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Coastal Transport Integrated System: Spatial Database Schema, Metadata and Data Dictionary

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***Abstract*— Co.Tr.I.S. is an under development integrated spatial information system for the optimal design of coastal transport lines. This paper presents the spatial database schema of the system, the metadata and data dictionary. The conceptual database design is based in an innovative set of rules which may be applied at any coastal transportation network.**

***Keywords*—coastal transport modeling, medata, data dictionary, spatial database schema**

I. Introduction

The aim of this paper is to present the spatial database of Coastal Transport Integrated System (Co.Tr.I.S.), the spatial data base schema, the metadata and the data dictionary. Co.Tr.I.S is developed in the frame of a research project co-funded by the European Union and the Greek Government and will contribute to a more effective design of coastal transportation lines in Aegean Sea, Greece.

Any Information system (IS) is based in a set of databases. The database development is realized with a Data Base Management System (DBMS). The initial step is the users needs analysis, the entities list development, the identification of their relations and attributes. Based on this information we create the conceptual model or schema of the data base(s) (Gemino, 2005, Batra, 2005). Co.Tr.I.S conceptual database design is based in an innovative set of rules describing the coastal transportation network.

In the second section, a summary of current costal transport system in Greece is presented. The third section discusses the methodological framework of the system. Fourth section includes the innovative system's rules concerning costal transportation. Spatial database schema is based on those rules. Fifth section presents system's spatial databases metadata and the data dictionary. The last section concerns some concluding remarks and future work.

II. Description of current costal transport system in Greece

The current coastal transport system in Greece faces different and complicated problems.

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These problems arise from the fact that there is an extended network of islands and ports. The majority of them are geographically scattered in small distances in the Aegean Sea (Lekakou et al., 2002). Moreover, coastal lines annually manage a large volume of passengers, vehicles and goods which has a greater intensity in the summer months (Psaraftis, 1992).

The coastal network consists of a number of lines, which fall into one of the following categories (Sturmey et al, 1994; FEK, 2014): a) Main lines: they originate in Piraeus and connect ports in different provinces, b) Secondary lines: they originate in ports other than Piraeus and connect ports in different provinces, c) Local lines: they connect ports in the same province. A number of main lines, -the so-called 'thin lines' - are not profitable and cannot be served by independent operators without substitution from the Greek government.

Those problematic situation integrates technical issues regarding infrastructure, but also institutional, regulatory and strategic issues and characterize the Greek coastal network system, affecting everyone who lives, works or visits the islands.

III. The methodological framework

A. *System description and Methodology*

Co.Tr.I.S. is based in a Geographic Information System (GIS) software and add-on traffic management applications. The system design is based on MECOSIG method (Pantazis and Donnay, 1996) and an innovative approach combining network (vector) analysis and spatial analysis of raster surfaces (e.g. representing the cost) (Pantazis, Stratakis, Karathanasis and Gkadolou, 2013). Coastal transport networks are stored in a geodatabase using a custom transportation data model (see system's rules). The data model allow maintaining all aspects of the coastal lines transport networks such as one way-two way rules, inter-island transport lines configurations, intersection attributes and geometry, passengers, cars, trucks or goods transport and other modes and schedules (Pantazis et al., 2013). Relationships between the coastline networks are automatically managed enabling true multimodal networks. The system's users are divided into five different categories (groups). Each group will use a slightly different version of application that is adjusted to their needs. The users are: Local Authorities, Ship-owners union, Coastal lines companies, Ministry of Marine and Aegean and Passengers.

