MILITARY GEOINFORMATION SYSTEM OF THE MINISTRY OF DEFENSE OF THE REPUBLIC OF CROATIA

ABSTRACT. One of the goals that Partnership for Peace has set, within domain of geospatial information, is implementation of the military geoinformation system. Besides this important strategic objective for the Republic of Croatia, the military geoinformation system will enhance activities of the Ministry of Defense and Armed Forces and in such way improve national defense and cooperation with the NATO members and members of the Partnership for Peace. This paper describes overall system principles based on relevant standards from domain of geospatial information with emphasis on the design of the conceptual data model and the object catalogue as main objective in the first phase of the whole project. Within this first phase of the project not only conceptual data model and object catalog was created, but also a GML application scheme that will serve as basis for data exchange with all anticipated users of the system.

Keywords: military geoinformation system, military cartography, NATO, FACC, DIGEST, CROTIS

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1. INTRODUCTION

The goal of the Military Geoinformation System - VoGIS project 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 fulfillment of the goals of the Partnership for Peace in the geoinformation domain." (MoD 2004).

Realization of the prime goal of the project would institute an effective multi-user geoinformation system that will contain all the elements necessary for the Ministry of Defense (MoD), Armed Forces (AF) and units of Croatian army. Moreover, this system would correlate with other existing information systems. The concept of the system would enable a secure two-way exchange of digital information with other members of the NATO and the Partnership for Peace; in that way completing the obligations Croatia has to realize according to the Working Plan 0122 of the Partnership for Peace (NATO 2002).

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In this paper are described main principles of the VoGIS system, with special emphasis on the production of the conceptual military topographic database model that is consonant with all relevant norms and standards in geoinformation.

Results of the first phase of the project will be used when implementing the military topographic database, and when modeling and implementing a cartographic database, which would be groundwork for creation of the military topographic maps in scale 1:50000 (VTK50) and Joint Operations Graphics in scale 1:250000 (JOG).

2. VoGIS system

VoGIS is a framework for definition of smaller components, as topography and cartography. Topographic component is result of conformance of the topographic database of the State Geodetic Administration (SGA) and military content to NATO norms. Cartographic component unifies cartographic database and the process of map creation. When implementing VoGIS, a principle applies according to which 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 type of data is collected and updated by profession that deals with specific type of data as a core business.

Originally proposed solution of VoGIS delivers a principle scheme of the system and relation of the system to so called civil sector i.e. State Geodetic Administration (fig. 1). According to this scheme, the foundation of the Military Geoinformation System is the topographic database made according to the product specifications based on the CROTIS standard, which were developed under the CRONO GIP project. Database should be transferred to the Ministry of Defense (MoD) and be upgraded with military content. This way, military topographic database would become the central part of MoD's GIS and groundwork for other geoinformation products, like small-scale databases, cartographic databases, cartographic products, Internet applications and other.

