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Critical issues relating to the integration of land and marine geospatial information

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Background Document Prepared by
The International Federation of Surveyors (FIG)

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Critical Issues Relating to the Integration of Land and Marine Geospatial Information International Federation of Surveyors:

Preamble

Fédération Internationale des Géomètres **(FIG)** is a United Nations and World Bank recognized non-governmental organization, is the international organization representing the interests of surveyors worldwide. It is a federation of national member associations and covers the whole range of the professional surveying community globally, representing a membership from 120 countries throughout the world, seeking to collaborate and to ensure that the disciplines of surveying and all who practise them are relevant and meeting the needs of both the places and the people we serve. FIG was founded in 1878 in Paris and in recent decades, is known as the ***International Federation of Surveyors***.

This professional community measures (including costing and valuation), models and manages the natural and built environment for the effective planning, efficient administration and sustainable use of the land, the seas and any structures thereon. These practitioners come from scientific, research and academic institutions; technologies, technological products and services providers; commerce and industry and public agencies. FIG provides an international forum for discussion and development aiming to promote professional practice and standards.

With its sciences, technologies, knowledge and practices, the International Federation of Surveyors has a vision to extend the usefulness of surveying for the benefit of society, environment and economy with the aim that the profession be increasingly positioned in significance and relevance, next door to everywhere.

Introduction

The rapid advances in geospatial information and technologies, and their easy accessibility, have made such information as invaluable tool in research, policy and business planning and implementation. Across all sectors of society, it is increasingly recognized that the effective use of geospatial information helps address many of the current humanitarian, peace and security, environmental and development challenges facing the world, such as climate change, natural disasters, disease pandemics, famines, population displacement, food and economic crises, which are of a cross-border nature requiring both global, regional and national policy responses (UNESC, 2011).
FIG had observed that three billion people (half of the world's population then) lives within 200 kilometres of the shoreline and estimated that by 2025, this figure may double (FIG, 2006). The need to effectively manage the coastal zone as well as the need for integration of data between the land, coast and marine environment requires a management system that

incorporates them all. Many countries have a land administration system and some kind of marine management system, but these generally operate as separate entities and thus can cause conflict within the coastal zone or the land-sea interface.

It is opined that "the oceans and seas that surround Europe offer new opportunities to meet the Europe 2020 goals" and continued "we need to know what the state of the sea is now, how it was in the past and how it might change in the future" (EC, 2012).

Additionally, land (topography) and marine (bathymetry) dataset were collected for differing purposes and using different methods. Hydrographic surveying has been traditionally conducted solely for the purpose of creating nautical charts for safety of navigation whereas topographic mapping has been conducted for the planning and development of the land mass. Surveys for coastal zone management involving both land (topography) and seas (bathymetry) are of increasing importance to address various challenges as well as opportunities within this coastal space. Incompatibility of data formats, coordinate system, geodetic parameters and other aspects of data pose problems in the ability to share and exchange data in this environment prompting researches into the development of seamless Spatial Data Infrastructure (SDI) across the land-sea interfaces that aimed to address these issues both at the national and regional level (FIG, 2006).

These has brought to the fore the need for interoperability and collaboration.

