Concept and Establishment of the Mine Information System within the CROMAC GIP Project

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***Abstract**: In order to solve mine problems in the Republic of Croatia, a unique project CROMAC GIP (Croatian Mine Action Centre Geoinformation Project) has been initiated significantly increasing the functional quality of the existing Mine Information System (MIS). Since mine problems are closely related to space, geodata are a crucial part of MIS intended for monitoring and planning of demining. Since the moment the Croatian Mine Action Centre was funded till today, the process of demining has progressed. The implementation of a topographic database in accordance with the CROTIS data model and the usage of orthophoto data produced according to the official product specifications can be pointed out in that progress. Usage of such geodata requires a sophisticated information system that enables a simultaneous usage of geodata and other data connected with solving mine problems. In order to reach all goals in demining and to use all advantages of geodata, it was indispensable to upgrade the existing Mine Information System by merging geodata and HCR data and to collect new data according to the standardized procedures, but controlling at the same time the quality and automated procedures of uploading into the system. Apart from being constructed in accordance with the Standard Operative Procedures (SOP), the modernised MIS is also based on generally accepted standards in the field of geoinformation and it is implemented on advanced technology. The core of the system is the Oracle database, and GeoMedia is a WebMap Professional tool on the basis of which the distribution and the work with spatial data is possible on intranet/Internet. In order to achieve full efficiency of the system, it is necessary to provide high quality and updated geodata. In this respect, photogrammetric data are the most efficient solution.*

***Key words**: CROMAC GIP, geoinformation, humanitarian demining, mine information system, CROTIS, digital orthophoto, geodata*

1 Introduction

Solving mine problems is a prerequisite for spatial management, and hence also economic and social development. Mine actions entail a number of tasks that are done within the frame of the works performed by the Croatian Mine Action Centre (CROMAC): collecting the data about mine-suspicious, mined and demined areas, control of database, marking and fencing of mine-suspicious area, execution of public tenders for demining processes, professional supervision of demining process, education about mine danger, helping mine victims, their rehabilitation and reintegration, research and development of new demining technologies, operative testing of methods and techniques and advocating prohibition of usage of anti-infantry mines (URL 1).

2 Existing Mine Information System

In order to achieve higher efficiency in demining processes, it has been necessary to record all relevant data. So far, the data have been acquired in various ways: certain data have been inherited from UN, other from the army and the police, and the rest have been collected by the employees of the Croatian Demining Centre.

Since the establishment of CROMAC until the present day, the reconnaissance of the entire territory of the Republic of Croatia has been made for the purposes of defining and classifying mine-suspicious areas. These works started at the end of the year 2004 and lasted 18 months (URL 2). Data collection is a very complex procedure demanding fieldwork. Significant research has been made in the field of aerial reconnaissance of mine-suspicious areas (Bajić, 2002). This paper concentrates mostly on the improvement of MIS functionality and on some procedures connected with database maintenance using GPS, geodata and data acquired by means of reconnaissance.

Koncept i uspostava Minskog informacijskog sustava u okviru projekta CROMAC GIP

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Sažetak: *Za potrebe rješavanja minskog problema u Republici Hrvatskoj započet je jedinstveni projekt CROMAC GIP (Croatian Mine Action Centre Geo-information Project), u okviru kojega je znatno unaprijeđena funkcionalnost postojećega Minskog informacijskog sustava (MIS). Budući da je minski problem usko vezan uz prostor, geopodaci su neizostavni dio MIS-a namijenjenog za praćenje i planiranje razminiranja. Od osnutka Hrvatskog centra za razminiranje do danas je poduzeto niz mjera za poboljšanje procesa razminiranja. Mogu se istaknuti implementacija topografske baze podataka sukladno modelu podataka CROTIS, upotreba ortofoto podataka izrađenih u skladu sa službenim specifikacijama proizvoda. Upotreba takvih geopodataka zahtijeva i sofisticirani informacijski sustav koji omogućava istodobnu upotrebu geopodataka i ostalih podataka vezanih uz rješavanje minskog problema. Kako bi se ispunili svi ciljevi razminiranja i iskoristile sve prednosti geopodataka, bilo je nužno unaprijediti postojeći Minski informacijski sustav stapanjem geopodataka i ostalih podataka HCR-a u jednu cjelinu te omogućaviti prikupljanje novih podataka prema standardiziranim postupcima, i to uz kontrolu kvalitete i automatizirane postupke učitavanja u sustav. Modernizirani MIS, osim što je izgrađen sukladno Standardnim operativnim postupcima (SOP), bazira se i na općeprihvaćenim standardima na području geoinformacija i implementiran je na naprednoj tehnologiji. Jezgru sustava čini baza podataka Oracle, dok je GeoMedia WebMap Professional alat temeljem kojega su omogućeni distribucija i rad s prostornim podacima preko intraneta/interneta. Za postizanje pune efikasnosti sustava trebalo je osigurati kvalitetne i ažurne geopodatke. U tom su smislu fotogrametrijski podaci najekonomičnije rješenje.*

Ključne riječi*: CROMAC GIP, geoinformatika, humanitarno razminiranje, minski informacijski sustav, CROTIS, digitalni ortofoto, geopodaci*

1. Uvod

Rješavanje minskog problema preduvjet je upravljanja prostorom, a time i preduvjet ekonomskog i društvenog razvoja. Protuminsko djelovanje obuhvaća niz zadaća koje se obavljaju u okviru poslova Hrvatskog centra za razminiranje (HCR): prikupljanje podataka o minski sumnjivim, miniranim i razminiranim područjima, vođenje baze podataka, obilježavanje i ograđivanje minski sumnjivog područja, provedba javnih nadmetanja za poslove razminiranja, obavljanje stručnog nadzora nad razminiranjem, edukacija o opasnostima od mina, pomoć žrtvama mina, njihova rehabilitacija i reintegracija, istraživanje i razvoj novih tehnologija u razminiranju, operativno testiranje metoda i tehnika te zagovaranje neuporabe i zabrane protupješačkih mina (URL 1).

2. Postojeći Minski informacijski sustav

Kako bi se postigla veća učinkovitost u protuminskom djelovanju, bilo je nužno organizirano bilježiti sve relevantne podatke. Do sada su ti podaci bili prikupljani na različite načine: dio podataka naslijeđen je od UN-a, dio ih je naslijeđen od vojske i policije, a dio podataka prikupili su djelatnici HCR-a.

Od osnutka HCR-a do danas obavljeno je izviđanje (opći izvid) cjelokupnog područja Republike Hrvatske u svrhu definiranja i klasifikacije minski sumnjivih područja. Ti su radovi započeli krajem 2004. godine i trajali su 18 mjeseci (URL 2). Prikupljanje podataka izrazito je složen postupak koji zahtijeva terenski rad. Značajna istraživanja provedena su na području izviđanja sumnjivih minskih područja iz zraka (Bajić, 2002). Ovaj rad pretežno se koncentrira na poboljšanje funkcionalnosti MIS-a te na neke od postupaka održavanja baze podataka koristeći GPS, geopodatke i podatke prikupljene izviđanjem.

