other subsidiary datasets straddling both. In these cases there will inevitably be some data interoperability issues. One of the typical problems is differences in scale when trying to join together data captured at different scales. Seaward datasets which are often at smaller scales simplifying the geometry of the features while landward datasets are large scale with much more complexity and greater density of details. This results in a disparity in the feature common to both zones. Another barrier to a seamless SDI is in different projections regarding land and sea data, which creates a problem in defining the parameters required for transformations (Gomm 2004).

Common standards and well documented metadata are essential for data discovery, management and compatibility within a SDI. These must be developed using the international procedures and practises in order to cover not only the national needs but also cooperation at an international level. In this respect the IHO has an important role to play in developing the appropriate standards needed for its hydrographic and cartographic applications, in close cooperation with appropriate organisations responsible for standardisation, such as ISO. As an example the IHO S-57 standard, although limited in scope and implementation, provides important compatibility for data sharing in the hydrographic information community. The next edition of the standard will not be a standard just for hydrography, but will have manageable flexibility that can accommodate change and facilitate interoperability with other GIS standards. It will also allow hydrographic offices to use other sources of geospatial data. The next edition of S-57 (which will become S-100), is being based on the ISO/TC211 base standard and will make provision for imagery and gridded data in addition to the existing vector data, defined in the present version. This will facilitate the development of additional products and services “other than for navigation” requirements. Funding for the development, maintenance and dissemination methods adapted to user needs and new technology of this Infrastructure, is a very crucial issue, which of course will depend on national policies for recovery or not of the necessary funds (Maratos 2007).

The complex physical and institutional relationships existing within the coastal zone make it impossible for development of a marine SDI to occur in isolation from land based initiatives. Furthermore a seamless infrastructure aids in ‘facilitating more integrated and effective approaches to coastal zone management, dealing with problems such as marine pollution from land based sources’ (Williamson *et al*. 2004). A seamless infrastructure was endorsed by the UN as part of the International Workshop on Administering the Marine Environment held in Kuala Lumpur, Malaysia, 2004 (Rajabifard *et al*. 2005). It was recommended that a marine cadastre act as a management tool within a marine SDI as an extension to NSDI’s across Asia-Pacific. Recently, a recommendation of the 17th United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP) in Bangkok further supported the inclusion and development of a marine administration component as part of a seamless SDI to “ensure a continuum across the coastal zone” (UNRCC-AP 2006).

If two separate SDI were created it would deepen the gap between these two administration systems and make coastal zone management more difficult. There is an opportunity for more research to be conducted into combining these initiatives and developing a seamless SDI that

can include spatial data from all environments. This will recognise the interrelatedness of the marine and terrestrial environments and also improve management of activities or resources that occur across these boundaries (Strain 2006).

A seamless SDI platform would enable the utilisation of common boundaries across the coastal zone to ensure no ambiguity exists and no areas are unaccounted for over the coastal interface. This infrastructure will become 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.

HOW DO WE CREATE A SEAMLESS SDI?

In order to create a seamless SDI across terrestrial and marine environments and jurisdictions, it is important to recognise and accept that building and maintaining a SDI is not an easy task even for well-developed states. It is a dynamic and complex process at different levels of government and requires research and collaboration with academia and private industry.
Research into the technical and institutional aspects of creating a seamless SDI in Australia is one of the major research priorities of a research project being undertaken in the Department of Geomatics at the University of Melbourne. The aim of this research project is to design an overarching architecture for developing a seamless SDI that allows access to and interoperability of data from marine, coastal and terrestrial environments. This architecture can then be used by government and Australian agencies such as AZNLIC to implement a seamless SDI.

Research centres on current theory and practice in SDI creation including the use of product and process based SDI models and marine SDI components currently under development throughout various countries (including Australia). The methodology for developing and creating the seamless SDI is under development, with the major research steps outlined below. These steps aim to overcome the institutional and technical issues outlined in this paper.

Step 1: Examine and document the needs of marine and coastal stakeholders in terms of availability, access and use of spatial information.

Step 2: Investigate the characteristics of current SDI initiatives (both terrestrial based and marine based) within Australia and internationally.

Step 3: Identify the commonalities and differences between terrestrial and marine based SDI initiatives. This will lead to the identification of opportunities for combining marine and terrestrial components of SDIs.

Step 4: Identify barriers to creation of a seamless SDI, such as the use of differing standards in the two environments, governance arrangements, technical specifications (2D, 3D and 4D nature of data) etc.

Step 5: Utilise a case study methodology of Port Phillip Bay to aid in steps 1-4.

Step 6: Utilise the current definition of the ASDI which includes the components of people, data, access network, standards and policies, and define actions within each component that will overcome identified barriers to creation of a seamless SDI. These would include:

- Investigation of fundamental marine and land datasets
- Research on the concept of interoperability
- Research on the data access conditions and requirements

- Metadata specifically marine/coastal metadata
- Reference datum
- Analysis of the concepts of pricing and licensing

Step 7: Test the new components defined in step 6 within the case study area. Do these new components overcome the issues and barriers identified?

Step 6: Refine the new SDI components tested as required, in order to create a seamless SDI model that covers both terrestrial and marine environments.

Step 7: Develop guidelines that can be used by jurisdictions to implement the seamless SDI model created.

The ultimate aim will be a refined SDI model and implementation guidelines that seamlessly covers both land and sea that can be used by jurisdictions to create an enabling platform for the use and delivery of spatial information and services. This development aims to aid in meeting the sustainable development (economic, environmental and social) objectives of the region through the development of a seamless enabling platform to provide more efficient and effective decision making capabilities across both the marine environment and the land-sea interface.

FUTURE DIRECTION

There is a growing need to develop the seamless SDI model as one platform instead of two to increase the efficiency and effectiveness of the management and administration of the land, marine and coastal environment. However, the differences in the marine and terrestrial environments in fundamental datasets, data collection and technology used in these environments will make interoperability and integratability between marine and terrestrial spatial data a big challenge.

In the terrestrial domain, the need to share and integrate spatial data for more efficient resource information management has been recognised for over a decade, and has led to the development of SDI at all geographical levels from the purely local to the national and global.

Today, there is increasing recognition by the public at large of the need to support sustainable development of the coastal zone. At the moment the practical implementation of a marine SDI is mainly occurring separately to the terrestrial SDI, using the same components but adapting them to suit the different environment. However the multidisciplinary interactions in the land–sea interface require sophisticated information infrastructures that not only do not yet exist, but which will not appear if disciplines continue to develop their SDIs in isolation from one another.

Research now needs to focus on combining these initiatives and developing a seamless SDI. The development of a seamless SDI will ensure this data is interoperable and thus improve decision-making and administration in the coastal and marine environments.

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