



THE ROLE OF GEOGRAPHIC INFORMATION SYSTEM (GIS) IN LOGISTICS FUZZY SYSTEM FOR VEHICLE DESIGN ROUTE

ULOGA GEOGRAFSKOG INFORMACIONOG SISTEMA (GIS) U LOGISTICI FAZI SISTEM ZA PROJEKTOVANJE RUTA VOZILA

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Abstract: Application of modern information technologies has an important role in improvement of efficiencies and effectiveness of logistic processes. Information technologies enable competitive advantages for all subjects in area of logistic. Area of logistic is tightly connected to geographical information: from strategic decisions where to locate factories, warehouses, and distributive centers to tactical decisions in making choice of logistic service providers, as well as operative decision of, for example, defining vehicle routing etc. Application of information technology can significantly improve business both for users and providers of logistics services. The aim of this paper is to present the role and different application possibilities of GIS in logistics.

Key words: Information Technology, GIS, Logistic, Decision Support

Apstrakt: Primena modernih informacionih tehnologija ima važnu ulogu u unapređenju efektivnosti i efikasnosti logističkih procesa. Informacione tehnologije omogućavaju konkurentne prednosti za sve subjekte u oblasti logistike. Oblast logistike je usko vezana sa geografskim informacijama: od donošenja strateških odluka, lociranja fabrika, skladišta i distributivnih centara, pa do odluka na taktičkom nivou kada logistički operatori donose odluku o, na primer, definisanju rute vozila, i td. Primena informacionih tehnologija može značajno da unapredi poslovanje kako za korisnika tako i davaoca logističkih usluga. Ovaj rad ima za cilj da predstavi ulogu i različite mogućnosti primene GIS u logistici.

Ključne reči: Informacione tehnologije, GIS, Logistika, Podrška odlučivanju

1 INTRODUCTION

Business conditions of companies nowadays are characterized by expanding of market, changing of business tasks, raising number of participants, etc. Because of that, making quick and good decisions enable the precaution of successful management. Various business decisions are made with the aim to provide harmony between potentials of company and demands for products and/or services of company. In that way,

1 UVOD

Današnje uslove poslovanja karakteriše proširenje tržišta, menjanje poslovnih zadataka, porast broja učesnika i td. Iz tih razloga, donošenje brzih i kvalitetnih odluka predstavlja uslov uspešnog poslovanja. Različite poslovne odluke se donose sa ciljem da omoguće uspostavljanje sklada između potencijala preduzeća i tražnje za proizvodima i/ili uslugama kompanije. U tom smislu, informacioni sistemi

information systems have main role in making decisions and improvement of efficiency and effectiveness of realization of logistics processes. Within development of information technologies (IT), geographic information systems (GIS) surely have one of the main spots. GIS technologies today provide simpler, faster and better presentation and usage of all information.

Knowing that every area of man's activity is directly or indirectly connected with partial or total logistic system, there is always will for rationalization processes that are going on in this system, followed by simultaneous reduce of logistic expenses. It is clear that these two opposite aims demand continuous making proper decisions, which demand qualitative information. In that sense, GIS supports making decisions on various levels of logistics: from strategic - defining the locations of factories and storages to creation of optimal vehicle route - on operative level.

The aim of this work is showing possibility of application GIS in logistic. The work is structured so that in its first part is description of GIS, its main components and application in various jobs. The second chapter is dedicated to possibilities of application GIS in logistic with description of most important software tools of ESRI company in this area.

2 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Geographic Information Systems (GIS) can be described as rationally organized group of computer hardware, software, geographical data and users, which is projected to provide efficient gathering, storing, analyzing and spatial displaying of geographical and all the other information that can be worthy for the consumer. Term geographic information systems can be observed as following (Kukrika, 2000):

- *Geographic* – represents platforms for spatial data displayed as digital maps, tables, etc.
- *Information* – provides processing and insight of spatial and other data by using tools for their input, storage, processing and presentation.

imaju glavnu ulogu pri donošenju odluka i poboljšanju efikasnosti i efektivnosti realizacije logističkih procesa. U okviru razvoja informacionih tehnologija (IT), svakako da jedno od značajnijih mesta zauzimaju geografski informacioni sistemi (GIS). GIS tehnologije danas omogućavaju znatno jednostavnije, bolje i brže predstavljanje i korišćenje svih informacija.

S obzirom, da je svaka sfera ljudske aktivnosti na direktan ili indirektan način povezana sa delom ili celokupnim logističkim sistemom, stalno je prisutna težnja za racionalizacijom procesa koji se odvijaju u ovom sistemu, uz istovremeno snižavanje logističkih troškova. Jasno je da ova dva suprotstavljena cilja zahtevaju neprekidno donošenje odgovarajućih odluka, što zahteva kvalitetne informacije. U tom smislu, GIS podržava donošenje odluka na različitim nivoima logističkog odlučivanja: od odlučivanja o lokacijama fabrika i skladišta na najvišem nivou, do kreiranja optimalne rute vozila na operativnom nivou.

Cilj ovog rada je prikazivanje mogućnosti primene GIS-a u logistici. Rad je strukturiran tako da je u prvom delu opisan GIS, njegove osnovne komponente i primena u različitim delatnostima. Drugo poglavlje je posvećeno mogućnostima primene GIS-a u logistici sa prikazom najvažnijih softverskih alata kompanije ESRI u ovoj oblasti.

2 GEOGRAFSKI INFORMACIONI SISTEMI (GIS)

Geografski informacioni sistem (GIS) se može opisati kao racionalno organizovan skup računarskog hardvera, softvera, geografskih podataka i korisnika, koji je projektovan tako da omogućava efikasno prikupljanje, čuvanje, obradu, analizu i prostorno prikazivanje geografskih i svih drugih informacija koje su od interesa za korisnika. Pojam geografski informacioni sistem se može posmatrati na sledeći način:

- *Geografski* – predstavlja platformu za prostorne podatke, koji se prikazuju u obliku digitalnih mapa, tabela i sl.
- *Informacioni* – omogućava obradu i pregled prostornih i drugih podataka, primenom alata za njihov unos, čuvanje, obradu i prezentaciju.

- *System* – connecting user and computer for support in managing, analyzing and making decisions for projecting and exploitation of business systems.
- *Sistem* – povezivanje korisnika i računara u cilju podrške upravljanju, analizi i donošenju odluka pri projektovanju i eksploataciji poslovnih sistema.

GIS is information system on space and built infrastructure, and is based on idea of integrated information about whole competent surrounding. All the data on objects, their characteristics and events in specified geographical area that are important for the users are conjoined in this system. GIS is very hard to be clearly and precisely defined, mostly because of complexity and intensive development of IT. The result is presence of various approaches so the authors described GIS in various ways:

- GIS is system for support in deciding which provides integration spatial referent data in business surroundings in which specified problems should be solved. (Cowen, 1994)
- GIS represents many software tools used for input, storage, manipulation, analyzing and display of geographic information. (Kukrika, 2000)
- GIS is system for processing, analyzing and display of geographical knowledge, and is displayed as groups of information such as digital maps, table data, data models and metadata. (www.esri.com)

There are many GIS products today which are used for various tasks, from simple software for map making to very sophisticated software applications. GIS manufacturers offer various versions of systems and products, which have the same aim: users need adequate information as support for business deciding. (Sonnen, 2000).

