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Proposal of an Academic Spatial Data Infrastructure for the Federal University of Viçosa*

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Abstract. Universities use and produce significant amounts of cartographic data. Besides the administrative sector, which is responsible for the management of the territory, several research, education and extension projects also involve large volumes of maps and other types of spatial information. However, much of the data produced in higher education institutions is lost in laboratories or in the possession of researchers - making it impossible to reuse this information and doubling expenses in the reproduction of such data. An Academic Spatial Data Infrastructure (SDI) would enable the availability and standardization of spatial data produced in higher education institutions. Understanding this potentiality, the article at hand describes the development of an Academic SDI for the Federal University of Viçosa (SDI-UFV). In order to identify all the elements to be provided by the SDI-UFV, we began with the conceptual modeling of existing data and user needs. For the implementation of this SDI, we had to establish partnerships with the administrative bodies of the university. This helped us to define an institutional structure that ensures the management, maintenance and continuity of the SDI within the university. We proposed the appointment of a permanent commission and a resolution model. Regarding the technological components, we decided to use Free and Open Source Software (FOSS). We used the PostGIS database management system, the i3Geo software for the publication of spatial data, the edpMGBs editor for creating metadata, and the GeoNetwork software for managing the metadata catalog. The standards adopted were those approved by the Brazilian National Spatial Data Infrastructure (INDE), which follow the standards of the Open Geospatial Consortium (OGC).

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1. INTRODUCTION

Spatial information is required in various sectors to aid decision making. However, the process of acquiring and producing spatial data is costly and time-consuming. For that reason, many organizations are looking for ways to share existing spatial data in order to save costs on duplicated information (Rajabifard & Williamson, 2001; Masser, 2002).

A Spatial Data Infrastructure (SDI) is a platform, made up of policies, standards, organizations and technologies, which allows both easier access to geographic information and the use of such information (Clinton, 1994; Rajabifard et al., 2006; Wanerst, 2005; Manisa & Nkwae, 2007). In an SDI, the hosting of spatial data and its sufficiently documented attributes are made available for evaluation, consultation and exploration, and the information is standardized based on governmental and institutional agreements (GSDI, 2004; Onah, 2009).

In the development of an SDI, one must determine norms, standards, policies and technologies for spatial data sharing (Rajabifard & Williamson, 2001, Rajabifard et al., 2002, Amorim et al., 2018). The norms and standards guarantee the interoperability of the available data, since it can be produced through different methodologies and has different levels of quality. In this sense, there are standards issued by the Open Geospatial Consortium (OGC) that guarantee interoperability in the sharing of geospatial data (OGC, 2011). SDI policies determine those responsible for the creation and management of infrastructures, the deadlines and goals to be met, and the necessary mechanisms to ensure the operation and maintenance of the SDI.

Technologies encompass hardware and software components for sharing data. Among these components, the access and distribution networks, such as geoportals, map viewers and metadata catalogs, where all the cartographic data available are documented can be highlighted.

In universities, spatial information is produced and used in diverse projects of research, education or extension, and in the territorial administration. Most of this information is funded by public funds and is often not made available, being restricted to the academics and likely to get lost in laboratories. And, when needed, this information is generated repeatedly, generating new costs. Therefore,

universities are institutions with the potential and need to develop an SDI (Brito et al., 2014; Coetzee et al., 2017).

An Academic SDI can be used in teaching, as a didactic resource. In research, Academic SDIs can enhance collaboration between researchers and avoiding costs of data duplication. It can also make the data produced by the university publicly available to all those who need them. The administration can benefit because an Academic SDI facilitates the territorial management of the university campus (Brito et al., 2014; Camboim, 2018; Silva et al., 2018).

Considering these potentials and needs, this study presents a proposal to implement SDI-UFV, an Academic SDI for the Federal University of Viçosa (UFV). The UFV is a public education institution that has three campuses in the cities of Viçosa, Florestal and Rio Paranaíba - all located in the state of Minas Gerais, Brazil.

The UFV offers high school and technical education, undergraduate and postgraduate programs to more than 20.000 students. The university offers undergraduate courses covering the bachelor degree and superior of technology modalities, divided in the areas of: Agricultural Sciences; Biological and Health Sciences; Exact and Technological Sciences; Humanities, Letters and Arts. Postgraduate studies are offered at Masters, Doctorate and Professional Masters levels. Initially, the institution excelled in the Agricultural Sciences, with courses in Agriculture and Veterinary. Today, besides continuing to be a reference in the area, it also has excellence in teaching, research and extension in Biological, Exact and Human sciences.

In defining the elements to be considered in the SDI-UFV, the first step was to elaborate a conceptual modeling of the existing data and needs. In order to guarantee mechanisms for the management and maintenance of the SDI, an institutional structure was proposed, developed in partnership with the Pro-Rectory of Administration (PAD). Regarding technology, priority was given to the use of Free and Open Source Software (FOSS) systems compatible with OGC standards, for the development of a geoportal, a metadata catalog and a publication of spatial information from a WebGIS.

