Brazilian Journal of Cartography (2017), Nº 69/5, Special Issue GEOINFO 2017: 1001-1007
Brazilian Society of Cartography, Geodesy, Photgrammetry and Remote Sense
ISSN: 1808-0936

NSDI-COMPLIANT REFERENCE MAP: EXPERIENCES ON IMPLEMENTING A STANDARDIZED DATA MODELING AT LARGE SCALE (1:2000)

Mapa de Referência Compatível com a INDE: Experiências na Implementação de Modelagem de Dados Padronizada em Grande Escala (1:2000)

Vitor Silva de Araújo, Claudia Robbi Sluter & Silvana Philippi Camboim

[1]Universidade Federal do Paraná - UFPR
Programa de Pós-graduação em Ciências Geodésicas
Grupo de Pesquisa (CNPq) Cartografia e Sistemas de Informações Geográficas,
Caixa Postal 19001 – 81.531-980 – Curitiba – PR – Brazil
{vitorsilvadearaujo, robbisluter, silvanacamboim}@gmail.com

Received on September 11, 2017/ Accepted on October 10, 2017
Recebido em 11 de Setembro, 2017/ Aceito em 10 de Outubro, 2017

ABSTRACT

Standardized urban maps are essential cartographic products to address the challenges of cities management. Brazilian NSDI (National Spatial Data Infrastructure) was created to facilitate geospatial data sharing and use, but its standards are not completely adapted for large scale mapping for urban areas. This work aims to propose a data models based on the existent standards to support the generation of reference maps at a large scale (1:2,000) that is logically consistent, standardized and aligned to the principles of the theory of Cartography. These characteristics allow the reference geodatabase to be maintained by several producers and shared among institutions. The results of this project are the geospatial database implemented for four municipalities in Paraná State, and a conversion model that enables the creation of topographic maps on a large scale with symbols defined in previous research.

Keywords: NSDI, Data Model, Large Scale Topographic Mapping.

RESUMO

Padronizações cartográficas para mapas de referência urbanos são essenciais para enfrentar os desafios do gerenciamento de cidades. A INDE (Infraestrutura de Dados Espaciais Nacionais) foi criada para facilitar o compartilhamento e uso de dados geoespaciais, mas seus padrões não são completamente adaptados para o mapeamento em grande escala para áreas urbanas. Assim, este trabalho tem como objetivo propor modelos de dados baseados nos padrões existentes para apoiar a geração de mapas de referência em grande escala (1:2.000), logicamente consistentes, padronizados e alinhados aos princípios da teoria da Cartografia. Essas características permitem que bases de dados geoespaciais de referência sejam mantidas por vários produtores e compartilhadas entre as instituições. Os resultados deste projeto são bancos de dados geoespaciais implementados para 4 municípios no estado do Paraná e um modelo de conversão que permite a criação de cartas topográficas em grande escala com símbolos cartográficos propostos e definidos em pesquisas anteriores, desenvolvida por este mesmo grupo de pesquisa.

Palavras-chave: INDE, Modelos De Dados Geoespaciais, Mapeamento Topográfico em Grande Escala.

1. INTRODUCTION

Although the legal basis of the National Topographic Mapping in Brazil, the decree 243/67, defines only standards for systematic mapping at 1:25.000 scale and smaller, large scale reference maps are an important source of geoinformation to urban areas planning and management. According to the 2010 Census (IBGE, 2010), 84% of Brazilian population lives in cities. An estimation from 2016 Brazilian population is that more than 94 million inhabitants live in 27 metropolitan areas (shown in Figure 1) with 1 million inhabitants or more (IBGE, 2016). This large population faces the issues that are common for cities around the world. In the UN-habitat 2016 World Cities report, the most important challenges are the growing number of urban residents living in informal settlements, provision of urban services, climate change, exclusion and rising inequality and insecurity (UN-HABITAT, 2016). Many of these challenges can be adequately addressed only when spatial data is available.