Regardless various definitions and approaches, it can be concluded that GIS technologies allows development of application for processing, analyzing and presentation of solution for specific problem. There are various GIS applications for different purpose (vehicle tracking, tracking loading/unloading equipment, display of retail objects, display of all suppliers' locations) within the scope of user's information system. Dependently by manner and level of usage, GIS can be treated as group of three basic components: (figure 1):

- geovisualization,

GIS je informacioni sistem o prostoru i izgrađenoj infrastrukturi, i zasniva se na ideji integralne informacije o celokupnom merodavnom okruženju. U ovom sistemu su objedinjeni svi podaci o objektima, njihovim karakteristikama i procesima i pojavama u određenom geografskom prostoru, koji su od značaja za korisnika. GIS je veoma teško jasno i precizno definisati, pre svega zbog kompleksnosti i intenzivnog razvoja IT. Različiti pristupi i autori opisali su GIS na različite načine:

- GIS je sistem za podršku odlučivanju koji omogućava integraciju prostorno referenciranih podataka u poslovna okruženja u kojima bi trebalo rešavati određene probleme. (Cowen, 1994)
- GIS predstavlja niz softverskih alata koji se koriste za unosenje, čuvanje manipulaciju, analizu i prikaz geografskih informacija. (Kukrika M., 2000)
- GIS je sistem za upravljanje, analizu i prikazivanje geografskih znanja, i predstavljen je u obliku skupova informacija kao što su digitalne mape, tabelarni podaci, modeli podataka i metapodataka. (www.esri.com)

Danas postoji veliki broj GIS proizvoda koji se koriste za različite zadatke, od jednostavnih paketa za pravljenje mapa do vrlo složenih softverskih aplikacija. GIS proizvođači nude različite varijante sistema i proizvoda, koji u suštini imaju zajednički cilj: korisnicima su potrebne adekvatne informacije kao podrška poslovnom odlučivanju (Sonnen, 2000).

Bez obzira na različite definicije i pristupe, može se zaključiti da GIS tehnologije omogućavaju razvoj aplikacija za obradu, analizu i prezentaciju rešenja konkretnog problema. U okviru informacionog sistema korisnika, najčešće postoji više GIS aplikacija različite namene (praćenje vozila, praćenje pretovarne mehanizacije, prikaz prodajnih objekata, prikaz lokacije svih dobavljača i dr). U zavisnosti od načina i nivoa primene, GIS se sveobuhvatno može posmatrati kao skup tri osnovne komponente (slika 1):

- geovizuelizacija (*geovisualisation*),

- geodatabase and
- geoprocessing.
- geo-baze podataka (*geodatabase*) i
- geoprocesiranje (*geoprocessing*).

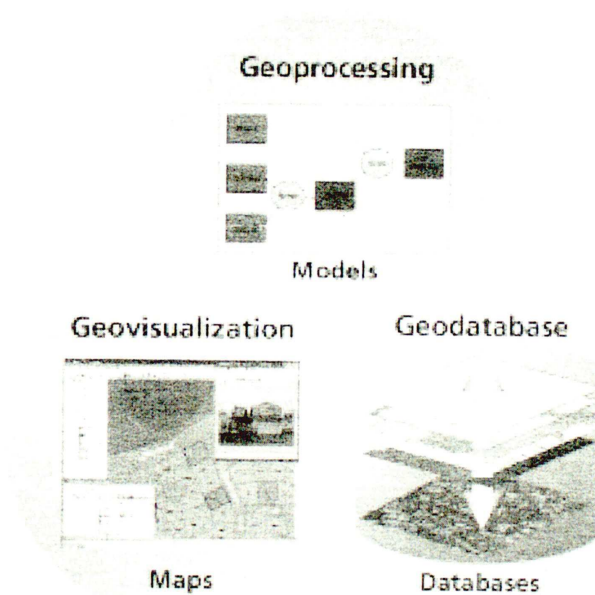


Figure 1 Three basic components of overall GIS (Source: www.geomatics.co.yu)
 slika 1 Tri osnovne komponente sveobuhvatnog GIS-a (Izvor: www.geomatics.co.yu)

Geovisualisation means that GIS has group of intelligent maps and other displays of area characteristics and their relations. These maps show different layers of spatial information and can be used as "views on data base" and by that examination, analyzing, import and data editing are provided. *Geodatabase* are overall bases that imply data group in vector and raster form. *Geoprocessing implies* group of tools for data transformation and usage of analytic functions and model of data processing.

Users of geographical information systems are numerous: from experts that deal with development and maintenance of GIS, to operators that execute everyday jobs. In wider sense, we can suppose that users of this technology are all business systems that on any way deal with space, management and exploitation of spatial objects. GIS is being used in federal government, education, health, financial sector, mining and geology, geodesy, architecture, agriculture, traffic and transport, army. Users of GIS are planners and analyst in all areas, teachers, demography, financial consultants, project engineers, dispatcher in all modes of transport, army and safety experts.

Geovizuelizacija podrazumeva da GIS sadrži skup inteligentnih mapa i drugih prikaza karakteristika prostora i njihovih odnosa. Ove mape prikazuju različite slojeve prostornih informacija i mogu se koristiti kao "pogledi na bazu podataka" čime se omogućava ispitivanje, analiza, unos i promena podataka. *Geo-baze* podataka su sveobuhvatne baze koje sadrže skupove podataka u vektorskom i rasterskom obliku. *Geoprocesiranje* obuhvata skup alata za transformaciju podataka i primenu analitičkih funkcija i modela obrade podataka.

Korisnici geografskih informacionih sistema su veoma brojni: od eksperata koji se bave razvijem i održavanjem GIS-a, do operatera koji izvršavaju svakodnevne poslove. U širem smislu, može se smatrati da su korisnici ove tehnologije svi poslovni sistemi, koji se na bilo koji način bave prostorom, upravljanjem i eksploatacijom prostornih objekata. GIS se koristi u državnoj upravi, obrazovanju, zdravstvu, finansijskom sektoru, rudarstvu i geologiji, geodeziji, građevinarstvu, poljoprivredi, saobraćaju i transportu, vojsci. Korisnici GIS-a su planeri i analitičari u svim oblastima, predavači u obrazovanju, demografi, finansijski konsultanti, projektanti, dispečeri u svim vidovima saobraćaja, vojni i stručnjaci bezbednosti.

Percentage ratio of GIS users in USA is displayed on figure 2 (www.pobonline.com). According to these data, the biggest usage GIS has in government sector, about 35% (local, state and federal government). Significant usage GIS finds in scientific institutions, research centers and universities, which use GIS for realization of their projects.

Procentualno učešće brojnih korisnika GIS-a u SAD je prikazano na slici 2 (www.pobonline.com). Prema ovim podacima, najveću primenu GIS ima u vladinom sektoru, oko 35% (lokalna, državna i federalna vlada). Značajnu primenu GIS nalazi i u naučnim institucijama, istraživačkim centrima i univerzitetima, koji koriste GIS za realizaciju svojih projekata.

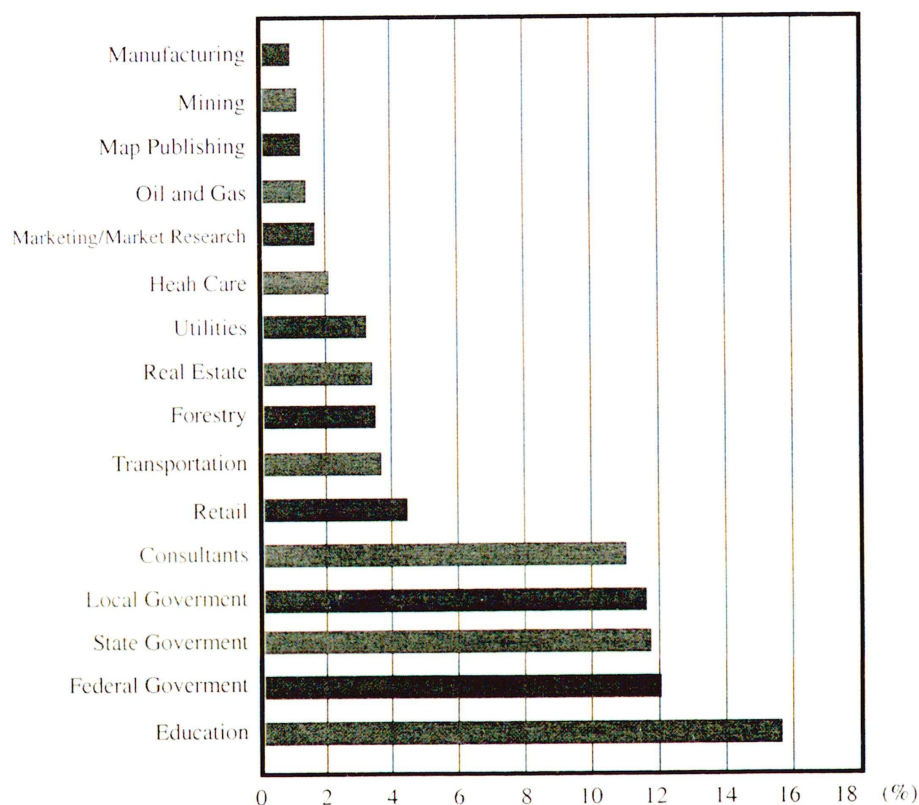


Figure 2 Display of most important GIS users (USA) (Source: www.directionsmag.com)
Slika 2 Prikaz najvažnijih korisnika GIS-a (SAD) (Izvor: www.directionsmag.com)

