PREDLOG IZDELAVE NACIONALNEGA TOPOGRAFSKEGA MODELA (TNTM) V REPUBLIKI HRVAŠKI

PROPOSAL FOR ESTABLISHMENT OF THE BASIC NATIONAL TOPOGRAPHIC MODEL (BNTM) IN THE REPUBLIC OF CROATIA

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IZVLEČEK

Začetek razvoja topografske izmere in izdelave topografskih kart v merilu 1 : 25.000 (TK25) v Republiki Hrvaški sega v leto 1993, ko je bil izdelan projekt STOKIS – Uradni topografski kartografski informacijski sistem (hrv. Službeni topografski kartografski informacijski sustav). S projektom STOKIS je bil določen topografski in kartografski model podatkov, določene so bile smernice za izdelavo hrvaškega topografskega informacijskega sistema (CROTIS) kot modela podatkov, na podlagi katerega je vzpostavljena temeljna topografska baza (TTB). Leta 2003 se je začela izdelava topografskih kart v merilu 1 : 25.000 (TK25) za celotno območje Republike Hrvaške, in sicer na podlagi obdelave podatkov, ki so jih uvažali v TTB. Model podatkov CROTIS se je z leti spreminjal glede na tehnološki razvoj področja prostorskih podatkov. Doslej so izdelali štiri različice sistema CROTIS. V članku je podan pregled razvoja sistema od prve do zadnje različice. CROTIS 2.0 je topografski model, ki se nanaša na zbiranje podatkov na kopenskem delu Republike Hrvaške. Ker je 30 % območja Hrvaške vezano na morje, bo v članku predstavljen tudi topografski model Hrvaškega hidrografskega inštituta (HHI) iz Splita. Z opisom možnosti za uskladitev obeh modelov je podan predlog novega temeljnega nacionalnega topografskega modela za območje Republike Hrvaške.

KLJUČNE BESEDE

topografski model, objektni razredi, hrvaški topografski informacijski model (CROTIS), temeljni nacionalni topografski model (TNTM)

ABSTRACT

The development of topographic survey and production of topographic maps in scale 1:25,000 in the Republic of Croatia started in 1993 with the completion of the project the Official Topographic-Cartographic Information System (STOKIS). The STOKIS project defined the topographic and cartographic data model. The Croatian Topographic Information System (CROTIS) was created using the guidelines from STOKIS as the data model that was a foundation for the establishment of The Basic Topographic Database (BTD). The topographic maps in scale 1:25,000 for the whole territory of Croatia were made by processing data uploaded in the BTD since 2003. The CROTIS data model has changed during the years due to technological development in the field of geospatial data. Up to this day, four versions of CROTIS have been produced. This paper will give an overview of the development from the first to the last version. CROTIS 2.0 is a topographic model that refers to the collection of data on the land area of the Republic of Croatia. As 35% of the area of the Republic of Croatia is covered by the sea, this paper will show the topographic model by the Croatian Hydrographic Institute (HHI) from Split. This paper for all propose The Basic National Topographic Model for the territory of the Republic of Croatia by the harmonization of the two mentioned models.

KEY WORDS

Topographic model, object classes, Croatian Topographic Information System (CROTIS), Basic National Topographic Model (BNTM)

1 INTRODUCTION

The topographic mapping, as well as the wide field of geographic information, has been strongly influenced by the development of geographic information systems in the past decades (Foerster et al., 2010; Goodchild, 2010). In the Republic of Croatia, the Official Topographic-Cartographic Information System (STOKIS) was defined in 1993. The Regulation Regarding Topographic Survey and the Creation of State Maps (Official Gazette, 2008: Article 23) stipulates that the basic principles of topographic and cartographic databases establishment should be in compliance with the STOKIS. In the Article 25, the Regulation further defines the topographic databases (TD) creation principle, and in the Article 26, it defines the cartographic databases (CD) creation principle. Accordingly, the current STOKIS data model with data sources and CD hierarchy is shown in Figure 1 (Racetin, 2013).