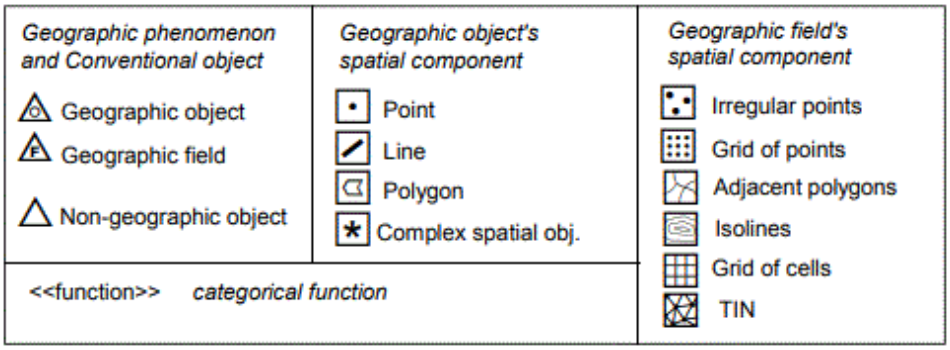
2. CONCEPTUAL MODELING

Modeling seeks to systematize the understanding of objects and phenomena that will be represented in a computerized system (Borges et al., 2001). In the modeling of spatial information, the various forms of interpretation of space concepts can present great obstacles for those who intend to develop some computational application, since it is necessary to perform an abstraction of the real world. By

means of this abstraction, it is possible to obtain a convenient form of representation, which is simplified and adequate to the computational purposes (Borges et al., 2001).

The combined use of the Unified Modeling Language (UML) class diagram and the GeoFrame conceptual framework allows the solution of most spatial data modeling requirements (Lisboa Filho & Iochpe, 2008, Zarate et al., 2014, Ferreira et al., 2016). A conceptual schema developed on the basis of the UML-GeoFrame model includes the modeling of spatial aspects of spatial information, allowing the differentiation between conventional objects and geographic objects or fields (Lisboa Filho et al., 2004). Figure 1 illustrates the set of stereotypes of the UML-GeoFrame model that allow the specification of the spatial elements considered.

Figure 1 – Stereotypes of the UML-GeoFrame model (source: Lisboa Filho et al., 2004).

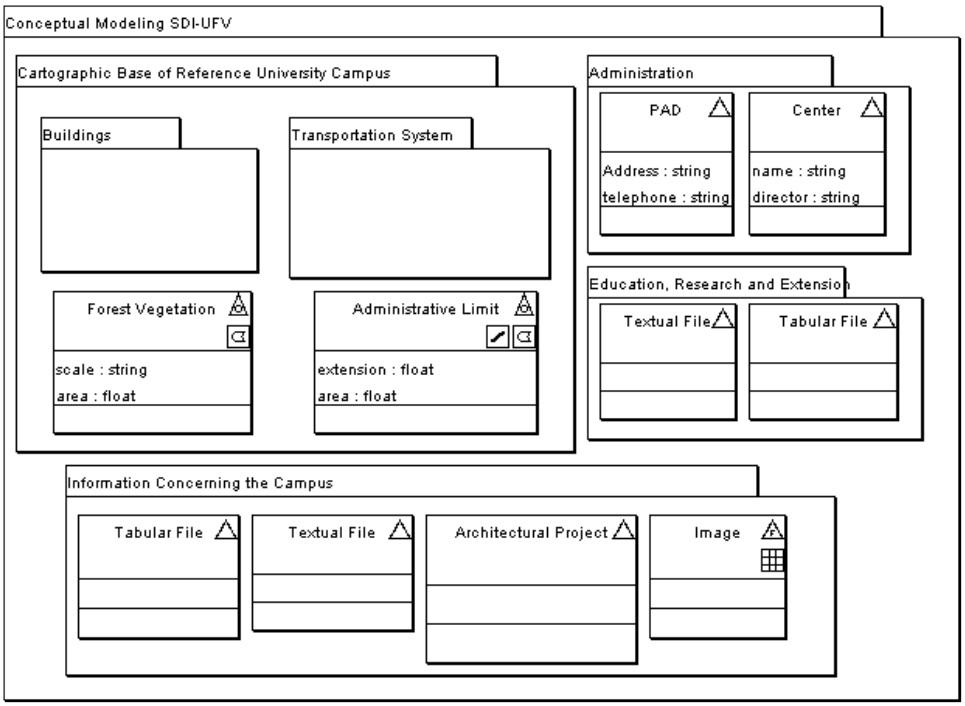


The first set of stereotypes “Geographic phenomenon and Conventional object” are used to distinguish the elements represented in geographic object, geographic field or non-geographic object. The sets “Geographic object’s spatial component” and “Geographic field’s spatial component” allow modeling the type of representation of geographic features in the object or field view, and it is possible to combine more than one stereotype in the same class. And the stereotype “<<function>>” is used to describe the relationship between phenomena in field view and categorical conventional objects.

In this study, the UML-GeoFrame model and the ArgoCaseGeo CASE tool (Lisboa-Filho et al., 2004) were used for the development of the conceptual modeling of the SDI-UFV. Four themes were modeled: (i) “Cartographic Base of Reference University Campus”; (ii) “Administration”; (iii) “Information Concerning the Campus”; (iv) “Education, Research and Extension”. The themes adopted are summarized in Figure 2, which shows a general summary of conceptual modeling, illustrating the main themes and classes.