3 GIS AND LOGISTICS

There is a hard connection between logistics and geographical information – as mentioned above, from deciding on location of factories and storages on highest level, to deciding on choosing best vehicle route on operating level. Efficient operations demand correct and time-precise making decisions to achieve basic logistic thesis: exact product on exact place at exact time... It is clear that fulfilling of this task asks to have qualitative information. In other words, it is necessary to know vehicle position or delivery in any moment to provide optimal delivery and to reduce expenses. For those tasks, GIS tools today can provide necessary information.

3. GIS I LOGISTIKA

Logistika je nerazdvojivo povezana sa geografskim informacijama - kako je već rečeno, od odlučivanja o lokacijama fabrika i skladišta na najvišem nivou, do odlučivanja o izboru najbolje rute vozila na operativnom nivou. Efikasne operacije zahtevaju tačno i vremenski precizno donošenje odluka kako bi se ostvario osnovni postulat logistike: prava roba u pravom obliku na pravom mestu u pravo vreme ... Jasno je da ostvarenje ovog zadatka nameće neophodnost posedovanja kvalitetnih informacija. Drugim rečima, neophodno je poznavanje pozicije vozila ili isporuke u bilo kom vremenskom trenutku, kako bi se omogućila optimalna isporuka i smanjenje troškova. U tom smislu, GIS alati danas mogu da pruže neophodne informacije.

GIS systems provides presentation all needed data of adequate spatial area when realizing logistic processes and making design about them. Spatial area can be city plan, schematic area display, etc. Spatial data describes specified territory on which certain process is being observed and represents group of incoming data, based on which the real status can be visually described. By connecting with other applications and mathematic model, it is possible to follow realization of processes in real time, to follow process simulation or see estimated process status, which is very important in logistic. By integration GIS with company's information system, all the needed data can be shown as space which covers company's working area.

The aim of each company is to provide service for which the consumer is ready to pay the amount that justifies invested resources. According to that, tending of management is permanent improvement of logistic and other activities, in which GIS has very important role. As result, many companies that offer software tools based on GIS technology are present on the market. In this paper, some software products of ESRI will be displayed.

The reason is that ESRI (Environmental Systems Research Institute) is at this moment the world biggest manufacturer of GIS software products. ArcGIS is group of ESRI's products, *integrated software tools* which allows implementation of GIS in different area of logistics.

Base for further software update in specific logistic activity consists of: ArcView, ArcInfo, ArcLogistic Route Software and ArcGIS Business Analyst (which won't be closer discussed in this work). Specific software developed on ArcGIS basis provides solving of following logistic tasks:

- Routing and Scheduling
- Asset Tracking
- Distribution and Fleet Management
- Motor Vehicles Administration
- Territory Optimization and Planning
- Site Selection
- Supply Chain Management

GIS sistemi, pri realizaciji logističkih procesa i donošenja odluka u okviru njih, omogućavaju prikazivanje svih potrebnih podataka na odgovarajućoj prostornoj podlozi. Prostorna podloga može biti plan grada, geodetska podloga neke teritorije, šematski prikaz prostora, itd. Prostorni podaci opisuju određenu teritoriju na kojoj se prati neki proces i predstavlja skup ulaznih podataka, na osnovu kojih se vizuelno može opisati realno stanje. Povezivanjem sa drugim aplikacijama i matematičkim modelom, moguće je pratiti realizaciju procesa u realnom vremenu, pratiti simulaciju procesa ili videti prognozirano stanje procesa, što je veoma značajno u logistici. Integracijom GIS-a sa informacionim sistemom kompanije moguće je prikazati potrebne podatke na prostornoj podlozi, koja pokriva oblast rada kompanije.

Cilj svake kompanije je da pruži uslugu za koju je korisnik spreman da plati iznos koji opravdava uložena sredstva. U skladu sa tim, težnja menadžmenta je neprekidno unapređenje logističkih i drugih aktivnosti, pri čemu GIS ima značajnu ulogu. Kao odgovor na ovakve ciljeve, vremenom se na tržištu pojavio veliki broj kompanija koje nude softverske alate zasnovne na GIS tehnologiji. U ovom radu će biti prikazani neki softverski proizvodi kompanije ESRI, koja danas pokriva najveći deo svetskog GIS tržišta.

ESRI (Environmental Systems Research Institute) je trenutno najveći svetski proizvođač GIS softverskih proizvoda. ArcGIS je ESRI-jev skup proizvoda, *integrirani softverski alati* koji omogućavaju primenu GIS-a u poslovnoj logistici.

Baza za dalju nadgradnju softvera u specifičnim logističkim aktivnostima ovuhvata: ArcView, ArcInfo, ArcLogistic Route Software i ArcGIS Business Analyst (koji u ovom radu neće biti detaljnije prikazani). Specifični softveri razvijeni na osnovi ArcGIS-a omogućavaju rešavanje sledećih logističkih zadataka, odnosno primenu u pojedinim oblastima logistike:

- Rutiranje i raspoređivanje
- Praćenje
- Distribucija i menadžment flotom prevoznih sredstava
- Uprava za motorna vozila
- Optimizacija i planiranje prostora
- Izbor lokacije
- Menadžment lancima snabdevanja

- Warehouse Operations
- DOTs and Roadway Management
- Railroads
- Intermodal Systems
- Aviation
- Water Transportation
- ITS
- Skladišne operacije
- Ministarstvo transporta i menadžment drumskim saobraćajnicama
- Železnice
- Intermodalni sistemi
- Vazduhoplovstvo
- Vodni transport
- ITS

Due to great importance in practical use in logistic, ESRI software solutions for these logistics tasks are displayed.

Routing and Scheduling

GIS software usually support finding optimal routes. Criteria when optimizing could be transport expenses, delivery time, distance or their combination. For example, ArcIMS Route Server calculates optimal route based on driving time, distance and road characteristics... Users of this application can get instructions for driving on certain relation by internet. ArcWeb Service displays its user's on-line guidance for driving through USA, Canada and Europe (www.esri.com). This software provides both operative routing and time schedule, including flowing route generation and issuing of documentation for various vehicles, and tracking and supervising of delivery. When routing, various data are being used to project the best route based on required criteria, current condition and quantity of transported cargo. On figure 3 is shown one example of visual display of created routes for different criteria.

Zbog izuzetnog značaja u praktičnoj primeni u logistici, u ovom delu rada je dat prikaz ESRI-jevih softverskih rešenja za navedene logističke zadatke.

Rutiranje i raspoređivanje

GIS softveri najčešće podržavaju pronalaženje optimalnih ruta. Kriterijumi pri optimizaciji mogu biti vreme prevoza, rastojanje ili njihova kombinacija. Tako na primer, ArcIMS Route Server proračunava optimalnu rutu baziranu na vremenu vožnje, rastojanju i osobinama puta. Korisnici ove aplikacije mogu preko interneta dobiti instrukcije za vožnju na nekoj relaciji. ArcWeb Servis korisnicima pruža on-line uputstva za vožnju kroz SAD, Kanadu i Evropu (www.esri.com). Ovaj softver omogućava i operativni rutiranje i vremenski raspored, uključujući tekuće generisanje ruta i izdavanje dokumentacije za različita vozila, kao i praćenje i nadgledanje isporuke. Prilikom određivanja ruta koriste se različiti podaci da bi se projektovala najbolja ruta na osnovu zadatih kriterijuma, trenutnog stanja i količine robe koja se prevozi. Na slici 3 predstavljen je jedan primer vizuelnog prikaza kreiranih ruta za različite kriterijume.