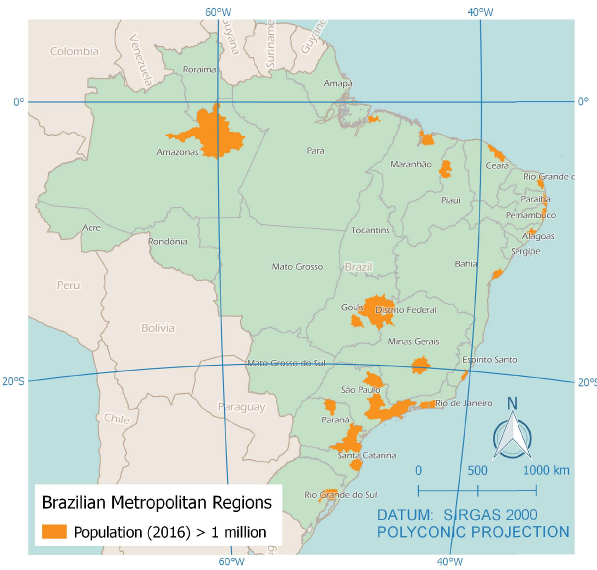

Fig. 1 - Brazilian Metropolitan areas with population larger than 1,000,000 people (source: IBGE).

Large-scale standardized mapping is an important information source for the spatial analyses needed to propose solutions for urban management. The Brazilian National Spatial Data Infrastructure (NSDI) was created in 2008 to facilitate geospatial data generation, use, and dissemination. However, the initiative is only mandatory for the Federal government, and, consequently, there are few examples of SDI (Spatial Data Infrastructures) in Brazil based on urban spatial data at state and local level governments. The mapping of urban areas is the responsibility of local governments and applying standards could help municipalities to exchange open format solutions to maximize the use of resources at the local administration level. State and federal level agencies, like the ones dealing with urban planning, can also take advantages from the use of standardized database models and cartographic solutions. Besides, data sharing is crucial when dealing with adjacent urban areas, such as Metropolitan Regions.

This paper describes some results of a research work that aims to propose a conceptual model, based on NSDI standards for large scale (1:2000) mapping in Brazil. These are follow-up results related to a research project which goal was to propose a standard symbology for topographic mapping at large scale for the State of Paraná, Brazil. It is a part of an extensive research developed in the Cartography and GIS research group at the Federal University of Paraná (CTCG, 2009, SLUTER *et al.*, 2013, NATINGUE, 2014).

Brazilian NSDI recommends the product of reference mapping to be a geodatabase in which the implementation must be based on a conceptual model called ET-EDGV (in Portuguese, *Estruturação de Dados Geoespaciais Vetoriais*) (CONCAR, 2010). However, the latest version (version 2.1.3) of ET-EDGV adopted by the National Commission on Cartography (in Portuguese, *Comissão Nacional de Cartografia* - CONCAR) is only suitable for 1:25.000 to 1:250.000. The Brazilian Army recently released another version, the ET-EDGV *Força Terrestre* (DSG,2015), that, though not officially yet approved by CONCAR, detailed the data model at large scale. In this standard, all main categories, classes, and attributes are specified, including the spatial relations and relational constraints among classes.

The Brazilian reference mapping at large scales presents challenges related to symbology and geodatabase modeling. In this paper, we describe a proposed solution for a conceptual model for a large-scale reference mapping that is not only related to but also coherent with the definition and classification of the topographic features that are the basis of the proposed symbology.

The coherence between the geospatial database model and the topographic features symbology is achieved by following the theory of Cartography. In previous research a set of cartographic features and their classifications were defined, that should be included in a large-scale reference mapping. Then, in this research, we compared to the ET-EDGV and its list of classes and their definitions. We, then, designed a geospatial data model based on the identified similarities and differences. In the next step, we implemented this geospatial database for four cities in the State of Paraná. In the final step, we have applied a proposed set of symbols to these datasets. Additionally, we stored the symbology using the OpenGIS® Styled Layer Descriptor (SLD) of the Open Geospatial Consortium (OGC, 2007) to allow the utilization of the proposed symbology when the geospatial database is shared.

This paper is based on Araujo, Sluter e Camboim (2016), previously presented at GEOINFO conference (http://www.geoinfo.info/).

2. MATERIALS AND METHOD

This section describes the area of study for which this research was developed, in addition to the data and software used and the listing of the procedures adopted for the generation of the data model, implementation of the database and creation of the maps with the standard symbology.

2.1 Study Are

We have tested all the achieved results in four municipalities of the State of Parana (Figure 2). These municipalities are Cascavel (24°57’21”S, 53°27’19”W), Guarapuava (25°23’43”S, 51°27’29”W), Ponta Grossa (24°05’42”S, 50°09’43”W) and, São José dos Pinhais (25°32’05”S, 49°12’23”W).

