GEOGRAPHIC INFORMATION SYSTEMS IN STRATEGIC DECISION MAKING IN LOGISTICS COMPANIES

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ABSTRACT

The developments in information technologies and the production processes of globalizing companies made the logistic activities very important. However, because of the same changes and developments the information at the decision phase that needs to be analyzed and evaluated became huge. The more a strategy-oriented enterprise uses an information system to process these data and information, the more it is coming up to its goals. If it is assumed that approximately 80% percent of data in enterprises have geographical features, then one could possibly say that it is quite important for companies to have geography-based information systems as part of their strategic management activities. Because of the geographical feature of the data used for decisions in logistics activities which increasingly become important in the global economy, it is almost a requirement for logistic companies to have geographic information systems which can collect, save, interpret, and show graphical and non-graphical data/information acquired by location-based observations.

Geographic information systems can make important contributions to logistic companies in the following areas: Routing, Optimization and Scheduling, Asset Tracking, Dispatching/Mobile, Territory Optimization and Planning, Site Selection and Optimization, Supply Chain Management, and Selecting the Supplier.

Keywords: Geographic information systems, logistics, decision making.

1. INTRODUCTION

The movement of people, products, and information was always the main subject in comunities. The improvement of the modern commercial processes made the mobility and the reachability a lot easier. Together with the Industrial Revolution and especially the start of the free commerce in the 20th century, the economics gained the ability and the skill of mass production (Rodrigue *et al.*, 2009). Thus, commercial activities evolved to an international structure whereby specialized business processes in different locations have been integrated. Especially in the last 15 years, the production gained an international dimension in the globalized world due to developments in information

technologies and some other factors. Despite the problems caused by being in different regions and different time spaces, using different languages, and having different jusristic conditions, production is considered as an integrated buisness process. In global economies, every unit participated in the commercial activity has inside and outside complicated, interdependent, and multidimensional business processes. Nowadays, almost no country and no company realizes the whole production from scratch by itself. Each commercial organization performing commercial activities mostly prefers an international division of labors as part of a global distribution and supply-demand chain.

On the other side, types of data and information which need to be used as a basis of appropriate decisions for an effective and efficient logistics management vary. Furthermore, the amount of the data and information grows within this division of labor. If it is assumed that approximately 80% percent of the data that have to be analyzed and evaluated are spatial, then one can conclude that the decision support systems which can process spatial and non-spatial data can provide important contributions to all enterprises, especially in logistic sector. Besides management of data of attributes, geographic information systems also have the capability of managing and analyzing spatial data and presenting them as visual information. Developing the transportation systems is an encounter that has gone on for a long time in order to support the economic progress, cover the mobility needs, and capture a market share from the global economy. Winning this encounter is impossible without using geographic information systems.

2. THE TERM LOGISTICS

Defining the term Logistics has been a process which started in the early 1900's and not yet concluded. It is possible to find different definitions of Logistics regarding to business and engineering sciences. These definitons are mostly based on definitions made by national and international logistic institutions such as Council of Logistics Management (CLM), Society of Logistics Engineers, (SOLE), and European Logistics Association (ELA). CLM defines Logistics as follows: *"The process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirementts."* (CLM, n.d.) This is the most commonly used definition in the literature and describes enterprise logistics. On the other hand, the broadest definition which is valid for economical sciences, the traffic science, engineering science, and even for the daily life is the definition of Comité Européen de Normalisation (CEN). According to this definition, the term logistics mean *„the planning, execution and control of the movement and placement of people or goods, and of the supporting activities related to this movement and placement, within a system organized to achieve specific objectives".* (Die grosse Enzyklopaedie der Wirtschaft, n.d.)