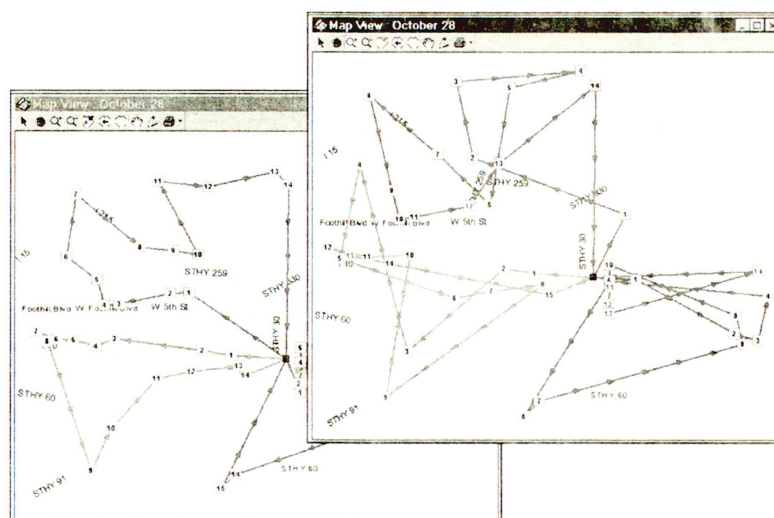


Figure 3 Screenshots on GIS applications for routing (Source: www.esri.com)

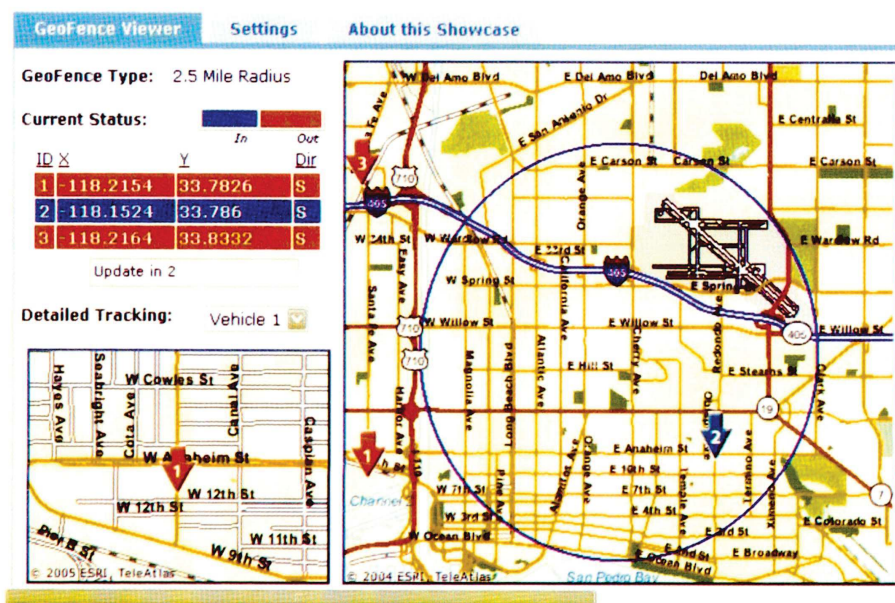
Slika 3 Prikaz GIS aplikacije za rutiranje (Izvor: www.esri.com)

Asset Tracking

Software packet offered by ESRI as solution for object tracking is ArcView, with add-on ArcView Tracking Analyst. It provides supervising of locations and asset tracking in real time. Objects which transmit their geographical location through GPS or similar devices can be dynamically tracked on ArcView map. Software allows dispatcher to track other characteristic of objects on the map (abandoning of working area, vehicle mail-function, cargo status, crew communication etc). On figure 4 is shown an example of vehicle tracking on map and its surrounding by configured radius.

Praćenje

Softverski paket koji nudi ESRI za praćenje objekata je ArcView uz dodatni ArcView Tracking Analyst. On omogućava potpuni uvid u lokaciju i praćenje u realnom vremenu. Objekat, čija se geografska lokacija prenosi pomoću GPS ili sličnog uređaja, može se dinamički pratiti na ArcView mapi. Softver omogućava dispečeru da prati i druge karakteristike objekata na mapi (napuštanje zone rada, otkaze-kvarove vozila, stanje tereta, komunikaciju posade i td.). Na slici 4 je prikazan primer praćenja vozila na mapi i okruženja sa zadatim prečnikom.



travel route. By tracking location of vehicle, dispatcher can track level of realization of the demand. On figure 5 is shown part of the map, through which the driver gets detail instructions for reaching certain location. Typical examples of usage can be Emergency Medical Assistance, police, fire department etc.

poziva i prikazuju potencijalne rute kretanja. Praćenjem lokacije vozila, dispečer je u mogućnosti da prati nivo realizacije zahteva. Na slici 5 je prikazan deo mape preko koje vozač dobija detaljne instrukcije za dolazak do određene lokacije. Tipični primeri primene su hitna pomoć, policija, vatrogasci i dr.

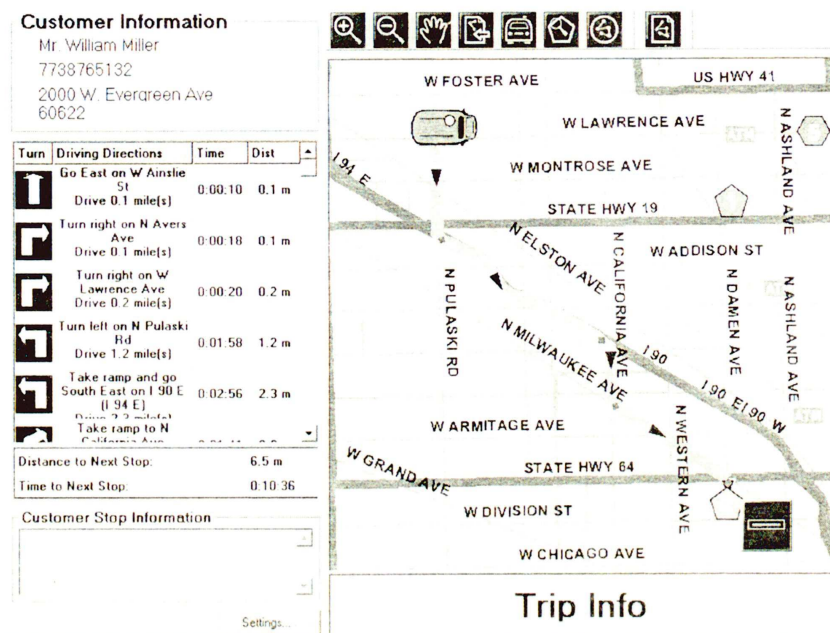


Figure 5 Display of map through which the driver gets the instructions for route-moving (Source:www.esri.com)

Slika 5 Prikaz mape preko koje vozač preuzima instrukcije o ruti za kretanje (Izvor:www.esri.com)

The matrix below shows a series of basic questions dispatcher might ask in the course of deciding on a tactical deployment plan or during a strategic review of his or her business. Next to each question is an application or capability of ESRI software that fleet managers can use to get an answer on typical questions.

Naredna tabela (tabela 1) prikazuje seriju osnovnih pitanja koje menadžer voznog parka postavlja sa ciljem donošenja taktičkih odluka u planu raspoređivanja ili tokom strateškog pregleda aktivnosti. Značajno je da menadžer voznog parka može da koristi ESRI softver radi dobijanja odgovora na svako od ovih pitanja.