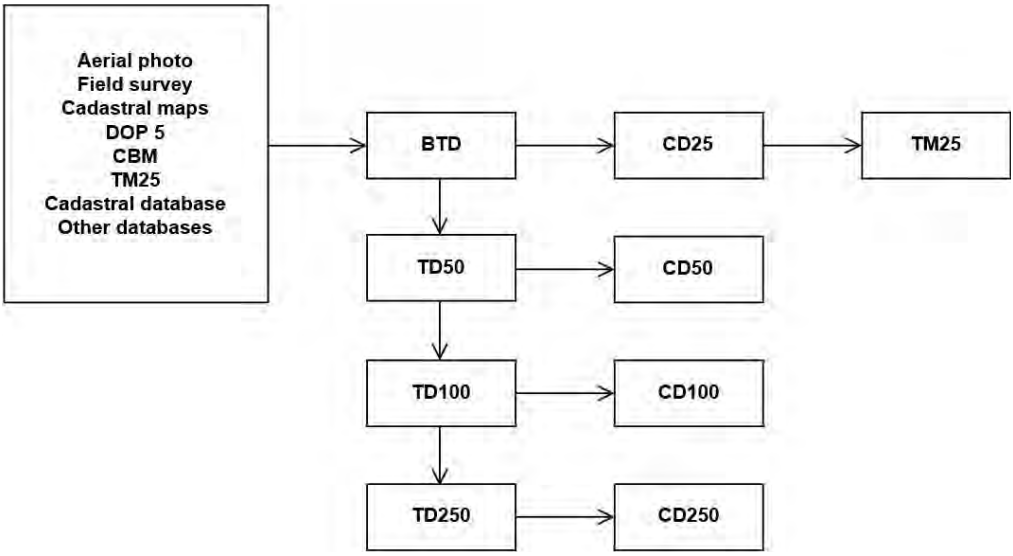

Figure 1: The Croatian Official Topographic-Cartographic Information System STOKIS.

The main source for the Official Topographic-Cartographic Information System is aerial photogrammetric imagery, while the secondary sources are field survey data, cadastral maps, digital ortophotos in scale 1:5000 (DOP 5), Croatian Base Maps in scale 1:5000 (CBM), Topographic Maps in scale 1:25,000 (TM 25) and other official databases and registers.

For the proposal of establishing a new topographic model in the Republic of Croatia, topographic models of Denmark, the Netherlands, Great Britain and Slovenia were analysed. In the Danish model, most of the inputs into the database are carried out on the basis of new aerial images and spot checks, i.e. the field survey (Bengtson, 2001). Furthermore, we analysed the Dutch basic model TOP10N within the Basic Topographic Registry (BRT), that is, analysis of main object classes of the TOP10NL (KADASTER, 2014) and the British topographic models (OS, 2014) . The National topographic and cartographic system Slovenia (TKSS) is a collection of topographic spatial data in numerical or graphical, analogue and digital form. According to TKSS, production of official maps in scales 1:5000, 1:25,000, 1:50,000, 1:100,000, 1:250,000, 1:500,000 and 1:1,000,000 is predicted. Every scale has a data model,

specifications and cartographic key. The data model consists of object entities, object types and object groups (Petrovič, 2005; GURS, 2014). Anyhow, according to Stoter (2005), cartographic products are no longer, as before, the main objective of creating and maintaining topographic information systems. An important aspect here is optimization of cartographic production with automated generalization of topographic data (Stoter et al., 2013).

2 DEVELOPMENT OF THE CROATIAN TOPOGRAPHIC INFORMATION SYSTEM (CROTIS)

After 1990, work on the official cartography development strategy in the Republic of Croatia started. Geospatial data are data about objects and appearances on the surface or under the earth's surface that are commonly shown on the maps. In the field of cartography, there is a big connection to the geospatial data. The Official Topographic-Cartographic Information System (Frančula and Lovrić, 1993) is the core document, which describes the strategy for multiannual development of cartography in the Republic of Croatia. After the introduction of the STOKIS, the analysis had been carried out to determine the most suitable data model for current situation in the Republic of Croatia. A research on the condition of geospatial data in the Republic of Croatia was conducted already in 1994 (Radić, 1994). Numerous scientists and experts from the Geodetic Faculty, State Geodetic Administration and private companies participated in the research. The Croatian Topographic Information System (CROTIS) was proposed and adopted as a result of the research (Biljecki, 1996). CROTIS is a basic document, which gives a classification of the official topographic data during its collection, editing, accuracy, depiction and exchange. After photogrammetric restitution and topologic processing, data are stored into the Basic Topographic Database (BTD). BTD was established in 2003, and by the end of 2010, the process of initial data upload for the whole territory of the Republic of Croatia was completed.

The first version of CROTIS data model was defined on the basis of the German Authorative Topographic-Cartographic Information System ATKIS (germ. *Amliches Topographisch-Kartographishes Informationssystem*) data model. ATKIS is a project for the German land survey by the BKG (germ. *Bundesamt für Kartographie und Geodäsie – Federal Agency for Cartography and Geodesy*), which in the first phase of digitalization consisted of one digital topographic model (DLM) and more digital cartographic models (DKM), and it had to be an upgrade of the classic analogue, printed map. Nowadays, the ATKIS has become a nationally standardised project, where the topography is described in a geo-topographic database and provided in the form of usage-oriented digital Earth surface models (ATKIS, 2016).

In 1990s, the Republic of Croatia did not have any experience in the production of topographic maps in scales smaller than 1:5000 (Basic State Map – BSM). After gaining independence in 1990, analyses were started to determine the most suitable topographic data model for the Republic of Croatia, supported also by the Norwegian funds. Based on the results of numerous researches and discussion at the national academic and professional level from that time, it has been concluded, that the best model was ATKIS. In parallel, analyses for the most suitable data model and possibilities of its implementation for the Republic of Croatia started. From 1990 to 1996, a number of studies were conducted to determine the basic guidelines for topographic model and it was named CROTIS 1.0. The CROTIS 1.0 model (Table 1) defined and standardized the data model as well as collection, processing, accuracy, topological relations and exchange of topographic data.