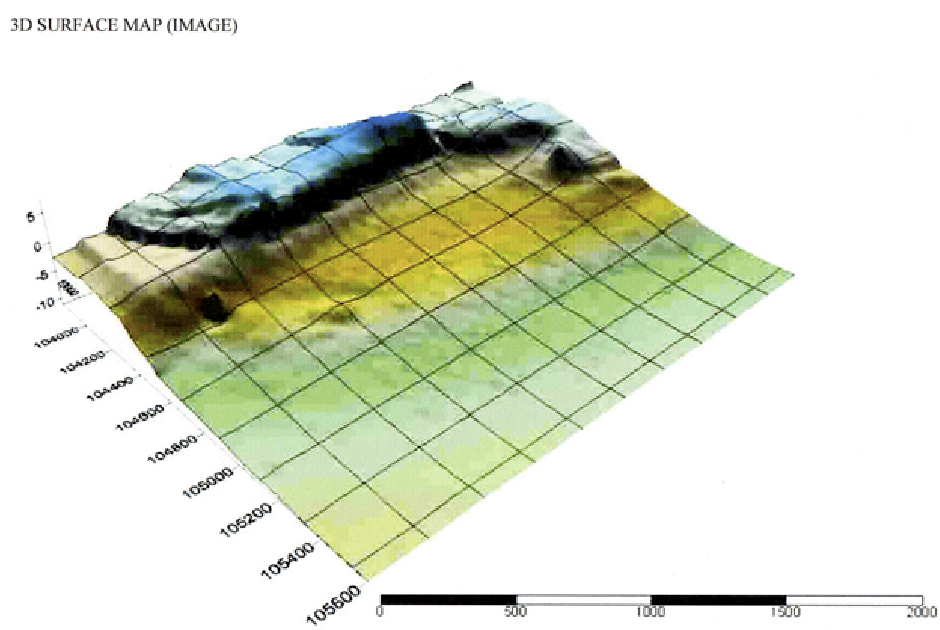

Figure 1: 3D Surface Map (from integrated topographic and bathymetric data acquired for a localized coastal development)

Some Issues related to Land and Marine Environment

Vaez (2010) discussed the issues related to land, coastal and marine environment and summarizes with the diagram below:

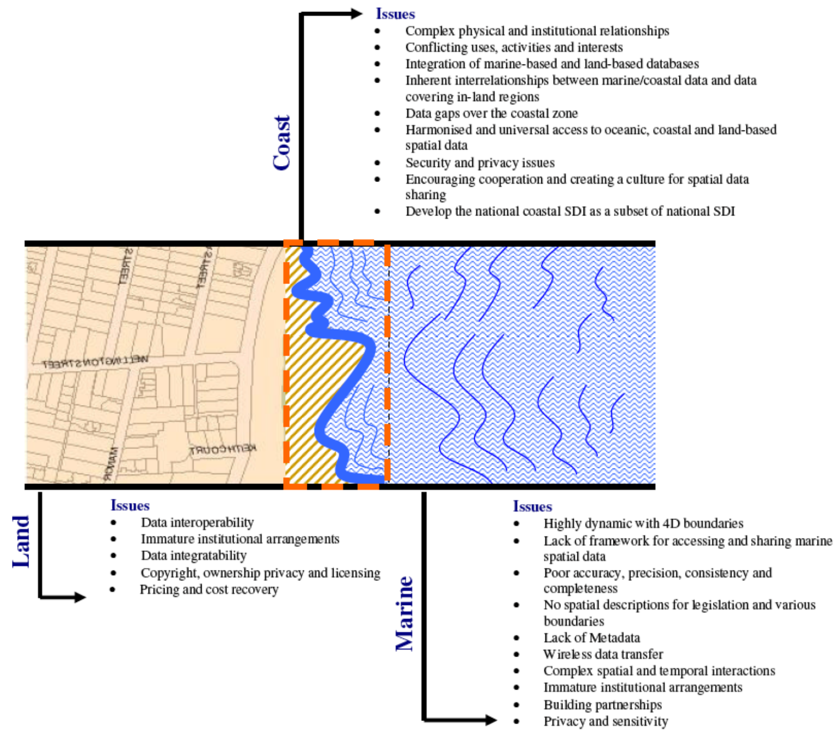

Figure 2: Issues related to land, coastal and marine environment (Vaez, 2010)

Vaez (2010) highlighted a number of technical issues that should be taken into consideration when integrating land and marine data that are from various data sources as it involved a series of differences – in spatial reference system (horizontal datum, vertical datum and coordinate system); in storage medium; in data accuracies; in scale of data source; in feature or object definition; in resolution or data acquisition method; and in data modeling.

Vaez (2010) also observed that from a technical point of view, the lack of spatial data standards that is implemented at national level is the main problem of the above differences and that the marine standards are not at the same level of completeness as ISO TC/211 standards.

Item	Topographic Map	Nautical Chart
Coastline	- Mean Sea Level (MSL) which is determined by modelling the topography	- Local Astronomic Tide (LAT)
Horizontal Datum	- GDA94 - WGS84	- GDA94 - WGS84 - AGD66
Vertical Datum	- AHD (Australian Height Datum or Mean Sea Level) for land elevations. - no depth information	- Mean Sea Level (MSL) for land elevations - Chart Datum for depth - information: LAT, ISLW
Projection system	- Universal Transverse Mercator (UTM).	- Mercator
Digital Storage Format	- Various format (DWG, ARC, SHP ,Hardcopy)	- Digital Nautical Charts: Raster(TIFF, ECW) - Electronic Navigation Chart: DIGITAL - S-57 Version 3.1 - Nautical Chart: Digital and Non digital - Raster HCRF V2 / GEOTIFF V1 (not to be used for navigation), Hardcopy Printed Charts - Bathymetric Map: Digital and Non digital-ASCII, Hardcopy - Printed maps
Scale	- Systematically (1 to 10K, 25K, 50K, 100K, 250K)	- Not Systematically (range from large scale to small scale)