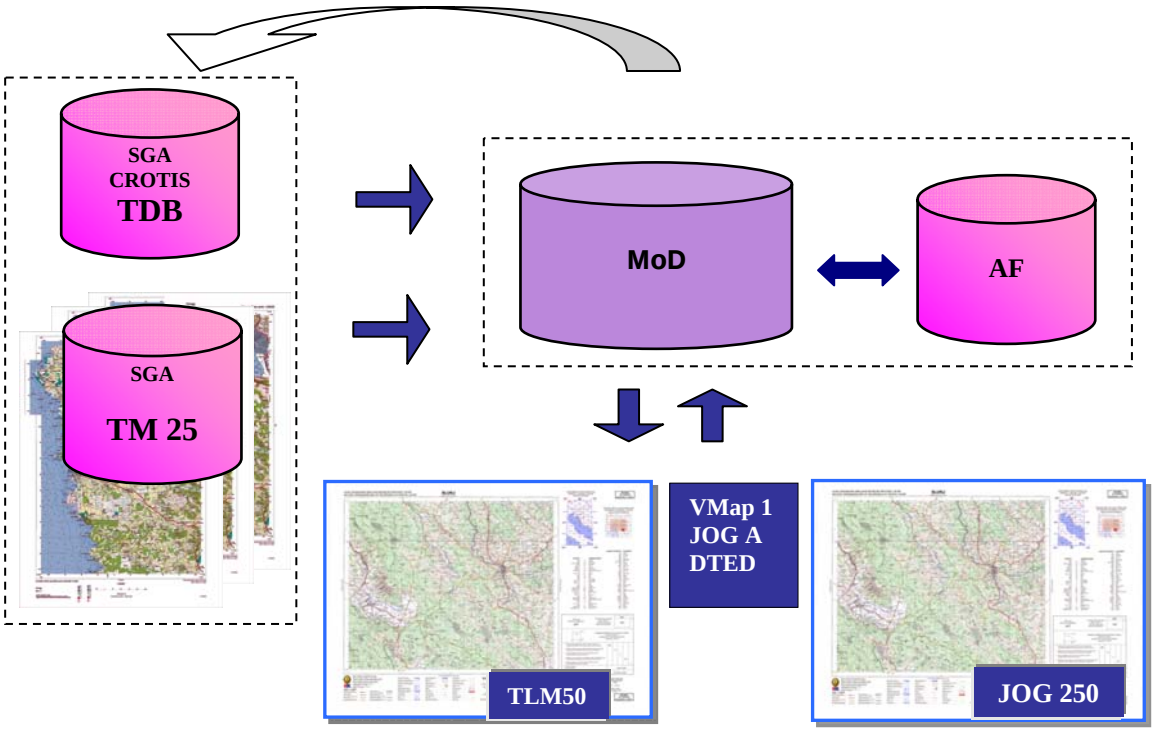

Figure 1. Relation of civil and military geoinformation systems (MoD 2004)

Undertaking the CROTIS model, means that Ministry of Defense will join SGA in construction of a new cartographic system based on topographic database and at the same time abandons the model based on update of existing (old) maps.

On the map production scheme (fig. 2), a scheme of the VoGIS system as a function in production of military tactic topographic maps is shown.

Of great importance is the interoperability of a system that enables data exchange between the Croatian state institutions and between the members of the NATO and the Partnership for Peace.

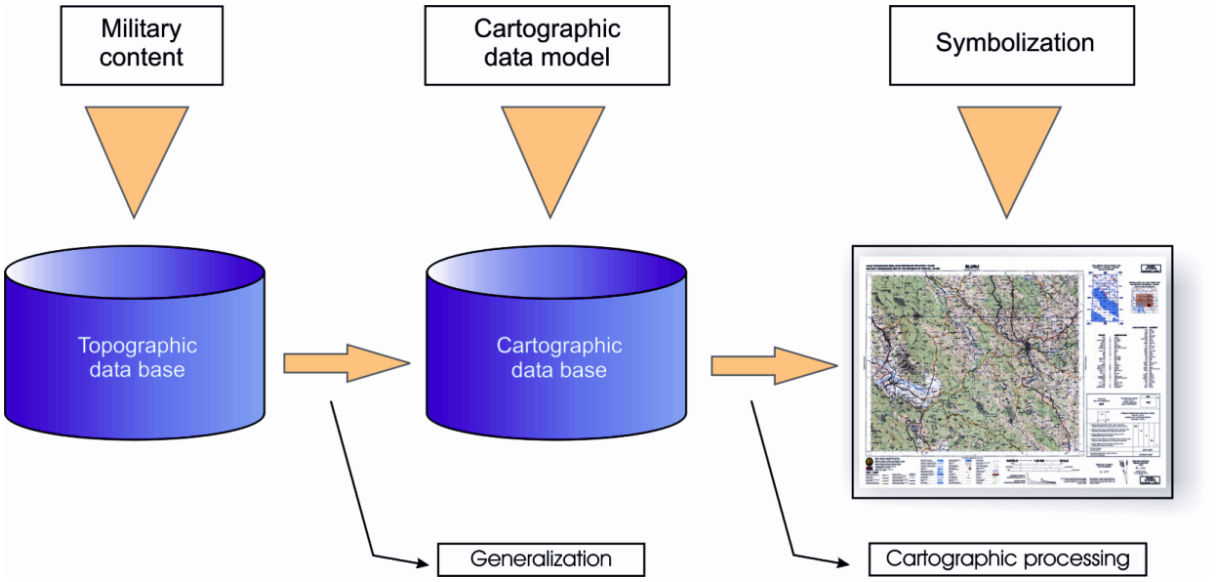

Figure 2: Map production scheme

Original proposal (MoD 2004.) states implementation steps which should be adjusted during the execution of the project according to obtained knowledge and technology. The topographic database model is the main result of the first phase of the project.

On the scheme of cartographic production (fig. 2), two main phases of production can be seen: a generalization (creation of cartographic database) and cartographic processing (assignation of symbols, styles, etc).

