Information technologies in the ports management: geographic information systems (GIS)
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Abstract

Port management needs tools to manage its territory. Geographical Information Systems (GIS) is a general purpose technology that can be adapted to manage Port space. Also GIS has capabilities in the fields of design, analysis and simulation, features that are being used in some Ports.

1 Introduction

In order to improve management of Port space and to increase decision-making capacity, the Port of Barcelona has decided to computerise the spatial representation of its physical area. To this end, it is implementing programs based on Geographical Information Systems (GIS).

GIS represents a group of technologies with more than 20 years of theoretical background and less than 10 years of real application in the business world. GIS are made up of a compendium of cartographic information, spatial-analysis techniques, image-processing techniques, digital cartography, relational and hierarchical data bases and computer-aided design (CAD) programs.
GIS can provide answers to common questions that arise in the management of a territory such as a port area:

1. What is the location of a particular lease?
2. What is the draught of a particular port basin?
3. Where is there space for a new lease with specific physical dimensions and for a specific date?
4. Where is a particular fire-fighting device located?

Normally, these questions can be immediately answered by a port manager. The following questions, however, are not so easy to answer:

1. What goods are located at a distance of less than 100 m from a container with hazardous material?
2. What is the performance of a particular wharf, considering the investments made by both the Port and lessees, the cargo handled on the wharf and the vessels that berth there?
3. What effect will a new lease have on road and rail traffic?
4. Where should future fire-fighting elements be located?
5. Which leases will be affected by the construction of a railway line?

The answers to the first set of questions are or should be known by the people directly responsible for managing each area. However, answers to the second set of questions require a pooling of information from different departments and access to spatial-analysis tools.

At a time when process re-engineering is attempting to recover the dispersed know-how hidden in different departments and when there is a need to pool information, GIS are appropriate tools.

At present, the use of this technology in ports is limited to maintaining basic cartography, controlling dredging and managing container loading and discharging. There are other areas where GIS can facilitate operations management, but the use of its graphic analysis and synthesis capabilities is becoming increasingly relevant.

GIS is not CAD. At first glance, GIS can be confused with CAD systems. It is true that both systems have many characteristics in common, such as software for representation of geometric elements, choice of elements to be viewed in certain circumstances and consultation of associated alphanumeric attributes. What, then, distinguishes GIS? On one hand, the incorporation of a complete relational data base and, on the other, its functions based on the spatial relationships of elements, which allows it to answer questions (some of which appear simple at first sight), such as what buildings are located on a specific lease and other, more
complex questions, such as which leases are within the risk area of a particular accident. For example, to answer the latter question, it is necessary to a) know the locations of the leases and b) determine the scope of the risk area according to the characteristics of the incident and the weather conditions, and c) superimpose both areas to obtain an alphanumeric or geometric list of the affected leases.

2 Territorial Responsibilities of a Port Authority

A port is an interface between different modes of transport and is defined by the limits of the area under its jurisdiction. The port authority is responsible to society in general and the public administration in particular for the management of this area.

These are some of the responsibilities of the Port of Barcelona which stand out due to the size of the territory in question:

- Planning and ordering the area.
- Managing vessel traffic.
- Infrastructure design and construction.
- Maintaining the facilities in good condition.
- Granting leases.
- Invoicing for services rendered.
- Safeguarding people and facilities.
- Conserving the environment.

3 Aspects which Require Management Based on Geographic Location

In any activity or management carried out by a port authority, the spatial component is especially important.

The different prices for services rendered contain aspects related to the use and operation of infrastructures and land. For this reason, prices can be reflected on a map. Maritime signposting, entry and stay of vessels, berthing, cargo and passengers, gantry cranes, warehousing and supplies.

1. Management of a port’s fixed assets can be improved by representing the distribution of investments in port space.
2. Security services need to be able to identify locations and take action when incidents occur, manage emergency resources and have the equipment to take preventive action and perform simulations.
3. Leases require spatial administration.
4. Infrastructure maintenance, dredging, etc.

4 The Need to Incorporate Gis in Regular Management Processes

It is common for port authorities to incorporate computer hardware and programs to provide support for the operations and responsibilities of each department (berths, leases, invoicing, accounts, etc.). These items are normally classified using alphanumeric management. What occurs in many cases is that this management does not contain the port’s spatial model, is not interpreted uniformly or is undermined by the lack of a direct relationship between the codes and territorial entities. If territorial representation is added to this management, two important improvements are obtained: the reliability of the information is increased and managers are able verify that information.

Improving the reliability of this source data makes it possible to increase confidence in levels of analysis and decision-making. Geographical reference takes on its full relevance at these levels.

5 The Use of Gis in the Area of Analysis & Decision-Making

The intrinsic complexity of decision-making processes makes it difficult to establish a specific, uniform methodology for all port authorities. It depends on factors such as the specialisation of a port and the objectives specified. Even so, port management requires synthesised information to be able to monitor the progress of a port and to establish management goals for the future. When carrying out this responsibility, it is common to use statistical tables containing the main indicators of the port. What added value can be provided by applying GIS in the area of analysis and decision-making?

