Feasibility Study on the Use of FLOSS
in the Cadastre Sector in Bosnia and Herzegovina
(Final Version)

Prepared by
Ivica Mićanović, Kemal Osmanović and Michael Wagner

March 2008

FAO Land Tenure and Management Unit (NRLA)
FIG Commission 7
World Bank Thematic Group on Land Administration
Table of Contents
1. Abbreviations .......................................................................................................................... 3
2. Objective of the study .................................................................................................................. 4
3. History of Cadastre and Land Registry in BiH ......................................................................... 4
4. Legal and Technical Framework ............................................................................................... 5
   4.1. New Law on Land Survey and Real Estate Cadastre ......................................................... 5
   4.2. Rulebook on cadastre data management ............................................................................ 6
   4.3. Data model .......................................................................................................................... 6
5. Review of Status of Cadastre Data ............................................................................................ 6
6. Review of Existing Digital Data in Cadastre and Land Registry ............................................. 7
   6.1. Cadastre data ....................................................................................................................... 7
   6.2. Software used for Cadastre Maintenance .......................................................................... 8
   6.3. Software used for Land Registration .................................................................................. 10
7. Tools for Migration of Existing Cadastre Data to the New Data Model ................................. 11
8. Cadastre Workflow in Bosnia and Herzegovina ....................................................................... 13
   8.1. Subsystem: BPKN ............................................................................................................... 14
   8.2. Subsystem of records on geodetic base ............................................................................ 19
   8.3. Subsystem of records on geodetic survey maps ................................................................. 20
   8.4. Subsystem Office operations ............................................................................................. 21
   8.5. Subsystem of System data distribution over internet and intranet ................................... 21
9. Requirements for Geographical Information Systems to be used for the Maintenance of Cadastre ......................................................................................................................... 23
   9.1. GRASS ............................................................................................................................... 24
   9.2. QuantumGIS ....................................................................................................................... 30
   9.3. gvSIG ................................................................................................................................. 34
   9.4. Kosmo .................................................................................................................................. 37
   9.5. Comparison Table ............................................................................................................. 41
   9.6. PostGIS ............................................................................................................................... 48
   9.7. Conclusion ........................................................................................................................... 49
10. Data exchange between cadastre and land registry ............................................................... 50
11. Development of a cadastre module ......................................................................................... 50

The table above will be used further in BiH to develop a specific cadastre maintenance software application.

Annex A - Terms of Agreement ...................................................................................................... 52

Annex A - Terms of Agreement ...................................................................................................... 53
1. **Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADA</td>
<td>Austrian Development Agency</td>
</tr>
<tr>
<td>AH</td>
<td>Austrian-Hungarian</td>
</tr>
<tr>
<td>BiH</td>
<td>Bosnia and Herzegovina</td>
</tr>
<tr>
<td>BPKN</td>
<td>Cadastre Database</td>
</tr>
<tr>
<td>DBMS</td>
<td>Database Management System</td>
</tr>
<tr>
<td>EPSG</td>
<td>European Petroleum Survey Group</td>
</tr>
<tr>
<td>FBiH</td>
<td>Federation of Bosnia and Herzegovina</td>
</tr>
<tr>
<td>FLOSS</td>
<td>Free / Libre Open Source Software</td>
</tr>
<tr>
<td>GEOS</td>
<td>Geometry Engine - Open Source</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GML</td>
<td>Geographic Mark up Language</td>
</tr>
<tr>
<td>GTZ</td>
<td>Deutsche Gesellschaft für Technische Zusammenarbeit GTZ (German Development Cooperation Agency)</td>
</tr>
<tr>
<td>ILAS</td>
<td>Integrated Land Information System</td>
</tr>
<tr>
<td>JTS</td>
<td>Java Topology Suite</td>
</tr>
<tr>
<td>LARIS</td>
<td>Land Registry Information System</td>
</tr>
<tr>
<td>OGC</td>
<td>Open Geospatial Consortium</td>
</tr>
<tr>
<td>QGIS</td>
<td>QuantumGIS</td>
</tr>
<tr>
<td>RS</td>
<td>Republic Srpska</td>
</tr>
<tr>
<td>SFS</td>
<td>Simple Feature Specification (of the OGC)</td>
</tr>
<tr>
<td>Sida</td>
<td>Swedish International Development Cooperation Agency</td>
</tr>
<tr>
<td>SRS</td>
<td>Spatial Reference Systems</td>
</tr>
<tr>
<td>SVG</td>
<td>Scalable Vector Graphics</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modelling Language</td>
</tr>
</tbody>
</table>
2. Objective of the study

This study has been initiated and funded by the Food and Agriculture Organization (FAO) of the United Nations. The FAO has contracted Mr. Ivica Micanovic graduated engineer of geodesy, to perform the study (see terms of reference in the annex A).

The purpose of this study is to analyze possibilities of applying Free Libre Open Source Software (FLOSS) solutions for the maintenance of real estate cadastre databases in BiH. In addition, it is crucial to also define the necessary applications which would enable the maintenance of the above mentioned cadastre databases in using GIS technology. The last part of the study consists in assessing approximately the necessary time frames and financial resources for the development of such additional applications.

In discussions with German governmental organization for technical cooperation (GTZ), we concluded that GTZ had already been very active in supporting the creation of a data model in the real estate cadastre and in testing the model implementation. For these reasons, GTZ has been included in the preparation of the study in order to improve its quality by their own experience and advices. Graduated engineers Michael Wagner and Kemal Osmanovic contributed to the study from the GTZ side.

In accordance with the agreement concluded between FAO and Ivica Micanovic, works have started on November 15, 2007, while the working draft study was delivered by February 15, 2008. The final report will be delivered no later than March 15, 2008.

3. History of Cadastre and Land Registry in BiH

The Austrian – Hungarian Administration was established in 1878 in BiH and immediately began preparations for the first land survey in Bosnia and Herzegovina. The decision on cadastre survey was passed in 1879, and the entire process was implemented between 1882 and 1886.

The survey itself was done by graphic methods producing cadastre maps at scale 1:6250 or sometimes 1:3125. In very limited urban areas, the scale was even larger. The accuracy was relatively low. Decisions about property rights were made by specialized judges and recorded in land registry books maintained in the land registry courts and referring to the cadastre survey. That kind of cadastre and land registry was kept in the entire until 1952. A new land survey was initiated at that time, but the process has not been fully completed so far.

The new land survey started with the adoption of the Law on Cadastre in 1952, which did not make the link with existing plans and books. The new land survey was used as a basis for new determination of land plots and for registering possessors as holders of some new types of rights in conformity with the socialist political system (right of use, right of disposal, social ownership, etc). The purpose of this cadastre was also to introduce a fiscal cadastre for the taxation of income generated by agricultural production. Hence there were two different sets of records with different definitions of land plots and different entries related to the property rights and other related rights. Due to the sporadic updating of old plans and land books on one side, and of the new cadastre survey on the other side, the differences between the two sets became bigger and bigger. Because of inconsistencies causing more and more problems in resolving property legal issues, a new Law on Real Estate Cadastre was adopted in 1984.

This law aimed to establish a single register partly based on already available cadastre new survey and partly on a new survey to be performed simultaneously. At that occasion, property rights were re-established on the basis of the new survey data while the old plans and land books
were put out of force. The establishment of new records was led by specific cadastre commissions in working out both the technical description of real estate and the decision on property rights. This system contributed to create modern, up to date and accurate record on real estate and property rights. Mostly because of huge amount of work, inappropriate and very expensive work methodology, insufficient number of qualified personnel and the war that happened in BiH from 1992 to 1995, this single record system could be established in only about 10% of territory until 2003.

The new Law on Land Registry imposed in November 2002 by the High Representative and adopted in 2003 by both Entity Parliaments was re-establishing a dual system, with cadastre records maintained by the public Administration and land registry records kept by the courts. That task is entrusted to land registry clerks employed in land registry offices within the first instance courts. Due to legislation changes and new organization in basic courts where the land registry offices are located there is no systematic establishment of property rights yet. Such modification of the legal system has created a complicated situation because it implies that cadastre and land registry will be fully compatible and refer to identical description of property units on the basis of the new survey. As a result we will again have a single record with divided jurisdiction. Cadastre offices will take care of establishment and keeping of technical data on real estate while land registry offices will be in charge of establishment and keeping of property rights. In the meantime, there are intensive activities on creating electronic databases of cadastre plans and records, and systematic data entering from land books into digital databases.

For the purpose of entering and keeping data on property rights, the Land Registry Information System (LARIS) has been developed to fully cover all functionality required to keep land registry in digital form, in accordance with the valid Law on Land Registry and related by-laws. For keeping cadastre data in digital form there are different solutions based on relational data bases which mostly meet the requirements, but there is no software providing establishment, keeping and archiving cadastre data in object-relational data bases.

Basically, as the development of the unified data model is very recent, none of the municipalities has implemented yet any GIS in cadastre that would meet the requirements stipulated by the new rulebook on establishing, keeping and archiving real estate cadastre databases (BPKN). In 2007, Geodetic Administrations in cooperation with GTZ have adopted a new Data Model as a significant basis for future IT systems in cadastre. The World Bank funded Land Registration Project will provide funds to develop an IT/IM strategy and purchase a new software for the Integrated Land Information System (ILAS) in about 3 to 4 years.

In the meantime, it is necessary to propose solutions at short term, to experience the new data model, to train the cadastre specialists in working with digital data, to realize the interoperability of cadastre and land registry databases, and to develop e-services. Especially in a country like BiH where financial resources for investments are limited, this study will demonstrate that existing FLOSS solutions, with creation of additional applications, can be used for operating real estate cadastre data bases.

4. Legal and Technical Framework

4.1. New Law on Land Survey and Real Estate Cadastre

Bosnia and Herzegovina consists of two entities – the Federation of Bosnia and Herzegovina and the Republika Srpska - and Brcko town as a District.

Geodetic administrations of both entities with assistance of GTZ, have prepared a new Law on Land Survey and Real Estate Cadastre. German laws were used as a model for this Law, and one of the most significant innovations is introduction of Licensed Surveyors for field works.
necessary to keep and update real estate cadastre data. This Law introduced for the first time GIS as a new technology for maintaining of real estate cadastre. The law is in force in one entity (Republika Srpska) where it is in use for more than one year. In other entity (Federation of Bosnia and Herzegovina) and in Brcko District the draft law is identical and is in phase of adoption.

4.2. Rulebook on cadastre data management

Besides the mentioned Law, very comprehensive rulebook on preparation, maintenance and archiving of real estate cadastre database has been drafted. This rulebook defines the conversion of analog plans into digital form, the rules on maintenance of such database, on archiving, keeping and disseminating data. During the preparation of the rulebook, all professional standards were considered, in order to preserve as much as possible existing quality of analog plans. The experience of neighboring countries which had similar problems was used for the very beginning of preparation of digital cadastre plans. The new data model is an integral part of this rulebook.

4.3. Data model

Data model of real estate cadastre had to meet all requirements by international standards related to geoinformation and simultaneously to take in consideration all specific rules of geodetic works prescribed by the Law on Real Estate Cadastre. The data model consists of:

- The catalogue of objects included in the cadastre, with their attributes, characteristics and corresponding quality requirements,
- The description of the data structures and business processes in UML, and
- The description of the standard interface for data exchange in GML.

