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SOME EXAMPLES OF GPS AND GIS TECHNOLOGY APPLICATIONS

NEKI PRIMERI PRIMENE GIS I GPS TEHNOLOGIJE

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Abstract: *GPS (Global Positioning System) is a system for real-time determination of objects position. By using the GPS technology, position of all mobile and fixed objects can be precisely measured. Mihajlo Pupin Institute has developed SPIDER system - the System for real time PosItioning, Data Acquisition, Automatic Control, SurvEillance, and MonitoRing. A part of the system is GIS application which provides monitoring on digital map of territory. In this paper are shown some examples of the use of SPIDER System.*

Key words: *GPS, GIS, Fleet Management System*

Apstrakt: *GPS (Globalni Pozicioni Sistem) predstavlja sistem za određivanje pozicije objekata u realnom vremenu. Primenom GPS tehnologije može se odrediti pozicija svih stabilnih i mobilnih objekata na zemlji. U Institutu Mihajlo Pupin je razvijen sistem PAUK, koji predstavlja Pozicioniranje, Automatiku, Upravljanje i Kontrolu mobilnih objekata u realnom vremenu. Deo sistema je i GIS aplikacija koja omogućava praćenje mobilnih objekata na odgovarajućoj digitalnoj podlozi teritorije. U radu su prikazani neki primeri primene PAUK sistema.*

Ključne reči: *GPS, GIS, Upravljanje voznim parkovima*

1 INTRODUCTION

A GPS (Global Positioning System) is a global satellite system that allows real-time determination of object locations. A wide variety of systems developed relying on GPS technology is available today. They are employed in various fields: land surveying, mining, power industry, transportation and traffic, navigation, etc. In this paper we will present the SPIDER system developed for use in various fleet management systems. The paper is organized in five parts. The GPS and GIS technologies as well as the areas of their applicability are described in Sections 1 and 2. The SPIDER system and its subsystems are presented in Section 3. The examples of SPIDER's practical real-life

1. UVOD

GPS (Globalni Pozicioni Sistem) predstavlja globalni satelitski sistem koji omogućava određivanje pozicije objekata u realnom vremenu. Danas u svetu postoji veliki broj razvijenih sistema koji se zasnivaju na GPS tehnologiji. Primena ovih sistema je u različitim oblastima: geodezija, rudarstvo, energetika, transport i saobraćaj, navigacija, i dr. U ovom radu će biti prikazan Sistem PAUK, razvijen za primenu u različitim sistemima upravljanja voznim parkovima. Rad obuhvata pet celina. U prvom i drugom delu su opisane GPS i GIS tehnologije i mogućnosti njihove primene. Treći deo rada obuhvata opis Sistema PAUK i njegovih podsistema. U četvrtom delu rada su prikazani primeri konkretne primene ovog sistema u praksi.

applications are given in Section 4. Various aspects of the use of digital maps in the SPIDER system are treated in Section 5. GIS applications with various digital maps in the actual examples are presented here.

2 THE GLOBAL POSITIONING SYSTEM

The Global Positioning System (GPS) is a system for real-time determination of object locations. Developed by the US Department of Defense, it has been used since 1973. Determining object positions was made commercially available in 1993 when the NAVSTAR (NAVigation Satellite Timing And Ranging) was launched.

GPS has found a wide range of applications in a large number of fields. It was used first by NASA for its own purposes and later on in military aviation and all transport modes. Today GPS is widely used in land surveying, mining, construction engineering, industrial processes, i.e., in all applications that require determining the location of stable or mobile objects. The last decade has witnessed a rapid expansion of systems based on the application of GPS technology. GPS systems are used in all transport modes for locating and monitoring of transportation means, reloading devices and logistic units (pallets, containers, etc.).

A large number of systems based on GPS technology have been offered to the market in Serbia in recent years. Sellers offer mainly the GPS equipment intended for various purposes and made by globally reputed manufacturers (Trimble, Garmin). One part of this offer covers systems based on GPS technology. These systems comprise, mainly, a set of GPS devices, communication equipment and a main center for data acquisition, processing and presentation. The largest number of GPS systems are used in land surveying, mining and transportation, i.e., in applications where it is necessary to determine precisely the location of an object and display it in a dispatching (cadastral) center.

3 THE GEOGRAPHIC INFORMATION SYSTEM

The Geographic Information System (GIS) may be described as a rationally organized set of computer hardware, software,

Peti deo rada opisuje različite aspekte primene digitalnih karta u Sistemu PAUK. Ovde je prikazano kako izgledaju GIS aplikacije sa različitim digitalnim podlogama u konkretnim primerima.

2 GLOBALNI POZICIONI SISTEM

Globalni Pozicioni Sistem (GPS) predstavlja sistem za određivanje pozicije objekata u realnom vremenu. GPS je razvijen od strane Ministarstva odbrane SAD i primenjuje se od 1973. godine. Određivanje pozicije objekata je postalo dostupno širokom krugu korisnika 1993. godine otvaranjem GPS sistema NAVSTAR (NAVigation Satellite Timing And Ranging), koji obezbeđuje komercijalnu primenu.

U svetu je GPS našao veliku primenu u različitim oblastima. GPS je prvo počeo da se koristi za potrebe NASA, zatim u vojnom vazduhoplovstvu i svim vidovima saobraćaja. Danas GPS ima veliku primenu u geodeziji, rudarstvu, građevinarstvu, industrijskim kompleksima, odnosno, svuda gde je potrebno snimanje pozicije stabilnih ili mobilnih objekata. Poslednjih desetak godina je ekspanzija sistema, koji se zasnivaju na primeni GPS tehnologije. GPS sistemi se primenjuju u svim vidovima saobraćaja za pozicioniranje i praćenje saobraćajnih i transportnih sredstava, pretovarne mehanizacije i logističkih jedinica (palete, konteneri, i dr.).

