The implementation of an Enterprise Geographical Information System to support Cadastre and Expropriation activities.
The case of Ferbritas Cadastre Information System.

Fernando José Pereira Gil

Project Report submitted in partial fulfilment of the requirements for the degree of *Mestre em Ciência e Sistemas de Informação Geográfica* (Master in Geographical Information Systems and Science)

Instituto Superior de Estatística e Gestão de Informação
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Project Report supervised by

Professor Doutor Marco Octávio Trindade Painho

July 2014

Credits

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The implementation of an Enterprise Geographical Information System to support Cadastre and Expropriation activities.

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Abstract

The processes of mobilization of land for infrastructures of public and private domain are developed according to proper legal frameworks and systematically confronted with the impoverished national situation as regards the cadastral identification and regularization, which leads to big inefficiencies, sometimes with very negative impact to the overall effectiveness.

This project report describes Ferbritas Cadastre Information System (FBSIC) project and tools, which in conjunction with other applications, allow managing the entire life-cycle of Land Acquisition and Cadastre, including support to field activities with the integration of information collected in the field, the development of multi-criteria analysis information, monitoring all information in the exploration stage, and the automated generation of outputs.

The benefits are evident at the level of operational efficiency, including tools that enable process integration and standardization of procedures, facilitate analysis and quality control and maximize performance in the acquisition, maintenance and management of registration information and expropriation (expropriation projects). Therefore, the implemented system achieves levels of robustness, comprehensiveness, openness, scalability and reliability suitable for a structural platform.

The resultant solution, FBSIC, is a fit-for-purpose cadastre information system rooted in the field of railway infrastructures.

FBSIC integrating nature of allows: to accomplish present needs and scale to meet future services; to collect, maintain, manage and share all information in one common platform, and transform it into knowledge; to relate with other platforms; to increase accuracy and productivity of business processes related with land property management.

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Resumo

Os processos de mobilização de terrenos para infra-estruturas do domínio público e privado são desenvolvidos de acordo com quadros legais próprios e confrontam-se sistematicamente com uma situação nacional insuficiente no que se refere à identificação e regularização cadastral, o que acarreta penalizantes ineficiências, com impacte muito negativo para a eficiência e produtividade global.

Este relatório descreve o projecto e ferramentas do FBSIC que, em conjunto com outras aplicações, permitem gerir todo o ciclo de vida de Aquisição de Terra e Cadastro, incluindo suporte para actividades de campo com a integração de informações recolhidas, o desenvolvimento de análises de informação multicritério, acompanhamento de todas as informações na fase de exploração, e a geração automática de relatórios e mapas.

Os benefícios são patentes ao nível da eficiência operacional, com a inclusão de ferramentas que possibilitam a integração de processos e a normalização de procedimentos, facilitam a análise e controlo de qualidade e maximizam a performance na aquisição, manutenção e gestão de informação de cadastro e expropriações. Desta forma, o sistema implementado atinge níveis de robustez, abrangência, abertura, escalabilidade e fiabilidade adequados a uma plataforma estruturante.

A solução resultante, FBSIC, é um sistema de informação cadastral ajustado à finalidade para que foi desenvolvido enraizado na temática das infra-estruturas ferroviárias.

A natureza integradora do SIC permite: suporte às necessidades presentes e possibilidade de expansão para atender à evolução natural das necessidades de negócio; integração de informação proveniente de outros sistemas; recolher, manter e gerir a informação numa única plataforma; e aumentar a eficiência e produtividade dos processos de negócio.

Keywords

Ferbritas, Cadastre Information System, FBSIC, Land, Land Administration, Land Administration System, Land Information System, Land Management Paradigm, Land Administration Domain Model, LADM, Social Tenure Domain Model, STDM, Crowdsourcing, Cadastre, Expropriations, Railway Public Domain, Inspire Directive, Geographic Information Systems, GIS, Web Mapping, ArcGIS Server, Flex, .Net (C#), SOA, GIScience, CyberGIS, Information Integration, Project Management, CyberLand.

Palavras-chave

Ferbritas, Sistema de Informação Cadastral, FBSIC, Território, Administração do Território, Sistema de Administração do Território, Sistema de Informação do Território, Paradigma de Administração do Território, Modelo Dominial de Administração do Território, LADM, Modelo Dominial Social de Posse da Terra, STDM, Crowdsourcing, Cadastro, Expropriações, Domínio Público Ferroviário, Directiva Inspire, Sistemas de Informação Geográfica, SIG, Cartografia na Web, ArcGIS Server, Flex, .Net (C#), Arquitectura Orientada a Serviços (SOA), Ciência e SIG, CiberSIG, Integração de Informação, Gestão de Projectos, CiberTerritório.

Acronyms

BIM	Building Information Modelling
CAD	Computer Aided Design
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CI	Cyberinfrastructure
CIO	Chief Information Officer
CORS	Cross-Origin Resource Sharing
CPO	Chief Project Officer
CyberGIS	Cyberinfrastructure-based Geographic Information Systems
DBMS	Database Management System
DGT	Directorate General for Land
DMS	Document Management System
DUP	Public Use Declaration
EC	European Commission
Esri	Environmental Systems Research Institute
EU	European Union
EuroGeographics	European National Mapping, Cadastral and Land Registry Authorities Organization
EXP	Expropriations Department
ExtCons	External Consultant

FAO	Food and Agriculture Organization of the United Nations
FB	Ferbritas S. A.
FBSIC	Ferbritas Cadastre Information System
FGDC	Federal Geographic Data Committee
FIG	International Federation of Surveyors
Gb	Giga Byte
GDP	Gross Domestic Product
GIO	Geographic Information Officer
GIS	Geographic Information Systems
GIScience	Geographic Information Systems Science
GLTN	Global Land Tool Network
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
HRSI	High resolution satellite imagery
ICT	Information and Communication Technologies
IGP	Portuguese Geographic Institute
ILC	International Land Coalition
INSPIRE	Infrastructure for Spatial Information in the European Union
ISSO	International Organization for Standardization
IT	Information Technologies
KP	Kilometric Point

LA	Land Administration
LADM	Land Administration Domain Model
LAN	Local Area Network
LARSI	Low altitude remotely sensed imagery
LAS	Land administration system
LCDM	Legal Cadastral Domain Model
LGAF	Land Governance Assessment Framework
LINZ	Land Information New Zealand
LIS	Land Information System
MAOT	Ministry for Environment and Spatial Planning
MAOTDR	Ministry for Environment, Spatial Planning and Rural Development
MFP	Ministry for Public Finances
MIG	Geographic Information Metadata Editor
MPAT	Ministry for Planning and Land Administration
MS	Microsoft, Inc.
NIP	Parcel Identification Number
NLIS	National Land Information Systems
NMCA	National Mapping and Cartography Agencies
NRC	National Research Council
PCC	Permanent Committee on Cadastre in the European Union
PCM	Ministries Council Presidency
PDF	Portable document Format

PM	Project Management
PMI	Project Management Institute
PPGIS	Public Participation GIS
PRJ	Railway Projects Department
R&D	Research and Development
REFER	Portuguese National Railway Infrastructure Manager
REFER DCC	Portuguese National Railway Infrastructure Manager Construction and Coordination Department
REFER DPI	Portuguese National Railway Infrastructure Manager Real Estate Department
REFER DSTI	Portuguese National Railway Infrastructure Manager Information Technologies and Systems Department
RFP	Request for Proposal
SAAS	Software as a Service
SAM	Spatial Analysis and Modelling
SDI	Spatial Data Infrastructure
SICE	Expropriations and Cadastre Integrated System
SiNErGIC	Cadastre Information Management and Development National System
SNIG	National System for Geographic Information
SOLA	Solutions for Open Land Administration
STDM	Social Tenure Domain Model
TOP	Survey Team
UK	United Kingdom
UN	United Nations

UNECE	United Nations Economic Commission for Europe
UN-GGIM	United Nations Initiative on Global Geospatial Information Management
UN-HABITAT	United Nations Human Settlements Programme
USD	United States Dollar
USN	Ubiquitous Sensor Network
WAN	Wide Area Network
Web ADF	Web Application Developer Framework
WFS	Web Feature Service
WMS	Web Map Service
WSN	Wireless Sensor Network

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1. INTRODUCTION

1.1. Framework

The project object of this report, Ferbritas Cadastre Information System (FBSIC), was developed between October 1, 2008 and October 12, 2012 in Ferbritas SA (FB) a Portuguese consultancy company owned by REFER (Portuguese National Railway Infrastructure Manager) known as REFER Engineering, SA since February 2013. The company is currently dedicated to the transport sector and in particular the railway (light, heavy, conventional and high speed).

The concepts of integration, complementarity and coordination are particularly important especially in the field of railway infrastructures. The requirements of the associated interventions are very technical in nature and involve multiple specialties and technologies, and the final result is only guaranteed if the various components of this interwoven puzzle are compatible and properly joined together. Moreover, linear infrastructures such as roads, rail, energy, etc. are long lasting, and with long lifecycles. Starting at the planning stage, these infrastructures can last for several decades, during which information is produced by multiple generations and organizations, running the risk of not being used at present, or future, or even get lost in time, if not properly organized and maintained. The resulting information and knowledge have high economic value and significance for organizations, making it vital to preserve.

Although the immediate reason for the development of this information system stems from the need to provide a complete answer to the dynamic control of the registration and real estate status of the national rail infrastructure, the results obtained are of relevance to individuals, companies and public administration. Land asset management is a cross cutting societal topic which is the basis for many economic and control activities. These results are very important since the opportunity and return on investment on, for instances, ownership transfers, land use and taxation cannot be based on inadequate or wrong information.

For these reasons, from the beginning, Cadastre Information System (FBSIC) was designed to meet the needs of the rail sector and beyond. It also is applicable to the activities of entities or organizations to which it is important to ensure the dynamic control of cadastral and real estate property.

FBSIC project framing presented in the next points is based on the 2011 article “Cadastre Information System for Rail in Portugal” (Gil & Mata, 2011e).

1.1.1. Why a Cadastre Information System?

Ferbritas decided to move forward with FBSIC implementation on May 2009, for purely internal reasons towards production processes improving, aiming productivity and efficiency increasing concerning land acquisition processes, which final aim is ensure the availability of sites for national rail infrastructure construction works (Figure 1).

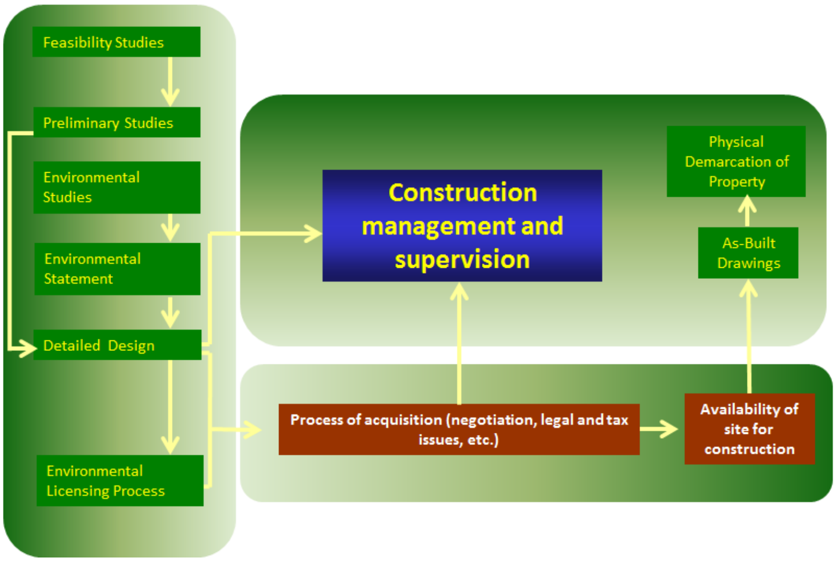


Figure 1 – Availability of site for construction (Gil & Mata, 2011c)

Business demands that expropriations projects have to deliver various documents (drawings, spreadsheets, reports), thus information after being collected and consolidated, has to be distributed to a wide set of reports with completely different formats. Moreover, tools and methodologies available on early 2009 implied that many hours were lost into numerous files and folders manipulation and subsequent digital drawings reports information incorporation, with lots of time lost only with its composition.

Difficulties soon arise, first, in the assembly of the whole process, but they are intensified soon after if there would be a need for an update. In this case, there is a need to replicate the updated information so many times and how often it was initially distributed by different formats or files.

The facts above described framed company awareness to proceed with a solution implementation to highly improve the way information was traditionally captured and transformed; to enable right information to be found and shared across the enterprise, boosting its use in a productively manner; and to provide users with day-to-day tools and capabilities integration, where the majority of the procedures would be automated and within reach of a click (therefore, when someone needed to produce a map or report, this document should be preset and obtained by access to a tool, in a simple manner, according to the context in which the user is in the solution and problem that had to be solve).

1.1.2. FBSIC planning stage

The process started with collecting and processing cadastre and expropriation information from the “foundations” and continued building up the collection of valuable information that the company already had, seeking its immediate availability to the customer and all internal specialties. Geographic information technology was adopted and a solution developed, that was properly integrated with other information subsystems of the organization, focused on the production and business management.

First we proceeded to update the design of the technical and business processes, then the objectives were detailed and the technological platform selected, which were the preconditions to start the project. From this point, the implementation process followed a standard design with the establishment of requirements, functional analysis, application design and related developments.

1.1.3.FBSIC implementation stage

Initially, a prototype was developed to support better decisions on the system to implement. In next stage, we proceeded with the Cadastre Information System (FBSIC) implementation. Below, in Figure 2 is presented an illustration composed of several images: FBSIC Central Module interface (v1.0) (as background image); examples of module outputs and overview images (on top of the base image).

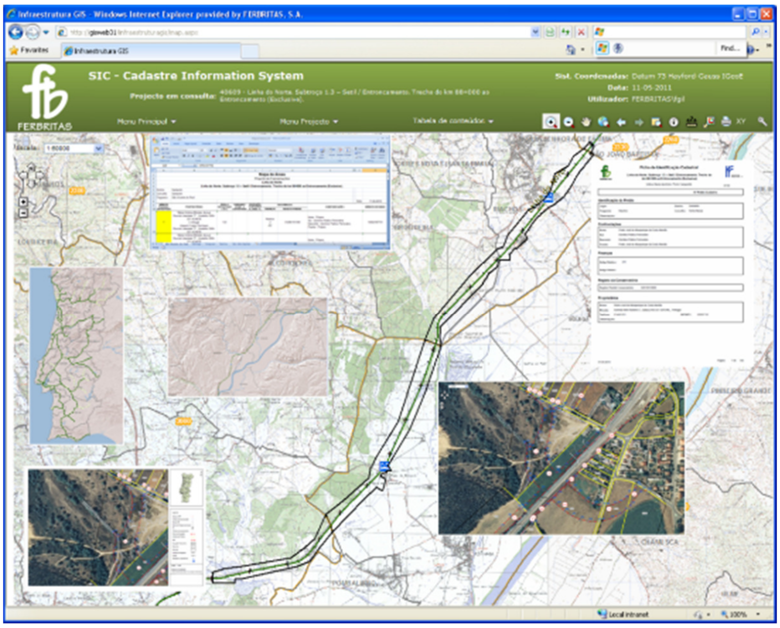


Figure 2 - Cadastre Information System (v1.0) (Gil & Mata, 2011e)

The project team was designed to adequately cover the needs of business and was therefore composed by functional units' elements that have business "know-how", coordinated by a GIS team and supported by an information systems team, with direct involvement of the first level of management. Another condition, that was also essential to promote internal and external resources integration, was performing the work at Ferbritas premises.

Ferbritas Cadastre Information System (FBSIC) is the first step of a business strategy that has multiple purposes, particularly related to increase value for customers and for the reference shareholder, with efficiency of services, information integrity, generation and "democratization" of knowledge in a timeless framework.

FBSIC is used permanently by three business areas and has allowed to formulate new innovative services, and to respond to the needs expressed by clients. They were metrics established that had confirmed the efficiency gains and significant rigor established in pilot projects developed in the preliminary phase that would be confirmed after production entry at cruising speed.

1.1.4. Benefits of FBSIC project

FBSIC is supported by a scalable architecture, standards-based information technology and communication, and interoperability, ensuring a high sustainability of long-term application. It allows viewing and editing of geographic and alphanumeric information of cadastre and expropriations projects. It has a modular character, comprising:

- Data Migration Module (geographic and alphanumeric), with some features for element validation;
- Field Module (information gathering activities support);
- Information Processing Module (field data import and validation);
- Central Module (provides tools that enable: information load and edit on a geographic, alphanumeric and document basis, monitor the quality of the project phases and their transitions (workflow); print maps and formal documents, among other features);
- Backoffice Module (system administrator support);
- Approval Module (enables to perform an approval cycle of expropriations design data before it is sent to DUP);
- Public Domain Management Module (enables to perform land parcels management cycle till their acquisition by the national authorities).

In Figure 3 are shown interface examples of the following modules: Data Migration, Field Module, Information Processing, and Approval.

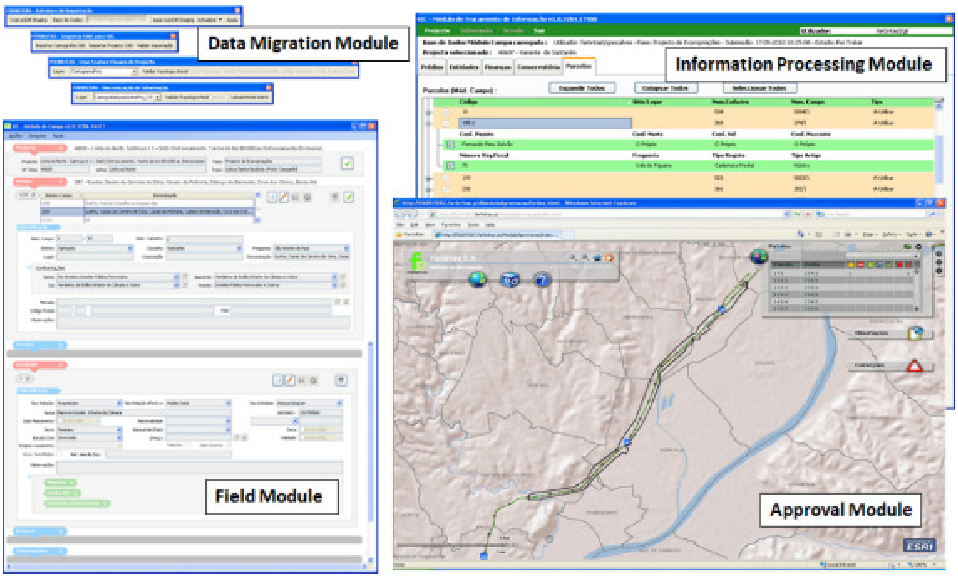


Figure 3 - FBSIC modules overview (Gil, 2010b)

The benefits are evident at the level of operational efficiency, with the inclusion of tools that enable process integration and standardization of procedures, facilitate analysis and quality control and maximize performance in the acquisition, maintenance and management of cadastre and expropriations information (expropriations projects). The implemented system achieves levels of robustness, comprehensiveness, openness, scalability and reliability suitable for a structural platform.

1.2. Objectives

The project report objective is, to review in detail all the aspects related with the implementation projects of an enterprise Geographical Information System (GIS) FBSIC, to support Cadastre and Expropriations activities in Ferbritas, SA (actually known as REFER Engineering, SA) from its early planning stage to the last maintenance phase (covering about four years); present a final overview and main conclusions.

From the beginning, FBSIC was designed to meet the needs of land in the rail sector (right-of-way), where Ferbritas is positioned, and beyond, as a generic cadastre tool, since it's also applicable to entities or organizations activities to which it is important ensure cadastral and real estate property dynamic control.

The processes of land mobilization for public and private domain infrastructures are developed according to proper legal frameworks and systematically confronted with the impoverished national situation as regards the cadastral identification and regularization, which leads to big inefficiencies, sometimes with very negative impact to the overall effectiveness.

1.3. Report organization

In short, I will make a guided tour from the beginning of the early planning stages; then I will make a stop at the main implementations that comprise FBSIC, and talk about the several integrations achieved with other subsystems, both from an inward perspective (what was implemented and why) and from an outward perspective (how were the solutions developed at a high level perspective) with an emphasis in project management; then I will refer the production activities carried out in parallel to the implementation works; and I will point out the presentations, conferences, articles and awards where FBSIC was an actor.

Finally, I will present a summary, the report main conclusions, and some future references.

1.4. Main personal contributions to Cadastre Information System

1.4.1. Main activities and responsibilities

I was the Geographic Information Officer and Head of the GIS Department at Ferbritas S.A. between October 2010 and April 2013 (1st line manager reporting directly to Company's CEO); and I was GIS Team leader and Senior GIS Project Manager, between October 2008 and September 2010. In both periods, my main activities and responsibilities were:

- Consolidate and extend the company's Geographic Information Systems skills, in accordance with the board strategic guidelines, providing increased business, marketing and technical support in GIS. I aimed to drive my conduit by quality principles, efficiency, efficacy, simplifying procedures, cooperating and communicating in an effective way;
- Conceive, plan, submit to board approval, manage and monitor the yearly GIS team/department activities and budget; lead FBSIC project teams that integrate other company units and external suppliers; FBSIC project champion; responsible for quality control of GIS solutions, and FBSIC users (internal and external) trainer;
- Coordinate the development of the corporate geographic information platform, understood as an added value product for railway studies and project departments, and other company's functional units. In this context, I lead the production teams of Cadastral Recovery of Rail Public Domain GIS projects, Railway Infrastructure GIS projects, Land Administration Systems, and Expropriation GIS projects;
- Contribute to REFER (Portuguese Railway Infrastructure Manager) GIS standard (Cartography and Railway Projects);
- GIS Project Management in Cadastre and GIS unit, GIS software manager (Esri ArcGIS Desktop/Server 10.1), Geodatabases manager (SQL Server 2008 R2), GIS modelling (model builder), user support and development of simple Web GIS Apps (ArcGIS Viewer for Flex v3.6);
- Present Ferbritas GIS solutions internally and in national and international fora (about 38 presentations between 2008 and 2012: 1-2008, 7-2009, 11-2010, 8-2011, 11-2012. See Annex 9 where FBSIC main presentations list between 2010 and 2012 is presented), and support board marketing initiatives related to GIS solutions.

Relating to the professional activity referred previously, I highlight the article, case studies, technical documents, posters and application manuals in which I collaborated, being responsible by all technical contents, text and figures, which are presented in section 4.

In what respects my participation in FBSIC project, I highlight the subsequent features: coordination and project management from end to end through initiating, planning, executing, monitoring, controlling, closing stages, and later guarantee and maintenance periods, between October 2008 and October 2012; and the following interventions:

- Semantic gaps bridge between software development team and business users;
- Database modelling collaboration;
- Interface definition and design participation;
- Workflows definition collaboration;
- Requirements gathering and analysis participation;
- FBSIC solution software tester;
- FBSIC solution's public presentations speaker.

2. LITERATURE REVIEW

The following sections contain a brief literature review of the main themes related to the topic of this report, such as: Land Administration, Cadastre, and GIS with emphasis to the relationships between them.

2.1. Land Administration

2.1.1. Land

The concept of land includes properties, utilities, and natural resources, and encompasses the total natural and built environment within a national jurisdiction, including marine areas (Williamson, et al., 2010).

Land can be viewed from a variety of perspectives, depending on the context within which it is being discussed, as exposed in Figure 4.

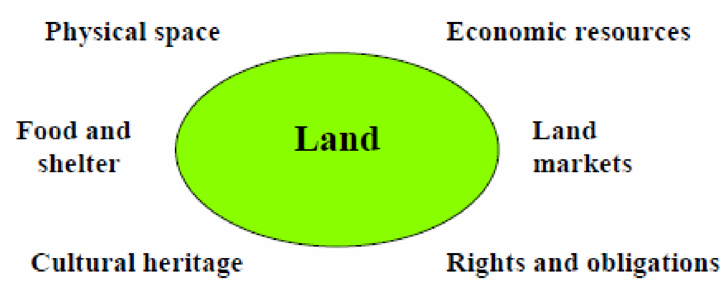


Figure 4 - Perspectives on land (United Nations, 2004)

Therefore, land has many different meanings in a society, and even to the same person. Those could include (Zevenbergen, 2002):

- economical asset (for industry, but especially for commercial farming);
- social security (especially for subsistence farming);
- place to live (compare the Habitat Global Campaign on Secure Tenure);
- 'a family heirloom' (like castles and mansions in England):
- power base for jurisdictions (governments in exile miss this very much);
- place to put down transport links;
- places of social-cultural importance (worship, historical monuments etc.), etcetera.

The way it is 'defined' differs between those approaches. Land is preliminary defined by the use of patterns, which if enough individualized and supported at some point by a legal construct, can be 'owned'. Even then a difference can exist between ownership and use (…) (Zevenbergen, 2002).

The role of land in the economy of each nation is not always obvious, but is of great significance. Without secure land rights there can be no sustainable development, for there will be little willingness by local people and by foreigners to make long-term investments. At least 20% of the gross domestic product (GDP) of most nations comes from land, property and construction (UNECE, 2005).

The land sector in a particular country is evidently a complex system composed by quite an extensive list of technical and legal aspects that have direct impact on economic development and environmental as well as social dimensions. Land policy, as the overall guideline for the formulation of regulatory frameworks and tools with respect to land and stating the values and objectives to be followed by the land sector, sets the basis for the construction of healthy land tenure systems (Antonio, et al., 2014).

As shown in Figure 5, under these frame conditions, there are a number of hierarchical levels. In this regard, Enemark (2009) cited by (Antonio, et al., 2014), argues that this hierarchy shows the complexity of organizing policies, institutions, processes, and information for dealing with land in society. This conceptual understanding provides the overall guidance for building a land administration system in a given society, independent of the level of development. The hierarchy should also provide guidance for adjusting or reengineering an existing land administration system.

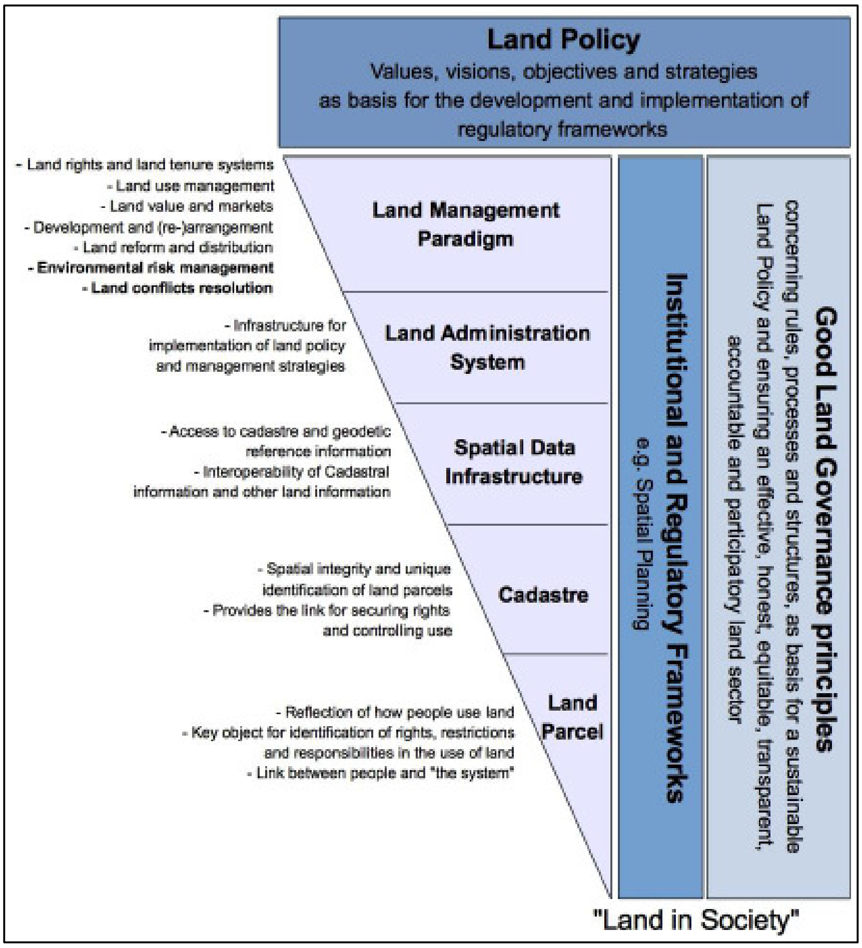


Figure 5 - A comprehensive representation of the land sector (Magel, Klaus and Espinoza, 2009), based on Enemark, 2006 cited by (Antonio, et al., 2014)

It is now internationally accepted that poverty, land rights, conflict and the sustainable use of natural resources are correlated, and that secure access to land for the rural poor is fundamental to improving their livelihoods. Furthermore, asset ownership by the poor is increasingly recognized as essential to sustained, broad-based economic growth (ILC, 2005).

Land is thus a scarce resource involving a wide range of rights and responsibilities. When poorly managed, it can become contentious often leading to disputes, conflict, degradation and other problems, all of them drivers of slum development and poverty in urban areas (Clos, 2011).

2.1.2.Land Administration

Land administration is not a new discipline. It has evolved out of the cadastre and land registration areas with their specific focus on security of land rights (Williamson, et al., 2010).

Land administration systems (LAS) are about addressing land tenure, land value, land use, and land development problems by providing a basic infrastructure for implementing land related policies and land management strategies to ensure social equity, economic growth and environmental protection.

The evolution of LAS is influenced by the changing people to land relationships over the centuries. Even though Figure 6 depicts a Western example of this evolving relationship, a similar evolution can be plotted for most societies (Williamson, 2008). This diagram highlights the evolution from feudal tenures, to individual ownership, the growth of land markets driven by the Industrial Revolution, the impact of a greater consciousness about managing land with land use planning being a key outcome, and, in recent times, the environmental dimension and the social dimension in land (Ting and others, 1999) cit. by (Williamson, 2008).

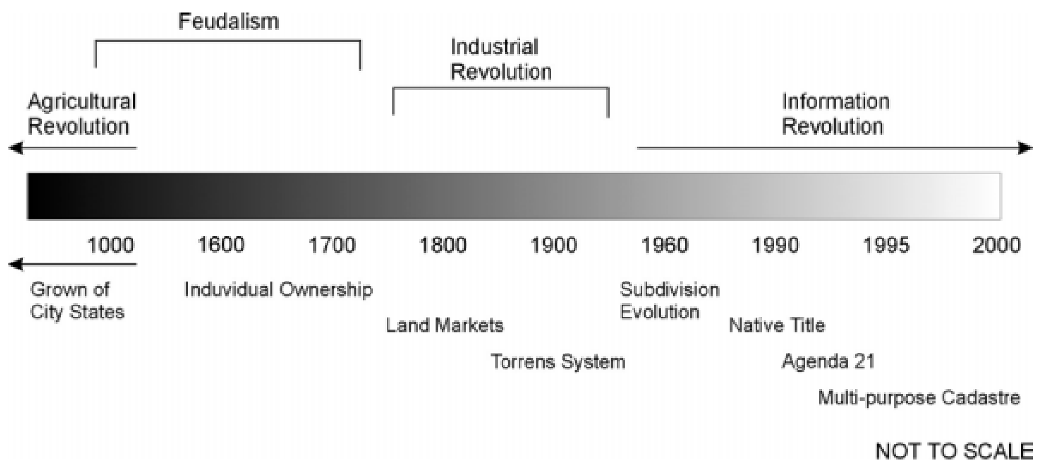


Figure 6 - Evolution of people to land relationship (Ting and others, 1999) cit. by (Williamson, 2008)

On the other hand, land management is the issue of putting land resources into efficient use, meaning producing food, shelter and other products or preserving valuable resources for environmental or cultural reasons. Land administration is the governmental responsibility to provide security of tenure and information about tenure issues for property markets and governmental and private business activities (UN-HABITAT, 2012).