For the development of the new data model, ISO and OGC standards were used so that a very modern data model was produced. After completion of the model, various tests were performed in order to verify its applicability and functionality, which shown that model is functional in the part which was possible to test. Since there is no GIS solution on the market which meets all specific requirements for keeping the cadastre in BiH, it has not been possible to perform all tests. Therefore, all aspects which will probably lead to partial corrections of the model will be considered in developing applications for cadastre maintenance.

Data model itself is adjusted to the basic contents of analog plans what significantly simplified the illustration of plans. That basic content is synchronized with the Law and includes only the objects on which rights are being established, that means land plots, part of land plots and buildings. All other contents included in the existing analog plans is to be integral part of extended contents and in initial collection of data for preparation of the real estate cadastre data base, shall not be converted in digital form.

5. Review of Status of Cadastre Data

As it is already mentioned above, 4 types of cadastre still exist in Bosnia and Herzegovina:

- The Listed Cadastre (or descriptive cadastre) which is kept only in written form and without analog plans.
- The Austrian – Hungarian Cadastre is based on the initial land survey with analog plans in scale 1:3125 and 1:6250; those plans are of low quality. Property rights are recorded in land books.
The Land Cadastre is based on aerophotogrametric survey made after 1952; those plans were made in scale 1:500, 1:1000, 1:2500 and 1:5000. Property rights have been re-established and kept in cadastre. Generally the same area is also covered by the Austrian – Hungarian plans and land books.

The Real Estate Cadastre is based on the law of 1984. Plans have been made in scale 1:500, 1:1000, 1:2500 or 1:5000. Property rights have been re-established in considering the rights entered into land books. Old land books were put out of force and related property rights were taken over by the courts after 2003.

<table>
<thead>
<tr>
<th>With old survey</th>
<th>With new survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH cadastre</td>
<td>Listed cadastre</td>
</tr>
<tr>
<td>Without new survey</td>
<td>Without new survey</td>
</tr>
<tr>
<td>New survey finished, establishment did not start</td>
<td>New survey finished, ongoing establishment</td>
</tr>
<tr>
<td>New survey finished, ongoing establishment</td>
<td>New survey finished, ongoing establishment</td>
</tr>
<tr>
<td>Land cadastre</td>
<td>Real estate cadastre</td>
</tr>
<tr>
<td>With DCP</td>
<td>Without DCP</td>
</tr>
<tr>
<td>Without DCP</td>
<td>Without DCP</td>
</tr>
<tr>
<td>With DCP</td>
<td>Without DCP</td>
</tr>
<tr>
<td>Without DCP</td>
<td>Without DCP</td>
</tr>
</tbody>
</table>

Table 5-1

The table above is summarizing the different possible situation of cadastre and land books in BiH and the Annex B is giving detailed statistics.

6. Review of Existing Digital Data in Cadastre and Land Registry

6.1. Cadastre data

This table presents the various applications (software) currently used in BiH and their formats.
<table>
<thead>
<tr>
<th>Software</th>
<th>ArcView</th>
<th>Katozor v.2.5</th>
<th>Digit98</th>
<th>MapSoft2000</th>
<th>ERC</th>
<th>GZ</th>
<th>KAT-ZEM</th>
<th>KAT-NEK</th>
<th>KataZE</th>
<th>KataNE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Import/Export Raster Data</strong></td>
<td>All supported files from ArcView</td>
<td>TIFF, BMP</td>
<td>TIFF</td>
<td>BMP, PCX, TIFF…</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Import/Export Vector Data</strong></td>
<td>All supported files from ArcView</td>
<td>DWG</td>
<td>DWG</td>
<td>DWG, SHP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Connection with external Data Base</strong></td>
<td>Personal Geo Data base</td>
<td>MS Access Database</td>
<td>MS Access Database</td>
<td>Cobol Database</td>
<td>Paradox Database</td>
<td>Progress Database</td>
<td>Progress Database</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data exchange format</strong></td>
<td>SHP</td>
<td>DXF</td>
<td>DXF</td>
<td>DAT</td>
<td>BDE</td>
<td>DBF</td>
<td>DBF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6-1

None of these software applications is complying with the data model requirements, which will imply a huge quantity of works to convert the data and control the quality. In addition, graphical and alphanumeric applications are not connected, and the experience has shown that many discrepancies must be identified and eliminated. This is generating a lot of manual works.

6.2. **Software used for Cadastre Maintenance**

We can say that first digitalization of cadastre data has started in mid 1980’s upon initiative of the republic geodetic administration which engaged at that time a group of people to develop and maintain the application for keeping the cadastre records. It is important to mention that this application was exclusively designed for the maintenance of the alphanumeric part of the cadastre, the so called “cadastral operate”, following of its procedure, of course, again depending on type of the cadastre kept for certain political municipality, that is cadastral municipality. The application was working under DOS environment and using Paradox database management system. This system has been installed in almost all cadastral offices in BiH and is still in use, while the changes on analog plans are made manually.

After the war, the scanning and vectorization of analog cadastre plans have started. Software solutions which are used for vectorization and maintenance are mostly based on CAD platforms, and most of them have are still in use today.

Two application solutions are used in the FBiH:

- The first one is a product of the Croatian company “Geoinformatika” which has developed the application “**Katozor**”. This application enables processing and
maintenance of spatial data and is specially designed for managing of cadastre data. It uses Microsoft Access database, and enables adjustment to specific users’ needs. It is characterized by simplicity of data management, structural layers, possibility of some geodetic calculations (arch intersection, intersecting forward and backward). This software works without possibilities of interoperability with other systems. History tracking is completely excluded, and possibility to keep some other type of history tracking, precisely the archiving, is reduced to archiving the screenshots of situations before and after changes on objects in data base.

- The worldwide well-known application ArcGIS, because it comes from the most powerful world’s GIS magnate ESRI, has also found its way to the users in BiH. This application mostly covers central and western cantons of the FBiH, and likewise to the first solution, there is an alphanumerical database separated from geometric part of database. For the needs of database maintenance a couple of simple applications have been developed, which partly make the work over the base easier. In this case the information are more consistent, it is more convenient and easier to manage them, but there is still a difficulty due to the separation of graphical and alphanumerical parts of database. Even here, like in the previous solution, the concept of history tracking and archiving has been completely neglected. The usual support to the ESRI concept is “Geo Databases” but data model itself where data are stored is relational, with the note that graphic data and alphanumerical data are separated in individual data bases.

In the Republika Srpska, there are also two application solutions for graphical part of database and two solutions for alphanumerical part of database in use:

- “Digit98” is the program system for digitalization of analog geodetic plans and their maintenance. It was developed by group of authors at the end of 90s in Belgrade, Serbia. The application itself represents an additional module or extension to AutoCAD software versions R14 and 2000 as well as 2000i, so the user interface (GUI) is completely the same as all AutoCAD tools. Digit98 includes following modules: basic module, module for digitalization of plans, module for calculation of surface, module for contour curve interpolation module for maintenance of digital geodetic plan.

- Similar software with better graphical interface is used by other cadastre units is “MapSoft2000”, the product of private Serbian company “Geomatics Company MapSoft”. As framework of basic program module, the standard ‘Document - View' architecture was selected, but the architecture itself is supported through MFC (Microsoft Foundation Classes) library of classes. The most important characteristics of MapSoft-a2000 are: user interface which corresponds to all appearances to standards for modern Windows applications - erasure of difference between textual and graphical working regime, the standard system of menu and dialogues as a basic way of communication with user, toolbars with possibility for adjusting the existing and creation of new toolbars, acceleration tasters, standardized interactive system for help (WinHelp, HTML), usage of the most modern controls for display and entry of data (grid, list box, combo box,...), usage of drivers for access to the periphery devices (screen, mouse, printer, plotter,...) and data base (DAO, ODBC,...).
The alphanumeric part as cadastral operate is supported by two software operating with already mentioned applications. Those links are not dynamic and not operated jointly, but the user independently searches for the number of land plots in both applications. Depending on type of cadastre, there are two versions of this software in use, „KataZe“ for land cadastre and „KataNe“ for real estate cadastre.

As it can be seen from the above various solutions, the situation in cadastral offices in BiH is uneven in a sense of software utilization and data storage. It should be underlined that most of them are based on CAD environment and do consequently not offer any analysis functionality. Until the use of the new data model will be effective, Geodetic Administrations of both entities are of the opinion that is necessary to keep dual system in operation to maintain existing digital cadastre data. They will be abandoned only when data will be definitely converted in a system complying with the requirements of the BPKN and the new data model.

6.3. Software used for Land Registration

In 2004, the Entity Ministries of Justice decided to develop a software application with the technical assistance of GTZ. A specific working group was in charge with drafting the terms of reference in full compliance with the law on land registry and related by-laws, and also in considering the experience of land registry clerks and local traditions in land registry management. The involvement of local experts lead to simplify in many aspects the maintenance and administration of the application. A local company was contracted to develop the software, and the working group was carrying out tests and supervising the development.

The first version of LARIS was installed from the beginning of 2005 in all 48 courts successively, and the users have been trained. Since that, various extensions and functions were added to the original version, improving the functionality according to the acquired experience and adapting it to the legal changes. The application presents a sound and simple tool for storage and maintenance of land registry database, and provides functionalities related to administrative and organizational activities within land registration offices. Function for creation of statistical data regarding the land registration entries is also supported by LARIS as an application.

LARIS is web-based application developed on the base of Oracle database management system which is inherited from a previous application, written in Java program language. The installation itself has been made exclusively on local servers in land registration offices while work stations use Internet browser. Such approach enabled flexibility of the system with regard to eventual centralization as well as to maintenance and exchange of hardware platform. Until the end of 2005, LARIS was installed in all land registration offices and their branch offices, and field offices and simultaneously was started with training of personnel to use the application. Due to impossibility of centralization of existing data, certain part of functionality in domain of administration has been left on the local level, but maintenance of the application itself, and upgrading arising as a result of experience in the field and users’ suggestions, have been carried out by staff of GTZ/Sida/ADA Land Administration Project. It is important to underline that LARIS due to its stability and reliability has been accepted very fast by all land registration officers, even if most of them used computers for the first time. LARIS itself has been designed on a way to enable, through the Internet or LAN, an approach in “read only” format for a wide range of users, starting with judges through public notaries and lawyers to ordinary citizens. But, it appeared that for reasons such as protection of original data and low skill of “ordinary’ users who are not trained to use LARIS, it was necessary to develop a product of basic application which shall be installed on separate servers and serve exclusively for review of original data. „LarisLight“ has been developed on the same platform as LARIS and it is in trial use in Municipal court in Sarajevo. (www.zkk.ba). Because of general trend of more often use of “open source” solutions, and due to the license policy of the Oracle company, it has been decided to
migrate the “LarisLight” application to an open source database management system and this process is ongoing. On this way use of software applications and access to data shall be clearly separated between persons authorized for keeping the land registration data (land registry clerks) whose number will not vary significantly in next period, and all other users of land registry services whose number theoretically and practically may be unlimited.

Within the ongoing changes, the control of different levels of data access shall be enabled (regardless that land book is public registry, the Law on Protection of Personal Data limits access to certain data) in order to make the difference between the users such as notaries, judges or ordinary citizens.