Representation of some of these indicators in a geographical context and on the right scale, i.e., when calculating the total goods discharged in a port, it is useful to make a comparison with ports in direct
competition for the same foreland or hinterland. However, when it is necessary to determine the performance of leases, it is more useful to represent these data on a map of the port. If the dimension of time is added to these thematic maps, a better understanding of the port’s global figures is obtained.

GIS offer a set of tools for obtaining an aggregate representation of these data on the desired geographic scales (hinterland, foreland, port), which demonstrate their use in the area of decision-making.

Also, there has recently been a shift in design and planning processes from using estimation techniques to using simulation techniques, i.e., a response to "what if" questions. If simulation is carried out in a spatial scenario such as a port, a dynamic image of future proposals can be obtained. However, to obtain a true model, the parameters of the model need to be calibrated. This calibration can be greatly facilitated by the data obtained from monitoring port activities. For this purpose, a system is required which is capable of obtaining data continuously and on a large scale. For example, when designing the communication routes of a port, a prior simulation should be made of the traffic flow generated by future leases, based on current data and trends according to type, location, permanence, etc.

### 6 Applications

#### 6.1 Berth Management

Berth management is a function specific to port authorities. In carrying out this function, the people responsible combine knowledge of the geographic characteristics of the port and its particular status in a specific period of time with the berthing requests of users. It is the responsibility of the port authority to assign a berthing area to each vessel that requests one.

The berthing department receives a request for a berth from a user, specifying the name of the vessel, the date and time of arrival, the wharf and approximate position where the vessel wishes to berth, the type of cargo to be loaded or discharged, resources required for the operation, length of stay of the vessel in port and other movements of the vessel within the port. It is the responsibility of this department to compare the details of the request with the physical characteristics of the port (especially water depths) and the condition of different port elements
occupancy of the berthing line, use of cranes, water connections, mooring posts, ramps, etc.).

GIS application in berth management in the Port of Barcelona makes it possible to represent berth requests and authorisations on spatial and temporal maps. This not only allows for daily monitoring of the vessels in the port, but also makes it possible to view the occupancy of the wharves on a particular day or during a specific period of time.

Current management is based on a combination of the log of wharf occupancy by vessels and a icon representation to scale of port wharves and vessels. The status of the vessel in the information system (request, authorised, in port, about to depart) is represented by different colours. If a temporal representation of the past or scheduled occupancy of the wharf is required, the wharf-time diagram can be generated.

6.2 Lease Management

Lease management is one of the areas of responsibility most characteristic of certain types of ports like the Port of Barcelona. Many of the traits which define a lease are based on its location. The price per square metre is directly related to proximity to wharves and to road and rail access. At departmental level, it is helpful to know the location, the area occupied, the type of cargo handled, the contract conditions, the expiry date and which property elements will revert back to the Port when the lease expires. It is also useful to be able to see some of these attributes summarised in a cartographic representation, especially the attributes which reflect differences in profitability.

These are some of the basic objectives of applying GIS in the Port of Barcelona:

1. Graphic representation of the space used and the space available for leases within the port.
2. Access to alphanumeric data on a lease for purposes of management or statistics.
3. A printout of a location map for each lease, showing its most important characteristics.
4. A printout of thematic maps summarising aspects relevant to leases: expiry date, charges, etc.

6.3 Traffic Simulation

The traffic generated by modal interchange of goods is also an important aspect in the design and operation of a port's internal and external
communication routes. In the present and future, where maximum and optimum operation of port resources is required, attention to factors which alter the composition and regulation of traffic is vital.

The characteristics of traffic in a port are determined by the amount and type of goods, the dimensions and characteristics of the road and rail network, regulation characteristics, port operating hours and congestion of the main arteries which connect with the port. The flow of traffic depends not only on the size of the network, but also on its design and regulation.

For this reason, the Port of Barcelona, together with the Universitat Politècnica de Catalunya, has initiated a project with the following goals:

- To obtain quantitative and qualitative information on the characteristics of the traffic generated by port activity.
- To identify points inside and outside the Port where bottlenecks occur.
- To propose improvements in the design of the Port road and rail system.
- To propose automatic metering systems to monitor the volume of traffic.
- To design a system which allows for simulation of the impact on traffic of installing new facilities and leases.
- To obtain information on the relationship between internal and external traffic in order to simulate situations and propose alternatives.

7 New trends

GIS applications are driving to new areas of development. Mainly are:

1. Web applications: Berthing on-line for examples. Port of Barcelona it will publish berthing in a near future. You could visit our web site at the address: http://www.apb.es. You are welcome.
2. Standard Interchanging promoted by international organisations such as International Hydrographic Organisation, and information designers such as Microsoft, Smallworld, ARC-INFO, Intergraph, ...
3. Real time delivering cartography of port plan to ships using ENC encoding.
4. GPS positioning of ships, cranes, containers.
8 Reflections for Implementing Gis

- Geographical Information Systems constitute a powerful tool for management, analysis, simulation and decision-making in a port authority.
- The data base of territorial information is expensive to maintain, but completely necessary to guarantee the consistency and integration of the information.
- Applying GIS in port management is useful on several scales: Internal port space, hinterland and foreland.
- GIS is a generic tool. To obtain the maximum yield from it in a port authority, it is necessary to incorporate the knowledge specific to the management of a port. It is necessary to know the questions it will have to answer and to implement the right data structure, as well as develop the right interfaces.