CHAPTER - V

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5.1 INTRODUCTION:

Transport networks are built on territorial areas and these networks are used for the movement of people, goods and energy. The form, capacity and efficiency of these networks make a considerable impact on our quality of life and they affect our perception of the world. When GIS are applied to transport, this is more than just a sphere of application of their generic functionality. Given the importance that their different applications to this particular field have acquired, in the Anglo-Saxon world a specific term has been coined called GIS-T (GIS for transport), integrating modeling, handling and data analysis processes that are not always included in conventional GIS [1].

When creating geographic databases in GIS-T, it is necessary to incorporate in-depth details, in the form of metadata, on the information being stored. This metadata documents database information that facilitates the identification of the data stored there. Metadata means comprehensive, systematic, deductive information on the contents, structure, relations, representation and context of the data stored in a database.

In the field of GIS-T, importing data is also considered one of the main sources of information for the creation of geographic databases. To this effect, big efforts have been made to establish geographic information standards for this particular field. The GDF (Geographic Data Files) format is a European standard used to describe and transfer information on road networks and on any associated data. It is much more than a generic GIS standard, because GDF give rules on how to capture the data, the type of features to store and the attributes and relations that must be defined. GDF was developed thanks to a technological research and development project known as EDRM (European Digital Road Map). Its initial use has been directed at vehicle navigation systems, with the participation of firms like Bosch, Philips and Volvo. Its applications are also well suited to ITS (fleet management, traffic analysis, route control etc.). Numerous firms (EGT, Bosch, ETAK, TeleAtlas etc.) and public bodies (the European Union) promote the use of the GDF format. On an international level there are other geographical data formats for the field of transport: the North-American Spatial Data Transfer Standard (SDTS) or the Japanese Data Standard (JDS).

During the last few years, the application of information technologies to the field of transport has led to the emergence of the well-known Intelligent Transport Systems (ITS). ITS use DBMS and GIS as instruments for the creation, management and analysis of geographic databases. ITS require efficient, accurate linear reference systems, able to represent the elements involved in a transport network. With ITS, the temporal component of geographic information also needs to be included in spatial databases so that applications can be carried out in real time.

Creating geographic databases for GIS-T is one of the most costly tasks, financially and from the perspective of time. Firstly, topographic bases have to be created for the transport infrastructure. Secondly, thematic attributes are compiled, providing information on the transport infrastructure and on the traffic flows carried by the latter. An extremely large amount of data is needed because information is required on a relatively large scale and the attributes vary continuously over the course of time. GIS-T have different sources of information: conventional ones, remote sensors, topography, GPS, aerial photos and data imported from other sources.

Three generic fields in which GIS have been applied to transport can be distinguished viz.,

1. Transport Planning,
2. The Management of Infrastructure and
3. Fleet and Logistical Management.

The first two areas are traditional fields for GIS technology and they have been continuously developed since the initial emergence of GIS. The third area, fleet and logistics management is the most recent and it is associated with the sudden emergence on the scene of ITS [2].

5.2 TRANSPORT PLANNING:

The application of GIS to transport planning is an extensive field of development, facilitating long and mid-term decision-making.

5.2.1 Accessibility Studies:

Accessibility is a key element to transport geography, and to geography in general, since it is a direct expression of mobility either in terms of people, freight or information. Well-developed and efficient transportation systems offer high levels of accessibility, while less developed ones have lower level of accessibility.

Accessibility is defined as the measure of the capacity of the location to be reached by, or to reach different locations. The notion of accessibility relies on two core concepts: The first is location where the relativity of places is estimated in relation to transport infrastructure, since they offer the means to support movements. The second is the distance, which is derived from the connectivity between locations. Connectivity can only exist when there is a possibility to link two locations through transportation.

There are two spatial categories applicable to accessibility problems, which are interdependent:

The first type is known as topological accessibility and is related to measuring accessibility in a system of nodes and paths, that is a transportation network. The second type is known as contiguous accessibility and involves measuring accessibility over a surface. Geographic Information System can be used to measure potential accessibility, notably over a surface [3].

5.2.2 Multimodal Transport Analyses:

GIS prototypes have been developed to design balanced networks for the transport demand, thus highlighting their capacity to offer a realistic representation of multimodal traffic. GIS ensure the integrity of geographic databases, incorporating information on different modes of transport. Thanks to their use in this field, it will be possible to develop complex financial models able to estimate the cost of the combined use of different types of transport [4]. One example is the estimation of the additional cost of combined transport in Europe using three modes of transport: rail, road and cargo ships. The Winsconsin Department of Transport in the USA has developed what is known as the *Commodity Information Management System* (*CIMS*) to model the state's transport. The CIMS makes it possible to simulate transport scenarios based on the route, type of transport and vehicle characteristics, together with an analysis of these scenarios and the generation of maps and reports [5].

