Geoinformatics in Shipping and Marine Transport

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Abstract. This paper discusses the role of Geoinformatics in Shipping and Marine Transport as a new independent, autonomous self-contained, scientific discipline created for dealing with geospatial information. Depending on the scientific background of those involved in shaping the emerging discipline, little emphasis may be placed on various aspects of Geoinformatics. Maritime applications and small developments may address spatial planning, surveying, or computer science related matters. The scientific field of Geoinformatics spans the acquisition and storage of spatial data, the modelling and presentation of spatial information, geoscientific analyses and spatial planning, and the development of algorithms and geospatial database systems, including Geographical Information System (GIS). The current paper emphasizes international and national trends of the discipline and provides a set of geospatial initiatives in the field of marine navigation, safety at sea, maritime shipping, sea transportation and logistics, transport telematics and geomatics.

Keywords: Geoinformatics · GIS · Shipping · e-Navigation · ITS · Marine transport · Transport telematics

1 Introduction

Increasingly used to analyze and manage marine, offshore and coastal areas, Geographical Information Systems (GIS) assure a powerful set of tools for integrating and processing spatial information. These technologies are increasingly used in the management and analysis of the shipping and marine transport processes. Supplying the guidance necessary to use these tools, marine GIS created for ocean and coastal zone management explores essential technical, theoretical, practical, and applications issues. Drawing on the practical experience of expert users in the maritime field, the paper presents samples of recent developments and specific applications.

The sections of paper present groundbreaking marine, offshore and coastal applications of GIS based decision support tools, spatial data infrastructures, remote sensing technology including GPS/GNSS, ECDIS/ECS, Radar/ARPA, VTS/RIS, AIS, LRIT, LiDAR, CASI, and more. A comprehensive, reliable, and up-to-date overview of the state-of-the-art in ocean and coastal areas GIS applications makes the information not only easily accessible but ready for immediate use [18].

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The use of GIS has seen unprecedented growth in the last twenty years. With more and more sophisticated, powerful technology becoming cheaper and system memories expanding, which means that we can handle much bigger volumes of data. We can say that GIS is in a golden age. It was once the preserve of the cartographer or surveyor - recently GIS has become a core part of modern sciences and technologies.

Many fields benefit from geoinformatics, including smart city planning and land use management, in-car navigation systems, virtual globes, geology, geography, agriculture, meteorology, climatology, archaeology, oceanography, environmental modelling and analysis, public health and epidemiology, biodiversity conservation, local and national press management, military service, transportation network planning and management, business site planning, architecture and archeological reconstruction, telecommunications, criminology and crime simulation, aviation, and maritime transport, logistics and shipping as well. The significance of the spatial dimension in assessing, monitoring and modelling various issues and problems related to sustainable management of natural resources is recognized around the world, the same as merchant fleet management and fright transport (the physical process of transporting commodities and merchandise goods and cargo). Geoinformatics is very important technology to decision-makers across a wide range of disciplines, industries, international organisations and agencies, local and national government, commercial sector, environmental management agencies, research and academia, emergency services, crime mapping, transportation and infrastructure, information technology industries, tourist industry, utility companies, national survey and mapping organisations, GIS consulting firms, market analysis and e-commerce, shipping, exploration of resources, etc. A lot of government (including maritime administration) and non-government agencies started to use spatial data for managing their day-to-day activities ashore and at sea [5, 16].

2 Geoinformation, GIS, Geomatics and Geoinformatics

Ordinary people often confuse with each other the following terms: Geoinformatics, Geomatics, Geographic(al) Information System (GIS), GIScience, Geoinformatics, Geomatics, and Geoinformation, Geospatial and GIS Technologies [2]. Geoinformatics has been described as "the science and technology dealing with the structure and character of spatial information, its capture, its classification and qualification, its storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information" [16] or "the art, science or technology dealing with the acquisition, storage, processing production, presentation and dissemination of geoinformation" [6].