U Srbiji se poslednjih godina pojavila velika ponuda različitih sistema, koji se zasnivaju na GPS tehnologiji. Prodavci uglavnom nude GPS uređaje poznatih svetskih proizvođača za različite primene (Trimble, Garmin). Jedan deo tržišne ponude se odnosi na sisteme koji se zasnivaju na GPS tehnologiji. Ovi sistemi se, uglavnom, sastoje od skupa GPS uređaja, komunikacije i glavnog centra, gde se podaci prikupljaju, obrađuju i prikazuju. Najveća primena GPS sistema je u oblastima geodezije, rudarstva i saobraćaja, gde je potrebno precizno odrediti poziciju nekog objekta i prikazati je u dispečerskom (katastarskom) centru.

3 GEOGRAFSKI INFORMACIONI SISTEM

Geografski Informacioni Sistem (Geographic Information System - GIS) se može opisati kao racionalno organizovan skup računarskog hardvera,

geographic data and users, designed so as to permit efficient capture, storage, analysis, arrangement and spatial presentation of geographic and all other information of interest to a user.

Depending on how and on what level it is used, a comprehensive GIS may be considered as a set of three basic elements (Figure 1):

- **Geovisualization,**
- **Geodatabase**, and
- **Geoprocessing**.

softvera, geografskih podataka i korisnika, koji je projektovan tako da omogućava efikasno prikupljanje, čuvanje, sređivanje, analizu i prostorno prikazivanje geografskih i svih drugih infomacija koje su od interesa za korisnika.

U zavisnosti od načina i nivoa primene, sveobuhvatni GIS se može posmatrati kao skup tri osnovna elementa (slika 1):

- **Geovizuelizacija**,
- **Geo-baze podataka**, i
- **Geoprocesiranje**.

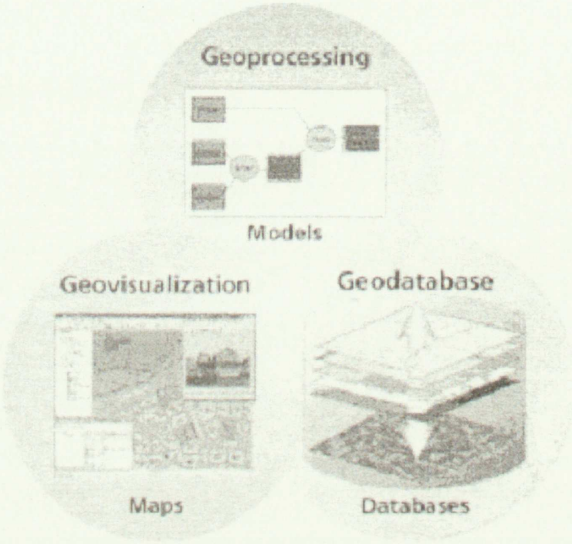

Figure 1 Three basic elements of a comprehensive GIS, (Source: www.geomatics.co.yu)
slika 1 Tri osnovna elementa sveobuhvatnog GIS-a, (Izvor: www.geomatics.co.yu)

- **Geovisualization** – A GIS is a set of intelligent maps and other presentations that show the characteristics of the Earth's surface and their relations. One can construct maps presenting various layers of geographic information and use them as «database windows» to support studies, analyses as well as data entry and modifications.

- **Geodatabase** – A GIS is a comprehensive database containing data sets in a vector (points, lines, polygons) and raster (topologies, networks, etc) form.

- **Geoprocessing** – A GIS is a set of tools for data transformation that derives new data sets from available ones. Geoprocessing functions apply analytical functions to the available data sets and enter the results into the newly derived data sets.

- **Geovizuelizacija** – GIS je skup inteligentnih mapa i drugih prikaza koji pokazuju karakteristike zemljine površine i njihove odnose. Mogu se konstruisati mape koje prikazuju različite slojeve geografskih informacija i iste se mogu koristiti kao "prozori u bazi podataka" da bi se podržala ispitivanja, analize kao i unos i promena podataka.

- **Geo-baze podataka** – GIS je sveobuhvatna baza podataka koja sadrži skupove podataka u vektorskom (tačke, linije, poligoni) i rasterskom obliku (topologije, mreže, itd.).

- **Geoprocesiranje** – GIS je skup alata za transformaciju podataka koji iz postojećih skupova podataka izvodi nove. Ove funkcije geoprocesiranja primenjuju analitičke funkcije na postojeće skupove podataka i rezultate zapisuju u novo-izvedene skupove podataka.

GIS has become popular and available to wider circles in the last two decades of the 20th century, whereas the last ten years have seen its largest commercial expansion. At the beginning the GIS technology was mainly employed for academic research; later on governmental bodies and agencies dealing with spatial data, public utility systems, space maintenance, environmental protection, etc. started to use it as well. GIS has thus become the major component of business and management operations all over the world in both the public and private sectors. Apart from being a technology, GIS is becoming a management concept applied in small and medium enterprises, large corporations, public institutions and governmental bodies.