5.2.3 Integral Transport Planning:

In 1993, there was a pioneering United States initiative in the field of GIS for transport management and planning in a multi-jurisdictional, multimodal environment. This was the GIS-T/ISTEA project (United States Intermodal Surface Transportation Efficiency Act), integrating 41 US states, the provincial transport departments of the district of Columbia in Canada and nine private companies. The project proposed the development of a GIS-T architecture that could be adapted for the planning and management of transport infrastructure including pavement and bridge management, safety and traffic congestion control, public transport management, intermodal management, traffic management and the control of atmospheric pollution [6].

5.2.4 Assessing the Environmental Impact of New Infrastructure or Policies:

Another important area of development is the use of GIS in transport planning and in assessing the potential environmental repercussions of certain action [7]. In this field, by combining GIS with virtual reality techniques, an evaluation can be made of the potential impact on the landscape that road infrastructure will have. With these technologies; geographic databases can be used to create virtual worlds. This means that a detailed analysis can be made of proposed infrastructure's potential effects on the land, so that the impact on the landscape can be assessed.

5.2.5 Pollution Control:

Different United States transport departments, together with local operators and private companies, are working on the development of a GIS-based congestion management system. System is based on statistical optimization techniques, transport models and atmospheric pollution models. It proposes an integrated model for environmental protection [8].

5.2.6 Risk Planning and Management:

Transporting Dangerous Goods: Another area of development is the application of GIS to route planning for heavy goods vehicles and vehicles transporting dangerous materials. At the University of Texas-El Paso an application has been designed for the Texas Department of Transport to automate the generation of routes for heavy goods vehicles, choosing the best route depending on the resistance of bridges that the vehicles must cross and the characteristics of all highways to be used.

5.2.7 The Construction of New Roads:

GIS are being used as a support in decisions regarding the construction of new roads. GIS makes it possible to analyze the effects of new infrastructure on area's accessibility, optimising the paths they take and minimizing the environmental and visual impact that the new roads might have.

5.3 INFRASTRUCTURE AND SERVICES MANAGEMENT:

The tasks involved in the management of transport infrastructure require highly detailed information on the said infrastructure, i.e. on road networks, street layouts, railway networks, river transport systems, airports, airlines etc. In fact GIS applications for this particular field of activity need detailed representations of the networks' geometry and their connections, together with the knowledge of numerous attributes associated with them. Management applications are more directed at the maintenance of geographic databases, map production and the generation of quality control reports than at data analysis.

This type of application facilitates mid-term decisions on the planning of infrastructure [9].

5.3.1 Road and Motorway Management:

Transport bodies use GIS to look after and maintain the transport infrastructure under their control and to keep it in good condition. GIS are being increasingly used to manage and plan urban transport networks. In San Diego, for example, they make it easier to keep an inventory of the city's transport networks and they facilitate the development of models to improve vehicle traffic.

5.3.2 Railway Network Management:

Railway transport is a sphere of application where GIS have a great deal of potential. There are many examples of ways in which they have been applied, both for the management of infrastructure and for planning and operational control. Studies carried out in real time. As a result of initiatives by the World Bank and a team of Indian railway officers, the Long- Range Decision Support System (LRDSS) was created. The aim of the LRDSS is to develop a GIS for the planning of India's railway transport system.

5.3.3 Airport Management:

GIS's are also being used to manage airport infrastructure, particularly for the management of certain areas of the airport and for communication networks. They are also used to prevent aircraft noise and its effect on areas close by airports. Likewise they are used to coordinate vehicle arrivals at the airport and to provide them with adequate parking facilities [10].

5.4. FLEET AND LOGISTICS CONTROL - INTELLIGENT TRANSPORT SYSTEMS (ITS):

This includes operational control applications characterized by their ability to manage information on transport infrastructure in real time. Their objective is to facilitate short-term decision-making. Included in this section is the application of GIS to ITS. In a short space of time ITS have incorporated geographic information technologies (GIT) as basic methodological instruments. The incorporation of GIS and ITS represents one of the greatest opportunities for industry and for professionals working with GIS.

ITS give priority to the use of real-time systems, involving the acquisition of data by means of remote on-line sensors, interactive communications, processing and distributed computing. GIS can be applied to all ITS applications. Much of the information processed by ITS is spatially referenced dynamic information (e.g. the volume of traffic, congestion, incidents etc), but information is also needed to indicate the location of facilities and infrastructure. More specifically, geographic databases are needed to assist in navigation, i.e. with basic data on the layout of the infrastructure and its characteristics. With this as a base, using different types of sensors it is then possible to manage and optimize vehicle flows and the movement of fleets, passengers or merchandise. The visualization of real-time geographic data via the Internet hugely increases the potential of GIS and ITS, not only from the perspective of being able to communicate a certain subject to millions more users but also by making this communication process much easier. Internet and geomatics are playing an increasing role in information technologies. The development of Internet-based distributed computing techniques facilitates access to geographic databases, whilst also offering remote access to GIS functionalities. In ITS-based fleet control and management, GIS make many different applications possible, including route planning, vehicle navigation systems, meteorological hazard control, vehicle fleet control, emergency management, tourist information systems, passenger assistance systems etc.