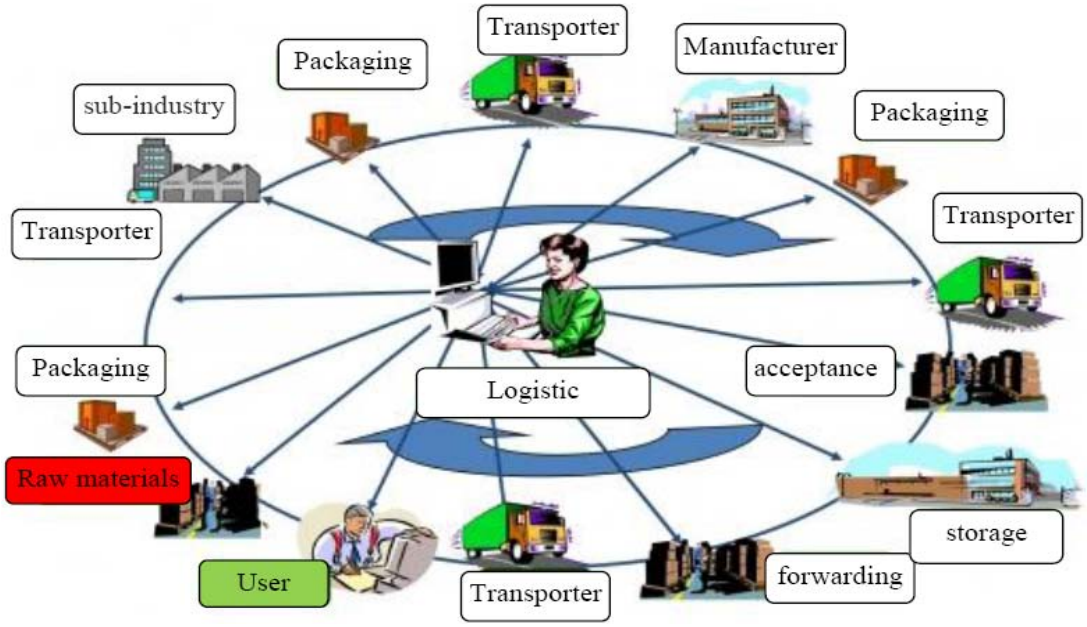

Figure 1: Logistics
Source: Beykoz Meslek Yüksekokulu; Geleceğin Mesleği, Geleceğin Sektörü; LOJİSTİK.
(Beykoz Vocational School of Logistics; LOGISTICS: The future job, The future sector) http://www.beykoz.edu.tr/tr/lojistik, accessed 4 May 2012

Nowadays, in logistic activities different tranportation vehicles such as truck, lorry, ship, train, plane are developing very fast; the delivery time of orders and products get shorter according to the customer requirements; customers want to track their cargo; transport ways are extended while integrating them; big markets capture more market share; information technologies are used and to code products and to follow the product and transport unit. Nowadays, to respond to these developments in the field of logistics and to follow them simultaneously, effective decision support systems such as GIS are essential for strategic enterprise management.

3. GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information Systems (GIS) which address a broad sprectrum of users such as public agencies, local communities, civil society organizations, the private sector, academic environment, and personal users has been aiming to solve problems occured in location-based area. GIS are important to get, combine, analyze and transfer the spatial data. The common use of PCs for personal needs, digital geography and improvements of software technologies, and the need to make socially acceptable business decisions facilitated the development and widespread use of GIS applications.

The first definition of the term GIS as a decision support system was made by Cowen: "A GIS is a decision support system involving the integration of spatially referenced data in a problem-solving environment" (Cowen, 1988, p. 1554). Another definition made by Christiansen ten years later was like a synthesis of older definitions: *"A GIS is a system, consisting of hardware, software, data, procedures and a proper organisational context which compiles, stores, manipulates, analyses, models and visualizes, spatial data, to solve planning and management problems"* (Christiansen, 1998, p. 1).

GIS is an information system consisting of four equally weighted components which are hardware, software, attribute data, and spatial data. With the help of these information systems, spatial data are digitally collected, organized, analyzed, and visually presented (Gürder, 2011). GIS can generally be defined as systems which combine spatial data ("where") with describing/explaining information ("what") (ESRI, 2008).