Building effective and enduring land administration systems requires long-term investment and continuing support. Although land records are expensive to compile and to keep up to date, a good land administration system produces many benefits (UNECE, 2005).

Likewise, one vision for a fully automated system would include more than just a GIS - other computer-based components such as document management system, database management system, and resolution of organizational and legal problems. Such a system would support not only mandated land records management responsibilities of local jurisdictions, but would also serve the needs of a broad range of actors using land information for a wide variety of programs and functions (Ventura, 1997).

Though, land administration is part of the infrastructure that supports good land management it should be treated as a means to an end, not an end in itself (UNECE, 2005).

So, land administration can be considered as basis for good governance, in fact, intelligent and effective land administration systems are a solid condition for good governance and economic development. This concerns developments regarding legal security (a basic requirement for investors), access to credit (mortgage), spatial planning (in support of economic and environmental development) and effective and efficient land taxation. In case this is not well organised, there may be many disputes, frustrating efficient land use. Therefore, protection of ownership through property registers is an important condition for good governance and sustainable economic development (de Zeeuw & Salzmann, 2011).

CheeHai Teo goes further on (Lemmen, 2013) to explain ‘fit for purpose’ we could, in a simplistic manner, say the following: it has to be applicable, it has to be appropriate – relevant to the contexts we are working with – and it has to be affordable. Therefore, when designing our intervention, we need to carefully consider the context and culture, the capacities and scale, the opportunities and options, the ability to innovatively and incrementally enhance the effectiveness and efficiency of the intervention at that point in time. And all of that with an eye on achieving maximum benefits.

In fact, an effective land administration is more than the provision of a register. Good data acquisition, management and distribution is essential, but if E-governance and a spatial enabled society are in place, it’s impact on good governance can be improved substantially (Zeeuw, et al., 2013).

So, as stated at (Enemark, 2013) the need to address land management issues systematically pushes the design of LAS towards an enabling infrastructure for implementing land policies. Such a global land administration perspective is presented in Figure 7.

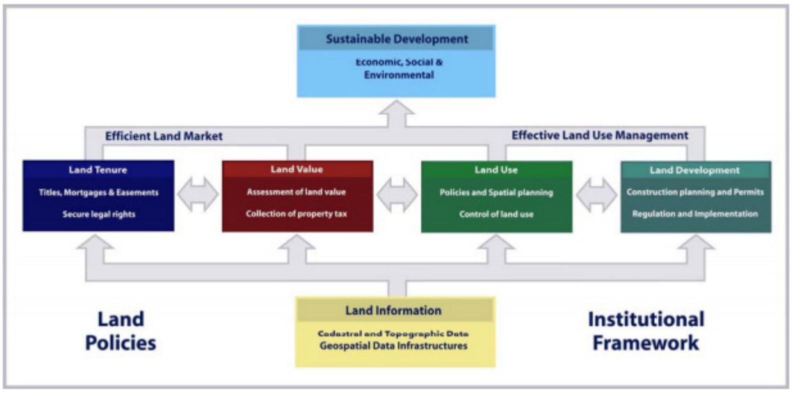


Figure 7 - A global land administration perspective (Enemark, 2004)

The four land administration functions are different in their professional focus. Even if land administration is traditionally centred on cadastral activities, modern LAS deliver an essential infrastructure and encourage integration of the processes related to land tenure (securing and transferring land rights); land value (valuation and taxation of land); land use (planning and control of the use of land); and land development (implementing utilities, infrastructure and construction planning). The four functions interact to deliver overall policy objectives, and they are facilitated by appropriate land information infrastructures that include cadastral and topographic datasets linking the built and natural environment (Enemark, 2013).

Lately, the land administration sector is developing data, standards, technologies and infrastructures as the basis for good land administration practices. In setting up a system, products should be used and developed, considering two important aspects according to (Zeeuw, et al., 2013):

1. The required investment made in tools and products, to make it possible. The investment that is needed in setting up a LAS can be defined by three components (in each, I refer a group of select features mentioned in the original work):
   a. Data and standards (…)
   b. A method for the collection of data, management of the systems (software) and the distribution of data, information and knowledge (…)
      - data distribution - internet based web services (Web mapping Services, (WMS) and Web Feature Services (WFS)), introducing new concepts like Software As A Service (SAAS));
   c. Choices on the system: people and organisations, service levels and infrastructure.
      - The LAS service level is highly society dependent. For example, the notary and banking system in The Netherlands asks for a 24/7 availability and double back-up system of cadastral and land registry information, provided through WMS and WFS services. As a result, land administration has become fully integrated in the Dutch economic system; (...)

2. The required return on investment in products, processes and services, to make it feasible:
    a. Based on the societal demand, strategic decisions should be made (…)
    b. Return on investment can be obtained on data, information and knowledge or a mixture of these.
        - For example, the Dutch Kadaster manages a database with more than nine million parcels (spatial and legal data). On yearly basis, about 25% of the Kadasters turn-over is generated by the provision of information products derived from this database.

Furthermore, the benefits of good land administration according to (Mclaren & Stanley, 2011) are shown in Figure 8.

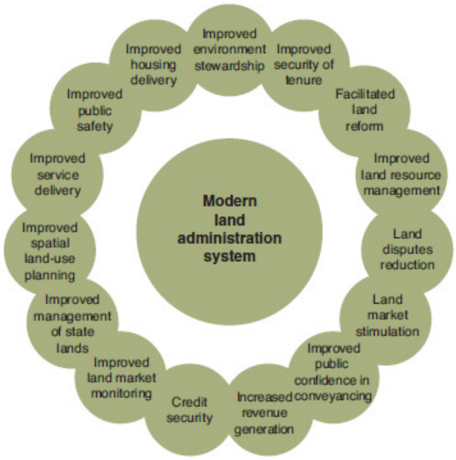


Figure 8 - Benefits of Good Land Administration (Mclaren & Stanley, 2011)

Nevertheless, and according to (Enemark, et al., 2014), the approach used for building land administration systems in less developed countries should be flexible and focused on citizens' needs, such as providing security of tenure and control of land use, rather than focusing on top-end technical solutions and high accuracy surveys. A fit-for-purpose approach includes the following elements:

- Flexible in the spatial data capture approaches to provide for varying use and occupation.
- Inclusive in scope to cover all tenure and all land.
- Participatory in approach to data capture and use to ensure community support.
- Affordable for the government to establish and operate, and for society to use.
- Reliable in terms of information that is authoritative and up-to-date.
- Attainable in relation to establishing the system within a short timeframe and within available resources.
- Upgradeable with regard to incremental upgrading and improvement over time in response to social and legal needs and emerging economic opportunities.

A final reference to the Land Governance Assessment Framework (LGAF), a diagnostic tool, intended as a first step to help countries deal with land governance issues.

The core version of LGAF comprises a set of detailed indicators to be rated on a scale of precoded statements (from lack of good governance to good practice) based, where possible, on existing information. These indicators are grouped within five broad thematic areas that have been identified as major areas for policy intervention in the land sector (Deininger, et al., 2012):

- Legal and institutional framework (…)
- Land use planning, management, and taxation (...)
- Management of public land (…)
- Public provision of land information (…)
- Dispute resolution and conflict management (…)

Therefore, the LGAF provides a holistic diagnostic review at the country or regional levels that can inform policy dialogue in a clear and targeted manner (Enemark, et al., 2014).

2.1.3. Land Management Paradigm

The cornerstone of modern land administration theory is, according to (Williamson, et al., 2010), the land management paradigm, in which, land tenure, value, use and development are considered holistically as essential and omnipresent functions performed by organised societies (Figure 9).

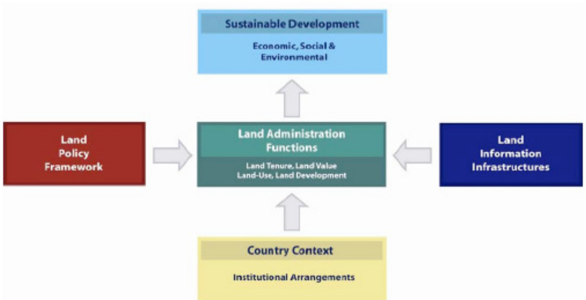


Figure 9 – The land management paradigm (Enemark, 2004) cit. by (Williamson, et al., 2010)

Land management activities reflect drivers of globalization and technology. These stimulate the establishment of multifunctional information systems, incorporating diverse land rights, land use regulations, and other useful data. A third driver, sustainable development, stimulates demands for comprehensive information about environmental, social, economic, and governance conditions in combination with other land related data (Williamson, et al., 2010).

In conclusion, modern land administration theory requires implementation of the land management paradigm to drive systems dealing with land rights, restrictions and responsibilities to support sustainable development. It also requires taking a holistic approach to management of land as the key asset of any jurisdiction (Williamson, et al., 2010). Moreover, in Figure 10 is presented (Zeeuw, et al., 2013) view of land administration in relation to sustainable development.

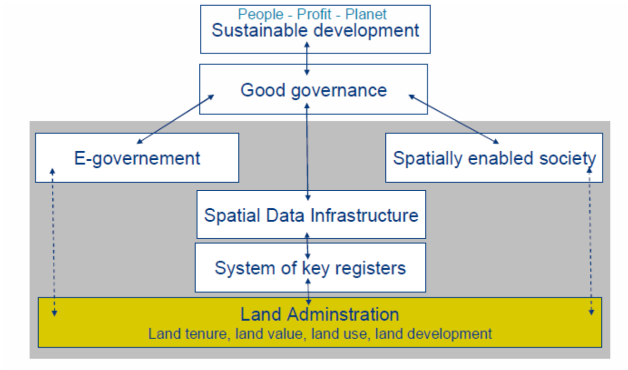


Figure 10 - Land administration in relation to sustainable development (Zeeuw, et al., 2013)

In Portugal, large steps towards land management paradigm implementation took place with the creation, in 2006, of the SiNErGIC project.

The SiNErGIC project vision was to create, under the coordination of Portuguese Geographic Institute (IGP), the Unique Parcel Information according with a shift of paradigm in Public Administration of looking for integrated, articulated and add-value solutions. On the other hand, and in accordance with the vision, it was defined a set of main goals to create the information system infrastructure to serve citizens, owners as well as State allowing them to access in one-stop spot to legal, fiscal and spatial parcel characterization (Julião, et al., 2010) (Roque, 2009).

Lately, SiNErGIC project is being reformulated in a new project designated the Cadastre Information National System (DGT, 2013).

2.1.4.Land Administration Domain Model

2.1.4.1. Goals and Basic Features

The Land Administration Domain Model (LADM) received ISO official approval as an official International Standard on 1st November 2012, as ISO 19152:2012 (ISO, 2012). LADM among other features, defines terminology for land administration, based on various national and international systems.

LADM will serve two goals, mainly (Uitermark, et al., 2010):

1. Provide a basis for the development of Land Administration systems (LA systems);
2. Enable involved parties, both within one country and between different countries, to communicate, based on the shared vocabulary (that is, an ontology).

On the other hand, LADM defines a reference model, covering basic information-related components of LA. Basic components relate to the following (Uitermark, et al., 2010):

1. Parties (people and organizations).
2. Rights, responsibilities, and restrictions (RRR's).

3. Spatial units (parcels, buildings and networks).
4. Spatial sources (surveying).
5. Spatial representations (geometry and topology).

Additionally, and according to (Seifert, 2012) is shown in Figure 11 an overview of LADM packages (with their respective classes).

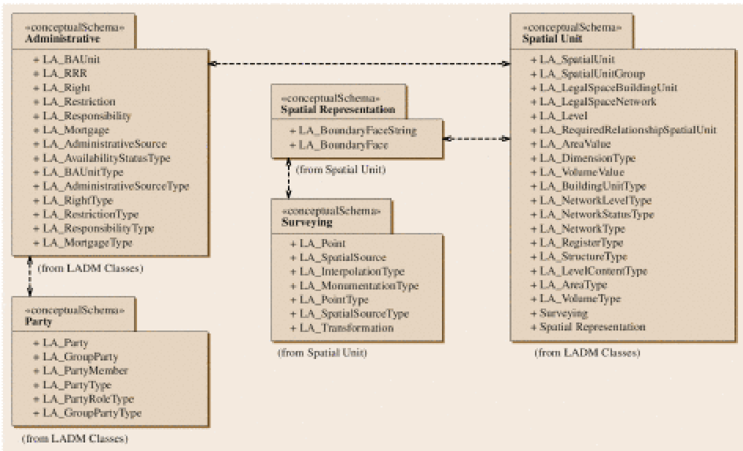


Figure 11 - Overview of LADM packages (with their respective classes) (Seifert, 2012)

(Hespanha, et al., 2013) state that LADM provides a generic data model for land administration based on common grounds. It is possible to use it in so-called informal and customary environments (Figure 12). This provides a basis to apply the model to support equal land rights for all. To support in avoidance of land grabbing by mapping the existing situation fast and with unconventional approaches as point cadastres, satellite images, boundary drawing instead of measuring, with participatory approaches, accepting errors and with the intention to improve quality later. With its broad functionality LADM can support in the development of concepts for land administration systems, which can support administration of multiple types of tenure. This is also valid for the Social Tenure Domain Model (STDM), presented later on.

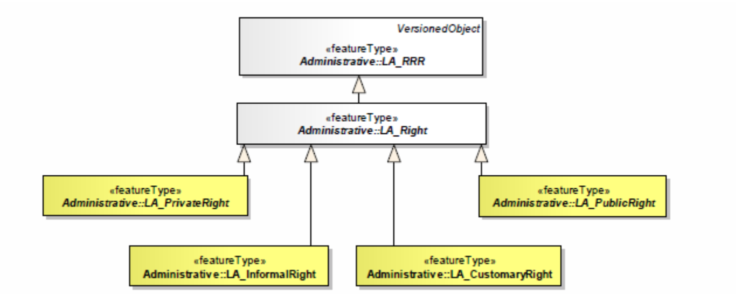


Figure 12 - Further alignment with LADM developments is needed (Hespanha, et al., 2013)

2.1.4.2. Portugal Country Model

Portugal Country Model is derived from the LADM focused on the geometric (Cadastral Survey and Mapping) and legal (Land Registry) components of the Cadastre, at

“Development methodology for an integrated legal cadastre” (Hespanha, 2012) PhD thesis. In Portugal, modelling of the Cadastral Domain has evolved significantly from the end of XX century to the first decade of the XXI century, where based on the latest Portuguese specifications, there’s a focus on just two of the three forms of property: (1) private ownership and (2) local community ownership, omitting thus public domain ownership. The end result is the absence of a strict view of a planar partition, once there will be gaps over the country territory. Furthermore, consideration of transitional areas that are currently of an informal legal status, as the Deferred Cadastre or the Urban Areas of Illegal Genesis (AUGI, in Portuguese), will form areas that could overlap private Real Property parcels (Lemmen, et al., 2010).

2.1.5. The Global Land Tool Network (GLTN)

The Global Land Tool Network (GLTN) is an alliance of global regional and national partners contributing to poverty alleviation through land reform, improved land management and security of tenure particularly through the development and dissemination of pro-poor and gender-sensitive land tools (GLTN, 2012).

According to (GLTN, 2012a) a land tool is a practical way to solve a problem in land administration and management. It is a way to put principles, policies and legislation into effect. The term covers a wide range of methods: from a simple checklist to use when conducting a survey, a set of software and accompanying protocols, or a broad set of guidelines and approaches. The emphasis is on practicality: users should be able to take a land tool and apply it (or adapt it) to their own situation.

To reach the overall goal of poverty alleviation through land reform, improved land management and security of tenure, the GLTN Partners are in the process of developing 18 key land tools (presented in Figure 13) which need to be addressed in order to deal with poverty and land issues at the country level, across all regions. Some of these tools are at an advanced stage of development and are being tested in selected countries (e.g. the Social Tenure Domain Model and Gender Evaluation Criteria), whereas others are still at the early stages of development (GLTN, 2012a).

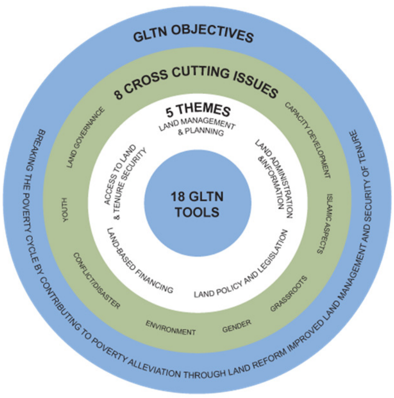


Figure 13 - GLTN Diagram Tools (GLTN, 2012a)

The Land Tool Development section of the above referred website provides two links, i.e. Themes, in which the tools are embedded, and Cross Cutting Issues (GLTN, 2012a).

2.1.6. Social Tenure Domain Model (STDM)

Where there is little land information, there is little or no land management. Conventional Land Administration Systems are based on the ‘parcel approach’ as applied in the developed world and implemented in developing countries in colonial times. A more flexible system is needed for identifying the various kinds of land tenure in informal settlements or in customary areas (Lemmen, 2010).

Traditional land surveys are costly and time consuming. For this reason alternatives are needed; e.g. boundary surveys based on handheld GPS observations, or by drawing boundaries on satellite images. This means of course a different accuracy of co-ordinates. Surveyors understand this and surveyors are needed to provide quality labels and to improve the quality of co-ordinates at a later moment in time (Lemmen, 2010).

In this same direction (Hespanha, et al., 2013) states that flexibility is needed in relation to the way of recording, the type of spatial units used, the inclusion of customary and informal rights, the data acquisition methodologies and in the accuracy of boundary delineation. It is less important to produce accurate maps. It is more important to have a complete cadastral index map and to know how accurate the map is.

In this context, UN-HABITAT develops an initiative to support pro-poor land administration: The Social Tenure Domain Model (STDM).

Because, as stated by (Augustinus, 2010a), currently, most poor people are not covered by a land administration system and its linked land information management system. This means that they do not benefit from these systems in regard to tenure security, planning and service delivery, slum upgrading, resolution of disputes and so on. STDM would make it possible for a country and/or local government to go to scale and include low-income people in their information systems and in their land delivery approaches. This would have a direct impact on the quality of life of the poor and on poverty reduction. It would also have a direct impact on the stabilisation and governance of cities, also through the empowerment of the poor. This is because it is not possible to create sustainable cities if the poor are not part of the solution.

In fact, STDM is a ‘specialization’ of LADM, that means, structurally it is a little less complex than LADM, but it contains almost the same functionality of LADM, under different terminology STDM is meant specifically for developing countries, countries with very little cadastral coverage in urban areas with slums, or in rural customary areas. It is also meant for post conflict areas. The focus of STDM is on all relationships between people and land, independently from the level of formalization, or legality of those relationships (Lemmen, 2010).

Moreover, the work presented in (Paasch, et al., 2013) paper show that it is possible to extend the Land Administration Domain Model, LADM and its code lists, using the Legal Cadastral Domain Model, LCDM and the Social Tenure Domain Model, STDM, to making it possible to describe non-formal rights, restrictions and responsibilities; it's also recommended by the authors further research in this issue.

In agreement with previously arguments (Hespanha, et al., 2013) states that LADM provides a generic data model for land administration based on common grounds. It is possible to use it in so-called informal and customary environments. This provides a basis to apply the model to support equal land rights for all. To support in avoidance of land grabbing by mapping the existing situation fast and with unconventional approaches as point cadastres, satellite images, boundary drawing instead of measuring, with participatory approaches, accepting errors and with the intention to improve quality later. With its broad functionality LADM can support in the development of concepts for land administration systems which can be in support administration of multiple types of tenure. This is also valid for the Social Tenure Domain Model (STDM).

2.1.7. Solutions for Open Land Administration (SOLA)

To support the issues referred above, concerning computerised cadastre and registration systems in developing countries, was launched, in mid-2010, the Solutions for Open Land Administration (SOLA) Project.

SOLA is an open source software system that aims to make computerised cadastre and registration systems more affordable and more sustainable in developing countries. Three countries (Samoa, Nepal and Ghana) have been identified for pilot implementation of the software (FAO, 2013).

According to FIG/FAO booklet (FIG and FAO, 2010) the costs of proprietary software licenses have proved to be a constraint, but even more, the lack of capacity, models and support to develop software have stopped initiatives. Open-source software, which has become a credible alternative to proprietary software, provides a way forward. Open-source solutions are more flexible and adaptable to local conditions and languages than proprietary software. By using and improving open-source software, cadastres can build local knowledge and contribute to the development of open-source projects that can in turn benefit other cadastres worldwide.

Finally, I would like to refer that, it is already possible to proceed with the installation of the SOLA Release Candidate Web Start applications, and install and configure the development tools used for SOLA, with the support of the SOLA Developer Setup Bundle (FAO, 2013).

2.1.8. Crowdsourcing land administration information

According to (Mclaren, 2009) the ease and increasing use of GPS for data capture, adoption of data standards, the availability of Web 2.0 tools and the efficiency of mashups for managing and distributing the information are accelerating the growth of crowdsourcing and distributed citizen sensing.

In this context, crowdsourcing is being used to improve public confidence in land administration records in several countries in Europe and Central Asia. Land records are now available through the Internet and citizens are encouraged to report discrepancies so they can be corrected (Tonchovska, et al., 2014).

But, the challenge for land professionals is not just to replicate elements of their current services using crowdsourcing, but to radically rethink how land administration services are managed and delivered in partnership with citizens. Land administration by the people can become a distinctly 21st century phenomenon (Mclaren, 2011).

2.2. Cadastre

2.2.1. Cadastre definition

2.2.1.1. Before 1995 FIG Statement

At Commission 7 Opening Address at the 1990 FIG Congress a set of clear and concise cadastral definitions were presented, as follows (Henssen & Williamson, 1990):

- Land Registration: is a process of official recording of rights in land through deeds or as title (on properties). It means that there is an official record (the land register) of rights on land or of deeds concerning changes in the legal situation of defined units of land. It gives an answer to the questions "who" and "how";
- Cadastre: is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. Such properties are systematically identified by means of some separate designation. The outlines or boundaries of the property and the parcel identifier are normally shown on large-scale maps, which, together with registers, may show for each separate property the nature, size, value and legal rights associated with the parcel. It gives an answer to the questions "where" and "how much";
- Land recording:
  - land registration and cadastre usually complement each other; they operate as interactive systems. Land registration puts, in principle, the accent on the relation subject-right, whereas cadastre puts the accent on the relation right-object. In other words: the land registration answers the questions as to who and how the cadastre answers the questions as to where and how much;
  - because land registration and cadastre ("who and how" along with "where and how much") complement each other, the terms "land recording" or "land records" are usually used to indicate these two components together as a whole. Often the term "land titling" is used instead of the term "land recording".

In the previous cited work (Henssen & Williamson, 1990) it´s also concluded that an adequate land recording system (being a land registration system and a cadastre) consists of two basic parts:

- A descriptive part containing registers or files which record legal facts (deeds) or legal consequences (titles) and other physical or abstract attributes concerning the parcels depicted on the maps described below;
- A cartographic part, consisting of (large scale) maps, based on a survey, which contain the division into parcels of an area and with appropriate parcel identifiers.

Finally, (Henssen & Williamson, 1990) stated that, depending often on the author's discipline (e.g. lawyer, land surveyor or layman) and country of origin:

- the words land registration and cadastre are also used to indicate the organisational unit, which operates in the concerned field of recording;
- the word land registration concerns only the system of registration of title (English influence);
- land registration covers also the cadastral system;
- cadastre includes also land registration (e.g. in "legal cadastre" or "multipurpose cadastre").

2.2.1.2. FIG Statement on the Cadastre

A cadastre is normally a parcel based, and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection (FIG, 1995).

This definition frames the so called conventional LA systems which are based on the 'parcel-based' approach.

2.2.1.3. A wider inclusive view

According to (Augustinus, 2010) the greatest challenges to any country's cadastral system are the informal settlements. By 2030 the urban population of all developing regions, including Asia and Africa, will far outweigh the rural. This massive shift towards urbanisation over the next twenty years will be characterised by informality, illegality and unplanned settlements. Urban growth will be associated with poverty and slum growth. Today about one third of urban residents in the developing world live in slums which either lie outside the cadastre or the occupation of which does not match it.

The land industry needs rather to be developing appropriate tools for users across the spectrum, including the poor, women and men, and in different regions of the world, not just for the developed world. So, what needs to be developed is a pro-poor land-administration system (LAS) of completely different design, interoperable with current cadastral systems (Augustinus, 2010). This technical gap needs to be filled for a range of purposes, including:

- forest management;
- wetland management outside the register;
- customary tenure with layers of group rights;
- informal settlement inventory in preparation for upgrading;
- large-scale identification of land rights and claims following natural disaster, including multiple households inhabiting same dwelling unit, as a pre-cadastral step;
- development of claims database in post-conflict environments, including overlapping claims.

In this context, alternative representations of area's and alternatives for traditional land surveys are needed. Traditional land surveys are costly and time consuming, and proved not to work in many situations in developing countries. Handheld GPS, or the use of satellite imagery, are considered to be inaccurate by the surveyor's community; but this attitude results in a lack of LA coverage. There is a need for complete and up-to-date LA coverage. A more flexible system has to be based on a global standard like LADM, and it has to be manageable by the local community itself. It is here where the Social Tenure Domain Model (STDM) comes in. This kind of standardization allows for the integration of data collected by communities into a formal LA system at a later moment in time (Uitermark, et al., 2010).

Furthermore, and according to (Roberge, 2010) developing countries, where the need for land-rights infrastructure is primary and resources are scarce, require light and low-cost solutions creating exact rather than accurate data.

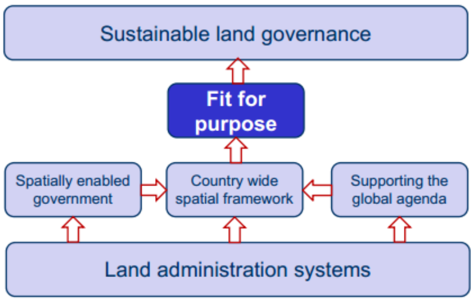


Figure 14 - A fit-for-purpose approach (Enemark, 2012)

Reinforcing this idea, (Enemark, 2013) framing cadastre as the core engine for spatially enabled land administration, states that spatial enablement is not primarily about accuracy: it is about adequate identification, completeness and credibility. Systems should be built using a "fit for purpose" approach (presented in Figure 14) while accuracy can be incrementally improved over time when justifying serving the needs of citizens and society. In relation to the concept of the continuum of land rights such a fit for purpose approach could then be referred to as a “continuum of accuracy”.

A final reference to “The Continuum Paradigm” concept (Teo, 2012), that is framed and extends the “Land Rights Continuum” (UN-HABITAT, 2011) (UN-HABITAT, 2012a) (Teo, 2012b) notion to broader aspects of land systems, compose by a Continuum of Approaches (from less to more rigorous), a Continuum of Technology (from less to more sophisticate), a Continuum of Measurement (from less to more precise); and a Continual Tools Development (from complex to greater complexity) as shown in Figure 15. Therefore, (Teo, 2012) states that this would be the only way to build land systems, especially in developing countries, in order to address the realities of different sections of society.

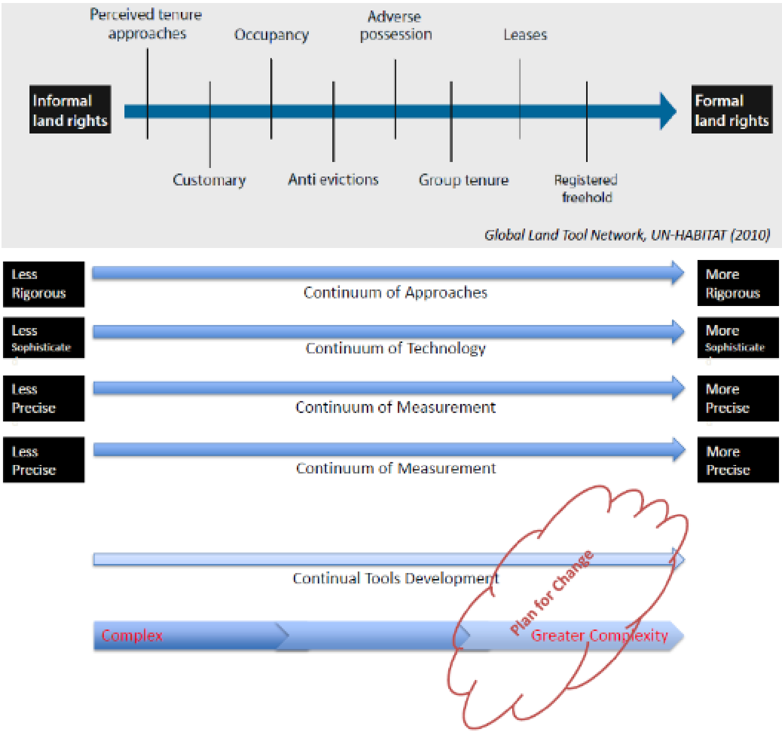


Figure 15 – The Continuum Paradigm (Teo, 2012)

2.2.2. Cadastre as the engine of LAS

According to (Williamson, et al., 2010) cadastre is one of the ten land administration principles, being at the core of any LAS providing spatial integrity and unique identification of every land parcel. Moreover, the land management paradigm makes a national cadastre the engine of the entire LAS, underpinning the country’s capacity to deliver sustainable development (Williamson, et al., 2010).

Figure 16 diagram demonstrates that the cadastral information layer cannot be replaced by a different spatial information layer derived from geographic information systems (GIS). The unique cadastral capacity is to identify a parcel of land both on the ground and in the system in terms that all stakeholders can relate to (Williamson, et al., 2010).

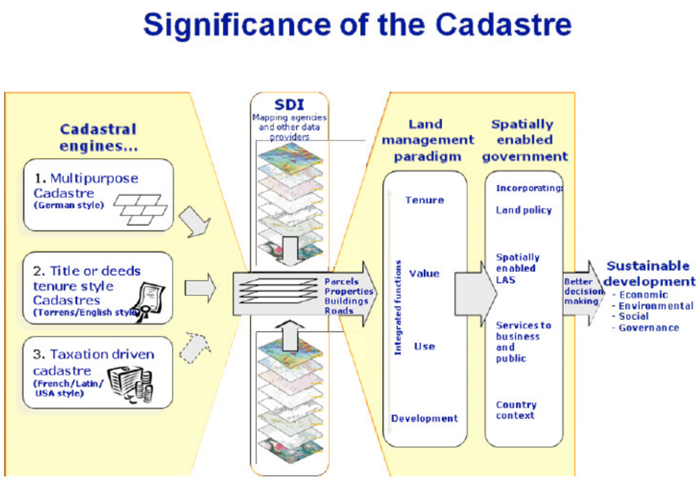


Figure 16 - The cadastre as an engine of LAS (Williamson, et al., 2010)

The diagram is a virtual butterfly: one wing represents the cadastral processes, and the other the outcome of using the processes to implement the land management paradigm. Once the cadastral data (cadastral or legal parcels, properties, parcel identifiers, buildings, legal roads, etc.) are integrated within the SDI, the full multipurpose benefit of the LAS, so essential for sustainability, can be achieved (Williamson, et al., 2010).

The body of the butterfly is the SDI, with the core cadastral information sets acting as the connecting mechanism. This additional feature of cadastral information is an additional role, adding to the traditional multipurpose of servicing the four functions. This new purpose takes the importance of cadastral information beyond the land administration framework by enlarging its capacity to service other essential functions of government, including emergency management, economic management, effective administration, community services, and many more functions (Williamson, et al., 2010).