Table 1 Presentation of answers on dispatcher's questions/problems

Tabela 1 Prikaz odgovora za pitanje/probleme dispečera

Question	Function	Application
Where are my trucks?	Vehicle Tracking	Dispatch
Where is my customer?	Geocoding	Customer Address Matching
How do I get there?	Network Topology	Routing and Scheduling
Where have the trucks been?	Route Logging	Post Trip Analysis, Fuel Tax Mileage Reporting
What is my potential demand?	Accessibility to Customer	Site Selection
Service from a proposed warehouse?	Order Fulfillment	Customer Service Job Pricing

Motor Vehicles Administration

Motor vehicle administrators work with a great deal of information that is continuously changing. GIS-based applications can help make sense of the information in your databases by pinpointing critical locations and identifying trends. Spatial analysis of safety factors, such as congestion, construction zones, and weather, reveal patterns that can be missed in simple tabular or statistical output. Combining digital maps with up-to-date data from accident and moving violation databases can speed the recognition of troublesome hot spots and lead to better solutions (figure 6).

In addition, the "motor carrier" department can use GIS tools to highlight trends, such as increases in over-dimensional and hazardous materials traffic, permit violations, fuel/mileage tax trends, and general commercial traffic route information.

Uprava za motorna vozila

Odeljenja pri upravama za motorna vozila rade sa velikim količinama informacija koje se kontinualno menjaju. GIS bazirane aplikacije mogu da budu od pomoći u smislu da informacije u bazama podataka ukažu na kritične lokacije i identifikuju pojedine trendove. Prostorna analiza faktora bezbednosti, kao što su zagušenja, zone gradnje, vremenske prilike, mogu da ne budu primećeni, odnosno upćeni pri jednostavnim tabelarnim ili statističkim prikazima. Kombinovanjem digitalnih mapa sa ažurnim (pravovremenim "up-to-date") podacima o nesrećama i dobijanjem baza podataka o poremećajima (prekršajima) može biti od pomoći za ubrzavanje raspoznavanja problemskih tačaka i iznalaženje boljih rešenja (slika 6).

Nadalje, odeljenje za prevoz motornim vozilima može da koristi GIS za razjašnjenje trendova, kao što su porast vangabaritnih prevoza, prevoz opasnih materija, dozvole prekoračenja (odstupanja), trendovi tarifa putarina/cena goriva i opšte komercijalne informacije o putevima (rutama).



Figure 6 Example of temporal analysis of crash locations by year (Source: www.esri.com)

Slika 6 Primer vremenke analize lokacija sudara na nivou godine (Izvor: www.esri.com)

Territory Optimization and Planning

Spatial projecting is specific task in logistic. For example, when projecting distribution or some other network, territory optimization and planning is the key for effective and productive system. No matter whether the planning is concerning distribution of goods, services or emergency, GIS provides the tools for dealing optimization. Availability of large number of data that are well organized and represented, allow logistic project engineer to give certain territories to the objects much easier. In combination with demographical data faster change tracking is provided, which are vital for getting optimal solutions. (figure 7).

Optimizacija i planiranje prostora

Planiranje prostora obuhvata specifične zadatke logistike. Na primer, pri projektovanju distribucione ili neke druge mreže, optimizacija i planiranje prostora su od ključnog značaja za dostizanje efikasnog i produktivnog sistema. Bez obzira da li je reč o distribuciji roba, uslugama ili službama za hitne intervencije, GIS je alat koji obezbeđuje potrebne podloge za optimizaciju. Raspolaganje velikim brojem dobro organizovanih i prikazanih podataka (slika 7) omogućava projektantu logistike znatno lakše dodeljivanje objekata pojedinim zonama. U kombinaciji sa demografskim podacima ostvaruju se preduslovi za brže praćenje promena, a koje je od vitalne važnosti za postizanje optimalnih rešenja.

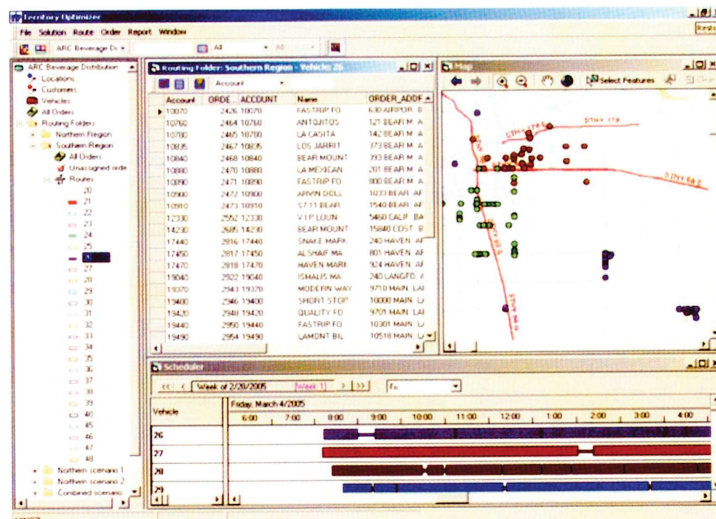


Figure 7 Display of spatial allocation of objects (Source:www.esri.com)
slika 7 Prikaz prostorne alokacije objekata (Izvor: www.esri.com)

Site Selection

Beside macro aspects, the preconditions for determining micro location of objects with help by GIS (whether it is storage, distribution center, service object etc.). By combining spatial and demographical data, user needs can be better seen and the situation on the market can be visualized. For these tasks, ESRI suggests ArcGIS Businesses Analyst. On figure 8 is shown application of software ArcGIS Businesses Analyst which analyzes the best location for new service objects regarding surroundings, location of potential users etc.

Izbor lokacije

Pored makro aspekta, GIS je od pomoći pri definisanju uslova za određivanje mikro lokacije nekog objekta (gde će biti skladište, distribucionni centar, servisni objekat i td.). Kombinovanjem prostornih i demografskih podataka, potrebe korisnika se mogu bolje sagledati a situacija na tržištu može da se vizuelizuje. Pri ovakvim zadacima, ESRI preporučuje primenu ArcGIS Businesses Analyst. Na slici 8 je dat primer prikaza ovog softvera kojim se analizira najbolja lokacija servisa u zavisnosti od okruženja, lokacije potencijalnih korisnika i td.

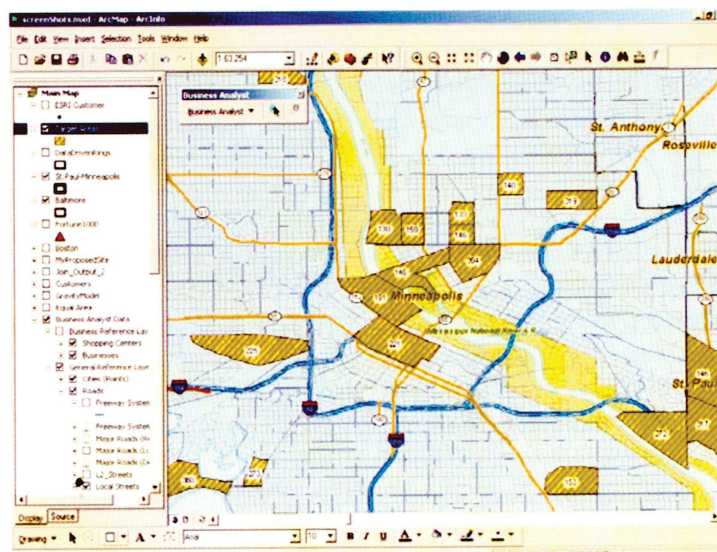


Figure 8 Screenshot on ArcGIS Businesses Analyst (Source:www.esri.com)
slika 8 Izgled displeja kod primene ArcGIS Businesses Analyst (Izvor: www.esri.com)

Supply Chain Management

ArcGIS Network Analyst can be of great help for management which deals with whole supply chain. It provides result analysis for modeling of supply and delivery, network surveying, routing optimizations etc. This software also allows defining zones around the objects and analysis of user in each zone, in order to get evaluation of complete expenses and other parameters for realizations of logistics services. (figure 9). Here is necessary to underline the complexity of chains of supply can often make development and use of application very hard in concrete cases. Numerous experiences shows that companies that are using GIS tools in combination with optimization techniques reach decrease of logistics expenses up to 10-15%.

