The third chapter, *Concept of cartographic database of Bosnia and Herzegovina* is of special importance, because it features the development and proposal of a concept of a cartographic database, according to all principles of the previous chapter. The main result of the research was applied and presented in an object-relational data model, using the Oracle Spatial system for managing databases. The complete procedure of producing an interoperable cartographic database was presented and proposed in great detail: from cartographic data in CAD-form, their saving in an interoperable database, to the distribution to a wide circle of users, via Internet.

The chapter *Conclusion* contains a clear summation and integration of the results of research.

Appendix A (*Simple Features Specification for SQL*) contains a detailed and precise description of component specification for SQL:1992 and SQL:1999, while Appendix B considers in detail the *Web Feature Service*, which is important for interoperability in the field of distributing vector data via Internet. Considering that the area this master thesis deals with is completely new and that most professionals are not acquainted enough with the new terminology, Appendix C is a *Dictionary of Basic Terms and Abbreviations*.

The main results of the master thesis are:

- A systematic overview of concepts and standards of geoinformation interoperability, that is interoperability of geospatial databases.
- Logical object-relational model of cartographic database.
- Proposal of concept of creating an interoperable cartographic database – from CAD-data to the distribution on the Internet.
- Concept and proposal of a prototype of interoperable object-relational cartographic database.
- Concept and proposal of distribution of cartographic data via Internet, using technologies based on OGC standards.

On the basis of review and evaluation of this master thesis, members of the Committee concluded that the candidate considered an exceptionally important, actual and interdisciplinary problem of geoinformatics and cartographic profession, studied in detail the relevant contemporary literature from the field of geoinformation interoperability within the context of databases and grasped the methodology of scientific-research work. We would like to mention the fact that this is the first research and master thesis in the field of cartographic and geoinformation interoperability produced in Bosnia and Herzegovina.

Miljenko Lapaine, Zdravko Galić

Mirko Husak, MSc in Technical Sciences

Mirko Husak finished the postgraduate scientific studies, orientation Photogrammetry and Cartography at the Faculty of Geodesy of the University of Zagreb and obtained his MSc degree on June 29, 2006. He passed all exams with excellent marks, and his thesis titled *Temporal and Historical GIS of Varaždin Old Fort*, produced as the final paper at the international postgraduate GIS studies *Comett* held in San Miniato in Italy in 1994, organised by the Department for Geoinformation of the Vienna University of Technology, and under the mentorship of Prof. Dr. Andrew U. Frank, was acknowledged as an equivalent to the master's thesis.

Mirko Husak was born in Zagreb on May 6, 1967. He has lived in Varaždin since 1970, where he finished elementary and high school. During gymnasium days he participated in competitions in mathematics, physics and informatics, and in first class he participated in the republic mathematics competition. As an excellent student, he graduated without the graduate exam and the graduate thesis. He graduated at the Gymnasium (Gabriel Santo High School Centre at the time) in Varaždin. He enrolled the Faculty of Geodesy of the University of Zagreb in 1986. During his studies, he was a student assistant for Computer Processing of Geodetic Data and Higher Geodesy. He graduated with great success in 1991, with a thesis titled *Calcomp 9100 Digitiser Accuracy Testing*. In 1994 he applied for the International Postgraduate Course on GIS within the scope of the COMETT program of the European Union, organised by the Vienna University of Technology, held in San Miniato near Florenze, Italy. The specialisation resulted in a GIS project with a final paper titled *Temporal and Historical GIS of Varaždin Old Fort*. In 1999 he enrolled the postgraduate scientific studies at the Faculty of Geodesy of the University of Zagreb.

He has been working at the cadastral office in Varaždin since 1992. He collaborated on professional projects Technical Cadastre of Varaždin (1994) and GIS-Supported Land Cadastre (1997). In teaching activities at the Faculty of Organisation and Informatics (FOI) in Varaždin, he has been responsible for exercises in the course Geographic Information Systems (GIS) since academic year 1994/1995. He is a GIS consultant for the development project E!2584 Euroturism Ulixes – Intelligent Tourist Agency (2002-2006) which are led by FOI Varaždin and the Town of Varaždin.