In this context, SDI is fundamentally a concept about coordinating the sharing of spatial data, services and other resources between stakeholders from different political/administrative levels. The commonalities between SDIs and the objectives Land Administration systems provide strong grounds for the derivation of shared evaluation and performance indicators (Bennett & Rajabifard, 2009).

2.2.3. Delivering a spatially enabled LAS

From the perspective of building and reengineering LAS, information that potentially offers the significant benefits delivered by new spatially enabling technologies includes (Williamson, et al., 2010b):

- Land administration information generated by cadastral, land recording, and sometimes valuation activities;
- Land information about land use, land planning, and some rights records;
- Geographic information about terrain, natural resources, and infrastructure that relates to them.

Related to this issue I will make reference to more two principles of Land Administration: Technology and Spatial Data Infrastructure (SDI), and how they are connected with LAS according to (Williamson, et al., 2010b):

- Technology:
    - Technology offers opportunities for improved efficiency of LAS and spatial enablement in terms of land issues.
    - Technology offers improvements in the collection, storage, management, and dissemination of land information. At the same time, developments in ICT offer the potential for spatial enablement in terms of land issues by using location or place as the key organizer for human activity, and
- Spatial Data Infrastructure
    - Efficient and effective LAS that support sustainable development require an SDI to operate.
    - The SDI is the enabling platform that links people to information. It supports the integration of natural (primarily topographic) and built (primarily land parcel or cadastral) environmental data as a prerequisite for sustainable development.
    - The SDI also permits the aggregation of land information from the local to the national level.

According to (Williamson, 2008), land information has grown in importance over the last few decades, and is considered by many to be more important and useful to government than in its traditional role of supporting security of tenure and simple land trading. Land administration systems and their core cadastral components are evolving into a new vision and essential infrastructure called iLand that spatially enables government and provides the "where" for all government decisions, polices and implementation strategies. This vision requires a clear understanding and institutional and legal structures that link the cadastre to the SDI and the wider LAS. Without this understanding and interaction delivering the vision is very difficult if not impossible. Ultimately, spatially enabled land information will provide the essential link between land administration and sustainable development, as presented in Figure 17.

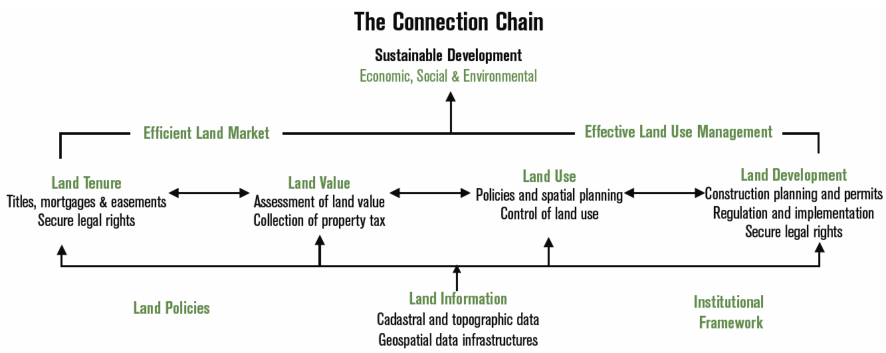


Figure 17 - A global land management perspective (Williamson, et al., 2010) cit. by (Enemark, 2014)

In brief, the primary purpose of the cadastral system is to define the 'where' in the property rights system. Significant value is added by enabling this "where" to be related to other location-based information datasets (LINZ, 2014).

I will end this point making reference to the concise overview about the Portuguese SDI state-of-art, its territorial management and integrated geographic information features, available at "Basis for a Strategy and Policy Making for Next Generation SDI" (Julião, 2013a) and (Julião, 2013).

2.2.4. The benefits of a modern cadastre

The organisations are now increasingly confronted with rapid developments in the technology: there is a technology push driven by developments in the Internet, (geo)-databases, modelling standards, open systems, GIS; and a market pull driven by increasing demand for enhanced user requirements, e-governance, sustainable development, electronic conveyancing, and integration of public data and systems (Lemmen & van Oosterom, 2004).

The modern cadastre is not primarily concerned with generalized data but rather with detailed spatially referenced information at the individual land parcel level. As such it should service the needs both of the individual and of the community at large. In particular, the following benefits arise (UNECE, 2005):

- Guarantee of ownership and security of tenure;
- Support for land and property taxation;
- Provide security for credit;
- Develop and monitor land markets;
- Protect land resources and support environmental monitoring;
- Facilitate the management of State-owned land;
- Reduce land disputes;
- Facilitate rural land reform;
- Improve urban planning and infrastructure development;
- Produce statistical data.

Rank	Country	Rating
1	Finland	8.6
2	New Zealand	8.4
3	Sweden	8.4
4	Norway	8.3
5	Netherlands	8.2
6	Switzerland	8.2
7	Luxemburg	8.1
8	Singapore	8.1
9	Canada	8.0
10	Denmark	8.0

Figure 18 - Countries where property rights are most secure in 2013 (Di Lorenzo, 2013b)

The benefits of the modern cadastre contribute to 2013 top ten countries where property rights are most secure, as can be seen in Figure 18 where are presented the rank of countries resulting of (Di Lorenzo, 2013b) work.

Moreover, and according to the report “Cadastre 2034. A 10-20 Year Strategy for developing the cadastral system” (LINZ, 2014), the efficiency and effectiveness of the present property rights system to the New Zealand economy cannot be overstated. The existing system has resulted in a low cost, low risk system with very high value (in the form of a Crown guarantee of ownership of the title in the case of private land in the Land Transfer tenure system). This system enables people to confidently and efficiently transact property rights, with very little fear that their transactions will be challenged and without the need for title insurance. The value of residential land in New Zealand was $688 billion in June 2013. This reflects the confidence of investors in the property rights system which, in turn enables capital to be leveraged for other economic activity.

In the other hand, and taking example of the 180 years old Dutch cadastre (Burmanje, 2012) states that registration of land and its ownership marks the beginning of a healthy economy; land registry and ownership can contribute to the economic growth of a country based on almost two centuries of cadastral framework, and that if people register their land and ownership, their investments will increase according.

Additionally, (Zeeuw, et al., 2013) also noted that land administration can lead to the creation of local or national commodities. But, what is the value of these commodities and what are these more than mortgages, credit or social security? What is the expected (economic and social) spin-off of a well-organized land administration system? Does this limit itself to the monetizing of land property rights or does it expand itself easily to other rights like land use rights, carbon sequestration/emission rights or energy rights?

The direct economic spin-off of land administration can be defined and quantified by direct land administration activities like (Zeeuw, et al., 2013):

- Legal security (basic requirement for investors and credibility);
- Access to credit (mortgage);
- Spatial planning (consumers, producers);
- Taxation (on property and land);
- Information services for decision making and added value products and processes.

The indirect economic spin-off in other domains, is more difficult to quantify but should also be part of the commodities that are of (national) importance (Zeeuw, et al., 2013):

- Environmental impact assessment;
- Energy certificates and carbon sinks;
- Justice (cultural, ethnical, gender, wealth);
- Good governance and transparency.

A final reference should be made to the conclusions of (Bennett, et al., 2013) work: the most recent chapter in the bridging story stems from the demonstration that conventional approaches deliver less than optimal outcomes in many cases. The increasingly dominant view is that a continuum of options for understanding and recording land tenures is needed.

So, according (Bennett, et al., 2013) to support the continuum of land rights in practical terms, a set of new tools is needed. These are underpinned by pragmatism, diversity in approach, and innovation. They will support conventional adjudication, demarcation, surveying, recording, and dissemination approaches. Many are already available and applied, many more are under construction.

2.2.5. Cadastre in the world. Brief status.

The main cadastral and land registration systems worldwide according to (Williamson, et al., 2010) are presented below in Table 1.

SYSTEM	LAND REGISTRATION	CADASTRE
French	– Deeds System – Registration of the transaction – Titles are not guaranteed – Notaries, registrars, lawyers & Insurance companies hold central positions – Ministry of Justice – Interest in deed is described in a description of metes and bounds and sometimes a sketch, which is not necessarily the same as in the cadastre	– Land taxation purposes – Spatial reference or map is used for taxation purposes only – Cadastral registration is a follow-up process after land registration – Ministry of finance or a tax authority
German	– Title system – Land book maintained at local district court – Title based on cadastral identification – Registered titles guaranteed by the state – Neither boundaries nor areas guaranteed	– Land & property identification – Fixed boundaries determined by cadastral surveys carried out by licensed surveyors – Cadastral registration is prior to land registration – Ministry of environment
Torrens / English	– Title system – Land records maintained at the land registration office – Registered titles usually guaranteed as to ownership – Neither boundaries nor areas guaranteed	– Fixed boundaries determined by cadastral surveys carried out by licensed surveyors – English system used general boundaries identified in large scale topographic maps – Cadastral registration integrated in the land registration process

Table 1 - Land Registration & Cadastral Systems Worldwide (Williamson, et al., 2010)

Mainly, the above-mentioned terms, concepts and definitions concerning the main cadastral and land registration systems worldwide can be found in the Multilingual Thesaurus on Land Tenure (FAO, 2003), where they are described and framed in English, French and Spanish.

Below, in Figure 19, the worldwide National Coverage of the Cadastre (Konecny, 2013) and in Figure 20 the 2013 Property Rights Index (Di Lorenzo, 2013), are presented.

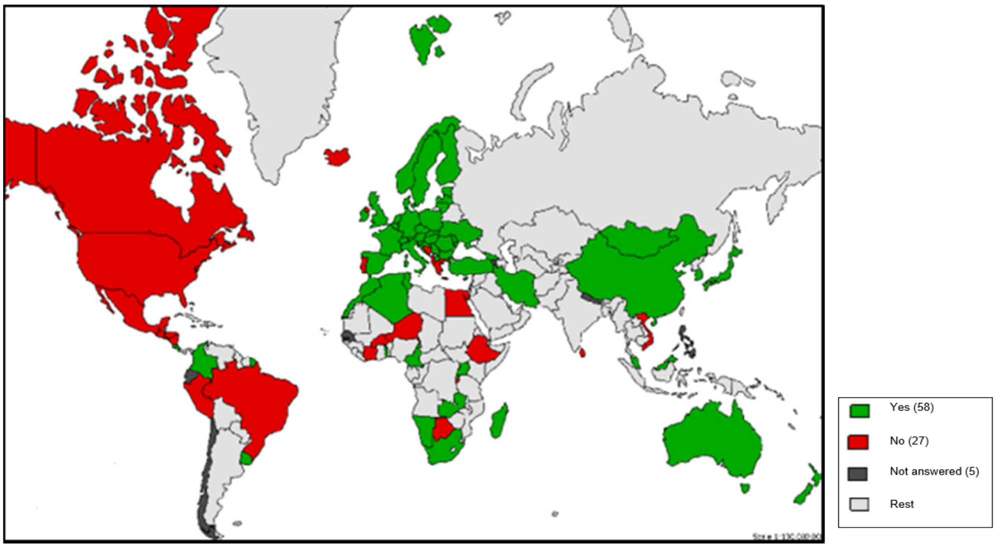


Figure 19 – National coverage of the cadastre (Konecny, 2013)

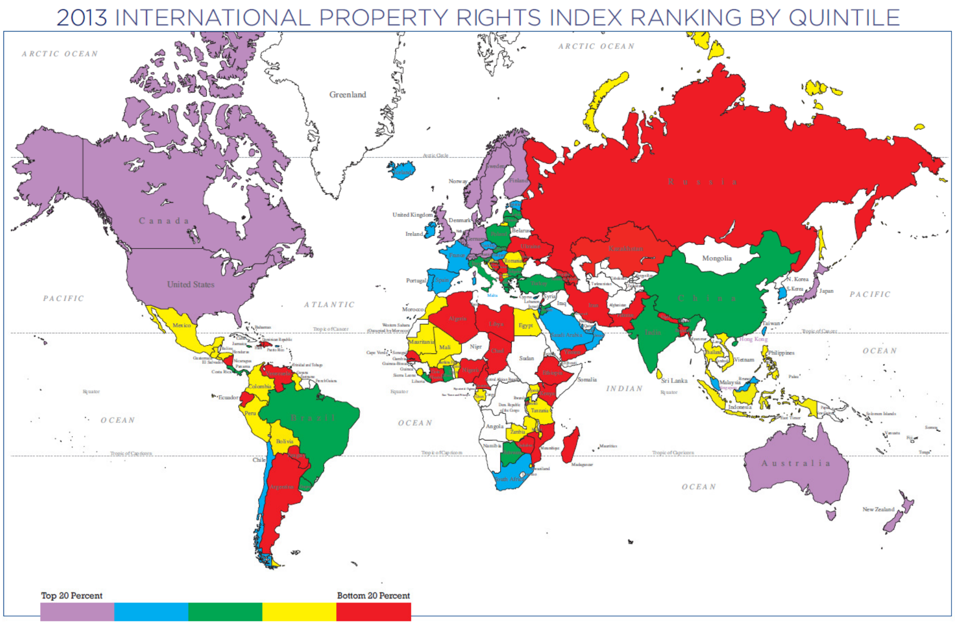


Figure 20 – 2013 Property Rights Index: from top 20% (purple) to bottom 20% (red) (Di Lorenzo, 2013)

A summary of the values showed in the map above, relating to the relative positioning of the several world regions according to (Di Lorenzo, 2013a), in terms of region rankings, is presented below in Figure 21.

Region	Overall	World Rank	Legal	World Rank	Physical	World Rank	Intellectual	World Rank
North America	7.8	1 of 7	7.8	1 of 7	7.4	1 of 7	8.2	1 of 7
Western Europe	7.5	2 of 7	7.67	2 of 7	7.14	2 of 7	7.65	2 of 7
Asia and Oceania	5.8	3 of 7	5.56	3 of 7	6.69	3 of 7	5.08	3 of 7
Middle East and North Africa	5.5	4 of 7	5.11	4 of 7	6.4	4 of 7	5.03	4 of 7
Cental/Eastern Europe and Central Asia	5.1	5 of 7	4.86	5 of 7	5.87	5 of 7	4.59	6 of 7
Latin America and Carribean	5	6 of 7	4.49	6 of 7	5.66	6 of 7	4.74	5 of 7
Africa	4.7	7 of 7	4.06	7 of 7	5.61	7 of 7	4.32	7 of 7

Figure 21 – 2013 Property Rights Index. Region Rankings (Di Lorenzo, 2013a)

In summary, no two countries operate identical cadastral systems since a cadastre is part of a country's social infrastructure. Like nations, each system has evolved with different characteristics (United Nations, 2004). Moreover is presented in Figure 22 an illustration of cadastre and land registration overlap according to (United Nations, 2004).

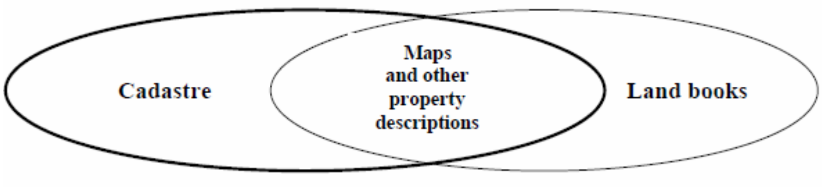


Figure 22 - Cadastre / land registration overlap (United Nations, 2004)

As an additional contribution to this overall characterization, the evolution of western cadastral system, in the last two centuries, according to (Enemark, 2012), is presented in Figure 23.

	Feudalism - 1800	Industrial revolution 1800-1950	Post-war reconstruction 1950-1980	Information revolution 1980-
Human kind to land evolution	Land as wealth	Land as a commodity	Land as a scarce resource	Land as a community scarce resource
Evolution of cadastral applications	Fiscal Cadastre Land valuation and taxation paradigm	Legal Cadastre Land market paradigm	Managerial Cadastre Land management paradigm	Multi-purpose Cadastre Sustainable development paradigm

Figure 23 - Evolution of Western Cadastral System (Enemark, 2012)

Moreover, (Rekha, 2012) states that it is evident that a cadastral divide does exist between the less developed and more developed worlds and that not one answer or solution exists. Unlike other markets, land is not a homogenous product. Each parcel is unique, with a particular set of locational and physical attributes. The players in the land market are diverse and often have conflicting agendas. So, it is important to take a coordinated approach and involve citizens in a big way. Industry can play an evangelising role in creating more awareness, in convincing the leadership and in understanding the needs of the market and tailor-make their solutions. It is essential to strike a balance between the push of technology and pull of customer needs.

Finally, according to (Fosburgh, 2011) the results of research and cadastral work in Africa, Asia and South America are encouraging. Developing nations can bypass the years of paper-based documentation and move directly to modern, low-cost cadastral systems, underpinned by modern spatial reference systems provided by GNSS and CORS. The return on the investment will be rapid and will carry large, long-lasting social and economic benefits.

2.2.6.Cadastre in Europe.

There is no single coherent solution in the field of cadastre within Europe at the current time. The institutional evolution, applied services as well as the definition of cadastre differ from country to country due to the influence of culture, history and other societal reasons. On the continent, cadastral GIS are acknowledged as an inevitable and supportive complement to land registry and together they serve not only the security of property rights, but directly foster the economic-societal prosperity and facilitate sustainable development (Remetey-Fülöpp, 2004).

According to (PCC; EuroGeographics, 2011) in Europe, "cadastre" includes several functions and types of information and not only strictly those of the "classical real estate" cadastre itself. The content of the cadastre in the European countries is more or less defined in each country's relevant legislation. An overview of the cadastral systems in the EU member states can be found in "Cadastral Information System: a resource for the EU policies" PCC publications: volume I (Austria, Belgium, Czech Republic, Germany, Italy, Slovakia, Spain and Sweden) (PCC, 2008); volume II (Cyprus, Finland, Greece, Hungary, Poland and Slovenia) (PCC, 2009); volume III (Estonia, Lithuania, Luxembourg, Denmark, Romania and Portugal) (PCC, 2009b) and volume IV (Bulgaria, France, Ireland, Latvia. Malta, Netherlands, and United Kingdom) (PCC, 2010), as well as in the results of the project "The role of the Cadastral parcel" (EuroGeographics; PCC, 2007), and the Cadastres and Land Registries reports (Kersten, et al., 2008) and (Kersten, et al., 2010).

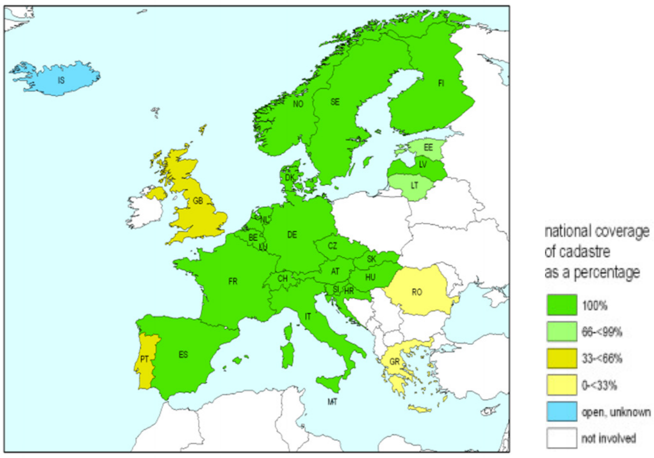


Figure 24 - National coverage of cadastre in European Union (EuroGeographics; PCC, 2007)

Furthermore, in Figure 24, above, is presented the national coverage of cadastre in European Union according to (EuroGeographics; PCC, 2007).

In terms of European cadastral and national mapping organizations GIS technology used, it's verified a predominance of Esri technology according to ArcNews 2011 Spring issue (Esri, 2011), as could be seen in Figure 25.

Figure 25 - Green represents European cadastral and national mapping organizations using Esri technology (Esri, 2011)

Moreover, a mention should also be made to EuroGeographics Cadastre and land registration knowledge exchange network, which has the goal of facilitating the exchange of 'best practice' to help its members to achieve a vision for cadastre and land registration in Europe 2012 (EuroGeographics, 2012a). Their work supports the decision makers of the EuroGeographics member organisations and other interested parties in creating effective spatial data infrastructures, securing (inter)national land administrations and contributing to sustainable development (EuroGeographics, 2012).

Finally, in Figure 26 is presented the web of organizational interaction of various European entities and initiatives / services relative to one another mapping the relationships between them according to (Grimsley & Roll, 2014), where it's highlighted the main connections and central role of land thematic in Europe.

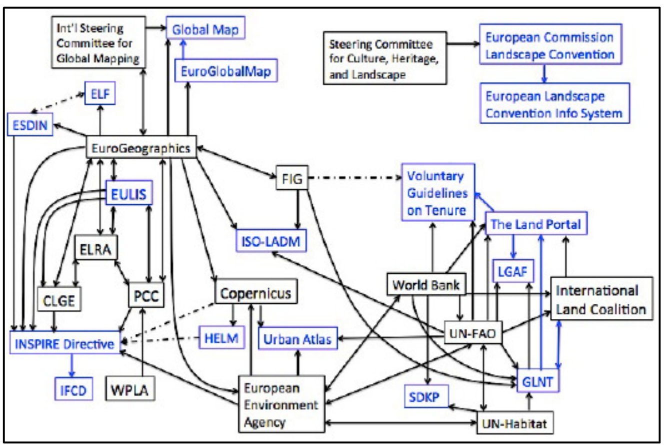


Figure 26 - The web of organizational interaction of various European entities and initiatives (Grimsley & Roll, 2014)

2.2.7. Cadastre in developing countries

In developing countries cadastral coverage is often less than 30 percent of the country (Lemmen, Augustinus, Haile and van Oosterom, 2009) cited by (Augustinus, 2010a). This means that about seventy percent of the land in many countries is outside of the freehold parcel based land administration system and its land information system. This implies that people living in these areas are often at a disadvantage, not just in regard to security of tenure, but also in regard to such things service delivery and land management approaches. The people in the seventy percent generally use a wide variety of social tenures to secure their land rights and claims. These tenures include documented, undocumented, individual and group, legal, illegal and informal and over-lapping rights and claims, such as those of slum dwellers, pastoralists, women whose rights are often nested in family rights, rights of groups, and multiple over-lapping claims in post conflict areas. This range of tenures cannot be easily captured on conventional cadastral and land administration systems because they are not based on unique parcel based polygons, which are also legal evidence of land rights (Augustinus, 2010a).

In summary, over 70 percent of the land in many countries is generally outside the land register. This has caused enormous problems for example in cities, where over one billion people live in slums without proper water, sanitation, community facilities, security of tenure or quality of life. This has also caused problems for countries in regard to food security and rural land management issues (Augustinus, 2010a).

As stated by (Bennett, 2012) first, the cadastral divide is a reality. In fact, the division is far more fragmented than presented here: all systems are at various states of establishment, renewal, maintenance or even decay. Second, whilst a divide is evident, by looking to both sides we see a bridge linking shared interests and challenges. These are the need for: system adaptation in order to support emerging societal roles; development of more holistic assessment tools for ensuring fit-for-purpose and construction of a range of design elements to support both pro-poor and more developed contexts. Third, and finally, overcoming the cadastral divide should be a focus for all. With the right mix of pragmatism and design selection, it can be reduced even in the short term.

	URBAN	**RURAL**
Developed	• Objects (3D, 4D)/Survey accuracy and RRR. • Exploiting advanced technology.	• Parcels / Survey accuracy and RRR. • Exploiting advanced technology.
Developing	• Determination of role in society. • Supporting good governance. • Getting cadastres off the ground. • Objects (3D) / survey accuracy. • Society first, technology next	• Determination of role in society. • Supporting good governance. • Getting cadastres off the ground. • Parcels/general boundaries. • Society first, technology next.

Table 2 - Urban and rural areas, developed / developing countries vision (Lemmens, 2010)

Likewise, according to (Lemmens, 2010) urban and rural areas, in developed and developing countries, each need vision, approach and solutions of their own (

Table 2). Furthermore, according to (Mclaren & Stanley, 2011) sustainable development needs both urban and rural inputs (Figure 27).

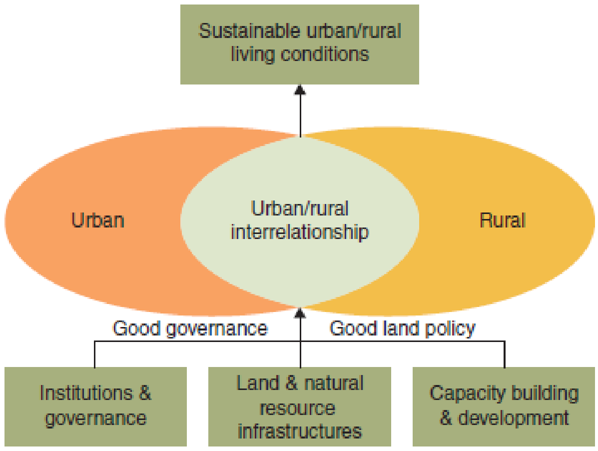


Figure 27 - Sustainable development needs both urban and rural inputs (Mclaren & Stanley, 2011)

Moreover, the more important question should be what constitutes, from a technical, legal, institutional, administrative, economic and social perspective, an appropriate cadastral system for a particular country or jurisdiction at some point in time. The debate should recognise that no two cadastres will be the same due to different geographic sensitivities and needs of each region or country. Unfortunately, unless appropriate cadastral systems are established, such systems can do more damage than good, to a nation's economy and society (Williamson, 1997).

Because, according to (Enemark, 2013) the discussion above underpins the need for a flexible approach to building the spatial framework in terms of technology and investment choices. Building such a spatial framework is of course not primarily about accuracy. It is about adequate identification and representation of the spatial objects and parcels; completeness to cover the total jurisdiction, and credibility in terms of reliable data being trusted by the users.

Concluding, the research literature and operational experience from developed economies indicates that in order to re-engineer the cadastre to best support the needs of government and society, for example, addressing e-government readiness problems, requires taking a holistic approach. This means that a cadastre should be viewed as a strategic government and societal asset, able to be used meet both traditional and emerging needs; and containing information that does not exist alone, but is part of a countries' spatial information infrastructure. In turn, this infrastructure needs to operate ways that facilitate spatial enablement in order help address major issues confronting government and society (Holland, et al., 2009).

2.2.8. Cadastre in Portugal.

2.2.8.1. Brief overview.

A very comprehensive overview of the Cadastre in Portugal from the beginning of XIX century till 2009, can be found in “The Cadastral System in Portugal” (PCC, 2009b) in terms of history and purposes of the cadastre, development of the institutional and organisational structure, financial and organisational issues and decentralisation, involvement of the private sector. Moreover this thematic can be revisited (in Portuguese) at (Julião, 2009).

The Portuguese cadastre, as many other in most of the South and West of continental Europe (PCC, 2008) (PCC, 2009) (PCC, 2009a) (PCC, 2010), was created on the basis of the Napoleonic Cadastre (Zevenbergen, 2002) (Williamson, 1997), purely to tax significant economical parcels which, at that time, were mainly rural parcels (Julião, et al., 2010) (Castanheira, 2012).

Nowadays in Portugal, cadastre is defined as an exhaustive, methodical and updated inventory that characterizes and identifies real estate properties in a certain territory (DGT, 2014) (Julião, et al., 2010), thus contributing to a paradigm shift in Portuguese cadastre: from tax purpose to multipurpose, according to (Julião, et al., 2010a), as shown in Figure 28.

Portugal still has two cadastral systems running, with different data models (IGP, 2009):

- Rural Property Cadastre:
    - The rural property cadastre has more entities, due to the fact that is tax driven and has additional elements regarding the rural property evaluation, such as land use. Its main elements are: parcels, sub-parcels, rural constructions, property marks, administrative boundaries and marks.
    - Currently is being carried on a migration process towards its integral digitalization (Mira & Bica, 2011), (IGP, 2010)
- Real Property Cadastre:
    - Legal Parcel definition: Parcel, designated as “prédio”, is a juridical autonomous limited part of land, which includes water, plantations, buildings and constructions of any nature incorporated in it.
    - Although a parcel boundary can be defined by a building, cadastre model doesn’t include them.
    - The basic spatial elements of the cadastre: parcel, its boundaries and the corresponding defining property marks.
    - There is also a special element, designated as no-parcel areas, which represents the areas not defined as parcels, which include public areas, unknown owner areas and litigation areas.

- The cadastre registers the parcel identification number – NIP, the corresponding identification codes from the land registry and real estate tax, the declared owner and corresponding personal data.

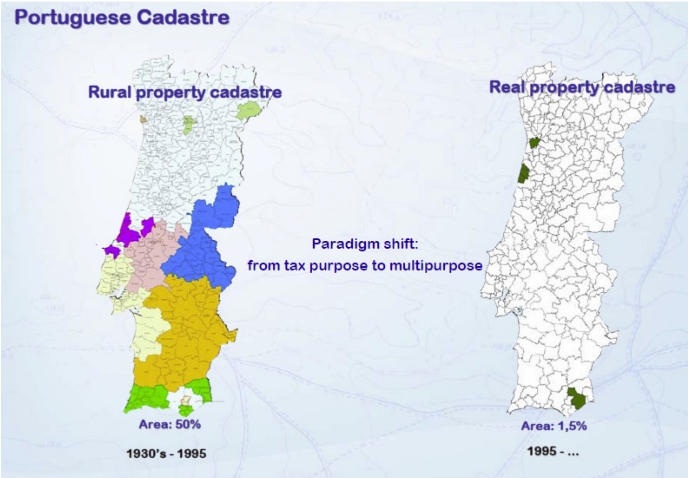


Figure 28 - Paradigm shift: from tax purpose to multipurpose (Julião, et al., 2010a)

2.2.8.2. Portuguese cadastre legislation references

Moreover, the Portuguese cadastre legislation main references, till February 2014, are the following:

- Council of Ministers Resolution n.º 56/2012 (guidelines and strategies for rural management and Cadastre) (PCM, 2012);
- Decree Law n.º 65/2011 (extends to forest intervention areas the experimental implementation, operation and access to cadastral information) (MAOT, 2011);
- Decree Law n.º 224/2007 (approves the scheme of experimental implementation, operation and access to cadastral information, aiming at the creation of the Cadastral Information Management and Operation National System - SINERGIC) (MAOTDR, 2007);
- Council of Ministers Resolution n.º 45/2006 (Cadastral Information Management and Operation National System (SINERGIC) guidelines and overall objectives) (PCM, 2006);
- Decree Law n.º 172/95 (approves the Property Cadastre Regulation) (MPAT, 1995);
- Decree Law n. º 143/82 (assigns the Cadastral and Geographic Institute the exclusive responsibility for the preparation and maintenance of all basic cartography for the construction of the Portuguese Cadastral Map and establishes the essentials legal instruments to achieve these objectives) (MFP, 1982).

2.3. The INSPIRE directive

2.3.1. Overview

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishes an Infrastructure for Spatial Information in the European Union (EC, 2007). It came into force on 15 May 2007 and its full implementation is required by 2019.

It has been known since then as INSPIRE Directive, and aims to establish an infrastructure for spatial information to support European Union environmental policies, and policies or activities which may have an impact on the environment.

The Infrastructure for Spatial Information in Europe is based on infrastructures for spatial information established and operated by the 28 sovereign Member States of the European Union. All the spatial data that is part of INSPIRE comes via the organisations responsible in the Member States and this EU-wide SDI is developed in a decentralised way, building on the SDIs and related activities established and maintained by the Member States (Craglia, 2014). In Figure 29, a group of seven INSPIRE competencies are listed and classified in three ranks (very low / low; average; and high / very high), illustrating the involvement levels in INSPIRE by the European Geo-ICT companies private sector (Cipriano, et al., 2013).