IV. System's rules and Spatial Database Schema

The initial analysis of the system, establish the methodological framework in which was based the spatial database schema. The developed set of system's rules had been transformed into relations between the spatial entities of the database. Those rules are presented below:

1. In practice / or in the reality is impossible to exist direct connections (by shipping lines) from any port to all other ports.
2. The term **"direct connection"** means the arrival in the destination port from the departure port without any intermediate stop.
3. The term **"intermediate stop"** or **"intermediate destination node"** is the place where a ship stops for embarking/disembarking of passengers/loads. It is situated between the departure and destination ports.
4. It is essential to exist local/intermediate itineraries from smaller ports to bigger ports and vise versa.
5. The term "**local/intermediate itinerary**" is the one serves small nodes with low number of passengers/loads/cars.
6. Any connection between nodes can considered as **"local/intermediate itinerary"**. This term is an additional explanatory term.
7. The term "**small node**" is related to its port infrastructure.
8. It is essential for the implementation of rule number three (3) the existence of **"connection shipping lines"** between main and local costal lines.
9. The term **"small port"** refers to the term **"small node"**.
10. The **"ports"** are defined as "**nodes of departure,** or **nodes of destination,** or **nodes of intermediate destination,** or **nodes of final destination**".
11. **"Initial departure node"** is the port of the initial departure of the ship.
12. **"Destination node"** is the port which consists the last station that the ship reach for the first time.
13. **"Final destination node"** is the port where it is not possible to have immediate and simultaneous embarking/disembarking of passengers/loads/cars, but there is a waiting time in between (defined as **"time delay"**).
14. The **"Destination node"** may be the **"Final destination node"**.
15. The term of **"Auxiliary node"** refers to points in the see where the navigation direction of the ship change.
16. **Ports (nodes)** are classified in different categories based on specific parameters (size, capacity, depth etc.).
17. The term **"Main shipping line"** refers to the distance between the initial node (departure node) and the final node (node of final destination).
18. The term **"Partial shipping line"** refers to the distance between two nodes where at least one of them is not departure node or final destination node.
19. One shipping line can include from 2 to N nodes.
20. A node may be the start (**Initial departure node or Intermediate destination node**) or the end (**Final destination node, Destination node, Intermediate node**) of 0 to N partial shipping lines.
21. The departure node may be a destination node as well.
22. Two nodes define minimum two partial lines (e.g. nodes A and B define the partial lines AB and BA). If a ship travels through those nodes set for a third time continually, a new partial line is defined (ABt3 or BAt3).
23. The term "**itinerary**" refers to the service of a shipping line from a specific maritime company, using a specific ship, at a specific time, at a specific ticket price (for every single passenger type and vehicle). Every single change to one of these parameters means that there is a new itinerary on this specific shipping line.
24. A shipping line may be serviced by one or more itineraries.
25. The itineraries are executed from specific maritime companies, at specific timetable of departure and arrival time to the nodes that are included at the itinerary.
26. In order for a node (port) to be a part of a shipping line, it must be either a departure node, or a destination node, or final destination node, or an intermediate node.

The conceptual schema of the spatial database (Figure 1) is based on an enriched entity relationship model with a) pictograms ([.], [/], [O]) for each type of spatial entity and b) with the graphic attributes of the spatial entities for lines (line color, line width, line type), points (symbol color, symbol size, symbol type) and polygons (outline color, outline style, outline width, Fill symbol type, Fill symbol color, Fill symbol size). Based on the previous system rules, the entities where defined with their attributes and classified in spatial (with graphic georeferenced representation) and alphanumerical.