He participated at professional and scientific meetings in Croatia and abroad, and is the author of several professional papers published in proceedings and a book of abstracts and a chapter in a book. He has been a member of the Croatian Geodetic Society from 1992, the Croatian Cartographic Society from 2005, and published in journals *Geodetski list* and *Cartography and Geoinformation* periodically. He is a member of the Croatian Chamber of Architects and Engineers in Construction.

During academic year 1988/1989, he was acknowledged by the University of Zagreb as one of the best students of the University of Zagreb, in 1989/1990 he was awarded scholarship as one of the best students ad the University of Zagreb, in 1991/1992 he was awarded the Rector's Award for the best student work *Centroid File of Croatian Settlements* produced at the Faculty of Geodesy of the University of Zagreb.

Treće poglavlje *Koncept kartografske baze BiH* od posebnog je značenja, jer se u njemu razvija i predlaže koncept kartografske baze podataka, sukladno svim principima izloženim u prethodnom poglavlju. Glavni rezultat istraživanja primijenjen je i prikazan u objektno-relacijskom modelu podataka, upotrebom sustava za upravljanje bazama podataka Oracle Spatial. Posebno je detaljno prikazan i predložen kompletan postupak stvaranja interoperabilne kartografske baze podataka: od kartografskih podataka u CAD-obliku, njihova spremanja u interoperabilnu bazu podataka, do distribucije širokom krugu korisnika, putem interneta.

U poglavlju *Zaključak* na jasan se način sumiraju i objedinjuju rezultati istraživanja.

Dodatak A (*Simple Features Specification for SQL*) detaljno i precizno opisuje specifikaciju komponenti za SQL:1992 i SQL:1999, dok Dodatak B detaljno razmatra *Web Feature Service*, koji je važan za interoperabilnost u području distribucije vektorskih kartografskih podataka putem interneta. S obzirom na to da je područje kojim se bavi ovaj magistarski rad sasvim novo i da većina stručnjaka ne vlada u dovoljnoj mjeri novom terminologijom, u Dodatku C priložen je *Rječnik osnovnih pojmova i kratica*.

Glavni rezultati magistarskog rada su:

- Sustavan pregled koncepata i standarda geoinformacijske interoperabilnosti, odnosno geoprostornih baza podataka.
- Logički objektno-relacijski model kartografske baze podataka.
- Prijedlog koncepta stvaranja interoperabilne kartografske baze podataka – od CAD-podataka do distribucije na internetu.
- Koncept i prijedlog prototipa interoperabilne objektno-relacijske kartografske baze podataka.
- Koncept i prijedlog distribucije kartografskih podataka putem interneta, uporabom tehnologija utemeljenih na standardima OGC-a.

Na temelju pregleda i ocjene ovoga magistarskog rada, članovi Povjerenstva su zaključili kako je kandidatkinja razmotrila jednu izrazito važnu, aktualnu i interdisciplinarnu problematiku geoinformacijske i kartografske struke, detaljno proučila relevantnu suvremenu literaturu iz područja geoinformacijske interoperabilnosti u kontekstu baza podataka i ovladala metodikom znanstveno-istraživačkoga rada. Posebno izdvajamo činjenicu kako je to prvi istraživački i magistarski rad na području kartografske i geoinformacijske interoperabilnosti izrađen u Bosni i Hercegovini.

Miljenko Lapaine, Zdravko Galić

Mirko Husak, magistar tehničkih znanosti

Mirko Husak završio je poslijediplomski znanstveni studij, smjer fotogrametrija i kartografija na Geodetskom fakultetu Sveučilišta u Zagrebu i stekao je stupanj magistra znanosti 29. lipnja 2006. On je položio sve ispite s odličnim uspjehom, a kao ekvivalent magistarskog rada priznat mu je rad *Temporal and Historical GIS of Varaždin Old Fort* (Vremenski i povijesni GIS stare varaždinske tvrđave) što ga je izradio kao završni rad na međunarodnom poslijediplomskom studiju o GIS-u *Comett* održanom 1994. u San Miniatu u Italiji, a u organizaciji Odjela za geoinformacije Tehničkog sveučilišta u Beču i pod vodstvom prof. dr. Andrewa U. Franka.