Menadžment lancima snabdevanja

ArcGIS Network Analyst može biti od velike pomoći za menadžment celokupnog lanca snabdevanja. Njime se obezbeđuju rezultati analiza za modeliranje snabdevanja i isporuka, istraživanje mreže, optimizacije ruta i td. Pomoću ovog softvera je omogućeno definisanje zona oko objekata i analiza korisnika za svaku zonu sa ciljem utvrđivanja i vrednovanja kompletnih troškova i ostalih parametara bitnih za realizaciju logističkih usluga (slika 9). Neophodno je naglasiti da kompleksnost lanaca snabdevanja može da uslovi da za konkretne slučajeve budu veoma otežani razvoj i primena ovih aplikacija. Brojna iskustva ukazuju da kompanije koje koriste GIS alate u kombinaciji sa optimizacionim tehnikama ostvaruju smanjenje logističkih troškova do 10 do 15 %.

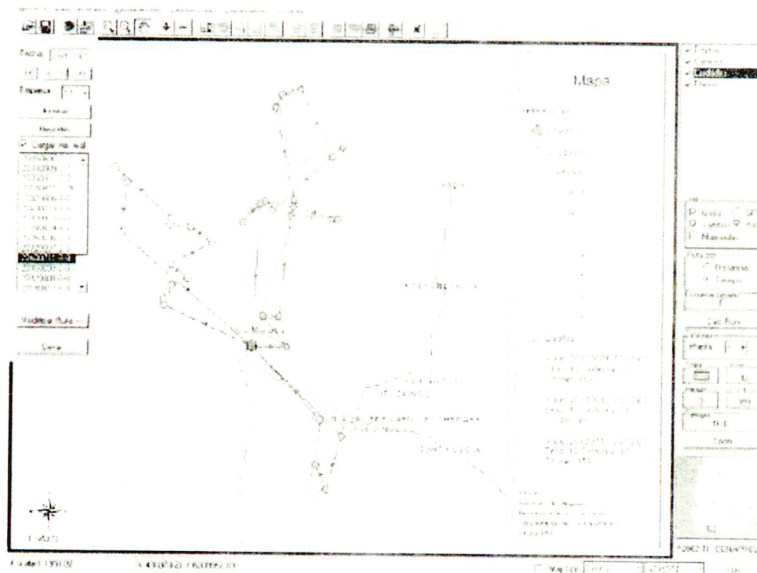


Figure 9 Visual display of routes and their characteristic for required chain of delivery
(Source: www.conaprole.com)

Slika 9 Vizuelni prikaz rute i njenih karakterisitka za traženi lanac isporuke
(Izvor: www.conaprole.com)

Warehouse Operations

Just as vehicles can be more efficiently routed over streets and highways, forklifts and other equipment can be routed for "picks and puts" with greater efficiency. You can use GIS to create a "street" database of the warehouse aisles and assign "address ranges" to shelves, parts bins, and other storage locations. By using GIS to analyze spatial patterns and seasonal variations,

Skladišne operacije

Kao što vozilo može da se efikasnije rutira na ulicama i (auto)putevima, viljuškari mogu efikasnije da se rutiraju na operacijama komisioniranja. GIS može da se koristi za formiranje baze podataka "ulica" (saobraćajnica i prolaza u skladištu) i da dodeli "adrese" pojedinim policama, segmentima čelija regala i drugim lokacijama u skladištu. Korišćenjem GIS-a pri analizi prostornih oblika i sezonskih varijacija, može da se poboljša iskorišćenje prostora, uštede vreme i resursa. GIS može da se primeni

you can improve space utilization, saving time and resources. GIS can also be used to tie the pick order system to the schedules database. This allows warehouse operations to more closely approach the "just-in-time" ideal without leaving material or merchandise near the dock for long periods of time where damage or loss can occur.

DOTs and Roadway Management

The gateway to economic development and, subsequently, a healthy economy, transportation infrastructure represents one of the largest and most critical investments made in any nation, at any stage of development. Similarly, for many firms in the transportation industry, profitability and a strong competitive position depend on a safe and reliable system. ESRI's integrated software solutions are being used for analysis and support throughout the infrastructure life cycle (figure 10):

- Evaluate alternative pavement treatment strategies on the desktop.
- Integrate GIS with other tools such as CAD or document management software.
- Integrate information from real-time traffic devices like cameras and loop detectors for congestion and incident management.
- Review and coordinate construction projects.
- Visualize output from popular transportation planning models.

kao veza sistema za komisioniranje i baze podataka za raspoređivanje. Ovo omogućava službama i personalu u skladištu da postignu da aktivnosti budu što bliže idealu JIT, i to bez smeštanja materijala i roba u blizini frontova pretova tokom dužeg vremena, zbog čega se, jasno, mogu očekivati njihova oštećenja i gubici.

Ministarstvo transporta i menadžment drumskim saobraćajnicama

Saobraćajna infrastruktura predstavlja osnov ekonomskog razvoja i shodno tome, za zdravu privredu predstavlja jednu od najkritičnijih (odnosno najznačajnijih) investicija. To je evidentno za svaku državu i to na svakom stepenu njenog razvoja. Slično, za mnoge firme u delatnosti saobraćaja, profitabilnost i jaka konkurentna pozicija na tržištu zavisi od sigurnog i pouzdanog sistema podrške. Iz tih razoga, ESRI-jeva integrisana softverska rešenja mogu da se koriste za analize i podršku tokom životnog ciklusa infrastrukture (slika 10) na sledeći način:

- Na desktopu se (pr)ocenjuju alternativne strategije tretiranja kolovoza.
- Integracija GIS-a sa ostalim alatima, kao što su CAD ili softveri za menadžment dokumentacije.
- Integracija informacija dobijenih od sredstava za praćenje u realnom vremenu kao što su kamere ili detektorske petlje u situacijama zagušenja ili incidenata.
- Nadzor i koordinacija izvođenja projekata.
- Vizuelizacija popularnih modela za planiranje saobraćaja.

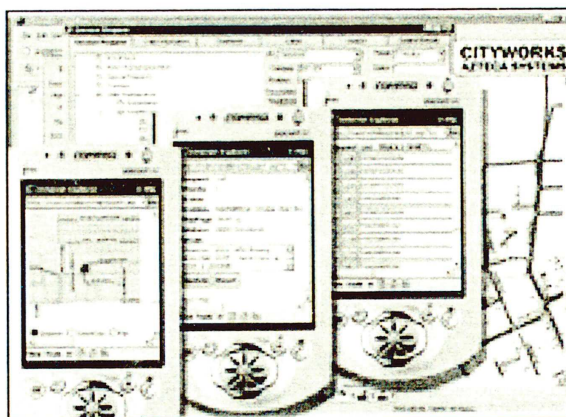


Figure 10 Visual display of city works and their characteristics
(Source: www.esri.com)

slika 10 Vizuelni prikaz gradskih aktivnosti i njihove karakteristike
(Izvor: www.esri.com)

Railroads

Railways around the world rely on GIS to manage key information for rail operations, maintenance, asset management, and decision support systems (figure 11). GIS has been successfully deployed in railway organizations for a variety of major functions and disciplines. Some of them are specific for railway and are mentioned here, as: Real estate management, Facility management (track, power, communications and signaling), Commodity flow analysis, Emergency response management, Environmental and construction management, Passenger information and Marketing.

Železnice

Železnice širom sveta se oslanjaju na GIS radi upravljanja ključnim informacijama o aktivnostima na železnici, održavanju, praćenju resursa i sistemu podrške donošenju odluka (slika 11). GIS se u železničkim organizacijama uspešno uključio i razvio u nizu različitih važnih funkcija i disciplina. Neke od njih su specifične za železnicu (kao što su: menadžment nekretnina, objekata - šina, snabdevanje energijom, komunikacije i signalizacija), a neke su već ranije pomenute, npr. analiza tokova roba, aktivnosti u opasnim situacijama, menadžment životne sredine i gradnje, informacije za putnike i marketing.