Table 1: CROTIS version 1.0 data model object units.

1000	PERMANENT GEODETIC POINTS
2000	BUILDINGS, COMMERCIAL AND PUBLIC OBJECTS
3000	UTILITY LINES
4000	TRANSPORT
5000	VEGETATION AND LAND TYPES
6000	WATERS
7000	RELIEF
8000	ADMINISTRATIVE AND TERRITORIAL ORGANIZATION, BORDERS
9000	GEOGRAPHICAL NAMES

The topographic model, issued by the Surveying and Mapping Authority of the Republic of Croatia, consisted of 9 object units, 31 object groups and 101 object types. Object units that were included into the first CROTIS 1.0 document were: *Permanent geodetic points, Buildings, Commercial and public objects, Utility lines, Transport, Vegetation and land types, Waters, Relief, Administrative and territorial organisation, Borders and Geographical names (toponymes)* (Table 1).

Following the CROTIS version 1.0 data model, the CROTIS version 1.1 was produced (Biljecki, 2009). Analyses and technological novelties showed that new exchange format EXPRESS, which was universal at that moment, must be adopted. The CROTIS version 1.1. was issued in 2002. In data model CROTIS version 1.1, 9 object units remained as in the model CROTIS version 1.0. Subsequently, the data model CROTIS version 1.2 was produced (Table 2), in which the object units of *Permanent geodetic points* and *Administrative and territorial organisation, borders* were extracted and are now maintained in the separated data bases. The data model CROTIS version 1.2 was adopted in 2009 (Table 2).

Taking into account the technological advances in the field of spatial data and European Union directives, new moments of spatial data development occurred. At the time of issuing of the INSPIRE Directive (INSPIRE, 2007), the Republic of Croatia had pre-accession agreements and all the novelties from the EU were carefully monitored. The EU published the INSPIRE Directive 2007/2/EC of the European Parliament and of the Council on 14 March 2007. The data model CROTIS version 2.0 is largely harmonised with the INSPIRE Directive and was adopted in 2014 (Divjak, 2013, 2014). The primary principle of the directive is sharing spatial data between all the interested subjects, and as the theme spectrum is very broad in the CROTIS version 2.0, all

of the basic components of interoperability concept and harmonisation were fulfilled (Landek et al., 2014).

Table 2: CROTIS version 1.2 data model object units.

1000 ~~PERMANENT GEODETIC POINTS~~
2000 BUILDINGS, COMMERCIAL AND PUBLIC OBJECTS
3000 UTILITY LINES
4000 TRANSPORT
5000 VEGETATION AND LAND TYPES
6000 WATERS
7000 RELIEF
~~8000 ADMINISTRATIVE AND TERRITORIAL ORGANIZATION, BORDERS~~
~~9000~~ 1000 GEOGRAPHICAL NAMES (TOPONYMS)

The data model CROTIS version 2.0 (Table 3) was defined in a way, compared to the CROTIS version 1.2, that the object unit *Vegetation and land type* was renamed to *Land cover and land use*. Unlike the previous model versions, this one was minimally expanded with the new contents. The new compound object classes, attributes and values occur due to the new approach to object grouping, the new data catalogue and due to harmonization of names with the associated definitions. The main objective was to minimize unidentified objects. Furthermore, all object classes, which were stored and updated in the Digital Terrain Model (DTM) database, were excluded from the object unit *Relief*. The former unit of *Vegetation and land use* was changed to a greater extent. The new object class *Land use* was introduced as a separate data layer within the unit of *Land cover and land use* that conceptually differ from the rest of the classes within the unit. The unit of Geographical names was renamed from "*Zemljopisna imena*" to "*Geografska imena*" (also Croatian translation for Geographical names but with the more suitable word). The greatest change refers to the way the polygon objects are presented. This is because the collection of data was adjusted to primitive graphical elements (point, line) and therefore area objects consisted of boundaries (line), which contained attributes of an area object. In the new model, every object can have one of a three given geometries (point, line, polygon) and contains all attributes provided by the model, as already defined by Mallgren (1982). Except from the definitions of object units, attributes and classes, definitions of attribute values are given in the new model, as well. In the model CROTIS version 2.0, abstract object upper-class „CROTIS object" was introduced, which is a carrier of basic attributes of all classes in the model, as unique identifier, accuracy of collection, origin, life cycle data and so on (Landek et al., 2014).

Table 3: CROTIS version 2.0 data model object units.

BUILDINGS	~~BUILDINGS, COMMERCIAL AND PUBLIC OBJECTS~~
UTILITY LINES	
TRANSPORT	
LAND COVER AND LAND USE	~~VEGETATION AND LAND TYPES~~
HIDROGRAPHY	~~WATERS~~
RELIEF	
GEOGRAPHICAL NAMES (changes in croatian translation)	

The data model CROTIS version 2.0 is a topographic model similar to the topographic models of the Kingdom of Denmark and the Netherlands (Ključanin et al., 2014), where the topographic databases are provided for the scale 1:10,000.