Mirko Husak rođen je u 6. svibnja 1967. u Zagrebu, živi u Varaždinu od 1970. gdje je završio osnovnu školu. Kao gimnazijalac sudjelovao je na natjecanjima iz matematike, fizike i informatike, a u prvom razredu se plasirao i na republičko natjecanje iz matematike. Oslobođen je polaganja mature i izrade maturalnog rada kao odličan učenik. Maturirao je na Gimnaziji u Varaždinu (tadašnji Srednjoškolski centar Gabriel Santo). Geodetski fakultet Sveučilišta u Zagrebu upisao je 1986. Tijekom studija bio je demonstrator iz Kompjutorske obrade geodetskih podataka i Više geodezije. Diplomirao je s odličnim uspjehom 1991., s temom *Ispitivanje točnosti digitalizatora CalComp 9100*. God. 1994. prijavio se na International Post-Graduate Course on GIS u sklopu programa COMETT Europske zajednice, u organizaciji Tehničkog sveučilišta u Beču, koji se održavao u gradiću San Miniato kraj Firence u Italiji. Rezultat specijalizacije bio je GIS projekt sa završnim radom *Temporal and Historical GIS of Varaždin Old Fort*. God. 1999. upisao je poslijediplomski znanstveni studij na Geodetskom fakultetu Sveučilišta u Zagrebu.

Radi u katastarskom uredu u Varaždinu od 1992. godine. Bio je suradnik na stručnim projektima Tehnički katastar Varaždina (1994) i Katastar zemljišta podržan GIS-om (1997). Na Fakultetu organizacije i informatike (FOI) u Varaždinu izvodi nastavu laboratorijskih vježbi za kolegij Zemljopisni informacijski sustavi od akad. god. 1994/95. Konzultant je za GIS razvojnog projekta E!2584 Euroturism Ulixes – Intelligent Tourist Agency (2002-2006) kojeg su nositelji FOI Varaždin i Grad Varaždin.

Sudjeluje na stručnim i znanstvenim skupovima u Hrvatskoj i inozemstvu, autor je nekoliko stručnih radova objavljenih u zbornicima radova i knjizi sažetaka i jednog poglavlja u knjizi. Član je Hrvatskoga geodetskog društva od 1992., Hrvatskoga kartografskog društva od 2005., povremeno objavljuje u časopisima *Geodetski list* i *Kartografija i geoinformacije*. Član je Hrvatske komore arhitekata i inženjera u graditeljstvu.

Akad. god. 1988/89. dobio je priznanje Sveučilišta u Zagrebu kao jedan od najboljih studenata na Sveučilištu u Zagrebu, 1989/90. dobio je stipendiju kao jedan od najboljih studenata na Sveučilištu u Zagrebu, 1991/92. dobio je Rektorovu nagradu

Temporal and Historical GIS of Varaždin Old Fort

The thesis *Temporal and Historical GIS of Varaždin Old Fort* was written in English, it consists of seven pages of introduction, 69 pages of the main textual part, and 61 pages of supplements. The introductory part contains acknowledgements, list of copyrights and trademarks, a copyright statement, a table of contents and a summary. The supplement contains a dictionary, a list of references and appendices. The main part of the paper is divided into following chapters:

1. Introduction
2. Objectives, contents, data collection
3. Spatial and temporal concepts in GIS
4. Technical solution
5. Organisation consideration and implementation plan
6. Cost-benefit analysis
7. Conclusions

The *Introduction* gives basic facts about the project, motivation and reasons why the paper was made.

The second chapter *Objectives, contents, data collection* describes objectives, the project content and data collection. The project objectives are laid down and explained, principle of temporal analysis and the project content, and used attribute and spatial data sources are briefly described.

The third chapter *Spatial and temporal concepts in GIS* describes spatio-temporal concepts in GIS, approach based on temporal layers and object approach, their comparison, map algebra with temporal layers, concepts of time and temporal algebra, concepts of database modelling in temporal GIS, concept of temporal GIS with many examples, queries and analysis. The chapter is accompanied by many pictures, tables and formulae. The principles of catching time and space are analysed, types of time intervals including intervals with "uncertain time limit".