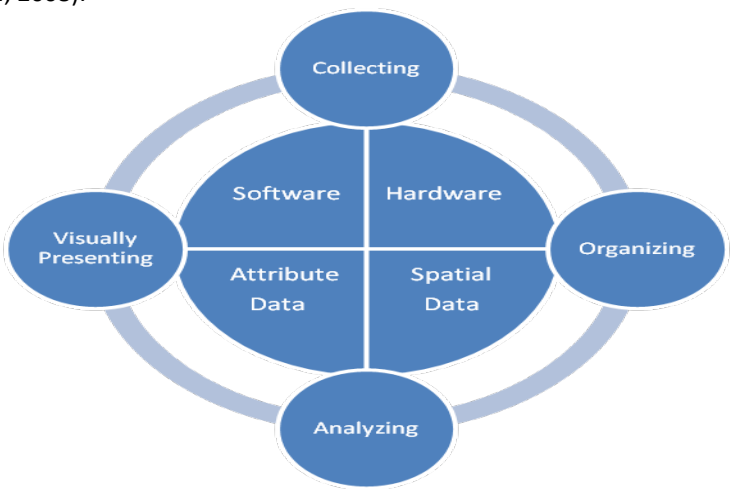

Figure 2: The Main Functions and Components of GIS
Source: Gürder, 2011, p. 59

4. THE USING AREAS OF THE GIS IN LOGISTICS and THEIR CONTRIBUTION POTENTIALS TO DECISIONS

There are a lot of areas using the GIS in transportation and logistics: commodity flow analysis; the planning and/or optimization of the locations of branches, customers and suppliers; the planning of tariff zones and delivery areas. With the help of spatial information, workflows can be improved and costs can be decreased.

In the figure below, some processes of logistic companies in that the GIS are used are shown. In business processes, especially in the processes of logistic companies, the integration of spatial information has a key role in relation to a good planning and detailed analysis. As a conclusion, this integration enables to optimize the relevant processes and make them more transparent.