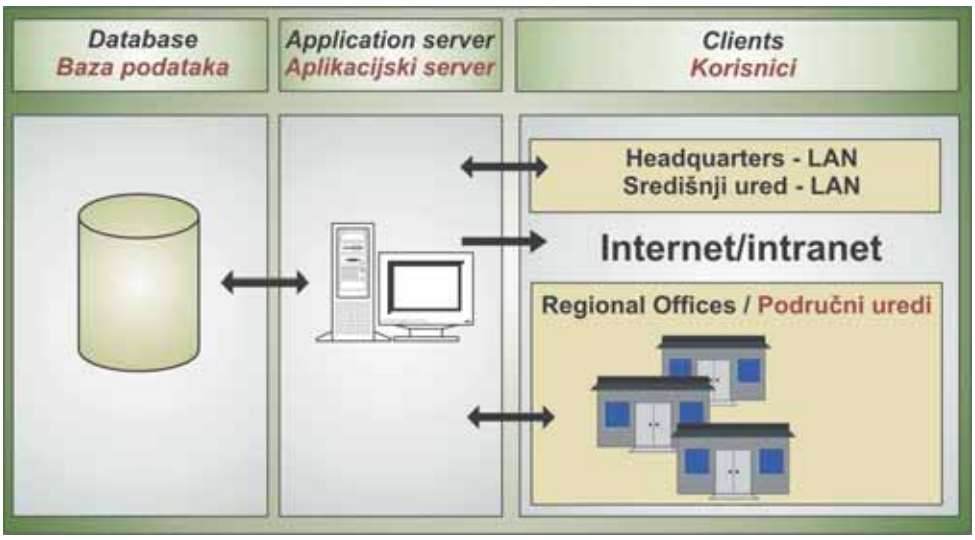


Fig. 1. Scheme of system architecture
Sl. 1. Shematski prikaz arhitekture sustava

The existing Mine Information System is based on the MapInfo and MS Access tools (Jelenić, 2001). The main deficiency of this system is the unmistakable duality in registering geometric data and attribute data, and especially the inability to collect data with GPS equipment. All coordinates determined with GPS had to be retyped from GPS equipment to the system. Besides, in order to adjust the data from MapInfo and MS Access, it was necessary to produce a special application for mapping the coordinates from one system into another. In the process of entering the data into MapInfo, there is no implemented automated value control option that would control the data entered into a specific field, which caused inhomogeneity of attribute data. There was also no topology control mechanism, which caused the overlapping of mine-suspicious areas, etc. The employees of the information department in CROMAC have managed to build a system that was used earlier for planning, monitoring and recording of demining tasks, but due to limited resources they were forced to leave further improvement to external associates. Hence, the CROMAC GIP project was initiated. Apart from removing functional deficiencies of the existing system, the new system was to implement all new SOP documents, then newly built geodata, prepare and publish the data on the Internet. Since the CROMAC offices are dislocated, a new universal solution unique in the world enables operations on intranet and Internet. The mentioned problems of the existing MIS are given in URL 3.

Considering geoinformation support to demining, the solution and the help from the International Centre for Humanitarian Demining in Geneva (URL 4) are often applied. Such solutions are not universal and are not applicable in all countries with mine problems, and they also do not include a larger part of the tasks that are performed along with removing the mines. This solution is applicable for the countries that do not have data about mines, mine-suspicious areas and that do not have their own geodata at disposal.

The standardisation in the field of demining has not encompassed the production of the information system. The production of such a standard is being planned, but since there is no final solution, the experts of the Geofoto d. o. o. company have developed their own solution in accordance with the published SOP documents (URL 5). It should be pointed out that SOP documents are based on the Croatian legislative and on international demining standards IMAS (URL 6).

3 Concept of the New Mine Information System

The main components of the Mine Information System are: spatial database, applications for system administration, system for collection of field data, and centre for data conversion (scan centre). The system has been established on three-layer architecture client server: application server, databases server and client.

The data are stored in the Oracle database on the base server. The application server has Intergraph technology GEoMedia WebMap Professional (GWM) implemented along with applications made with that technology. Most business logic is still implemented on a client (fat client); GWM is used for generating the presentation and storage of the data created on the client.

Clients interested only in getting the insight into the situation of a mine-suspicious area can browse through the data by means of a simple Internet browser. Thus, the clients can browse through the live situation in the CROMAC database from any location equipped with the Internet connection, regardless of the operation system.

Clients of the application implemented in the CROMAC system (central office and subsidiaries) are made in the Visual Basic programme language and they contain implemented business logic. Smaller part of application is written with PL/SQL (Oracle 2003a) and implemented in the database.

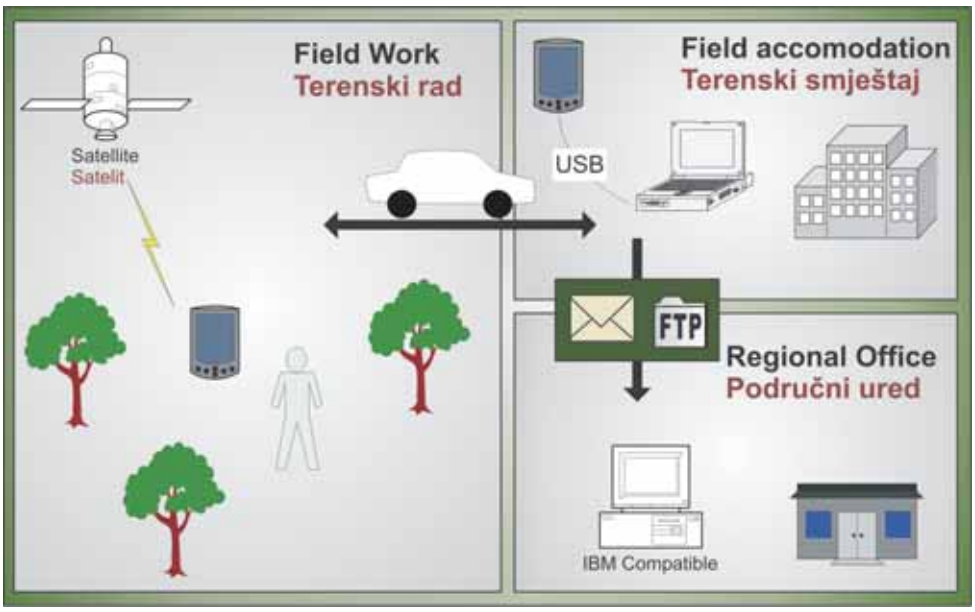


Fig. 2. Scheme presentation of data collection with manual GPS
Sl. 2. Shematski prikaz prikupljanja podataka ručnim GPS-om

Postojeći Minski informacijski sustav temeljen je na alatima MapInfo i MS Access (Jelenić, 2001). Osnovni je nedostatak toga sustava izražena dvojnost pri registriranju geometrijskih podataka i atributnih podataka, a posebno je izražen nedostatak prikupljanja podataka s GPS uređajima. Sve koordinate prikupljene GPS-om trebalo je pretipkavati iz GPS-uređaja u sustav. Osim toga za usklađivanje podataka iz MapInfo i MS Accessa bila je izrađena posebna aplikacija koja je iz jednog sustava u drugi mapirala koordinate. Pri unosu podataka u MapInfo nije postojao ugrađen automatizam kontroliranja vrijednosti koje su se unosile u pojedino polje, što je izazvalo nehomogenost atributnih podataka. Nije postojao ni mehanizam kontrole topologije, što je izazvalo preklapanja minski sumnjivih područja i sl. Djelatnici informatičkog odjela HCR-a uspjeli su izgraditi sustav koji je u prethodnom razdoblju poslužio za planiranje, praćenje i evidenciju poslova razminiranja, no s obzirom na ograničene resurse bili su primorani daljnja poboljšanja prepustiti vanjskim suradnicima. U tom je smislu i započet projekt CROMAC GIP. Osim uklanjanja funkcionalnih nedostataka postojećeg sustava, novi sustav imao je zadaću implementirati sve nove SOP-dokumente, implementirati novoizrađene geopodatke, pripremiti i objaviti podatke na internetu. S obzirom na dislociranost ureda HCR-a novo i u svijetu jedinstveno i univerzalno rješenje omogućuje rad intranetu i Internetu. Navedena problematika postojećeg MIS-a navedena je na URL 3.