The fourth chapter *Technical solution* describes what was needed for finishing this practical project: hardware, software, lifeware and orgware (the last uniting these four items). A technical solution includes: used hardware and software, database modelling, data collection and preparation, data input: maps and other data (graphical and textual), description of chosen GIS environment and used tools, problems during the project and future project extensions. Digitising with graphical tablet, scanning, digital map data georeferencing in state coordinate system and data layering are described. The GIS environment Intergraph MGE PC-1 with MicroStation PC, I/RAS PC and Oracle RDBMS was used. Tools used for the project frame, data input, data processing and for customized tools are described. At the end of the chapter, the problems identified and suggestions for avoiding them and future extensions of the project are described

The fifth chapter *Organisation consideration and implementation plan* contains a timetable of the project phases: pilot project, main project and exploring project. For each project phase the project participant tasks timetable was made: informatics expert and GIS expert, museum professional and technician and project administrator. Each phase of the project is briefly described.

The sixth chapter *Cost-benefit analysis* describes the current way of the budgeting of The Varaždin Town Museum and investment program for financing the project. The structure and estimation of costs and benefits of all three project phases are worked out here. The costs include hardware, software and theirs maintenance, human resources costs and data preparation and processing costs. Project benefits are tangible and intangible. The current situation, and investment program suggestion including benefit plan reliable during the project are described. The investment program includes equipment purchase on the lease, pilot project and partly the main project financing, and returning of the investment by exploring the project. In the chapter there are tables that contain estimations of each resource and its costs. The cost-benefit analysis is graphically presented. The possibility of the project bankruptcy is presumed and briefly described. The subchapter *Sensitivity Analysis* analyses some possible risks during all three project phases. At the end, key moments of the cost-benefit analysis are discussed.

The seventh chapter, *Conclusions*, shows the author's overview of the issues described and overall view at the whole paper: what were the project objectives, what problems were solved: starting with data integration, time and space modelling in GIS with solution suggestions, implementation plan of all three project phases and the cost-benefit analysis. The production of the pilot project was made harder by numerous software-hardware problems caused by using several external units and program support conflicts. The time spent to solve them would have better been spent on the GIS itself.

The *Appendix* follows the work on the GIS pilot project: map photographs digitised with digitising tablet, scanned maps, digital maps georeferenced in state coordinate system, overlaying historical maps, database tables with corresponding data types and database contents, ER (entity-relationship) diagram, project data and project area, analysis tools, street names (according to temporal epochs), multilingual database, project entities and user-defined tools for this project.

Prepared by Miljenko Lapaine

za najbolji studentski rad *Datoteka centroida naselja Hrvatske* izrađen na Geodetskom fakultetu Sveučilišta u Zagrebu.

Rad *Temporal and Historical GIS of Varaždin Old Fort* napisan je na engleskom jeziku, sastoji se od uvodnog dijela na 7 stranica, glavnog pisanog dijela na 69 stranica i dodatka na 61 stranici. U uvodnom dijelu su zahvale, popis zaštićenih pro-izvoda, izjava o autorskom pravom, sadržaj i sažetak. U dodatku su rječnik, literatura i prilozi. Glavni dio rada podijeljen je na sljedeća poglavlja:

1. Introduction
2. Objectives, contents, data collection
3. Spatial and temporal concepts in GIS
4. Technical solution
5. Organization consideration and implementation plan
6. Cost-benefit analysis
7. Conclusions

Vremenski i povijesni GIS stare varaždinske tvrđave

Uvod *Introduction* daje osnovne podatke o projektu, motivaciju i razloge zašto je došlo do ovoga rada.

Drugo poglavlje *Objectives, contents, data collection* opisuje ciljeve i sadržaj projekta te prikupljanje podataka. Navedeni su i ukratko obrazloženi ciljevi projekta, prikazan je princip vremenske analize te je ukratko opisan sadržaj projekta, upotrijebljeni izvornici opisnih i prostornih podataka.

Treće poglavlje *Spatial and temporal concepts in GIS* opisuje prostorno-vremenske koncepte u GIS-u, pristup zasnovan na vremenskim slojevima i objektni pristup, njihovu usporedbu, kartografsku algebru s vremenskim slojevima, koncepte vremena i vremensku algebru, koncepte modeliranja baza podataka vremenskoga GIS-a, koncepte vremenskog GIS-a s brojnim primjerima te primjere upita i analiza. Poglavlje je popraćeno brojnim slikama, tabelama i formulama. Razrađeni su principi zahvaćanja vremena i prostora, vrste vremenskih intervala uključujući i intervale s "nesigurnom vremenskom granicom".