The advantages of GIS include data visualization, establishing relations between geographic and attribute information as well as interdisciplinary decisionmaking possibilities. Although GIS itself cannot make a decision, it does help in organizing and analyzing the information better and thus provides support to faster and better decisionmaking. GIS technologies are widely used in traffic and transportation area: creation of road and traffic infrastructure cadastre, analysis of transport networks, road maintenance, safety level analysis, modelling of various transport problems, design routes and scheduling, etc.

The application of GPS technology is related directly to the use of GIS. GIS provides the presentation of the locations of various mobile and stable objects that are obtained using GPS. The location of important fixed objects and the motion of transport means, reloading equipment, logistic units, etc. can be presented on an appropriate digital geographic map of a territory. GIS provides the visual presentation of various types of information, allows spatial effects to be recognized, allows faster inferring from visual presentations, offers various possibilities for the presentation of phenomena and processes.

4 THE SYSTEM SPIDER

Since 1988 the Mihajlo Pupin Institute's specialists have focussed their research and development efforts on a system based on the use of GPS technology. The **SPIDER** (**S**ystem for Real-time **P**os**I**tioning, **D**ata Acquisition, Automatic Control, Surv**E**illance and Monito**R**ing) is the result of these efforts.

GIS je postao popularan i dostupan u većoj meri u poslednje dve decenije XX veka, a najveću komercijalnu ekspanziju ima u poslednjih 10 godina. U početku se GIS tehnologija koristila uglavnom u oblasti akademskog istraživanja, a zatim je počela da se primenjuje u državnim organizacijama i agencijama, koje se bave prostornim podacima, komunalnim sistemima, održavanjem prostora, zaštitom okoline i dr. GIS je postao deo glavnih poslovnih i menadžment operacija širom sveta kako u javnom tako i u privatnom sektoru. Pored toga što se nameće kao tehnologija, GIS sve više postaje i koncept upravljanja počevši od malih i srednjih organizacija, pa sve do korporacija, javnih ustanova i državne uprave.

Prednosti GIS-a su u vizuelizaciji podataka, povezivanju geografskih i atributivnih obeležja, kao i u mogućnosti interdisciplinarnog odlučivanja. GIS nije sistem koji može da donese odluku, ali pomaže da se bolje organizuju i analiziraju informacije kao podrška za brže i kvalitetnije odlučivanje. GIS tehnologije se veoma mnogo koriste u oblasti saobraćaja i transporta: formiranje katastra putne i saobraćajne infrastrukture, analiza transportnih mreža, održavanje saobraćajnica, analiza nivoa bezbednosti, modeliranje različitih transportnih problema, projektovanje ruta i redova vožnje, i dr.

Primena GPS tehnologije je direktno povezana sa primenom GIS-a. GIS obezbeđuje prikazivanje lokacija različitih mobilnih i stabilnih objekata, do kojih se dolazi pomoću GPS-a. Na odgovarajućoj digitalnoj geografskoj podlozi teritorije moguće je prikazati lokaciju značajnih fiksnih objekata i kretanje saobraćajnih sredstava, pretovarne mehanizacije, logističkih jedinica, i dr. GIS obezbeđuje vizuelno predstavljanje različitih informacija, sagledavanje prostornih uticaja, brže zaključivanje iz vizuelnih prikaza, različite mogućnosti prikazivanja pojava i procesa.

4 SISTEM PAUK

Institut Mihajlo Pupin se od 1998. godine bavi istraživanjem i razvojem sistema, koji se zasniva na primeni GPS tehnologije. Razvijen je Sistem **PAUK**, koji predstavlja **P**ozicioniranje, **A**utomatiku, **U**pravljanje i **K**ontrolu mobilnih objekata. Ideja pri razvoju ovog sistema je bila da se primenom

In developing this system the Institute's specialists were led by the idea of applying modern information and communication technologies to provide a powerful fleet management tool for various purposes. SPIDER is a centralized computer system for real-time fleet control and management. SPIDER is a GPS-based system allowing the positions of all vehicles from a fleet on a transport network to be determined in real time. Dispatchers in the center have the possibility of monitoring visually vehicles on a territory in order to make appropriate high-quality decisions in real time. The SPIDER system with its subsystems is illustrated in Figure 2.

savremenih informacionih i komunikacionih tehnologija obezbedi moćan alat za upravljanje voznim parkovima različite namene. Sistem PAUK je centralizovan računarski sistem za automatsku kontrolu i upravljanje voznim parkovima u realnom vremenu. Sistem PAUK se zasniva na GPS tehnologiji i obezbeđuje u realnom vremenu određivanje pozicije svih vozila iz voznog parka na transportnoj mreži. U dispečerskom centru je omogućeno vizuelno praćenje vozila na nekoj teritoriji i donošenje kvalitetnih dispečerskih odluka u realnom vremenu. Na slici 2 je prikazan Sistem PAUK i njegovi podsistemi.