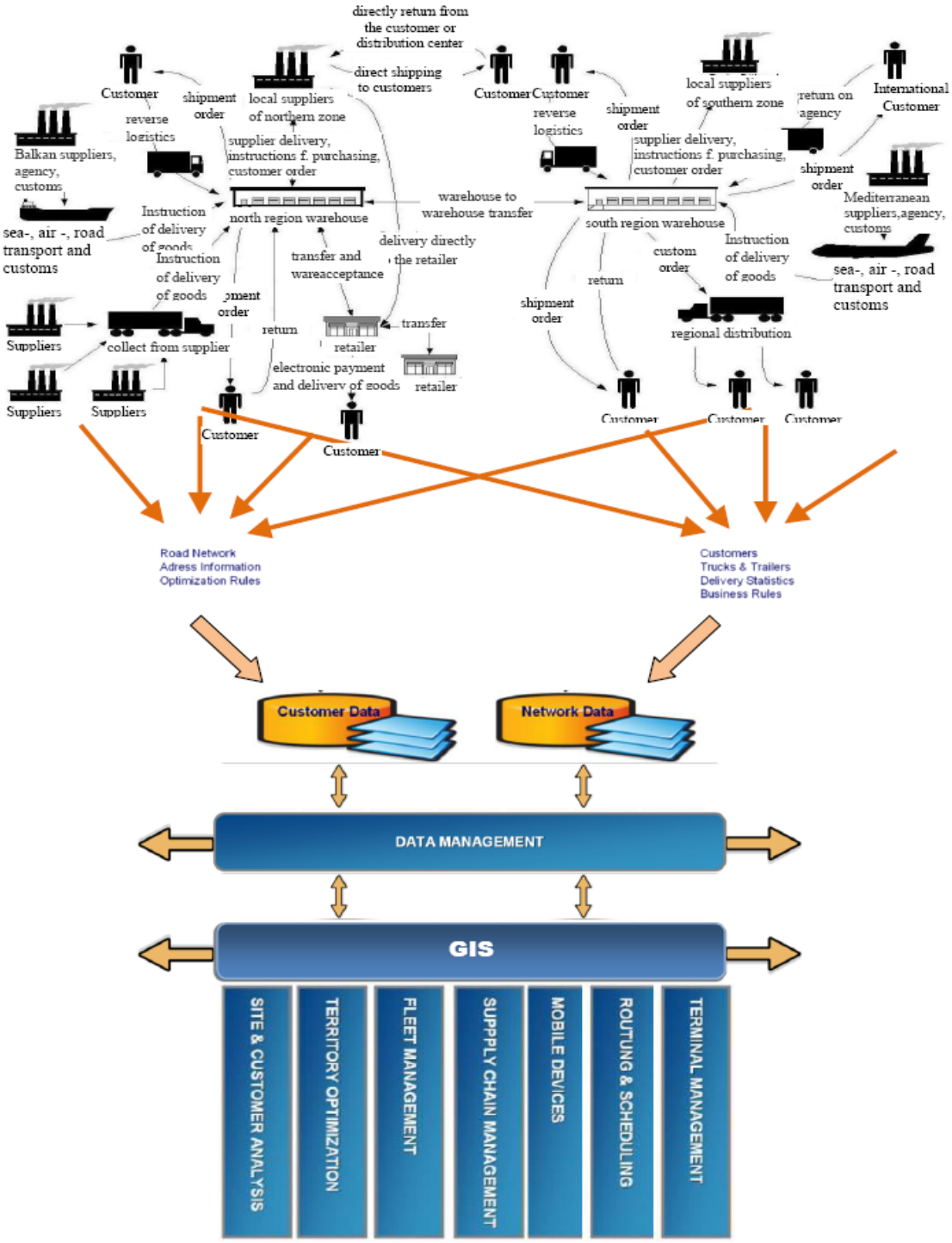

Figure 3: Using Areas of GIS in Logistics
Source: Adapted from Beykoz Meslek Yüksekokulu, Geleceğin Mesleği, Geleceğin Sektörü; LOJİSTİK (Beykoz Vocational School of Logistics; LOGISTICS: The future job, The future sector), http://www.beykoz.edu.tr/tr/lojistik, accessed 4 May 2012 and
ESRI; Transport und Logistik. http://www.esri.de/industries/transport/index.html, accessed 11 April 2012.

4.1 Routing, Optimization, and Scheduling

In planning routing, shortest ways between two or more points are searched. In order to do this, maps on which streets are represented are used as vector data. The orders of the customers are digitally placed on digital maps which include way-networks implemented in the GIS through geographic codification. After the relevant attribute data such as order information of the customers which can be displayed on the map according to their locations, vehicle characteristics, and driver information have been entered into the GIS, the information needed for routing decisions can be displayed through relevant queries by the GIS. Based on this information, depending on the order, and the location of the most appropriate vehicle, the delivery route is determined. With this information and the location of the vehicle, the easiest and most profitable route is chosen. Since these routing decisions made by utilizing GIS applications are more flexible, faster, and cheaper, they will be in accordance with the concept of Green Logistics.

Fleet optimization is an extended version of route planning. Herewith, each route is not planned on its own. The planning is realized for several vehicles that compose a fleet at the same time. With the help of the GIS applications (e.g. ArcLogistics, RouteSmart), vehicle fleet operators can easily find out which vehicles are available, minimize the idle time of vehicles, decrease the traffic intensity in transportation sector, make the company save on fuel costs and other expenses. In this way, the relevant decisions take into account the external costs of logistics in relation to environmental issues (Green Logistics), which increasingly becomes important. For example, the firm Pennsylvania Power and Light uses GIS for track locations of their meters, and car rental agencies such as Avis and Herz use GIS for providing in-vehicle navigation systems (McAdams, n.d.; Sarkar, 2007). Examples for the GIS applications developed for routing and vehicle fleet optimizations are ArcLogistics, and RouteSmart.

4.2 Asset Tracking and Dispatching/Mobile

Apart from tracking logistics activities, monitoring the real-time tracking of assets, and planning all enterprise operations, it is possible to optimize business process through using GIS. Today, the expectations of customers for carrying sensitive products such as high-tech or health goods are considerably increasing. These expectations require that the relevant information systems are able not only to use the GPS positions of the vehicles, but also to monitor the real-time features of these vehicles such as speed, temperature, and convoys. These are the requirements which can be effectively fulfilled through using GIS. With the help of GIS, the companies and some authorized customers are able to control the transport vehicles continuously, and to contact the driver. Thus, if a problem occurs during the transportation, the reason can easily be found and immediately solved. Moreover, the risk of the vehicle to be stolen or lost is reduced to the minimum.

For example, Coca Cola is using GIS to support transportation logistics and shipment tracking. United States Postal Services has equipped all their vehicles with radio transmitters and GPS's (McAdams, n.d.; Sarkar, 2007). Radio transmitters regularly send the location of the transport vehicle to the command center. After that, these signals are interpreted by the GIS software and the relevant locations are shown as symbols on map views. Thus, the real-time location information in related to the relevant vehicle and other vehicles in the fleet can be easily acquired and the vehicles can be tracked (Marmar, 1999).

4.3 Territory Optimization and Planning

The GIS applications enable to deliver products to customers, provide services, and even prepare emergency plans. Spatial tracking of business processes is especially important to companies which have comprehensive branch networks and big vehicle fleets and make instant distribution and sales

through field teams. To minimize the warehouse costs, enterprise branches give their orders nearly to the date of the customer's consumption. This fact requires that the order arrives at the branch as fast as possible. During the transportation of the products it is important to be able to track the process from leaving the warehouse to arriving at their destination.