In the theme “Cartographic Base of Reference University Campus”, the elements of the reference cartography of the campuses of UFV were included, the definition of subthemes and classes was based on the existing cartographic information and on the necessary information for the spatial representation of the campuses. Thus, the following sub-themes were inserted: “Buildings”, “Hydrography”, “Transportation System” and “Sports and Leisure”. In addition, the following classes were added: “Water Supply”, “Forest Vegetation”, "Meteorological Building Area”, “Geodetic Reference Point”, “Administrative Limit”, “Communication Antenna” and “Image”. For matters of brevity and space available, we only illustrate a few of these themes in Figures 2 and 3.

Figure 2 – Themes of Conceptual Modeling

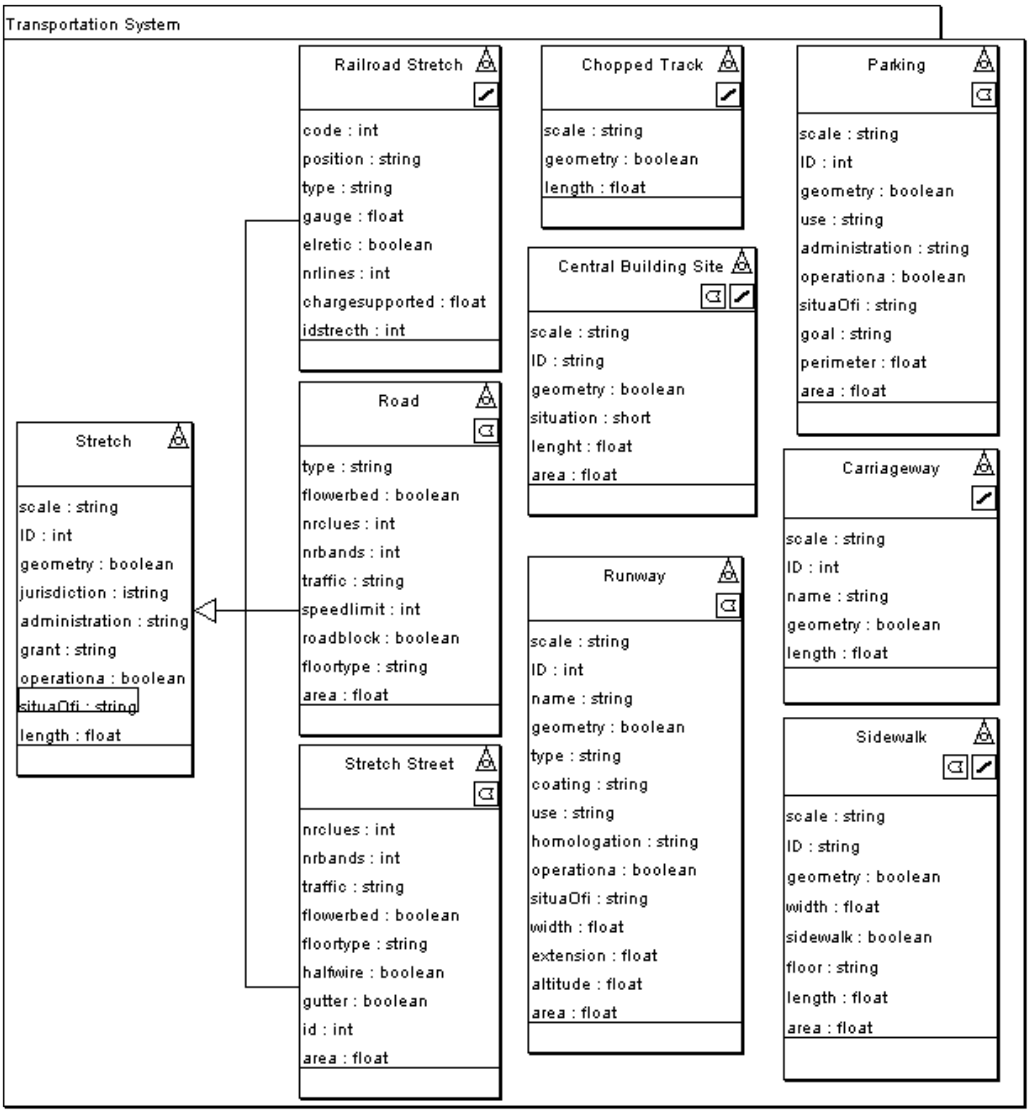


In the theme “Administration”, we considered the administrative bodies of UFV that produce, analyze or require spatial information. The following classes were created: “Pro-Rectory of Administration”, “Pro-Rectory of Education”, “Pro-Rectory of Research and Graduate Studies”, “Pro-Rectory of Extension and Culture”, “Center”, “Department”, “Program” and “Graduate Program”.

A problem presented by Pro-Rectory of Administration (PAD) is the organization and availability of information regarding the buildings and improvements in the campus infrastructure, such as the architectural plans of the buildings and the

photos of facades. Regarding that, the theme “Information Concerning the Campus” was created to consider these types of information, which are spatial in character, but are not part of the basic cartography of the campus.

Figure 3 – Exemplification of Conceptual Modeling (Transportation System)



Spatial data can be produced and used in education, research and extension projects, therefore, the theme “Education, Research and Extension” was created. However, this study focused on data from the reference cartography of the *campus*, because the UFV does not yet have a unified spatial information system.

For that reason, considering the later expansion of the SDI-UFV, the generic classes were created: “Vector File”, “Image”, “Tabular File” and “Textual File”.