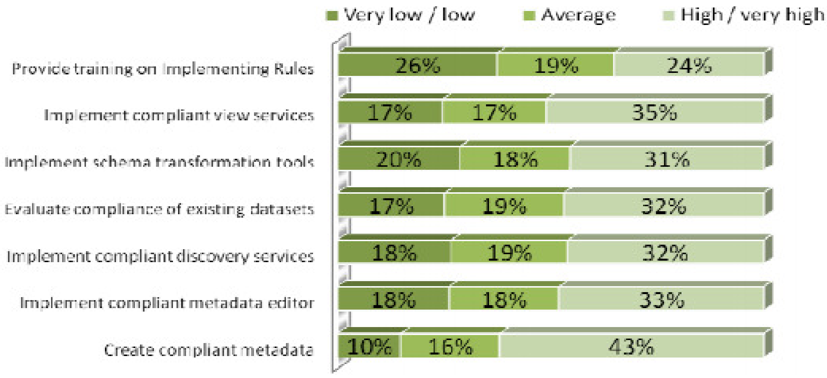


Figure 29 - INSPIRE competencies (Cipriano, et al., 2013)

The six principal objectives of INSPIRE are:

- Data should be collected once and maintained at the level where this can be done most effectively;
- It should be possible to combine seamlessly spatial information from different sources across Europe and share it between many users and applications;
- It should be possible for information collected at one level to be shared between all the different levels, e.g. detailed for detailed investigations, general for strategic purposes;
- Geographic information needed for good governance at all levels should be abundant and widely available under conditions that do not restrain its extensive use;
- It should be easy to discover which geographic information is available, fits the needs for a particular use and under which conditions it can be acquired and used;
- Geographic data should become easy to understand and interpret because it can be visualized within the appropriate context and selected in a user-friendly way.

According to (Craglia, 2014), the prime purpose of INSPIRE is to support environmental policy, and overcome barriers affecting the availability and accessibility of relevant data. These barriers include: inconsistencies in spatial data collection; lack or incomplete documentation of available spatial data; lack of compatibility among spatial datasets that cannot, therefore, be combined with others; incompatible SDI initiatives in the Member States that often function only in isolation; cultural, institutional, financial and legal barriers preventing or delaying the sharing of existing spatial data.

The key elements of the INSPIRE Directive to overcome these barriers include (Craglia, 2014):

- Metadata to describe existing information resources so that they can be more easily found and accessed;
- Harmonisation of key spatial data themes needed to support environmental policies in the Union;
- Agreements on network services and technologies to allow discovery, view, download of information resources, and access to related services;
- Policy agreements on sharing and access, including licensing and charging;
- Coordination and monitoring mechanisms.

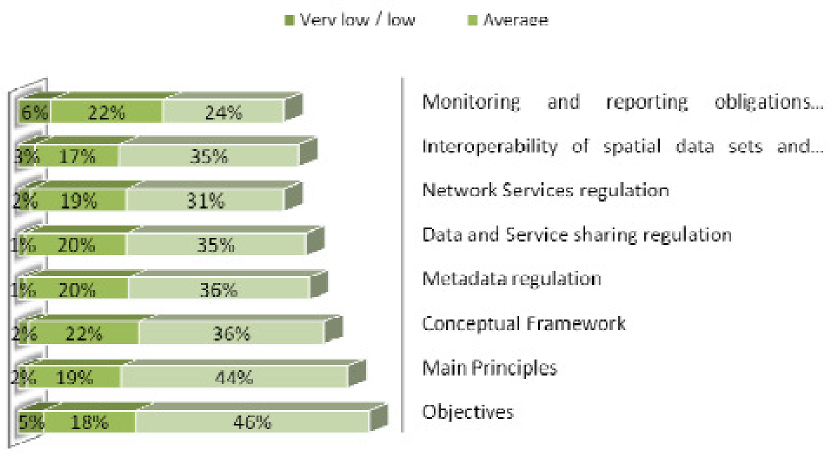


Figure 30 - Knowledge of INSPIRE (Cipriano, et al., 2013)

Moreover, in Figure 30, according to (Cipriano, et al., 2013) a group of eight knowledge of INSPIRE categories are listed and classified in three ranks (very low / low; average; and high / very high) illustrating the awareness levels in INSPIRE by the European Geo-ICT companies private sector (Cipriano, et al., 2013).

Therefore, INSPIRE is based on the infrastructures for spatial information established and operated by all Member States of the European Union. It addresses 34 spatial data themes (EC, 2008), divided in three annexes: annex I (9 themes, including cadastral parcels) and annex II (4 themes) mainly comprising reference data; and annex III (21 themes - thematic data). Their key components are specified through technical implementing rules.

Furthermore, according to the report “INSPIRE Public Consultation 2014” (Joint Research Centre, 2014) where were presented the findings of the public consultation on INSPIRE organised by the European Commission in December 2013-February 2014, there was an almost unanimous view across all participants in the previously referred consultation that the objectives of INSPIRE of making spatial data and services more easily shared and used are still as pertinent as ever.

In what concerns, the INSPIRE Directive in Portugal, it can be found a concise overview at “INSPIRE implementation in Portugal: the operational approach” (Reis, et al., 2012), “The role of R&D projects in the implementation of the INSPIRE directive in Portugal” (Reis, 2012) and “Monitoring and Reporting INSPIRE Directive in Portugal” (Reis, et al., 2013).

The main reference about INSPIRE Directive in Portugal is the Decree-Law n. º 180/2009 (MAOTDR, 2009), of August 7, 2009, to which I make a brief reference in the following points. In summary, it:

- Review the national spatial data infrastructure - National System for Geographic Information (SNIG);
- Transpose the INSPIRE Directive into national law; and
- Establishes rules for the creation of spatial data infrastructures in Portugal

According to (Geirinhas, et al., 2011), on 2011, the Portuguese strategy for INSPIRE implementation relied in four major vectors:

- Organization: a major effort was placed in the creation of contact networks of public authorities, as the collaboration and joint involvement of national public authorities is considered a critical for the process success. The transposition enabled the identification of stakeholders’ contact points and the mandatory appointment of Metadata Managers;
- Contents: Mainly focused on metadata through the creation of the National Metadata Profile and the development of a metadata production and editing tool – MIG Editor – made freely available to all. Moreover, IGP developed geowebservices for some of its spatial data that are available through SNIG;
- Capacity Building: Training actions in relevant areas such as metadata and geowebservices have been undertaken - training actions have been organised for approximately 262 metadata managers and a training plan has been set up on geowebservices;
- Dissemination: Performed through the INSPIRE-PT website, the contact point’s networks of public authorities and several public sessions organised in various locations around the country during recent years. It contributed to raise awareness on the INSPIRE concept and principles, spread information, disseminate developments already achieved within European SDI projects in which Portugal is participating and share knowledge associated to best practices.

2.3.2.Cadastral parcels data theme

In INSPIRE Directive Annex I, theme 6 the cadastral parcels are referred as areas defined by cadastral registers or equivalent (EC, 2011) (EC, 2009).

According to (Salzmann & Ernst, 2008) the cadastral parcel will be a core spatial data theme in the European SDI through the INSPIRE-directive.

In Figure 31, according to (Seifert, 2012) is presented the INSPIRE UML data model for cadastral parcels.

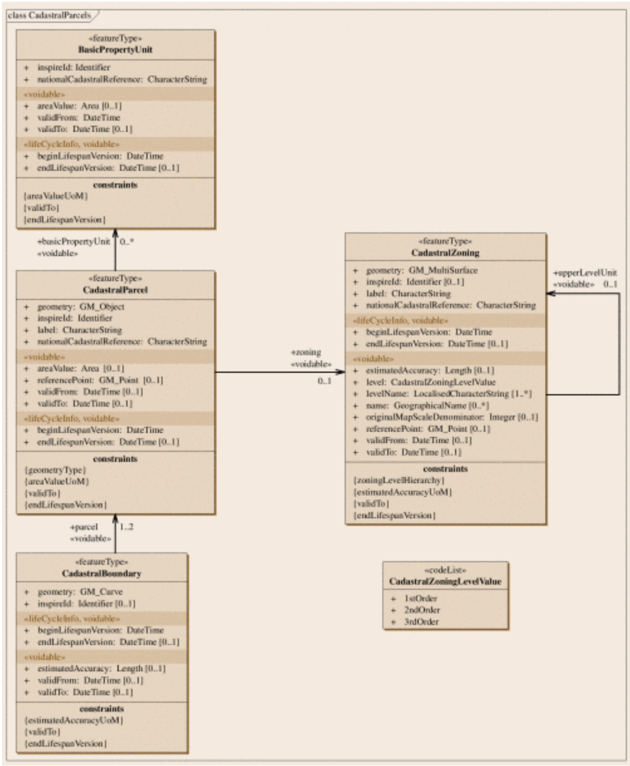


Figure 31 - INSPIRE UML data model for cadastral parcels (Seifert, 2012)

Moreover, in the INSPIRE context, cadastral parcels focus on the geographical part of cadastral data (e. g. they are only considered in INSPIRE scope if they are available as vector data) and will be mainly used as locators for geo-information in general, including environmental data. As much as possible, in the INSPIRE context, cadastral parcels should be forming a partition of national territory. Rights and owners are out of the INSPIRE scope, but buildings, land use, and addresses are considered in other INSPIRE themes.

The benefits of Cadastral Information for themes in INSPIRE Annexes II and III were specified by a joint working group consisting of members of the Permanent Committee on Cadastre (PCC) and EuroGeographics (Knowledge Exchange Network on Cadastre and Land Registry) (PCC; EuroGeographics, 2011)

Finally, as stated by (Martín-Varés & Salzmann, 2009) at the same time the ubiquitous presence of cadastres and land registries throughout Europe warrants the maintenance at the national level of the cadastral parcel and is at the basis of making the cadastral parcel a sustainable core element within the European spatial data infrastructure.

The arguments above are integrated and consolidated in the EuroGeographics vision on geospatial reference data presented in Figure 32.

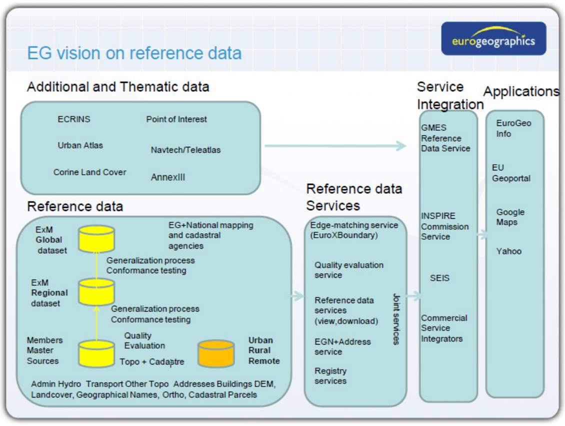


Figure 32 - The EuroGeographics vision on geospatial reference data (Jakobsson, 2012)

2.4. Geographic Information Systems (GIS)

2.4.1. Introduction

Geospatial technologies provide attractive integrative approaches for meeting current requirements to "do more with less." New approaches are demanded, supported, and must be implemented quickly for technology, collaboration, workforce development, funding, and other resources. This will include raising awareness of the unique aspects of geolocation from a privacy standpoint. Geospatial technology will increasingly be aligned with and integrated into the broader, ever-evolving technology ecosystem.

The geospatial technology field is at a remarkable point in its evolution, presenting an opportunity to rethink the deployment and use of these resources, and to enhance our ability to solve problems using geographic information while ultimately saving time and money (FGDC, 2013).

2.4.2. GIS from the early days till today

Bartelme in a journey through GIS, from the early days till today, groups them in two ways: in classic and modern senses (Bartelme, 2012):

- Classical GIS:
  - In the classical sense, an information system consists of a database representing the inner core of the system, being managed by a database management system (DBMS), and of an outer shell of tools that can be utilized by the user for manipulating and analysing this data.
- Modern GIS
  - But nowadays, we are faced by GIS in a client–server architecture. The traditional setup of a GIS has been modified in several ways, due to the arrival of new technologies and new concepts. The arrival of the Internet, of web-based service approaches, tools, and applications, has greatly influenced and modified the whole IT arena. The second boost has been initiated by mobile technology and the miniaturization of hardware components. Therefore, also the paradigms of GIS have

changed, and the architecture of a GIS nowadays is quite different from what it was a few years ago.

- Data are no longer restricted to the user's primary domain of interest and control, but they can in principle be imported from everywhere, anytime, and to any device (…) We talk about ubiquitous geographic/geospatial information as the universal availability of geographic information as seen on mobile devices such as cell phones, where maps, satellite images, positioning, routing services, and even 3-D simulations are gaining an ever-larger segment of the consumer market.
- Also, in contrast to earlier times when a GIS consisted of a well-balanced combination of hardware, software, and data components, today the borderlines between the functionality of an ordinary Internet browser and GIS functionality is often fuzzy. Likewise, content is displayed that may, via web services such as web map services (WMS), be composed on the fly, coming from different sources but having the appearance of a combined dataset, whereas in many cases the data themselves are not transported but are rather visualized on the fly. The data remain at their various home localities, which is an asset as far as currency and lack of redundancy is concerned.

In Figure 33, according to (Kim & Jang, 2012) is presented the evolution of geographic information from its 1st to 4th generations.

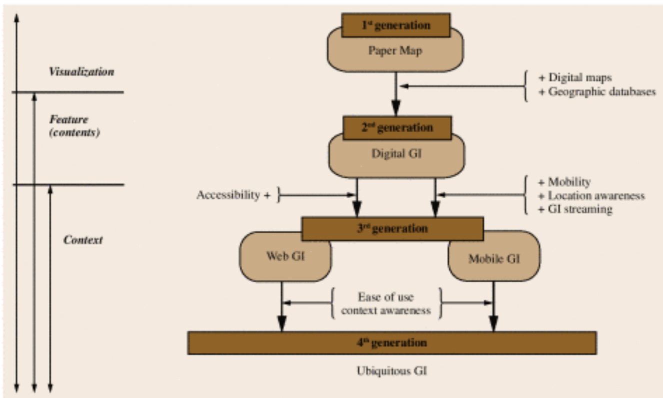


Figure 33 – Evolution of Geographic Information (Kim & Jang, 2012)

Lately, according to (Dangermond, 2012) Cloud GIS arises as the new platform that allows geographic knowledge to be widely shared, enabling widespread access and use of GIS (Figure 34). At the same time, other trends, such as widespread measurement, big data, and ubiquitous computing, are advancing rapidly, including Software as a Service computing, device computing with lightweight and locationally aware applications, as well as supporting scientific exploration and innovation. The convergence of GIS with these trends will enable us to integrate geographic knowledge into everything we do. This new pattern integrates all types of geographic information— maps, data, imagery, social media, crowdsourced information, sensor networks, and much more. Cloud GIS enables ubiquitous access and integrates the traditional work of geospatial professionals with a whole new world of GIS applications.

Figure 34 – Cloud GIS enables pervasive access, integrating traditional GIS with a whole new world of applications (Dangermond, 2012)

2.4.3.GIS definition

In 1999, Chrisman after passing in review several GIS definitions makes a new GIS definition proposal (Chrisman, 1999), - Geographic Information System (GIS) - The organized activity by which people:

- measure aspects of geographic phenomena and processes;
- represent these measurements, usually in the form of a computer database, to emphasize spatial themes, entities, and relationships;
- operate upon these representations to produce more measurements and to discover new relationships by integrating disparate sources; and
- transform these representations to conform to other frameworks of entities and relationships.

Additionally, the parts of a geographic information system according to (Tomlinson, 2011) are presented in Figure 35.

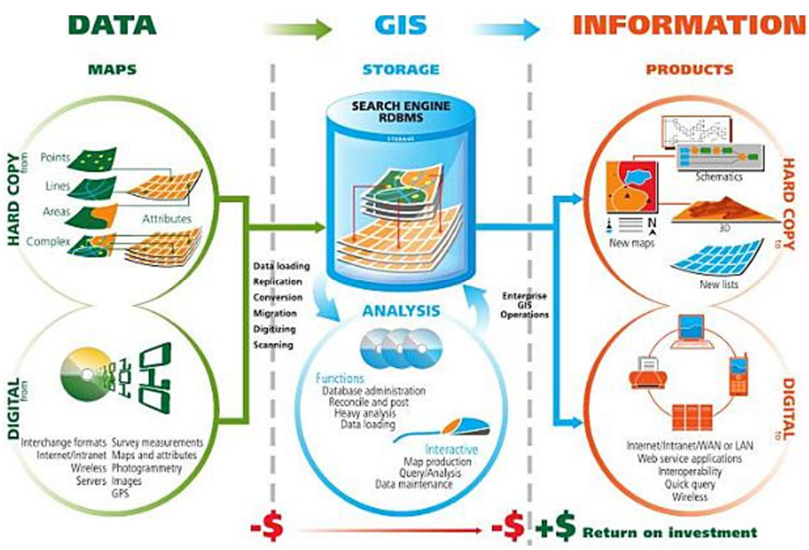


Figure 35 - Parts of a GIS (Tomlinson, 2011)

2.4.4.GIScience

Presently we cannot talk about GIS without framing it in science, and in what GIScience means. Goodchild highlights two GIScience definitions (Goodchild, 2010):

- the succinct definition adopted by the University Consortium for Geographic Information Science: “The development and use of theories, methods, technology, and data for understanding geographic processes, relationships, and patterns.”, and
- GIScience defined as “The basic research field that seeks to redefine geographic concepts and their use in the context of geographic information systems.” (in a cited report to the National Science Foundation following a 1999 workshop)

2.4.5.CyberGIS

According to (Wang, et al., 2013) in the foreseeable future, GIS will likely continue to play essential roles in many fields (e.g., ecology, emergency management, environmental engineering and sciences, geography and spatial sciences, geosciences, and social sciences) for solving scientific problems and improving decision-making practices, resulting in broad and significant societal impacts (Wilson and Fotheringham 2007, Wang and Zhu 2008, NRC 2010 cited by (Wang, et al., 2013)).

However, conventional GIS software based on closed and monolithic architecture is limited in its ability to efficiently handle very large spatial (i.e., geographically referenced) data and effectively manage sophisticated spatial analysis/modelling (SAM) and visualization (Wang, et al., 2013).

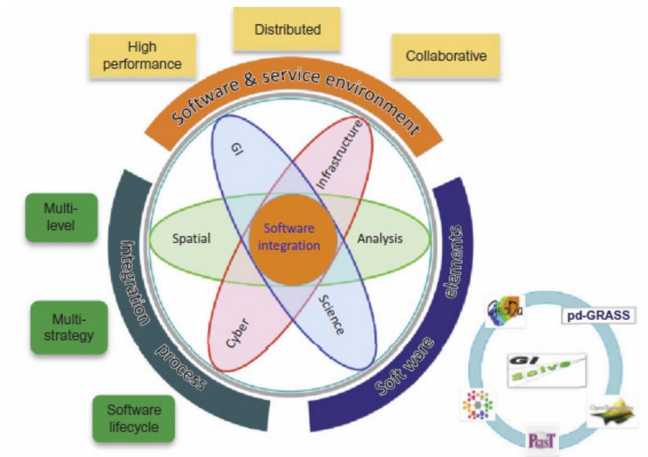


Figure 36 - CyberGIS Component Architecture (Wang, et al., 2013)

In this context, the following definitions emerge:

- Cyberinfrastructure (CI) consists of computing systems, data storage systems, advanced instruments and data repositories, visualization environments, and people, all linked together by software and high performance networks to improve research productivity and enable breakthroughs that are not otherwise possible (Stewart et al. 2010 cited by (Wang, et al., 2013)).

- Cyberinfrastructure-based GIS (CyberGIS) has emerged as a fundamentally new GIS modality comprising a seamless integration of CI, GIS, and SAM capabilities, likely leading to widespread scientific breakthroughs and broad societal impacts (Wang and Zhu 2008, Wright and Wang 2011, Wang et al. 2012 cited by (Wang, et al., 2013)).

The CyberGIS Component Architecture according to (Wang, et al., 2013) is presented in Figure 36.

2.5. Cadastre, GIS, Geospatial Information integration and Railways.

2.5.1.Cadastre, GIS and Geospatial Information integration

The evolution of ICT (ICT is an umbrella term that encompasses all forms of computing, information technology, Internet, and telecommunications) location information infrastructures (also known as land information systems or services) in underpinning land administration is illustrated in Figure 37. The initial phase focuses on large-scale programs for capturing data by scanning records or conducting field surveys, with corresponding computerization of internal land administration processes. The next series of phases are all outward facing, improving the level of customer services and increasingly providing online services. Initially this effort involved providing extranet services to key customers; as Internet services matured, they supported an increasing number of information services and e-transactions. Finally, as interoperability among government agencies improves, radical changes and efficiencies will be achieved in delivering e-government services based on land administration (Mclaren & Stanley, 2011).

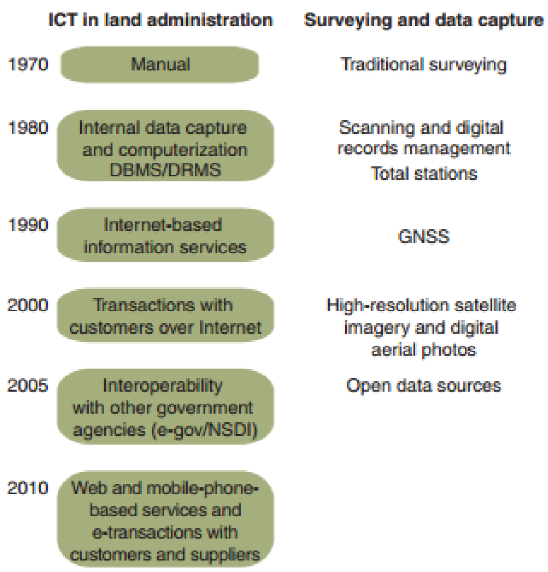


Figure 37 - Evolution of ICT in Land Administration (Mclaren & Stanley, 2011)

Nowadays, GIS Land Administration applications in a local, regional, national and trans-national levels are becoming a major integrator between different Land data sources. I choose two main topics, from the several pointed by (Dale & McLaren, 2005), to summarize this issue:

- As GIS and associated technologies mature and more data become available in computer form, the use of GIS for integrating land-related data becomes more opportune. Increased openness and integration of data are, however, more than technical issues and are often seen as a threat rather than as an opportunity.
- National Land Information Systems (NLIS) provide ease of access through the transparent integration of a diverse set of discrete datasets, many of them authoritative. Successful NLIS require common spatial referencing standards and appropriate GIS technology to support spatial data servers, federated DBMS, temporal management, high security, charging mechanisms, efficient WAN technology, and effective client customisation tools. In this context is presented GIS as the platform for Land Administration (Jones, 2013) in Figure 38.

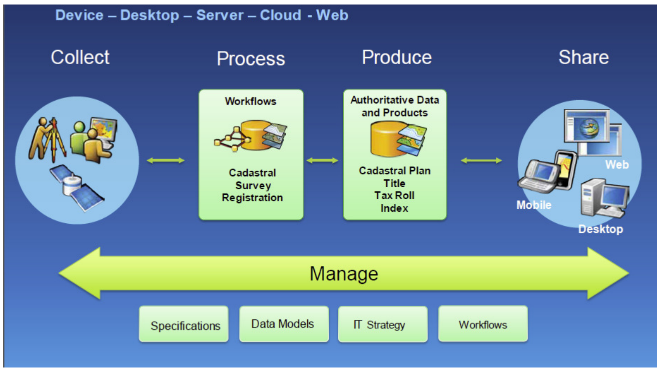


Figure 38 - GIS - The platform for Land Administration (Jones, 2013)

A new generation of GIS-based tools is now available, supported by maturing spatial data infrastructures, to enhance the interaction experience and effectiveness with the citizen. Public Participation GIS (PPGIS) is being applied to participatory community planning (Zhao and Coleman 2006) cit. by (Mclaren & Stanley, 2011) to help neighbourhood community groups and individuals use mapping and spatial analyses in community development and public participation. One of the most advanced and participatory e-planning portals is in Denmark (see http://plansystemdk.dk). The solution provides public access to all statutory land-use plans such as municipal plans and development plans (called a lokalplan), both adopted or proposed, across Denmark. The areas of the development plans can be displayed in combination with cadastral maps, topographic maps, orthophotos and other kind of land-use constraints, such as conservation areas and coastal protection zones. This open, transparent e-planning portal also serves as an authoritative legal register. It is an excellent example of land registration and cadastral information services being integrated into wider e-government services (Mclaren & Stanley, 2011).

2.5.2. Cadastre and Railways

Infrastructure Railway Managers and Operators are huge property owners, managing very relevant areas of the territory related with railway infrastructures and facilities. Due to historical reasons – railway is a centenary industry - and further developments, within this valuable real estate assets, there are significant possessions in urban and suburban environments associated to lines, railway stations, logistic terminals and interfaces, yards, workshops, etc (Mata, 2012).

Each network, private or public, has its own context (world region, history, culture, values, leadership, …), but one thing is quite common among them regarding property and real estate control: information, when it exists, relies on old paper support deposited in “dark” basements of buildings or warehouses and it’s not an easy process to create knowledge from it under this conditions (Mata, 2012).

According to (Mata, 2012), when we are referring to land cadastre, applied to railway land assets or generally speaking about the territory, we basically must relate two main variables: property and ownership. Further on, within a railway organization cadastre control (Figure 39) is quite an important issue to several activities that should be developed over a very same reality: the railway domain.

Figure 39 – Cadastre Control (Ferbritas, 2012c)

In conclusion, cadastre control is a basic and strategic issue (as illustrated in Figure 39 and Figure 40), not only from the point of view of taking advantage from possessions and profit from it, but also for the general performance of the organization and for its relations with external entities (Mata, 2012).

Figure 40 - Why a Cadastre Information System? (Gil & Mata, 2011a)

2.5.3.GIS and Railways

Investing in current and reliable geodata is rewarding. There are lots of examples where efficiency gain can be attained but also an increase in safety and avoidance of damage to the environment. The public receive a better service, including the fast availability of substitute transport, shorter incident problem-solving times and prevention planning. Quality geodata should be a precondition for management in the railway sector and ideally one shouldn't set up a business case for the improvement of data quality. In different countries there's attention for BIM and geoinformation in the whole lifecycle of the railway network: from feasibility study, design and construction to the maintenance and management phase (van Driel & Zhao, 2012). Figure 41 presents a comprehensive list of railways activities where GIS support have a prominent role.

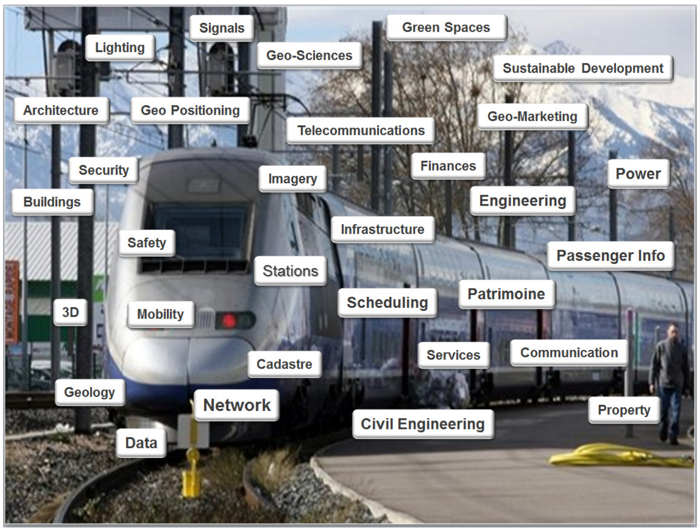


Figure 41 - GIS and Railways (Bills, 2013)

Railway managers, whether focused on passenger or freight delivery, can use the spatial and analytic components of GIS to efficiently manage assets, maximize throughput, and monitor safety. The ability to share maps and information online improves communication with your stakeholders, including customers (Esri, 2014), empowering entire railways infrastructure life-cycle management as presented in Figure 42.

Figure 42 - GIS and Railway Management (Koeppel & Engstrom, 2012)

2.6. Institutional issues

Several institutional issues arise within Land Management. Summarizing I will present five of them:

- The creation of data in digital form is necessary, but not sufficient, for effective land administration to occur. Experience to date suggests that it is essential that the legal, political, economic, and social issues also be addressed. Given that any inherent problems can be overcome, significant benefits should ensue (Dale & McLaren, 2005); and
- In advanced systems, integrated cadastral layers within a jurisdiction's SDI ideally deliver spatially enabled LAS to support the multipurpose of tenure, use, value and development. However building this kind of interaction between these four functions is not easy. The historic institutional silos, separate data bases, separate identifiers, and separate legal frameworks need to be reorganized. For most countries this presents another major land administration challenge (Williamson, et al., 2010);
- The politicians and decision makers in the land sector are key in this change process and need to become advocates of change through understanding the social and economic benefits of this journey of change. This will then allow any legal framework and professional barriers to be dismantled (Enemark, et al., 2014);
- Land information now assumes far more significance that it did in the comparatively simple times of 19th and 20th centuries when it was collected and maintained in silo agencies. Land information must now be shared across agencies and throughout a nation to enable the delivery of spatially enabled societies (see Annex 1 where this subject is further developed). The challenge to land registries are not new: in all the democracies, these agencies are being asked to accept radical change in order to meet social and economic needs (Wallace, et al., 2010).
- In the Portuguese Cadastre case Silva's thesis (Silva, 2005) points out "The conclusion is that it is not likely that any development will take place in the short term, since it is not foreseeable that a development agent will emerge.", and related causes of development to stakeholder configurations (Çagdas & Stubkjær, 2008), which is highlighted by (Enemark, et al., 2014) when its argued that, the largest change will be focused on the public sector where this may involve institutional and organisational reforms, including legal framework, processes and procedures, and awareness in terms of incentives and accountability.

On the other hand, Land Administration Systems are not an end in itself but facilitate the implementation of the land policies within the context of a wider national land management framework. Land administration activities are, not just about technical or administrative processes. The activities are basically political and reflect the accepted social concepts concerning people, rights, and land objects with regard to land tenure, land markets, land taxation, land-use control, land development, and environmental management. Land administration systems therefore need high-level political support and recognition (Enemark, 2009).

A last statement from UN-GGIM "Future trends in geospatial information management: the five to ten year vision, July 2013" (Carpenter & Snell, 2013), about the vital future role of governments in geospatial provision and management:

- The increasing use of authoritative, trusted geospatial information will drive adoption of geospatial information and ensure that it reaches ubiquity in the government and business decision-making process, as well as in the consumer sphere. Increasing recognition of the value inherent in the data means that NMCAs are likely to become more closely aligned with other 'official' bodies in government who look after, for example, statistics, the economy or land. Governments will have a vital role in ensuring that frameworks are in place that will enable the effective cooperation and collaboration between the plurality of actors that will increasingly be involved in the provision and management of geospatial information, and in ensuring that the benefits that a spatially-enabled society has the potential to offer, are realised.

2.7. Future Developments

According to (Bennett, et al., 2011) new drivers impacting on the nature of role of future cadastres were discussed under the categories of political drivers, environmental drivers, technological drivers, and socio-economic. Globalisation, population urbanization, good governance, climate-change response, environmental management, 3D visualization/ analysis technologies, WSNs, standardization, and interoperability were found to be critical factors driving developments in the cadastral domain. Based on these drivers, six design elements of future cadastre emerged: Survey-Accurate Cadastres, Object-Oriented Cadastres, 3D/4D Cadastres (example presented in Figure 43), Real-Time Cadastres, Global Cadastres, and Organic Cadastres. Together, these elements provide a potential vision for the role and nature of future cadastres.

