Spatial Information Management of Croatian Ministry of Defence

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Key words: cartography, generalisation, geoinformation systems, military, standards

SUMMARY

Ministry of Defence of the Republic of Croatia, with the project "Military geoinformation system – VoGIS" started with the building of the unique geoinformation system for the Ministry and the Armed Forces which is in accordance with the Croatian and international geoinformation standards and is fully conform to the NATO standards. According to the Preliminary design, the goal of the VoGIS is implementation of geoinformation system that will be the basis for development of all further activities in domain of military spatial data, with special emphasis on creation of military cartographic database and military maps, along with the fulfilment of the Partnership for Peace goals.

The VoGIS system is based on the Topographic Information System of the State Geodetic Administration of the Republic of Croatia that is established according to the CROTIS standard. The SGA collects and controls spatial data in systematic way through the Government's Program of State Survey and Real Estate Cadastre. The precise spatial data (+/- 1m) are the basis for Croatian NSDI and have to serve the purposes of all other Governmental bodies, including military.

In the first phase of the project, the object-oriented data model of the basic topographic database (Digital Landscape Model) has to be developed based on the MoD's needs. In the second phase, the development has to be expanded to development of the concept and implementation of the whole topographic-cartographic production workflow which, as a final goal, has the creation of Military Topographic Map 1:50,000 and Joint Operations Graph 1:250,000. The concept has to give the technological solution and standards for collection of special "military" content with upload into the Digital Landscape Model, design and data catalogue of cartographic database, methods and procedures for generalization, develop map indexes, map design and methodology for production and printing.

This paper describes the Croatian original concept of establishment of modern military geoinformation system with solutions of all elements of cartographic production that are based on topographic and cartographic databases, designed in the Geofoto d.o.o. company.

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1. INTRODUCTION

One of the basis of the Croatian NSDI is the Croatian Topographic Information System (CROTIS) which task is the establishment of the basic, multipurpose seamless Topographic Database (TdB) with positional accuracy of +/-1m on well defined details and +/-3m on other details (State Geodetic Administration, 2001).

The responsible institution – State Geodetic Administration (SGA), through the *Program of State Survey and Real Estate Cadastre* that was adopted by the Croatian Parliament and is financed mainly through the State and local administrations' budgets, started data acquisition, organised the Quality Control through the Croatian Geodetic Institute (CGI) and started the upload of data into the Topographic Database.

Ministry of Defence (MoD) of the Republic of Croatia recognised the importance and value of such database on one hand through the content (very precise and well described spatial data) and on the other through the economical fact that it is not needed to invest once more into collection of such information. Signing the Agreement between those two governmental institutions, the mutual cooperation has started. It includes, among others, the use of the Topographic Database for the purposes of the MoD.

The Ministry of Defence, together with the Armed Forces started the Project "Military Geoinformation System of the MoD of the Republic of Croatia - VoGIS". The VoGIS as a system has to establish the necessary databases that will serve as a basis for all military activities in the spatial data domain, and one of the first results have to be establishment of the production line and production itself of the Military Topographic Maps 1:50,000 according to the NATO standards.

2. VoGIS AS A SYSTEM

The project started in 2004 with the document "Military geoinformation system of MoD - Preliminary design" which introduced the acronym "VoGIS" for the entire project. Preliminary design established the basic roles, the ultimate goals and main principles of the project realisation.

2.1 The Roles

As agreed, the SGA's topographic database that is created according to the CROTIS standard is going to be the main source of spatial information. Its precision and level of details together with the wide coverage of features and attributes are more than enough to be the basis for the

central military topographic database. Missing information, important for the military purpose will be collected separately in a form of additional features and attributes and added into the military database. The Ministry of Defence will host and provide newly established geoinformation system to the entire Ministry and the Armed Forces (AF), assure necessary IT infrastructure and professionals for keeping the system running. The Ministry will not maintain topographic data; it will still be in hands of the SGA. As the Cartographic Department in MoD has the same organisational and functional role as the SGA, the role that does not encompasses production facility; hence all production (on the first place collection of additional data and cartographic production) is going to be offered on the Croatian market to the private companies. That "formula" has already been proved in civilian sector where SGA all of its production needs successfully realises with the Croatian private companies. The main tools for this are clear standards for data collection and processing in form of specifications, together with the rigorous Quality Control process made by the independent institution - CGI.