Because it is a conceptual modeling, there is a high level of abstraction of technological criteria, so implementation aspects are not considered (Elmasri & Navathe, 2010), which facilitates the understanding by the end users and allows the developed modeling to be used as a starting point for other projects.

3. PROPOSAL FOR INSTITUTIONAL STRUCTURE FOR SDI-UFV

The definition of the institutional structure of an SDI is important because it guarantees well defined objectives and goals, determines the actors and their functions in the infrastructure management. In addition, through the institutional structure, the strategies and deadlines to be met for the creation, maintenance and continuity of the SDI in an institution can be planned.

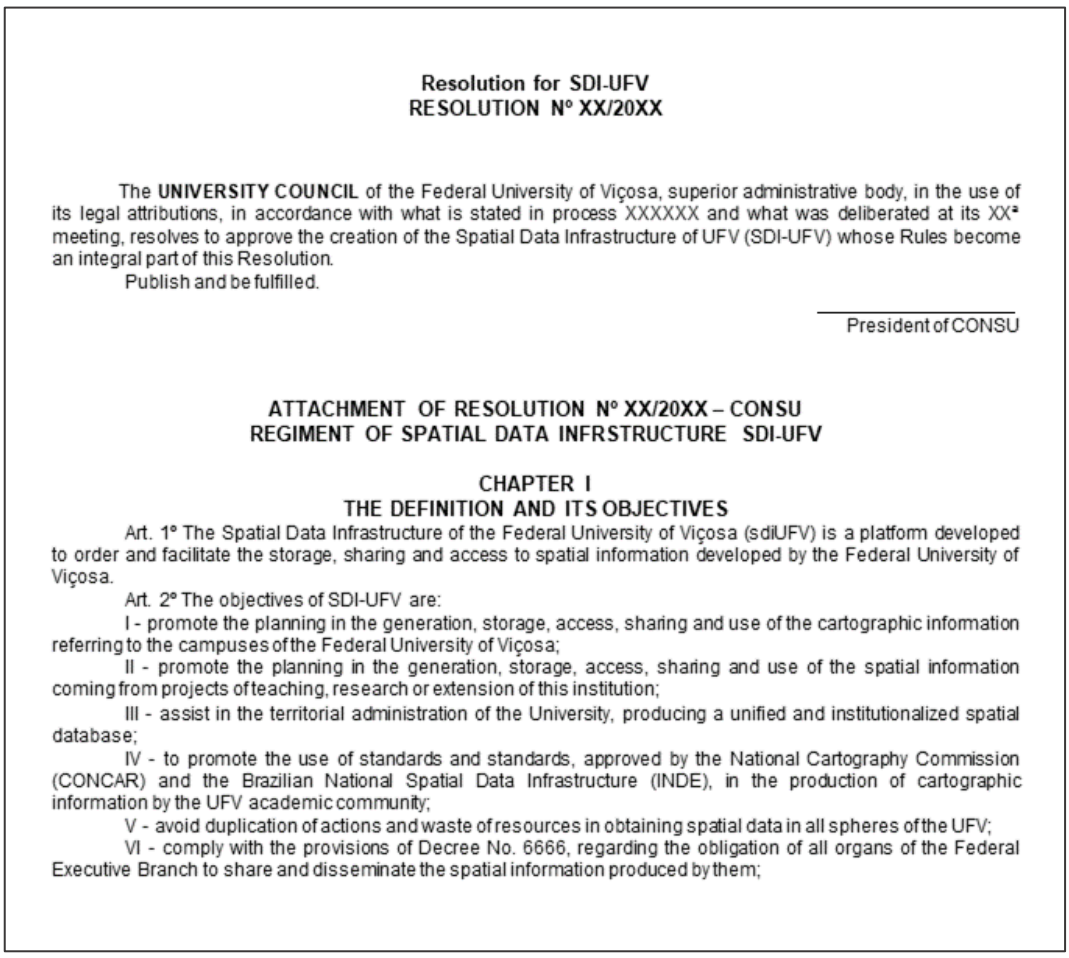
In this sense, the proposal of this study was presented to the Vice-Dean of Administration, demonstrating what constitutes an SDI and what justifications exist for its implementation in the university. The PAD representatives were interested in the proposal, they considered that the university already was challenged because it did not have a single database with all the data referring to the campus, which was detrimental to the administration. However, although they saw the existing problems, the PAD representatives were not aware of both the concept of SDI and the benefits that the development of an SDI could bring to UFV.

To that end, meetings guided by professors from the departments of Civil Engineering and Computer Science were held, where the concepts of an SDI and what advantages it would promote for the university were presented to some members of the PAD and the Directorate of Information Technology. At these meetings, it was discussed how an SDI-UFV could be developed, which and how the data could be integrated and made available, and who would be responsible for managing and maintaining the SDI.

From these meetings, it was defined that in the development of the institutional structure the NSDI development model, documented in its Action Plan (Brasil, 2010), would be followed.

For a possible institutionalization of the SDI, it was proposed the elaboration of a Resolution defining SDI-UFV, the academic community’s obligations to this infrastructure, and the establishment of the competencies and responsibilities of the actors (Figure 4).