Figure 43 - Augmented reality view of right and restriction boundaries in 3D (LINZ, 2014)

Moreover, I would like to highlight the theses exposed in (Comtesse & Pauletto, 2012) article "Cadastre: Vision for the Future. The Impact of New Dimensions", which identify six major trends that will most likely have an influence on the vision of cadastre and influence the entire evolution of the field in which the cadastre operates, according to the previous cited authors:

- Thesis 1: The cadastre will include the third dimension of the landscape and of the objects beyond the current legal framework.
- Thesis 2: The cadastre will blend the strategic map and the dynamic map of the land to show its historical evolution. Both views will evolve independently.
- Thesis 3: The cadastre will be multifunctional and multijurisdictional.
- Thesis 4: Social networks will transform the cadastre.
- Thesis 5: New commons will emerge as a referenced object of the cadastre.
- Thesis 6: The cadastre will become an essential element of knowledge society.

Future activities need to take into account emerging trends in geospatial information and the new opportunities they present for the application of spatial technologies and geographic information (Steudler & Rajabifard, 2012). According to the previous cited FIG nº 58 report (Steudler & Rajabifard, 2012) these trends include (but are not limited to):

- location as the fourth element of decision-making;
- differentiating between authoritative and volunteered (including crowdsourced) information, yet recognising the importance and value of both types of information towards spatial enablement and the enrichment of societies;
- changing directions: simple to complex, autonomous to interdependent, spatial ubiquity;
- growing awareness for openness of data e.g. licensing, and resultant improvements in data quality;
- move towards service provision; and
- recognizing the difference between spatial enablement and spatial dependency.

However lately, according to (Bennett, 2012), it seems that a paradigm shift is taking place - at least amongst geospatial and land administration professionals. There is now wide agreement that full title with accurately surveyed boundaries should not be attempted upfront in many contexts. The concept of the 'continuum of land rights' has taken hold: a staged or phased approach to delivering more secure land rights is needed. From a land administration perspective, this means, in the short term, that we need to develop and utilise faster, cheaper and more fit-for-purpose land administration designs. The range of new approaches and tools is emerging at a rapid pace. Tools already available include:

- The social tenure domain model (STDM) - a design approach that enables the capture of non-traditional forms of land tenure. The model is already implemented in off-the shelf software packages.

- Point cadastre - a fast cadastral approach that captures a single coordinate (potentially captured using handheld GNSS) to represent a parcel rather than a complete set of surveyed boundaries.
- Digital pen - a tool that greatly reduces transcription processes between the field and office, thus reducing errors and speeding up recordation time.
- Crowdsourced cadastre (or Cadastre 2.0) - an approach where citizens are trained to undertake adjudication, demarcation, surveying and recordation processes themselves using low cost processes and mobile technology.
- High resolution satellite imagery (HRSI) - for fast paced participatory adjudication and mapping programmes in rural areas.
- Low altitude remotely sensed imagery (LARSI) - imagery captured by lightweight and unmanned aircraft equipped with a camera, GNSS receiver and other positioning tools. Like HRSI, the imagery can be used to speed up adjudication and mapping programmes. The higher resolutions available enable utility in more built up areas.
- The pro-poor land recordation system - a set of transparent principles and processes developed by UN-Habitat that enable the recordation and maintenance of land interests in places where individuals might live on less than USD 2 a day.

Finally, I would like to highlight a group of ubiquitous positioning technologies in rapid development that may revolutionize cadastre and land administration in mid-term (see Annex 2 where this subject is further developed).

3. METHODOLOGY

3.1. Introduction

I started this work in section 1 framing FBSIC in its main roots: Land Administration, Cadastre, land acquisition for railways infrastructure construction, GIS, and how all these themes are related together; afterwards I formulate this work objectives, and pointed out the report organization, and main personal contributions to FBSIC.

After the introductory points I presented in section 2 a literature review embracing all the previous mentioned themes: (a) Land Administration mentioning: Land Administration Domain Model (LADM) standard with a reference to Portugal Country Model (Hespanha, 2012); (b) Cadastre: the cadastral tool as the left wing of LADM “butterfly” diagram (Williamson, et al., 2010), (Williamson, et al., 2010b); and finally (c) GIS, namely GIS in Railways, and related business models.

Subsequently, in this chapter, this report will address, in detail, the methodology behind FBSIC projects (its overview is shown in Annex 4), with emphasis on the coordination and project management activities, in which, I was actively involved, from its early planning stage to maintenance phase and closing, covering about a four years period, between October 1, 2008 and October 12, 2012. In this chapter, the main points will be the following:

- Base methodologies;
- Preliminary and Planning stages (October 1, 2008 to May 7, 2009);
- FBSIC software development projects, comprising two phases:
  - Phase 1 - FBSIC prototype (May 8, 2009 to August 11, 2009); and
  - Phase 2 - FBSIC - Web ADF (September 15, 2009 to October 4, 2010);
- FBSIC Upgrading and Corrective Maintenances (October 4, 2010 to October 12, 2012), briefly summarized in the activities listed below:
  - FBSIC/FBX integration software developing services;
  - REFER Domain Module and Final expropriation parcels drawings generation;
  - 2011 FBSIC upgrading and corrective maintenance;
  - GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration;
  - FBSIC production support tools and procedures; and
  - 2012 FBSIC upgrading and corrective maintenance.
- Overall Closing of FBSIC projects (October 12, 2012);
- FBSIC production stages (June 1, 2009 to July 1, 2013).

FBSIC projects overview composed by each project main features list, from FBSIC planning to overall closing and production stages, is presented in Annex 4.

Furthermore, FBSIC global calendar, presented in Figure 44, illustrates and shows together all projects and related time frames from October 1, 2008 to July 1, 2013.

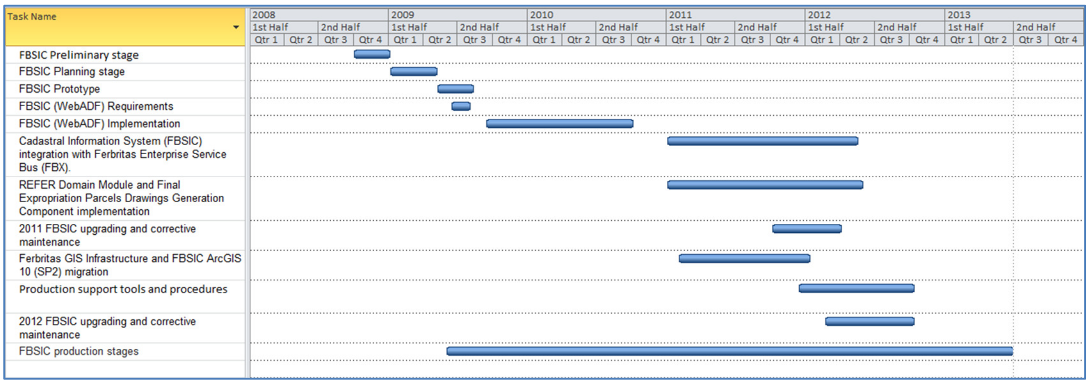


Figure 44 – FBSIC global calendar

The immediate reason for the development of this information system stems from the need to provide a complete answer to the dynamic control of the registration and real estate status of the Portuguese national railway infrastructure. FBSIC is, thus, a fit-for-purpose cadastre information system rooted in the field of railway infrastructures.

3.2. Base methodologies

3.2.1. Introduction.

FBSIC project, which itself was comprised by a group of projects, followed a flexible Project Management methodology, framed within PMI procedures, and anchored in "organized common sense" as sustained by (Wysocki, 2009).

On the other hand, the FBSIC software development stages, adopted the prototype and waterfall development models, which are briefly characterized in next chapters.

3.2.2. FBSIC software developments models. Brief review.

There were two main software development models applied in FBSIC: prototyping and waterfall, which main characteristics are presented below.

3.2.2.1. Prototype development model

The prototype development model has an iterative framework type, especially in what refers to the requirements definition, system design, coding and testing tasks, followed by implementation and maintenance tasks in a linear fashion. Prototype life cycle is presented in Figure 45.

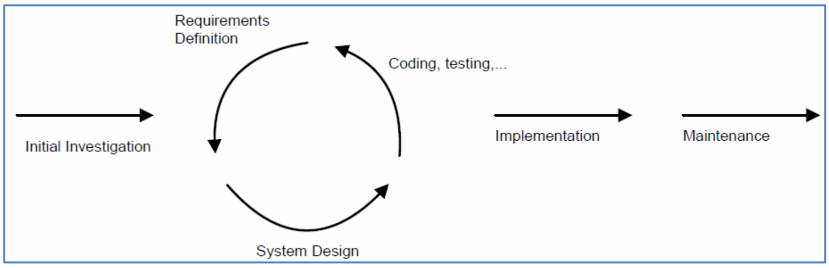


Figure 45 – Prototyping life cycle (CMS, 2008)

The reason why this approach was adopted in two occasions (further on detailed) can be summarized in the following points:

- Development and validation of user requirements, and experimenting with or comparing various design solutions;
- Helping to easily identify confusing or difficult functions and missing functionality;
- Improvement of both user participation in system development and communication among project stakeholders;
- Specifications generation for the final product application; and
- Provision of a quick implementation of an incomplete, but functional, application.

3.2.2.2. Waterfall development model

On the other hand, the waterfall development model (whose first formal description is frequently cited as (Royce, 1970) article) is a sequential design process having a linear framework type, with requirements definition, system design, coding, testing, implementation and maintenance tasks disposed in a linear fashion. It is a sequential software development model in which development “flows” steadily downwards through several phases. Waterfall life cycle is presented in Figure 46.

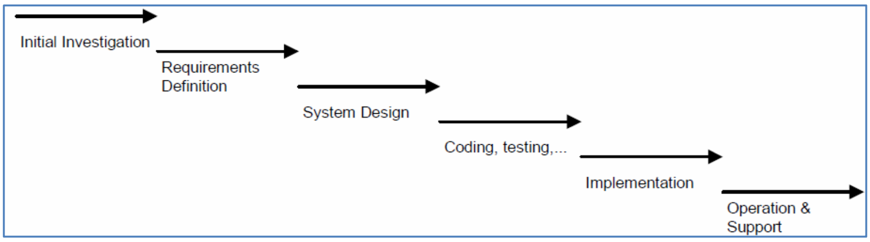


Figure 46 – Waterfall model life cycle (CMS, 2008)

The main reasons why this software development strategy was adopted, are listed below:

- Project appeared to be large, and complicated;
- Project had clear objectives and solution;
- Project requirements could be stated unambiguously and comprehensively;
- Project requirements were stable or unchanging during the system development life cycle;
- User community was fully knowledgeable in the business and application;
- Resources needed to be conserved;
- Strict requirement implementation for formal approvals at designated milestones.

In the executing stage, two prototypes (desktop GIS and web GIS) and several waterfall processes (one for each project) will be pointed out and described.

3.2.3. Project Management

3.2.3.1. Introduction

In the following points, I will identify the main global project management stages, as applied in FBSIC projects:

1. Initiating: where the entire project object was scoped;
2. Planning: where a three year plan comprising hardware, software, services and training acquisition was made;
3. Executing: where the project was carried on, which was composed by:
   i. external contractor teams (hardware, software, services and training) on company’s headquarters comprising several individual projects; and
   ii. internal production teams (base information system loading, analogical and digital cadastral and expropriations information migration (mainly dated before 2009); and cadastral and expropriations digital information system loading (from 2009 and beyond));
4. Monitoring and Controlling: where the main status activities occurred; and
5. Closing: where the works were formally concluded, thus beginning the guarantee and maintenance period.

In the above mentioned stages, along all the main project life cycle, two project management layers coexisted:

- Ferbritas project management – ensured by the author between October 1, 2008 and October 12, 2012 (simultaneously being GIS team head (from October 1, 2008 till September 30, 2010), and afterwards Geographical Information Officer – GIO (starting on October 1, 2010 till March 31, 2013); and
- Contractor's (Esri Portugal) project management (software developing system services).

3.2.3.1.1. Overall Development Processes

In brief, each software developing component, in each project, was considered as a systematic process framed, in most cases, within waterfall model (the prototype model its used only twice), consisting in the phases that supported their execution, outlined below in broad terms (each project's overview is presented in Annex 4):

I. Kick-Off – was a meeting that occurred at the beginning of the works and aimed to set and align expectations regarding the project; and project communication plan definition, identifying contractor's team and client team, as well, as their roles.

II. Requirements gathering - this phase was done gathering all the assumptions of the system that somehow would have an impact on the functional definition of the system to implement. At this stage meetings were promoted between the major stakeholders of the customer whether they will be the project leaders or end users of the system. The resulting report of this phase formally accepted, by the company, was the condition for this stage to be considered accomplished.

III. Functional Analysis and Technical Design Report - in this phase, the operations to be carried out by the system, as well as the technical solution were described in detail. System features to implement were modulated. The resulting report of this phase formally accepted, by the company, was the condition for this stage to be considered accomplished.

IV. Tests Reports - this document included all operations that the system had to perform as well as their expected results. All tests that could justify the acceptance or non-acceptance of the project and its components were described here. The resulting report of this phase formally accepted, by the company, was the condition for this stage to be considered accomplished.

V. Implementation - In this phase the system was developed according to the specifications of the Functional Analysis and Technical Design report in order to respond to the requirements of the system requirements report.

VI. Acceptance Tests - this phase were conducted by Ferbritas key users and GIS team in order to carry out the final system tests according to the Tests Reports. Once the system is according with the test terms, we proceed to the next phase: the acceptance of the project. This phase took place at the end of each individual project.

VII. Project Closure - At this stage the project was formally accepted and the warranty period started. Training and start-up operational support were also given at this point.

As described above, the scope was defined iteratively, in several phases. Thus, it was considered that the document that defined the scope of the project was the last of the approved documents from the following:

- Proposal for Services Acquisition;
- System Requirements Report;
- Functional Analysis and Technical Design Report, and Tests Report.

3.2.3.1.2. Overall Production Processes

All FBSIC related production processes were led by the author, and took place between June 1, 2009 and July 27, 2013, moreover, the production tasks were entirely accomplished by Ferbritas GIS, Survey and Expropriations internal teams, which are listed below with reference to the responsible team:

- context information system loading - GIS team,
- analogical and digital cadastral and expropriations information migration (mainly dated before 2009) - GIS team; and
- cadastral and expropriations digital information system loading (from 2009 and beyond) - GIS, Survey and Expropriations teams.

FBSIC related production processes, executed by the author, included the following main tasks:

- Context information definition;
- Cadastral and Expropriations Projects data and official rules preliminary analyses;
- Cadastral and Expropriations Projects data migration strategy, and existing data standardization definitions;
- Processes documentation;
- Production teams training;
- Alphanumeric, and geographic work packages definition, distribution, monitoring and auditing with task workflow control tool support;
- Migration of existing data to the geospatial database quality control;
- Alphanumeric, geographic and documents data loading quality control;
- Automatic quality control procedures definition; and
- Automatic quality control checks with quality control dashboards (project and infrastructure) support.

The production results will be presented on Chapter 4 - Results.

3.2.3.2. Change Control System

A Project Scope Amendment Agreement was defined between Ferbritas and the software development contractor which defined and typified all changes that could affect the final product of the project. Depending on the phase of the project in which a specific change was raised, it was validated differently.

A change may impact a project on several levels:

- Time: can delay the final date of the project;
- Quote: may be the target of a new budgeting;
- Framework already developed: should make it necessary to redo work already done and therefore increase the time and budget.

Thus, even if a change had no impact on the project budget it was reviewed by both Project Manager (internal, i.e. Ferbritas (the author) and external, i.e. contractor) and was documented and approved by Ferbritas.

3.2.3.3. Communication Plan

In order to ensure project objectives achievement, Ferbritas and the contractor agreed to deploy one instance of project control - the Steering Committee, whose main responsibilities are described below:

- was responsible for strategic decisions and guidelines of the project;
- was intended to adopt amendments to the planning, project documents and set / change priorities;
- would meet monthly (approximately) and could be convened extraordinarily.

After the kick-off meeting, a Communication Plan document was issued by the contractor's project manager, submitted for Ferbritas approval with the constitution of the Steering and Monitoring Committees and the main information flows definition between all the stakeholders.

It was agreed with the contractor that before the follow-up meetings, a Status Report document would be sent to Ferbritas, containing the following information:

- % Execution of deliverables;
- Update planning;
- Needs of interaction with the customer until the next meeting of the Monitoring Committee;
- Identification / Update of risks and their mitigation actions.

3.2.3.4. Final notes

I will describe explicitly with further detail in the next sections that, after having established the overall project frame and planning, in some cases, we divided the main project in several "subprojects" each of them relating to an application module with their own correspondent waterfall development cycle, always articulated and coexisting within the main "mother" project.

3.3. Preliminary stage

3.3.1. Introduction

This project was a Ferbritas board initiative in order to accomplish the related strategic objectives defined by the main stakeholder REFER E.P.E., thus from the beginning, it was established as a Top-Down process.

The preliminary stage started on October 1, 2008 with Ferbritas initial project team first meeting and ended on May 7, 2009, when senior management approved project launching.

The initial project team was composed by a comprehensive Ferbritas staff group[1] ranging from board members, project manager, heads of GIS, IT and Survey departments, GIS, IT and Expropriations team members, and one external consultant (Figure 47).

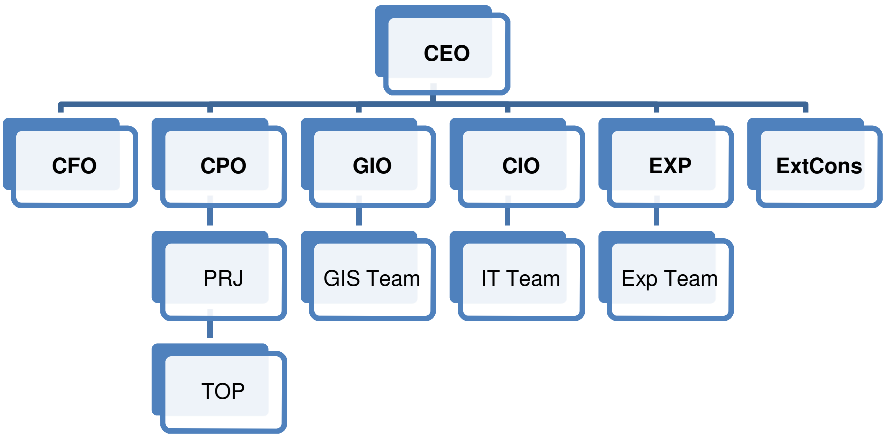


Figure 47 – FBSIC project team.

From day one, the GIS team started collecting and processing information from scratch and continued building up the collection of valuable information that the company already had, seeking its immediate availability to the client and all internal specialties, in order to achieve and accomplish the GIS team mission objectives presented below.

Since the beginning it was adopted a wide geographic information technology frame in the pursuit of a solution properly integrated with other information subsystems of the organization, focused on production and business management.

First, we proceeded to draft technical and business processes design update; afterwards we carried out an assessment to address the company internal and external services needs and

[1] Eng. Luis Mata: CEO, and main project sponsor; Dr. Jorge Lavaredas: board member and CPO; Prof. Marco Painho: external consultant; Eng. Fernando Gil: GIO, head of GIS team, and FBSIC projects manager; Dr. Tiago Gonçalves: GIS team; Dr. Nuno Calhau: CIO; Dr. Bruno Sequeira: IT team; Mr. João Miranda: IT team; Eng. Luis Ribeiro: head of Survey team (TOP); and Mr. João Meireles: Expropriations team member.

support in multiple information products aiming to prioritize their development. The previous actions led to needed activities and tools identification aiming at an implementation solution; followed by master objectives definition and consolidation and technological platform selection, which were the preconditions to start the project.

The preliminary stage had two main steps:

1. Initiating process: whose main objective was gaining senior management approval to the project plan (which occurred right after January 5, 2009 meeting); and
2. Planning process: whose main objective was gaining senior management approval to launch the project (which was achieved after the preliminary stage conclusions presentation on May 6, 2009 Ferbritas board meeting).

3.3.2. The GIS team mission

Ferbritas created a core competences GIS team on October 1, 2008, and soon afterwards, the company spatial information platform implementation become one of the actions identified in the strategic objectives framework guiding of the Plan and Budget for 2009.

Ferbritas GIS team evolved into Ferbritas GIS department on October 1, 2010. Its mission, in brief, was composed by the following main tasks:

- Consolidate and extend the company skills in Geographic Information Systems, in accordance with its strategic guidelines, providing increased business, marketing and technical support in GIS domain;
- Carry on with the projects Cadastre Information System (FBSIC) and Cadastre and Expropriation Integrated System (SICE). Lead the project teams that integrate other company units and external suppliers; and execute Quality Control of developed solutions;
- Coordinate the geographic information platform development, understood as an added value product for the railway studies and projects, and for other functional units of the company, and, in this context, lead the production and development teams of Land Administration Systems, Cadastral Recovery of Rail Public Domain GIS projects, and Expropriation GIS projects, and Railway Infrastructure GIS projects.

3.3.3. Initiating process.

The Initiating Process included the following processes:

- Recruiting the project manager;
- Eliciting the true needs of clients (internal and external);
- Documenting the internal and external client’s needs;
- Negotiating with the clients about how those needs will be met;
- Writing a document describing the project; and
- Gaining senior management approval to plan the project.

3.3.3.1. Project Scoping

The project began with the first project meeting on October 1, 2008. First, the cadastre and expropriations backgrounds were presented, the actual objectives were framed and established by the project sponsor (Ferbritas CEO, Eng. Luis Mata). Afterwards the first structured conversation between the internal clients (Survey and Expropriations teams) and the project manager (the author) took place in order to obtain a high level picture of what was to be done, aiming to collect more detailed information later on to obtain an initial scoping document, and finally submit to the board a preliminary plan with recommendations.

3.3.3.2. Initial Project Scoping Meetings

The initial Project Scoping Meetings, started on October 15, 2008, and were extended by approximately three months. Although the high-level scope for the project was already established, in the first project meeting, more detail was needed relating to cadastre and expropriation processes in order to conduct a preliminary analysis, propose alternative solutions, describe costs and benefits to consolidate in a preliminary plan with recommendations.

In this meetings, the project manager (the author) acted like the meeting facilitator, for the core project team, the internal clients, several key managers, and the end users of the project deliverables. It was agreed that there was a need to consolidate cadastre and expropriation workflows processes within the organization's objectives and the nature and scope of the problem under study. Afterwards, it proceeded to see how the problem being studied fitted in with all of the processes.

The GIS team started then digging into the organization's cadastre and expropriations objectives and specific issues, trying to realize if some of them could have already being covered by some other solution, and of course, trying to figure out alternate proposals by interviewing colleagues, clients, consultants, and by studying what competitors were doing. It was concluded that, in the end of this process, with all this data collected, we would face three choices: leave the system as it was, improve it, or develop a new system.

Likewise, the initial requirements, describing the highest level of requirements within the project started to take shape.

3.3.3.3. Approaches to Gathering Initial Requirements

The steps to generate the initial requirements began by looking at the business cadastre and expropriations functions as a whole. This was followed by the selection of methods for requirements gathering, and their planning. Within the several approaches to requirements gathering, it was chosen to adopt the following:

- Interviews;
- Requirements reuse; and
- Business process diagramming.

We chose to start identifying requirements for the project by mapping the current business processes (the ‘‘As Is’’ process) that were going to be affected, and to map the business processes after the solution would be installed (the ‘‘To Be’’ process). The gap between the ‘‘As Is’’ and ‘‘To Be’’ processes would be filled with new or enhanced project deliverables.

After just a few meetings we realized that some internal clients could not relate to a narrative description of the system but they could relate to a visual representation of that system. So, to help our internal clients to define what they wanted, the requirements gathering process continued with the development of a prototype, they could comment on it and give the developers more insight into what constitutes an acceptable solution.

About mid-December 2008, another internal project meeting took place where the status of the initial requirements gathering, and the first version of an Expropriations Project GIS prototype developed on ArcGIS Desktop 9.3.1. were presented to the internal project team At the end of that meeting the project sponsor (Ferbritas CEO, Eng. Luis Mata) considered that the time had come to share this work with Ferbritas main shareholder and main external client REFER E.P.E. (in particular with Real Estate and IT departments), and start to collect their feedback too.

The first meeting between Ferbritas (FB) and REFER Real Estate (REFER DPI) and IT (REFER DSTI) departments, took place on late December 2008, at REFER headquarters, during which the use of GIS technology applied to cadastre and expropriations in railways domain was discussed. A second meeting, now in Ferbritas headquarters, to present the demo of the Expropriations Project GIS prototype, was planned for the beginning of January 2009.

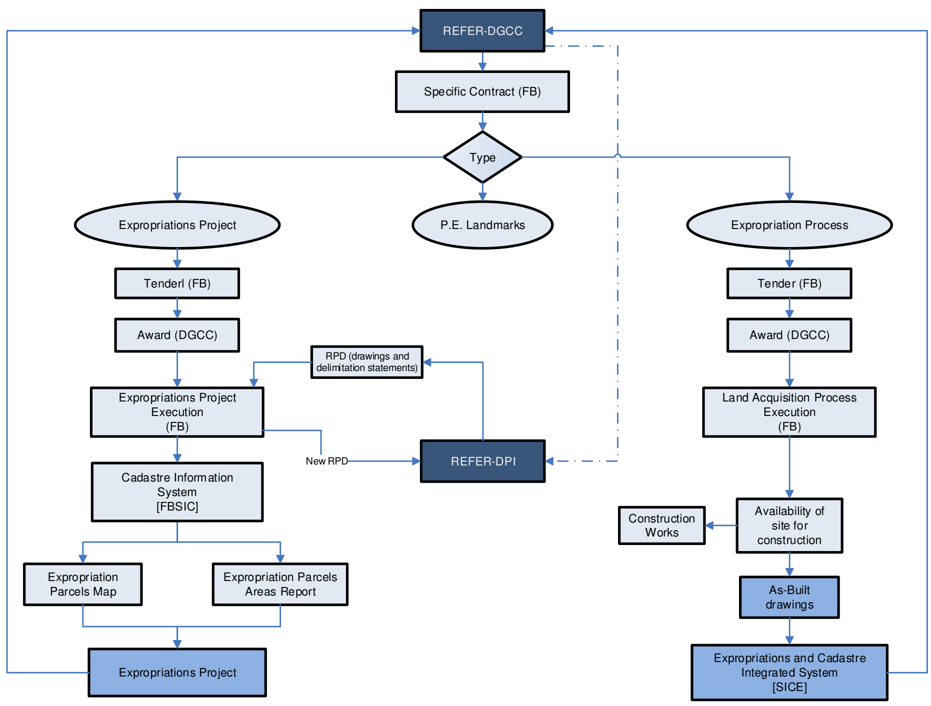


Figure 48 – High level workflow of Ferbritas Expropriations Projects and Processes (Ferbritas, 2010)

On January 5, 2009 meeting, the high level process workflow of Ferbritas Expropriations Projects and Processes was discussed and agreed on. This was followed by the presentation of examples of an expropriations project GIS prototype based on Esri technology (ArcGIS desktop / ArcReader), implemented by Ferbritas GIS team based on a small real data sample. It was demonstrated that a solution of this nature allowed integration, and a unified view of all base information: graphical, alphanumerical, documents, imagery (military base maps and orthophotomaps) and AutoCAD files, which was in line with the objectives pursued at that time by REFER DPI. This new approach represented a significant evolution from the situation that existed so far (all kind of results in paper and digital format, not integrated, with various formats, and dispersed by various media support), although there was still much to do in terms of information systems to implement an enterprise level solution The conviction arouse that the implementation of such a system had to be developed by a collaborative effort between the various entities. Also there was a need to design a high level process workflow integrating Ferbritas cadastre and expropriation works and REFER DPI needs, presented in Figure 48, and to develop an action plan. These issues would be revisited and detailed in the following meetings between Ferbritas and REFER DPI.

3.3.3.4. Gaining Approval to Plan the Project

After the previously referred meeting, a preliminary document with a summary of the information gathered at that point, the specifications of the GIS prototype (see Annex 3) and main REFER meetings occurred that far, was submitted to Ferbritas board by the project manager (the author). The evaluation of the previous elements resulted in the approval to plan the project by Ferbritas board.

3.3.4. Planning Process

The previously mentioned approval of the preliminary document by Ferbritas board only committed the resources required to complete a detailed plan for the project. It was not the approval to do the project itself.

The planning process lasted about four months from January 5, 2009 till May 7, 2009, and comprised a three year plan comprising hardware, software, services and training acquisition.

One of the main conclusions present in the preliminary document was that the resources that existed in the company, at that time, especially in the GIS and IT areas, did not allow us to respond properly to the previously identified needs.

So, we started considering several reasons in the project planning meetings that led to using outside resources for our project, some of them are listed below:

- We did not have the necessary skills and competencies within the company staff;
- Software development was not part of company’s core business activity;

- It would be more cost-effective (and risk effective) to have a GIS software house to provide the service; and
- It would be wiser to accelerate GIS skills development by first using a contractor.

Afterwards, the acquisitions responsibilities were split by Ferbritas board, between IT department and the project manager. In summary: the IT department became responsible for hardware acquisition, and the author (project manager and head of the GIS team) was responsible for GIS software, software development services, and GIS training acquisitions.

3.3.4.1. Procurement Management Life Cycle

Basically, in what concerned GIS software, software development services, and GIS training acquisitions, it was comprised of a procurement management life cycle of the following processes:

- Contractor solicitation;
- Contractor evaluation;
- Contractor selection;
- Contractor contracting; and
- Contractor management.

3.3.4.1.1. Contractor Solicitation

After the initial requirements gathering were done (see Annex 3), the project manager (i. e. the author), began to prepare the Request for Proposal (RFP), since the company didn't have a procurement office at the time to do it. This document (the RFP is a procurement document for solicitation) would be the source that allowed the Contractor to determine how they should respond to the company needs. It was comprised by a three year phased GIS software plan acquisition, a phased IT and GIS teams training schedule, and a GIS software developing services acquisition (web GIS Cadastre Information System prototype, and global cadastre solution requisites gathering).

Facing the specifications gathered in the initial requirements (Annex 3), the GIS technology software already being used in Ferbritas and in Ferbritas main client REFER (Esri ArcGIS), Ferbritas board decided to submit the RPF to Esri Portugal on March 1, 2009.

Considering the time needed to review the responses and make a report with the conclusions to submit to board approval, 30 days were given to Esri Portugal to respond.

In this time period, all the questions about the RFP were received and answered by email, and managed by the author.

The Contractor was asked to make an onsite presentation, which was attended by key users who would interact with the solution. Each contractor's proposed solution was evaluated using the criteria developed specifically for this onsite presentation.

ESRI Portugal delivered FBSIC solution Phase 1 Proposal, on March 30, 2009.

Similar procedures were followed, in subsequent contractor solicitation project phases (phase 2, and maintenance). In each of them, after budget framing validation, the corresponding RFP was issued, followed back with a Proposal, which after being fully analysed, negotiated and sometimes revised, ended with an evaluation report that was submitted to the board for consideration and approval.

3.3.4.1.2. Contractor Evaluation

In this phase, the main objective was to ensure that all RFP responses evaluation were consistent, objective, and comprehensive. The main criteria used are listed below:

- First, the evaluation team (mainly the project sponsor, and IT plus GIS departments heads) decided what the desired vendor relationship would be and defined the problem to be solved;
- Throughout the proposal analysis all evaluation team members were involved; and
- The reviewed baseline contractor evaluation criteria checklists were debated with the other team members about the relative importance of each criterion, and consensus was reached.

The contractor RFP response was evaluated for assessing their ability to successfully deliver against the requirements stated in the RFP. It was carried out by an internal team with the best knowledge of the disciplines represented in the RFP (IT and GIS).

Similar procedures were followed, in subsequent contractor evaluation project phases (phase 2, and maintenance).