2.2 Materials

We have developed this research work using the following software and data:

- *LibreOffice* 2007 (http://www.libreoffice.org/) - we used to generate the spreadsheets of definitions and symbology.
- *Astah Community* (http://www.astah.net)/ - we used this solution for the database modeling as UML class diagrams.
- *PostgreSQL* (http://www.postgresql.org/) - with its extension *PostGIS* - we used this database management system to store the geographic database.
- *QGIS* (http://www.qgis.org/) - we used this open source GIS software for data manipulation and definition of symbology. Additionally, we used the plugin *DSG Tools* created by the Brazilian Army to implement the ET-EDGV model.
- The large-scale topographic mapping (1:2,000) was provided by *Paranacidade* in *shapefile* format (PARANACIDADE,2012)

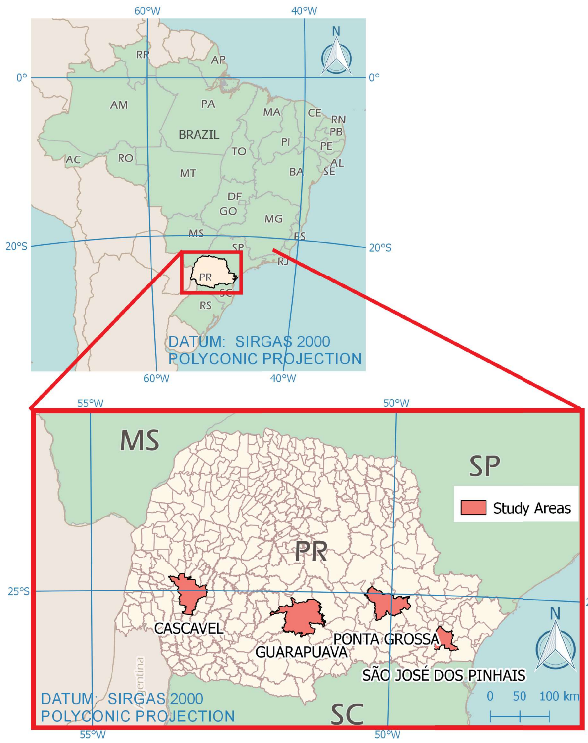

Fig. 2 - The State of Paraná, highlighting the four studied areas.

2.3 Methods

This research work was developed in three steps:

1. Comparing the ET-EDGV and CTCG data models to find the corresponding classes and attributes, and the discrepancies between those models. This step allowed us to correlate the existing symbology, to the classes of ET-EDGV, whenever it is possible.

2. Acquiring the digital topographic maps of the four municipalities we have chosen as experimental areas, verifying and editing the geometric characteristics of the categories of the digital topographic maps to adjust them the geospatial database.
3. Applying the symbology to databases created to urban topographic maps at the scale 1: 2,000.

3. RESULTS

The results of this work are divided into two main parts: the implementation of standardized modeling and the application of symbology to generate test maps for the previously described areas of study

3.1 Data model

The definition of which cartographic features should be represented at large scale topographic mapping is a result of extensive research project, which included user needs analysis with the members of the Technical Chamber of Cartography and Geoprocessing of the State of Parana, Brazil (in Portuguese, *Câmara Técnica de Cartografia e Geoprocessamento*) (CTCG,2009). In previous research, after defining the cartographic features to be represented in topographic maps, the meaning of each one was described.

In this work, we verified which classes from CTCG model were already part of ET-EDGV data model, and which ones are not (Figure 3). We, then, grouped the classes according to EDGV categories: relief, recreation area, buildings, hydrography, infrastructure, boundaries, reference points, transportation, and vegetation. We organized a spreadsheet with the symbology and the definition of each class. This spreadsheet was the input to model the geodatabase as a class diagram based on the relationships between objects in a logical structure. The conceptual modeling in UML focuses on the Class Diagrams for each category. With the definition of all classes and categories proposed for a large-scale topographic mapping of municipalities under study, we defined the database scheme at the logical level. The results are the class diagrams and a general table that relate different classes and definitions from ET-EDGV to the of CTCG model.

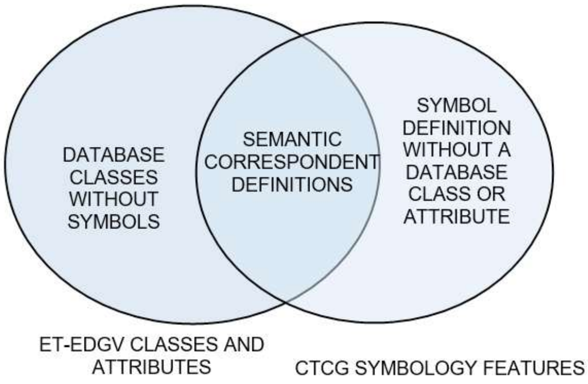

Fig. 3 - Comparison between ET-EDGV and CTCG data models.