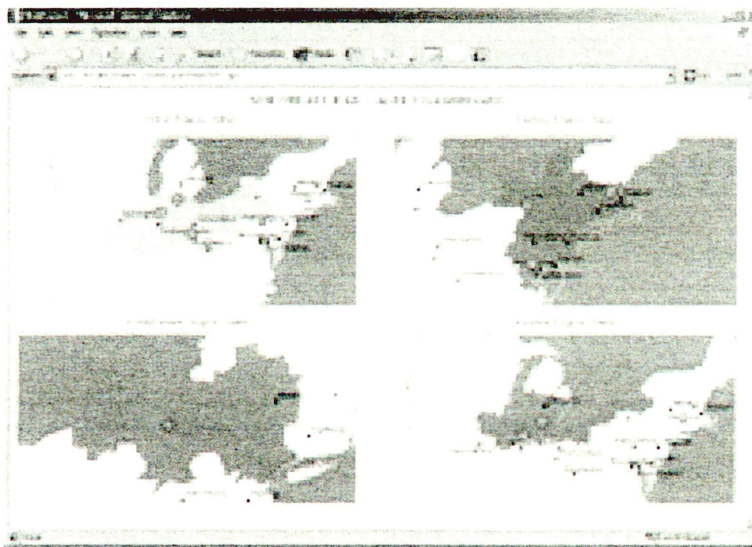


Figure 11 Integrate GIS with business intelligence software tools to identify trends
(Source:www.esri.com)

slika 11 Integracija GIS sa "business intelligence" softverskim alatima pri idebtifikaciji trendova
(Izvor: www.esri.com)

Intermodal Systems

Transporting cargo by rail includes shipping, roadway, and aviation networks. GIS can help manage shipments and transfers more effectively by providing accurate and timely information. ArcGIS Network Analyst gives you the ability to combine multiple transportation networks (figure 12) for routing shipments more efficiently, saving time and money. GIS also supports the development of "executive dashboards" that bring the benefits of spatial information and intuitive map graphics directly to facility and operations managers.

Intermodal Systems

Transport roba železnicom može da obuhvati mrežu otpreme, drumskih i vazdušnih saobraćajnica. GIS može, kroz obezbeđenje tačnih i pravovremenih informacija, da omogući znatno efikasnije upravljanje realizacijom otpreme i prevoza. Tako na primer, ArcGIS Network Analyst omogućava kombinovanje mreža različitih vidova saobraćaja (slika 12) u cilju efikasnijeg rutiranja otprema, štedeći vreme i novac. GIS takođe podržava razvoj "komandnih panoa" koje menadžerima procesa i objekata, pružaju koristi od intuitivnih grafičkih mapa i poznavanja prostornih informacija.

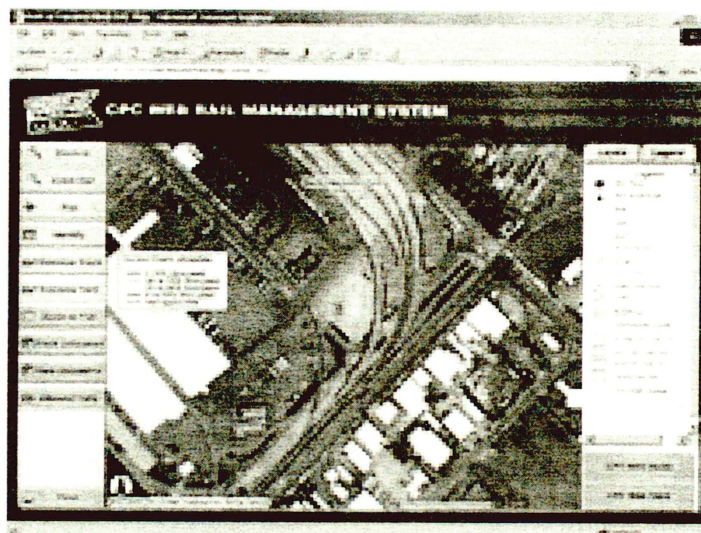


Figure 12 The Port of Tacoma Intranet Rail Management System integrates near real-time ArcIMS displays and dynamic tabular reports (Source: www.esri.com)

slika 12 Železnički intranet menadžment sistem luke Tacoma integriše približno real-time ArcIMS prikaz i dinamičke tabelarne izveštaje (Izvor: www.esri.com)

Aviation

Airports around the world plan for and manage their facilities by integrating GIS with many other information technology tools. Missions as diverse as security and environmental compliance are served effectively by GIS analysis. Air traffic control organizations use GIS for both its 2D and 3D capabilities to maintain safe flight paths and efficient re-routing when severe weather conditions interfere with normal operations. Airline and airfreight firms utilize GIS for many activities including facilities management and capacity planning.

Water Transportation

GIS is an important technology tool that manages and analyzes timely information effectively and efficiently for use in a number of key areas. GIS allows for data integration in a way that facilitates understanding and improved decision making. In addition, many water bodies are extremely sensitive to pollutants and excessive traffic. GIS helps engineers and planners accommodate design goals and environmental constraints more easily. Local models can be developed which provide a glimpse at the potential impact of traffic growth or new construction (figure 13).

Vazduhoplovstvo

Aerodromi širom sveta planiraju da za potrebe upravljanja svojim objektima integrišu GIS sa drugim alatima informacionih tehnologija. Uloge u okviru širokog spektra zadataka, npr. vezanih za bezbednost i prilagodavanje okruženju, efektivno se ostvaruju putem GIS analiza. Organizacije za kontrolu vazdušnog saobraćaja koriste mogućnosti 2D i 3D GIS-a kako bi održavali bezbednost vazdušnih puteva i omogućili neophodne promene ruta kada loši vremenski uslovi ometaju normalno funkcionisanje vazdušnog saobraćaja. Vazduhoplovni prevoznici i transporter koriste GIS za mnoge aktivnosti, uključujući menadžment resursima i planiranje kapaciteta.

Vodni transport

GIS je važan alat koji u vremenu efektivno sprovodi menadžment informacijama radi njihove efikasne i efektivne primene u velikom broju važnih oblasti. GIS omogućava integraciju podataka na način koji olakšava razumevanje stanja i unapređuje postupke donošenja odluka. Pri tome, mnogi plovni putevi su veoma osetljivi na zagađenja i preobiman saobraćaj. GIS pomaže inženjerima i projektantima da se mnogo lakše prilagode projektnim ciljevima i ograničenjima okruženja. Mogu da se razvijaju modeli za lokalne uslove koji obezbeđuju brz pregled potencijalnih uticaja porasta saobraćaja ili novih konstrukcija (slika 13). Tako se, na primer, PLTS Nautical Solution koristi GIS za produktivnu izradu i održavanje

PLTS Nautical Solution is used for high-volume production and databases from a variety of sources. Nautical Solution includes desktop production tools to efficiently create and maintain National Geospatial-Intelligence Agency VPF DNC compliant data as well as the Harbor Approach and Coastal chart cartographic product.

standardnih digitalnih baza podataka nautičkih karata (standard Digital Nautical Chart databases) iz niza različitih izvora. Nautička rešenja uključuju izradu desktop alata kako bi se efikasno formirali i održavali relevantni podaci (National Geospatial-Intelligence Agency VPF DNC) kao i izrada kartografskih proizvoda za potrebe luka i službi koje se brinu o stanju obala.