Further investigations will tell what data from the VoGIS system will be useful for the SGA projects. On the first place, it is expected that cartographic database of scale 1:50,000 (generalised features) can be sent to the SGA for production of "civilian" maps.

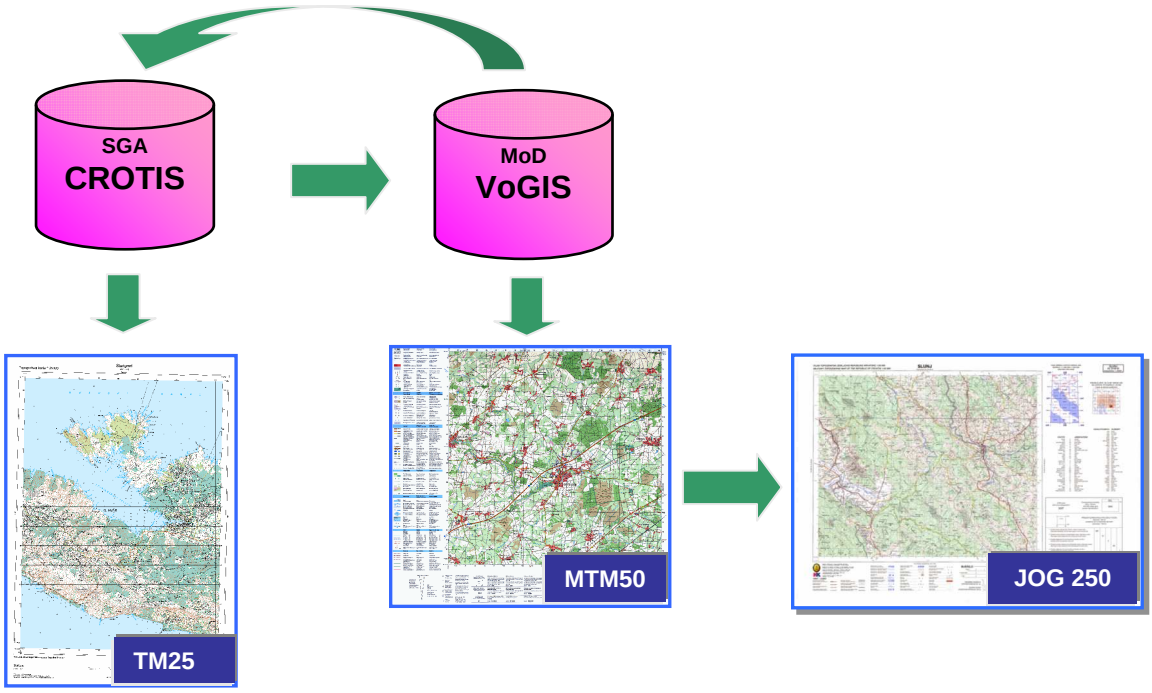

Figure 1: Cartographic production in two governmental institutions

2.2 The Objectives

The ultimate goal of the VoGIS is to: "establish a geoinformation system that will be a foundation for development for all further activities in the military spatial data domain, with

special emphasis on production of the military cartographic database and military maps, and fulfilment of the goals of the Partnership for Peace (PfP) in the geoinformation domain" (MoD, 2004). The project will fulfil the goals through three basic tasks:

1) to design efficient multi-user geoinformation system that will include all elements necessary to the Ministry of Defence and the Armed Forces
2) to design a system that will be in correlation with other existing geoinformation systems in the Republic of Croatia, firstly with the CROTIS system of the State Geodetic Administration
3) to design a system which will enable secure bi-directional exchange of digital information with other members of the NATO and the Partnership for Peace, fulfilling in this way the obligations that Croatia has according to the Work plan 0122 of the Partnership for Peace.