7. Tools for Migration of Existing Cadastre Data to the New Data Model

As shown in chapter 6.1 there are several software applications used currently for the maintenance of cadastre data in BIH. Each application keeps the data in its own specific format. Those applications are neither based on a common data model nor have structure, content and format for the exchange of data between different applications ever been defined. This is causing a lot of effort now, when data kept in those applications has to be migrated to the new data model for cadastre in BIH. In fact there are about ten different migration processes to be considered. Each time there is a different format, content or structure of original data an additional migration process is required. The following options are conceivable to carry out the migration technically:

- Implementation of a customized migration tool for each different format
- Using existing software specialized for conversion / migration of spatial data like ogr2ogr¹, Talend Spatial Data Integrator², FME³ (commercial) etc.

The following section concentrates on the second option and is introducing some FLOSS tools for conversion of spatial data. The tools can be divided in two groups, those where the actual conversion process can be influenced and customized by the user and those where it cannot. The later group just converts data “one-to-one” from the source format to the target format. In most cases this still requires some manual rework after the conversion. This group includes tools like ogr2ogr, shp2pgsql⁴ and gdal_translate⁵. The first group permits the user to configure the conversion process e.g. for the purpose of joining two attributes in the source format into one attribute in the target format. Talend is a representative of this group.

While Talend is a tool with a graphical user interface the other tools are run from the command line.

shp2pgsql converts an ESRI shape file to a PostgreSQL / PostGIS dataset as one can assume from the tool's name. psql2shp is to be used for the reverse conversion. The tool works well but manual rework is required later on if more than a simple conversion is needed.

¹ http://www.gdal.org/ogr/
² http://www.spatialdataintegrator.com
³ http://www.safe.com
⁴ http://www.gdal.org/
⁵ http://postgis.refractions.net/
**ogr2ogr** supports the conversion between all vector data formats as supported by the *ogr* library, currently about fifteen.

**gdal_translate** is the counterpart to “ogr2ogr” for the conversion of raster data. The tool supports about thirty different formats.

*Talend* is (going to be) a very interesting tool but initiated by a very recent project and therefore not yet so developed and sophisticated. Still it is expected to become a powerful conversion tool judging from its concept and philosophy. That makes it deserve some more attention:

In September 2007, the two well known companies from the FLOSS world, the „CampToCamp“ and „Talend“, presented a new product which is based on already known Talend Open Studio” application. The new software has been named „Spatial Data Integrator“ and it was specialized for manipulation of geospatial data and represents the spatial extension of „Talend Open Studio“. This ETL (Extract- Transform- Load) tool provides the manipulation with data such as: extraction of data from certain entities, verification of quality, transformation, conversion of data, enables vector and raster analysis, managing of data and metadata as well as series of other components. The idea for existence of such product is reasonable considering the fact that there is no any of SDI in the world of FLOSS so far. Commercial software such as FME (Feature Manipulation Engine) is one of the most conformal solutions in this field, with several of its transformers and manipulators with geospatial data, what is explained by its market price.

By preparation of this study it has been tried to go in direction of use of this robust application. Robust, because it really, at the first sight, offers a great number of transformers and connectors, but it still has to be considered that the project is in development phase and further improvement. Used version is 2.2.1 and there are some noticed disadvantages, for example: large utilization of RAM when starting up the application, then graphic environment (GUI) has mostly remained unshaped and a little bit confused for ordinary user, and besides of great number of supported formats the one of the most important is missing, it is DWG. Due to these reasons, it was not possible to use this ELT in purpose of data conversion, because the original data was in DWG format.
8. Cadastre Workflow in Bosnia and Herzegovina

This chapter is an attempt to summarize the typical workflow in the cadastre sector in BIH. Common use cases and the involved activities are documented in UML diagrams. The use case diagram in Figure 8-1 shows possible requests for change a cadastre authority might receive and the involved stakeholders. In most cases these requests will result in an updating of cadastre data. Figure 8-2 shows further tasks a cadastre authority has to deal with and which are not necessarily related with updating of the cadastre data.
8.1. **Subsystem: BPKN**

Alphanumerical part
It has to meet the requirements to implement the process of establishment of real estate/land cadastre and maintenance of real estate cadastre.

**Specification of cadastre establishment process:**
- Taking over (conversion) of data from other records;
- Initial collection of data;
- Storage of data within PostgreSQL / PostGIS;
- Review and research of data;
- Checking of consistency of entered data;
- Preparation of reports

**Specification of Real estate/land cadastre maintenance process:**
- Authorization / Authentication of users;
- Maintenance of data within PostgreSQL / PostGIS;
- Review and research of data upon the number of cadastre registry folder or title of deed, parcels and their parts, buildings and their parts;
- Review and updating of right holder over the real estate;
- Prompt keeping of data about cadastre registry folders or titles of deed, parcels and users (until defining the rights for mentioned cadastre municipality in accordance to the Law on Land Books);
- Managing of changes in real estate/land cadastre data with the history of changes;
- Checking of data consistency after managed changes;
- All processes of change in cadastre record have to be done on-line link towards data in graphical part and on-line checking of data integrity in alphanumerical part of base;
- Printing of certificates and extracts from real estate/land cadastre records;
- Calculation of cadastre income (until the change of the Law on Method of Taxation);
- Preparation of statistic review of real estate/land cadastre data and so on.

**Graphical part**
Subsystem of graphical part BPKN includes the following basic process groups:

a. Collection of data;
b. Maintenance;
c. Basic geodetic calculations;

**a. Collection of data**

**Data model:**
Data model for facilities in this working phase has to enable keeping of following attributes:
- Geometric
- Qualitative

**Process specification:**
- Taking over of digital data by conversion
- Delivery of digital data by conversion
- Storage of data within PostgreSQL / PostGIS
- Display of BPKN contents in conventional cartographic form on screen in real time
• Drawing of plans in standard cartographic form
• Analytical calculation which correspond to measurements on analog geodetic plan
• Collection of data in digital form with direct verification in state coordination system
• Interactive editing of digital contents in accordance with land surveys and geodetic profession

All processes of collection have to conduct by on-line link towards data of real estate/land cadastre and on-line checking of data integrity in alphanumerical part and graphical part base. Harmonization of data in alphanumerical part of the base and graphical part of base (statistic reviews of uncoordinated status, classification of mistakes and procedures of harmonization of record status, tools for correction of mistakes in alphanumerical part of base, tools for correction of mistakes in graphical part of base).

b. Maintenance of BPKN

Figure 8-3 is an activity diagram showing the overall workflow initiated by a request for change, while Figure 8-4 presents in particular those activities which could be well supported by using a GIS when processing a client's request for change. A “request for change” might be the splitting of a parcel, recording of a new building, a change of ownership etc.

Software is purposed for maintenance of BPKN contents in client/server environment in accordance with rules of the state land survey.
Figure 8-3: Request for Change, involved Activities
Figure 8-4: Workflow to be supported by the Use of GIS

**Data model:**

Data model should enable, in this stage of work, to keep the following attributes for facilities:

- Geometric
• Topological
• Thematic
• Qualitative
• Time

Process specifications:
• Taking over of data through conversion
• Display of DGP content in conventional cartographic form on the screen in real time
• Analytic calculations corresponding to measurements on analog geodetic plan
• User authorization / authentication
• Multi-user work
• Keeping the database within the PostgreSQL / PostGIS
• Connecting to external bases with use of ODBC, JDBC, ActiveX or similar technologies
• Keeping of history of changes with memorizing-saving all previous entries in database,
• Verification of topological and geometric consistency after each cadastral change
• All processes of maintaining contents of BPKN have to be done with online connection to alphanumeric and graphic data in BPKN

c. Basic geodetic calculations
Process specifications:
• Construction of points – setting the coordinate points;
• Measuring of lengths, angles and surfaces and reading of coordinate points, polar and orthogonal;
• Leveling of coordinate points in polygon line with textual and graphic display;
• Preparation of data for transfer on filed by coordinates;
• Transformation of coordinates;
• Calculation of geographic coordinates.

8.2. Subsystem of records on geodetic base

Subsystem of records on geodetic base has to satisfy the needs of establishing and maintaining of records on geodetic basis.

Specification of process of establishing the records on geodetic base:
• Initial gathering of data
Review and searching of data
Inspection of consistency of entered data
Preparation of reports

**Specification of process for maintenance the records on geodetic base:**
- User authorization / authentication
- Keeping, maintenance and manipulation with data under PostgreSQL / PostGIS;
- Review and searching of data;
- Prompt keeping of data on geodetic basis;
- Implementation of changes in data on geodetic basis;
- Inspection of data consistency after implemented changes;
- Printing of excerpts from records on geodetic basis;
- Preparation of statistical review of data on geodetic basis etc.

**8.3. Subsystem of records on geodetic survey maps**

**Subsystem of records on geodetic survey maps** should contain the following data:
- Scanned raster geodetic survey maps,
- Scanning resolution,
- Type of survey maps (geodetic plans, maps, photo sketches, photos…),
- Type of survey,
- Scale,
- Year of production,
- Survey maker,
- Coordinates of bottom left corner,
- Dimensions of useful space,
- Status of survey map (scanned, digitalized…)

**Specification of process for setting up the records of geodetic survey maps:**
- Initial gathering of information
- Review and searching of data
- Inspection of entered data consistency
- Reports preparation

**Specification of process for maintenance of records on geodetic survey maps:**
- User authorization / authentication
- Keeping, maintenance and manipulation with data under PostgreSQL / PostGIS
- Review and searching of data;
- Prompt keeping of data on geodetic survey maps;
- Implementation of changes in data on geodetic survey maps;
- Inspection of data consistency after implemented changes;
- Printing of excerpts from records on geodetic survey maps;
- Preparation of statistical review of data on geodetic survey maps etc.
8.4. **Subsystem Office operations**

Subsystem **Office operations** have to meet the needs of work process management and office operations:

- Work with clients
- Reception (scanning) and issuing of documents,
- Signing and forwarding in electronic form
- Setting up and maintenance of received mail, i.e. acts,
- Connection with subsystem, **Calendar, Scheduling and electronic mail**
- Keeping, maintenance and manipulation with data under **PostgreSQL / PostGIS**
- Setting up and maintenance of register of received mail by person,
- Setting up and maintenance of register of applications
- Setting up and maintenance of register of basic records: list of acts, registry, entry book of cases for first-instance administrative procedure, entry book of cases
- Second instance administrative procedure,
- Setting up and maintenance of register of internal delivery
- Setting up and maintenance of archived documents,
- Quality check of contents of basic registers
- Insight into basic records of office operations
- Following the work on cases with changes and decisions,
- Statistics for solving of cases

8.5. **Subsystem of System data distribution over internet and intranet**

Subsystem of System **data distribution over internet and intranet** has to meet the needs of distribution and presentation of real estate/land cadastre, utilities cadastre, streets and house numbers cadastre, DGP and geodetic base over internet and intranet.
Process specification:
- Demonstration of database contents to potential users with application of internet/intranet technology
• User authorization / authentication
• Display of contents in conventional form on the screen of the client in real time
• Connecting with external databases by application of ODBC, JDBC, ActiveX or similar technologies
• Recording of amounts of issued data with fee calculation
• Keeping the database within PostgreSQL / PostGIS

Figure 8-5 shows the workflow when distributing data.

9. Requirements for Geographical Information Systems to be used for the Maintenance of Cadastre

Four FLOSS GIS have been selected, tested and analyzed regarding their capabilities to support the maintenance of cadastre in BIH. These software solutions are in particular “gvSIG”, “QuantumGIS”, “Kosmo” and “GRASS”. The GIS have been selected out of seven which have been already introduced and compared in the “Scoping Paper on the Use of FLOSS in Cadastre and Land Registration”6. They are considered by the authors of this study as some of the most advanced and sophisticated FLOSS GIS currently available. Following there will be a section dedicated to each of the GIS and its particularities and a table comparing the characteristics of the four solutions and showing the availability of functions / features which were considered especially important for the maintenance of cadastre. Some of the characteristics which will be discussed here, have been already mentioned in the scoping paper mentioned previously and were selected for this study again only when considered of particular importance for the cadastre.