Precondition for data exchange between various institutions will be production of detailed exchange models, according to which particular data structure will be mapped to another data structure. These exchange models are:

- model for mapping data from CROTIS system to the VoGIS topographic database
- model for mapping cartographic database from VoGIS system to CROTIS system of SGA
- model for data exchange according to NATO standards.

Access to VoGIS databases will be possible trough an application server (fig. 3). With export functions of GIS tools and specially made applications, users who will need own copies of the whole database or part of the database, will be able to obtain them.

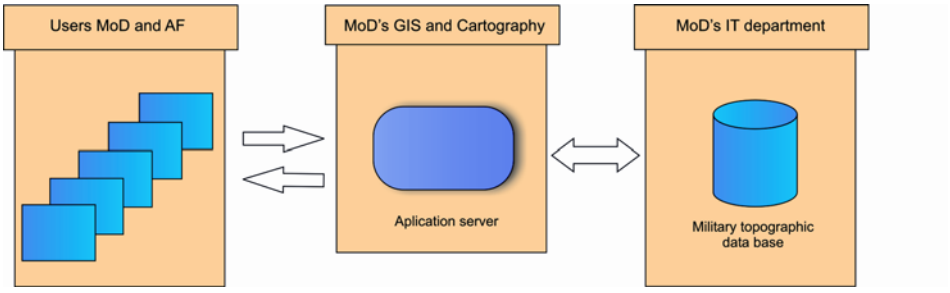

Figure 3: Direct access to the topographic database

3. Norms in geoinformation

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 a users, as well as interoperability and compatibility between countries and multinational systems.

Standards/norms in geoinformation are delivered by competent institutions and organizations. During creation of this project, different standards and norms were used. The norms are from the geoinformation field, issued by the Technical Committee ISO/TC 211 (URL 1), the NATO and from the Open Geospatial Consortium - OGC (URL 2).

In the Republic of Croatia, the Product specification for topographic data (SGA 2003) which is based on CROTIS standard (SGA 2000) is used as standard for collection, processing, presenting and exchange of topographic data.

As ISO norms and specifications regulated by OGC were already described on couple occasions in other works, in next section can be found short explanations of NATO norms used in this project.

3.1. NATO norms

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 (NGC).

This working group has developed the DIGEST (Digital Geographic Information Exchange Standard) as an exchange standard (URL 3).

DIGEST, as a standard, supports exchange of raster, matrix and vector digital geographic data between producers and users. Moreover, the standard supports entire sequence of topological structures. From 1990s until today, DIGEST became NATO standardization agreement number 7074 (STANAG 7074).

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 modeling and encoding of military objects of topographic database. FACC is basically a dictionary of feature definitions and attributes, where features and attributes are coded according to the standardized code system.

This is structured in following way:

- first four chapters are introduction, purpose and field of application, adjustment, references and terminology
- the fifth chapter explains in detail code structures of features, attributes and their values; as well as rules about documentation of new features and attributes
- Annex A is a list of features and their codes
- Annex B is a list of attributes and associated codes, as well as of attribute values with descriptions
- Annex C is alphabetical list of all features and attributes.

When modeling military topographic database, existing features from the SGA topographic database (SGA 2003.) are mapped to the features of the VoGIS model; by usage of definitions from the FACC catalogue.

Large numbers of features from existing SGA database have not been simply translated (one to one) to VoGIS. Explicitly, for a feature from topographic database does not always exist an adequate feature in FACC catalogue that could be accepted as a new VoGIS feature. Therefore, features from topographic database were mapped to a VoGIS features by combination of values defined in the FACC catalogue for features, attributes and attribute values. By establishment of relations between features, attributes and their values, the VoGIS topographic database model version 1.0 has been made.

VoGIS catalogue has been harmonized with the FACC catalogue as much as possible, so that when a specific features from the topographic database were not defined in FACC catalogue; a new VoGIS codes were created according to the FACC catalogue.

As FACC is just a dictionary and does not specify data model and does not provide relations between features and attributes, for creation of a data model additional NATO standards based on FACC were used. These are: Digital Topographic Data - DTOP (NIMA 2002.), Vector Map Level 1 - VMap1 (NIMA 1995.), Vector Map Level 2 – VMap2 (DMA 1996.), Urban Vector Map – UVMap and many other standards.

Demands of Croatian MoD and AF were received trough a survey and working group meetings. Existing data from topographic database together with mentioned NATO norms were used as the foundation for development of the VoGIS database. That way, to please all the demands, original FACC catalogue was extended and VoGIS catalogue was made.