2.3 Basic principles

In designing and implementation of the project and its components, following principles have to be followed:

1) object-oriented conceptual modelling in dB design of topographic and cartographic databases
2) GIS databases have to be designed for multifunctional usage. While the cartographic production is at the end of the implementation process it must not be considered that it is the only functionality of the system. Many user in Ministry and AF such as logistics, have to recognise (and use) the VoGIS topographic data as a basis for their GIS projects
3) acceptance and use of relevant standards. When classifying and coding a content of a databases it is necessary to use the NATO standards, the ISO norms in modelling and the OGC standards in implementation wherever possible
4) rationalisation in data acquisition, which means that data once gathered in any state institution, can be of multiple use in other state institution. This principle not only attributes to rationalization, but also to quality of data, as each data category is collected and updated by profession that deals with specific category as a core business
5) all production processes have to be computerised and use of automated processes have to be investigated for each of the steps.

3. CONCEPTUAL SOLUTION

Considering the roles and the objectives, the solution of using the existing SGA's topographic database as a basis for military geoinformation seemed natural and with no alternatives. Thus, the starting and ending points for the project have been defined: the TdB with accuracy +/- 1m is the starting point, while the topographic maps 1:50,000 and 1:250,000 are at the end.

The first issue which authors faced was disproportion in scales of the source (1:10,000) and scale of the maps (Biljecki et al, 2006). As very unfavourable, ratios 1:5 and 1:25 eliminated

direct production of a smaller scale map from a larger scale map. Project team had to find a solution for data "flow" through a system (through databases of different scales) keeping in mind that printed map is actually only a media on which spatial data is shown (Kraak and Ormeling, 1998).

Considering that a GIS system of the Ministry of Defence has to fulfil several expectations and not only map production, the project team developed a concept which in the centre has topographic databases (Digital Landscape Models) and in which databases of smaller scale (i.e. accuracy) develop from larger scale databases (Figure 2).

The basic Digital Landscape Model (DLM10), after appending the specific military data, becomes a source for the topographic database of smaller accuracy (planned is +/- 5m) - DLM50 which is used as source for development of Cartographic Database of scale 1:50,000 (CdB50). The DLM50 is also source for the topographic database of accuracy +/- 20m - DLM250 which will be used as source for development of the Cartographic Database in the scale 1:250,000 - CdB250.