At the end the described capabilities shall support the workflow in cadastre as shown in Figure 8-3 and particular in Figure 8-4. Plug-ins are available for all of the analyzed GIS to extent their functionality and capabilities. Only plug-ins included in the standard installation of these systems have been considered in this study. One section in this chapter is also dedicated to PostGIS, the “Spatial” extension for the PostgreSQL database management system. PostGIS has powerful features and can compensate the lack of certain analysis capabilities in the compared GIS very well.

Information system should be implemented in accordance with:

• Law on Land survey and real estate cadastre,
• Rulebook on maintenance of land survey and land cadastre,
• Rulebook on preparation, maintenance and archiving BPKN
• Act on office operations,
• And other valid regulations from this field.

Software solution should provide:

• That it is modular, so the specific subsystems-modules may be individual developed, distributed and used from each other,
• Total connection of subsystem-modules (functional connection of all mutually logical and dependable sizes and data of GIS),

---

- Non-repetition of data of all subsystems what means that one data (information) may be found (appear) only on one place in GIS (for example plot number, surface, culture etc.),
- Consolidation and harmonization of existing data of the land cadastre, real estate cadastre, streets and house numbers cadastre and digital geodetic plan,
- Keeping the data within PostgreSQL / PostGIS
- Work with distributed database architecture and data replication,
- User authorization and authentication
- Multi-user work,
- System being open for other GIS products,
- Presentation of user queries over data in graphic and alphanumeric surrounding (form),
- Conformity with work place where application is used,
- Remote control – administration and maintenance of local databases from central position,
- Archiving – making of backup copies of system data,
- Principle of unlimited space (derivation of queries, making of reports, display of data in graphic environment of DGP for entire area of certain municipality),
- Meeting the conditions of existing data model,
- Object oriented Data Model which respects OGC and ISO standards,
- Possibility for usage of standard programs and Macros (for example VB, Java, VC++),
- Protection of System data on highest possible level.

9.1. **GRASS**

**General**

GRASS is by far the most developed and matured FLOSS GIS available when it comes to the processing and analysis of vector and raster data.

It provides several hundred commands. All of them can be accessed via command line; the use of many of them is facilitated by an appropriate dialogue window. Working with GRASS might not be very intuitive for someone accustomed to a typical window application and the GRASS developer community is working diligently to improve the software's user interface.

GRASS runs natively on Unix / Linux and the Macintosh Operating System, it requires the Cygwin (Unix-like) environment to run on MS Windows. Beginning with version 6.3.x is shall run natively on MS Windows, too.

**Stability and performance**

GRASS is quite stable and of good performance. The authors did not experience any problems even with larger datasets. The creation of topology for a vector dataset can be a bit time consuming but is normally done only once when importing data from a GRASS-external format or when rebuilding topology.

**Interoperability**

GRASS can import many different formats of vector data, mainly those supported by the underlying ogr library. In the particular installation on the author's laptop the ogr library provided support for about 20 formats e.g. ESRI Shapefile, KML, GML, MapInfo, Interlis and
PostGIS. Import means that the dataset's geometries are converted to a GRASS specific and file based format. This is required in order to use the full capabilities of the data processing and analyzing tools in GRASS (see also the Topology section). Because GRASS is a pure topological GIS, it stores and maintains the topology of vector data instead of simply their geometry. The descriptive data (attributes) are by default stored in a PostgreSQL table which GRASS creates during the import. Attributes and geometry are linked via a special ID attribute. It was found that when importing data, certain data types were either changed (converted) or not recognized correctly by GRASS respectively the ogr library. During the import of a PostGIS table containing an attribute of data type „Timestamp” GRASS tried to recreate it as a „DateTime” attribute which is not a valid data type in PostgreSQL / PostGIS and therefore led to an error.

GRASS also supports the export to several vector formats (about 15), again based on the underlying ogr library. Data is converted from the GRASS specific format to the selected one (e.g. ESRI Shapefile, PostGIS etc.). Again some issues were found regarding the data types. An attribute of the original type “Date” was created as a “Varchar” in the new PostGIS table. Therefore care should be taken of the data types when importing or exporting data with GRASS.

Regarding the vector data formats, GRASS also supports the import of GPS points (using the GPSBabel library) and the import of ASCII files containing coordinates. This is quite useful when importing data captured with a total station.

Another aspect to consider are the supported geometry types. To store and maintain the topology of vector data GRASS uses natively points, lines, boundaries (as the borderline of an area), centroids (as a point within a closed boundary) and areas (as the topological composition of a boundary and a centroid). It can import / convert geometries from other data formats if these geometries are of type Point, Multipoint, Linestring, Multilinestring, Polygon or Multipolygon. When exporting from GRASS, the software will always export to one of the geometry types Point, Linestring or Polygon.

![Figure 9-1: Multipolygon](image)

Shown in Figure 9-1 is a multipolygon in GRASS, consisting of two polygons with only an outer ring and one polygon with an outer and an inner ring. Each of the single polygons has a centroid (the little white mark) which is linked to the same entry in the attribute table. Thus, when clicking at any of the centroids the same attributes will be shown (which is correct). If the vector data is now exported to a PostGIS table it will result in three separate entries, each one representing a single polygon. This might not necessarily be the expected behavior especially as
PostGIS supports natively multiple geometries via its implementation of the OGC Simple Feature Specification.

When it comes to the support of raster data there are many formats GRASS can handle via the underlying gdal library. Almost 60 formats can be imported and GRASS can export to about 30 different formats. Data provided by a Web Map Service can be viewed in GRASS, too. GRASS can work with raster images already georeferenced (e.g. via a Tiff World File) but it is also possible to georeference raster images directly in GRASS.

Besides supporting several data formats and geometry types, the support of different spatial reference systems (SRS) is an important aspect of interoperability. GRASS does support all SRS as listed and defined by the European Petroleum Survey Group (EPSG). Additionally the user can define customized coordinate systems and map projections. It is also possible to re-project data and perform coordinate transformations within GRASS.

Creating and editing topology / geometry

Topology in GRASS is built automatically during the import of a vector dataset. This works very well and reliable. On the other hand the tools to edit geometry or topology are rather poor. There is no “Undo” option or option to finish an edit session without saving the changes! Thus, a lot of care must be taken during an edit session. Almost no construction tool is available (e.g. to create a line perpendicular to another one). Copy / paste of features (e.g. a parcel and its attributes) are not possible because of GRASS’s topological data model. Snapping functionality is provided but works only with geometries in the same layer. This is a big lack as one cannot use e.g. a supportive point layer (resulting from imported coordinates) to construct a parcel. This issue and several more related to the edit functionality shall be solved with the new GRASS version 6.3.x. Creating points by entering coordinates directly (manually) is not supported. Polygons can be split as well can polygons with holes and multipolygons be created. A multipolygon in GRASS would in fact consist of several single polygons where each polygon's centroid is linked with the same database entry (see also Figure 7). Topological nodes can be created (e.g. by splitting a line) but is not possible to move a node and the connected edges. That makes it difficult again to correct e.g. a border mark in the cadastre map as each connected borderline has to be corrected (moved) separately. GRASS provides tools to check topology / geometry and can export the erroneous geometries to a separate layer to be analyzed. There is also a tool available to fix topological errors automatically (remove duplicate lines etc.).

Queries and analysis

When it comes to geometry processing, GRASS can create new geometry as the result of a union, difference or intersection of two geometries. The creation of buffers around geometries is supported as well. To analyze the relationship between two geometries only the “Overlap” operator is currently supported.

Attributive queries are fully supported and thematic layers, too. When working with a thematic layer only attributes of a numeric data type can be used to create the categories. A new dataset can be created from the results of all type of queries (spatial / attributive).

It shall be mentioned here that GRASS provides many more powerful analysis tools when it comes to network tracing (shortest route, travelling salesman etc.) and linear referencing. These capabilities have not been analyzed for this study as they are not of relevance for cadastre purposes.
Each vector dataset in GRASS can be joined to one or more tables of a database to provide additional attributes with the dataset. Between the geometries and the attributes “many-to-one” relationships are permitted.

**Map production and printing**

GRASS supports printing in PDF and EPS (Encapsulated Post Script) format. Maps can also be sent directly to a PostScript capable plotter or printer. GRASS provides a simple north arrow, scale bar and a grid to be included in the map. For more sophisticated features regarding the plotting and publishing of maps an additional module must be used, e.g. the GMT (Generic Mapping Tools) package.

Some simple symbols are predefined for point geometry in GRASS. No information could be found about how to create user defined symbols and the graphic formats allowed for symbols.

Labelling is supported by GRASS with the restriction of only one attribute to be used for the labels. That means to label parcels with their number and sub number a single attribute has to be created before, containing both numbers like “12/4”. Labels can be set at nine different positions regarding to their base point.

**User management**

Authentication and authorization of users is mainly done on operating system level. When GRASS is connecting to a database the database's authentication / authorization mechanism will of course become active.

GRASS users can access the same data simultaneously via the so called “MapSets”. All data in GRASS is part of a certain mapset which is created by a certain user. Only the creator of a mapset can modify data in it, everyone else has only read-access to the data.

**Request management**

This term relates to a client's request for change in cadastre (e.g. splitting of his / her parcel). A GIS for cadastre purposes should provide some request management which allows the staff member in the cadastre office to register a new request or edit an existing one. When registering a new request, information like name of the client (owner), affected parcel(s), date of request, name of staff member to process the request etc. shall be recorded. The involved parcels shall get a kind of “locked” status indicating that they are part of an ongoing cadastre updating process. A dialogue window as shown in Figure 9-2 could be used to enter the needed information. A request management requires of course consideration in the applied data model (by providing certain classes / tables to maintain this kind of data). As GRASS and all of the analyzed GIS in this study do not provide any request management, this is definitely a feature to be developed.
Figure 9-2: Dialogue Window for Request Management

**Cadastre documentation**

When a request for change has been processed and completed (including all previously necessary activities like field work etc.) a protocol of changes needs to be issued. One reason is to inform the land registry office about the changes. Thus, sheet “A” of the related land book can be updated with the information from cadastre. The GIS should provide a “Generate” function (Figure 9-3) to write the required information to GML which is the declared format for data exchange in the data model for BIH. What might be a simple button or dialogue window within the GIS requires a lot of programming for the processes in the background. A protocol of changes shall also be created in PDF format for the documentation of the cadastre office and as a document for the owner. Further on it would be comfortable if out of the GIS a special form can be generated to inform the owner about the completion of his / her request. All of this functionality is to be developed.
History tracking and management

The data model for BIH also defines the maintenance of a history for all features in cadastre. This is modelled by including two attributes “LifeTimeBegin” and “LifeTimeEnd” with each feature class. Thus, when splitting a parcel, the new parcels have their “LifeTimeBegin” attribute set while for the original single parcel the “LifeTimeEnd” attribute is set. None of the features shall ever be deleted from the database!