We organized the general table as a set of spreadsheets. The spreadsheets refer to each category and, the first line of each specifies the category name and origin, which can be ET-EDGV or CTCG. The first column of each spreadsheet shows the classes that compose it. The second column presents the classification criteria for each classification of the reference mapping features. For example, in the transportation category, there is the "Special Structures" class in the CTCG standard, and several classes, e.g., Tunnel, Bridge, in the EDGV. Therefore the classification criteria are different in both standards. The fourth column presents the definition of every feature in the classes. To be able to propose a solution for a geospatial data model based on both CTCG and ET-EDGV, the differences between CTCG standards and ET-EDGV for features definitions, classification, and classification criteria were highlighted.

We created the geospatial database using this reference table and class diagrams. In this step, we used the *QGIS Plugin DSG Tools*, a free and open-source solution that enables the generation of geospatial data in full compliance with the NSDI, which makes the physical implementation of the ET-EDGV standard in the geospatial databases possible (DSG, 2015).

After generating of the geospatial database, we could transfer the features geometries from the shapefiles of the topographic maps of those four municipalities to the corresponding tables in the databases. We had to manually set the attributes of the feature from the original data source to the corresponding ET-EDGV data model when it was a complete related to CTCG data model. When it was necessary, we created additional compliant classes and their attributes accordingly with the conceptual data model.

3.2 Symbology

After establishing the relation between both conceptual models, we could apply the proposed symbology to the ET-EDGV-based geographic database. The symbols' definition includes area fillings and outlines colors, text fonts and shapes and sizes of point symbols.

We applied the symbology to the datasets of the four municipalities (figures 4 and 5). The Figure 6 presents a simplified legend for both extracts. We exported the resulting symbology using SLD style to be used in data sharing applications, for example, servers of WMS (*Web Mapping Services*).

Fig. 4 - Extract of the results for the city of Cascavel (state of Paraná, Brazil)

Fig. 5 - Extract of the results for the city of Guarapuava (state of Paraná, Brazil).

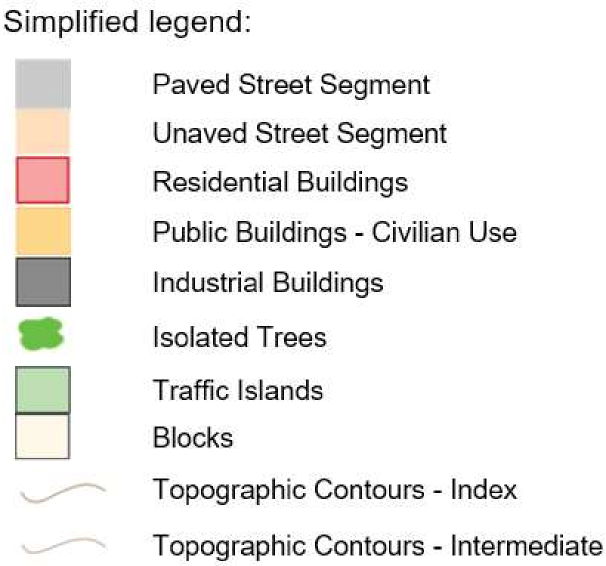

Fig. 6 – Simplified legend for both extracts (figures 4 and 5)

4. CONCLUSION

The standardized geodatabase and symbology of the data that compose the large-scale reference mapping guarantee the interoperability amid systems at different social and political levels (local, state or federal). The standardization enables the integration between different geospatial databases, which is an important result of this work in planning, engineering, and urban projects. The standards for geospatial database and symbology make spatial data review and update possible, minimize the time for spatial analyses, and ensure information quality.

The main obstacles for developing this work were the data models' discrepancies since ET-EDGV and CTGC standards were proposed for different purposes in different time. The *DSG Tools* plugin facilitated the process to create ET-EDGV compliant database and showed how the development of open source tools can be a benefit for several uses on a standardized environment.

The solution proposed in this research can be implemented in any geospatial database at 1:2000 scale and it could be adopted for using at another scale with some adjustments in the method. More users could be involved in the conceptual modeling and testing steps to expand the use out of the state of Parana context. The proposition and management of standards is a continuous task. Several studies on cartographic generalization, geospatial semantics, user's cognition and others can benefit from the results of this conceptual model.