3.3.4.1.3. Contractor Selection

Before the evaluation team started to read the response to the RFP, a group of criteria for choosing the contractor were set. These criteria were mainly based on technical expertise, experience, time to deliver the solution and cost.

In summary, the participants in this process were:

- Project Sponsor;
- Core project team;
- Project team;
- Project manager;
- Resource managers; and
- Function or process managers.

3.3.4.1.4. Gaining Approval to Launch the Project.

In early April 2009, after receiving all the contributions of the evaluation team, and the compilation of the initial requirements document (see Annex 3 where is presented its short version), the author jointly submitted them to Ferbritas board of administration for consideration and approval.

After the proposal had been submitted to Ferbritas board, it was requested that the author (as project manager) present and explain the project to all Ferbritas board. This meeting occurred on April 7, 2009.

Ferbritas board of administration approval to proceed with the project (hardware, GIS software, GIS training and GIS software developing services acquisition) occurred on May 6, 2009.

Similar procedures were followed, in subsequent project phases (phase 2 and maintenance).

3.3.4.1.5. Contractor Contracting

All GIS related contracts referred in this report, after Ferbritas board approval, were managed by Ferbritas Financial department together with the project manager (the author) support.

3.3.4.1.6. Contractor Management

Ferbritas project management culture always aimed (and succeeded most of the times) to make the contractor feel like an equal partner in the project, as a member of the project team, that meant including them in every team activity for which it would make sense to have them involved, so that, both teams, could function as a unified team throughout the project. Moreover, it made part of company's procedures that, contractor teams, should work on site within Ferbritas headquarters, especially in software development projects cases.

In every single project, the contractor's project manager issued a communication plan, which was distributed at the kick-off meeting, in order to enable communication establishment among all relevant stakeholders, and thus, optimizing development environment before implementation started.

Right after the kick-off meeting, the implementation process started (which was previously described in section 3.2.3.1.1) comprising: requirements gathering, functional analysis, application design and related developments, testing, deployment, application transitioning from contractor to client, and contract closing.

At last, a brief reference to project activities standard performance monitoring, which were done in a pace adequate to the project's characteristics, and composed by key metrics to track actual versus planned contract performance, mainly comprising labour hours, cost, and schedule.

These parameters were provided by contractor's project manager, in first place, and then monitored by the author, within his project manager responsibilities.

3.4. Executing stage

3.4.1. Introduction

FBSIC projects described further on were a direct result of previous preliminary and planning stages actions that culminated in Ferbritas board of administration approval to proceed with the project on May 6, 2009.

3.4.2.FBSIC project Phase 1 - FBSIC prototype

FBSIC project phase 1 (FBSIC prototype) occurred between May 8, 2009 and August 11, 2009, having its main steps listed below:

- Kick-off meeting;
- GIS Infrastructure (hardware and software) set-up and install;
- Prototype Requirements;
- Prototype Software Analysis and Design:
- Prototype Developing;
- Acceptance Testing;
- Final deploy;
- FBSIC solution phase 2 requirements;
- Meetings;
- Closing.

3.4.2.1. Kick-off meeting

The kick-off meeting took place in Ferbritas headquarters' on May 8, 2009, with Ferbritas and Esri Portugal entire project teams' presence. The meeting was led by the contractor's project manager, with the following agenda:

- Project scope;
- Management methodology overview;
- Planning milestones with brief chronogram review;
- Risk management framing;
- Communication plan initial set-up;
- Client satisfaction criteria definition; and
- Next steps listing.

The meeting main output was the Communication Plan document with Steering and Monitoring committee's definition. It was distributed between both project team members prior validation after the meeting.

3.4.2.2. GIS Infrastructure (hardware and software)

GIS Infrastructure software set-up and install began on June 1, 2009, soon after hardware became available, having the following main carateristics:

- Application Server:
  - Hardware: 4 Cores Intel Xeon 3.0 GHz VM (VMWARE) with 8 Gb RAM;
  - Operating System: Windows Server 2008 R2 STD x64, IIS 7.5;
  - GIS software: ArcGIS Server 9.3.1 Enterprise Standard, and ArcGIS Image Server 9.3.1;

  - Web Application: prototype developed in C # (Web Application Developer Framework for the Microsoft NET Framework .NET Web ADF) / JavaScript, MS Visual Studio 2008, Framework v3.5 (FBSIC - Central Module).
- Enterprise Database Server:
  - Hardware: 4 Cores Intel Xeon 3.0 GHz VM (VMWARE) with 8 Gb RAM;
  - Operating System: Windows Server 2008 R2 STD x64;
  - Enterprise Database: SQL Server Enterprise 2008 x64 SP1.
- Network: Corporate LAN 1 Gb; LAN Servers 2 x 10 Gb access.
- WorkStations (production team):
  - Hardware: 2 Cores Intel Xeon 3.0 GHz with 4 Gb RAM;
  - Operating System: Windows XP SP5;
  - GIS software: ArcGIS Deskop ArcEditor (concurrent) / ArcView (single use) 9.3.1 and extensions (Spatial Analyst; 3D Analyst. Network Analyst, Data Interoperability; Publisher; and ArcPAD).

In summary, FBSIC phase 1 physical architecture is presented in Figure 49:

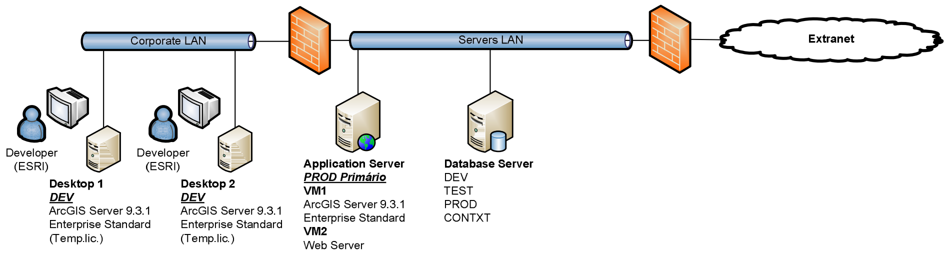


Figure 49 – Physical architecture (FBSIC phase 1) (Ferbritas, 2009)

3.4.2.3. Prototype Requirements

At this stage all system features with influence in prototype functional solution definition were surveyed. This task was carried out by Esri Portugal (project manager and senior software analyst) with Ferbritas project manager (the author) support, through a group of meetings between Esri Portugal and Ferbritas key users (ranging from project responsible to system end-users).

The system requirements were divided into three main groups:

- Functional Requirements: all requirements for operation, transaction processing or to be provided by the system, such as alphanumeric data visualization, user authentication, alphanumeric and geographic searches and data structure;
- Interface Requirements: all interface requirements level between the user and the system, such as map base and business geographic layers, map tool bar, and print tool definitions;
- Technical Requirements: all technical requirements (infrastructure, software, etc.) that have influence on the functional definition of the system to implement.

The final outcome document (Prototype Requirement Specifications) was revised by Ferbritas project manager (the author), further submitted to Ferbritas project team which formally accepted it, thus ending this step and enabling Prototype Software Analysis and Design to start.

3.4.2.4. Prototype Software Analysis and Design

At this step, Esri Portugal senior software analyst collected all functions to be performed by the system and pointed out their detailed description, which composed the technical solution definition.

Ferbritas project manager revised the resulting document (Prototype Software Analysis and Design Report) that was, further submitted to Ferbritas project team, which formally accepted it, thus ending this step and enabling Prototype Developing to start.

3.4.2.5. Prototype Developing

At this step, Esri Portugal developers carried out prototype's implementation according to Requirements Specifications and Software Analysis and Design Report.

Throughout the works, several contacts between both project managers took place in order to clarify some system behaviours.

The resulting document (Tests Report) was compiled by Esri Portugal project manager, and delivered to Ferbritas project manager enabling Acceptance Testing to start.

3.4.2.6. Prototype Acceptance Testing

The Tests Report lists all functions to be performed by the system and their expected outcome, in summary, it reflects all tests to be conducted.

Ferbritas key users with GIS team support conducted by Ferbritas project manager carried out all tests for all Report entries. All non-compliance features and behaviours, and other software bugs alike were reported back to Esri Portugal project manager. After their correction had been communicated to Ferbritas, and a new software version had been deployed, another test cycle began till all tests stated full compliance.

At the end, the Tests Report was revised by Ferbritas project manager, further submitted to Ferbritas project team which formally accepted it, thus ending this step and enabling the system to pass to the final acceptance.

3.4.2.7. Prototype Final deploy

When in a given test cycle all tests stated full compliance, the application was ready for final deployment, enabling application transitioning from contractor to client. In the present case, FBSIC phase 1 final deploy took place on August 7, 2009.

3.4.2.8. FBSIC solution phase 2 requirements

FBSIC solution phase 2 requirements were composed by all the works involved on land acquisition identification needs, to carry out railway related construction works. Its requirements report consisted on a document aiming to enumerate the requirements or assumptions that somehow, had influence on the functional definition of the system to implement, within the framework established in project proposal.

This task was carried out by Esri Portugal (project manager and senior software analyst) with Ferbritas project manager wide support, through a group of meetings between Esri Portugal and Ferbritas key users (ranging from project responsible to system end-users), from June 15, 2009 till August 2, 2009.

So, from the beginning, there was a deep focus in long-term project sustainability, in implementing a scalable solution, supported by standards for information technology and communication, and interoperability. The requirements craft had a deep support of all Ferbritas project team, aiming, in summary, the following initial objectives:

- Expropriations Project geographic and alphanumeric information view, query and edit;
- Quality control measures wide implementation (in each project stage, including transitions);
- Processes traceability;
- Map printing and formal documents creation, and
- Customer Final Approval application support.

The requirements document was an important tool for subsequent analysis and system design as well as for development and testing stages, which would be, always, checked according to requirements.

Likewise, one of FBSIC first results was its main stages definition. As shown in Figure 50 (along main outputs listing), six stages were considered on FBSIC v1.0: cadastral surveying preparation; cadastral surveying; cadastral surveying internal validation; expropriations project; expropriations project internal validation; and public use declaration (DUP).

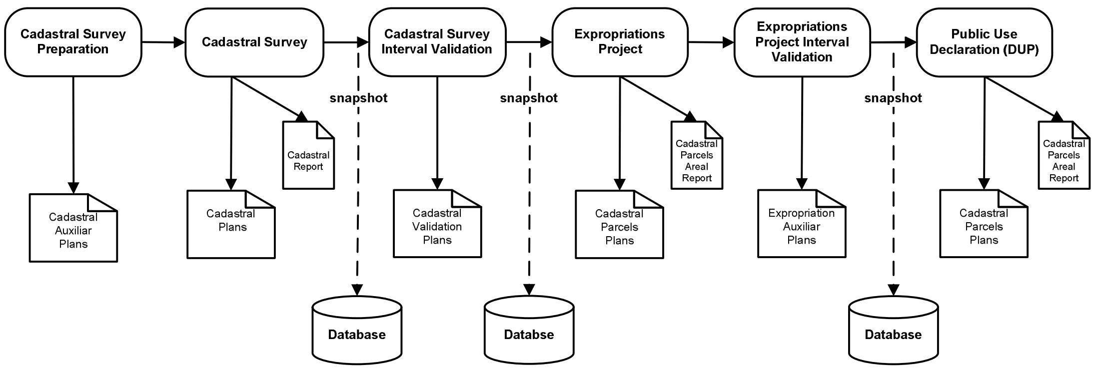


Figure 50 – FBSIC v1.0 main stages (Ferbritas, 2010a)

The system requirements were divided into three main groups:

- Functional Requirements: all requirements for operation, transaction processing or to be provided by the system, such as:
  - Data Migration Module features, comprehending: alphanumeric data; geographic data; and migration rules;

    - Central Module features, including mainly:
        - Generic requirements, such as: context data import, project data import, documents creation, user authentication, queries definition, alphanumeric data visualization, alphanumeric data creation/editing, geographic data creation/editing, geographic bookmarks, data import specifications, data export specifications;
        - Operation modes, comprising: full query mode, geographic query mode, and editing mode;
        - Workflow management;
        - FBSIC stages definition: cadastral surveying preparation; cadastral surveying; cadastral surveying internal validation; expropriations project; expropriations project internal validation; and public use declaration (DUP).
        - Quality control including: alphanumeric data editing, cadastral surveying preparation; cadastral surveying; cadastral surveying internal validation; expropriations project; expropriations project internal validation; and public use declaration (DUP).
        - Reports and Auditing;
        - Backoffice;
    - Field Module features encompassing field data collection (internal teams and external teams);
    - Information Processing Module;
    - Approval Module.
- Interface Requirements: all interface requirements level between the user and the system, such as:
    - Central Module, briefly highlighting the following:
        - Map features: default base information, cadastral surveying preparation; cadastral surveying; cadastral surveying internal validation; expropriations project; expropriations project internal validation, among others;
        - Map toolbar;
        - Print toolbar;
    - Field module.
- Technical Requirements: all technical requirements (infrastructure, software, etc.) that have influence on the functional definition of the system to implement.

In summary, by the end of requirements gathering it was decided to develop a modular system, comprising the following modules:

- Data Migration Module (geographic and alphanumeric data);
- Field Module (field information collection);
- Information Processing Module (data validation);
- Central Module (view/edit of geographic and alphanumeric information, quality control, generation and printing of documents, …);
- Approval Module (expropriations project by REFER); and
- BackOffice (support for system administration).

The previous listed modules were supported main system components listed below:

- Database (Alphanumeric / GIS): MS SQL Server 2008;
- File Server: Pictures, CAD files, etc.;
- GIS Services: ArcGIS Server and ArcGIS Image Server;
- Desktop GIS: ArcGIS / ArcInfo and its extensions;
- Web Application: Taylor made solution: user interfaces, alpha/geo editing, extended image support, automatic document generation, linked with document management).

I will finish this abridged system characterization presenting, in the next two figures (Figure 51 and Figure 52), the FBSIC Physical and Conceptual Architectures.

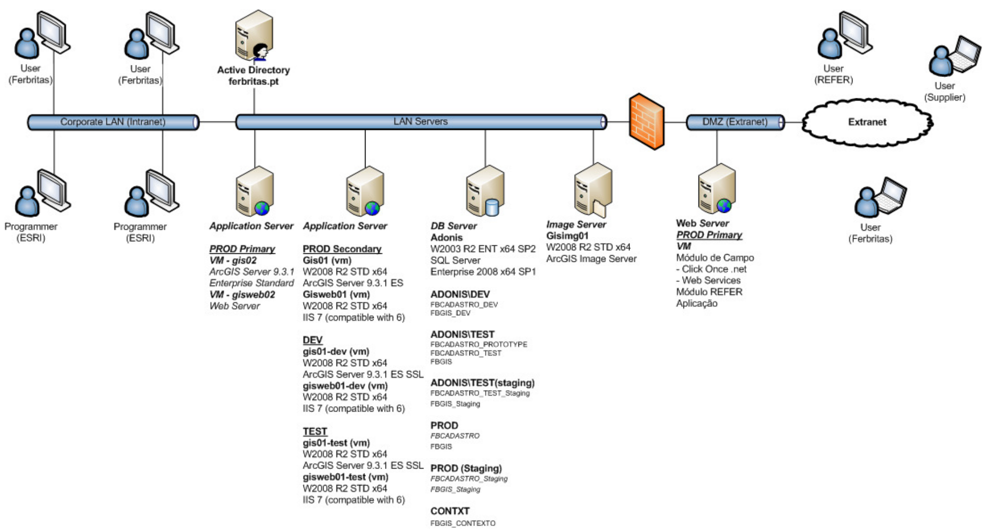


Figure 51 – FBSIC v1.0 Physical Architecture (Ferbritas, 2010a)

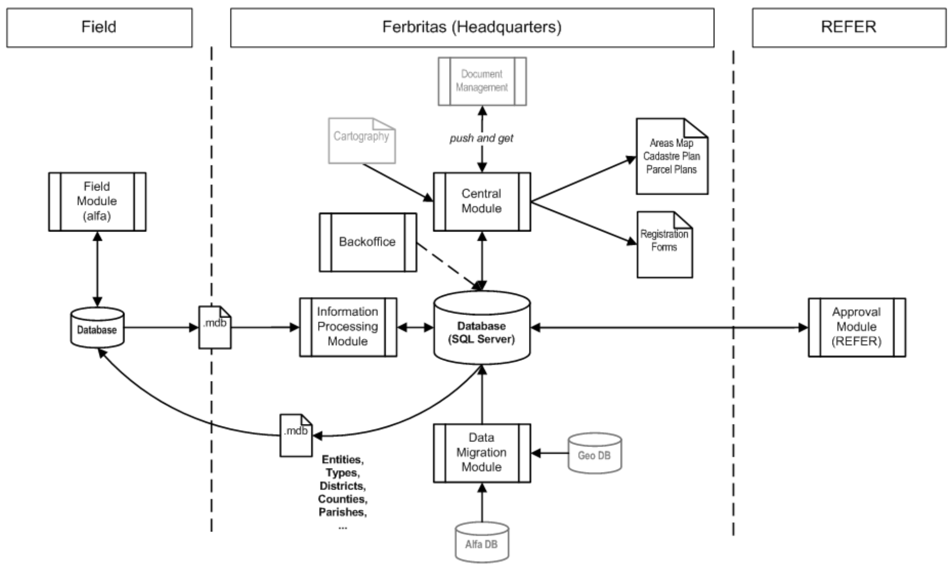


Figure 52 – FBSIC v1.0 Conceptual Architecture (Ferbritas, 2010a)

3.4.2.9. Meetings

Two different types of meetings were established, each one reflecting a particular scope and responsibilities. At the operational level, Monitoring Committee meetings occurred on a weekly basis starting on May 20, 2009 and ending on July 29, 2009. On the other hand, the decision level Steering Committee meetings occurred on a monthly basis starting on May 8, 2009 (kick-off) and ending on August 11, 2009 (closing).

In both cases, the contractor's project manager issued a Project Status Report before each meeting. These reports contained:

- Physical % of the work done;
- Planning Update;
- Interaction needs (until next of Monitoring Committee meeting);
- Delays identification;
- Risks identification and their mitigation actions.

The contractor's project manager issued the slides and the meeting minutes after each meeting (both distributed by email).

3.4.2.10. Closing

The project was formally accepted on August 11, 2009 at the final Steering meeting (the closing meeting).

Afterwards, began Esri Portugal application warranty period and the training of Ferbritas GIS team key users (led by the author), as well as their start-up support.

FBSIC project phase 1 (FBSIC prototype) final calendar, with main steps highlighted, is presented in Figure 53, and Annex 4 (global overview of FBSIC projects).

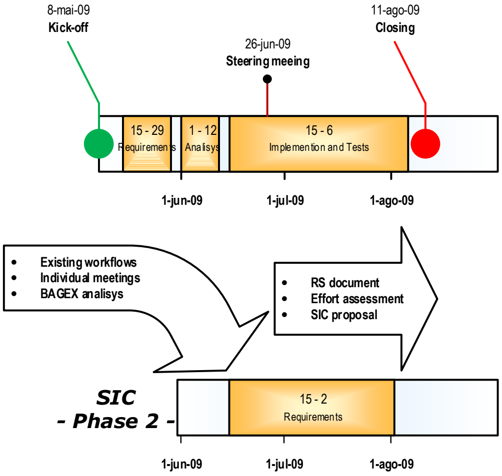


Figure 53 – FBSIC project phase 1 (FBSIC prototype) final calendar (Ferbritas, 2010a)

3.4.3. FBSIC project Phase 2 (FBSIC Web ADF)

3.4.3.1. Procurement procedures

The procurement procedures applied in this stage where similar to the ones fully described in chapter 3.3.4.1. So, in brief, FBSIC project phase 2 procurement life cycle was comprised of the following processes:

- Contractor solicitation;
- Contractor evaluation;
- Contractor contracting; and
- Contractor management.

In face of phase 2 specifications gathered between June 15, 2009 and August 2, 2009 (see chapter 3.4.2.8 for detailed references), Ferbritas board decided to submit a request to Esri Portugal on August 11, 2009, to elaborate a proposal to carry on FBSIC phase 2 software solution, and FBSIC solution phase 3 specifications gathering. ESRI Portugal delivered FBSIC solution Phase 2 Proposal, on August 24, 2009.

In early September 2009, after receiving all the contributions of the evaluation team, and the compilation of FBSIC solution phase 2 requirements document, the author jointly submitted them to Ferbritas board of administration for consideration and approval.

After the proposal had been submitted to Ferbritas board, it was requested that the author (the project manager), would present and explain the full project to Ferbritas board. This meeting occurred on September 3, 2009.

Ferbritas board of administration gave approval to proceed with the project (FBSIC phase 2 software solution, and FBSIC solution phase 3 specifications gathering) on September 15, 2009.

3.4.3.2. Main features

FBSIC projects phase 2 (FBSIC Web ADF) took place between September 15, 2009 and October 4, 2010, having its main steps listed below:

- Kick-off meeting;
- System Analysis and Design;
- Implementation:
  - Data Migration Module;
  - Field Module;
  - Information Processing Module;
  - Central Module;
  - Backoffice Module;
  - Approval Module;
  - Public Domain Management Module.
- Acceptance Tests;
- Final deploy;
- FBSIC solution Phase 3 requirements;
- Meetings;
- FBSIC Phase 2 Closing.

3.4.3.3. Kick-off meeting

The kick-off meeting took place in Ferbritas headquarters' on September 15, 2009, with Ferbritas and Esri Portugal entire project teams' presence. It was presented by the contractor's project manager, with the following agenda:

- Project scope:
- Management methodology overview;
- Communication plan initial set-up;
- Planning milestones with brief chronogram review;
- Risk management framing;
- Client satisfaction criteria definition; and
- Next steps listing.

The main output of this meeting was the Communication Plan document with Steering and Monitoring committee's definition. It was distributed between both project team members for validation after the meeting.

3.4.3.4. Software Analysis and Design

FBSIC solution phase 2 requirements were gathered within the previous project frame (see chapter 3.4.2.8), where all system features with influence in the functional solution definition were surveyed. This task was carried out by Esri Portugal (project manager and senior software analyst) with Ferbritas project manager wide support, through a group of meetings between Esri Portugal and Ferbritas key users (ranging from project responsible to system end-users). In Annex 5 FBSIC life cycle diagrams for each phase are presented.

At this step, Esri Portugal senior software analyst collected, between September 16, 2009 and November 19, 2009, all functions to be performed by the system and pointed out their detailed description which composed the technical solution definition.

The resulting document (Software Analysis and Design Report) was revised by Ferbritas project manager, further submitted to Ferbritas project team which formally accepted it, thus ending this step and enabling FBSIC project's phase 2 developing to start.

3.4.3.5. Developing

At this step, Esri Portugal developers carried out implementation according to previously discussed Requirements Specifications (chapter 3.4.2.8), and Software Analysis and Design Report (chapter 3.4.3.4).

In face of priorities established at joint project meetings, implementation was divided in two sub phases: so, in the designated phase 2.1 Migration, Field, and Information Processing modules, were developed, thus allowing production teams and external survey teams collecting cadastre and expropriations information supported in FBSIC by March 15, 2010. The rest of FBSIC solution (comprising Central, Approval and Backoffice modules), designated phase 2.2, was ended by early September 2010. Implementation splitting implied that the testing campaign was also split in two.

Throughout the development period several contacts between both project managers, and between Ferbritas project manager and Ferbritas project team took place in order to clarify some system unexpected behaviours.

The resulting document (FBSIC solution phase 2 Tests Report) was compiled by Esri Portugal project manager, and delivered to Ferbritas project manager enabling FBSIC solution phase 2 Global Acceptance Testing to start.

3.4.3.6. Global Acceptance Testing

FBSIC solution phase 2 Global Tests Report lists all functions to be performed by the system and their expected outcomes; in summary, it reflects all tests to be conducted.

As mentioned before, this step was headed before by a group of tests at the end of each 2.1 and 2.2 sub-phases.

All tests were carried out by Ferbritas key users with GIS team support and conducted by Ferbritas project manager and followed all Tests Report entries. All non-compliance features and behaviours, and other software bugs alike were reported back to Esri Portugal project manager. After their correction has been communicated to Ferbritas, and a new software version has been deployed, another test cycle began till all tests stated full compliance.

As part of the testing procedures, two series of Load and Stress Tests were performed, in synchronized and asynchronous (Figure 54) modes that allowed the contractor to state good end user productivity levels facing applications good response time in both test modes.

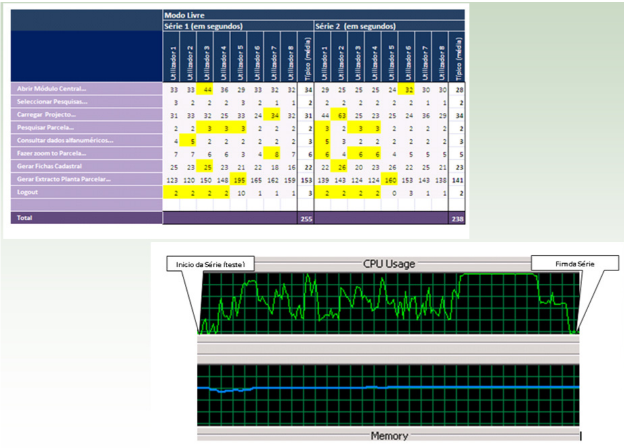


Figure 54 – Load and Stress Tests: asynchronous mode example (Ferbritas, 2010a)

At the end, the Global Tests Report was revised by Ferbritas project manager, further submitted to Ferbritas project team which formally accepted it, thus ending this step and enabling the system to pass to the final acceptance.

3.4.3.7. Final deploy

When in a given test cycle all tests stated full compliance, the application was ready for final deployment, enabling application transitioning from contractor to client. In the present case, FBSIC solution phase 2 final deploy took place on October 1, 2010.

FBSIC Central module web application initial screen is showed in Figure 55.

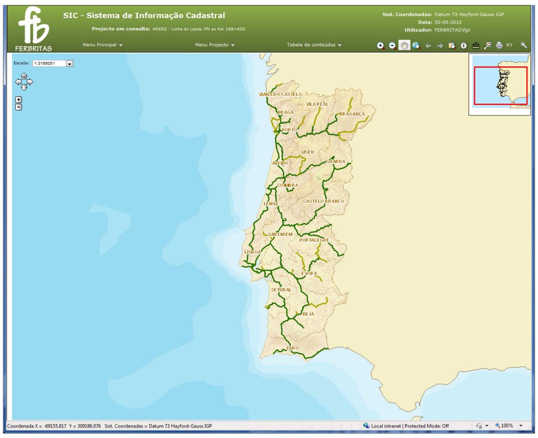


Figure 55 – FBSIC Central module web application initial screen (Ferbritas, 2010a)

3.4.3.8. FBSIC project Phase 3 requirements

FBSIC solution phase 3 requirements is related to the Expropriation Process activities and tasks that are carried out right after Expropriations Project approval by REFER. As this requirements were conducted with the same methodologies already described in other phase’s requirements gathering stage, and because FBSIC project’s phase 3, soon after requirements gathering, was discontinued facing a Ferbritas strategic change decision, this stage will not be further detailed in the present report.

3.4.3.9. Meetings

There were established two different meetings groups, each one reflecting a particular scope and responsibilities, likewise FBSIC previous phase. At the decision level, Steering Committee meetings occurred in a monthly basis starting on September 15, 2009 (kick-off) and ending on October 4, 2010 (closing). On the other hand, the operational level, Monitoring Committee meetings occurred in a weekly basis starting on September 22, 2009 and ending on June 24, 2010. In both cases, the contractor's project manager issued a Project Status Report before each meeting, with the same structure already presented in the previous phase.

3.4.3.10. Closing

The project was formally accepted on October 4, 2010 at the final Steering meeting (the closing meeting). The Esri Portugal application warranty period began immediately after, and the training of Ferbritas GIS team key users (led by the author), as well as their start-up support. FBSIC project phase 2 final calendar, with main steps highlighted, it's presented in Figure 56 and Annex 4 (global overview of FBSIC projects).

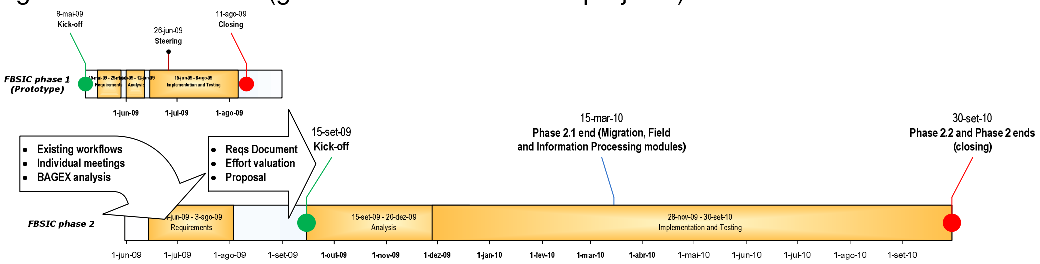


Figure 56 – FBSIC phase 2 final calendar (Ferbritas, 2010a)

3.5. FBSIC Solution Upgrading and Corrective Maintenances

3.5.1. Introduction

After October 4, 2010 FBSIC entered in a two years upgrade and corrective maintenance cycle, composed by the following projects:

- FBSIC/FBX integration software developing services;
- REFER Domain Module and Final expropriation parcels drawings generation;
- 2011 FBSIC upgrading and corrective maintenance;
- GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration;
- FBSIC production support tools and procedures; and
- 2012 FBSIC upgrading and corrective maintenance.

GIS software updating, and software development services acquisitions above listed followed Ferbritas formal acquisition procedures, already highlighted on previous chapters

(FBSIC project phases 1 and 2), whose main features correspond to the procurement management life cycle activities described in detail in chapter 3.3.4.1 - Procurement Management Life Cycle, showed project by project, are listed in Table 3, and Annex 4.

FBSIC UPGRADE AND CORRECTIVE MAINTENANCE PROJECTS	CONTRACTOR SOLICITATION	ESRI PT PROPOSAL	CONTRACTOR CONTRACTING	CONTRACT END
FBSIC/FBX integration software developing services	08/11/2010	16/12/2010	03/01/2011	18/05/2012
REFER Domain Module and Expropriation Parcels as-built drawings	08/11/2010	16/12/2010	03/01/2011	31/05/2012
2011 FBSIC upgrading and corrective maintenance	06/12/2010	23/12/2010	06/10/2011	05/04/2012
GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration	06/12/2010	28/12/2010	02/02/2011	13/01/2012
FBSIC production support tools and procedures	02/11/2011	30/11/2011	15/12/2011	12/10/2012
2012 FBSIC upgrading and corrective maintenance	03/01/2012	25/01/2012	21/02/2012	12/10/2012

Table 3 - FBSIC upgrade and corrective maintenance projects main dates.

Besides, as Ferbritas after FBSIC project phase 2 ending had entered in FBSIC solution full production cycle, the company decided to reduce the number of project meetings from this date onward, thus maintaining all remaining project management and procurement procedures that were applied successfully from October 2008 to October 2010.

Moreover, each project was considered as a systematic process group composed of several phases that supported its development. Since all this phases were already fully described in previous chapters, I will simply list the most relevant ones in this case: requirements gathering; functional analysis and technical design report; tests reports; implementation; acceptance tests; and final deploy. Moreover FBSIC project's overview is shown in Annex 4.

3.5.2. FBSIC solution upgrade and corrective maintenances main features

In next chapters, each FBSIC upgrade and corrective maintenance main features will be briefly described (see also Annex 4 - global overview of FBSIC projects). All software development services described below were executed by Esri Portugal.