3 TOPOGRAPHIC MODEL OF THE CROATIAN HYDROGRAPHIC INSTITUTE

The Hydrographic Institute of the Republic of Croatia (HHI), for its own purposes, has symbols and abbreviations, which are used for depiction on Croatian nautical charts. Symbols and abbreviations are published in the publication "Symbols and abbreviations used on charts" (Gržetić et al., 2013).Symbols and abbreviations are organised in following units (Gržetić et al., 2013):

- General,
- Topography,
- Hydrography,
- Navigational means and services and
- Alphabetical indexes.

From the publication, it is evident, which data are required to produce the topographic model of the Hydrographic Institute of the Republic of Croatia (Gržetić et al., 2013). In two object units of *Topography* and *Hydrography*, there are object classes that have been already processed in CROTIS. This means that most of the topographic and hydrographic data are collected, although the same data are already processed and collected in the Basic Topographic Database (BTD), which is based on the data model CROTIS at the State Geodetic Administration (DGU).

In the Republic of Croatia, as stipulated by the law, the State Geodetic Administration is responsible for topography of the land, while the Hydrographic Institute of the Republic of Croatia is in charge of topography of the sea. Therefore, a common data model would be the most appropriate basis for the national topographic model. Based on the publication about symbols and abbreviations used on charts from 2013 (Gržetić et al., 2013), object units, groups, classes and subclasses that the Hydrographic

Institute of the Republic of Croatia is collecting, were selected and compared with the data model of CROTIS 2.0 (Table 4).

Table 4: Overview of the topographic model structure from HHI and comparison to the CROTS 2.0.

		HHI		CROTIS 2.0
TOPOGRAPHY	Natural features	Coastline	Hillocks	
			Flat coast	
			Sandy shore	
			Stony shore	
			Sandhills, Dunes	
		Relief	Contour lines with values and spot height	✓
			Spot heights	✓
			Form lines with spot height	✓
		Water features	River	✓
			Lakes	✓
			Salt pans	✓
		Vegetation	Wood	✓
			Deciduous tree	✓
			Evergreen (except conifer)	✓
			Conifer	
			Palm	
			Swamp	✓
		Supplementary national symbols	Grass field	✓
			Vineyard	✓
			Paddy field	
			Park, garden	✓
			Bushes	✓
			Lagoon	
			Slough	✓
			Spring	✓
	Cultural Features	Settlements, Buildings	Buildings	✓
			Important building	✓
			Ruin	✓
		Roads, Railways, Airfields	Motorway	✓
			Road	✓
			Track, Path	✓
			Railway, with station	✓
			Cutting	✓
			Embankment	✓
			Tunnel	✓
			Airport, Airfield	✓

		HHI		CROTIS 2.0
		Other Cultural Features	Bridge	✓
			Aerial cableway	✓
			Power cable	✓
			Telephone line	
			Overhead pipe	
			Pipeline on land	✓
		Supplementary national symbols	Fence	
			Airplane landing field	✓
	Landmarks	Landmarks	Church	✓
			Church tower	✓
			Chapel	✓
			Cross	✓
			Temple	✓
			Mosque, Minaret	✓
			Cemetery	✓
			Tower	✓
			Water tower	✓
			Chimney	✓
			Flare stack	✓
			Windmill	✓
			Wind turbine	✓
			Wind farm	
			Radio mast	
			Radio tower	
			Radar mast	
			Dish aerial	
			Tanks	✓
			Silo	✓
			Fort	✓
			Mine	✓
			Caravan site	
		Supplementary national symbols	Watermill	✓
			Well	✓
			Fountain	✓
			Stadium	✓
	Ports	Hydraulic Structures in General	Dyke, Levee, Berm	
			Seawall	✓
			Breakwater	✓
			Groyne	
		Harbour Installations	Fishing harbour	✓

		HHI		CROTIS 2.0
			Boat harbour, Marina	✓
			Yacht club, Sailing club	
			Pier, Jetty	✓
			Pontoon	
			Dry dock	
			Basin	✓
		Canals, Barrages	Canal	✓
			Terminal	
		Public Buildings	Harbour Master's office	
			Custom office	✓
			Health office	✓
			Hospital	✓
			Post office	
HYDROGRAPHY	Depths	Depth Contours	Drying contour	
	Offshore Installations	General	Wind farm	
			Platform	
		Submarine Cables	Supply pipeline: oil, gas	✓
			Supply pipeline: water	✓
	Tracks and Routes	Ferry	Ferry	
	Areas and Limits	Anchorages and Anchorage Areas	Sea-plane operating area	
NAVIGATION AIDS AND SERVICES	Services	Supplementary national symbols	Public inn	
			Restaurant	
			Fuel station	
			Car park	
			Water Police	

From the Table 4, it is clear that the majority of subclasses are already included and data are collected within the State Geodetic Administration's Basic Topographic Database (BTD) based on the topographic data model CROTIS version 2.0. Since the Hydrographic Institute of the Republic of Croatia (HHI) does not have a topographic data model, we suggest that the CROTIS version 2.0 topographic data model is updated with required extensions aiming to include object classes from the proposed HHI's topographic model. This new topographic model would be the basic national topographic model, as it would contain object classes that represent basic data on land and at sea.