Figure 4 – Proposal of the resolution for the institutionalization of the SDI-UFV



Resolution for SDI-UFV
RESOLUTION Nº XX/20XX

The **UNIVERSITY COUNCIL** of the Federal University of Viçosa, superior administrative body, in the use of its legal attributions, in accordance with what is stated in process XXXXXX and what was deliberated at its XXª meeting, resolves to approve the creation of the Spatial Data Infrastructure of UFV (SDI-UFV) whose Rules become an integral part of this Resolution.

Publish and be fulfilled.

President of CONSU

ATTACHMENT OF RESOLUTION Nº XX/20XX – CONSU
REGIMENT OF SPATIAL DATA INFRSTRUCTURE SDI-UFV

CHAPTER I
THE DEFINITION AND ITS OBJECTIVES

Art. 1º The Spatial Data Infrastructure of the Federal University of Viçosa (sdiUFV) is a platform developed to order and facilitate the storage, sharing and access to spatial information developed by the Federal University of Viçosa.

Art. 2º The objectives of SDI-UFV are:

I - promote the planning in the generation, storage, access, sharing and use of the cartographic information referring to the campuses of the Federal University of Viçosa;

II - promote the planning in the generation, storage, access, sharing and use of the spatial information coming from projects of teaching, research or extension of this institution;

III - assist in the territorial administration of the University, producing a unified and institutionalized spatial database;

IV - to promote the use of standards and standards, approved by the National Cartography Commission (CONCAR) and the Brazilian National Spatial Data Infrastructure (INDE), in the production of cartographic information by the UFV academic community;

V - avoid duplication of actions and waste of resources in obtaining spatial data in all spheres of the UFV;

VI - comply with the provisions of Decree No. 6666, regarding the obligation of all organs of the Federal Executive Branch to share and disseminate the spatial information produced by them;

As the administrative positions have terms of office and go through various managements, it was suggested to create a permanent committee to manage and coordinate the SDI, following as a model the existing commissions in the UFV, such as the Physical Space Committee (CONSU UFV, 2009a) and the Environment Committee (CONSU UFV, 2009b). The SDI-UFV committee should be composed of members representing the various university bodies, being those who can actively participate in the development, administration and maintenance of an SDI. Hence, based on what was discussed at the meetings, the actors presented in Table 1 were suggested.

Table 1 – Bodies with representatives in the standing committee of the SDI-UFV

Body	Justification
Pro-Rectory of Administration	Responsible for the organization and administration of campus infrastructure
Pro-Rectory of Budget and Planning	Responsible for planning and budgetary decisions of UFV
Pro-Rectory of Education	Responsible for coordinating education activities
Pro-Rectory of Extension and Culture	Responsible for coordinating extension activities
Pro-Rectory of Research and Graduate Studies	Responsible for coordinating research and graduate activities
Information Technology Directorate (DTI)	Responsible for the support and execution of activities related to computer science policies at the university
Department of Civil Engineering	Department to which the program of Surveying and Cartographic Engineering is linked, one of the lines of research of this program is Spatial Data Infrastructures, soon it can contribute with innovations for the SDI-UFV
Department of Informatics	The Graduate program in computer science has a line of research related to SDI

The Global Spatial Data Infrastructure Association (2004) points out that the following groups of actors must be involved in the development of an SDI: organizational and administrative actors; producers of geospatial reference and thematic data and information; users; producers of value-added data and information; and providers of products and services in the field of geoprocessing and related areas. Table 2 lists the actors indicated for the SDI-UFV according to the types presented by the Global Spatial Data Infrastructure Association (2004).

Table 2 – Actors of the SDI-UFV

Types of Actors		Actors
Organizational and administrative actors		Standing Committee of the SDI-UFV
Producers of spatial data and information	Reference	Pro-Rectory of Administration and Departments
	Value-added	Developers of Education, Research and Extension projects

Types of Actors	Actors
Users	Academic Community and Citizens
Providers of product and service	Directorate of Information Technology (DTI) and Developers of Education, Research and Extension projects

Among the actors suggested for the permanent management committee of SDI-UFV, at the meetings held, representatives of the Pro-Rectory of Administration, Pro-Rectory of Budget and Planning, Information Technology Directorate, Department of Civil Engineering and Department of Informatics were already present. UFV was undergoing a transition in administrative management when it was proposed to create a commission for the management of the Academic SDI, so, it was agreed to ratify the commission for the next management. In this sense, the participants of the meetings committed themselves to continue with the SDI development project, and the professors from the Departments of Civil Engineering and Computer Sciences were appointed as responsible for providing training. The training will be for dissemination and awareness about the SDI, and specific training will also be given to those who will be responsible for maintaining and feeding the academic infrastructure database and training for SDI-UFV users.

For the development of the SDI-UFV, it was proposed the division into three cycles:

Cycle I:

- Presentation of the SDI-UFV development proposal for the representatives of administrative bodies of UFV.
- Definition of the proposal for the institutional structure for the SDI-UFV.
- Elaboration of the proposal of Resolution for the creation of the SDI.
- Development and implementation of the technological part.
- Inclusion of the reference data of the Viçosa campus.

Cycle II:

- Establishment of the permanent committee for SDI-UFV management.
- Campaigns to publicize and raise awareness about the importance of Academic SDI.
- Specific training for those responsible for maintaining and expanding the SDI.
- Inclusion of reference data of other campuses.
- Test of usability of the technological components of the SDI-UFV.

- Integration of other academic spheres (education, research and extension).
- Integration with NSDI, making SDI-UFV a spatial data provider node.