U pogledu geoinformatičke podrške razminiranju često se primjenjuje rješenje i pomoć Međunarodnog centra za humanitarno razminiranje u Ženevi (URL 4). Takvo rješenje nije univerzalno i nije primjenjivo u svim zemljama s minskim problemom, a osim toga ne obuhvaća veći dio poslova koji se obavljaju uz uklanjanje mina. To je rješenje povoljno za zemlje koje ne posjeduju podatke o minama, minskim sumnjivim površinama i koje nemaju na raspolaganju vlastite geopodatke.

Standardizacija na području razminiranja nije obuhvatila izradu informacijskog sustava. U planu je izrada takvog standarda, no u nedostatku gotovog rješenja, stručnjaci tvrtke Geofoto d. o. o. razvili su vlastito rješenje sukladno svim objavljenim SOP-dokumentima (URL 5). Ti su dokumenti temeljeni na hrvatskoj zakonskoj regulativi i na međunarodnim standardima za razminiranje IMAS (URL 6).

3. Koncept novoga Minskog informacijskog sustava

Glavne su komponente Minskog informacijskog sustava: prostorna baza podataka, aplikacije za upravljanje sustavom, sustav za prikupljanje terenskih podataka i centar za konverziju podataka (*Sken centar*). Sustav je uspostavljen na troslojnoj arhitekturi klijent poslužitelj: poslužitelj aplikacija, poslužitelj baza podataka i klijent.

Podaci su spremljeni u bazu podataka Oracle na poslužitelju za baze. Na poslužitelju aplikacija implementirana je Intergraphova tehnologija GeoMedia WebMap Professional (GWM) zajedno s aplikacijama izgrađenima na toj tehnologiji. Većina poslovne logike ipak je implementirana na klijentu (debeli klijent), dok GWM služi za generiranje prikaza podataka i za spremanje podataka kreiranih na klijentu.

Klijentima koje zanima samo uvid u stanje sumnjivoga minskog područja omogućen je pregled podataka s pomoću običnog internetskog preglednika. Na taj je način postignuto da klijenti neovisno o operativnom sustavu mogu, s bilo koje lokacije gdje postoji veza na internet, pregledavati aktualno stanje iz baze podataka HCR-a.

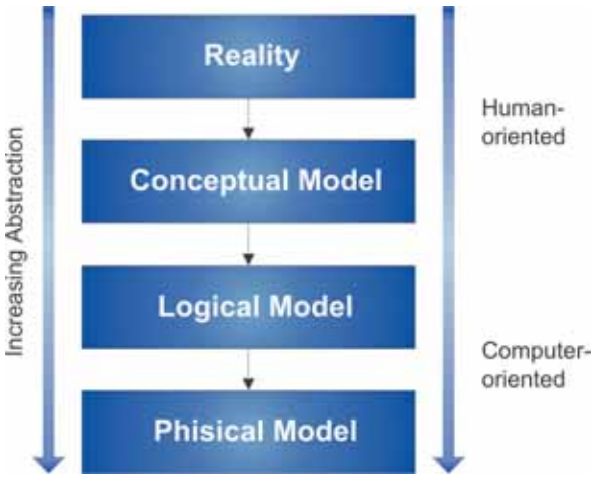


Fig. 3. Level of abstraction in the GIS data model (Longley et al., 2005)

Fig. 1 presents simple system architecture.

Apart from the mentioned components, a *Scan centre* has been founded within the frame of MIS intended for permanent digitising of military cartographic documents that were used during the Homeland War. The automated vectorizing of military objects was also performed in the Centre after the digitising of military maps. These objects are used to reconstruct military action as efficiently as possible and to obtain high quality information about the scope of a mine-suspicious area in this way. Complete equipment: scanners, working stations, servers and applications made especially for that purpose was delivered to CROMAC to be used for the works in *Scan Centre.*

The data are collected in the field with manual GeoXT GPS device, and the data transfer to the device and from the device into the database is made by means of the IntellWhere OnDemand software. OnDemand is not an independent application, but is integrated into GeoMedia Professional (GMP) providing thus the data transfer from the central database into the portable device and vice versa. GMP is a tool intended within the frame of CROMAC for the administration of spatial component of the database. The simplified operation sequence for the collection of data in the field is presented in Fig. 2.

The data for field operations are prepared in regional CROMAC offices and transferred into the GPS device. The field operators are usually at the locations far away from subsidiaries, so they need organised accommodation for several days in order to fulfil their daily plans. Depending on given circumstances, the data about object geometry and attribute data are collected in the field.

Depending on the situation in the field, the data in digital form need not be entered completely. The control and entering of the rest of the data can be done later on at some more quite and secure place.

After the data have been recorded and controlled, they are sent to regional offices for additional control and loading into the database.

4 Production of the Mine Information System

During the initial phase of the project, the project team spent about a month monitoring the work of CROMAC and interviewing the employees engaged in jobs of planning, demining project production, monitoring the companies performing the demining activities. The interviews were also made with other employees for the purpose of acquiring a better vision of the system.

After the initial phase, the existing system of recording the mine data was documented. All data saved in Access databases were related to geometric data in the MapInfo format. The existing applications were analysed, providing partial automation of the work of CROMAC.

The process of modelling the system can generally be presented with the scheme in Fig. 3. Individual phases of the model are presented on the scheme in correlation with the abstraction level.

On the basis of the information collected in the analysis of the CROMAC work, the conceptual, and after that the logical system model has been made according to the principles of object-oriented modelling. Congruent to the standards in the field of geoinformation, the conceptual model is given in UML (Booch et al, 2000).

The models that do not depend on implementation have been developed by means of the MS Visio Microsoft tool. According to object-oriented design, attribute data and geometry are of equal value and are presented identically in the model.

The implementation has been presented with a physical model. Since the relational databases are today most often in the markets, the physical models are most often given with relational schema. Oracle is a relational database (object-related) too, and therefore, the physical data model is presented with relational schema. The object component of the base is conveyed using a specially defined type of data (SDO_GEOMETRY) that enables storing the coordinates of a geometric object into one file in the base.

The model is realised on the basis of the DBDesigner software. Fig. 4 presents a segment of physical (implementation) model.

The physical model includes detailed definitions of all fields in the tables, prime key, foreign key, data type, and connections between tables. For the purpose of providing clear visualisation, the model in Fig. 4 presents only the connections together with prime and foreign keys. Other fields and types are hidden.

The SQL script has been designed for creating tables in the Oracle environment on the basis of the relational schema by means of the DBDesigner tool. A large number of tools for model production do not support the geometric data type, which requires some additional actions after creating the tables in the base. Since GWM requires creating and adding additional target tables,

Klijenti aplikacije implementirane u sustavu HCR-a (centralni ured i podružnice) izrađeni su u programskom jeziku Visual Basic i sadrže u sebi implementiranu poslovnu logiku. Manji je dio aplikacije napisan u jeziku PL/SQL (Oracle 2003a) i implementiran je u bazi podataka. Na slici 1 predočena je pojednostavljena arhitektura sustava.