Figure 3: Different aspects of land and marine spatial data integration within a national context (Vaez, 2010)

Land and Marine Data

The shoreline as depicted on a set of nautical charts and topographic maps need not necessarily be one and the same in reality. According to the recommendation of the International Hydrographic Organization (IHO), shoreline (or coastline) is defined as the intersection of the mean high water with the land. This gave rise to a temporal dimension to the definition of shoreline. In another instance, the shoreline as depicted on topographic maps is derived from mapping methodologies that may include aerial photography and photogrammetry. The temporal dimension in this instance is more about the time of recording or rather the photography. Consequently, nautical charts and topographic maps can have differing shoreline. In order to resolve this problem, it is proposed to define the height datum using unique and consistent methodology (Leder et al, 2011)

As the vertical land (topography) and marine (bathymetry) data were collected for different purposes and related to different vertical reference surfaces, for example, leveling datum for land and chart datum for marine. The need to merge the two data types has driven the need to resolve these differences. One surface that is used for modern data collection on both land and sea is the reference ellipsoid. Traditionally, reference ellipsoids are being used to define horizontal datums but with the emergence of high-accuracy Global Navigation Satellite Systems (GNSS), reference ellipsoids are being used to define vertical datums. Data collected both on land and at the sea can be related to the same satellite based vertical reference surface, making the merging of the two a trivial process.

It should be noted that though these reference ellipsoids are convenient, they are not “physical” surfaces, such as those defined by gravity (geodetic datum) or mean sea level (tidal datum), therefore, for analysis and map or chart production, satellite (GNSS) derived vertical information must be translated. Translation from the ellipsoid to geodetic or tidal datums is usually performed through transformation models. The ellipsoid can be used as the reference for all of the translation models. Currently, this is a complex process and is not as trivial as one may like to. (Mills et al, 2013).

The Baltic Sea Initiative

A common reference surface on land and sea supports development of services and products for maritime applications and other seamless descriptions of land and sea or ocean floor. The value of integrating land and marine data is immense even if one has limited knowledge (Lijle, 2013) of regional or global drivers and needs such as in areas of transportation, environment, planning and development.

Countries bordering the Baltic Seas such as Sweden, Finland, Germany, Russia, Poland, Lithuania, Estonia and others have established a joint reference surface for hydrographic and oceanographic information through collaboration, between the regional IHO-based structure BSHC (Baltic Sea Hydrographic Commission) and the regional oceanographic structure BOOS (Baltic Operational Oceanographic System) supported by the geodetic institutes (many are responsible for land-based geospatial data) that are involved with Regional Reference Frame Sub-Commission for Europe (EUREF) of the International Association of Geodesy (IAG). The conclusions and experience from the collaboration is then discussed with the global working group of the International Hydrographic Organization (IHO) called TWLWG (Tide and Water Leveling Working group). They are interested in the response from organizations responsible of “non-water waters”.

The collaboration demonstrates the importance of the establishment of geodetic reference systems and frames of high quality, longer-term sustainability covering as large geographical areas as possible so that the organizations involved can secure the usefulness and acceptance of the initial investment. It is also importance that there is knowledge of the various components included within the geodetic infrastructure including, for example, land based height systems and geoid model.

Baltic Sea countries area also working together to create a bathymetric sea depth model that includes shallower areas, for example, depth less than 10 metres, and connecting these to a land based height system. It should be noted that these measurements have up till now been too expensive and impractical but a convergence of platforms, sensors, technologies and approaches (IHO, 2013) are allowing for such data acquisition.

The collaboration, in this instance, between hydrographers and geodesists and the convergence of approaches are very important to the successful integration of land and marine data and the realization of a seamless dataset that can serve as an information base for the generation of knowledge.

Integrating Land and Marine Information

It is important to note that the International Hydrographic Office (IHO) Marine Spatial Data Infrastructure Working Group has recognized that "there is a need to identify and recommend solutions to technical issues related to interoperability between land and sea data" (IHO, 2009). Furthermore, a resolution of the 17th United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP) supported the inclusion and development of a marine administration component as part of a seamless spatial data infrastructure to "ensure a continuum across the coastal zone" (UNRCC-AP, 2006).