This philosophy requires certain considerations in the implementation of the GIS and a customized splitting function. The normal procedure in a GIS when splitting a polygon (assuming this functionality is provided at all) would lead to two new polygons while the original polygon is deleted from the dataset. The customized splitting function would exactly do what was described before - setting only the “LifeTimeBegin” and “LifeTimeEnd” attributes but not deleting any feature from the dataset. Whenever a feature is modified it just leads to another historical version of that feature. By the time this can result in many overlaying features at the same location. Most GIS would now read the features according to the order of their database ID when drawing the screen graphic. Thus, a user would only see the feature which has the higher ID in the dataset. If the user would apply the info tool of the GIS and click on a parcel, the tool would show him / her that there is more than one parcel at the clicked position. To avoid any conflicts, a filter should be set to read only the most current features from the database which are those not having set their “LifeTimeEnd” attribute yet. This can be done by a simple attributive query (“... where LifeTimeEnd is null”). By using an attributive query a user can also display the cadastre map at any point in history.

The whole idea as described before works only with a GIS which supports the Simple Feature Model where each feature is described by its own independent geometry. As GRASS is a pure topological GIS, it will lead to a conflict if one tries to split a polygon but also wants to keep the original polygon (as necessary for the history!). From the point of GRASS this is clear violation
of topological rules and will result in many problems when left unfixed. The conclusion is that
GRASS cannot be used as a stand-alone application for the maintenance of cadastral according to
the data model for BIH. It can be used in combination with one of the other tested GIS
(preferable QuantumGIS) in this study to carry out certain analysis.

**Customization of the application**

There are already many additional GRASS modules available. If this is not enough, GRASS can
be customized by using its several hundred commands in user developed shell scripts. Finally
one can write his / her own GRASS module in C / C++.

**9.2. QuantumGIS**

**General**

QuantumGIS (QGIS) is an easy-to-begin-and-use GIS with a very intuitive and modern user
interface. Its strength is the visualization, presentation and the plotting of data. Although
QuantumGIS does not have sophisticated analysis tools, it can be enhanced in combination with
PostGIS or GRASS. QGIS can be installed natively on Unix / Linux, MacOS and MS Windows
based on the platform independent “QT” library.

**Stability and performance**

QGIS (written in C++) works very stable and with a good performance. QGIS has currently no
option to restrict the amount of data loaded. It will always load the full dataset (the complete
shape file, the full PostGIS table etc.). When working with very large datasets that might result in
a performance problem.

**Interoperability**

QGIS can work with several vector data formats via the underlying ogr library e.g. ESRI
Shapefile, MapInfo and GML. No conversion is necessary, QGIS works natively with the
supported formats. Further on QGIS supports data from a PostgreSQL / PostGIS database and via
a special plug-in vector data from GRASS. All those formats can be read and written to. Another
plug-in allows for connection to a Web Feature Service (WFS). The GPX format (GPS
Exchange) can be read and ASCII files containing coordinates can be imported as point layers.
The last two options are also provided by a plug-in.

Regarding the geometry types QGIS allows for types *Point, Linestring, Polygon, Multipoint, Multilinestring* and *Multipolygon*.

When working with PostgreSQL / PostGIS data one has to take care when using data types
“boolean” and “bigint“ (int8). These types are currently not supported by QGIS. If a PostGIS
layer containing an attribute of type “Boolean” is added to QGIS, its features can for some reason
not be identified using the info tool. This is most probably a bug and expected to be fixed in one
of the next versions.

QGIS supports also most common raster formats as used in the GI sector e.g. GeoTiff, Erdas
Imagine, JPEG2000, ECW and via a plug-in GRASS and data received from a Web Map Service.

QGIS can read georeferenced raster images but raster images can also be georeferenced in QGIS
plug-in “Georeferencing”). QGIS supports all SRS as listed and defined by the EPSG.

Additionally the user can define customized coordinate systems and map projections. It is also
possible to re-project data within QGIS.

**Creating and editing topology / geometry**
There is a difference between editing a GRASS vector layer and any other type of vector layer in QGIS. With the “GRASS Toolbox” almost the complete functionality of GRASS is provided within QGIS. Thus, everything mentioned in the GRASS section of this study is valid for QGIS when editing a GRASS vector layer. All remarks made in the QGIS column of the comparison table are therefore related to the situation when a different type of vector layer then GRASS is edited.

Currently there is no tool available to split a polygon where as polygons with holes and multipolygons can be created. Merging of two or more polygons is not possible. Features can be copied and pasted. Points cannot be created by entering their coordinates directly. They can be created on mouse click or by importing a text file containing a list of coordinates. No special construction tools (parallel, perpendicular etc.) are available. Snapping functionality is provided but works only with geometries in the same layer.

Although QGIS also supports the geometry types *Multipoint*, *Multilinestring* and *Multipolygon*, only the multipolygons can really be created currently with the edit tools available.

No tools are available for topological editing (like moving nodes etc.) and topological or geometric control. If the layer is a PostGIS layer the PostGIS methods “ST_IsValid” and “ST_IsSimple” can be used for a basic check for correct geometry. In combination with GRASS geometry can be imported into GRASS and a topology check performed there.

**Queries and analysis**

QGIS provides no methods for testing geometry relationships and just one method for geometry processing, “Buffer Objects”. This method is added via a plug-in and did not work when the authors tried to apply it.

If one decides to work with PostGIS layers (which is very much recommended by the authors), the full geometry processing and analysis functionality of PostGIS can be used. This includes tests on overlapping, touching, intersection etc. of feature geometries. Some of the methods can be used directly from within QGIS's „Query Builder“ while other methods can be used only via the interactive SQL terminal of PostgreSQL („psql“). Using the terminal a „View“ can be created and added to QGIS as a normal PostgreSQL view. Figure 9-4 shows how a view is created as result of a query to find all parcels which contain a building while Figure 9-5 shows how this view is added as layer to QGIS. Figure 9-6 shows the query results in the map (brown color).

QGIS supports all kind of attribute queries.

Thematic layers are fully supported by QGIS and many options are available to configure such layer. Joining a layer with a database table is not supported.
Figure 9-4: Creating a view with PostgreSQL's Interactive Terminal „psql“

```
postgres@mordor:~
Datei Bearbeiten Ansicht Terminal Beiter Hilfe

postgres@mordor:~$ psql lakfao -U katastar
Password for user katastar:
Welcome to psql 8.2.5, the PostgreSQL interactive terminal.

Type: \copyright for distribution terms
\h for help with SQL commands
\? for help with psql commands
\v or terminate with semicolon to execute query
\q to quit

lakfao-> create or replace view parcels_with_buildings as select distinct a.dbid, a.geometrija from kat_parcela a, kat_zgrada b where st_contains(a.geometrija, b.geometrija);
```

Figure 9-5: Adding a PostGIS „View“ in QuantumGIS
Figure 9-6: „View“ results shown in the Map (brown areas)

Map production and printing

QGIS provides the so called “Map Composer“ - a tool where maps can be prepared for printing. A scale bar, logo, text labels and legend can be added to a map in a very comfortable way. A special plug-in also provides grid lines to be overlaid with the map. A map can be exported to several raster formats, to SVG and PDF and can also be sent to a printer / plotter directly.

In QGIS it is possible to create customized symbols. This is done in SVG format.

Features can be labeled with the value of a single attribute where the label position can be one of nine related to the base point.

User management

When using file based data formats authentication and authorization of users is done on operating system level, otherwise it is done on database level. Simultaneous access to the same data is only supported when working with a PostGIS dataset. QGIS does currently not track if somebody else is editing a feature at the same time. The last user writing to the database will „win“.

Request management

As described in the GRASS section.

Cadastre documentation

As described in the GRASS section

History tracking and management

The concept of how to maintain the history has already been described in detail in the GRASS section. In GRASS this concept fails at the end because of GRASS's topology model. QGIS
supports the simple feature model and features can be overlayed without causing any conflict. Thus, several versions of the same feature can exist at the same location. The history concept as described can be supported manually but would be less error-prone if implemented as a function. When working with PostgreSQL / PostGIS a lot of functionality for the history management could be implemented directly in the database using its powerful features like triggers, rules, procedures, views etc. That would require less programming work in the GIS and would make the history management more independent from a particular GIS.

**Customization of the application**

QGIS can be customized and extended by plug-ins written in C++ and Python.

### 9.3. gvSIG

**General**

gvSIG is desktop application for management of graphic data, developed upon the initiative of Ministry of Generalitat Valenciana by the company IVER Tecnologías de la información from Valencia, Spain. Usage of this application is useful in purpose of display of graphic data in business as well as in public administration (municipal or regional cadastres, regional or national ministries). This software is of open type (Open Source) with GPL license, which gives the possibility to programmers to upgrade this program. The program is programmed in JAVA program language. gvSIG supports standard vector and raster formats, and it has easily acceptable user interface. It has the possibility of reading the data locally and in network WMS, WFS, WCS and JDBC. gvSIG may be installed on Windows operating system as well as on Linux system. For starting of gvSIG it is necessary to install JDK 1.4 or 1.5 software for opening of Java applications.

**Stability / Performance**

During the work, loaded were data from one cadastre municipality, little bit more than 20 times, with approximately 600 cadastre plots. No significant problems were noticed, except the application became slower in work with vector and raster data. That also depends on configuration of the computer.

**Interoperability**

gvSIG supports importing of vector formats as well as the geo databases, and those are: SHP, DNG, DWG, DXF, GML (through WFS), files in from of PostGIS, HSQL, MySQL and Oracle Spatial. For export, it supports the following formats; Oracle Spatial, SHP, dxf, PostGIS, GML. On testing of databases, used was PostgreSQL /PostGIS which was read without any problems. Graphic display as well as the labeling of land plots, it shows without any difficulties. gvSIG supports work with MultiPoint, MultiLine and MultiPolygon. In the settings it offers large number of extensions which may be configured as wanted.
Creating and editing topology / geometry

gvSIG creates three types of geometric objects; point, line and polygon. During creation of certain feature class it has to be set which of these three types user wants to create. In editing of geometry used were the data which were in PostgreSQL/PostGIS database. Editing may be created only if feature class is one of these types, i.e. point/point, line/line and polygon/polygon. Regarding the topology control gvSIG does not offer any possibility of control as such.

Queries

With gvSIG-om it is possible to set spatial and attribute queries, which are provided solely trough PostGIS.

Map production and printing

In Project Manager, beside viewer and tables there is also a possibility to create map or chart which user wants to print on the printer. Regarding the possibilities gvSIG is in this segment very rich with functions such as setting the layout of printout, paper format, entry of elements into the map (Views, Images, Scale bars, Legends, Graphic objects, North, Texts, Boxes). Except printout there is also the export of map functions to PDF and PostScript format.
User management

gvSIG supports authorization only on level of database. In the application itself, user authorization is not possible.

Request management

gvSIG as well as all other analyzed applications does not support neither one form of request management, what would for sure be one of the tasks, to develop such function in future application.

Cadastre documentation

After the change has been made, the software should archive some of the documents which are relevant to cadastre operations, as well as the printing of protocol of changes (Prijavni List A and B) and generating forms for information on the owner. Currently gvSIG does not support such form of keeping of documentation, and the task would be to develop such functionality.

History Tracking and management

Even though this item is related to database, for sure the future version should have the possibility to keep the history. This is primarily related to newly created objects and objects which were changed, so the user may see the situation before and after the change. gvSIG does not have the possibility to keep the history, so this function should be additionally programmed.
Conclusion

gvSIG as desktop application is reasonably adjusted for the user. It offers large number of possibilities and extensions, but also deficiencies, such as keeping of cadastre documentation and tools for topological control. Newly developed extensions and codes for upgrading the applications are available on internet and they may be downloaded. There are also various tutorials as well as the extensive documentation in English and German language.