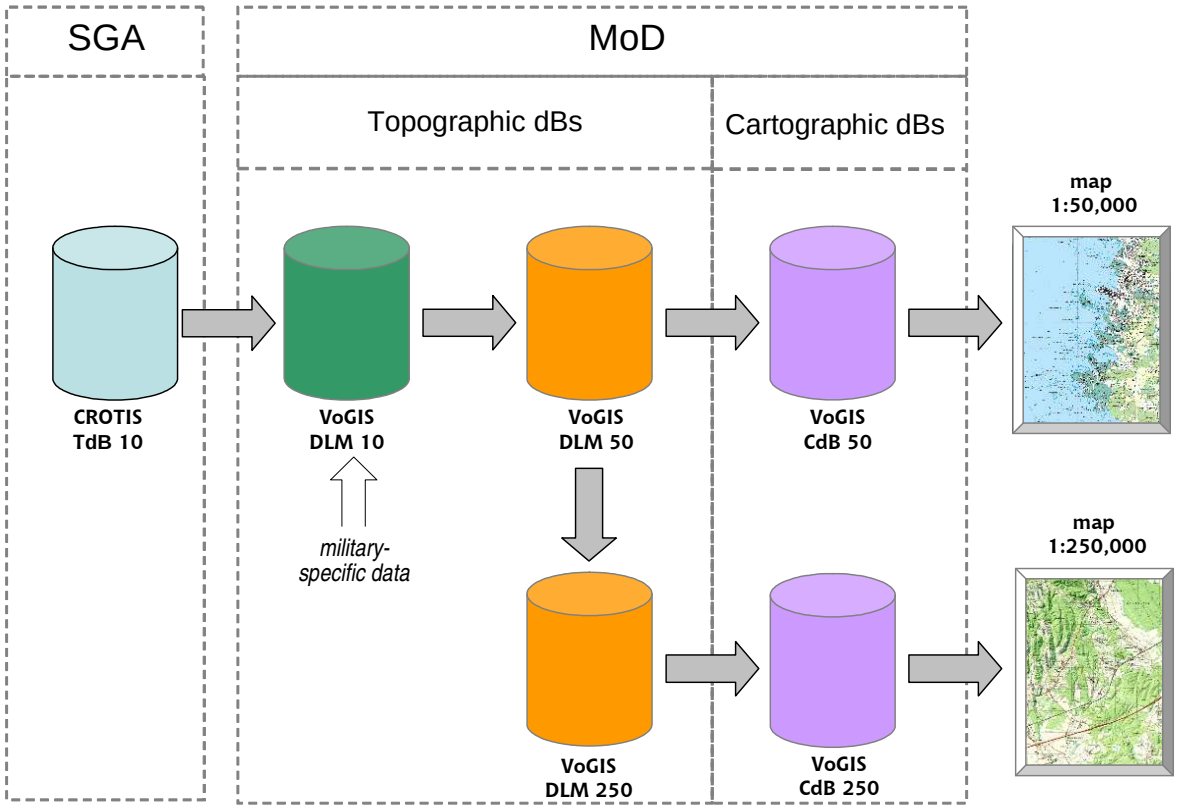

Figure 2: The Concept of the Military Geoinformation System of the Republic of Croatia

4. IMPLEMENTATION OF THE CONCEPT

The Ministry of Defence and experts from Geofoto LLC were aware that the realisation of the project can not be executed straight forward due to many unknowns and with the potential risk that the concept itself is not practical. Therefore, the implementation was divided into several phases.

4.1 Phase I

The objective of the first phase was to collect and evaluate the user's needs for the system. Several meetings were held with the military experts from various fields and the primary information were transformed into the conceptual model of the basic topographic database – DLM10, the data catalogue and the GML application schema (Biljecki et al, 2005).

Unified Modelling Language (UML) has been used to describe the conceptual scheme (data model) and the object catalogue. The UML is a graphic language for object oriented modelling that enables visualization, specification, construction and documentation of program support system (Booch et al, 2000). The UML enables standardized planning systems, covering conceptual issues as business processes and system functions, as well as concrete issues. These concrete issues are classes written in one of the programming languages, database schemes and reusable program components.

Data catalogue is a document that provides classification of features, attributes and connection between features for one or more data sets. Catalogue includes similar information provided in UML scheme as well, but in text form, and in a less expressive but more strictly organized way. This way catalogue enables:

- unambiguous and consistent feature definition
- unambiguous way of feature search
- consistent definitions of feature attributions, feature operations and connections between features.

For the purpose of open data exchange between heterogeneous or homogenous systems, the application scheme for data exchange has been made. Application scheme has been made according to the GML specification as direct mapping of entities from a database in order to use possibilities of the tools that directly support the GML specification and enable import and export of data in and out of the system.

4.2 Phase II

As previously said, the whole concept (Figure 2) had to be approved and the technology for data "flow" through the databases had to be known before start of the mass production. Hence, the pilot project was delivered to the private company – Geofoto LLC which had to develop and test the whole system with the production of one map sheet in scale 1:50,000 and one JOG-G map sheet.

The realisation of the second phase consists of:

1) acquiring the testing data form the SGA's CROTIS Topographic database, checking and preparing the data
2) development and implementation of the mapping (connecting) of the CROTIS and the VoGIS DLM10 data models
3) checking and correcting the topological consistency in the VoGIS DLM10 database
4) collecting and adding the new content into the database (mostly attributes)
5) development and implementation of the mapping (connecting) of the DLM10 and the DLM50 data models
6) development and implementation of the model generalisation parameters for generalisation of content of the DLM50 database
7) development and implementation of the mapping (connecting) of the DLM50 and the CdB50 data models
8) development and implementation of the cartographic generalisation parameters for generalisation of content of the DLM50 database
9) map preparation for printing
10) development and implementation of mapping, model and cartographic generalisation for the transfer of data from the DLM50 to the DLM250 and to the CdB250.

The development and implementation very often resulted in stepping backwards to correct previous data models or mapping connectors.