4 THE PROPOSAL FOR THE BASIC NATIONAL TOPOGRAPHIC HYDROGRAPHIC MODEL (BNTHM)

Joining the classes and sub-classes of the topographic models from the Hydrographic Institute of the Republic of Croatia and the State Geodetic Administration is the proposal of the new Basic National Topographic Hydrographic Model (BNTHM). BNTHM will be a unique model, which will provide the basis for topographic and hydrographic data collection, which will be available to use in different institutions. This will definitely reduce the costs and will avoid the problem of duplicating data as stipulates also by the INSPIRE (2007).

BNTHM would consist of object units and object classes that represent geospatial data for which both the Hydrographic Institute of the Republic of Croatia and the State Geodetic Administration are responsible.

In the continuation, a detailed overview of the Basic National Topographic Hydrographic Model by the object units is given: *Buildings, Transport, Land cover and land use, Relief* and *Hydrography*. In the contrary to the CROTIS version 2.0, the BNTHM model suggests that the object units of *Geographical names* and *Utility lines* are omitted i. e. it is suggested to extract them in the separate databases. Other institution in the Republic of Croatia will be responsible for the databases *Geographical names* (Institute for Croatian Language and Linguistics, Croatian Institute of History) and *Utility lines* (HEP – Hrvatska elektroprivreda, PLINACRO – transmission and sales of natural gas, JANAF etc).

BNTHM – basic package

BNTHM – basic package contains information on the life cycle of objects and code lists that describe the method of determining the object, accuracy, data source and reason for the change on object (Figure 2).

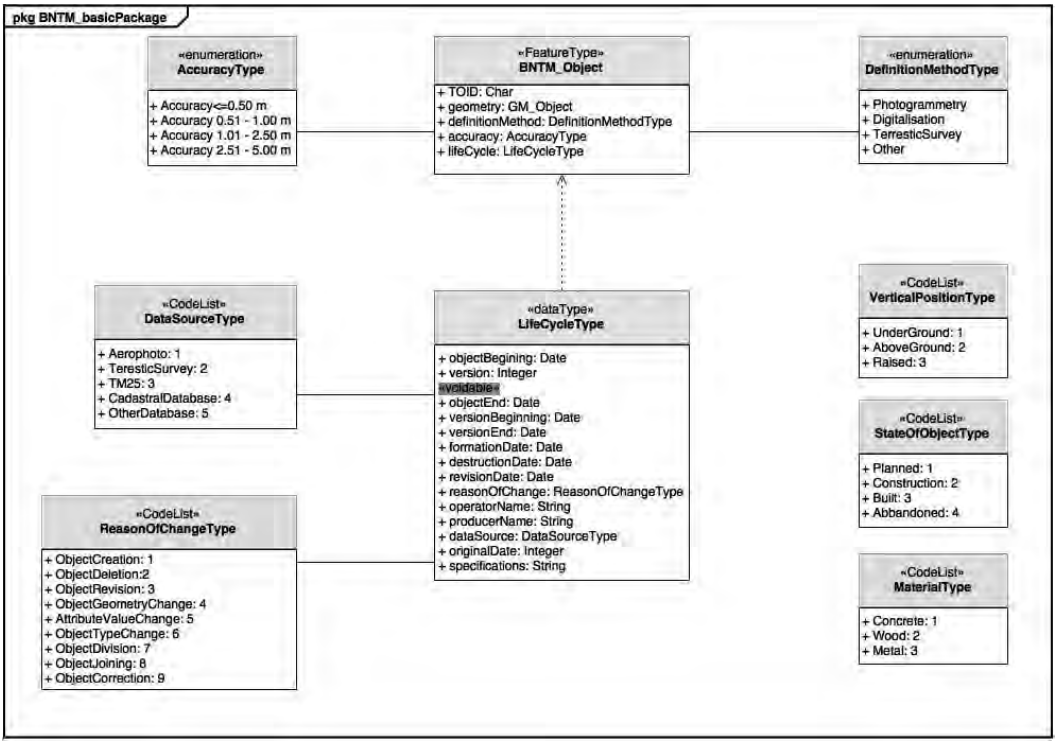

Figure 2: BNTHM – basic package.

BNTHM – object unit *Buildings*

The proposed BNTM, the object unit *Buildings* (Figure 3) foresees the following change:

On the Code list for *BuildingType* from the Croatian Hydrographic Institute's topographic model *Fort* and *Caravan site* have to be added.