ACKNOWLEDGMENTS

The authors would like to thank *Paranacidade* for the data provided, and the members of the *Câmara Técnica de Cartografia do Estado do Paraná* and other authors for the proposition of the symbology standards used in this research.

REFERENCES

ARAUJO, V. S.; SLUTER, C. R.; CAMBOIM, S. P. NSDI-compliant reference map: experiences on implementing a user-centered cartographic symbology and standardized data modeling at large scale (1:2000). In: **SIMPÓSIO BRASILEIRO DE GEOINFORMÁTICA, 17. (GEOINFO),** 2016, Campos do Jordão. Anais. São José dos Campos: INPE, 2016

CONCAR, **Especificações Técnicas para Estruturação de dados Geoespaciais Digitais Vetoriais.** 246p., 2010. Disponível em <http://www.geoportal.eb.mil.br/images/PDF/ET_EDGV_Vs_2_1_3.pdf >. Acesso: 18 de Janeiro 2018.

CONCAR, **Plano de Ação da INDE**. 205p. 2010 Disponível em <www.concar.gov.br/pdf/PlanoDeAcaoINDE.pdf> Acesso: 18 de Janeiro 2018.

CTCG – Câmara Técnica de Cartografia e Geoprocessamento do Estado do Paraná, **Relatório Técnico Preliminar: Proposta de Convenções Cartográficas para o Mapeamento Topográfico em Grande Escala no Estado do Paraná**. 50p. , março 2009.

DSG – Diretoria do Serviço Geográfico do Exército, **Manual Técnico T34-700 convenções cartográficas 1ª. parte: Normas para o emprego dos símbolos.** 109p, 1998.

DSG, **Norma da Especificação Técnica Para Estruturação De Dados Geoespaciais Vetoriais de Defesa da Força Terrestre ET-EDGV-DefesaFT .** 1a Parte, 1ª Edição, 319p. 2015. Disponível em <http://www.geoportal.eb.mil.br/images/PDF/EDGV_Defesa-Forca_Terrestre_2015.pdf> Acesso: 18/01/2018.

DSG, **Geoportal do Exército Brasileiro** <www.geoportal.eb.mil.br>. Acesso: 18/01/2018.

IBGE, **Censo Demográfico 2010**. Disponível em <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/default.shtm>. Acesso: 18/01/2018.

IBGE, **Estimativas populacionais para os municípios e para as Unidades da Federação brasileiros em 01.07.2016**. Disponível em <http://www.ibge.gov.br/home/estatistica/populacao/estimativa2016/estimativa_dou.shtm> Acesso: 18/01/2018.

KEATES, J.S. **Cartographic design and production.** London: Longman, 1973. 240 p.

KEATES, J.S. **Understanding maps**. 2nd Edition. Harlow, England: Longman, 1996. 334 p.

OGC. **OpenGIS Styled Layer Descriptor Profile of the Web Map Service Implementation Specification** 54p., 2007 Disponível em <http://portal.opengeospatial.org/files/?artifact_id=22364>. Acesso: 18/01/2018.

NATINGUE, G.R. **Proposta de simbologia para as cartas na escala 1:5.000 no contexto de mapeamento topográfico do estado do Paraná**. Dissertação de Mestrado do Programa de Pós-graduação em Ciências Geodésicas-UFPR. 130p, 2014 Disponível em <http://acervodigital.ufpr.br/handle/1884/40870> Acesso: 18/01/2018.

PARANACIDADE. **Bases Cartográficas dos Municípios de Guarapuava, Ponta Grossa, Cascavel e São José dos Pinhais.** Várias datas. Disponibilizadas em 2012.

PARANACIDADE. **Processo licitatório de Convite n°008/2010 - Plano Diretor Municipal - Município de Lunardelli - Termo de referência padrão elaborado pelo Paranacidade que atende a lei 15229/2006**. 2010 Serviço Social Autônomo Paranacidade, Curitiba, Brasil.

SLUTER, C.R.; BRANDALIZE, M.C.B.; VAN ELZAKKER, C.J.P.; and IVÁNOVÁ, I. Defining Standard Symbols for Street Network Maps for Urban Planning Based on User Requirements. In

Annals of the 26th Cartographic Conference – ICC 2013. Dresden, Alemanha. 15p.

UN-HABITAT **World Cities Report 2016, Urbanization and Development: Emerging Futures** Disponível em <http://wcr.unhabitat.org/> Acesso: 18/01/2018.