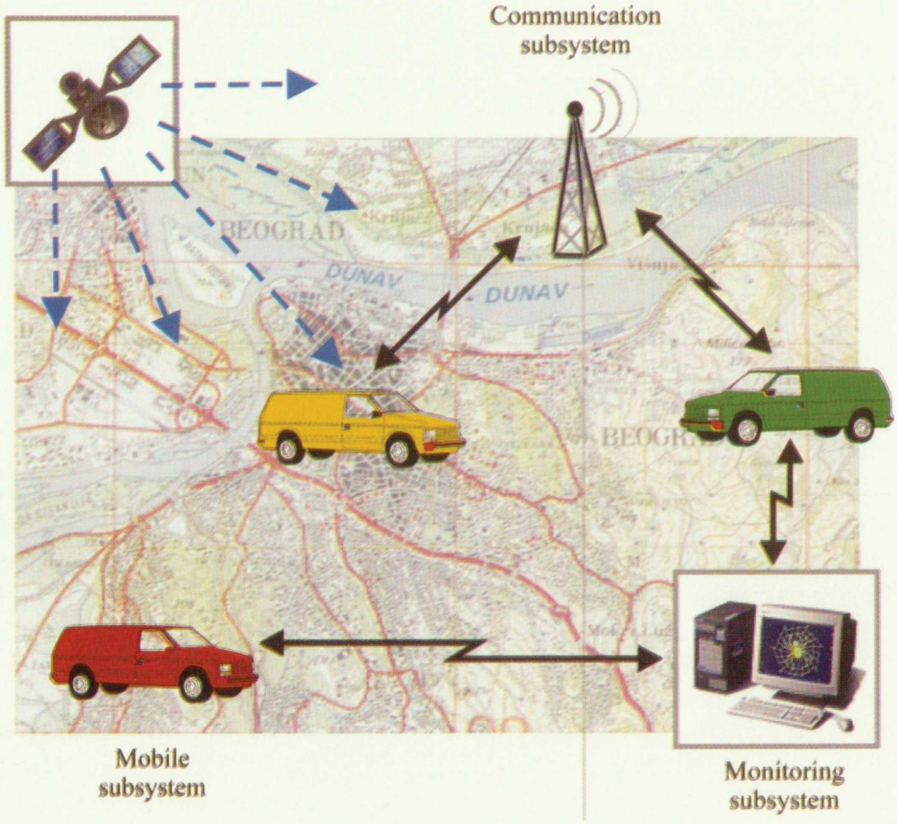

Figure 2 The System SPIDER
slika 2 Sistem PAUK

The mobile subsystem includes the set of all mobile SPIDER devices located in vehicles. The communication subsystem, a set of all links, provides the complete communication within the SPIDER system. The control (monitoring) subsystem is the SPIDER system Center where all information is collected and from where the entire system is controlled. The operation of all vehicles from the fleet can be monitored at this Center.

Mobilni podsistem obuhvata skup svih Mobilnih PAUK uređaja, koji se nalaze u vozilima. Komunikacioni podsistem je skup veza, koje obezbeđuju kompletnu komunikaciju u okviru Sistema PAUK. Upravljački podsistem je Centar sistema, gde se prikupljaju sve informacije i upravlja celokupnim sistemom. U Centru sistema je omogućeno praćenje rada svih vozila iz voznog parka.

Software support to the SPIDER system installed at the Center is based on GIS technology and permits the current positions and movement of vehicles in the transport network to be seen at the system Center. GIS tools allow the presentation of digital geographic maps of the territory on which vehicles travel.

5 SPIDER SYSTEM APPLICATION

So far the SPIDER system has been implemented to perform the monitoring of mobile objects in various business systems. We mention here some of these systems:

- Potisje Company in Kanjiža – BAGIS
- Serbian Armed Forces – ART
- Belgrade Water Supply and Sewerage System – BVK
- Novi Sad Water Supply and Sewerage system – NSVK
- Roads Enterprise in Niš – PZP

The Bagis System was developed to serve the needs of the Potisje Company in Kanjiža. This system permits the monitoring of a mechanical system (a so-called BTO system) working on the Majdan 3 surface mine in Kanjiža. The BTO system involves dredgers, conveyer belts and a repositioning dredger that excavate, transport and reposition clay to a storage from where it is transported to a processing plant. Four dredgers and one repositioning unit are equipped by mobile Spider units that allow the operation of this machinery to be monitored continuously at the dispatcher center. In addition to data on dredger and repositioner positions, the following sensor data are also transmitted to the center: is the machine working or not, is it communicating with the center, the type of clay excavated (blue or yellow).

The Art System was designed to serve the needs of one unit of Serbia's Army. This system is intended to monitor a set of vehicles on a certain territory. The Art System is specific in that it has several mobile and one main dispatcher center. Mobile dispatcher centers are installed in vehicles travelling on some territory. Each mobile center monitors the movement of a particular set of vehicles. All mobile centers and all vehicles from the fleet are monitored from the main dispatcher center.

The BVK and **NSVK Systems** were designed for water supply and sewerage utility companies in

Softverska podrška PAUK Sistema u Centru se zasniva na GIS tehnologiji i obezbeđuje da se u Centru sistema može videti trenutni raspored i kretanje vozila na transportnoj mreži. GIS alati omogućavaju prikaz digitalne geografske podloge teritorije, na kojoj se kreću vozila korisnika.

5 PRIMENA SISTEMA PAUK

Do sada je Sistem PAUK primenjen i realizovan u različitim poslovnim sistemima za praćenje mobilnih objekata. Neke od primena su sledeće:

- Potisje - Kanjiža – BAGIS
- Vojska Srbije – ART
- Beogradski vodovod i kanalizacija – BVK
- Novosadski vodovod i kanalizacija – NSVK
- Preduzeće za puteve Niš – PZP

Sistem BAGIS je razvijen za potrebe kompanije "Potisje" iz Kanjiže. Ovaj sistem omogućava praćenje mobilnih objekata – mašina BTO kompleksa, na površinskom kopu Majdan 3 u Kanjiži. BTO kompleks obuhvata sistem bagera, trakastih transportera i odlagača, koji iskopavaju, transportuju i odlažu glinu na deponiju, odakle ona ide u proces prerade i proizvodnje. Četiri bagera i jedan odlagač su opremljeni mobilnim Pauk uređajima, tako da se u dispečerskom centru neprekidno može pratiti njihov rad. Osim podataka o poziciji bagera i odlagača, u dispečerski centar se prenose i podaci sa senzora: da li mašina radi, da li ima komunikaciju i vrsta gline koja se kopa (plava ili žuta).