Cycle III:

- Consolidation of the SDI-UFV as a source for data search and research tool.

In the development of this study, the first cycle of the SDI implementation has already been carried out, while the execution of the other cycles is planned for the future.

4. IMPLEMENTATION OF TECHNOLOGICAL COMPONENTS

An SDI shares data from different sources, in various formats, scales and quality, among other differentiations. Thus, the architecture used to develop an SDI must be able to integrate all the information, ensuring interoperability.

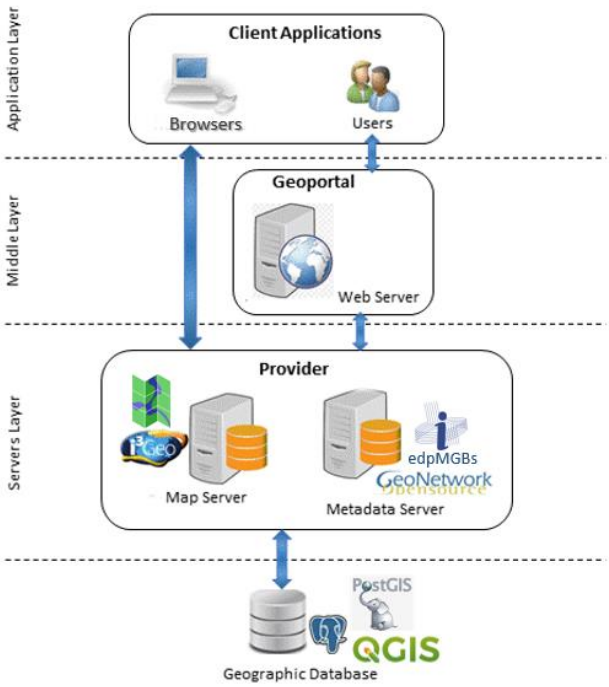
The main architectures used to develop an SDI are client-server, service-oriented and hybrid (Fonseca, 2016). Among these, Service Oriented Architecture (SOA) has been the most used (Davis et al., 2005; Barik et al., 2011; He et al., 2015). Because it is independent of technologies, and based on standard services, this architecture ensures the interoperability of spatial information, integrating several services (Carvalho, 2013).

The Infrastructure for Spatial Information in Europe (INSPIRE) was based on a SOA, defining INSPIRE network services to ensure interoperability between information shared by the various Member States (INSPIRE, 2008; Cetl, 2019).

To implement the SDI-UFV, the service-based architecture was adopted, as shown in Figure 5. The designed architecture is composed of a database for the storage and management of geographic data, a map server that allows their publication, a metadata server that allows the visualization, consultation and access to the metadata files and a geoportal that promotes the communication among the users, services and data offered.

Next, the software systems and procedures used for database deployment, the publication of spatial data, the metadata catalog, and the creation of the geoportal are described.

Figure 5 - Architecture designed for the SDI-UFV



4.1. Database

There is no official cartographic base for the campus at the UFV. As a starting point, the development of a database containing the reference cartographic data of the campus, presented in the conceptual modeling, such as buildings, roads and hydrography, was adopted. This reference cartographic base was elaborated from the compilation of existing topographic data, provided by PAD, and from the digitalization of VANT and IKONOS orthoimages. The data was standardized according to the standards defined by NSDI, followed by the Technical Specification for Geospatial Data Acquisition (ET-ADGV) and the Technical Specification for Structuring Vector Geospatial Data (ET-EDGV) (Matta & Cunha, 2017). In this way, the generated data followed the proposed model and the existing ones were adapted, resulting in a cartographic base consistent with the conceptual modeling developed.

The use of a spatial Database Management System (DBMS) offers advantages in terms of data updating, since it allows updating concomitantly on different machines, ensuring data consistency and security, as well as controlling access to such data.

In the SDI-UFV, the PostgreSQL (https://www.postgresql.org/) DBMS was used, with its spatial extension PostGIS (https://postgis.net/). These systems stand out as robust free platforms for storing large amounts of spatial data and performing complex searches and for having a large community of users and a good documentation; in addition, they are compatible with OGC standards (Elmasri & Navathe, 2010; Obe & Hsu, 2015).

The spatial extension PostGIS was hosted on a server of UFV, where the reference cartographic base (Table 3) of the campus was stored, which is consistent with the conceptual modeling presented.

Table 3 – Vector files contained in the database

Cartographic Reference Base		
Water supply	Municipal building	Landing track
Communication Antenna	Religious building	Drainage Point
Approximate Area of UFV	Water layer	Geodetic Reference Points
Meteorological Station Area	Parking	
Streets	UFV Approximate Limit	Dam
Wagon path		
Pitch or sports ground	Water Mass Limit	Highway
Central Building	Railway	Sink or Spillway
Health Division	Tour	Drainage Section
Edification	Pool	Track or sidewalk
Weather Station Building	Cinder track	Vegetation