Geomatics is a similarly used term which contains geoinformatics, but geomatics focuses more so on surveying. Geoinformatics has at its core the technologies supporting the processes of acquiring, analysing and visualizing spatial data [2]. Both geomatics and geoinformatics include and rely heavily upon the theory and practical implications of geodesy. But geoinformatics is a subset of geomatics. GIScience is highly related with the term Geoinformatics that is a shorter name for Geographic Information Technology.

Geomatics is a similarly used term, geoinformatics, but geomatics focuses more so on survey covers. Geoinformatics has to support the technology in the core of data, the processes of detection, analysis and visualization. Both geomatics and geoinformatics are and rely heavily on the theory and practical implications of Geodesy. But Geoinformatics is a subset of geomatics. GIScience is highly in the concept Geoinformatics related, which is a shorter name for Geographic Information Technology [2].

Geography and Earth science increasingly rely on digital spatial data acquired from remotely sensed images analysed by Geographical Information Systems and presented on paper or visualized on the computer screen.

Geoinformatics combines geospatial analysis and modelling, information systems design, development of geospatial databases, human-computer interaction and both wired and wireless networking technologies. Geoinformatics uses geocomputation and geovisualization for analyzing geoinformation [2].

All terms, the meaning of which is explained above, they are now very trendy words. In the last ten years, most universities have offered masters degrees specifically in GIS, or post-graduate certificates and diplomas with undergraduate degree in Geoinformatics.

3 Geoinformatics in Transport

In a broad sense a Geographic Information System (GIS) is an information system specializing in the input, management, analysis and reporting of geographical (spatially related) information. Among the wide range of potential applications GIS can be used for, transportation issues have received a lot of attention, including maritime branch. A specific branch of GIS applied to transportation issues, commonly labelled as GIS-T, is one of the first, pioneer application areas of GIS [17]. GIS for Transportation is a large application area of GIS.

Geographic Information Systems for Transportation (GIS-T) refers to the principles, rules and applications of applying geographic information technologies in the field of transportation, and the transport-related problems. Technologically, GIS-T, like GIS as a whole, benefited from developments in management information systems and database techniques in general, and relational databases in particular.

GIS-T is well represented in GIS journals such as: *Computers, Environment and Urban Systems, the International Journal of Geographical Information Science, Geographical Systems, Transactions in GIS, and Geographic Information Sciences, the Journal of Advanced Transportation*, *TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation, Archives of Transport System Telematics,* and the *Journal of Transportation Planning and Technology*. In addition, in the last decade there have been numerous government and research reports, books and other materials written about GIS-T and closely-related topics.

GIS-T research can be approached from two different, but complementary, directions. While some GIS-T research focuses on issues of how GIS can be further developed and enhanced in order to meet the needs of transportation applications, other GIS-T research investigates the questions of how GIS can be used to facilitate and improve transportation studies. In general, topics related to GIS-T studies, according to Shaw and Rodrigue [17], can be grouped into three main categories:

– data representations (How can different components of transport systems be represented in a GIS-T?),
– analysis and modelling (How can transport methodologies and procedures be used in a GIS-T?),
– applications (What types of applications are particularly proper for GIS-T?).

3.1 GIS-T Data Representations

Data representation is a core research topic of GIS. Before a GIS can be used to tackle real world problems, data must be properly represented in a digital computing environment. One unique characteristic of GIS is the capability of integrating spatial and non-spatial data in order to support both display and analysis needs. There have been various data models developed for GIS. The two basic approaches are object-based data models and field-based data models [17]:

– An object-based data model treats geographic space as populated by discrete and identifiable objects. Features are often represented as points, lines, and/or polygons;
– On the other hand, a field-based data model treats geographic space as populated by real-world features that vary continuously over space. Features can be represented as regular tessellations (a raster grid, e.g. RNC) or irregular tessellations (e.g., triangulated irregular network - TIN).