Sistem ARTt je projektovan za potrebe jednog sektora u Vojsci Srbije. Osnovni cilj sistema je praćenje skupa vozila na određenoj teritoriji. Specifičnost ovog sistema je u postojanju više mobilnih i jednog glavnog dispečerskog centra. Mobilni centri su instalirani u vozilima, koja se kreću na nekoj teritoriji. Svaki mobilni centar prati kretanje određenog skupa vozila. U glavnom centru se prate svi mobilni centri i sva vozila iz voznog parka.

Sistemi BVK i **NSVK** su projektovani za komunalne sisteme vodovoda i kanalizacije u

Belgrade and Novi Sad. Mobile Spider units are installed in sewerage vehicles which maintain these utility systems. These are special purpose and very expensive vehicles used to clean various objects in the city sewerage system. The BVK and NSVK systems provide continuous monitoring of all vehicles from the fleet, vehicle operation supervision, reports on the status of units installed in vehicles as well as reports on vehicle operation for any past period. The effects gained by applying these systems are manifold: more efficient utilization of vehicle operation time and of drivers' working hours, faster responses to operating tasks, a lower level of fraud, etc.

The PZP System is implemented to serve the needs of the Roads Enterprise in Niš. The system in intended to monitor the vehicles maintaining the road infrastructure in the region of Niš. In addition to vehicle location data, the following vehicle sensor data are also transmitted to the dispatcher center: fuel level, equipment status, etc. Vehicle movements are monitored at the Center and data obtained from the sensor for each vehicle can also be seen at the Center.

6 GIS APPLICATIONS

GPS technology cannot be applied without the appropriate integration with GIS technologies. Connecting GPS and GIS technologies into an integrated system provides real-time monitoring of mobile objects and presentation of object positions on a geographic map. In the SPIDER system GIS technology is integrated in the control Center and in vehicles (if a display or a laptop is available in a vehicle). GIS technology has been implemented in the ESRI ArcView environment that provides the connection to other software packages used in system development as well as the capabilities of presenting various data sets. The SPIDER system applications developed so far have included different digital maps, depending mostly on research needs and actual user requests. The developed GPS systems will be presented here.

System BAGIS

The GIS application integrated in the BAGIS system has been designed in the ArcView environment and has three views: the territory on which dredgers operate, the territory on which

Beogradu i Novom Sadu. Mobilni Pauk uređaji su instalirani u vozila kanalizacije, koja održavaju sisteme u ovim gradovima. To su specijalna vozila posebne namene i veoma velike vrednosti, koja se koriste za čišćenje različitih objekata gradskog kanalizacionog sistema. Sistemi BVK i NSVK obezbeđuju neprekidno praćenje svih vozila iz voznog parka, kontrolu rada vozila, stanje određenih uređaja u vozilima i dobijanje izveštaja o radu vozila za bilo koji prethodni period. Efekti primene ovih sistema su višestruki: efikasnije iskorišćenje rada vozila i radnog vremena vozača, brže reagovanje na operativne zadatke, smanjenje zloupotreba u sistemu rada, i dr.

Sistem PZP se realizuje za potrebe Preduzeća za puteve Niš. Cilj ovog Sistema je praćenje vozila za održavanje putne infrastrukture u regionu Niša. Osim podataka o lokaciji vozila, u dispečerski centar se prenose i podaci sa senzora u vozilu o nivou goriva, stanju opreme, i dr. U Centru se prati kretanje vozila i za svako vozilo se vide i podaci dobijeni sa senzora.

6 GIS APLIKACIJE

Primena GPS tehnologije nije moguća bez odgovarajuće integracije sa GIS tehnologijama. Povezivanjem GPS i GIS tehnologije u jedinstveni sistem obezbeđuje se praćenje mobilnih objekata u realnom vremenu i prikazivanje tačne pozicije objekata na odgovarajućoj geografskoj karti. Sistem PAUK ima integrisanu GIS tehnologiju u upravljačkom Centru i vozilima (kada u vozilima postoji displej ili laptop za praćenje kretanja). GIS aplikacija je urađena u ESRI ArcView okruženju, koje obezbeđuje povezivanje sa drugim programskim paketima, korišćenim u razvoju sistema, i velike mogućnosti prikazivanja različitih skupova podataka. U dosadašnjim primenama Sistema PAUK, korišćene su različite digitalne podloge, što je u najvećoj meri zavisilo od potreba istraživanja i konkretnih zahteva korisnika. Ovde će biti prikazani razvijeni GPS sistemi.

Sistem BAGIS

GIS aplikacija za Sistem BAGIS je projektovana u ArcView okruženju, ima tri pogleda (view), koji obuhvataju: teritoriju na kojoj rade bageri, teritoriju na kojoj radi odlagač i celu teritoriju

the repositioning unit operates and the whole BTO system territory. Digital maps in this system represent the terrain on which blue and yellow clay is excavated and have been made by geodesic measurements of this terrain. Geodesic measurements are performed in particular time periods (about two months) when changes in terrain configuration take place. New geodesic maps are entered automatically into the application. The BAGIS application is shown in Figure 3.