Osim spomenutih komponenti u okviru MIS-a uspostavljen je *Sken centar*, uloga kojega je permanentno digitaliziranje vojnih kartografskih podloga koje su se koristile tijekom Domovinskoga rata. U Centru za skeniranje nakon digitalizacije vojnih karata obavlja se i automatizirana vektorizacija vojnih objekata. Ti objekti služe kako bi se što efikasnije izradila rekonstrukcija vojnih akcija i na taj način došlo do kvalitetne informacije o prostiranju sumnjivoga minskog područja. Za potrebe poslova *Sken centra* HCR-u je isporučena kompletna oprema, od skenera, radnih stanica, servera do aplikacija posebno izrađenih za tu svrhu.

Prikupljanje podataka na terenu obavlja se uz pomoć ručnoga GPS-uređaja GeoXT, a transfer podataka na uređaj i iz uređaja u bazu podataka obavlja se s pomoću softvera IntellWhere OnDemand. OnDemand nije samostalna aplikacija već se integrira u GeoMediju Professional (GMP) i na taj način omogućuje prijenos podataka iz centralne baze podataka na prijenosni uređaj i obratno. GMP je alat koji je u okviru HCR-a namijenjen administriranju prostorne komponente baze podataka. Pojednostavnjeni tijek operacija za prikupljanje podataka na terenu predočen je na sl. 2.

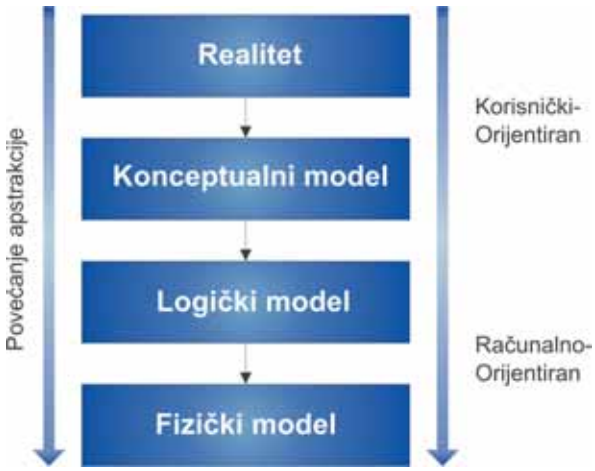
U područnim uredima HCR-a pripremaju se podaci za terenske operacije i prenose na ručni GPS-uređaj. Terenski su operativci obično na lokacijama udaljenima od podružnica, stoga na više dana trebaju organizirani smještaj kako bi mogli realizirati dnevne planove. Na terenu se, ovisno o prilikama, prikupljaju podaci o geometriji objekata i atributni podaci.

Ovisno o prilikama na terenu podatke u digitalnom obliku nije potrebno unositi u potpunosti. Kontrola i upisivanje preostalih podataka može se obaviti nakon radnog dana na mirnijem i sigurnijem mjestu.

Pošto se podaci unesu i prekontroliraju, šalju se regionalnim uredima na dodatnu kontrolu i učitavanje u bazu podataka.

4. Izrada Minskog informacijskog sustava

Za vrijeme početne faze projekta projektni je tim proveo oko mjesec dana u promatranju rada HCR-a i u intervjuiranju zaposlenika angažiranih na poslovima planiranja, izrade projekta razminiranja, obavljanja nadzora nad tvrtkama koje obavljaju razminiranje. Intervjui su također obavljeni i s ostalim djelatnicima kako bi se stekla što bolja vizija sustava.



Sl. 3. Razina apstrakcije u modelu podataka GIS-a (Longley i dr., 2005)

Nakon početne faze dokumentiran je postojeći sustav bilježenja minskih podataka. Dovedeni su u vezu podaci spremljeni u bazama podataka Accessa s geometrijskim podacima u formatu MapInfa. Pregledane su i analizirane postojeće aplikacije na temelju kojih je automatiziran dio poslova HCR-a.

Proces modeliranja sustava generalno se može predočiti shemom na sl. 3. Na shemi su predočene pojedine faze izrade modela u korelaciji s razinom apstrakcije.

Na temelju saznanja prikupljenih analizom rada HCR-a, prema načelima objektno orijentiranog modeliranja izrađen je konceptualni te nakon toga i logički model sustava. Sukladno standardima na području geoinformacija konceptualni je model iskazan UML-om (Booch i dr., 2000).

Modeli neovisni o implementaciji razvijeni su s pomoću Microsoftova alata MS Visio. Sukladno objektno orijentiranom dizajnu atributni podaci i geometrija su jednakovrijedni i u modelu su predočeni identično.

Fizičkim modelom prikazana je implementacija. Budući da su danas na tržištu najzastupljenije relacijske baze podataka, fizički modeli najčešće se iskazuju relacijskom shemom. Oracle je također relacijska baza podataka (objektno-relacijska) stoga je fizički model podataka predstavljen relacijskom shemom. Objektna komponenta baze sastoji se u korištenju posebno definiranog tipa podataka (SDO_GEOMETRY) koji omogućava spremanje koordinata geometrijskog objekta (ili objekata) u jedan zapis u bazi.

Model je realiziran upotrebom softvera DBDesigner. Na sl. 4 predočen je segment fizičkog (implementacijskog) modela.

Fizički model uključuje detaljne definicije svih polja u tablicama, primarni ključ, strani ključ, tip podatka, veze između tablica. Zbog pregledne vizualizacije model na sl. 4 prikazuje samo veze zajedno s primarnim i stranim ključevima. Ostala su polja i tipovi skriveni.

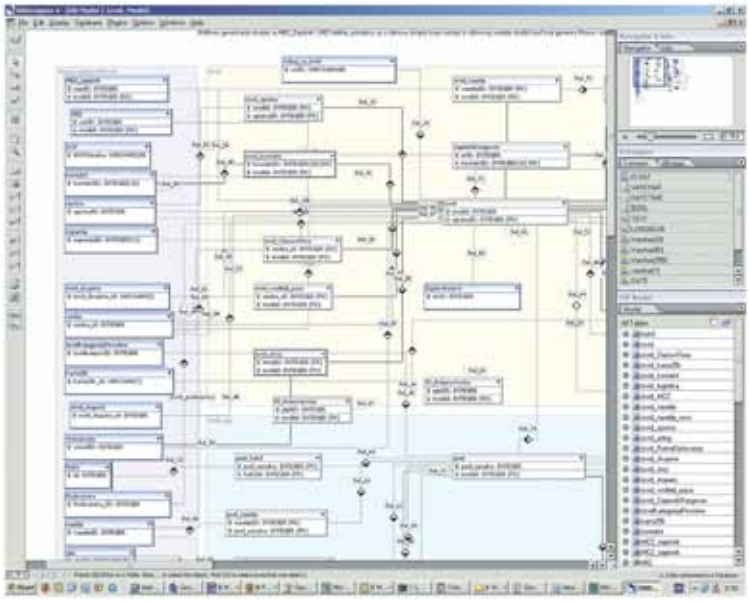


Fig. 4. Segment of physical system model
Sl. 4. Segment fizičkog modela sustava

supplementing geometric fields additionally into the tables already created in the Oracle environment is not considered a large deficiency. A separate application has been produced for such purposes that on the basis of table name, prime key and geometry type (point, line, area) creates the field of the type SDO_GEOMETRY, in each table into the frame of user scheme, in the scheme MDSYS it completes the fields of target table SDO_GEOM_METADATA_TABLE (Oracle 2003b), and all target tables in the GDOSYS schema (Intergraph, 2004). In this way, it is possible for GWM/GMP or another GIS tool to work with the spatial database.

The documentation for programming with the processes, appearance and the contents of the form, the connection of a single field on the form with the field in the database and other things essential for programming have been made with the model.