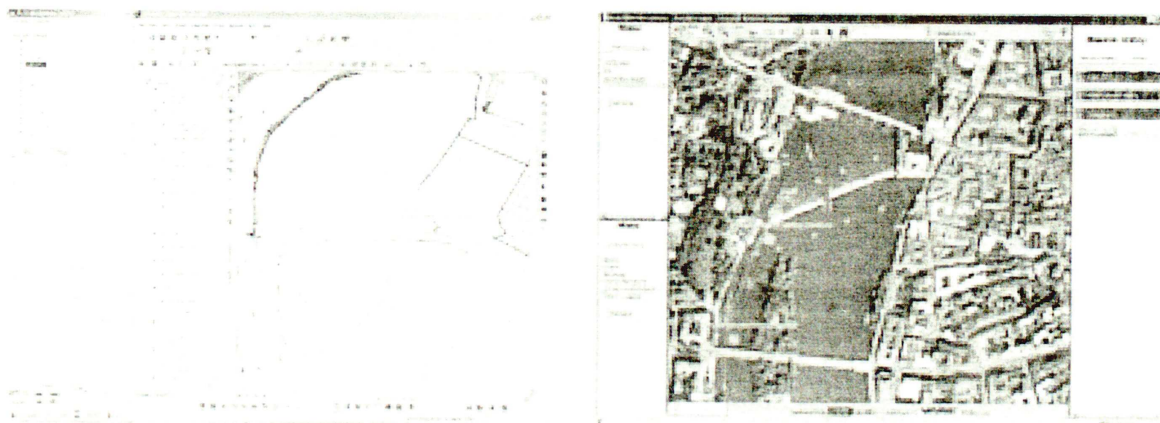


Figure 13 Czech Republic manages inland waterways with ArcGIS

(Source: www.esri.com)

slika 13 Češka Republika koristi ArcGIS za menadžment unutrašnjih plovnih puteva

(Izvor: www.esri.com)

ITS

The Intelligent Transportation System (ITS) market is one of the world's most diverse in terms of participant types, technologies deployed, and project goals. ITS uses computer and telecommunication technologies to help in periods of downtown traffic jams in Tokyo; improve rural road safety in Colorado; speed toll-paying and snow-clearing in northern Virginia; improve public transportation in Florida; ease trucking slowdowns from Canada to the Mexican border; and provide a plethora of in-vehicle services for commuters, commercial carriers, and travelers (figure 14).

GIS can be integrated with other systems (e.g., CCTV-Video and VMS) to provide a responsive, ergonomic, and intuitive interface for incident management staff. This is critical for high-stress and extended shift positions, especially during the emergency period. Extended weather emergencies, unusual traffic activity, and security-related events require adaptive and easy-to-use tools.

ITS

Svetsko tržište ITS karakteriše najveći spektar razlika sa aspekta tipa korisnika, primenjenih tehnologija i ciljeva projekata. ITS primenjuje računarske i komunikacione tehnologije da bi pomogao saobraćajnim kolapsima u centru Tokija; poboljšao bezbednost na lokalnim putevima u unutrašnjosti Kolorada, ubrzao naplatu putarina i rasčišćavanje snega u severnoj Virdžiniji; poboljšao javni prevoz u Floridi; olakšao prevoz od Kanade do Meksika; obezbeđuje dovoljnost kapaciteta prevoznih sredstava kod prevozu putnika, špeditera i td. (slika 14)

GIS može da se integriše sa drugim sistemima (npr. CCTV-Video i VMS) kako bi rukovodiocima za hitne službe obezbedio povratni, ergonomski i intuitivni interfejs u slučaju nesreća. To je kritično za radna mesta po smenama koja su sa jakim stresnim situacijama, posebno tokom perioda hitnih intervencija. Produženi periodi nevremena, neuobičajene saobraćajne aktivnosti i događaji vezani za sigurnost nameću potrebu za adaptivnim alatima koji su laki za korišćenje.

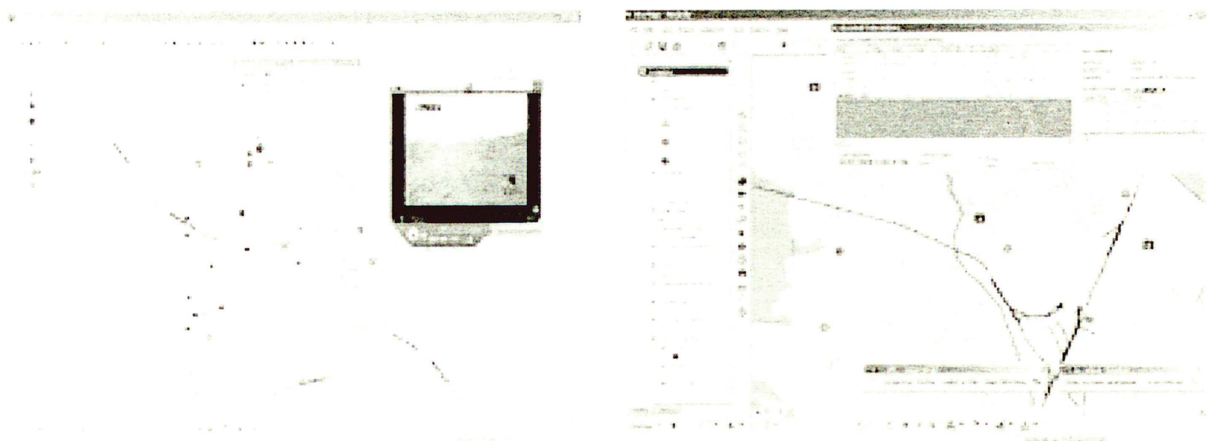


Figure 14. Visual display of routes and their characteristic for required chain of delivery or Incident Management and Emergency Response (Source:www.esri.com)

slika 14. Vizuelni prikaz ruta i njenih karakteristika za potreban lanacisporuke ili menadžment incidentima i postupcima u hitnim slučajevima (Izvor: www.esri.com)

4 CONCLUSION

The harder market conditions demand making quick and good decisions. This is especially important in logistics where decision-making in real time is often a postulate of successful business. Having that in mind, IT development is from essential importance for logistic, and GIS has special role within IT. Development of vast and public GIS is for a long time one of the strategic concerns of developed countries because of the influence such system could have on the development of society. Because of that, GIS technologies are being investigated and present systems are being continuously updated.

Because of that importance, this paper shows the review of basic components of GIS technology, variety of business application of GIS in the world, with special look on logistic area. Data in literature about GIS technology show that 80% of all business data has component, which shows necessity of application GIS in data analysis and decision-making. Users of this technology are all business and other systems, which by any way deal by space, or processing and exploitation of spatial objects. In this paper, some of the most important GIS softwares are being shown, and all the aspects points on remarkable development and raise of application of these tools in the world. Industries that benefit from GIS software include transportation, logistics, health care, public safety, education, utilities, local government, business, and many more.

4 ZAKLJUČAK

Sve oštriji uslovi na tržištu zahtevaju brzo donošenje dobrih odluka. To je od posebne važnosti u logistici, gde je on-line donošenje odluka po pravilu preduslov uspešnog poslovanja. Imajući to u vidu, razvoj IT je od esencijalne važnosti za logistiku, pri čemu u okviru IT-a, GIS ima specijalno mesto i ulogu. Razvoj rasprostranjenog i javnog GIS-a je, dugoročno, od strateške važnosti za zemlje u razvoju zbog mogućnosti uticaja ovih sistema na razvoj društva uopšte. Iz tih razloga GIS tehnologije su bile predmet istraživanja a i sadašnji sistemi se stalno unapređuju.

Zbog takvog značaja, u radu je dat prikaz osnovnih komponenti GIS tehnologije, varijante poslovnih primena GIS-a u svetu, sa posebnim osvrtom na područje logistike. Prema podacima iz literature, vezane za GIS tehnologije, uočava se da 80% svih poslovnih podataka imaju komponente koje ukazuju na potrebu primene GIS pri obradama podataka ili donošenju odluka. Korisnici ove tehnologije su svi poslovni i drugi sistemi, koji su na neki način vezani sa prostorom ili procesima i iskorišćavanjem prostornih objekata. U ovom radu su prikazani neki od najvažnijih GIS softvera, kao i aspekti koji su od značaja za uočljiv razvoj i porast primene ovih alata u svetu. Delatnosti koje imaju koristi od GIS softvera obuhvataju saobraćaj, logistiku, zdravstvo, javnu bezbednost, obrazovanje, lokalnu upravu, poslovanje i mnoge druge.

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