Through GIS-based territory optimization and planning, it is possible that the nearest vehicle to the customer is determined and sent. Thus, it is ensured that customer requirements are satisfied in the shortest possible time. Furthermore, the sale and the customers can be monitored real-time, it can be easily controlled whether employees are working productively, and ad hoc reports in relation to the effects of advertising can be quickly created. GIS is also used to create Yellow Freight service maps and perform terminal service area analysis. Yellow Freight is using GIS to create service maps and perform terminal service area analysis (McAdams, n.d.; Sarkar, 2007).

4.4 Site Selection and Optimization

GIS-technologies enable enterprises to answer the questions such as "Where is the best place?" or "Where is the highest customer potential?" In the founding phase, enterprises decide where warehouses and service centers will be located. This planning decision made at the beginning of the commercial life of an enterprise is one of the most critical and strategic decisions which influence the commercial life of the enterprise and its future success. As a consequence of wrong decisions at the beginning of the commercial life, the enterprise can reconsider its location, relocate or close its facilities such as warehouses and service centers. Therefore, planning and optimizing the location of the enterprise requires that spatial data are used as the basis for these decisions in addition to the attribute data. In order to make such decisions, geographical areas covered by relevant locations can be analyzed through the GIS. While selecting the new location of the enterprise, the locations of service centers can be displayed on GIS-applications. Thus, the most appropriate candidate locations can be determined according to these locations. Examples for GIS-software developed for this purpose are BusinessAnalyst, MarktAnalyst and Optisite.

4.5 Supply Chain Management

Logistics activities are a sequence of activities involved in global economics. This chain begins with the production of raw materials and ends with the final point where the product is consumed by customers. Through the supply chain, the flow of products and services must be effectively and efficiently planned, performed, and controlled in both directions. Monitoring the existing supply network (network tracing) and planning the supply network (network planning) have a key role regarding this process. The GIS analyses ensure not only to use mapping software and show specific points on the map, but also to display the relationships spatially and determine the value of each relationship. In other words, GIS is a decision support system which tracks and controls the product beginning from the raw material suppliers through transportation until its arrival at the production planned and furthermore after assembly, from the production plant to the distributor, and finally from the distributor to the customer. The mostly used GIS software with respect to the supply chain management are ArcLogistics Route and Arc/Info. These softwares are able to track and control the existing inventory scenario through the whole supply chain (Marmar, 1999).

4.6 Selecting the Supplier

The logistics decisions of the enterprise also include the decisions about the suppliers from which raw materials and semi-finished goods are purchased, since the suppliers providing the best quality product in the shortest time and at the least cost is selected. Purchasing the product in the shortest time depends a.o. on the variety of transportation options (air, road, rail, water, etc.) and the

proximity of the supplier to the enterprise. The variety of transportation options and the proximity of the supplier to the enterprise allow to save on transportation costs. With the help of GIS, the transportation options and proximity of the potential suppliers and the suppliers who are subject to an evaluation can be easily analyzed. Moreover, the appropriate data can be converted so that they become comprehensible. On the other hand, it is also possible to perform more comprehensive analysis by adding more criteria for evaluating suppliers to the same visual representations.

4.7. Future Trends of GIS in Logistics

Predicting the future of information technologies is absolutely hard. However, if the Gartner Hype-Curve 2009 is analyzed, one can easily see the following IT trends which directly affect the GIS-market: Cloud Computing, 3-D Printing, Sensor Networks, RFID, Location Aware Applications, Tablet PC, SOA, Electronic Paper, Augmented Reality.