There are efforts and initiatives to address the various, particularly the technical, challenges in integrating land and marine information as has been discussed to a certain extent above. These efforts and initiatives coupled with a convergence of platforms, sensors, technologies and approaches as well as sound policies are beginning to bear some results though many will remain convinced that the geospatial community is still a long way off from realizing a seamless land and marine geospatial information base that will contribute towards the betterment of society, environment and economy.

To integrate land and marine geospatial information, FIG sees the need to -

- build and use common standards and frameworks to ensure interoperability;
- enhance institutional arrangements and stakeholder collaborations; and
- improve returns on investment through better coordination, use and reuse of data, information and systems and to enhance innovation and productivity.

FIG has identified these five elements that are critical for the realization of an integrated set of land and marine information where the primary motivation is the translating of data into useful knowledge and resource (FIG, 2012). These elements are -

- legal framework to provide the institutional structure for data sharing, discovery, and access;
- positioning infrastructure to enable and benefit from satellite based positioning possibilities and reference systems;

- data or information infrastructure to facilitate data sharing, to reduce duplication and to link data producers, providers and value adders to data users based on a common goal of data sharing;

- data integration concept that is sound, to ensure multi-sourced data interoperability and integration; and

- information to respect certain basic principles and to increase the availability and interoperability of free to re-use data from different actors and sectors.

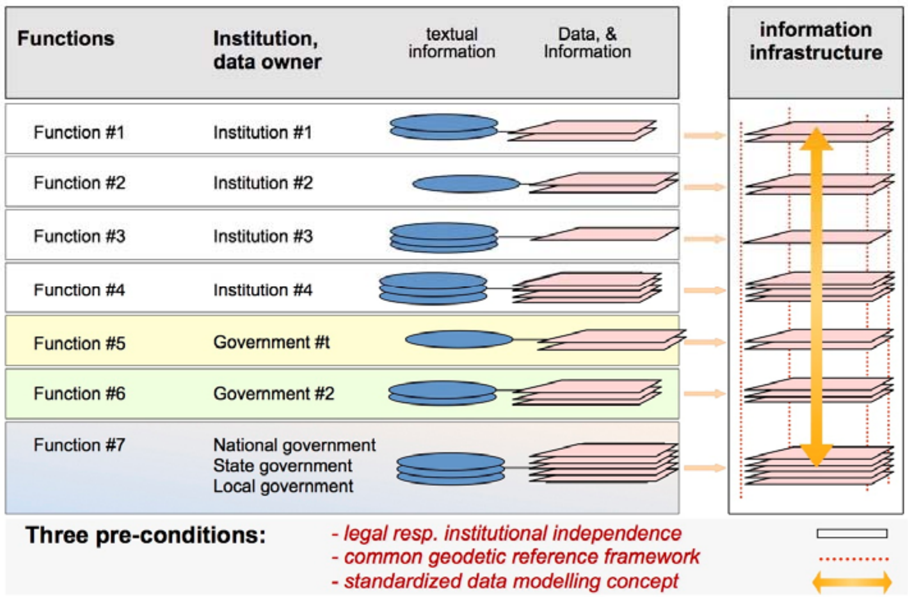

Figure 4: Common Integration Concept (after Steudler, 2012)

Technical challenges are being addressed and could be resolved progressively and with time but there remains the people and the policy issues that will need to address. The non-technical obstacles of data integration can be institutional, policy and legal issues (Williamson et al, 2006).

Building infrastructure for the gathering, validation, compilation and dissemination of geospatial information is as important to countries as the building of roads, telecommunications networks, and the provision of other basic services. This is a critical aspect of the national and global information infrastructure. However, it is increasingly recognized that the major barriers and impediments to building geospatial information infrastructures will not be technical ones, but rather institutional and organizational, including the ability to bring countries to collaborate with one another (UNESC, 2011)

Both policy-willingness and people-readiness is needed to consider, develop and build interoperable standards, frameworks and infrastructures; to ensure that institutions and jurisdictions collaborate and in this era of limited resources, improve returns on any investment. Whilst we observe that advances in number, types and capacities of platforms and sensors together with volunteered information provides a spectrum of possibilities and opportunities in data acquisition as well as integration, the need for interoperability and collaboration remain to harness the full potential and opportunities afforded by integrating land and marine geospatial information.

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FIG

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