GIS-T studies have employed both object-based and field-based data models to represent the relevant geographic data. Some transportation problems tend to fit better with one type of GIS data model than the other. For example, network analysis based on the graph theory typically represents a network as a set of nodes interconnected with a set of links. The object-based GIS data model therefore is a better candidate for such transportation applications. Other types of transportation data exist which require extensions to the general GIS data models. One well-known example is linear referencing data (e.g. canal, waterway, mileposts). Transportation agencies often measure locations of features or events along transportation network links. Such a one-dimensional linear referencing system (i.e. linear measurements along a waterway segment with respect to a pre-specified starting point of the waterway segment) cannot be properly handled by the two-dimensional Cartesian coordinate system used in most GIS data models. Consequently, the dynamic segmentation data model was developed to address the specific need of the GIS-T community. Origin-destination (O-D) flow data are another type of data that are frequently used in transportation studies. Such data have been traditionally represented in matrix forms (i.e. as a two-dimensional array in a digital computer) for analysis. Unfortunately, the relational data model widely adopted in most commercial GIS software does not provide adequate support for handling matrix data. Some GIS-T software vendors therefore have developed additional file formats and functions for users to work with matrix data in a GIS environment. The above examples illustrate how the conventional GIS approaches can be further extended and enhanced to meet the needs of transportation applications. Modern information and communication technologies (ICT) such as the Internet and cellular phones have changed the ways that people and businesses conduct their activities. These changing activity and interaction patterns in turn lead to changing spatio-temporal traffic patterns. Our world has become more mobile and dynamic than ever before due to modern ICT. With the advancements of location-aware technologies (e.g., GPS/GNSS, ECDIS/ECS, AIS, LRIT, cellular phone tracking system, and Wi-Fi positioning system), it is now feasible and affordable to collect large volumes of tracking data at the individual level. Consequently, how to best represent and manage dynamic data of moving objects (vessels, or shipments) in a GIS environment presents new research challenges to GIS-T, especially when we have to deal with the Big Data issues. In short, one critical component of GIS-T is how transportation-related data in a GIS environment can be best represented in order to facilitate and integrate the needs of various transportation applications. Existing GIS data models provide a good foundation of supporting many GIS-T applications. However, due to some unique characteristics of transportation data and application needs, many challenges still exist to develop better GIS data models that will improve rather than limit what we can do with different types of transportation studies.

3.2 GIS-T Analysis and Modelling

GIS-T applications have benefited from many of the standard GIS functions (query, geocoding, buffer, overlay, etc.) to support data management, analysis, and visualization needs. Like many other fields, transportation has developed its own unique analysis methods and models. Examples include shortest path and routing algorithms (e.g. route planning, voyage planning, optimisation of the trajectory), spatial interaction models (e.g. gravity model), network flow problems (e.g. traffic flow, container/cargo flow problem, minimum cost flow problem, maximum flow problem, network flow equilibrium models), vessel traffic problems, facility location problems (e.g. set covering problem, maximal covering problem), travel demand models (e.g. the four-step trip generation, trip distribution, modal split, traffic assignment models, and more recent activity-based travel demand models), and land use-transportation interaction models. While the basic transportation analysis procedures (e.g. route planning, shortest path finding, RL/GC sailing) can be found in most commercial GIS software, other transportation analysis procedures and models (e.g. travel demand models) are available only selectively in some commercial software packages. Fortunately, the component GIS design approach adopted by GIS software companies provides a better environment for experienced GIS-T users to develop their own custom analysis procedures and models. It is essential for both GIS-T practitioners and researchers to have a thorough understanding of transportation analysis methods and models. For GIS-T practitioners, such knowledge can help them evaluate different GIS software products and choose the one that best meets their needs. It also can help them select appropriate analysis functions available in a GIS package and properly interpret the analysis results. GIS-T researchers, on the other hand, can apply their knowledge to help improve the design and analysis capabilities of GIS-T. Due to the increasing availability of tracking data that include both spatial and temporal elements, development of spatio-temporal GIS analysis functions to help better understand the dynamic movement patterns in today's mobile world has attracted significant research attention in recent years [17].