4. Conceptual data model

UML has been used to describe conceptual scheme (data model) and object catalogue. Unified Modeling Language (UML) is a graphic language for object oriented modeling that enables visualization, specification, construction and documentation of program support system (Booch and others 2000, Carlson 2001). 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.

For a spatial database modeling is usually used UML as it can be seen in ISO 191xx norms. Rules which define production of an application scheme according to UML are defined in the ISO/DIS 19109 norm *Rules for application schema* (ISO 2002).

Key element of UML that has been used for military topographic database modeling is Class. Stereotype <<FeatureType>> can be found in title of classes. This stereotype describes in detail functions of specific classes in the system. Beneath the stereotype is the name of the class.

After stereotype and name of the class is written an attribute list with belonging data types. After attributes, methods can be listed. In the VoGIS model are all classes defined with name and attributes, but without methods. During development of specifications for military data collection, which will be made in following project phases, some of the classes will have methods defined as well.

The classes that depend on each other are connected with relations. When modeling VoGIS, relations of generalization are described as primary mean for model description.

Generalization is relation by which objects of generalized element or parent can be substituted with objects of specialized element, or in other words child.

In the model were three stereotypes used: <<FeatureType>>, <<Abstract>> and <<CodeList>>. According to these stereotypes following classes can be distinguished:

- classes that are realized as features
- abstract classes from which children take over attributes
- code lists that define domain of certain attributes

When defining a class, attributes are listed together with data type. There are some simple data types as Integer, CharacterString, etc.; but there are also some complex data types which are shown in the model as classes with <<CodeList>> stereotype (fig. 6).

In the created VoGIS UML database model, classes are organized in thematic layers, which in UML present separate organization units - UML packages. Theme layers are defined according to NATO norms for different products as DTOP, VMap1, VMap2, and similar.

Thematic layers used in the VoGIS model are:

- BND - Boundaries
- HYDRO - Hydrography
- HYPSO - Hypsography
- IND - Industry
- POP - Population
- REF - Reference
- TRANS - Transportation
- UTIL - Utilities
- VEG - Vegetation

Layer BND is used for storing and description of administrative areas, and areas not necessarily emphasized with visible borders and some special marks, but are defined by authorized official institutions.

Layer HYDRO is used for storing and description of all waters: running and stagnant, underwater objects, natural and built objects on the water that in any way influence flow of the water.

Layer HYPSO is used for storing and description of all objects necessary for terrain height modeling.

Layer IND is used for storing and description of all objects that are used for excavation, remodeling, production, transport, storing and discard of raw materials, products or waste.

Layer POP is used for storing and description of all built and finished objects related to population. These objects are characterized by variety of usage and that people assemble, in bigger or smaller groups, in or around these objects. These are widely recognizable objects, and as such are important for orientation. Typical military objects are included in this layer.

Layer REF is used for storing and description of text content that is impossible to attach to objects from different layers and for description of object necessary to achieve system functionality.

Layer TRANS is used for storing and description of all objects in traffic network or objects that are part of traffic infrastructure. All objects assigned for traffic control/regulation, navigation and natural objects which aggravate normal traffic flow are included in this layer.

Layer UTIL is used for storing and description of objects necessary for production and distribution of electrical energy. Communication objects which do not have navigation function and pipe-lines are included in this layer, too.

Layer VEG is used for storing and description of all objects that define vegetation of the territory including natural objects on the earth surface, which, based on their nature do not have cover.

As part of thematic layers are defined abstract classes, which additionally bind objects inside a thematic layer.

Except for typical inheritance of geometric attributes (*GM_Curve*, *GM_Surface*, *GM_Point*), UML diagram describes some other attributes associated with inheritance mechanism. Therefore, classes that are realized through different geometries, *AdministrativnaGranicaLine* and *KatastarskaOpćinaArea* have a mutual parent class *PolitičkaGranica*. This means that a linear object that belongs to class *AdministrativnaGranicaLine* and a surface object from class *KatastarskaOpćinaArea* can have some mutual attributes, defined in class *PolitičkaGranica*, or in other words, they both represent political border, independent upon the fact that instant object can be of different geometry.

5. Data catalogue

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 schemes 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.

The VoGIS catalogue is made according to the ISO norm 19110 *Feature cataloguing methodology* (ISO 2001) that defines a feature catalogue production. This norm specifies the approach to classification organization and presentation, so that it would be consonant with a standard practice. Norm ISO 19110 is also used for new systems for which there is no other catalogue and for revision and coordination of existing catalogues.