Četvrto poglavlje *Technical solution* opisuje što je bilo potrebno da se dovrši taj praktični projekt: hardver, softver, ljudi (lifeware) i organizacija (orgware) koja tu četvorku objedinjuje. Tehničko rješenje uključuje: upotrijebljenu strojnu i programsku podršku, modeliranje baze podataka, prikupljanje i pripremu podataka, unos podataka: karata, drugih podataka (grafičkih i tekstualnih), opis odabranog GIS okruženja i upotrijebljene alate, probleme pri izradi i buduća proširenja projekta. Opisana je digitalizacija s grafičkom pločom, skeniranje, transformacija digitaliziranih kartografskih podataka u državni koordinatni sustav i razvrstavanje podataka u slojeve. Upotrijebljeno je GIS okruženje tvrtke Intergraph: MGE PC-1 uz MicroStation PC, I/RAS PC i Oracle RDBMS. Opisani su upotrijebljeni alati za izradu projektne osnove u GIS-u, unos i obradu podataka i izradu korisničkih alata. Na kraju poglavlja opisani su uočeni problemi i prijedlog njihova poboljšanja te moguća buduća proširenja projekta.

Peto poglavlje *Organization consideration and implementation plan* sadrži vremenski plan projekta: pilot projekt, izrada glavnog projekta i korištenje projekta. Za svaku fazu projekta tablično su raspoređeni poslovi sudionicima projekta: informatičkom i GIS ekspertu, stručnjaku muzeja, tehničaru i tajnici projekta. Ukratko je opisana svaka pojedina faza projekta.

Šesto poglavlje *Cost-benefit analysis* opisuje dosadašnji način financiranja Gradskog muzeja Varaždin i investicijski program u kojem je razrađena struktura i procjena troškova i prihoda svake od tri faze projekta. Troškovi uključuju strojnu i programsku podršku i njihovo održavanje, troškove ljudskih potencijala i troškove pripreme i obrade podataka. Prihodi projekta su financijski prikazivi i neprikazivi. Opisana je sadašnja situacija, prijedlog investicijskog programa koji sadrži plan prihoda ostvariv projektom. Investicijski program uključuje nabavku opreme na leasing i financiranje pilot projekta, djelomično i glavnog projekta te vraćanje investicije korištenjem projekta. Poglavlje je popraćeno tabelarnim prikazima procjene pojedinih resursa sa cijenama koštanja i grafičkim prikazom cost-benefit analize. Predviđen je i mogući bankrot projekta koji je ukratko opisan. Potpoglavlje *Sensitivity Analysis* (analiza osjetljivosti) analizira pojedine moguće rizike tijekom sve tri faze projekta. Na samom kraju je diskusija ključnih momenata cost-benefit analize.

Sedmo poglavlje *Conclusions* prikazuje i autorov osvrt na obrađenu materiju i na cjelokupan rad: što je radom želio postići, koje je probleme pokušao riješiti, počevši od integracije podataka, modeliranja prostora i vremena u GIS-u s prijedlozima rješenja, plan realizacije sve tri faze projekta i cost-benefit analizu. Izrada pilot projekta bila je otežana zbog brojnih softversko-hardverskih problema uzrokovanih korištenjem više vanjskih jedinica i konflikata programske podrške za što je provedeno vrijeme i utrošenu energiju bilo bolje usmjeriti na sam GIS.

Dodatak prati izradu GIS projekta: fotografije karata koje su digitalizirane ručnim digitalizatorom, skenirane karte, digitalne karte svedene u državnu projekciju, preklapanje povijesnih karata, tablice baze podataka s pripadnim tipovima podataka i sadržaj baze podataka, ER (entity-relationship) dijagram, podatke o projektu i područje zahvata projekta, alate za analizu, imena ulica (po vremenskim epohama), višejezičnu bazu podataka, entitete projekta i korisničke alate izrađene za ovaj projekt.

Priredio Miljenko Lapaine