3.3 GIS-T Maritime Applications

GIS-T is one of the leading GIS application fields. Many GIS-T maritime applications have been implemented at various shipping companies, maritime administrations, maritime research, education and training institutions, transportation agencies and private firms. They cover much of the broad scope of transportation and logistics, such as infrastructure planning and management, transportation safety analysis, travel demand analysis, route planning, traffic monitoring and control, public transit planning and operations, environmental impacts assessment, intelligent transportation systems (ITS), routing and scheduling, vessel tracking and dispatching (LRIT, AIS), fleet management, site selection and service area analysis, and supply chain management. Each of these applications tends to have its specific data and analysis requirements. A maritime traffic engineering application, on the other hand, may require a detailed representation of individual traffic lanes. Turn movements at intersections also could be critical to a traffic engineering study, but not to a area-wide travel demand study. These different application needs are directly relevant to the GIS-T data representation and the GIS-T analysis and modelling issues discussed above. When a need arises to represent transportation networks of a study area at different scales, what would be an appropriate GIS-T design that could support the analysis and modeling needs of various applications? In this case, it is desirable to have a GIS-T data model that allows multiple geometric representations of the same transportation network. Research on enterprise and multidimensional GIS-T data models discussed above aims at addressing these important issues of better data representations in support of various transportation applications. With the rapid growth of the Internet and wireless communications in recent years, a growing number of Internet-based and wireless GIS-T applications can be found. ECDIS/ECS and Global Positioning System (GPS) navigation systems also are available as a built-in device in watercrafts/vehicles (vessels or boats) or as a portable device. Coupled with wireless communications, these devices can offer real-time traffic information and provide helpful location-based services (LBS). The concept of e-Navigation gives a huge field of new possibilities of applications in this field. Another trend observed in recent years is the growing number of GIS-T applications in the private sector, particularly for logistics applications. Since many businesses involve operations at geographically dispersed locations (e.g., broker/ship chandler/supplier sites, distribution centres, warehouses, terminals, retail stores, and customer location), GIS-T can be a useful tool for a variety of logistics applications. Many of these logistics applications are based on the GIS-T analysis and modelling procedures such as the routing and facility location problems. Transportation GIS (GIS-T) is interdisciplinary in nature and has many possible applications. Transportation geographers, who have appropriate backgrounds in both geography and transportation (and of course in disciplines related to them), are well positioned to continue GIS-T studies [14].

3.4 More Samples of Maritime Applications of GIS Technology

Geospatial Technology (GST or GIS) has become pervasive nowadays in a wide variety of applications. The maritime industry has increasingly applied geospatial technologies such as GNSS/GPS, remote sensing (RS), hydrographic surveying and coastal mapping [20], ports planning and management, and charting, as well as development of a marine spatial data infrastructure (MSDI). The GIS technology in marine transportation is certainly useful in varied areas namely: routing of vessels and the type of vessel, knowing the positions of vessels in real time, mapping and analyzing incidence, selecting new sites and analyzing marine aids to navigation such as AtoNs, signal lights, and other manmade coastal and offshore objects and structures, hydrographic and bathymetric mapping of harbours, approaches, and channels, delineating shipping channels, maritime zones, and marine protected areas, producing, managing and upgrading IMO compliant navigation charts, designing and analyzing transportation networks, and monitoring and analyzing climate patterns and ocean currents [1]. Maritime mapping can also best be accomplished by GIS software [20]. To address the challenges in maritime mapping and charting, the International Hydrographic Office (IHO) has proposed competencies in several spatial related skills such as cartography, hydrography, geodesy, GPS, IMO compliant electronic navigational chart (ENC) and digital nautical chart (DNC) production based on IHO former S-57 and new IHO S-100 and S-101 standards, spatial database management system (SDBMS), GIS software such as ArcGIS and SevenCs, and electronic chart display and information system (ECDIS) [11, 19]. Some examples of software tools used in maritime GIS are ESRI suite of software, CARIS, dKart, and SevenCs.