A catalogue primarily describes object types and is not assigned to represent certain instances of object types. Application range of this norm does not assign spatial reference, time reference or portrayal criteria given trough the ISO 19107, ISO 19108 and ISO 19117. Also, data collection criteria are not included.

Accordingly, main purpose of a catalogue is to define meanings of features that are modeled for a specific usage or to adjust feature definitions if these features are used in more than one application. Definition of spatial relations, time relations and criteria for data collection is not in data catalogue, and can be given only as a proposition, but not as a regulation.

From the ISO 19110 norm, following information elements for model description have been taken:

- on the catalogue level are given name of the catalogue, list of application areas, number of the version, date of the version and creator data
- on the feature level, for each object from data collection defined in the catalogue, are given name of the object, definition of the object, object code and list of attributes names
- on the attribute level, for each attribute from data set, are given name of the attribute, definition of the attribute, code of the attribute, data type of the attribute, unit of measure and type of domain (0 for counted and 1 for other domains). With counted domains, acceptable attribute values are given
- On the attribute value level are given acceptable values and description

The norm anticipates the possibility of extra elements, primarily operation definitions and feature connections that were not given in this VoGIS catalogue.

For a military topographic database to satisfy all interoperability conditions, VoGIS catalogue has been made as a bilingual catalogue - in Croatian and English language. Catalogue shows in detail 206 objects.

6. Application scheme for data exchange

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 (OGC 2002.) 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.

In the next picture (fig. 4) is shown a data exchange scheme from a system A to a system B, based on data in the GML and associated application scheme.

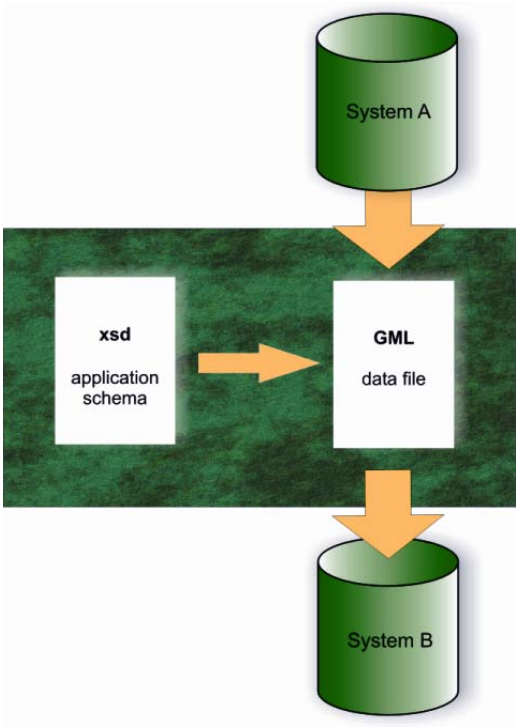

Figure 4: Data exchange from system A to system B

As the GML is a dialect of the XML, syntax and language elements have been given with the XML through the W3C recommendation (W3C 2004), which is published on web pages: http://www.w3.org/TR/REC-xml/ and http://www.w3.org/XML/.

7. CONCLUSION

Military geoinformation system of the Ministry of Defense (VoGIS) represents a modern system that has military topographic database as foundation. By further processes of generalization, selection and cartographic processing the other, mainly digital, products are derived for use in the Ministry of Defense and the Armed Forces.

Three main principles were followed throughout the VoGIS database modeling:

1) object oriented approach to a database modeling
2) usage of accepted standards and norms
3) relying on existing resources.

Object oriented modeling is a modern and widely acceptable procedure for a spatial database modeling. Not so long ago has implementation of spatial systems been mostly based on relational databases, and systems were modeled and described with the ER (entity-relations) diagrams. Today is the object approach much more present and spatial systems are realized as object systems or as an object oriented systems, modeled and presented with UML diagrams.

Usage of the existing norms and standards ensures easy accessibility and interoperability of the system. For modeling the VoGIS database, certain ISO norms, NATO standards and specifications issued by the OGC (Open Geospatial Specification) have been used. Moreover, specifications for the official CROTIS Topographic database creation have been used.

One of main principles in the *e*-Croatia concept, which has been established by the Government of the Republic of Croatia, is collection of a data once with its multiple uses. As the State Geodetic Administration, based on the Program of State Survey and Real Estate Cadastre has already began activities related to creation of the spatial information system, it is only logical to use these date in the military geoinformation system as well. Therefore, the project CROTIS has been taken into account as the standard and the groundwork, in order to establish the military geoinformation system faster and more rationally.

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