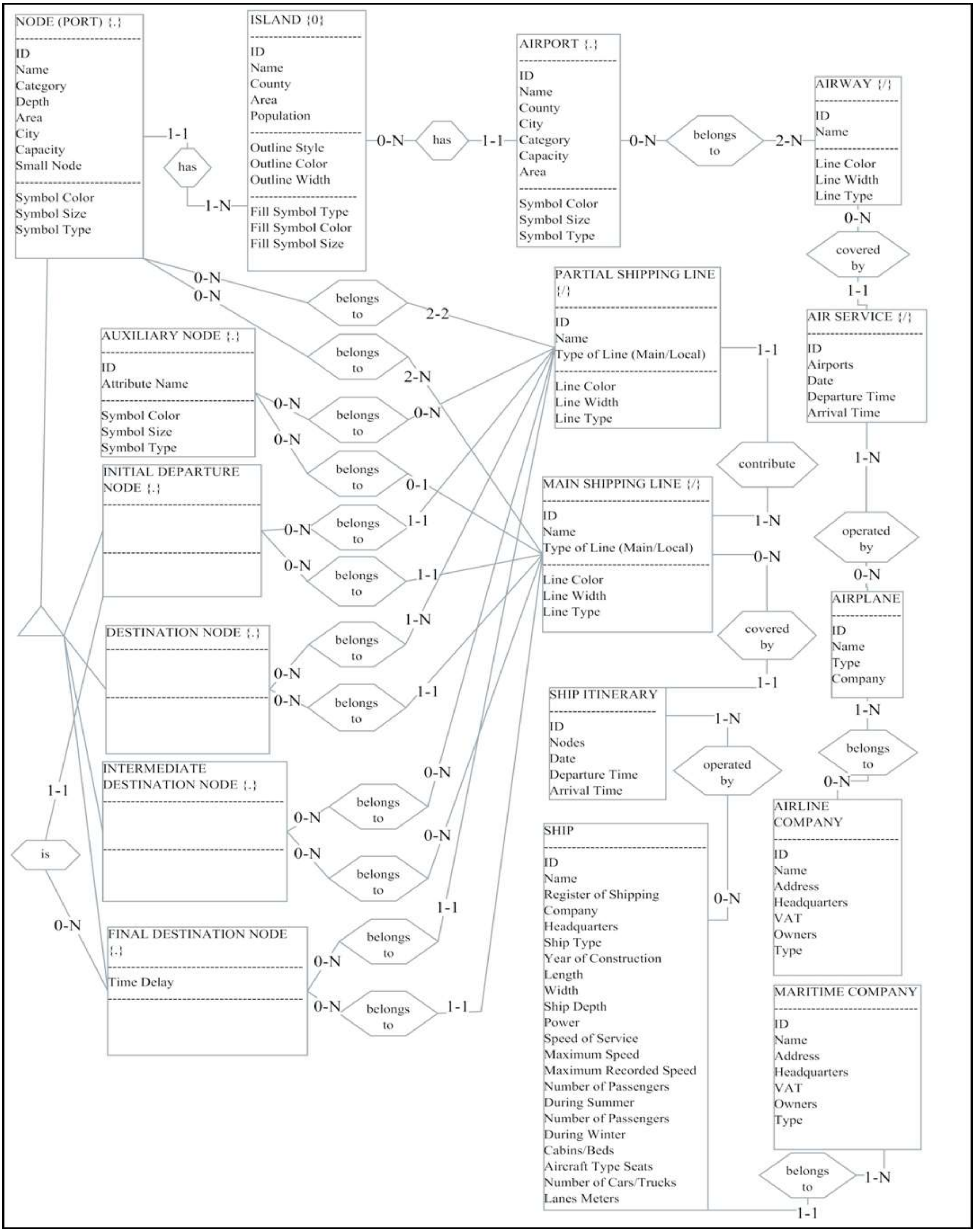

Figure 1. Spatial Database Schema

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The suggested conceptual model includes: Eleven (11) spatial entities which include three (3) line entities, seven (7) point entities and one (1) polygon entity, Six (6) alphanumeric entities, Twenty four relations (24), Forty eight (48) relationship numbers. In the Figure (1), it is presented the spatial database schema that was created with DBmain V. 9.16 CASE (Computer Software/System Engineering)-tool.

V. Metadata and Data Dictionary

Co.Tr.I.S spatial data documentation follow the metadata standards proposed by the International Organization for Standardization (ISO 19115). ISO 19115 defines more than 400 metadata elements for the description of the geographic information. Co.Tr.I.S. use metadata editor of ArcGIS 10 software that supports the above mentioned standard. The metadata used, are the minimum required core elements for spatial data and include: Identifier, Title, Author, Date, Type, Summary, Description, Topic, Scope of the data, Distribution format, Dataset language, Spatial Representation type, Geographic extent, Spatial Reference and Scale of the resource data.