Amongst several technological solutions that might contribute to the emergence of maritime-based decision-aid systems, integration of Geographical Information Systems (GIS) with maritime navigation systems appears as one of the promising directions to explore. There are several contributions to such a field of maritime GIS: from the real-time monitoring of navigations for a local authority and maritime clients, to the diffusion of maritime data to mobile interfaces, and the development of a relative-based model and visualisation system for maritime trajectories [4].

4 GIS Solutions for Ports and Maritime Transport

Port operators today face increased demands for operational efficiency, effective facility management, comprehensive safety and security, and sensitive environmental management. These diverse challenges require access to detailed, up-to-date information and careful analysis to achieve optimum results. Geographic Information System (GIS) technology provides management solutions that incorporate the position of operator assets to gain a decisive competitive advantage.

There are the following areas of interest (potential fields) for GIS application where GIS can improve port and maritime efficiency [7]: infrastructure and expansion planning, port design, environmental management (storm water management, environmental compliance), facility and utility management, asset and inventory management, maintenance/work order management, utility operations and control, property and lease management, security operations, emergency response and management (spill response and management, and incident tracking), port operations (real-time vehicle and asset location, vessel routing and tracking, berth occupancy and assignment, cargo and berth time calculations, and dangerous cargo display), intermodal management, meteorological monitoring, water depth assessment and visualization, marine navigation, nautical charting, public information (shipping channels location, and restricted area awareness).

5 GIS for Offshore Zone Management

Except of port and maritime applications Geographic Information Systems technology offer also the following applications for coastal and offshore areas, especially for Offshore Zone Management [18, 21].

5.1 Coastal Spatial Data Infrastructure (SDI)

The term Spatial Data Infrastructure (SDI) is now in common use in many countries around the world, although definitions for the term differ quite considerably. The stated objectives of SDI initiatives vary as much as do the definitions, legal mandates, types of organisation responsible for specifying and implementing SDI and actual progress achieved in creating national and regional SDIs. One complication in specifying any SDI is the nature of spatial information, i.e. information with an important location attribute. The visionaries and designers of SDI must accommodate the widely varying information needs of highly diverse disciplines and sectors of society, business and government. Then knowledge of the coastal zone fauna and flora, hydrography, tides and tidal currents, nearby land use practices of industry and agriculture and transport routes, roads, anchorages, fishing areas, wind farms and zones all become intertwined. The complex relationships between various types of spatial information are one reason that countries take different ways to specify their SDI, ranging from visions to strategies to goals to detailed content and implementation plans. We all recognize that the coastal area is a difficult geographical zone to manage due to temporal issues (tides and seasons) and the overlapping of physical geography and hydrography (offshore, near shore, shoreline, inshore), of jurisdictions, legal mandates and remits of government agencies and the often competing needs of stakeholders. Typically, many different local, national and regional government agencies are responsible for different aspects of the same physical areas and uses of the coastal zone, e.g. fisheries, environment, agriculture, transport (inland, coastal, offshore and marine), urban planning and cadastre, national mapping agency and the hydrographic service [12].