9.4. Kosmo

General

Kosmo is less known desktop software, and it has been developed by several Spanish enthusiasts who used the platform of formerly known Open Source Project – „Open Jump“ Later on, further care on development of Kosmo, has been taken over by SAIG („Sistemas Abiertos de Informacion Geografica“), so that at the moment 9 programmers of this company work on the Kosmo project. Entire program is written in Java program language with already used codes and libraries, such as GeoTools and JTS. Kosmo is applicable under Unix/Linux operating systems and also under the Windows OS. Before the installation of Kosmo it is necessary to meet a minimum of software requirements, and those are JRE windows 1.4.2.11 and JAI (Java Advanced Imaging).
Stability / Performance

In work on Kosmo, used were the data of several cadastral municipalities, with approximately 2100-2200 cadastre plots. Significant problems were not noticed, except in work with large number of data, and especially, the software becomes slower in work with combination of vector and raster data.

Interoperability

Kosmo is very flexible application concerning the interoperability. It supports import of approx. 10 raster formats as well as the possibility of export to them. Out of vector data, Kosmo may load Shape file, Dxf file, Dwg file and Dgn file, while connection with geo date base may be established with Oracle, MySQL and PostgreSQL /PostGIS. Regarding the recognition types of data from the data base (in this case that is PostgreSQL / PostGIS ), Kosmo has without any problems recognized some of the types of data characteristic only to data bases. On the other side, regarding the support for geometry types, Kosmo does not support work with MultiPoint and MultiLine, but it works very well with MultiPolygon. The last version of Kosmo is improved with Extension Manager, which in its settings offers five extensions, and those are: CAD Tools, CSV DataSource, Generate Topology Check File, Geoprocessing Wizard and Raster Tools.

Creating and editing topology / geometry

As well as the most of the desktop GIS software, Kosmo creates three types of geometric objects: point, line and polygon. In creation of specific feature class, first it has to be specified which of these three types the user wants to create. In editing of geometries, it was tested with data which were in PostgreSQL / PostGIS data base. Before the editing, it is necessary first to specify which of the feature classes we want to edit, i.e. start so called. “Edit session”. It is important to mention that in Kosmo editing is possible only on one feature class. Regarding topology control
Kosmo offers several tools, which by criteria requested by the user, checks topologic and geometric accuracy. This is presented on the following image:

![Topology Queries](image)

**Figure 9-9: Topology**

**Queries**

With Kosmo it is possible to create Spatial Queries and Attributive Queries. For both it may be said that they are working comfortably, and the work with functions itself is eased and it is graphically acceptable for ordinary user. Lets say, Query was created to find a land plot with number 345, and of course all of its remaining attributes.

![Query](image)

**Figure 9-10: Query**

**Map production and printing**

In work with Kosmo, first it is necessary to get used on usage of “Project Manager”. It contains three tabulators, with whom it manages data which we want to see, alphanumeric data from tables, and data we want to print. This form of data management and its printing is a little bit
difficult for users, not so much user-friendly, so the new application should definitely have simpler access to printing of certain map, which is located in graphic environment of the program.

**User management**
The entire authorization and authentication of users is done on database level, but not on the level of the application. Kosmo does not support different levels of users, but the future application should support such an important segment of functionality of a quality GIS software.

**Request management**
Kosmo, as well as the other analyzed application does not support neither one from of request management, what should certainly be one of tasks, to develop such functionality in future application.

**Cadastre documentation**
After the performed change, the software should archive some of the documents which are relevant to cadastre operations. Currently, Kosmo does not support such form of keeping of documentation, and without a doubt the task should be to develop such functionality.

**History Tracking and management**
Even though this item is primarily related only to database, certainly the future application should have the option to track the history. This is primarily related to newly created objects (“new version”), and objects that have sustained certain changes (“old version”), so that user in any given moment may look at the status of situation as it was before the change on certain object.

Kosmo, as well as the other open source software does not have the option for keeping the history, so this functionality should be additionally programmed.

**Conclusion**
In general, Kosmo is basically one improved version of already mentioned open source software „Open Jump“, and as such it has for sure found its place with users. Even though the Kosmo project is relatively young, it lasts for almost two years already, it has to be admitted that a lot of good functionalities came out from such a project. That is witnessed by new versions of Kosmo, as well as the extensions which are being developed lately.

It is maybe important to mention that Kosmo, as well as the other FLOSS examples, is very limited with documentation. Indeed, documentation exists, but it is currently only available in Spanish language. We hope that developers and programmers of Kosmo will have in mind its significance, and help other developers in the community by primarily translating their documentation in English language, and that they will generally broaden the documentation related to the code itself.
## 9.5. Comparison Table

<table>
<thead>
<tr>
<th>Categories</th>
<th>Properties / Functionality</th>
<th>GRASS (6.2.3)</th>
<th>QuantumGIS (0.9.1)</th>
<th>gvSIG</th>
<th>Kosmo</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Supported operating system(s)</td>
<td>Unix / Linux, MacOS natively, MS Windows via the “Cygwin” environment, with version 6.3.x natively also MS Windows</td>
<td>Unix / Linux, MacOS and MS Windows natively via the “QT” library</td>
<td>Unix / Linux and Windows</td>
<td>Linux and Windows</td>
</tr>
<tr>
<td>Stability and performance</td>
<td>Stability and performance when working with large datasets</td>
<td>Stability and performance ok. When working with large datasets a region can be created to restrict the amount of data to work on.</td>
<td>Stability and performance ok, no way to restrict the amount of data loaded</td>
<td>Stability and performance ok, it’s getting difficulties with huge amount of data.</td>
<td></td>
</tr>
<tr>
<td>Interoperability</td>
<td>Supported vector formats (import / read)</td>
<td>Via “v.in.ogr” all formats supported by the “ogr” library (about 20), Garmin GPS waypoints, GPS waypoints using GPSBabel, ASCII files containing coordinates, MatGen and MatLab vector maps, DXF</td>
<td>Via the “ogr” library ESRI shape file, MapInfo und GML, GRASS via plug-in, PostGIS</td>
<td>DNG, DWG, DXF, GML (via WFS), shape file, PostGIS, HSQL, MySQL, Oracle Spatial</td>
<td>SHP, DGN, DWG, DXF, and Geo Data Bases (MySQL, Oracle Spatial, and PostGIS)</td>
</tr>
<tr>
<td>Categories</td>
<td>Properties / Functionality</td>
<td>GRASS (6.2.3)</td>
<td>QuantumGIS (0.9.1)</td>
<td>gvSIG</td>
<td>Kosmo</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------</td>
<td>---------------</td>
<td>------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Supported vector formats (export / write)</td>
<td>Via “v.out.ogr” all formats supported by the “ogr” library (about 15), ASCII files for GRASS point layers, DFX</td>
<td>Via the “ogr” library ESRI shape file, MapInfo und GML, GRASS via plug-in</td>
<td>Oracle Spatial, SHP, dxf, PostGIS, GML</td>
<td>Oracle Spatial, SHP, dxf, PostGIS, GML</td>
<td>SHP, DGN, DWG, DXF,and Geo Data Bases (MySQL, Oracle Spatial, and PostGIS)</td>
</tr>
<tr>
<td>Geometry types</td>
<td><strong>Native:</strong> point, line, boundary (borderline of an area), centroid (point within a closed boundary), area (topological composition of boundary and centroid) <strong>Import from:</strong> point, multipoint, linestring, multilinestring, polygon, multipolygon</td>
<td>point, linestring, polygon, multipoint, multilinestring, multipolygon</td>
<td>Point, multipoint, line, polygon, multipolygon</td>
<td>Point, line, polygon, multipolygon</td>
<td></td>
</tr>
<tr>
<td>Data types not supported</td>
<td>PostgreSQL “Timestamp” not supported by v.in.ogr, PostgreSQL “Date” converted to “VarChar” by v.out.ogr</td>
<td>PostgreSQL data types “Boolean” and “bigint (int8)”</td>
<td>- All which has been tested</td>
<td>All which has been tested</td>
<td></td>
</tr>
<tr>
<td>Categories</td>
<td>Properties / Functionality</td>
<td>GRASS (6.2.3)</td>
<td>QuantumGIS (0.9.1)</td>
<td>gvSIG</td>
<td>Kosmo</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td>-----------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Supported raster formats</td>
<td>(import / read)</td>
<td>Via “r.in.gdal” all formats supported by the gdal library (about 60), images from a WMS, MAT-File array, SPOT vegetation data sets</td>
<td>GeoTiff, Erdas Imagine, JPEG2000, ECW&lt;br&gt;GRASS via plug-in&lt;br&gt;WMS (Web Map Service) via plug-in</td>
<td>TIFF, JPG, PNG, BMP</td>
<td>TIFF, ECW, PTIF, SID, BMP, JPG, JPEG, GIF, PNG.</td>
</tr>
<tr>
<td>Supported raster formats (export / write)</td>
<td></td>
<td>Via “r.out.gdal” all formats supported by the gdal library (about 30), MAT-File array, TIFF, PNG, PPM</td>
<td>none&lt;br&gt;JPG, PNG, BMP</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Supported spatial reference systems and map projections</td>
<td></td>
<td>All reference systems and projections as listed by the EPSG, Custom reference systems and projections</td>
<td>All reference systems and projections as listed by the EPSG, Custom reference systems and projections</td>
<td>Yes, Supported EPSG, ESRI, IAU 2000</td>
<td>YES, Supported EPSG</td>
</tr>
<tr>
<td>Support the import of georeferenced raster images</td>
<td></td>
<td>Yes&lt;br&gt;Yes&lt;br&gt;Yes</td>
<td>Yes&lt;br&gt;Yes&lt;br&gt;Yes</td>
<td>Yes&lt;br&gt;Yes&lt;br&gt;Yes</td>
<td>Yes&lt;br&gt;Yes&lt;br&gt;No</td>
</tr>
<tr>
<td>Support for georeferencing</td>
<td></td>
<td>Yes</td>
<td>Yes, via a special plug-in</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Coordinate transformation and reprojection</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Categories</td>
<td>Properties / Functionality</td>
<td>GRASS (6.2.3)</td>
<td>QuantumGIS (0.9.1)</td>
<td>gvSIG</td>
<td>Kosmo</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>---------------</td>
<td>--------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Creating and editing topology / geometry</td>
<td>Split polygons</td>
<td>Yes</td>
<td>To be developed</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Create polygons with holes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Create multipolygons (islands and disjoint polygons)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Merge polygons</td>
<td>Yes</td>
<td>To be developed</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Create points and vertices by entering coordinates</td>
<td>No</td>
<td>To be developed</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Copy and paste features (geometry and attributes)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Construction tools (perpendicular, parallel etc.)</td>
<td>Parallel</td>
<td>To be developed</td>
<td>Symmetry, Rotate, Select tools, Scale, Move, Edit vertex, Internal polygon, Point, Multipoint, line, Arc, Polyline, Polygon, Rectangle, Circle, Eclipse</td>
<td>Yes. Additionally has CAD toolbar</td>
</tr>
<tr>
<td></td>
<td>Create points from coordinates in ASCII file</td>
<td>Yes</td>
<td>Yes</td>
<td>To be developed</td>
<td>To be developed</td>
</tr>
<tr>
<td></td>
<td>Snapping</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, to any point on the line and to points</td>
<td>Yes. With possibilities to adjust radius of snapping</td>
</tr>
</tbody>
</table>