BTO kompleksa. Digitalne podloge u ovom sistemu predstavljaju teren na kome se radi iskopavanje plave i žute gline i napravljene su geodetskim premerom terena na kome se radi iskopavanje i odlaganje gline. Geodetski premer terena se radi u određenim periodima (oko dva meseca), kada dolazi do promene konfiguracije terena. Nove geodetske podloge se automatski unose u aplikaciju. Na slici 3 je prikazan izgled aplikacije BAGIS.

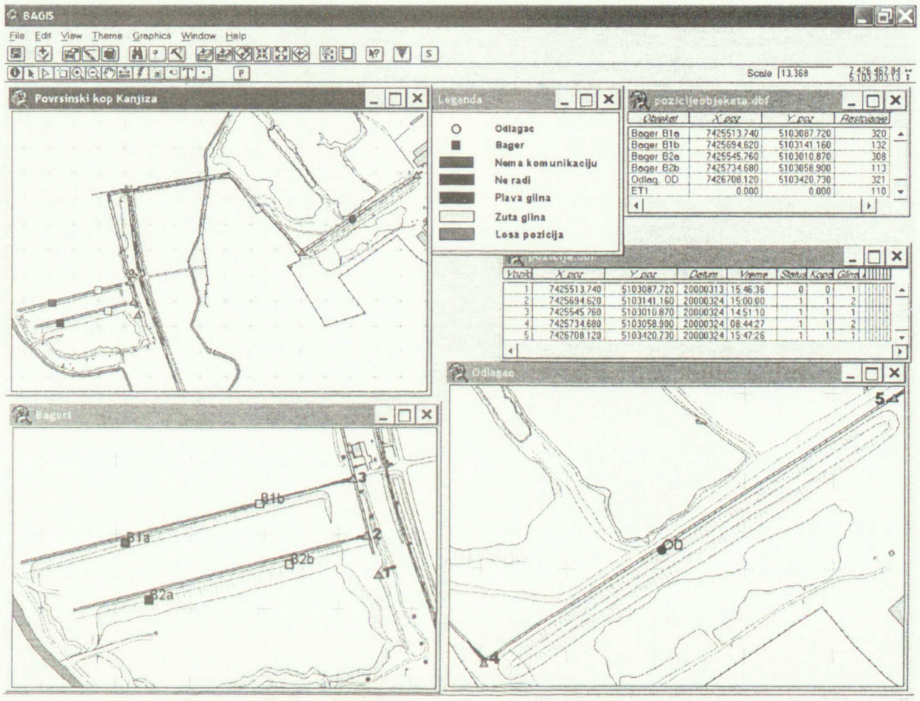

Figure 3 The System BAGIS
slika 3 Sistem BAGIS

System ART

The ART System permits monitoring a group of military vehicles on the territory of Serbia. This system is specific in that mobile dispatcher centers are installed in vehicles. Movements of mobile centers and all vehicles are monitored at the main dispatcher center. Applications for vehicle monitoring at mobile centers and at the main dispatcher center have been developed. Raster maps of Serbia and some bigger cities (as requested by users) are employed in this system. Applications permit selecting a territory on which vehicles are monitored, i.e., selecting a digital map presented on a display. The ART application is shown in Figure 4.

Sistem ART

Sistem ART omogućava praćenje jedne grupe vojnih vozila na teritoriji Srbije. Specifičnosti ovoga sistema su postojanje mobilnih dispečerskih centara koji se nalaze u vozilima. U glavnom dispečerskom centru se prati kretanje mobilnih centara i svih vozila. Razvijene su aplikacije za praćenje vozila u mobilnim centrima i glavnom dispečerskom centru. U ovom sistemu se koriste rasterske podloge Srbije i nekih većih gradova (prema zahtevima korisnika). Aplikacije omogućavaju izbor teritorije na kojoj se prate vozila, odnosno, izbor digitalne mape koja se prikazuje na ekranu. Na slici 4 je prikazan izgled aplikacije ART.