4.2. Publication of Spatial Data

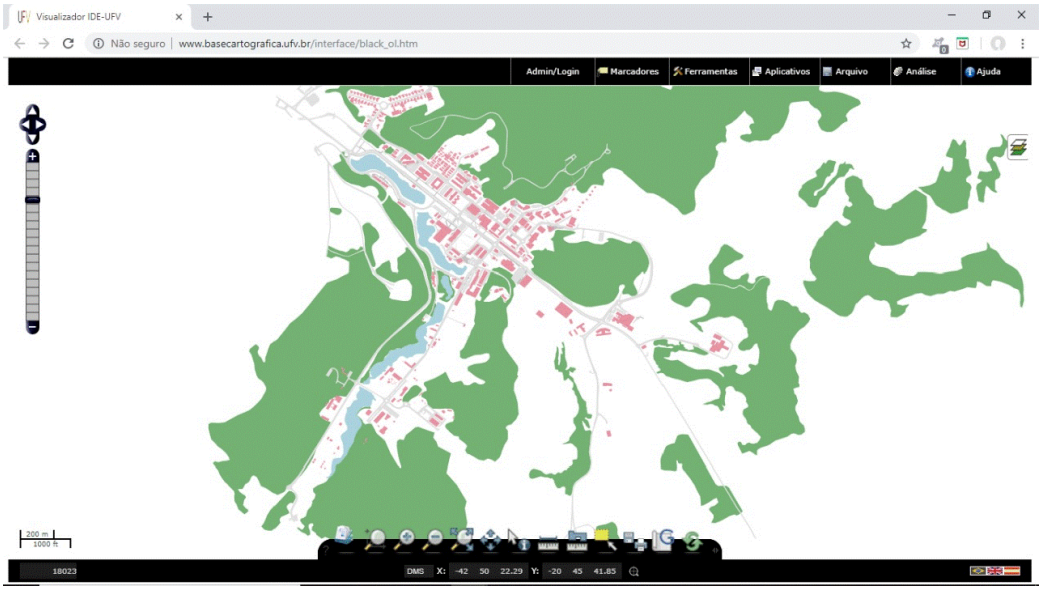
When publishing spatial data on the Internet, the interface provided is extremely important, as the data is made available to many users and not all of them have prior knowledge on cartography, so it is advantageous to develop a user-friendly interface.

For SDI-UFV, we used the free framework i3GEO (http://mapas.mma.gov .br/i3geo/ principal.htm) that is based on the open source MapServer (https://mapserver.org/)for the development of the WebGIS, where the Viçosa campus reference map was published through the WMS service.

The WebGIS application was developed by adapting to the i3GEO interface, connecting to the PostGIS DBMS and defining the layers that would be presented and the tools that would be available. Finally, the application was hosted on a server of UFV and made available online.

The application developed allows the visualization of the spatial data (Figure 6). This includes access to attributes, the selection of features on the map or conditioned in relation to the attributes, the calculations of distances and areas, the turning on and off of layers, the export of data, the change of the symbology, the insertion of new points, the insertion of texts and labels, the filtering of information, the creation of graphs, considering the attribute information, distance analysis and point distribution, calculation of midpoint, the tools of dissolve and buffer, the creation of the heat map, etc.

Figure 6 – SDI-UFV platform of publication of spatial data



PostGIS and QGIS are open source technologies compliant with OGC standards. QGIS has native support for PostGIS data and there are several QGIS plugins that allow access to a database stored in PostGIS. This connection between QGIS and PostGIS promotes advantages by combining the benefits of a DBMS and a GIS, thus having greater security, possibility of indexing, availability of various selection tools, spatial analysis, and editing and feature creation, in addition to visualization of geometric and textual information. Thus, updates to the data belonging to the database of the SDI-UFV can be directly achieved in QGIS after establishing a connection to the PostGIS database.

Since the available WebGIS has direct communication with this PostGIS database, all changes made to the data stored in the database are automatically updated in the WebGIS.

4.3. Metadata Catalog

The documentation of spatial data is achieved through metadata. Norms and standards are created, which propose metadata profiles to be followed. In Brazil, CONCAR created the Geospatial Metadata Profile of Brazil (MGB Profile) based on ISO 19115/2003, which defines a universal standard for the storage and distribution of geospatial metadata (Brasil, 2010).

The MBG Profile is the standard used and indicated by NSDI for the creation of metadata. In the development of this profile, the Summarized MGB Profile was elaborated, which presents the main elements that should be considered in the elaboration of a metadata file. In this study, the metadata files were elaborated according to the Summarized MGB Profile.

Pereira et al. (2018) developed a metadata editor, called edpMGBs (http://www.dpi.ufv.br/projetos/edpmgb/), for the Summarized MBG Profile. In this editor, all the descriptive elements that are in the profile are requested, and in each element an explanation of what is to be filled is given. After completing all the information, the editor generates an XML file for the metadata. This editor was used to generate the metadata files related to the elements stored in the database, which make up the reference cartographic base of the Viçosa campus of UFV.

GeoNetwork (https://geonetwork-opensource.org/) is a free and open source metadata catalog application designed to manage spatially referenced resources. It provides a web interface for searching geospatial data, and allows the cataloging of this data through metadata, based on the metadata standards ISO19115, ISO19139, FGCD and Dublin Core (GeoNetwork, 2018).

GeoNetwork was used for the implementation of the SDI-UFV Metadata Catalog, through the CSW service. The application was customized and hosted on a server of UFV, defining the administrator user responsible for editing the catalog. Subsequently, the elaborated metadata files were uploaded as well as miniature images, which illustrated each of the cataloged data (Figure 7).

Through the metadata catalog, one can search for keywords, view and download the metadata files in XML or PDF format and there is also a link that redirects to the map viewer.