5.2 Bridging the Land-Sea Divide Through Digital Technologies

There are many different types of users of coastal zone information, from the casual user who may only want to browse, to the sophisticated user who makes frequent use of mapping and demands continuous improvement. These user communities are diverse in the topics they address, covering such areas as local and regional government, environmental and economic analysis, and also increasingly leisure use. A common mapping framework that bridges the land-sea divide allows users to build applications and decision-making tools necessary to promote the shared use of such data throughout all levels of Government, the private and non-profit sectors and academia. A consistent framework also serves to stimulate growth, potentially resulting in significant savings in data collection, enhanced use of data and assist better decision-making. As well as a physical division, the land-sea divide has also, for many spatial data suppliers, acted as a limit to their area of responsibility, or formed a data product boundary. As a result users wanting to model the diverse aspect of the coastal zone across this divide have had to identify, obtain and combine separate datasets to provide the data coverage they require. The combination process must resolve integration problems resulting from the differing projections, scale of capture and other specification issues of the source datasets. This process can be time consuming, result in inconsistent data and can cause a hindrance to the management of a particularly sensitive environmental zone [10].

5.3 Spatial Uncertainty in Marine, Offshore and Coastal GIS

The dynamic nature of coastal landscapes and the inherent complexity of the biophysical processes operating in these environments challenge the application of GIS methods. It is well recognised that spatial data models representing static objects are rife with uncertainty [8]. However, the mobility of many coastal and marine phenomena and the nebulous nature of boundaries in these environments provide an additional dimension to the problems associated with spatial data uncertainty. In abstracting the infinite complexity of reality into a finite computer based storage structure, multiple levels of uncertainty are introduced. The more encompassing or inclusive a data set, often the more complex the process of abstraction. Users of coastal and marine GIS are faced with both uncertainty in the information derived from spatial data, and uncertainty that inherently exists in the models. The ubiquitous nature of uncertainty in spatial analysis highlights the need to examine the implications for coastal and marine decision-making. This paper examines the sources of uncertainty, methods for assessing reliability, model uncertainty and the cognitive and practical implications associated with the communication and incorporation of uncertainty in coastal and marine [3].

5.4 Visualisation of Offshore Areas

3D landscape visualisation is increasingly used in spatial sciences and planning, including marine, offshore and coastal areas applications. Currently available visualisation tools permit creating highly realistic representations of landscapes based on geodata, such as digital elevation models, aerial photographs, or remote-sensing data. However, in contrast to traditional 2D representations, photorealistic 3D landscape visualisations offer a higher degree of visual clarity, thus contributing to a better understanding of spatial structures and processes and promoting visual thinking. Photorealistic landscape visualisations can be generated with the aid of either pure landscape-rendering systems, which usually do not support interactivity, or real-time visualisation environments.

Methods to visualise landscapes and landscape processes in three dimensions are increasingly used in regional planning. Based on a steadily growing volume of geodata with a high degree of geometrical resolution, such as digital elevation models, topographical data, and aerial or satellite images, today's visualisation environments are capable of rendering landscapes in three dimensions with a photorealistic effect. Compared to conventional two-dimensional maps, these visualisations are more illustrative, enabling the information contained in maps and plans, which is generally abstract and difficult to interpret for nonexperts, to be communicated in a format that is more easily understood. 3D landscape visualisations are of particular interest in the context of integrated Coastal Zone Management and Offshore Zone Management which aims for general public participation to gain acceptance for future protection, preservation, and development measures in coastal areas at an early time [9].

5.5 Application of a GIS-Based Decision Support System (DSS) in the Development of a Hydrodynamic Model for a Coastal Area

Recent advances in numerical modelling of physical processes and field survey technology nowadays allow the development of numerical models with extensive data sets. As a consequence, model developers are facing new challenges to handle the increasing amount of data and its analysis. Furthermore, model development and application concerning coastal areas are heavy time demanding tasks that need tools to assist the researcher. Most of the time they involve analysis of field measured data and its comparison with numerical model outputs. An application of a Decision Support System (DSS) in the development of a hydrodynamic model for a coastal area, as well as description of the DSS components, their interaction, and its GIS capabilities to handle spatial data are presented in details in items [13, 15].