Fig. 5 presents the final appearance of the application. Since some users do not need spatial data in their work, and some of them request high-quality visualisation in a window as large as possible, the application is made in such a way that the forms are separated from the presented geodata.

A part of applications presenting the objects with geometry is based on GMW. The visualisation is created on the side of the application server and it is sent to clients by means of the *http* protocol. Fig. 6 shows the scheme of application operation.

In order to work with objects without geometry, the client application communicates directly with the Oracle database, and in order to present, enter and change geometric data, the communication is made by means of the *http* protocol to webmap service and then to the base.

The server component consists of IIS ActiveX component and ASP site. The Active X component performs operations on geometry on the basis of webmap objects and saves all parameters on the client site. The ASP site is the interface between the Active X component and the application on the client site. The client application sends the data to it by means of *http* GET requests, and it receives the data through the html code.

The GeoMedia WebMap server communicates directly with the Oracle database and secures the object for work with geometry. It sends maps to the client in raster or vector form.

5 Data

Data are the most valuable part of each system. MIS combines various types of geodata and data about demining activities. In the context of MIS, geodata encompass all data that are used as auxiliary data for demining activities, and they are made according to the official product specifications issued by the State Geodetic Administration (SGA). Orthophotos of high resolution (DOF2) and the topographic database have the most important role.

Data related to demining activities are spatial data (they are stored with geometry in the database), but some of them are attribute data. These data have been taken over from the previous system for registration of demining activities.

The data of the *Scan Centre* also have a very important role in the system. These are all spatial data produced by means of the digitising/vectorizing procedure.

5.1 Data about demining activities

After the new data model has been made, the old data have been mapped by means of the FME Oracle software from the old model into the new one. Fig. 7 shows the visualization of the so-called *FME workbench* files intended for mapping the data from model to model.

A larger number of *FME workbench* files have been made for the purpose of mapping the data into the new model. FME is convenient for this type of tasks because it provides integration of various data types, data about various geodetic datums and projections, within the frame of one file.

The workbench files are also used as the documentation of processes for model mapping.

Original data are organised in several files. Some of them are in the Access database, and some in the MapInfo files. Within the frame of the FME workbench file,

Na temelju relacijske sheme izrađene s pomoću alata DBDesigner generirana je SQL-skripta za kreiranje tablica u Oracle okruženju. Veliki broj alata za izradu modela ne podržava geometrijski tip podataka, što zahtijeva neke dodatne radnje nakon kreiranja tablica u bazi. Budući da GWM zahtijeva kreiranje i popunjavanje dodatnih metatablica, naknadno dodavanje geometrijskih polja u tablice već kreirane u okruženju Oracla nije smatrano velikim nedostatkom. Za te je potrebe izrađena zasebna aplikacija koja temeljem naziva tablice, primarnoga ključa i tipa geometrije (točka, linija, površina) na pojedinoj tablici u okvir korisničke sheme kreira polje tipa SDO_GEOMETRY, u shemi MDSYS popunjava polja metatablice SDO_GEOM_METADATA_TABLE (Oracle, 2003b), te popunjava sve meta-tablice u shemi GDOSYS (Intergraph, 2004). Na taj je način omogućeno da GWM/GMP ili neki drugi GIS-alat radi s prostornom bazom podataka.

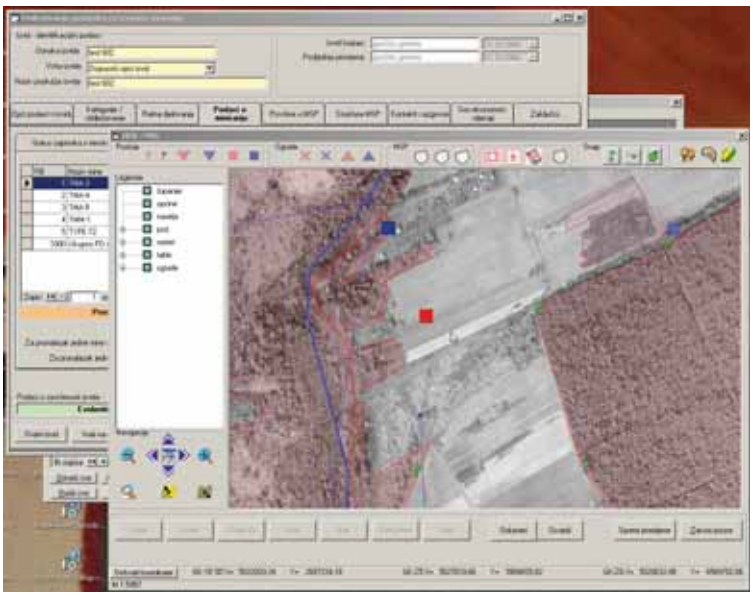


Fig. 5. Application for MIS control
Sl. 5. Aplikacija za upravljenje MIS-om

Paralelno s izradom modela podataka izrađena je i dokumentacija za programiranje u kojoj su definirani procesi, izgled i sadržaj formi, povezanost pojedinog polja na formi s poljem u bazi podataka i druge stvari nužne za programiranje.

Na sl. 5 predočen je konačni izgled aplikacije. Budući da dio korisnika u radu ne treba prostorne podatke, a dio korisnika zahtijeva kvalitetnu vizualizaciju u što većem prozoru, aplikacija je izvedena tako da su forme odvojene od prikazanih geopodataka.

Dio aplikacija koji prikazuje objekte s geometrijom temelji se na GMW-u. Vizualizacija se kreira na strani poslužitelja za aplikacije te se putem *http* protokola šalje do klijenta. Na sl. 6 predočena je shema rada aplikacije.

Za potrebe rada s objektima bez geometrije klijentska aplikacija komunicira direktno s bazom podataka Oracle, dok se za potrebe prikaza, unosa i izmjene geometrijskih podataka komunikacija odvija putem *http* protokola do webmap servisa pa zatim do baze.

Serverska komponenta sastoji se od IIS ActiveX komponente i ASP stranice. ActiveX komponenta temeljem webmap objekata obavlja operacije nad geometrijom i pohranjuje sve parametre mape na strani klijenta. ASP stranica je sučelje između ActiveX komponente i aplikacije na strani klijenta. Klijentska aplikacija joj šalje podatke putem *http* GET zahtjeva, a prima podatke kroz html kod.

GeoMedia WebMap server komunicira izravno s bazom podataka Oracle i osigurava objekte za rad s geometrijom. Prema klijentu šalje mape u rasterskom ili vektorskom obliku.

5. Podaci

Podaci su najvrjedniji dio svakog sustava. MIS objedinjuje različite vrste geopodataka i podatke o poslovima razminiranja. U kontekstu MIS-a, geopodaci podrazumijevaju sve podatke koji se koriste kao pomoćni podaci za poslove razminiranja, a izrađeni su prema službenim specifikacijama proizvoda izdanih od Državne geodetske uprave (DGU). Najveću ulogu imaju ortofoto visoke rezolucije (DOF2) i topografska baza podataka.

Podaci koji se tiču poslova razminiranja dijelom su prostorni podaci (u bazi podataka spremljeni s geometrijom), a dijelom su atributni podaci. Ti su podaci preuzeti iz prethodnog sustava za evidenciju poslova razminiranja.

Znatnu ulogu u sustavu imaju i podaci *Sken centra*. To su redom prostorni podaci koji nastaju postupkom digitalizacije/vektorizacije.