Figure 7 – Metadata catalog of the SDI-UFV

4.4. Geoportal

In the implementation of the SDI-UFV, a geoportal was elaborated as the access point to the services provided by the SDI. Here, the SDI-UFV concepts are synthesized and the links that allow access to the WebGIS and the metadata catalog are presented (Figure 8). This geoportal is available on the internet and can be accessed by: https://sites.google.com/view/ide-ufv. The geoportal includes links that allow access to the other online platforms of SDI-UFV.

Figure 8 - Geoportal SDI-UFV

The technological components were hosted on the UFV server, and FOSS systems, compatible with the university server, were adopted. According to the proposed institutional structure, for the second SDI deployment cycle, the dissemination and evaluation of the usability of the SDI is foreseen. From that analysis it will be possible to assess whether the adopted architecture meets the needs of the academic community.

5. CONCLUSIONS

The development of an Academic SDI brings advantages for educational institutions, since, in addition to complying with Decree 6666/2008. This Decree requires the mandatory sharing of geographic information by federal agencies, the sharing of spatial information in an SDI saves costs on redundant information and promotes the transparency and diffusion of knowledge, making public, except in cases of secrecy due to security or ethical reasons, the geographic data from the studies developed by the university. Another advantage observed, especially in the case of the UFV, is related to territorial administration. By storing and sharing all the cartographic data referring to the campuses, the institution produces a single, institutionalized database may be constantly updated.

The elaboration of conceptual modeling makes it easier to visualize the elements that will be considered in the development of university projects. In the case of the SDI-UFV, the modeling concentrated on the elements of the reference cartographic base of the Viçosa campus, since this was the initial focus for the creation of the SDI. Nevertheless, in a more comprehensive way, administrative bodies, programs and projects of education, research and extension were also considered. It is expected that the elaborated modeling may serve as a basis for the development of other modeling for new Academic SDI projects in other institutions with similar administrative structures to the UFV.

The concept of SDI is complex and indicates that, besides the concern with the data to be shared and the technologies involved, one must consider the whole organizational structure, which will allow the information to be shared in a safe, ordered and effective manner. In the case of Academic SDI, attention should be paid to the administrative structures of educational institutions in order to define policies that are consistent with reality and that are plausible for implementation. The participation of the Pro-Rectory of Administration of the UFV was essential in the elaboration of the proposal of institutional structure of the SDI-UFV, making it possible to design a structure considering the peculiarities of the university. In the UFV, there are already some permanent committees in operation, thus, a proposal

was made for a permanent committee responsible for the management and maintenance of the SDI-UFV.

Defining the standards to be adopted in an SDI is necessary to ensure interoperability between the information made available. In the SDI-UFV, the international standards defined by the OGC were followed, using systems compliant with the WMS, as well as the standards approved by NSDI and CONCAR for the production of spatial data and metadata files. The metadata files were developed following the MGB Standard Summary, however, when it comes to data for research, there may be peculiarities regarding the information needed in respect to the available data. It is indispensable, in future studies, to evaluate which metadata profile better serves the data coming from research, and, if necessary, to develop a new metadata profile for the academic area.

Using FOSS systems, it was possible to deploy the technological components of the SDI-UFV. Following a Service Oriented Architecture, the SDI is available on the internet and the hosting was done on the Internet server of UFV; in subsequent steps it is proposed to evaluate the usability of the developed infrastructure. PostGIS was used to manage and update the database, i3GEO for the publication of spatial data (WebGIS), the edpMGBs editor for preparing the metadata files and GeoNetwork for creating the metadata catalog.

Due to the complexity of the steps to build an SDI, it was proposed that the development of an SDI-UFV was carried out in cycles. The objectives of cycle I are the presentation and initiation of the SDI development project, proposing the creation of an infrastructure with the administrative bodies, raising awareness of the importance of an Academic SDI, in addition to proposing an institutional structure, the elaboration of the Resolution model for the creation of the SDI, the development of the technological part and the inclusion of the reference data of the Viçosa campus in the SDI-UFV. These steps were concluded with the accomplishment of this work.

For future projects, it is proposed to execute the following cycles. In the second cycle, it is proposed to establish the Permanent Commission responsible for SDI-UFV, to carry out publicity and awareness campaigns about the SDI, to develop specific training for those responsible for managing and maintaining the infrastructure, in addition to training for users, the inclusion of data from other UFV campuses and data from teaching, research or extension projects, the evaluation of SDI usability, analyzing whether the adopted architecture meets the academic needs and the integration of the SDI-UFV into NSDI, making it a spatial data provider node. From the measures developed and the proposals, it is expected

that in the third cycle, SDI-UFV will be consolidated and that it will become a source for university administration and research development.

Within the university, spatial data are produced in various spheres by the administration, projects of education, research, and extension. Thus, in future studies, it should be considered if possible, nodes exist within the UFV that can be integrated into the SDI-UFV. For example, laboratories and research groups that produce and use spatial data can create their own SDI, and they can become spatial information producer nodes for the SDI-UFV.

It is expected that the methodologies applied in this study and the considerations set forth herein may serve as a support for the development of other Academic SDIs, and that research related to this topic will continue, consolidating the concept of Academic SDI, promoting improvement of the systems of software for the development of technological components and determining effective measures for the development of policies for SDI in educational institutions.

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