5.6 Developing an Environmental Oil Spill Sensitivity Maps for Offshore

Marine oil spill sensitivity mapping has become widespread. The purpose is to provide oil spill response planners and responders with tools to identify resources at risk, establish protection priorities and identify appropriate response and clean-up strategies. GIS is an important tool in the development of oil spill sensitivity maps and can also be used for presentation [18].

To improve the performance of satellite-based Synthetic Aperture Radar (SAR) oil spill detection and monitoring, in coastal area, a combination of model data and SAR data has been developed. Such concepts may include oil drift components and SAR image models. If a possible oil spill is detected in an SAR image, the GIS-based models are used to try to reconstruct the spill given wind, current and wave height history of the area.

5.7 GIS Applications in Integrated Coastal Zone Management (ICZM)

The emergence of Integrated Coastal Zone Management (ICZM) represents a paradigm shift for a range of practitioners who work in the complex, dynamic area where land meets sea. The structure and implementation of geomatics technologies has been strongly affected by this shift, and GIS/RS practitioners have stepped up to meet the information needs of ICZM by creating coastal information systems featuring increased rigour, openness, and usability. As a result of this forcing, coastal GIS/RS is increasingly differentiating itself from the marine sciences and emerging as a unique discipline. In 2000, Wright wrote: "it may be fair to say that marine applications of GIS have been more in the realm of basic science whereas coastal applications, due in part to the intensity of human activities, have encompassed both basic and applied science, as well as policy and management" [21]. This move towards an integrated approach is being realized in parallel with similar shifts in the approach of other actors in the coastal zone, including scientists, managers and planners. The principles of Integrated Coastal Zone Management make explicit what coastal GIS/RS practitioners have known for years: that the coastal zone is a uniquely complex system that requires new and innovative management approaches. Here we outline the nature of this paradigm shift and the ways in which the authors in this volume have tackled the challenges of applying GIS to the integrated management of the coastal zone. The outcome of these principles is a planning methodology that employs an ecosystem approach to management (considering interconnected elements of the ecosystem) and incorporates adaptive management to deal with uncertainty, variability, and change [18].

6 Conclusion

The development of integrated maritime and GIS systems still requires the integration of different geographical information sources to be combined, adapted and shared in real-time between different levels of users acting in the maritime environment. The development of information and telecommunication technologies brings new and often unexpected possibilities for integrating, analyzing and delivering maritime traffic data within GIS. Integrating GIS information architectures and services with maritime information systems should improve the economic and technological benefits of transportation information by allowing the diffusion of traffic information to a larger community of decision-makers, engineers and final end-users (GIS-T, ECDIS, e-Navigation, e-Maritime, and maritime ITS concepts).

Research challenges are varied: development of cross-domain protocols and exchange standards for the transmission and interoperability of traffic data. Conventional statistical, geographical data analysis and visualization methods should also be adapted to the specific nature of traffic information often associated with large volumes of data. At the implementation level, there is a need for the development of GIS-based distributed computing environment, computational and processing capabilities as traffic data and applications are usually physically allocated in different geographical locations and computationally expensive in terms of the data volumes generated. The diversity of concepts and ideas presented in this paper illustrates the range of opportunities of the integration of GIS and Intelligent Transportation Systems (ITS) for marine transport (GIS-T) and navigation (ECDIS). The Author believes that all these application domains in shipping and marine transport should benefit for this information integration and those methodological findings should be shared and cross-fertilized amongst the research communities active in these fields.