5.1. Podaci o poslovima razminiranja

Pošto je izrađen novi model podataka, stari podaci se putem softvera FME Oracle mapiraju iz starog modela u novi. Na sl. 7 je vizualizacija jedne od tzv. *FME workbench* datoteka namijenjene mapiranju podataka iz modela u model.

Za potrebe mapiranja podataka u novi model izrađen je veći broj *FME workbench* datoteka. FME je pogodan za tu vrstu zadaća jer u okviru jedne datoteke omogućuje integraciju različitih tipova podataka, podatke u različitim geodetskim datumima i projekcijama.

Workbench datoteke također služe i kao dokumentacija procesa mapiranja modela.

Izvorni podaci organizirani su u više datoteka. Dio je u bazama podataka Accessa, a dio u datotekama

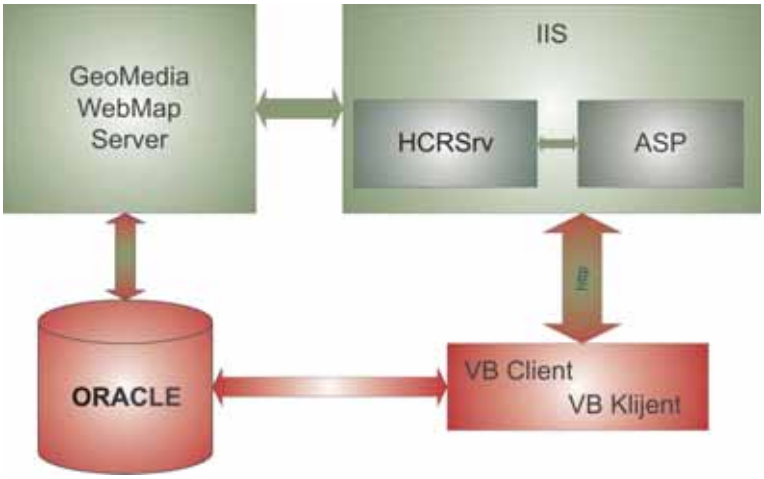


Fig. 6. Scheme of application operation

Sl. 6. Shematski prikaz rada aplikacije

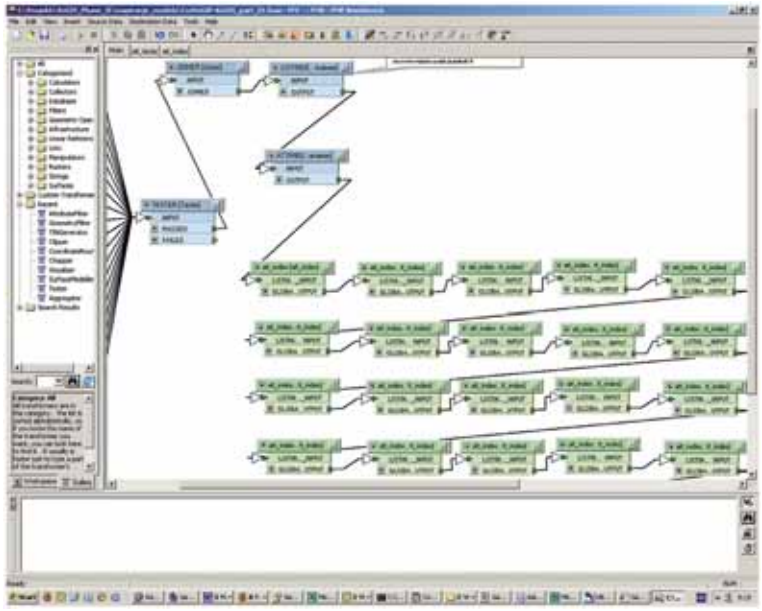


Fig. 7. Mapping the data into the new model by means of FME Oracle software

Sl. 7. Mapiranje u novi model podataka s pomoću softvera FME Oracle

geometric objects (MapInfo) have been merged with the data from the Access database, and after that the data have been imported into the Oracle database. Data that have no geometry with the change of model have been loaded directly into the Oracle.

Apart from changing the data model, the conversion of coordinates has also been performed. The data originally saved in the zone 5 and 6 of the Gauss-Krüger map projection have been stored into the Oracle database in a unique coordinate system. The Gauss-Krüger projection with the central meridian of 16° 30' has also been used.

5.2 Digital orthophoto and topographic database

In order to connect spatial information quickly and reliably, the orthophoto maps are used presenting a product that unifies with its characteristics the properties of a photograph in the sense of interpretation and geometrical accuracy that is to be found in traditional geodetic documents, i.e. plans. Digital orthophoto (DOF) is a geometrically corrected photograph in digital form that resulted from transforming digital images from central into orthogonal projection.

The production of digital orthophoto maps is a simple process, in technological, as well as in financial and time-related senses. Their geometric characteristics are similar to the characteristics of topographic maps of the same scale.

The optimal solution for demining activities is digital orthophoto (colour) with the resolution of 20 cm (DOF 2). The production of such an orthophoto for the areas of mine-suspicious territories has just started. This is the area of approximately 1800km^2 for which over 7000 images have been produced.

Fig. 8 shows MSP (black) with especially highlighted municipalities that it covers.

DOF is made in accordance with the specifications of products defined by the State Geodetic Administration. The quality of DOF is stipulated by the quality of all products being its direct predecessors. Each of the products stipulating the quality of DOF is also described in the specification. CROMAC needs DOF 2 to be made in TIFF + TFW and the ECW format. ECW and JPEG2000 are today the standard for compression and the work with a larger number of rasters. They found application in most of GIS, CAD, Web applications, on various operative systems (Windows, Macintosh, Solaris, HP/UX, PocketPC).

The cartographic documentation produced so far and used in the work of CROMAC has not met the needs of demining. This relates in the first place to the topical quality, degree of generalisation and resolution. Newly-produced maps at the scale of 1:5000 (HOK), (Šaban, 2004) do not cover the whole area of MSP, and the field operators were often forced to work with either old or new maps in smaller scales, the presentation of which significantly deviates from the reality, and is also not detailed enough.

MapInfa. U okviru FME workbench datoteke obavljeno je spajanje geometrijskih objekata (MapInfo) s podacima iz baze podataka Accessa, nakon čega su podaci importirani u Oraclovu bazu. Dio podataka koji nema geometriju uz promjenu modela izravno je učitan u Oraclovu bazu.

Osim promjene modela podataka pri mapiranju je obavljena konverzija koordinata. Podaci izvorno spremljeni u 5. i 6. zoni Gauss-Krügerove projekcije spremljeni su u bazu podataka Oracle u jedinstvenom koordinatnom sustavu. Upotrijebljena je također Gauss-Krügerova projekcija sa srednjim meridijanom 16°30'.

5.2. Digitalni ortofoto i podaci topografske baze

U svrhu brzog i pouzdanog načina povezivanja prostornih informacija koriste se ortofotokarte, proizvod koji svojim karakteristikama objedinjuje značajke fotografije u interpretacijskom smislu i geometrijsku točnost kakva je prisutna na tradicionalnim geodetskim podlogama, odnosno planovima. Digitalni ortofoto (DOF) geometrijski je ispravljena fotografija u digitalnom zapisu, nastala kao rezultat računskog prevođenja digitalnih snimaka iz centralne u ortogonalnu projekciju.

Izrada digitalnih ortofotokarata jednostavan je proces, kako u tehnološkom tako i u financijskom i vremenskom smislu. Njihove geometrijske karakteristike slične su karakteristikama topografskih karata istoga mjerila.