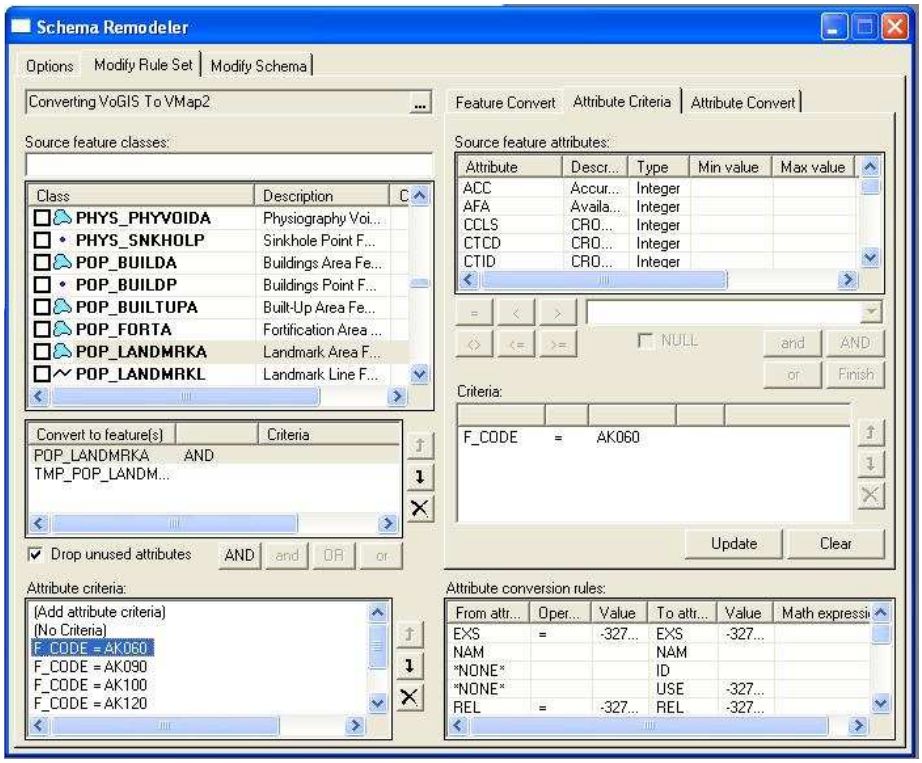

Figure 3: Schema mapping between two data models

4.2.1 Generalisation

The most challenging part of the project was generalisation. To correctly create topographic databases of smaller scale (reduced accuracy and content) and to correctly create cartographic databases of certain scale and certain graphic symbolisation, the process of generalisation have been split into model generalisation (between two topographic databases) and cartographic generalisation (between topographic and cartographic databases).

Model generalization is defined as controlled reduction of data in spatial, thematic and time sense (Weibel, 1995), and encompasses following processes:

- selection of object classes
- selection of certain objects according to the attributes and appearance context
- geometry change (areas in lines, areas in points, lines in points)
- geometry simplification
- filling blanks that are result of selection (preservation of topology)
- simplification of networks (roads, waters)
- feature dissolving.