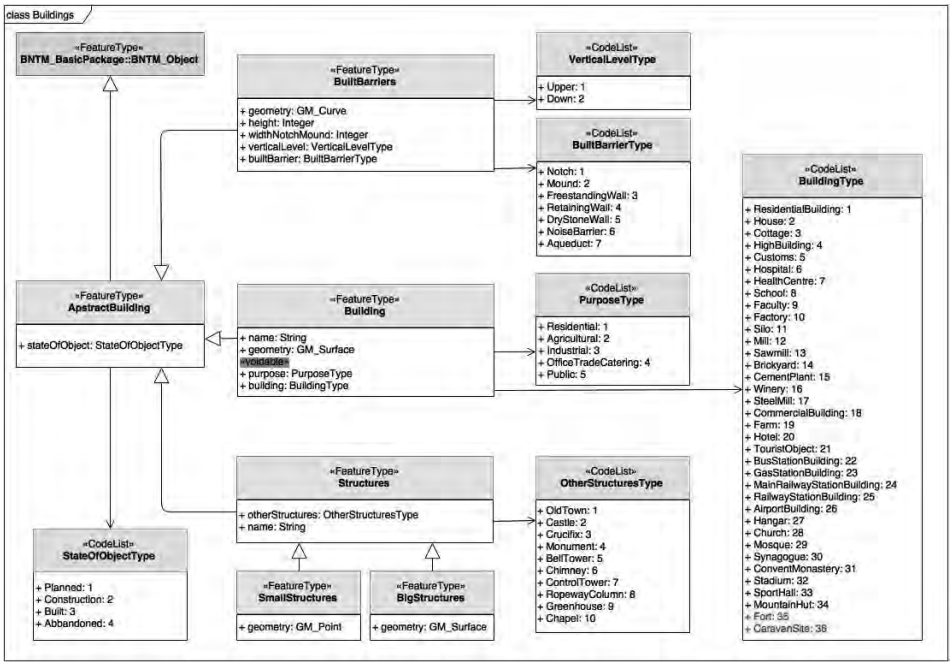

Figure 3: BNTHM – object unit Buildings

BNTHM – object unit *Transport*

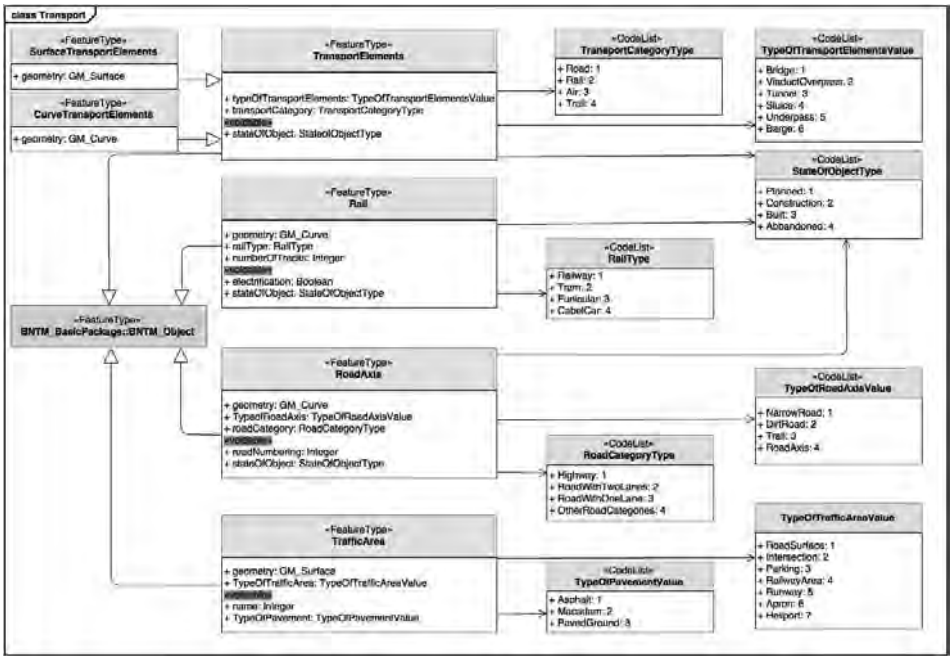

Figure 4: BNTHM – object unit Transport

The proposed BNTM object unit *Transport* (Figure 4) has no changes compared to object unit *Transport* within the CROTIS version 2.0.

BNTHM – object unit *Land cover and land use*

The proposed BNTM object unit *Land cover and land use* (Figure 5) foresees the following changes:

— On the Code list for *TypeOfPublicAreaValue* from the Croatian Hydrographic Institute's topographic model *Runway, Apron* and *Seaplane Landing Area* have to be added,
— On the Code list for *TypeOfAgriculturalLandValue* from the Croatian Hydrographic Institute's topographic model *Meadow, Conifer* and *Palm* have to be added,
— On the Code list for *TypeOfLandUseValue* from the Croatian Hydrographic Institute's topographic model *Lawn, Paddy Field* and *Tree Plantation* have to be added.