5.4.1 Route Planning:

One of the most widely used applications in the field of GIS-T is route planning. GIS make it possible to plan journeys and find the best route by road, rail, air, bicycle and public or private transport. They even make it possible to plan routes that combine different means of transport or that make optimum use of different criteria, such as the journey time, financial cost, and cultural or ecological value of the route etc. Optimum routes are found in cities, regions, countries, continents or on a global level. Even in countries with badly defined road networks and cities with complex urban structures, optimum route models are proposed on different regional and urban scales. Real-time route planning is one application that is beginning to be introduced by public and commercial transport companies in order to minimize costs and maximize the service given to citizens.

5.4.2 Car Navigation Systems:

Using GIS in conjunction with GPS not only offers a spatial vision of journeys but it also includes the time variable [11]. GIS define queries and tables of attributes, and they draw up digital maps with data relating to the journey time along motorways. The joint use of GPS, with direct, real-time information on the speed and direction of vehicles, and GIS-administrated databases creates an efficient system for monitoring the vehicle, as indicated by the Australian Transport Systems Centre. In all cases, this type of system needs digital maps as a base on which moving vehicles can be plotted. With this in mind, the EU NextMAP project was created to define, design a prototype and assess the contents of digital maps required by vehicles with ITS applications, particularly Advanced Driver Assistance Systems (ADAS) [12].

5.4.3 Meteorological Hazard Control:

Meteorological conditions play a very important role in transport planning, management and control. By using GIS, this type of information can be included in route planning. One example is the model introduced in the United States by the Union Pacific Railroad, which supplies real-time information on the meteorological conditions of areas where rail transport will pass. These systems incorporate warning mechanisms to prevent catastrophes and avoid unnecessary fuel costs.

5.4.4 Traffic Control:

To control the traffic GIS databases must include the temporal component of geographic data. An important area being developed by the Department of Urban Studies & Planning of the Massachusetts Institute of Technology is the use of multimedia techniques and GIS to improve the interfaces of transport applications. Worthy of mention is the work carried out by Michael J. Shiffer (1999) to develop prototypes for traffic control systems. The National Transit Geographic Information System (GIS), created by the North-American Federal Transit Administration, includes an active inventory of transit operations on the country's public transport routes. The information helps to rationalize decision-making in transport policies and planning. This work is being carried out in collaboration with Bridgewater State College's Geographic Laboratory via the digitalization of public bus routes (http://www.fta.dot.gov/research/fleet/its/gis.htm).

Lyons, McFonald, Bunford (1998) indicate, one big field of research, with applied examples, is the incorporation of travel information onto the Internet, transforming it into intelligent travel data for users and planners [13]. Travel information is dynamic and interactive, and having this information makes it possible to improve the traffic conditions in cities. Also, in the near future, it will help drivers to select the best route before beginning a journey.

The Hampton Roads Traffic Information system, for example, assigns different colours to different road sections depending on the fluidity of the traffic or its congestion (http://www.vdot.state.va.us/roads/tunnel.html). Likewise, traffic conditions can be combined with tourist information, as occurs at the Real Time Traffic Disneyland Area website (http://www.anaheim.net/dept). Some systems are interactive, like the Athens Real-Time Traffic Congestion Map (http://transport.ntua.gr/map/). Other more advanced modalities integrate Internet into the driving process, like the Internet Car concept. The car integrates a mobile communications system and a computer that connects it to the Internet via a server.

5.4.5 Passenger Assistance Systems:

There are several examples. The Metropolitan Transport Agency (Agency Metropolitaine de Transport (AMT) and the Montreal Urban Community's Transportation Corporation in Quebec, Canada offer users interactive map representations. The mission of the first (http://www.amt.qc.ca/) is to improve traveler efficiency by promoting the use of collective means of transport in the Montreal region. It offers useful information on timetables, routes, fares, the location of stations, the capacity of car parks where parking is encouraged, their location etc. All this information is backed up by a map representation of the area, with an interactive navigation system. You can even register a chosen route by public transport and receive information if there are possible changes to timetables.

The second allows you to find out information about all the possible forms of collective transport inside Montreal's Urban Community (http://www.stcum.qc.ca/), with timetables, fares, routes and even maps of journeys that can be downloaded via PDF files. This website has an automatic route calculator where the user can specify the parameters of his/her journey and the calculator shows a detailed version of the itinerary, in table version, indicating the public transport routes involved and the arrival time at all the changeover points [14].

5.4.6 Vehicle Fleet Control:

The system introduced by the Capital District Transit Authority (CDTA) for the integrated control of buses combines the use of GIS, GPS and automatic passenger counters (APC) so as to optimize public bus routes [15].

5.4.7 Emergency Management:

Since their original appearances, GIS have been used to facilitate the duties of the emergency services: the police, ambulance service, fire brigade etc. However, the emergence of GPS geopositioning techniques and mobile telephones and their connection to GIS have led to an extraordinary development. There are number of examples of how GIS can be used to facilitate the calculation of optimum routes for the emergency services. Another important field of application is associated with emergency assistance in connection with the evacuation of cities and regions as a result of environmental or technological catastrophes [16].

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