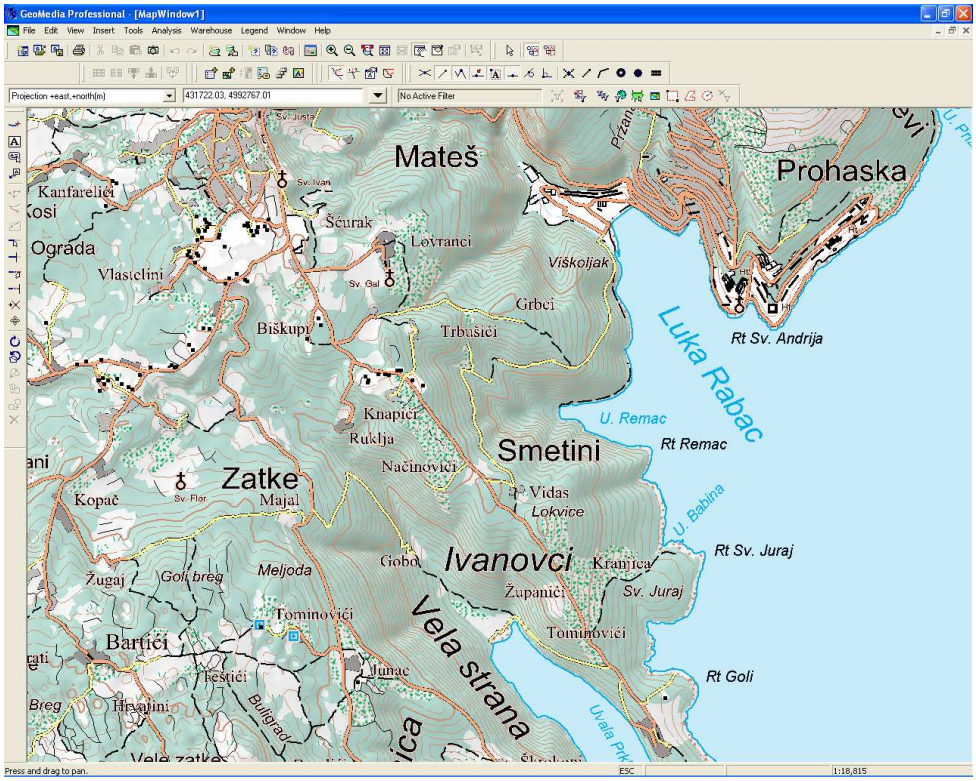

Figure 4: Visualisation of Digital Landscape Model DLM50

The very important fact about model generalization is that there are no feature movements, so that required accuracy of topographic data is not decreased.

Cartographic generalization includes:
- application of map specific displays
- movement of objects
- text positioning.

4.2.2 Technology

Through the duration of the project, several tools have been tested and used. The greatest efforts have been pointed towards the use of the Intergraph's Digital Cartographic Suite (DCS) software but the given results have not been satisfactory and it's use have been minimized primarily due to the fact that software does deal with a vector cartographic models. Main tool for generalisation and cartographic design used in project is Intergraph's Geomedia version 6 and the tools for model mappings are Feature Manipulation Engine and Geomedia Schema Remodeler. Further investigation and testing of technology is still going on, among which is use of the PDF files for printing purposes and use of the Geomedia ImageStation Stereo for collection of additional content to the database.

5. STANDARDS

The use of standards is important in most GIS projects but is obligatory in such large infrastructure projects. Standardization in geoinformation is necessary for foundation of a common system for collecting, production, updating, presenting and exchanging of spatial digital data between different producers, users, systems and locations. Digital geoinformation has had an extreme growth, and has become the crucial element in planning and creation of civil and military operations. The requested size and complexity of projects and data require introduction of multinational agreements and norms, in order to achieve compatibility. The norms used in this project enable data exchange between producers and users, as well as interoperability and compatibility between countries and multinational systems.

Besides ISO standards, such as ISO 19103, ISO 19107, ISO 19110 that are used in this project, the NATO standards took most important part. As Croatia already is member of Partnership for Peace and is going to be a member of the NATO, it has obligation to be able to communicate with other partner countries and to exchange spatial information. Because of that, in all VoGIS databases the NATO standards are implemented, among which of the greatest importance is Feature and Attribute Coding Catalogue - FACC. In database modelling, following standards are applied: Vector Smart Map Level 2 (VMap2) in DLM50, Vector Smart Map Level 1 (VMap1) in DLM250 and JOG-G in CdB250.

5.1 DIGEST

The Digital Geographic Information Working Group (DGIWG) was established in 1983 to develop standards which would enable efficient data exchange between the NATO member states (DGIWG, 2000). DGIWG is not an official NATO body, but its work on standards is recognizable and approved by the NATO Geographic Conference. This working group has developed the DIGEST (Digital Geographic Information Exchange Standard) as an exchange

standard. DIGEST, as a standard, supports exchange of raster, matrix and vector digital geographic data between producers and users. From 1990s DIGEST became NATO standardization agreement number 7074 (STANAG 7074).
The forth part of the DIGEST standard consists of the catalogue of feature and attribute codes - FACC (Feature and Attribute Coding Catalogue). FACC catalogue has been used as the base for encoding of all features, attributes and attribute values in all topographic and cartographic databases inside the VoGIS system. FACC is basically a dictionary of feature definitions and attributes, where features and attributes are coded according to the standardized code system.

Code		Page
A - Culture		A-1
AA - Culture-Extraction		A-1
AA010	Mine	A-1
AA011	Quarry/Mine Shear Wall	A-1
AA012	Quarry	A-1
AA013	Pit	A-1
AA040	Rig/Superstructure	A-1
AA050	Well	A-1
AA051	Wellhead	A-1
AA052	Oil/Gas Field	A-1
AA060	Gradation Works	A-1

Figure 5: FACC Example of Feature codes

AA - Culture-Extraction

AA010 Mine
An excavation made in the earth for the purpose of extracting natural deposits. (See also AQ090)

AA011 Quarry/Mine Shear Wall
The wall facing of the excavation within a quarry/mine.