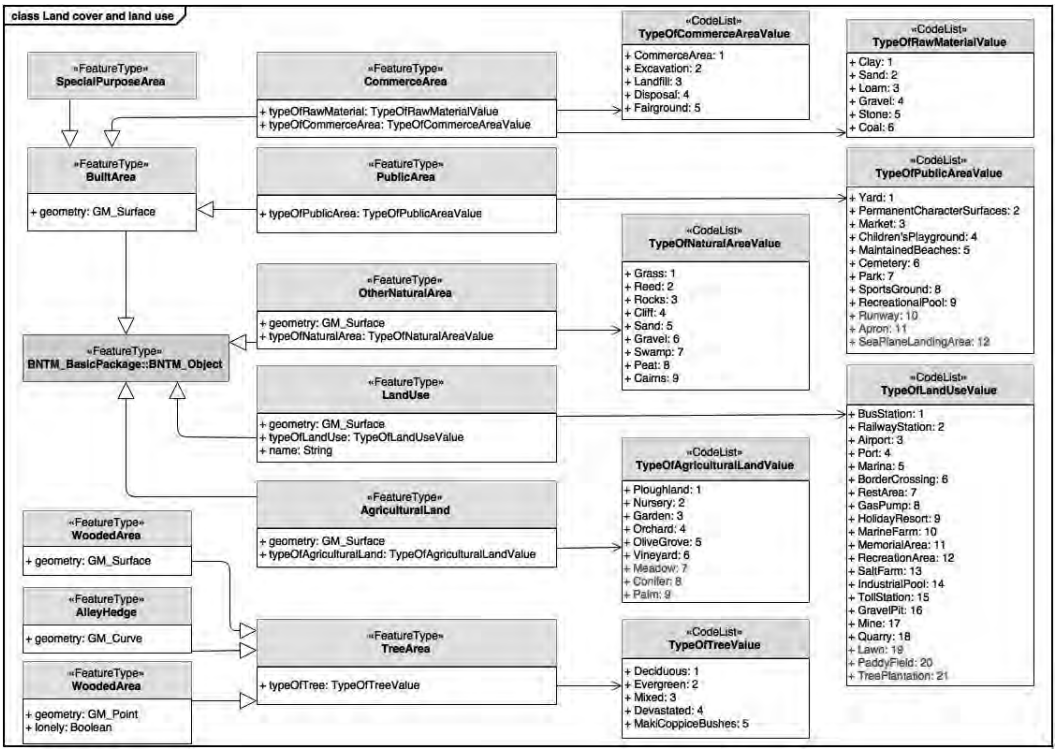

Figure 5: BNTHM – object unit Land cover and land use

BNTHM – object unit *Relief*

Within the proposed BNTM object unit *Relief* (Figure 6), the following changes have to be applied/ added:

— *DataType, Isoline – Geometry: GM_Curve; IsolineCategory: IsolineCategoryType* together with the
— *DataType: Contour Line* and *DataType: Depth Contour,*
— *DataType HeightPoint; Geometry: GM_Point* and
— *DataType DepthPoint; Geometry: GM_Point*.

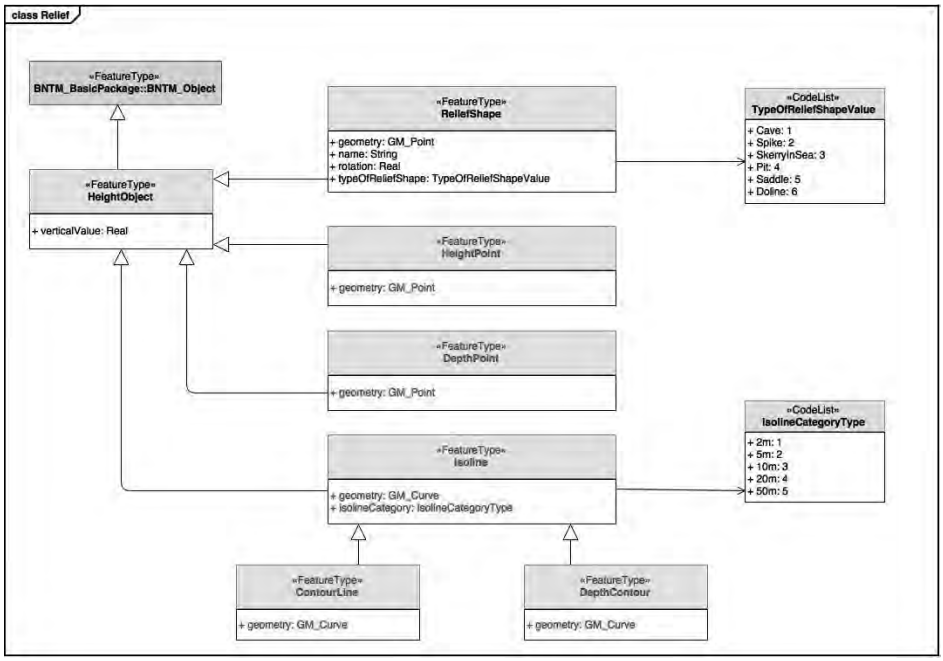

Figure 6: BNTHM – object unit Relief.