- Yes
- To be developed
- No
<table>
<thead>
<tr>
<th>Categories</th>
<th>Properties / Functionality</th>
<th>GRASS (6.2.3)</th>
<th>QuantumGIS (0.9.1)</th>
<th>gvSIG</th>
<th>Kosmo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topological editing</td>
<td>Inserting nodes supported, moving a node and the connected edges not supported</td>
<td>To be developed</td>
<td>Moving nodes supported</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>geometric editing (moving</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nodes, inserting nodes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tools for topological and</td>
<td>Yes (Control and repair tools)</td>
<td>To be developed</td>
<td>To be developed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>geometric control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queries and analysis</td>
<td>Methods for geometry processing</td>
<td>Creation of buffers, intersection (“and”), difference (“not”, “xor”), union(“or”)</td>
<td>Creation of buffers (via a plug-in), many methods available when using PostGIS</td>
<td>Yes, but provided explicitly via PostGIS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attributive queries</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Create new vector layer</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>from query results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Categories</td>
<td>Properties / Functionality</td>
<td>GRASS (6.2.3)</td>
<td>QuantumGIS (0.9.1)</td>
<td>gvSIG</td>
<td>Kosmo</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Support of thematic layers</td>
<td>Yes, only attributes with a numeric data type can be used</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Support of joining to table(s) of a database</td>
<td>Yes, each vector layer can be joined to as many tables as required</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, supported via Query Builder</td>
</tr>
<tr>
<td>Map production and printing</td>
<td>Printing / plotting capabilities</td>
<td>EPS, PDF, directly to a PostScript capable printer / plotter, advanced publishing capabilities via the GMT (Generic Mapping Tools) package</td>
<td>SVG, PDF, directly to a printer / plotter</td>
<td>PDF, PS, to all installed printers and plotters</td>
<td>to all installed printers and plotters</td>
</tr>
<tr>
<td>Display of north arrow, grid and scalebar</td>
<td>Yes</td>
<td>Yes, grid only via plug-in</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Support of user defined symbology</td>
<td>No information could be found</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Supported graphic formats for symbology</td>
<td>No information could be found</td>
<td>SVG</td>
<td>SVG</td>
<td>SVG</td>
<td>Yes</td>
</tr>
<tr>
<td>Labeling of features with attribute values (one/multiple attributes)</td>
<td>Yes, with the value of a single attribute</td>
<td>Yes, with the value of a single attribute</td>
<td>Yes</td>
<td>Yes, but only one attributive</td>
<td></td>
</tr>
<tr>
<td>Positioning of labels in relation to base point</td>
<td>Vertical (top, centre, bottom), horizontal (left, centre, right)</td>
<td>Vertical (top, centre, bottom), horizontal (left, centre, right)</td>
<td>Vertical and horizontal, Right, left, centre</td>
<td>Yes. Vertical or horizontal</td>
<td></td>
</tr>
<tr>
<td>User management</td>
<td>Authentication and authorization of users</td>
<td>On operating system level respectively database level</td>
<td>On operating system level respectively database level</td>
<td>On database level</td>
<td>On database level</td>
</tr>
</tbody>
</table>

46
<table>
<thead>
<tr>
<th>Categories</th>
<th>Properties / Functionality</th>
<th>GRASS (6.2.3)</th>
<th>QuantumGIS (0.9.1)</th>
<th>gvSIG</th>
<th>Kosmo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Support of simultaneous access to the same data</td>
<td>Yes, via the so called “MapSets”, only the owner of a MapSet can modify data in it</td>
<td>Yes, only when using a database management system</td>
<td>Yes, only when using a database management system</td>
<td>Yes, only when using a database management system</td>
</tr>
<tr>
<td>Request management</td>
<td>Dialogue window to register, edit or delete a request for change</td>
<td>No</td>
<td>To be developed</td>
<td>To be developed</td>
<td>To be developed</td>
</tr>
<tr>
<td>Cadastre documentation</td>
<td>Generate protocol of changes (“Prijavni List B”) as PDF for the cadastre documentation</td>
<td>No</td>
<td>To be developed</td>
<td>To be developed</td>
<td>To be developed</td>
</tr>
<tr>
<td></td>
<td>Generate protocol of changes (“Prijavni List A”) as GML for the land registry</td>
<td>No</td>
<td>To be developed</td>
<td>To be developed</td>
<td>To be developed</td>
</tr>
<tr>
<td></td>
<td>Generate form to inform the owner (PDF)</td>
<td>No</td>
<td>To be developed</td>
<td>To be developed</td>
<td>To be developed</td>
</tr>
<tr>
<td>History tracking and management</td>
<td>Versioning of features</td>
<td>Not possible, see text section for details</td>
<td>To be developed</td>
<td>To be developed</td>
<td>To be developed</td>
</tr>
<tr>
<td>Customization of application</td>
<td>Supported scripting languages</td>
<td>all GRASS commands can be used in shell scripts</td>
<td>Python for QT</td>
<td>Jython (Python for Java Virtual Machine)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Plug-ins supported</td>
<td>Extensions can be written in C / C++</td>
<td>Yes, plug-ins can be written in C++ or Python</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other</td>
<td>Command line available</td>
<td>Yes. All commands and functions can be executed from the command line</td>
<td>Yes. A Python console is available to run QGIS functions from the command line</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 9.5: Comparison Table – Capabilities of FLOSS GIS Solutions for the Maintenance of Cadastre
9.6. PostGIS

PostGIS is an extension to the PostgreSQL database management system, adding spatial capabilities to it. It provides data types and functions to store, process and analyze geometry. PostGIS is certified by the OGC as complying with the Simple Feature Model of the OGC.

The geometry types PostGIS is able to store and maintain include Point, Linestring, Polygon, Multipoint*, Multilinestring and Multipolygon as the most important and frequent ones used.

When it comes to the processing and analysis of geometry PostGIS provides many powerful methods:

**Analysis of geometry relationships:**
- Distance
- WithinDistance (“DWithin”)
- Equals
- Disjoint
- Intersect
- Touches
- Crosses
- Within
- Overlaps
- Contains
- Covers
- CoveredBy
- Relate

**Processing of geometry:**
- Centroid
- Area
- Length
- PointOnSurface
- Boundary
- Buffer
- ConvexHull
- Intersection
- Difference
- Union
While most of the FLOSS GIS do not (yet) provide many functions for geometry processing and analysis this lack can easily be compensated by using PostGIS.

As almost all of the GIS provide support for PostGIS layers this could be a perfect combination. Processing and analysis of geometry is done directly on database level - taking also a “burden” off the GIS. GIS developers could rather concentrate on improving the edit and construction tools which are still very basic in many cases. The GIS should only provide an appropriate user interface facilitating the creation of a spatial query and than simply pass through the query to the database system. Right now none of the compared systems does provide this option. To bypass this current lack a trick would be to run the spatial query via the terminal-based frontend to PostgreSQL (“psql”) and create views from the query results. Those views can then be loaded in a GIS like any standard PostGIS layer.

There is one more aspect to consider. As a GIS normally supports several formats of vector data it still has to implement basic analysis functionality for all those formats different from PostGIS. The recommendation of the authors is to use PostGIS as the main format for vector data in the cadastre sector.

PostGIS is constantly improved and extended and support for raster data and topology is expected in the future as well.

9.7. Conclusion

Three of the compared systems have the potential to be used for cadastre purposes; yet none of them has been tailored for this. GRASS fails as its topological model conflicts with the way history will be maintained according to the data model for cadastre in BiH. Nevertheless GRASS can be used in combination with one of the other GIS (preferable QuantumGIS) to extend their functionality of processing and analysis of geometry.

The combination of a GIS with the PostgreSQL / PostGIS database management system is very much recommended. “QuantumGIS”, “Kosmo” and “gvSIG” work already very well with PostGIS. It should be the right philosophy to leave most of the spatial analysis and processing to the database system while focusing on the provision of proper editing and construction functionality in the GIS software.

When it comes to the history management (e.g. after having split a parcel) a lot of work could again be left to the database management system using its native and powerful technologies like triggers, rules, procedures etc. By doing this the history management could be implemented rather independent from a particular GIS.

The complete history and request management as well as all functionality related the cadastre documentation needs to be implemented. All functionality which is seen mandatory for cadastre purposes but is not yet available in a GIS has been marked as “To be developed” in the comparison table.

For all of the compared systems it should be mentioned that they are being improved constantly and that there is big and very active community of users and developers behind. This is not a guarantee for an everlasting support but it certainly reduces the risk that the development suddenly stops.
10. Data exchange between cadastre and land registry

Cadastre and land registry data in BIH are kept and maintained in separate IT systems and by different authorities. In fact it was stipulated by the law on land registry from the end of 2002 that the land registry must be kept and maintained separately and under the responsibility of the Ministry of Justice. It is not expected to have a single unified system soon as the main focus is currently on the harmonization of cadastre and land registry data.

For the maintenance of the land registry the software “LARIS” has been developed. There is one chapter in this study dedicated to LARIS where more information can be found about the software.

Data exchange between cadastre and land registry is still carried out in analogue form. Signed paper forms are sent or handed over between cadastre and land registry to notify about changes and updates. With the new data model for cadastre data exchange shall be carried out in digital form, in fact by using the XML / GML as an open and system independent format. A qualified electronic signature is required to avoid manipulation of data during “transport” and to identify the addressee.

The software solutions for both registries have to be adapted to allow for data exchange by providing an appropriate import / export interface. Those interfaces have not been developed yet.

11. Development of a cadastre module

Originally it was planned for this chapter to give an estimation of the timely effort required to develop a cadastre module. While trying to estimate the effort, it turned out that a general estimation can hardly be made as the effort varies a lot depending on the methods (functions) already provided by the underlying libraries used in a particular GIS. Because of this the following table (Table 11-1) shows only the main development tasks as seen by the authors, without any statement on the time required. It is advised to check in how far already available (external) libraries such as JTS or GEOS can be used to avoid double work and parallel development. Besides the pure programming tasks to develop a cadastre module, data model and database schema have to be considered and extended accordingly, too. When a particular GIS has been chosen based on which the cadastre module shall be developed, it is recommended to prepare a detailed concept for the software development e.g. by using UML and the ICONX process.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Properties / Functionality</th>
<th>Development Tasks</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating and editing topology / geometry</td>
<td>Split polygons</td>
<td>1. Copy polygon to be split</td>
<td>This edit task is closely linked with the history management.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Split copied polygon</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Set “LifeTimeBegin” attribute for the new polygons</td>
<td></td>
</tr>
</tbody>
</table>