Optimalno rješenje za poslove razminiranja je digitalni ortofoto (u boji) s rezolucijom od 20 cm (DOF2). Za područje prostiranja sumnjivoga minskog područja (MSP) započeta je izrada takvog ortofota. To je područje približne površine od 1800km^2, za koje je izrađeno više od 7000 snimaka.

Na sl. 8 predočen je MSP (crno) s posebno istaknutim općinama na kojima se proteže.

DOF2 izrađuje se sukladno specifikacijama proizvoda koje definira Državna geodetska uprava. Kvaliteta DOF-a uvjetovana je kvalitetnom svih proizvoda koji mu izravno prethode. Svaki od proizvoda koji uvjetuje kvalitetu DOF-a također je opisan specifikacijom. Za potrebe poslova HCR-a DOF2 se izrađuje u formatima TIFF + TFW i ECW. ECW i JPEG2000 danas su standard za kompresiju i rad s većim brojem rastera. Primjenjuju se u većini GIS, CAD, Web aplikacija, i to na različitim operativnim sustavima (Windows, Macintosh, Solaris, HP/UX, PocketPC).

Dosadašnje kartografske podloge korištene u radu HCR-a nisu uvijek zadovoljavale sve potrebe razminiranja. To se u prvome redu odnosi na aktualnost, stupanj generalizacije i rezoluciju. Novoizrađene karte u mjerilu 1:5000 (HOK) (Šaban, 2004) ne postoje za cijelo područje MSP-a pa su terenski operativci često bili prisiljeni raditi na starim kartama ili na kartama sitnijega mjerila na kojima prikaz znatno odstupa od realnosti, a osim toga nije dovoljno detaljan.

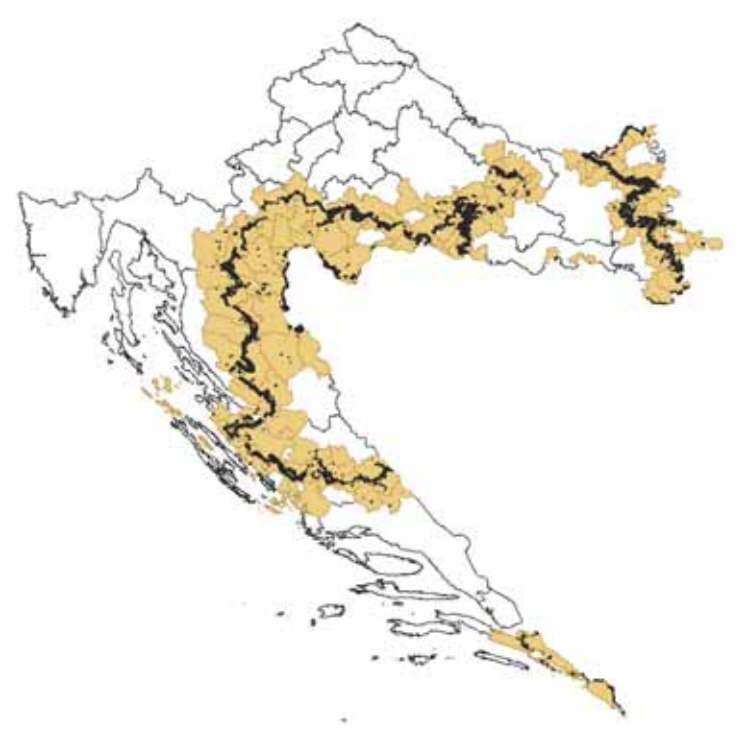


Fig. 8. Mine-suspicious area
Sl. 8. Sumnjivo minsko područje

Fig. 9. Parallel presentation of DOF 5 and DOF 2
Sl. 9. Usporedni prikaz DOF5 i DOF2

Topographic maps at the scale of 1:25 000 are generalised to the extent that makes it impossible to produce a project of searching, demining or monitoring in adequate way. Black and white orthophoto with the resolution of 0.5 m is not clear enough to be used in demining processes and does not exist for the whole MSP area.

Considering the above mentioned, it is clear that DOF 2 provides required quality for successful planning, project production, monitoring, and thus significantly improves demining activities. The next figure presents both black and white DOF 5 used so far in CROMAC and newly-made colour DOF 2.

Fig. 10. Visualisation of the topographic database with MSP
Sl. 10. Vizualizacija topografske baze podataka s MSP-om

Topographic data are vector data with the accuracy of ± 1m. The topographic database has been realized in accordance with the CROTIS standard (Biljecki, 2000.). CROTIS defines the data model, data collection criteria, topological relations and object catalogue. This is an official standard for geodata collection and storage.

On the basis of topographic database, one can obtain the attribute value that help in the production of searching/demining project. Fig. 10 presents a part of a topographic database together with the data about MSP. MSP is presented with hatched figures.

Apart from these singled-out geodata, the data of the Central regional unit are also registered, topographic maps (TK25), state base maps (HOK) and other maps at smaller scales with less important roles are included into the system.

5.3 Scan Centre

A large number of data that are significant for the process of demining are available in analogous form. These are mostly maps used for planning military actions with delineated positions of various military objects. The input of these data into MIS is of extreme importance, which encouraged the establishment of the Scan Centre.

Map digitising and vectorizing of objects delineated on maps is done at the Scan Centre. Fig. 11 shows the schemes of the main processes.

Analogous maps are placed on a scanner specially adjusted for such purposes (KartoScan FB V). With CCD

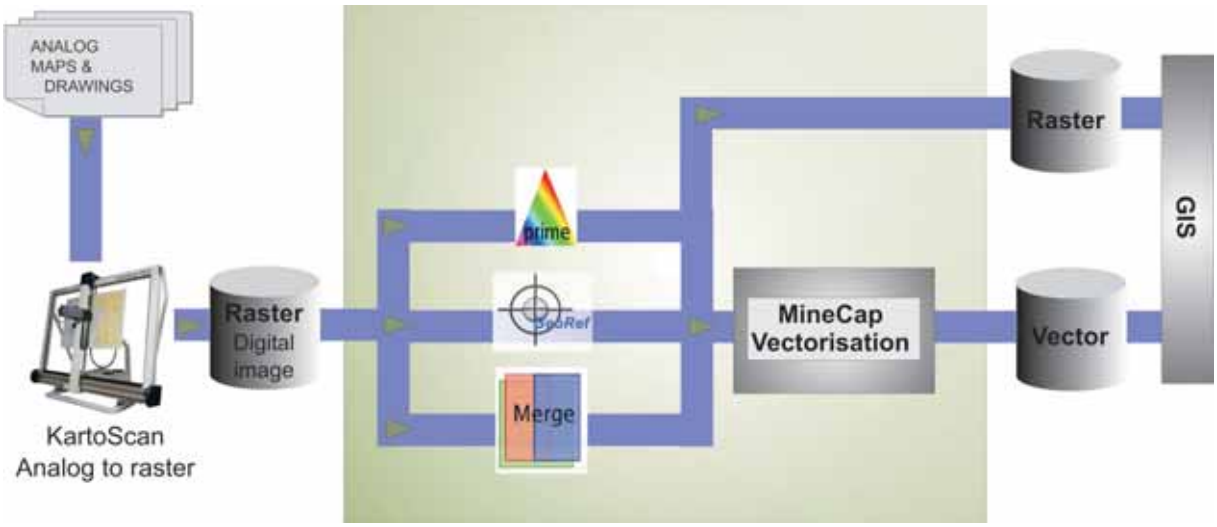


Fig. 11. The scheme of the processes in the Scan Centre at CROMAC

Topografske karte u mjerilu 1:25 000 generalizirane su do te mjere da na njima nije moguće na adekvatan način izraditi projekt pretraživanja i razminiranja ili voditi nadzorne poslove. Crno-bijeli ortofoto s rezolucijom od 0,5m za potrebe razminiranja nije dovoljno čitljiv i ne postoji za cijelo područje MSP-a.