References

1. Baylon, A.M., Santos, E.M.R.: Introducing GIS to TransNav and its extensive maritime application: an innovative tool for intelligent decision making? TransNav Int. J. Mar. Navig. Safety Sea Transp. **7**(4), 557–566 (2013)
2. Bhatta, B.: Remote Sensing and GIS. Oxford University Press, New York (2008)
3. Bruce, E.: Spatial uncertainty in marine and coastal GIS, Chap. 5. In: Bartlett, D., Smith, J. (eds.) GIS for Coastal Zone Management. CRC Press, Boca Raton (2004)
4. Claramunt, C., Devogele, T., Fournier, S., Noyon, V., Petit, M., Ray, C.: Maritime GIS: from monitoring to simulation systems. In: Popovich, V.V., Schrenk, M., Korolenko, K.V. (eds.) Information Fusion and Geographic Information Systems. Springer, Heidelberg (2007)
5. Clark, J.R.: Coastal Zone Management Handbook. Lewis Publishers, CRC Press, Taylor and Francis Group, New York (1996)
6. Ehlers, M.: Geoinformatics and digital earth initiatives: a German perspective. Int. J. Digit. Earth **1**(1), 17–30 (2008)
7. ESRI: Port operators today face increased demands for operational efficiency (2007). www.esri.com. Accessed 12 Dec 2015
8. Fisher, P.F.: Models of uncertainty in spatial data. Geograph. Inf. Syst. **1**, 191–205 (1999)
9. Gabler-Mieck, R., Duttman, R.: Application of geovisualisation techniques in coastal-zone management. In: 10th AGILE International Conference on Geographic Information Science 2007, Aalborg University, Denmark (2007)
10. Gomm, S.: Bridging the land-sea divide through digital technologies, Chap. 2. In: Bartlett, D., Smith, J. (eds.) GIS for Coastal Zone Management. CRC Press, Boca Raton (2004)
11. Hecht, H., et al.: The Electronic Chart: Fundamentals, Functions and other Essentials. A Textbook for ECDIS Use and Training, 3rd edn. Geomares Publishing, Lemmer (2011)
12. Longhorn, R.A.: Coastal spatial data infrastructure technologies, Chap. 1. In: Bartlett, D., Smith, J. (eds.) GIS for Coastal Zone Management. CRC Press, Boca Raton (2004)
13. Mayerle, R., Toro, F.: Application of a decision support system in the development of a hydrodynamic model for a coastal area, Chap. 9. In: Bartlett, D., Smith, J. (eds.) GIS for Coastal Zone Management. CRC Press, Boca Raton (2004)
14. Murray, A.T.: GIS and transportation, Chap. 29. In: Teodorovic, D. (ed.) Routledge Handbook of Transportation. Routledge, Taylor and Francis Group (2016)
15. Populus, J., et al.: Decision-making in the coastal zone using hydrodynamic modelling with a GIS interface, Chap. 10. In: Bartlett, D., Smith, J. (eds.) GIS for Coastal Zone Management. CRC Press, Boca Raton (2004)
16. Raju, P.L.N.: Fundamentals of geographic information systems. In: Sivakumar, M.V.K. (ed.) Satellite Remote Sensing and GIS Applications in Agricultural Meteorology. World Meteorological Organization, Geneva (2003)
17. Shaw, S.L., Rodrigue, J.P.: Geographic information systems for transportation (GIS-T). In: Rodrigue, J.P., Comtois, C., Slack, B. (eds.) Geography in Transport Systems. Routledge, New York (2013)
18. Smith, J.L., Bartlett, D.J.: Meeting the needs of integrated coastal zone management. In: Bartlett, D., Smith, J. (eds.) GIS for Coastal Zone Management. CRC Press, Boca Raton (2004)

19. Weintrit, A.: Handbook on Operational Use of ECDIS, A Balkema Book. CRS Press Taylor & Francis Group, Boca Raton, London, New York, Leiden (2009)
20. Weintrit, A.: Six in one or one in six variants. electronic navigational charts for open sea, coastal, off-shore, harbour, sea-river and inland navigation. TransNav Int. J. Mar. Navig. Safety Sea Transp. **4**(2), 165–177 (2010)
21. Wright, D., Bartlett, D.J.: Working on the frontiers of science: applying GIS to the coastal zone. In: Wright, D.J., Bartlett, D.J. (eds.) Marine and Coastal Geographical Information Systems. Taylor & Francis, London (2000)

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