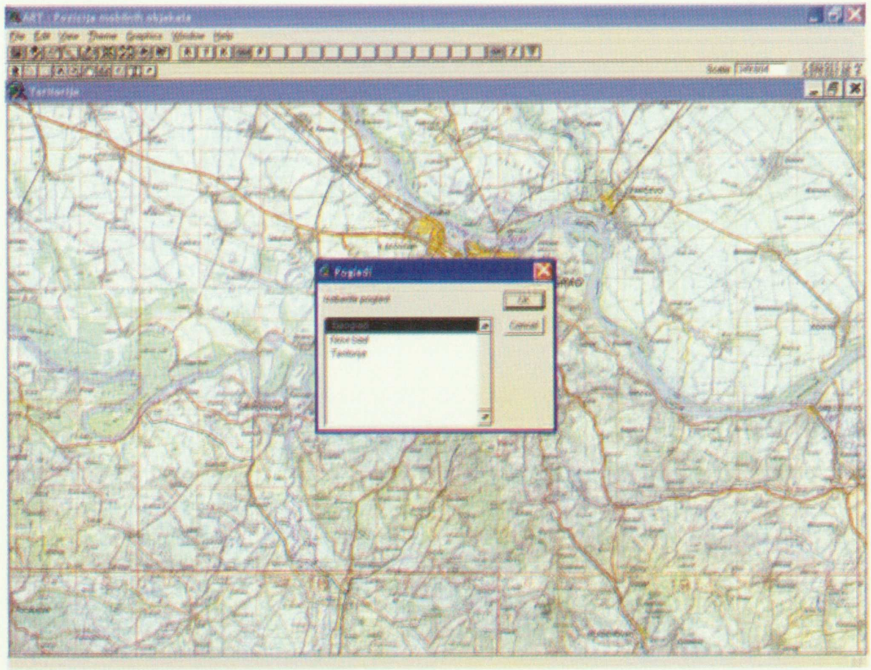

Figure 4 The System ART
slika 4 Sistem ART

System BVK

The GIS application integrated in the BVK system allows monitoring of special-purpose vehicles used to maintain the objects of Belgrade water supply and sewerage utility system. The digital map used is the vector map of the city of Belgrade that includes thematic layers of different groups of spatial objects (s8trets, blocks of buildings, buildings, green areas, rivers, etc.). New thematic layers containing the objects of Belgrade water supply and sewerage system (depots, pumping stations, etc.) have been added to the existing ones. Vehicles are monitored on the whole territory of the city of Belgrade. The application permits automatic setting of the scale of the map displayed. Depending on this scale, particular thematic layers are displayed. By zooming a particular vehicle it is possible to determine precisely its location. The application also permits displaying the basic characteristics of a vehicle (registration plate number, garage number, vehicle type, intervention performed, etc.). The BVK application is shown in Figure 5.

Sistem BVK

GIS aplikacija u Sistemu BVK omogućava praćenje specijalnih vozila za održavanje objekata gradskog komunalnog sistema vodovoda i kanalizacije. Digitalna podloga je vektorska karta grada Beograda, koja obuhvata tematske slojeve različitih grupa prostornih objekata (ulice, blokovi zgrada, zgrade, zelene površine, reke, i dr.). Na postojeće tematske slojeve dodati su novi slojevi sa objektima vodovoda i kanalizacije u Beogradu (depoi, pogonske stanice, i dr.). Praćenje vozila se radi na celoj teritoriji grada Beograda. Aplikacija omogućava automatsko podešavanje razmere mape koja se prikazuje na ekranu. U zavisnosti od razmere prikazuju se određeni tematski slojevi. Zumiranjem određenog vozila može se tačno videti na kojoj lokaciji se vozilo nalazi. Aplikacija omogućava i prikazivanje osnovnih karakteristika vozila (registarski i garažni broj, tip vozila, vrsta intervencije, i dr.). Na slici 5 je prikazan izgled aplikacije BVK.

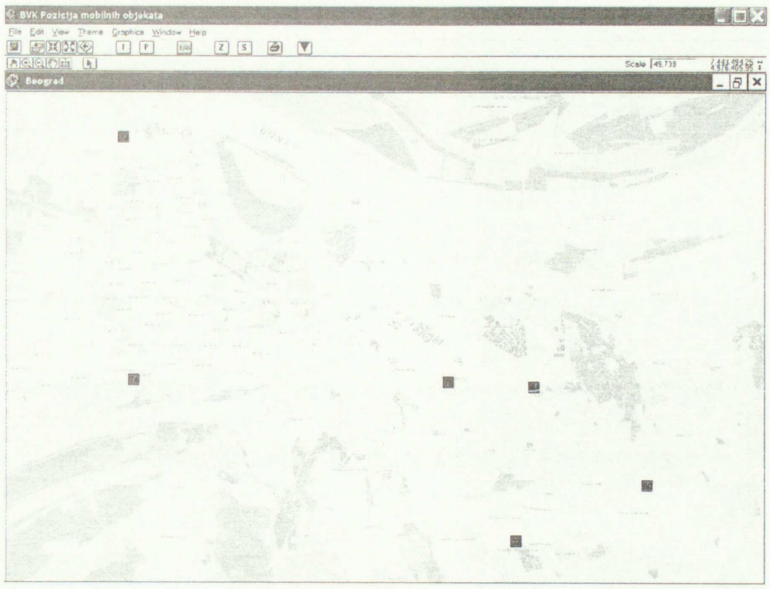

Figure 5 The System BVK
slika 5 Sistem BVK

System NSVK

The raster map of the city of Novi Sad is used as a digital map in the NSVK system. In accordance with user requirements, thematic layers including objects of interest to the water supply and sewerage system of Novi Sad have been created. The NSVK application permits monitoring the vehicles of Novi Sad water supply and sewerage system. The application allows displaying a current position of any vehicle, the basic characteristics of any vehicle and generating a report on the movement of any vehicle for any past period. The NSVK application is shown in Figure 6.

Sistem NSVK

Digitalna podloga u Sistemu NSVK je rasterska karta grada Novog Sada. Prema zahtevima korisnika kreirani su tematski slojevi koji obuhvataju objekte od značaja za gradski vodovod i kanalizaciju grada Novog Sada. Aplikacija NSVK omogućava praćenje vozila gradskog vodovoda i kanalizacije. Za sva vozila se može videti njihova trenutna pozicija, osnovne karakteristike i mogu se dobiti izveštaji o kretanju vozila za bilo koji prethodni period. Na slici 6 je prikazan izgled aplikacije NSVK.

Figure 6 The System NSVK
slika 6 Sistem NSVK

System PZP

Vehicles of the Roads Enterprise in Niš perform their tasks on a wider territory surrounding the city of Niš. Digital maps used in the PZP system are raster maps covering the Central and Eastern Serbia territory. These raster maps do meet the present user requirements, but, if necessary, they can be expanded by thematic layers with groups of particular objects. The PZP application is shown in Figure 7.