BNTHM – object unit *Hydrography*

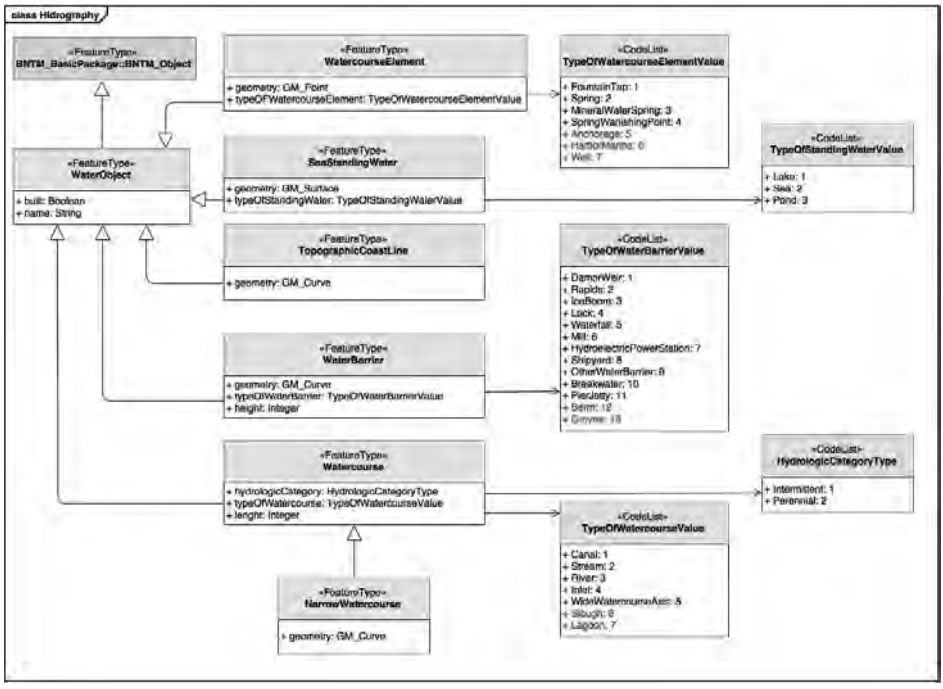

Figure 7: BNTHM – object unit Hydrography

The proposed BNTM – object unit *Hydrography* (Figure 7) foresees the following changes:

- On the Code list for *TypeOfWaterBarrierType* from the Croatian Hydrographic Institute's topographic model *Berm* and *Groyne* have to be added,
- On the Code list for *TypeOfWatercourseElementValu*e from the Croatian Hydrographic Institute's topographic model *Anchorage, Harbor/Marina* and *Well* have to be added,
- On the Code list for T*ypeOfWatercourseValue* from the Croatian Hydrographic Institute's topographic model *Slough* and *Lagoon* have to be added.

5 CONCLUSIONS

The development of digital cartography in the Republic of Croatia began in 1990, when the project STOKIS (Official Topographic-Cartographic Information System) was proposed. After STOKIS, the Croatian Topographic Information System (CROTIS) was launched. CROTIS was developed as a part of the Croatian-Norwegian project in the 1990s. Experts from the Kingdom of Norway participated in this project. The project defined the first topographic data model in the Republic of Croatia.

The latest version of the topographic data model CROTIS version 2.0 is harmonized with the INSPIRE Directive EC/2/2007. In the proposed topographical model, certain changes have been applied within and between object classes, and some object classes have been left out because they are not under the jurisdiction of the State Geodetic Administration and are not collected in the Basic Topographic Database (BTD). According to the proposal of the topographic model, object unit *Geographical names* and object unit *Utility lines* are omitted and they are to be in separate databases. Similar happened already in CROTIS version 1.2, when the object units of the *Permanent geodetic points* and *Administrative and territorial organisation, borders* were displaced in separate databases.

For the purpose of the new topographic data model, all the analysed topographic data models (Danish, Dutch, British and Slovenian), although not presented in this paper, were considered in the research phase. At the first glance, they are similar, but depending on the country and the level of its economic development, each country has its own specifics. The proposed basic national topographic and hydrographic model (BNTHM) is unique and as such is best suited to the needs of development of the overall economy in the Republic of Croatia.

After a detailed analysis of the object classes that are collected by the Croatian Hydrographic Institute, it was noticed that the object units *Buildings, Transport, Land cover and land use, Relief* and *Hydrography* of CROTIS 2.0 differ in a small number of object classes. In this article the proposal for the establishment of the Basic National Topographic Hydrographic Model (BNTHM) is given. Since the State Geodetic Administration is in charge of topographic survey on land and the Croatian Hydrographic Institute for topographic survey at sea, the common BNTHM for the whole territory of the Republic of Croatia was proposed. BNTHM would be the basis for all institutions in the Republic of Croatia, which need geospatial data of the topographic survey in scale 1:10,000 in their work.

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