7 http://iconixprocess.com/
<table>
<thead>
<tr>
<th>Categories</th>
<th>Properties / Functionality</th>
<th>Development Tasks</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4. Set “LifeTimeEnd” attribute for the original polygon</td>
<td></td>
</tr>
<tr>
<td>Merge polygons</td>
<td></td>
<td>1. Copy polygons to be merged</td>
<td>This edit task is closely linked with the history management.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Merge copied polygons</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Set “LifeTimeBegin” attribute for the new polygon</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Set “LifeTimeEnd” attribute for the original polygons</td>
<td></td>
</tr>
<tr>
<td>Create points and vertices</td>
<td></td>
<td>1. Provide a dialogue window to enter coordinates (x, y)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>by entering coordinates</td>
<td>2. Forward coordinates entered to the currently active edit function</td>
<td></td>
</tr>
<tr>
<td>Construction tools</td>
<td>Line perpendicular to</td>
<td>Line perpendicular to another line, line parallel to another line with a user</td>
<td>Most construction tools are especially needed when splitting a parcel or</td>
</tr>
<tr>
<td>(perpendicular, parallel etc.)</td>
<td>another line, line parallel</td>
<td>defined distance, line parallel to a polygon side with a distance calculated</td>
<td>registering a new building.</td>
</tr>
<tr>
<td></td>
<td>to another line with a</td>
<td>automatically according to a user defined polygon size, snap to an arbitrary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>user defined distance,</td>
<td>point on a line, snap to end points of a line, snap to vertices of a line</td>
<td></td>
</tr>
<tr>
<td>Topological editing</td>
<td>line parallel to a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(moving nodes, inserting</td>
<td>polygon side with a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nodes)</td>
<td>distance, line parallel to</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a polygon side with a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>user defined distance,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>snap to an arbitrary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>point on a line, snap to</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>end points of a line,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>snap to vertices of a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tools for topological and</td>
<td>When moving a node all</td>
<td>Topology shall be built on the fly (when an edit session is started) as it not</td>
<td></td>
</tr>
<tr>
<td>geometric control</td>
<td>connected edges shall be</td>
<td>supported by the SFS.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>moved, too.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>When a parcel is split, a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>new vertex shall be</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>inserted automatically</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in the boundary of the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>of the neighbor of the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>parcel split and a new</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>node shall be created.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Request management</td>
<td>Dialogue window to</td>
<td>1. Provide a dialogue window to facilitate the creation of spatial queries for the</td>
<td>When using PostGIS (as recommended) geometric and topological control can</td>
</tr>
<tr>
<td></td>
<td>register, edit or</td>
<td>user</td>
<td>be carried out using the PostGIS capabilities. Whether a single geometry</td>
</tr>
<tr>
<td></td>
<td>delete a request for</td>
<td>2. Create the appropriate SQL statement in the background and pass it through to</td>
<td>is valid in itself can be checked with the “ST_IsValid” function.</td>
</tr>
<tr>
<td></td>
<td>change</td>
<td>the DBMS</td>
<td>Overlapping parcels can be detected by using the ST_Overlaps function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Provide a dialogue window to register a request for change (Figure 9.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Store request related data in</td>
<td></td>
</tr>
<tr>
<td>Categories</td>
<td>Properties / Functionality</td>
<td>Development Tasks</td>
<td>Comments</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>the underlying DBMS</td>
<td></td>
<td>3. Lock affected parcel(s) and neighbor parcels</td>
<td></td>
</tr>
<tr>
<td>Cadastre documentation</td>
<td>Generate protocol of changes (&quot;Prijavni List B&quot;) as PDF for the cadastre documentation</td>
<td>1. Provide a dialogue window to select the type of document to generate (Figure 9-3) 2. Create a protocol in PDF format with the cadastre situation before and after the change (update)</td>
<td>A free PDF library shall be used to create PDF documents e.g. “PDFlib Lite”</td>
</tr>
<tr>
<td>Generate protocol of changes (&quot;Prijavni List A&quot;) as GML for the land registry</td>
<td>1. Provide a dialogue window to select the type of document to generate (Figure 9-3) 2. Create a GML file according to the schema as defined for the data exchange between cadastre and land registry</td>
<td>An export / import interface has to be implemented to exchange data between cadastre and land registry according to the GML schema file.</td>
<td></td>
</tr>
<tr>
<td>Generate form to inform the owner (PDF)</td>
<td>1. Provide a dialogue window to select the type of document to generate (Figure 9-3) 2. Create a notify letter in PDF format for the parcel owner</td>
<td>A free PDF library shall be used to create PDF documents e.g. “PDFlib Lite”</td>
<td></td>
</tr>
<tr>
<td>History tracking and management</td>
<td>Versioning of features</td>
<td>1. Provide a dialogue window to allow the user to set the date for which the cadastre data shall be shown. 2. Create the appropriate SQL statement in the background and pass it through to the DBMS (e.g. “… WHERE LifeTimeBegin … AND LifeTimeEnd …”).</td>
<td>The History Management is closely linked to many edit tasks as described e.g. in the section “·Split polygons” of this table.</td>
</tr>
</tbody>
</table>

**Table 11-1: Development Tasks**

The table above will be used further in BiH to develop a specific cadastre maintenance software application.
Annex A - Terms of Agreement

Case Experiment of Use of Free Libre and Open Source Software in Cadastre Development in Bosnia Herzegovina (ICT specialist)

FLOSS Cadastre

1. Background

FAO Land Tenure and Management Unit (NRLA) assists member nations and other FAO units in the analysis, policy formulation and design of strategies to improve access to land and other natural resources and to increase tenure security for environmentally sound and sustainable rural development. Primary responsibilities are related to improving access to land and other natural resources and improving tenure security. NRLA’s normative entity 2KA05 defined for MTP 2006-11 is called sustainable and affordable systems, including security of tenure, for access to land and other natural resources. It will aim on the one hand to produce materials to develop sustainable, affordable systems of access to land and other natural resources, and on the other hand to produce guidelines and methods to develop sustainable, affordable systems of land tenure security. The four main areas that will be focused are the low-cost land tenure security, good governance in land administration, post emergency land institutions and land information for the poor.

The low-cost land tenure security innovative will investigate innovative solutions for cadastral mapping and for cadastral systems. NRLA, in cooperation with FIG and the World Bank Thematic Group on Land, will carry out several activities aiming to clarify availability and suitability of Free/Libre and Open Source Software (FLOSS) for cadastral systems and solutions, and to seek ways to support cadastral system development in setting with poor resources. The activities in 2007 will include the preparation of a scoping paper, a FAO – FIG – WB expert group meeting in Rome and two case studies/experiments. The aim of the initiative is to support FAO member countries to develop and maintain sustainable ICT systems to support cadastre operations.

These terms of reference relate to the preparation of the case experiment in Bosnia Herzegovina, in connection to the World Bank funded the Land Registration Project and a multi-donor (Sweden, Austria and Germany) funded the Land Administration Project, which provides technical assistance to the local institutions in charge of land administration. Among others, both Projects support the development of an IT/IM strategy for the land administration sector in Bosnia and Herzegovina, which is planned to be completed by mid-2008. This case experiment directly contributes to the development of the IT/IM strategy.

2. Terms of Reference

2.1 Description of Activities

All activities will be planned and implemented by the consultant under the guidance of the Chief, Land Tenure and Management Unit FAO in close cooperation with the corresponding the Land Administration Project and the Land Registration Project specialists.

The consultant will:

2.1.1 Review the Open for Change; Scoping paper on the Use of FLOSS in Cadastre and Land Registration Applications and prepare a work plan for the systems’ analysis and
experiment on the use and development of FLOSS solutions for the cadastre and land registration systems in Bosnia Herzegovina.

2.1.2 Carry out a thorough systems analysis on the current and planned cadastre and land registration IT systems in Bosnia Herzegovina.

2.1.3 Carry out a feasibility study on the use of FLOSS solutions for the existing and planned modules of the cadastre(s) and land register(s) IT modules in Bosnia Herzegovina.

2.1.4 Analyse and propose strategy and approach for using/developing FLOSS solutions in the future cadastre and land register systems development. Make corresponding inputs to the write up of IT/IM strategy in land administration for Bosnia Herzegovina.

2.1.5 Develop demo-level OSS solutions for up to 4 selected modules of the cadastre/land registration system(s) in Bosnia Herzegovina as agreed upon with the the Land Administration Project and the Land Registration Project specialists.

2.1.6 Prepare a draft version of the Use of FLOSS solutions for the Cadastre and Land Registration in Bosnia Herzegovina report including general conclusions and recommendations on using FLOSS in cadastre and land registration development.

2.1.7 Prepare a final version of the report which addresses comments on the draft version made by FAO, FIG, WB, GTZ and other partners and the outcome of the Expert Meeting.

2.2 Outputs

2.2.1 A brief work plan paper of maximum 5 pages.

2.2.2 A demo-level OSS solutions for selected modules of the cadastre/land registration system(s).

2.2.3 A draft version of the Use of FLOSS solutions for the Cadastre and Land Registration in Bosnia Herzegovina report not exceeding 50 pages excluding annexes.

2.2.4 A version of the Use of FLOSS solutions for the Cadastre and Land Registration in Bosnia Herzegovina not exceeding 50 pages excluding annexes.

The paper will be prepared in English and it shall be in A4 format, Times New Roman 12 font, and the digital versions shall be submitted as “Word” files. The final report will be translated to a local language by the Land Administration Project as a contribution to the development of the IC/IM Strategy for Bosnia and Herzegovina.

2.3 Duration and Timing

2.3.1 The consultancy starts 15 November 2007.

2.3.2 The work plan shall be submitted to the assignment partners and FAO not later than 12 November 2007.

2.3.3 A draft version of the Use of FLOSS solutions for the Cadastre and Land Registration in Bosnia Herzegovina report including documentation on the developed demo-level OSS solutions for selected 1-3 modules of the cadastre/land registration system(s) shall be submitted by 31 January 2008.

2.3.4 The submission of the final report by 15 March 2008.

3. Budget
The total budget amounts to EUR 8,328 (€ 2,082 per 4 months of work - equivalent to US$ 3,000/month)
Annex B – Overview of various situations in cadastre and land registry in Bosnia and Herzegovina

<table>
<thead>
<tr>
<th>Statistics of cadastre municipalities by type of cadastre and status of land books</th>
<th>With old survey</th>
<th>With new survey</th>
<th>With old survey</th>
<th>With new survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austrian-Hungarian cadastre</td>
<td>Listed cadastre</td>
<td>Land cadastre</td>
<td>Real estate cadastre</td>
<td></td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
<td>New survey finished establishment of cadastre ongoing</td>
<td>Without new survey</td>
<td>New survey finished establishment of cadastre not started</td>
</tr>
<tr>
<td>Starting situation No.</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Number of KO</td>
<td>149</td>
<td>205</td>
<td>173</td>
<td>16</td>
</tr>
<tr>
<td>per-cent</td>
<td>4.3%</td>
<td>5.9%</td>
<td>5.0%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Starting situation No.</td>
<td>5.1</td>
<td>5.2</td>
<td>5.3</td>
<td>6.1</td>
</tr>
<tr>
<td>Number of KO</td>
<td>10</td>
<td>36</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>per-cent</td>
<td>0.3%</td>
<td>1.0%</td>
<td>0.6%</td>
<td>0.7%</td>
</tr>
<tr>
<td>Total by type of cadastre</td>
<td>594</td>
<td>327</td>
<td>2'135</td>
<td>409</td>
</tr>
<tr>
<td>per-cent</td>
<td>17.1%</td>
<td>9.4%</td>
<td>61.6%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Total by type of survey</td>
<td>921</td>
<td>2'544</td>
<td></td>
<td></td>
</tr>
<tr>
<td>per-cent</td>
<td>26.6%</td>
<td>73.4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data source: DEVELOPMENT OF TECHNICAL STANDARDS FOR PRODUCING DATA FOR THE LAND INFORMATION SYSTEM OF BiH, report No 3, April 2006, by BCEOM consultants.