Sistem PZP

Vozila Preduzeća za puteve Niš obavljaju svoje radne zadatke na široj teritoriji Niša. Digitalne podloge u Sistemu PZP su rasterske podloge, koje obuhvataju teritoriju centralne i istočne Srbije. Rasterske podloge zadovoljavaju trenutne potrebe korisnika i omogućavaju dodavanje tematskih slojeva sa grupama određenih objekata. Na slici 7 je prikazan izgled aplikacije PZP.

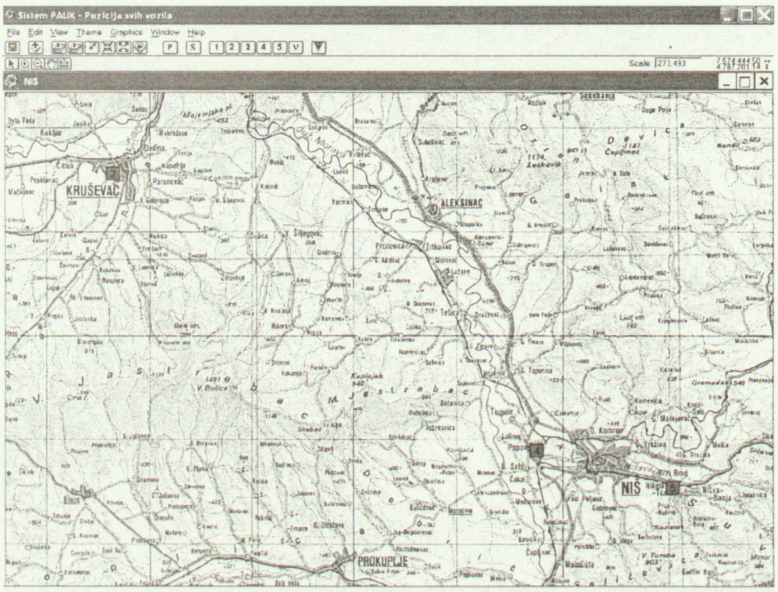

Figure 7 The System PZP
slika 7 Sistem PZP

7 CONCLUSION

The SPIDER system has been developed for fleet management purposes in various areas. It relies on the use of the latest technologies worldwide. The ESRI GIS technology allows developing and designing applications for presenting the locations of stable and mobile objects on various digital maps. In the examples described in this paper the geodesic terrain maps and the vector and raster maps of cities and of Serbia have been used. Satellite-made terrain maps combined with raster maps have been used in some other examples. The developed GIS applications involve a large set of functions with spatial data: selection of objects to be displayed, zooming of objects and locations, spatial analyses, generation of various reports, etc. The main advantages provided by the SPIDER system are:

- System functions are tailored to the needs of various vehicle fleets. System flexibility and modularity allow its functions to be adaptable to the requirements of a wide range of users.

7 ZAKLJUČAK

Sistem PAUK je razvijen za upravljanje voznim parkovima različitih namena. Sistem se zasniva na najsavremenijoj svetskoj tehnologiji. Primena ESRI GIS tehnologije omogućava razvoj i projektovanje aplikacija za prikazivanje lokacije stabilnih i mobilnih objekata na različitim digitalnim podlogama. U opisanim primerima mogu se videti geodetske podloge terena, vektorske i rasterske podloge gradova i države Srbije. U nekim drugim primerima korišćeni su i satelitski snimci terena u kombinaciji sa rasterskim podlogama. Razvijene GIS aplikacije obuhvataju veliki skup funkcija sa prostornim podacima: izbor objekata za prikazivanje, zumiranje objekata i lokacija, prostorne analize, dobijanje različitih izveštaja, i dr. Osnovne prednosti razvijenog Sistema PAUK su:

- Funkcije sistema su prilagođene potrebama različitih voznih parkova. Fleksibilnost i modularnost sistema omogućavaju da funkcije budu prilagođene potrebama širokog skupa korisnika.

The SPIDER system is developed in stages, i.e., it can be implemented in certain parts of a vehicle fleet first and later in all vehicles.

- Data transmitted by the communication subsystem are protected to the highest possible extent. Automatic data transmission ensures the absence of errors and human impact.
- Software developed for the SPIDER system is modular and allows modifications to be made in accordance with specific requests of any user.
- Home-made hardware is incorporated in the SPIDER system. The GPS card and radio station are the only imported components.
- The system permits the use of various models of spatial data and digital maps, depending on the specific requirements of each user.
- The importance of the use of digital maps in this system is extremely high, because quality monitoring and control of mobile objects is achieved through the use of GIS and appropriate spatial data.

- Sistem PAUK se razvija fazno tako da je moguća njegova primena na pojedine delove voznog parka, a zatim na sva vozila.
- Podaci koji se prenose komunikacionim podsistemom su maksimalno zaštićeni. Automatski prenos podataka obezbeđuje odsustvo greške i ljudskog uticaja.
- Softver, koji je razvijen u Sistemu PAUK je modularan i dozvoljava modifikacije prema specifičnim zahtevima svakog korisnika.
- Hardver, koji je ugrađen u Sistem PAUK je kompletno domaći. Jedine uvozne komponente su GPS kartica i radio-stanica.
- Sistem omogućava primenu različitih modela prostornih podataka i digitalnih karata u zavisnosti od potreba konkretnog korisnika.
- Značaj primene digitalnih karata u ovom sistemu je izuzetno veliki jer upravo primena GIS-a i kvalitetnih prostornih podataka omogućavaju kvalitetan monitoring i upravljanje mobilnim objektima.

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