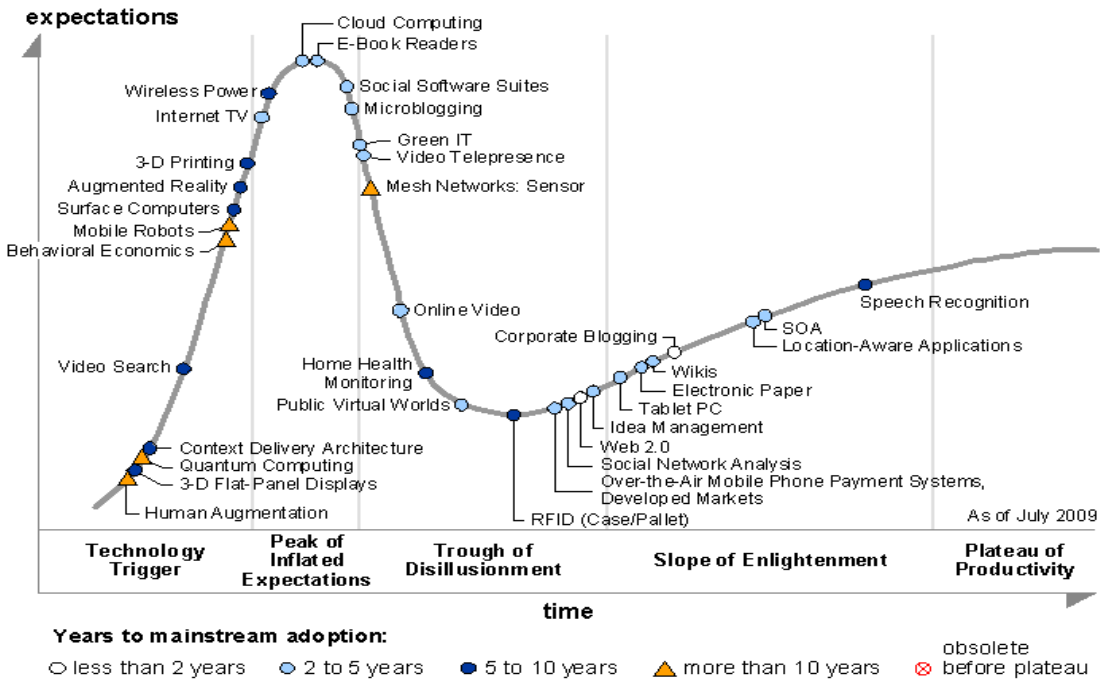

Figure 4: Gartner's 2009 "Hype Cycle of Emerging Technologies".
Source: Gartner's 2009 Hype Cycle Special Report Evaluates Maturity of 1,650 Technologies, http://www.gartner.com/it/page.jsp?id=1124212, accessed 8 March 2010

It is expected that Cloud Computing will decrease the costs of the GIS even though the customers will not be aware of this fact. 3D-technologies enable to use new and interesting applications besides the typical application areas of GIS. It is anticipated that these new application areas will become

common in relation to logistics activities (DVW, n.d.). In addition, higher network speed, broader bandwidth and servers with more capacity ensure that the distributed data are managed by its source. Further, Service-Oriented Architectures (SOAs) will introduce important changes in geographical data infrastructure by means of providing appropriate services. Thus, the geographical data market will exist longer than expected. Changes in this area will make the geographic data able to be used longer (DVW, n.d.).

Sensor networks are capable of collecting various new data and these data can be used in relation to the GIS. Thus, the application areas of GIS can be extended. Sensor Networks and new opportunities in mobility and communication technologies change application domains and data usability. The main requirement with respect to all these future trends is that the person or organization is aware of its local position (DVW, n.d.).

Along with the developments in the internet and wireless networks in recent years, web-based GIS and wireless logistics applications increasingly become common. Websites such as Google Maps and Mapquest are used by people to find their ways. It is also possible to use Global Positioning System (GPS)-navigation tools built in vehicle or portable devices. Thanks to wireless communication, real-time traffic information can be provided, and location-based services (LBS) such as the time of arrival to the next ATM can be provided (dependent on the location of the next ATM and traffic intensity) (Shaw and Rodrigue, 2012).

Another important development in logistics is that GIS is more commonly used in relation to logistics and transportation activities performed by private companies. It is expected that this intensity will increase because of the relevant future trends mentioned above. In summary, today, using GIS in relation to logistics and transportation activities is indispensable for strategic business management (Shaw and Rodrigue, 2012).

CONCLUSION

GIS is a powerful tool to make many strategic decisions in relation to logistics such as selecting the location of the enterprise, the locations of branch networks, the supplier, etc. Using the PC's hardware capabilities reduce the costs and perform more efficient operations. However, the effectivity of a GIS depends on the quality and reliability of the data and the information that are used in the system. Besides, skills and experiences of the user influence the effectivity of the relevant practices as well.

Today, investing in GIS will make enterprises more powerful both in private and public sector. If the purchased GIS can be effectively used, then enterprises can obtain important benefits in the medium and long term. As a consequence, it can be concluded that the GIS-market will continue to grow in the future, the relevant systems will become more important to all sectors, especially to logistics, and the enterprises aiming the most effective and efficient strategic decisions should focus on these systems.

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