3.5.2.1. FBSIC/FBX integration software developing services

FBSIC integration with Ferbritas Enterprise Service Bus (FBX) software development was based on the GIS infrastructure already installed, and included all functionalities needed to cadastral information providing to users in other Ferbritas applications (i.e. FBDoc).

FBSIC integration with Ferbritas Enterprise Service Bus (FBX), made cadastral information available into other Ferbritas applications, thus potentiating registration processes efficiency and accuracy, and covering all Ferbritas expropriations resources.

In Annex 6 chapter 6.2: FBSIC integration with Ferbritas Enterprise Service Bus (FBX) implementation, this project's phase main features are further listed and described.

3.5.2.2. REFER Domain Module and Final expropriation parcels drawings generation

REFER Domain Module and Expropriation Parcels Final Drawings Generation Component was implemented based on the existing Ferbritas GIS infrastructure, and included REFER Domain and cadastre recovery process features.

This application was implemented on a web application format, akin to previously described Approval Module, and it's composed by two main components:

- An alphanumeric and geographic information viewer, with the aim of providing REFER internet access to all "historic" cadastre information, accumulated over Ferbritas years of activity, as well as information about what's currently being acquired by compulsory purchases (expropriations) process.
- Ferbritas users group, similarly will also have intranet access to this module but, in this case, an editor section was added where parcels status can be changed thus allowing REFER Domain updating. In this case the module will allow also expropriation parcels final drawings generation.

The application has two operation modes (viewing and editing) and has incorporated specific outputs generation, called Expropriation Parcels Final Drawings.

In Annex 6 chapter 6.3: REFER Domain Module and Final Expropriation Parcels Drawings Generation Component implementation, this project's phase main features are further listed and described.

3.5.2.3. 2011 FBSIC upgrading and corrective maintenance

2011 FBSIC upgrading and corrective maintenance intended to ensure Ferbritas GIS platform updating. Moreover, adding to FBSIC technology supports base update, this intervention aimed: business areas requests response, increase operational efficiency, Ferbritas new services creation and business development opportunities promotion.

Project development activities scope were grouped into three intervention types:

- Technological developments are intended to update the technology base that supports the Cadastral Information System;
- New features evolution or creation; and
- Existing features modification.

Both upgrading and corrective maintenance can result in changes at application or database levels, and as such, always require analysis of process performance, design, implementation and testing. In Annex 6 chapter 6.4: 2011 FBSIC upgrading and corrective maintenance implementations, this project's phase main features are further listed and described.

3.5.2.4. GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration

ArcGIS 10 main upgrading benefit (and mandatory motivation) was to ensure GIS integration with AutoCAD 2010 platform, which had widespread use in 2011 at Ferbritas internal processes. This GIS infrastructure update enabled the ability to keep geographic information transfer compatibility between CAD and GIS formats. In detail and in particular, with "ArcGIS for AutoCAD" new version upgrade Ferbritas could:

- Add AutoCAD "World Street Map" ArcGIS Online services;
- Eased Data sharing between ArcGIS and AutoCAD;
- AutoCAD environment .ArcGIS Online free and premium maps, as well as GIS corporate data and images published by ArcGIS Server access;
- GIS attributes provide CAD drawing context information;
- Take advantage of faster and better image quality performance when accessing map services in AutoCAD; and
- AutoCAD 2010 and AutoCAD 2011 (build 250) support.

Ferbritas GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration software development activities proceeded to base technology (that supported Ferbritas GIS Infrastructure and FBSIC components) update. The main interventions are listed below:

- FBSIC ArcGIS support platform upgrade (test and production environments) ;
- GIS infrastructure applications migration (Central Module, Approval Module, Migration Module, etc.);
- Functional, integration and performance tests;
- Production environment applicational update; and
- Migration management (end-to-end).

In Annex 6 chapter 6.5: Ferbritas GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration implementation, this project's phase main features are further listed and described.

3.5.2.5. FBSIC production support tools and procedures

FBSIC production support tools and procedures implementation, was comprised by the activities listed below:

1. Geographic database compress automatic daily procedure implementation (production);
2. Interface for process / service delivery creation development
3. Interface for map index information creation and loading
4. Interface for parcels grouping
5. Geographical and alphanumeric features linking automation
6. Cadastral parcels, Expropriation parcels and Entities delete feature availability (Central Module - Flex)
7. Geographic feature editing Flex availability
8. Central Module Flex migration, including multi language support structure
9. Expropriation parcels automatic numbering

In Annex 6 chapter 6.6: FBSIC Production support tools and procedures implementation, this project's phase main features are further described in detail.

3.5.2.6. 2012 FBSIC upgrading and corrective maintenance

FBSIC upgrading and corrective maintenance works carried out on 2012, comprised a set of software development activities intended to FBSIC evolution and Ferbritas business areas operational efficiency increase.

Upgrading and corrective maintenance aims to follow up the necessary Ferbritas GIS platform updating. One of the main benefits of these developments focuses on reducing the effort associated with operational activities implementation, with introduction of process acceleration mechanisms, allowing to perform services at a lower cost and in shorter periods. Another essential benefit regards the quality of the end product, since these developments have been additionally foreseen to facilitate the control mechanisms and non-conformities identification, thus minimizing anomalous situations.

The previously referred set of activities, are listed below in the following points:

1. Auditing and information quality check tool
2. Operation Key Performance Indicators (KPIs) calculation tool
3. Quick reference map tip tool, including analysis, implementation, testing and deployment of quick reference map tip pop-up.
4. Objects identification within project validation.
5. Global Improvements
6. Legend lateralization

In Annex 6 chapter 6.7: 2012 FBSIC upgrading and corrective maintenance implementation, this project's phase main features are further described.

3.6. Overall Closing of FBSIC projects

The overall closing of 2011 / 2012 upgrade and corrective maintenance FBSIC projects occurred on a single project closure meeting on October 12, 2012, during which the projects were formally accepted thus starting Esri Portugal applications warranty period.

This last FBSIC projects steering meeting, was presented by the author and included a FBSIC version 3.0.2 live demo.

Key users final trainings and start-up support took place afterwards, being carried out by Ferbritas GIS team, led by the author.

4. RESULTS

4.1. Introduction

FBSIC tools, in conjunction with other applications for Cadastre and Expropriations Projects, allow managing the entire life cycle of expropriations and cadastre projects, including field activities support with field collected information integration, multi-criteria analysis information development and projects stage monitoring.

The integrative nature of the architecture allowed Ferbritas fit current needs, providing the possibility of scaling the platform to meet future services. The application had increased the rigor and productivity of the cadastre and expropriation process, and represented to Ferbritas a solution for Cadastre and Expropriations Projects information management, including all other additional background information.

A first illustration of FBSIC tools is presented in next figures (Figure 57 and Figure 58): FBSIC Central Module screen shot and map output examples.

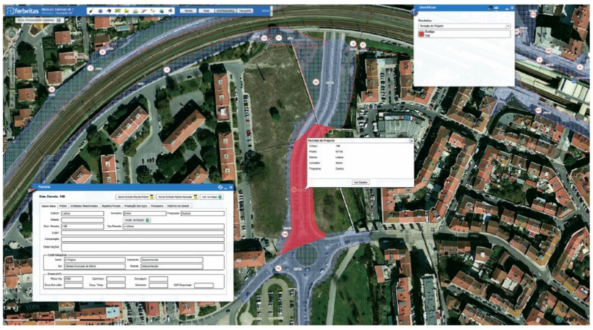


Figure 57 - FBSIC Central Module screen shot example (Ferbritas, 2012c)

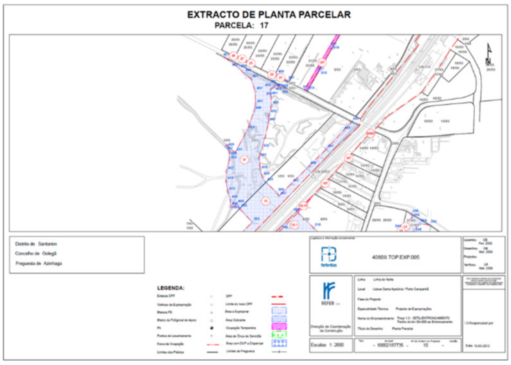


Figure 58 - FBSIC map output example (Gil & Mata, 2012a)

In the following points, I will present FBSIC last version (v3.03 deployed on December 19, 2012) main results divided in the themes listed below:

- FBSIC implementation and production phases:
  - Implementation phase (FBSIC v3.0.3 solution main features); and
  - Production phase results.
- Main conference presentations, posters, and article; and
- Awards.

4.2. FBSIC v3.0.3 implementation and production phases

4.2.1. Implementation phase solution's main features

4.2.1.1. Introduction

Ferbritas Cadastre Information System v3.0.3 (FBSIC v3.0.3) is FBSIC project's cycle (2008-2012) end product, comprehending a fit-for-purpose solution with very unique and distinctive features among others:

- Brings together a multitude of use cases in pre-defined formats and streamlined immediately to the user;
- Integrates standardized and normalized information produced by third parties (Courts, Land Property Registries and Financial Services, Postal codes, etc.).
- Focuses on the user's perspective;
- Allows integrated and multidisciplinary uses within an enterprise or institution;
- Adds accuracy, efficiency and effectiveness of action;
- Ensures changes traceability;
- Exports to other information technology platforms, including SAP;
- Provides a platform for information and knowledge, a valuable asset in itself;
- Adds immediate value in a trend that grows exponentially over time, as the database is being enriched.

4.2.1.2. FBSIC v3.0.3 Main features

FBSIC v3.0.3 is supported by a scalable architecture, standards-based information technology and communication, and interoperability, ensuring a high sustainability of long-term application. It allows for geographic and alphanumeric viewing and editing and documental information. In order to make a comprehensive characterization of the solution's main features I will present in next points: FBSIC v3.0.3 Layers Diagram; Conceptual and Physical Architectures; and I will make a brief reference to its data model.

4.2.1.2.1. FBSIC v3.0.3 Layers Diagram

FBSIC v3.0.3 Layers Diagram, as it can be seen below (Figure 59), is divided in two parts: client (Graphical User Interface - GUI) and server (GUI, Functionality and Data) layers, each of them further detailed in their corresponding figure section.

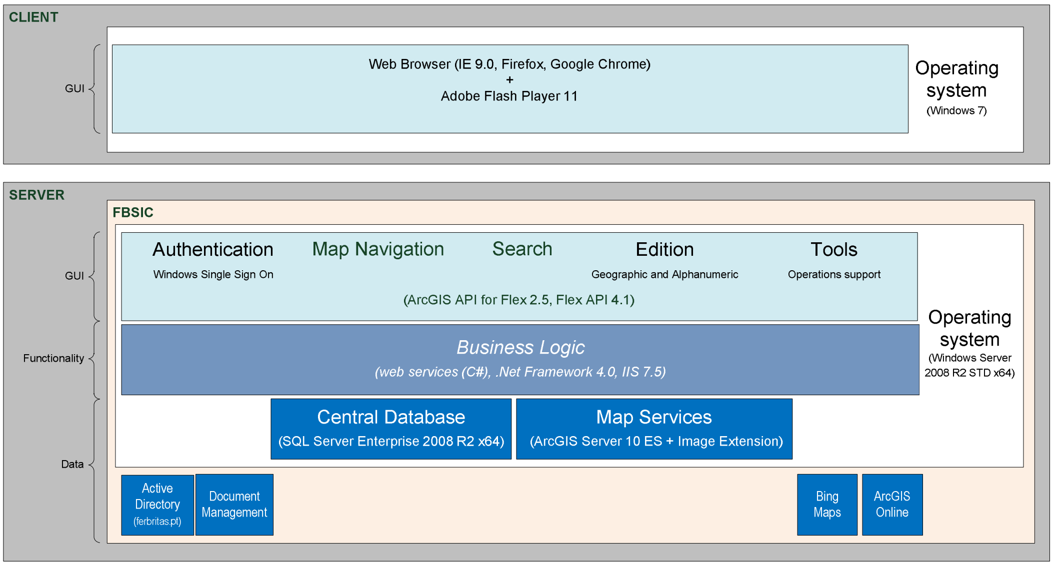


Figure 59 – FBSIC v3.0.3 Layers Diagram (Ferbritas, 2011a)

4.2.1.2.2. FBSIC v3.0.3 Conceptual and Physical Architectures

Figure 60 depicts FBSIC v3.0.3 Conceptual Architecture, with particular emphasis to each module's and main components use places, information flows and main outputs.

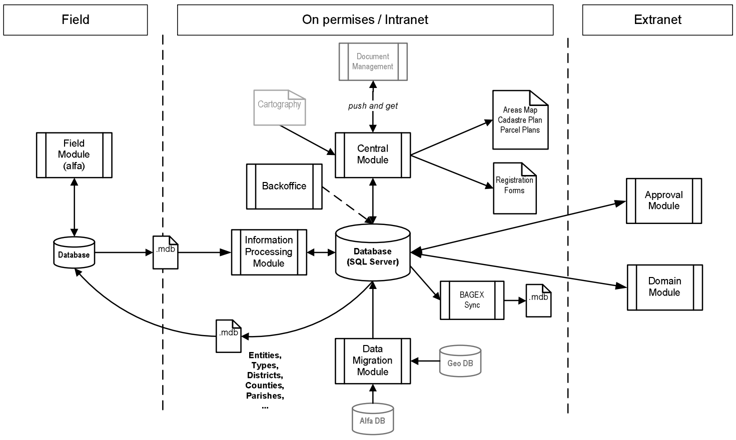


Figure 60 – FBSIC v3.0.3 Conceptual Architecture (Gil & Mata, 2012a)

Figure 61 presents FBSIC v3.0.3 Physical Architecture main components referred to corporate LAN (intranet), LAN Servers (for instance application, database and image servers) and Extranet. In order to optimize the existence, in parallel, of production and developments works there were created three separate environments: development (DEV), tests (TEST) and production (PROD), as it's illustrated below.

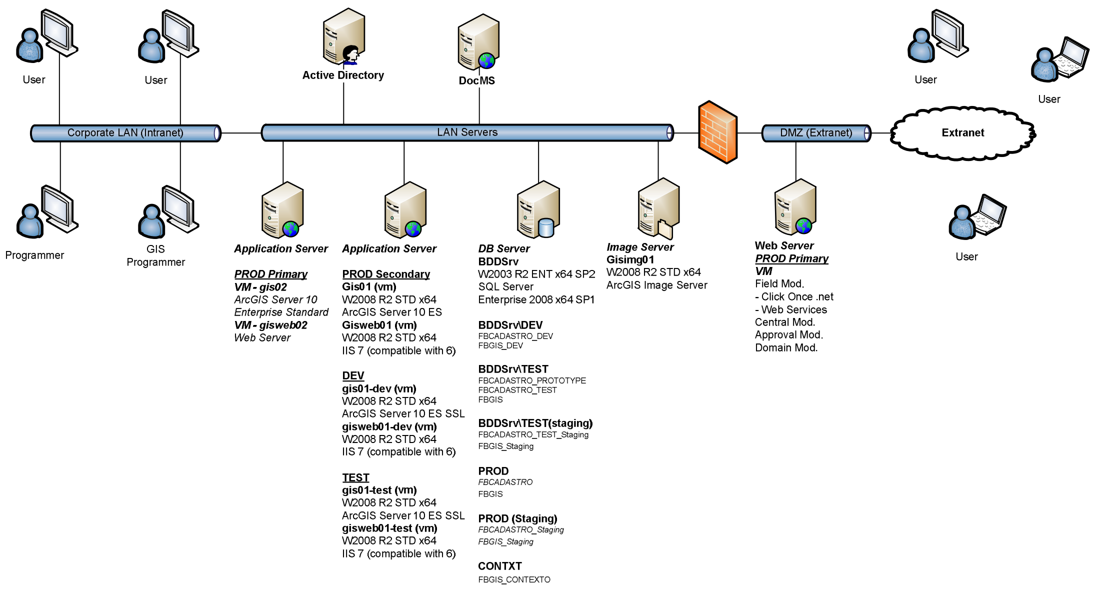


Figure 61 – FBSIC v3.0.3 Physical Architecture (Gil & Mata, 2012a)

Although it wouldn't be possible to print FBCADASTRO (production alphanumeric database that can be found in previous Physical Architecture figure) Entity-Relation diagram, presented below, in a page format feasible to include in this report and, at the same time, that could result in a readable document, I decided to include it, in Figure 62, to illustrate the complexity of FBSIC data model. Thus, referring only to the production alphanumeric database FBCADASTRO, I highlight its composition comprising 241 tables (shown below), 147 views, and 136 stored procedures.

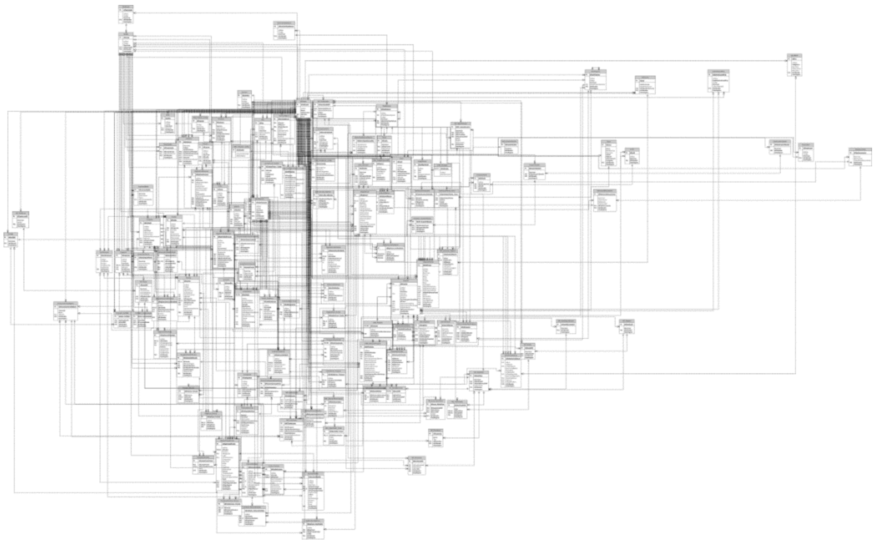


Figure 62 – FBCADASTRO Entity-Relation diagram

4.2.1.3. FBSIC v3.0.3 modules

FBSIC v3.0.3 has a modular character comprising seven modules listed below:

- Data Migration (geographic and alphanumeric data import with feature integrated validation);
- Field (information gathering activities support);
- Information Processing (field data import and validation);
- Central (geographic, alphanumeric and document information load and edit; project phases and transitions (workflow) quality monitoring; maps and formal documents print; among many other features);
- Approval (expropriation data approval cycle before final client delivery);
- Domain Management (management of expropriation parcels life cycle till their acquisition and integration in railway public domain by national authorities);
- Backoffice (system administrator support).

In the following points I present each module's main characteristics, whose detailed features and interfaces will be presented in Annex 7 - FBSIC v3.0.3 functionalities matrix.

4.2.1.3.1. Data Migration Module

Data Migration Module is an ArcGIS ArcEditor/ArcInfo (v 10.0) extension comprised by four toolbars: import structure, CAD/GIS import, project features class creation, and information synchronize.

4.2.1.3.2. Field Module

Field Module is a desktop application with intranet and internet user authenticated access and a compact interface comprised by the following sections: cadastral project, cadastral parcels, expropriation parcels, entities, tax and land property registries. In brief, its main features are: user authentication, access restrictions on a user base, secured access via intranet/extranet to download and upload data; data insert, edit and query (cadastral parcels, expropriation parcels, entities, tax and land property registers); addresses validation according to Portuguese postal address format; data validation (format and completeness) for cadastral parcels and cadastral project; warnings and errors log for performance quality metrics; data validation before submission to the central database; and operation autonomy in offline mode.

4.2.1.3.3. Information Processing Module

Information Processing Module is an office desktop application with user-authenticated access and an interface comprised by the following sections/tabs: cadastral parcels, entities, tax registries, land property registries and expropriation parcels. In brief, its main features are: user authentication, secured access via intranet to download and upload data, validation and acceptance of data (cadastral parcels; entities; tax and land property registers; expropriation parcels), recording of the work session (save my work), and submission to the central database.

4.2.1.3.4. Central Module

Central Module is a web application with intranet and internet user authenticated access with an interface comprised by the following tools: navigation bar, map, identify, search, create, business objects, print, audit and quality, table of contents, imagery, about, and map symbology. In brief, its main features are: user authentication; data access restrictions for profile / user; data insert, edit and query (cadastral parcels, expropriation parcels, entities, tax and land property registers); addresses validation according Portuguese postal address format; integration of geographic and alphanumeric information, imagery and documents; workflow control of the project phases; query and generation of snapshots; documents generation (cadastral parcels draft report (.pdf), cadastral parcels report (.pdf), expropriations parcels areas report (.xls), easy print map (.pdf), cadastral parcels map (.pdf), expropriations project map (.pdf), expropriations project single parcel map (.pdf)); and Document Management System integration (land property and tax registry documents).

4.2.1.3.5. Approval Module

Approval Module is a web application with intranet and internet user authenticated access Flex technology based. In brief, its main features are: user authentication; data access restrictions for profile, user, phase and project; project navigation; cadastral and expropriation parcels information analysis (geographic and alphanumeric); annotation and / or correction events notes insertion into data in analysis; information visualization to support analysis (criteria); Railway Engineering Project information integration; measurement tools availability; search tools availability (query builder); analysis and validation track log (what, who and when); search by analysis state.

4.2.1.3.6. Domain Management Module

Domain Management Module is a web application with intranet and internet user authenticated access Flex technology based. In brief, its main features are: access to data with user restrictions; Expropriations Projects, Cadastral Parcels, Expropriation Parcels, Railway Lines, Railway Line Segments and KPs query; integration between of geographic and alphanumeric cadastral information; context geographic information visualization (orthophotos, military and street maps); expropriation parcels process state control; Railway Public Domain automatic update after an expropriation parcel acquisition; parcel status log view; official documentation generation (Cadastral Parcels and Expropriations Project maps, Expropriations Project single parcel map, Cadastral Parcels report, and Expropriations parcels area report); Document Management System integration; alphanumeric and geographic data and related documents export.

4.2.1.3.7. Backoffice Module

Backoffice Module is a web application with intranet and internet user authenticated access. In brief, its main features are: user authentication; profile / user data access restrictions; users definition; user profile definition; profile functionality definition; profile user association; module/application access restriction; project and phase access restriction (Field Module); Active Directory integration; expropriations projects creation, copy and maintenance.

4.2.1.4. Technical documentation

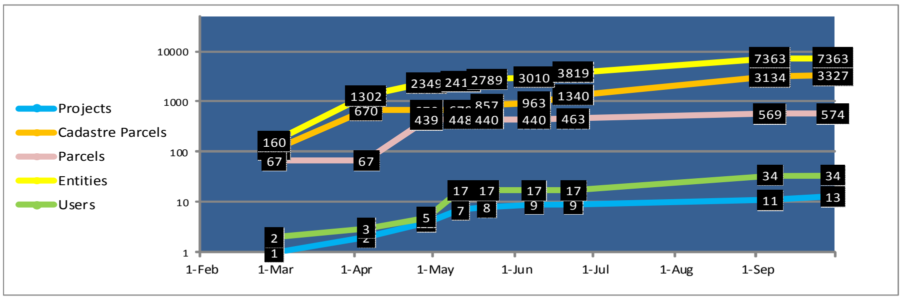
The author elaborated, along FBSIC projects life time, various technical documentation related to FBSIC project and solution, from which are highlighted the following:

- Cadastre Information System – FBSIC use case (Portuguese version);
- Cadastre Information System – FBSIC. Memo (English version), (Ferbritas, 2011);
- Cadastre Information System – FBSIC use case (English version);
- FBSIC. Cadastre Information System. Functionalities Matrix (English version), (Ferbritas, 2011a);
- Cadastre Information System Executive Summary Report (English version), (Ferbritas, 2012c); and
- Cadastre Information System manuals (Portuguese version): administration manual; and operations manuals.

4.2.2. Production phase

The modular step by step FBSIC development strategy allowed Ferbritas start to benefit from FBSIC applications support since an early stage. As briefly presented in chapter 3.4.3.5, at the end of FBSIC project's sub-phase 2.1 (March 15, 2010) internal productions teams and external survey teams could start collecting cadastre and expropriations information within FBSIC environment. This allowed that, in the end of FBSIC project's phase 2 (six months later) we had already collect the information volumes presented in

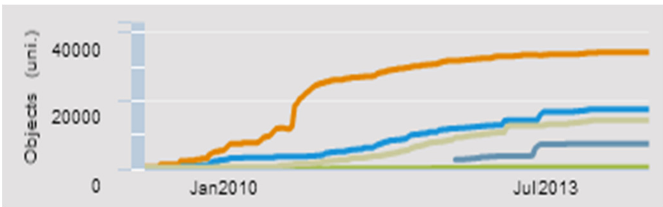
Figure 63, thus largely anticipating the benefits of FBSIC solution usage within Ferbritas cadastral survey and expropriations works.



		1-Mar-10	5-Apr-10	28-Apr-10	11-May-10	21-May-10	8-Jun-10	23-Jun-10	6-Sep-10	30-Sep-10
Projects		1	2	4	7	8	9	9	11	13
Cadastre Parcels		109	670	670	678	857	963	1340	3134	3327
Parcels		67	67	439	448	440	440	463	569	574
Entities		160	1302	2349	2412	2789	3010	3819	7363	7363
Users		2	3	5	17	17	17	17	34	34

Figure 63 – FBSIC Production teams work volume (September 30, 2010)

At last, I will present, in Figure 64, the global evolution of cadastral and expropriation projects data collected with FBSIC on July 27, 2013, with reference to FBSIC auditing and quality dashboard, and I will present in Table 4, FBSIC production teams total and railway line work volume details on July 27, 2013.



Objects		Numb
Entities		34107
Projects		427
Cadastral parcels		17442
Expropriation parcels		15970
Annotations		7401

Figure 64 – FBSIC Production teams work volume (July 27, 2013)

Railway Lines	**Projects Number**	**Parcels Number**	**Parcels Area (m2)**	**Parcels Length (m)**
Minho Railway Line	2	518	292 054	6 031
Douro Railway Line	1	46	29 955	4 591
Norte Railway Line	164	8456	4 858 645	181 816
Lousã Branch Railway Line	11	1191	302 325	33 967
Oeste Railway Line	2	41	16 258	1 839
Beira Baixa Railway Line	43	1023	697 762	55 415
Leste Railway Line	1	11	7 413	981
Sintra Railway Line	32	474	731 694	21 181
Alentejo Railway Line	14	110	91 786	36 000
Sul Railway Line	59	2637	4 212 904	161 576
Sines Railway Line	1	17	7 710	1 022
Évora Railway Line	9	390	503 700	22 320
Algarve Railway Line	11	1056	380 415	37 383
Total	**350**	**15970**	**12 132 622**	**564 121**

Table 4 - FBSIC Production teams total and railway line work volume (July 27, 2013)

4.3. Presentations, posters and article

Between 2008 and 2012 I made more than 38 public presentations related to FBSIC, whose yearly distribution was as follows: 1 on 2008, 7 on 2009, 11 on 2010, 8 on 2011 and 11 on 2012. In Annex 9 - FBSIC main results complements is presented FBSIC main presentations list between 2010 and 2012.

Along with the referred presentation the following posters were elaborated:

- FBSIC - Cadastre Information System. 2011 Esri, Inc. International Users Conference Poster (Ferbritas, 2011b),
- FBSIC - Sistema de Identificação Cadastral. 2012 Esri Portugal Users Conference (EUE 2012) Poster (Ferbritas, 2012a),
- FBSIC - Cadastre Information System. 2012 FBSIC Poster (Ferbritas, 2012b).

Finally, I will make reference to FBSIC article published in Vector1 Media (currently known as Sensors & Systems: http://www.sensorsandsystems.com/) on June 2011: Cadastre Information System for Rail in Portugal (Gil & Mata, 2011e), available at http://sco.lt/7EZJ5d.

4.4. Awards

The main achievements between 2010 and 2012 were the following:

- FBSIC poster 4th place at 2012 Esri Portugal Users Conference (Ferbritas, 2012a);
- Cadastre Information System for Rail in Portugal – Vector1 Media 2011 Top 10 Features, (Thurston, 2011) (Gil & Mata, 2011e);
- Special Achievement in GIS Award (Figure 65): Ferbritas received a Special Achievement in GIS (SAG) award at the 2011 Esri International User Conference. This award is given by Esri to user projects around the world to recognize outstanding work with GIS technology (Esri Inc., 2011); and
- Ferbritas received the GIS Project Achievement at 9º Esri Portugal User Conference – EUE 2011 (March, 2011) (Esri Portugal, 2010).

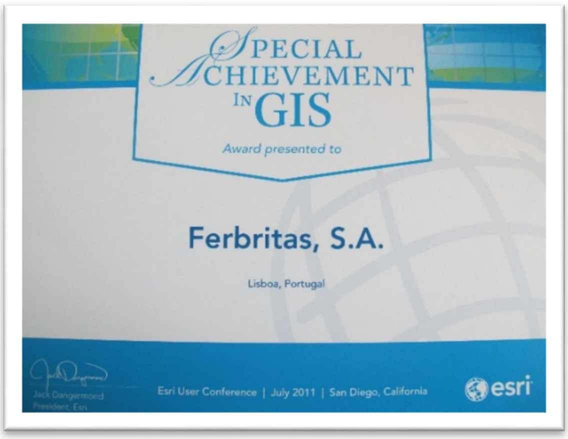


Figure 65 – Special Achievement in GIS awarded by Esri Inc. to Ferbritas on July 13, 2011

5. CONCLUSIONS

FBSIC is a fit-for-purpose cadastre information system rooted in the field of railway infrastructures, which stemmed from the need to provide a complete answer to the dynamic control of the registration and real estate status of the Portuguese national railway infrastructure. In this last chapter, I will address the work conclusions in three parts: a summary and main conclusions, present limitations, and future works.

5.1. Summary

I started this work framing FBSIC in its main roots: Land Administration, cadastre, land acquisition for railways infrastructure construction, GIS, and how all this themes are related together; afterwards I formulated these work objectives. After the introductory points I presented a literature review embracing all the previous mentioned themes: Land Administration (mentioning: Land Administration Domain Model (LADM) standard with a reference to Portugal Country Model (Hespanha, 2012); Cadastre: the cadastral tool as the left wing of LADM "butterfly" diagram (Williamson, et al., 2010), (Williamson, et al., 2010b)); among others, namely GIS, and related business models.

The concept of land includes properties, utilities, and natural resources, and encompasses the total natural and built environment within a national jurisdiction, including marine areas (Williamson, et al., 2010). On the other hand, land administration systems (LAS) are about addressing land tenure, land value, land use, and land development problems by providing a basic infrastructure for implementing land related policies and land management strategies to ensure social equity, economic growth and environmental protection (Williamson, et al., 2010).

Likewise, where there is little land information, there is little or no land management. Conventional Land Administration Systems are based on the 'parcel approach' as applied in the developed world and implemented in developing countries in colonial times. A more flexible system is needed for identifying the various kinds of land tenure in informal settlements or in customary areas (Lemmen, 2010). (Enemark, 2013) framed cadastre as the core engine for spatially enabled land administration and states that spatial enablement is not primarily about accuracy: it is about adequate identification, completeness and credibility. Systems should be built using a "fit for purpose" approach while accuracy can be incrementally improved over time when justifying serving the needs of citizens and society. In relation to the concept of the continuum of land rights such a fit for purpose approach could then be referred to as a "continuum of accuracy". So, according (Bennett, et al., 2013) to support the continuum of land rights in practical terms, a set of new tools is needed. These are underpinned by pragmatism, diversity in approach, and innovation. They will support conventional adjudication, demarcation, surveying, recording, and dissemination approaches. Many are already available and applied, many more are under construction.