There are no official directions or standards on the structure of a data dictionary. A data dictionary is a subset of the entire metadata set. However, in some cases, modifications of the existing metadata or creations of metadata specific to the dictionary are necessary (Pantazis et al, 2002). The main assets of a data dictionary are its flexibility (in comparison to the complete metadata set), and its easiness of access for the end user (Pantazis et al, 2002). While most real world elements have a commonly accepted cognitive meaning, their representation in (spatial) databases requires a precise and unambiguous semantic definition. This definition is different from the (geo-) graphic (spatial) object's definition in the database (e.g. the real object is different of his representation). Co.Tr.I.S. databases dictionary mainly concerns the potential end users. The focus is on the comprehensive help that a database dictionary can provide to the end user. The main difficulty was to balance between the contradictory requirements of exhaustively and of minimal information. The dictionary's selected elements are (figure 2): a) Type: type of geographical implementation (point, line, polygon or any combination of this types). The type is described by a text and a pictogram. b) Name: name of the object, should be unique. c) Real object definition: description of the corresponding object in the real world. This textual definition must be illustrated by a scheme, a photo or any kind of visual information that can help to understand the object. d) Identifier (included in the logical attribute): characteristic that allows to identify strictly each instance of the object. Usually this attribute is a numeric integer. e) Logical attributes: all the alphanumeric (non geometric) attributes describing the object's instances f) Graphic attributes g) Example of graphic representation, h) Definition of the graphic representation of the object: description of the graphical representation of the object. This description is textual and visual using real example of the database. i) Sources and /or digitalization process: origin of the data (document, property, etc.). Co.Tr.I.S. is not a static system; in the same way, the proposed dictionary is not a static tool too, nor a definitive product, it is an evolving one.

The dictionary is not complementary to another document e.g. a conceptual data model, or to another metadata set, or to the database itself. In this sense, the dictionary is an autonomous document, in our specific case. Nevertheless, the dictionary is not an independent document, for it cannot exist by itself. The database dictionary is related with the database: modifications to the database imply modifications to the data dictionary. This is a feature common to every dictionary (Pantazis et al. 2002).

Type of spatial entity: Simple point {.}	**Name of entity:** Node (Port)

Real object definition:
Node or port is a location on a coast or shore with facilities where ships can dock and transfer people, vehicles or cargo to other ports.

Logical attributes

	Type	Range	Example
ID	Alphanumerical	10 digits	02112
Name	Alphanumerical	30 characters	Piraeus
Small node	Yes/No	3 characters	Yes
Category	Alphanumerical	6 digits	International
Area	Alphanumerical	30 characters	Attica
Capacity	Numerical	3 digits	20

Graphic attributes:
Symbol color
Symbol size
Symbol type

Example of graphic representation in database:

⊕

Definition of the graphic representation of the object:
Symbol in the center of the port area

Sources and /or digitalization process of spatial entity:
Digitization as a point

Figure 2. Example of Co.Tr.I.S. Dictionary

VI. Concluding remarks and future work

The optimal design of coastal transportation lines is a complex, interdisciplinary and multidimensional problem especially when it concerns an important number of no similar capacity's ports. In order to give solutions to this problem, an integrated spatial information system, named Co.Tr.I.S., is under development. The presented system's spatial database schema, is based in an innovative and original set of rules concerning the coastal transport. The necessary metadata and the data dictionary were also summarily discussed.

Future work, includes the Co.Tr.I.S. process development and its operational implementation from its potential users. It is expected, that the final version of Co.Tr.I.S. will contribute to: a) the optimal design of coastal lines b) the improvement of the relative decision making process c) the visualization of the spatial information required for the optimal design of the coastal lines. Co.Tr.I.S. may be considered as virtual platform of a Game board. In this context, optimization of coastal network design is the process of selecting unique combinations of port and lines. The optimization process is assisted by the sales' man problem concepts, the Games theory's elements, Nash equilibrium and spatial analysis.

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