S obzirom na navedeno, jasno je da DOF2 osigurava potrebnu kvalitetu za uspješno planiranje, izradu projekata, vođenje nadzora, i na taj način znatno unaprjeđuje poslove razminiranja. Na slici 9. predočeni su usporedno crno-bijeli DOF5, koji se do sada koristio u HCR-u, te novoizrađeni DOF2 u boji.

Podaci topografske baze podataka su vektorski podaci točnosti ± 1m. Topografska baza podataka realizirana je sukladno standardu CROTIS (Biljecki, 2000). CROTIS definira model podataka, kriterije za prikupljanje podataka, topološke relacije i katalog objekata. To je službeni standard za prikupljanje i pohranu geopodataka.

Na temelju topografske baze podataka mogu se dobiti vrijednosti atributa koji pomažu pri izradi projekta pretraživanja/razminiranja. Na sl. 10 predočen je isječak topografske baze podataka zajedno s podacima o MSP-u. MSP je prikazan šrafiranim poligonima.

Osim ovih posebno istaknutih geopodataka u sustav su uključeni i podaci Središnjeg registra prostornih jedinica, topografske karte (TK25), državne osnovne karte (HOK) i druge karte sitnijih mjerila uloga kojih u sustavu nije toliko značajna.

5.3. Sken centar

Velik broj podataka značajnih za proces razminiranja postoji u analognom obliku. Većinom su to karte korištene za planiranje vojnih akcija s ucrtanim položajima različitih vojnih objekata. Unos tih podataka u MIS od iznimne je važnosti, te je u tom smislu u HCR-u uspostavljen centar za skeniranje (Sken centar).

U okviru Sken centra obavlja se digitalizacija karata i vektorizacija objekata ucrtanih na karte. Na sl. 11 shematski su predočeni glavni procesi.

Analogne karte postavljaju se na specijalno prilagođen skener (KartoScan FB V). S pomoću CCD senzora razlučivosti 2048 piksela za pojedinu RGB komponentu kreira se digitalna verzija karte koja se u posebno izrađenom softveru prilagođava za daljnji rad. Softver se sastoji od tri modula: Prime, GeoRef i Merge. Prime služi za separaciju boja te poboljšanje kvalitete rastera, GeoRef za georeferenciranje, a Merge za izradu mozaika.

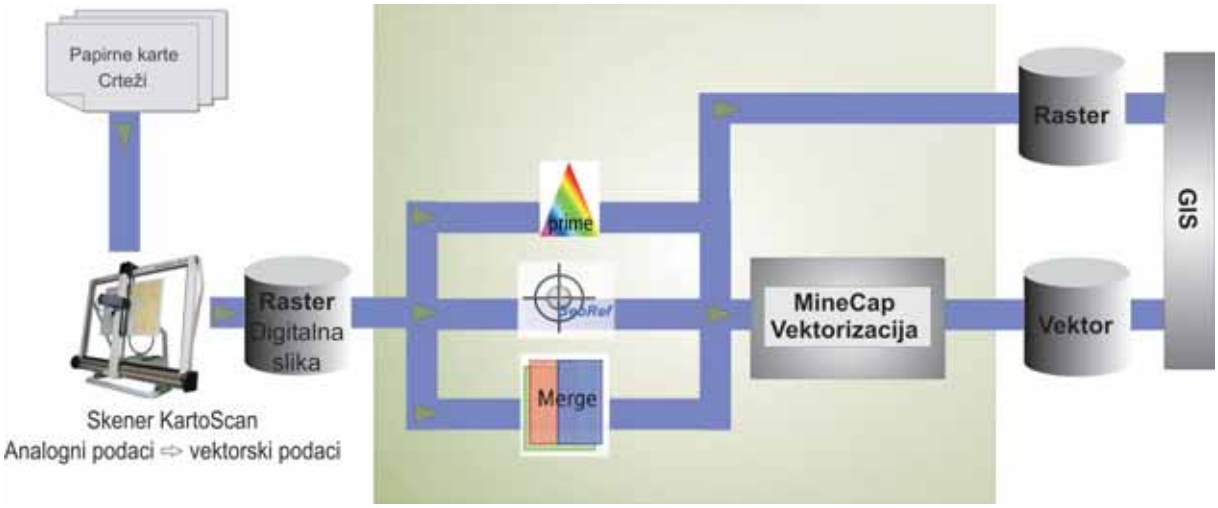
Nakon primarne obrade, s pomoću posebno razvijene aplikacije MineCap i prema modelu podataka minskih objekata, obavlja se automatska vektorizacija objekata s karte. Sadržaj u rasterskom i vektorskom formatu učitava se u GIS odnosno MIS. Prije uspostave Sken centra spomenuti objekti nisu bili predmet analize u MIS-u.

6. Zaključak

Minski informacijski sustav modeliran je i implementiran kroz kompleksni geoinformacijski projekt pod nazivom CROMAC GIP. Sustav ujedinjuje najmoderniju tehnologiju na području geoinformacija, a razvijen je na temeljima objektno orijentiranog modeliranja prema preporukama, specifikacijama i standardima koje su definirali Open Geospatial Consortium (URL 7) i tehnički odbor ISO/TC 211 (URL 8).

Osim što su u sustav implementirani standardi na području geoinformacija, sustav je izgrađen i temeljem domaćih (SOP) i međunarodnih standarda (IMAS) na području razminiranja.

S obzirom na nedostatak standarda za izradu informacijskih sustava namijenjenih za planiranje, obavljanje i praćenje humanitarnog razminiranja, s tendencijom definiranja takvog standarda, rješenje u okviru projekta CROMAC GIP bit će prezentirano institucijama UN-a i Međunarodnom centru za humanitarno razminiranje u Ženevi GICHD (URL 9). Prezentaciju tog originalnog rješenja prihvatio je GICHD.



Sl. 11. Shema procesa u Sken centru pri HCR-u

sensors having the resolution of 2048 pixels for an individual RGB component, digital map is created, and then adjusted in specially designed software for further operation. The software consists of three modules: Prime, GeoRef and Merge. The Prime module is used for separating colours and improving raster quality, the GeoRef module is used for georeferencing, and the Merge module for the production of a mosaic.

After the primary analysis, automatic vectorizing is done by means of specially developed MineCap application and according to the data model of mine objects. The content is then further loaded into GIS, i.e. MIS in raster and vector format. The mentioned objects have not been objects of analysis in MIS before the establishment of the Scan Centre.

6 Conclusion

The Mine Information System is modelled and implemented through a complex geoinformation project named CROMAC GIP. The system includes the most modern technology in the field of geoinformation and has been developed on the basis of object-oriented modelling according to all recommendations, specifications and standards defined by the Open Geospatial Consortium (URL5) and ISO/TC 211 technical committee (URL 6).

Apart from the mentioned standards, norms in the field of geoinformation implemented in the system, the system has also been produced on the basis of Croatian (SOP) and international standards (IMAS) in the field of demining.

Based on the shortage of standards for production of information systems intended for planning, performing and monitoring of demining, the solution within the frame of CROMAC GIP will be presented to the institution of UN and to the International Centre for Humanitarian Demining in Geneva GICHD (URL 7) with the tendency of defining such standards as standards for efficient solution of mine problem. The presentation of this original solution has been accepted by GICHD.

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