AA012 Quarry
An excavation created by removal of stone by blasting or cutting.

AA013 Pit
An excavation where gravel, sand, or clay are removed for use elsewhere.

Figure 6: FACC Example of Feature definitions

6. CONCLUSION

The concept of the geoinformation system of the Ministry of Defence describes modern, open and standardized system, original in Croatian GIS community, the system that enables the Ministry of Defence to accomplish all set of goals towards its users and to member states of the NATO alliance and the Partnership for Peace. Production procedure that this project suggests is fully tested and proved to be implementable. The focal point of the system is the DLM10 database, the highly-precise and detailed database for analysis at local level which

can serve as a source for all Ministry's geo-topographic products together with two derived databases: DLM50 which can be used for spatial analysis at regional level and DLM250 for analyses on state and interstate level. Last two databases do not contain smaller and less important objects; have less density of objects and components which enables analysis of bigger surfaces and bigger number of objects. It is important to point out that these two DLM databases are made according to the NATO standards (VMap2 and VMap1).
The concept of the topographic-cartographic production of the Ministry of Defence is hereby compatible to the Croatian official topographic-cartographic system, i.e. leans on and can fulfil the system of the State Geodetic Administration. This way the Ministry of Defence can use all existing resources of the SGA and the funds that the Republic of Croatia is investing in spatial data.
The next step for the Ministry is to start the mass production of 180 map sheets of the military map 1:50,000 with continuous effort in improvement of production and implementation of latest technological innovations.

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BIOGRAPHICAL NOTES

Zvonko Biljecki was born 1960 in Derventa. He graduated on Geodetic faculty in Zagreb in 1984 and in 1997 started the Ph.D. study on *Technische Universität* in Vienna (theme: Concept of Croatian Topographic Information System – CROTIS). His professional work started in 1984 at the *Geodetic Faculty* as a Surveying expert and Research assistant. In 1989

he moved to *Geofoto SA* company in Lugano, Switzerland as a Production engineer. In period 1994-1997 he worked as a Director of the company. In 1993 he established the first photogrammetric service in Croatia through the company *Geofoto LLC* in Zagreb. He worked on many projects as a Team leader in Switzerland, Ukraine, Belarus and Croatia. He is president of Croatian photogrammetry, remote sensing and geoinformation society and vice president of Croatian Cartographic Association. As a president of STOKIS he leads group of experts in Croatian geoinformatics.

Mladen Rapaić was born 1960 in Zagreb, Croatia where he graduated on Geodetic faculty. At the beginning, he worked in private geodetic company *Zavod za fotogrametriju d.d.* on IT implementation in all surveying processes. After transferring to company *Gisdata d.o.o.* in 1996, he established and managed production of geographic data needed for running the GIS projects of South-eastern Europe. From the year 2002 he worked in the Croatian Geodetic Institute as Head of Department for GIS and Databases where he participated in projects of the national topographic database and processes of quality control implementation. In 2004 he moved to private company *Geofoto LLC* as a manager of GIS department. Mr. Rapaić is member of Croatian geodetic and cartographic societies and member of Croatian institute for normisation.

Tomislav Tonković was born 1967 in Vinkovci, Croatia. He graduated on Geodetic faculty in Zagreb, Croatia where he started his professional career in the domain of photogrammetry. Mr Tonković has extensive experience in modern Photogrammetry and Cartography techniques. He spent several months in *TU Institute*, Vienna to develop and apply digital orthophoto processes utilised for Croatian and Swiss conditions. Furthermore, Mr Tonković has introduced new digital cartographic processes in map production. He has spent more than a year for practical cartographic specialisation at *Federal Office of Topography*, Wabern, Switzerland. The further developing of digital map key, cartographic data model and digital orthophoto are the main goals of his activities. He has been participating in the Norwegian Croatian GeoInformation Project as Photogrammetry and Cartography Expert. Quality Control Systems has been developed for topographic data, digital terrain model and orthophotos based on 1:20,000 aerial photos. At the moment, Mr. Tonković is Deputy Director in *Geofoto LLC*, Zagreb, where he also performs duties of Head of Aerial Survey Department.

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