In fact, land information now assumes far more significance that it did in the comparatively simple times of 19th and 20th centuries when it was collected and maintained in silo agencies. Land information must now be shared across agencies and throughout a nation to enable the delivery of spatially enabled societies (see Annex 1 where this subject is further developed). The challenges to land registries are not new: in all the democracies, these agencies are being asked to accept radical change in order to meet social and economic needs (Wallace, et al., 2010). On the other hand, Land Administration Systems are not an end in itself but facilitate the implementation of the land policies within the context of a wider national land management framework. Land administration activities are, not just about technical or administrative processes. The activities are basically political and reflect the accepted social concepts concerning people, rights, and land objects with regard to land tenure, land markets, land taxation, land-use control, land development, and environmental management. Land administration systems therefore need high-level political support and recognition (Enemark, 2009).

Moreover, according to (Bennett, et al., 2011) new drivers impacting on the nature of role of future cadastres were discussed under the categories of political drivers, environmental drivers, technological drivers, and socio-economic. Globalisation, population urbanization, good governance, climate-change response, environmental management, 3D visualization / analysis technologies, WSNs, standardization, and interoperability were found to be critical factors driving developments in the cadastral domain. Based on these drivers, six design elements of future cadastre emerged: Survey-Accurate Cadastres, Object-Oriented Cadastres, 3D/4D Cadastres, Real-Time Cadastres, Global Cadastres, and Organic Cadastres. Together, these elements provide a potential vision for the role and nature of future cadastres. Finally, according to (Becek, 2014) for the first time in human history, the Internet of Things technology allows for the collection of spatial data so that physical objects become active participants in the process.

Subsequently, in chapter 3, this report addressed, in detail, the methodology behind FBSIC projects, with emphasis on the activities, in which, I was actively involved, from its early planning stage to maintenance phase and closing, covering about a four years period, between October 1, 2008 and October 12, 2012. In the previous referred chapter, I reviewed in detail the following points: base methodologies; preliminary and planning stages; FBSIC software development projects, comprising two phases: phase 1 (FBSIC prototype); and phase 2 (FBSIC - Web ADF); FBSIC Upgrading and Corrective Maintenances; Overall Closing of FBSIC projects; and FBSIC production stages. FBSIC project, which in fact was comprised by a group of projects, followed a flexible Project Management methodology, framed within PMI procedures, and anchored in "organized common sense" as sustained by (Wysocki, 2009).

Moreover, in chapter 4, this report presents, FBSIC last version (v3.03 deployed on December 19, 2012) main results, divided in the themes listed here after: FBSIC implementation and production phases: implementation phase (FBSIC v3.0.3 solution main features); and production phase results; main conference presentations, posters, and article; and awards.

The present chapter contemplates the work conclusions in three parts: a summary and main conclusions, the present limitations, and futures works.

5.2. Main conclusions

FBSIC can be briefly characterized in three words: exactitude, accuracy and efficiency, which root into three pillars: **data integrity** (centralization of information; validation of data quality (amount and form); and log into a relational database); **data availability** (speed of access; secure access to profile, functionality and design; and possibility of integration with other systems); and **data usability** (geographical and alphanumeric display; generation of documentation; analysis of efficiency indicators of the operational process).

Summarizing, the integrating nature of FBSIC allows:

- to accomplish present needs and scale to meet future services;
- to collect, maintain, manage and share all information in one common platform, and transform it into knowledge;
- to relate with other platforms;
- to increase accuracy and productivity of business processes related with land property management.

5.3. Present limitations

The present limitations root in 2011 Portuguese financial crisis which conducted to a severe reduction in investment particularly in research and development expenses leading FBSIC upgrade and maintenance to end on October 12, 2012.

5.4. Future works

In face of nowadays new technologies development speed and spreading I will present in next points, a small group of FBSIC updates relating to a short and medium term periods:

- Short term:
  - ArcGIS platform v10.2.2 migration;
  - FBSIC platform integration enabling evaluation and its wide use across group organizations facing “Infraestruturas de Portugal” group integration;
  - Solution self-service capabilities implementation widening, such as enabling AutoCAD drawings end user’s (internal and external) direct upload into GIS (with full topological and context automatic validation support);
  - FBSIC ArcGIS On-line and ArcGIS Pro full integration implementation;

- Inspire compliance improving;
- LADM compliance implementation;
- New tools development:
  - Mobility: Field module geographic component implementation with geo-trigger and augmented reality capabilities;
  - Real estate valuation module implementation;
  - Geographic web services integration and embedding with SAP-DMS platform.

- Medium term:
  - Advances in modern browser technology combined with limited browser support for Flex, will encourage FBSIC web GIS Flex technology based applications migration to JavaScript/HTML5 technologies;
  - Business Processes Modelling capabilities integration;
  - Enabling FBSIC to receive information from future public web services, such as, SNIC cadastre web services, or postal codes web services, for instance;
  - Enabling future land acquisitions cadastral updates exporting directly into the future SNIC platform;
  - Assessing the feasibility of FBSIC solution framing within a ubiquitous cadastre ecosystem.

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Available at:
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Annexes

Annex 1 - Spatially Enabled Government and Society

Societies can be regarded as spatially enabled where location and spatial information are regarded as common goods made available to citizens and businesses to encourage creativity and product development' (Williamson et al., 2006) cit. by (Rajabifard, et al., 2010).

More recently, a reference to UNRCC-PCGIAP Kuala Lumpur Declaration on Spatially Enabled Government and Society (FIG, 2012), cited by (Teo, 2013), points towards a similar direction:

- Spatially enabled Government and Society, recognizing that all activities and events have a geographical and temporal context, make decisions and organize their affairs through the effective and efficient use of spatial data, information and services; and
- Spatial enablement, that is the ability to add location to almost all existing information, unlocks the wealth of existing knowledge about social, economic and environmental matters, and can play a vital role in understanding and addressing the many challenges that we face in an increasingly complex and interconnected world.

Additionally, and according to (Wallace, et al., 2010), spatially enabled societies demand accurate and timely information about land: land information provides the link between people and activities, within an ecosystem illustrated in Figure 1.1.

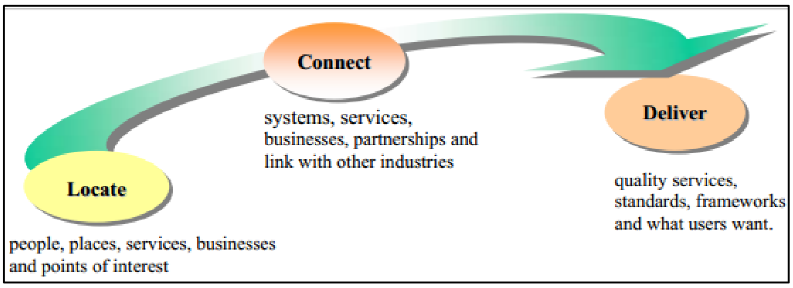


Figure 1.1 - Locate, connect and deliver spatial information (Rajabifard, 2009)

But, to achieve the benefits of spatial enablement, people who design and build systems need to set up the right foundations. Future directions associated with realizing spatially enabled societies will need to include a focus on creating awareness of the importance of maintaining existing spatial and land infrastructures. The modern challenge is to redesign the existing tools used to perform fundamental business processes in order to achieve much more relevant results across society (Williamson, et al., 2011).

Moreover, spatially enabling Governments and societies for sustainable land administration and management will require structural changes in the institutional, legislative and professional domains as well as embracing Open Standards, interoperability (systems, institutional and legislative), culture of collaboration and sharing, avoiding duplication such as mapping once, use many times, encourage the incorporation of volunteered information and developing platforms by locating, connecting and delivering information from difference scales, purposes and origins (Teo, 2012a), as illustrated in Figure 1.2.

Figure 1.2 - From Data to Informed Decisions and Sustainable Actions (Teo, 2013)

In fact, according to (Steudler & Rajabifard, 2012) spatial is everywhere and our ability to leverage and harness the ubiquity of spatial information will correlate to benefits in terms of wealth creation, social stability and environmental management. Spatial information intrinsically reflects the relationship between people and land by connecting activities to location. Additionally, see also Wallace vision of place as an important factor to improve information manageability illustrated in Figure 1.3.

Location is increasingly regarded as the fourth driver in decision-making, in addition to social, economic and environmental drivers. Consequently, land-related information has a key role in spatial enablement where good land governance can facilitate the delivery of a spatially enabled government to respond to the global agenda and achieve sustainable development. Societies and their governments need to become spatially enabled in order to have the right tools and information at hand to take the right decisions (Steudler & Rajabifard, 2012).

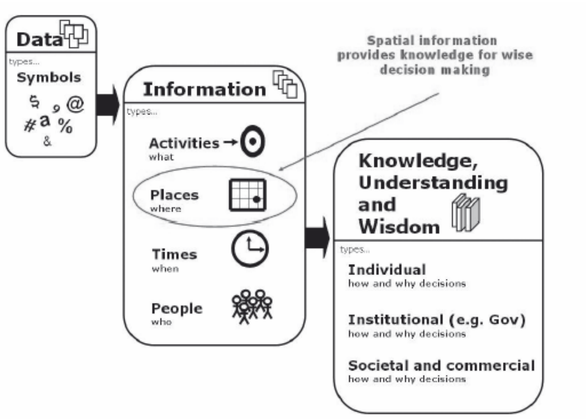


Figure 1.3 - Place as an important factor to improve information manageability (Wallace 2007) cit. by (Rajabifard, et al., 2010)

Annex 2 - Cyberland, towards an Ubiquitous Intelligent Land

2.1 Introduction

According to (Conti, et al., 2011) a significant proportion of the content available on the Internet has a spatial dimension. This may be either explicit or implicit, for instance a place name within a document or the location of a place referred to within a tweet. However, if we take a look from a geospatial standpoint at the various types of Internet resources and applications used today, we see a fairly fragmented picture. The original concept of the "web of documents" has been complemented, in recent years, by various Web 2.0 or "mashup" technologies. An increasing number of real-time sensor data feeds and an unprecedented amount of unstructured crowdsourced information now complement standard geospatial resources. This evolution is multifaceted, leveraging concepts such as "Internet of sensors," the "Internet of things" and the geospatial Web.

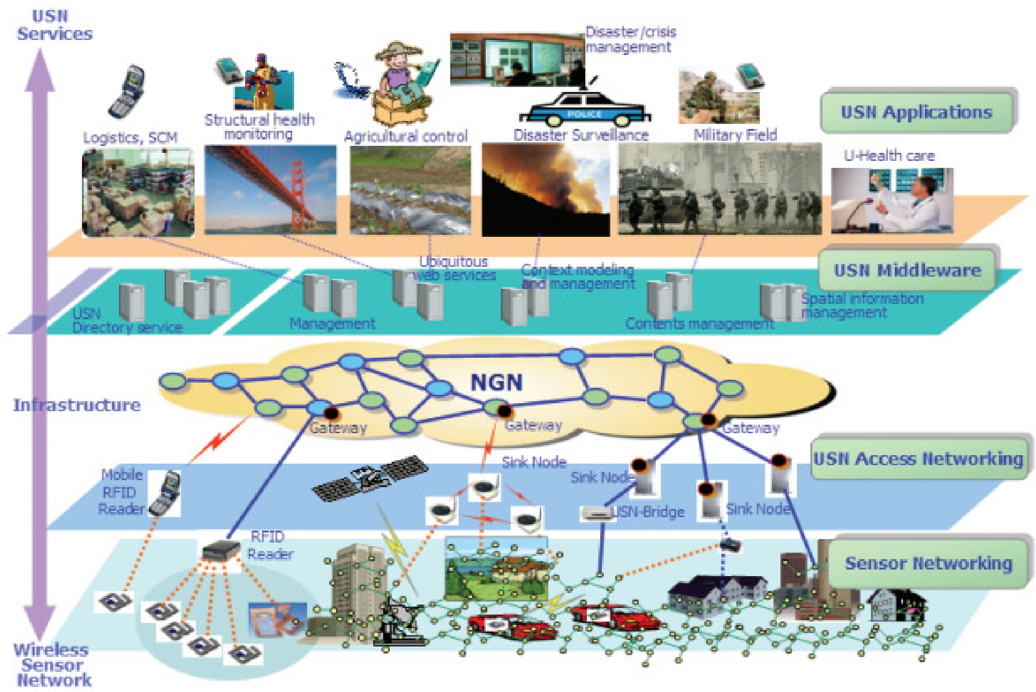
The "Internet of things" (IoT) is seen, according to (European Commision, 2009) one major next step in the Internet development, progressively evolving from a network of interconnected computers to a network of interconnected objects, from books to cars, from electrical appliances to food (see ITU Internet Reports 2005: "The Internet of Things (ITU, 2005) for further details).

In fact, an explosion in the instrumentation of our environment using sensors of all descriptions is driving the development of infrastructure to manage the wealth of information they collect. The Sensor Web aims to simplify the publication of, and access to, sensor resources, just as the World Wide Web has done for documents (Woolf, 2009). This is the vision of the Sensor Web. Its guiding principle is that better information helps people to make better decisions and that by harnessing the potential of the sensor web we can help people to live healthier, safer, and more productive lives (Smyth, 2009).

On the other hand, and according to (ITU, 2008a), the term "Ubiquitous Sensor Networks" (USN) is used to describe a network of intelligent sensors that could, one day, become ubiquitous. The technology has enormous potential as it could facilitate new applications and services in a wide range of fields — from ensuring security and environmental monitoring, to promoting personal productivity and enhancing national competitiveness which is illustrated in Figure 2.1. But USN will also require huge investments and a large degree of customization. As such, it presents a standardization challenge with an unusually high degree of Complexity.

As illustrated in Figure 2.1, a USN is not simply a network but can be an intelligent information infrastructure used to support a multitude of different applications. USNs can deliver information to "anywhere, anytime, by anyone" (Kelly, 2005). But it is the ability to deliver the information also to "anything" which is ground-breaking (ITU, 2008a).

Figure 1: Schematic Layers of a Ubiquitous Sensor Network



Source: ITU NGN-GSI Rapporteur Group Meeting "Draft Recommendation *Y.USN-reqts*, Requirements for support of USN applications and services in NGN environment," (Geneva, 11-21 September 2007), available at: www.itu.int/md/T05-NGN.GSI-DOC-0266/en (Note: Access restricted to TIES Users).

Figure 2.1 – Schematic Layers of a Ubiquitous Sensor Network (ITU, 2008).

Moreover, although such a radically different perspective requires addressing a number of fundamental challenges, the existing stack of Web 2.0 and GI technologies could be reused to interweave a "spatio-temporal fabric" on top of both existing and new Internet resources, to ensure spatio-temporal access, thus creating what we call the "Internet of Places" (Conti, et al., 2011).

According to (ITU, 2008a) value is added to the information by using "context awareness", which comes from detecting, storing, processing and integrating situational and environmental information gathered from sensor tags and/or sensor nodes affixed to any object. For instance, context awareness may relate to where the object is located; (…).

In this framework, I highlight Open Geospatial Consortium (OGC®) approval of OGC Sensor Model Language (SensorML) 2.0 Encoding Standard, on December 12, 2013, which provides a standard encoding for describing sensors ("things that measure"), actuators ("things that act"), and processors ("things that calculate") (OGC, 2014). Furthermore, because OGC Sensor Web Enablement (SWE) standards are open standards based on open and universally accepted standards for the Internet and web, and for spatial location, they are foundational standards for communicating with sensors, actuators and processors whose location matters. They are a key enabler for the Internet of Things (OGC, 2014).

2.2 Ubiquitous Positioning applied to Cadastre

In the next points I'll make reference to some research examples of ubiquitous positioning applied to Cadastre in Korea and Malaysia (mainly based on radio frequency identification technology (RFID)), to US and European patents to securing a land surveyor's mark based on use of a radio frequency identifier tag, and to (Becek, 2014) proposition towards an active data acquisition method.

In the Korean case "A Study on the U-cadastral Space Data Modeling in Korea" (Tcha, 2006) proposes that in order to enhance public service by using the characteristics of cadastre, use of computerized graphical cadastral maps has to be more frequent. In order to support the function of surpassing time and space, reforming method as follows are needed. Namely, U-Cadastral Data Model is connected to the Ubiquitous communication system of electronic tag method which can maintain descriptive data on boundary on the ground, and should be developed as follows (Tcha, 2006):

- In cadastral management system, it is one way system focusing managing it. However, in case of Ubiquitous, it plays a role of a provider of information by n:m free space, supplying service both ways in real time.
- Through the method of setting up database of boundary point and standardization of it, the model of U-Cadastre is established. In this case, coordinate system for space recognition is maintained in RFID by data application of current cadastral map system and ITRF.
- Both the descriptive type of relative location information and absolute type of information on the field should be obtained in order to form management model of cadastral boundary points, operating mutually and being more stable than the current system.

On the other hand, in Malaysian case "Integration of Multi-Sensor for Modern Cadastral Boundary Mark: First Experience" (Musliman, et al., 2012), is presented ubiquitous positioning by integrating of multi-sensor and mobile database management system as an ICT innovation implemented to support modern Malaysian cadastral system and infrastructure. This research also could be seen as a contribute in terms of infrastructure for modern cadastral boundary mark.

In (Musliman, et al., 2012) research is proposed a ubiquitous positioning approach into existing workflow of eKadaster system (Mohd Yusoff, et al., 2013) of Department of Surveying and Mapping Malaysia (JUPEM). Therefore, RFID integrating with GPS technology is used to get non-spatial information and to navigate cadastral boundary mark easily in term of providing a low cost technology solution. Signal from GPS can be derived to determine the position of cadastral boundary mark. The RFID tag will activated or ‘wake up’ when it passes through a radio frequency range and send back response to RFID reader. Useable alternative of geo-location is to install RFID tags at specific landmarks (or points of interest) and if the user is in range, the tag information with its location can be retrieved. This would lead to the concept of active landmarks such as modern cadastral boundary mark (Musliman, et al., 2012). This ubiquitous positioning for cadastral boundary mark system architecture is presented in Figure 2.2.

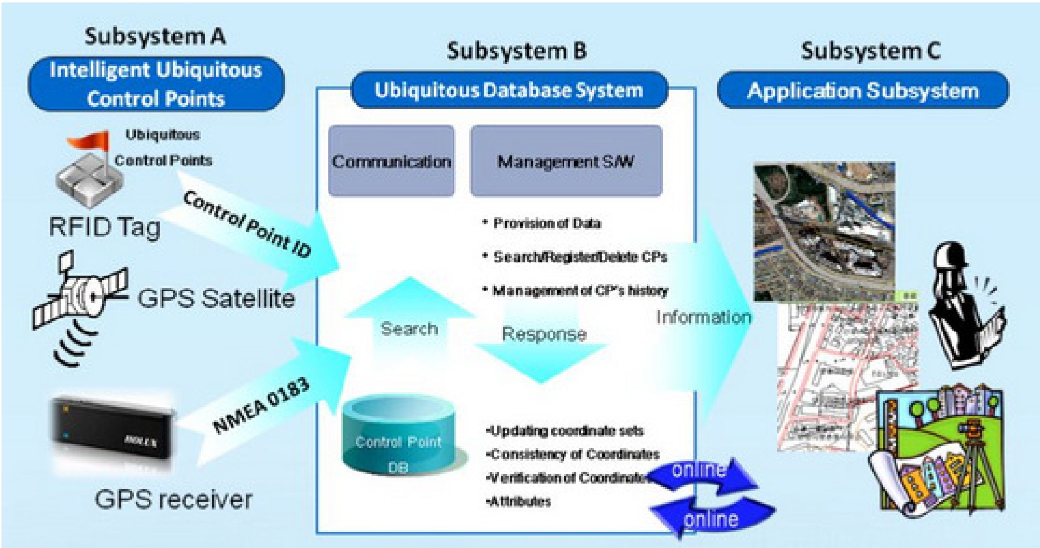


Figure 2.2 – Ubiquitous positioning for cadastral boundary mark system architecture (Musliman, et al., 2012)

Still according to (Musliman, et al., 2012) future research will concentrate more on integrating Internet Differential GPS (DGPS) correction for better position accuracy and introducing digital compass with the RFID for better tag discovery.

Other Malaysian example can be found at “RFID-Based Cadastral Boundary Mark System (RCBMS)“ 2014 FIG congress presentation (Musa, et al., 2014). In this paper, a RFID-based cadastral boundary mark system (RCMBS) is discussed, following a presentation of ubiquitous positioning by integrating multi-sensor and mobile database management system as an ICT innovation, which can provide benefits to the cadastral surveying community, such as aiding users in finding and/or updating information on cadastral boundary mark on site (Musa, et al., 2014).

Furthermore, according to (Retscher, et al., 2006) the significant advantages of RFID are the miniaturised unit, non-contact, non-line-of-sight nature of the technology. Some tags can be read through a variety of substances such as concrete, snow, fog, ice, paint, and other environmentally challenging conditions which cannot be achieved with barcodes or other optically read technologies. RFID tags can also be read in these circumstances at an amazing speed (< 10 milliseconds).

Moreover, (Retscher, et al., 2006) presented a RFID positioning system for indoor and outdoor location determination of a pedestrian proposing that RFID beacons are installed at known locations in the surrounding environment (e.g. at active landmarks, street crossings, entrances of buildings and offices, at regular distances inside buildings, etc.). Users of the system are equipped with a portable RFID reader module. If the tag's information can be retrieved the user is located in a cell of circular shape with the location of the tag in the centre and a radius equal to the possible read range of the tag. The used location method is referred to as Cell of Origin (CoO) and this concept is also employed for the location determination of mobile or cellular phones. Several tags located in the smart environment can overlap and define certain cells that intersect. The position of the user can therefore be determined using a network of tags which can be made available in a database.

I present in the following points two examples of patents (USA and Europe) aiming to securing a land survey mark based on the use of a radio frequency identifier tag:

- European patent – EP 2035775 B1: Apparatus for securing a land survey mark based on the use of a radio frequency identifier tag (Secondo, et al., 2009); and
- USA patent – US 20120326872 A1: Securing a land surveyor's mark based on use of a radio frequency identifier tag (Bauchot, et al., 2012).

Another approach, framed in the IoT, is propose by (Becek, 2014) opposing to actual methods used in geomatics which are based on a 'passive' way of spatial and attribute data acquisition on geographical objects. The adjective 'passive' means that an object of interest is simply just a subject of measurements and observations. However, in the context of IoT technology, an alternative situation is imaginable, which could be described as 'active' data acquisition. In this scenario, the object of interest makes all relevant data on its position, navigation and attributes readily available to an inquiring agent. So, the role of a surveyor would be reduced from facilitating data flow from a field to a map to just quering objects in the area of interest for relevant data via an IoT-enabled interface. This kind of arrangement means that all geographical objects would need to possess sensors to represent them in the IoT network. Obviously, these sensors must also be able to keep the data and metadata records assigned to objects in an updated state at all times. A basic requirement for creating such an IoT-enabled sensor is that each geographical object must be assigned a unique IP address (Becek, 2014).

2.3 Final notes

We should certainly not underestimate the technical and conceptual challenges of extending existing core Internet services to accommodate multi-dimensional data natively. However, the prospect of gaining accurate spatio-temporal context for many, if not all, Web resources and applications, while avoiding the complex and brittle manual configuration steps required today, is a prize worth striving for. The Internet of Places is a Web which sees and fuses information together in ways much more like our human imagining than simple keyword searches and mash-ups. In building the next generation of Web information services, we will need to dissolve the artificial barriers that surround spatio-temporal and other multi-dimensional data, and doing so will bring the substance of the virtual world an intuitive step closer (Conti, et al., 2011).

Finally, and according to (Becek, 2014) there is no doubt that a variety of societal, sociological, psychological, economic, legal and technical challenges must be faced before the fully operational real-time mapping based on IoT technology will become a reality. These various challenges are normal obstacles during a transition phase from the old paradigm to the new paradigm for all human activities, including geomatics. In geomatics, the dynamics of this paradigm change will be controlled by development of the Internet of Things. Moreover, rapid progress in the field of IoT is almost unavoidable, because 'A world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes' (Haller, 2009) cited by (Becek, 2014) is already here and expanding.

Annex 3 - Initial requirements overview

3.1 Introduction

The Initial Requirements document was elaborated by the author on March 10, 2009 comprising two reports: a complete version and a resumed version. The elements presented below are based in the resumed version report.

3.2 Cadastral Survey and Expropriations Projects – GIS Projects diagnosis.

3.2.1 Railway Public Domain Macro Process

Expropriations Projects (1st and 2nd steps), Expropriation (3rd step) and Demarcation (4th step) Macro Process presented in Figure 3.1, were designed as a result of several initial FBSIC project team meetings (October 1, 2008 to March 3, 2009) with project sponsor, project manager, Ferbritas Railway Projects Department (PRJ), IT department (STI), Survey Division (TOP), Expropriations Department (EXP) and GIS team (SIG) heads that led to a combined inter department process analysis and design, and latter approval.

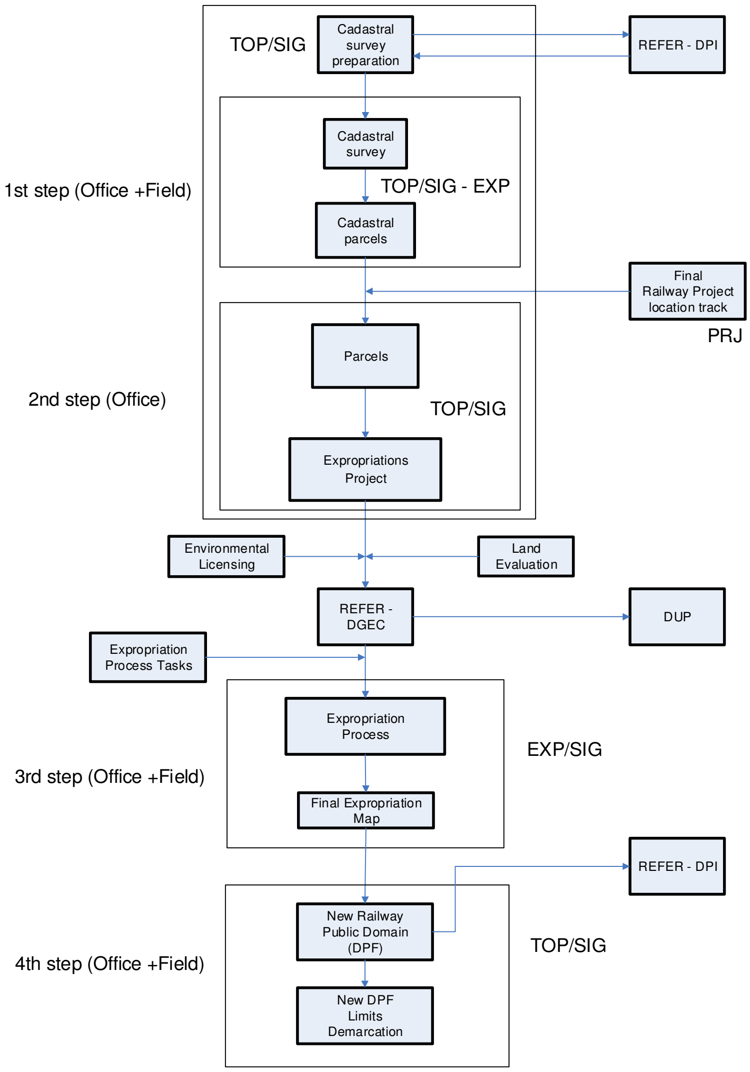


Figure 3.1 - Railway Public Domain Acquisition and Delimitation Macro Process

3.2.2 Defining priorities

After a first global review of the macro process involved in Railway Public Domain (DPF) Identification (Cadastral Survey and Expropriations project), Acquisition (Expropriation Process) and Delimitation (Demarcation) Ferbritas decided to focus the efforts, in first place, in a sub-set of the macro process presented in previous figure, thus concentrating analysis and further developments in steps 1 and 2 in what later became Ferbritas Cadastre Information System (FBSIC).

3.2.3 Identification phase initial characterization

Identification phase initially was divided in two steps:

- Step 1 – Cadastral Survey, which itself was compose by two sub-steps:
    - Sub-step 1.1: Cadastral survey preparation, and
    - Sub-step 1.2: Cadastral field survey;
- Step 2 – Expropriations Project (mainly office based operations).

In next points I will present, for both steps, the initial analysis base elements comprising: main workflows, and output examples.

3.2.3.1 *Sub-step 1.1: Cadastral survey preparation*

Cadastral survey preparation is compose by a series of office based operations whose workflow, as depicted in initial FBSIC project meetings, is presented in Figure 3.2.

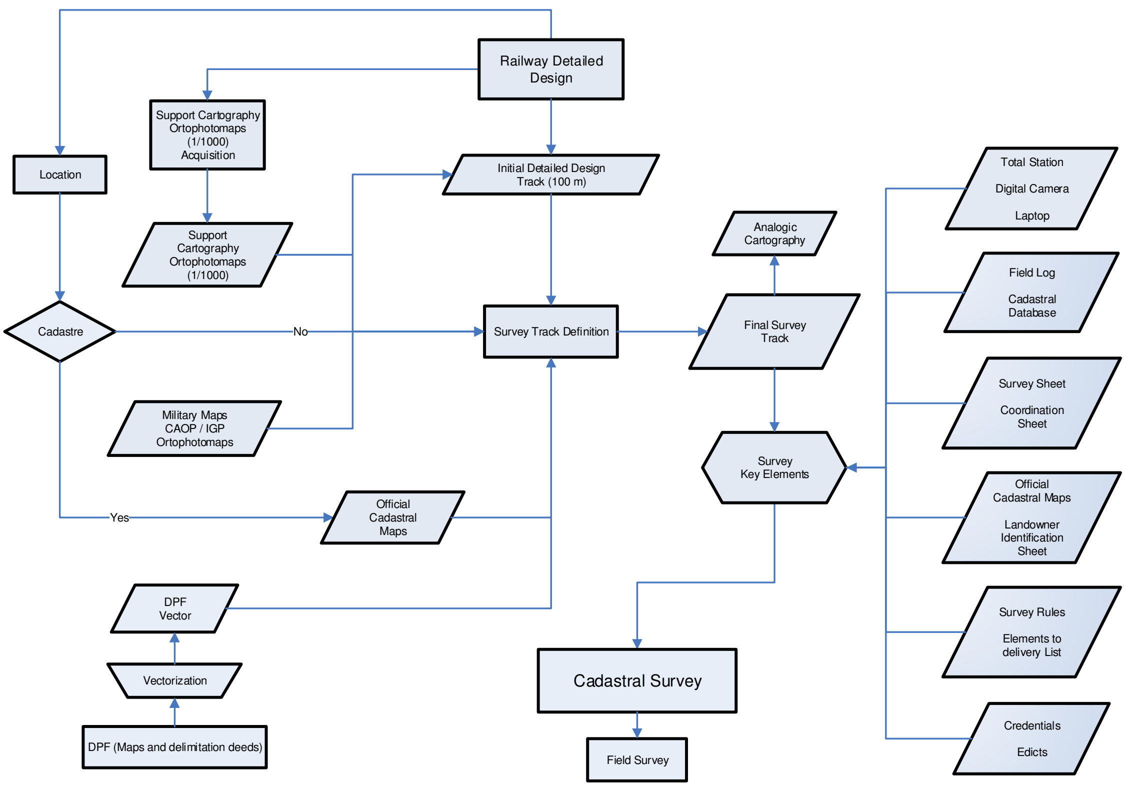


Figure 3.2 - Cadastral survey preparation workflow

Furthermore is presented below (Figure 3.3) an example of a Cadastral Survey support map (produced with GIS support).

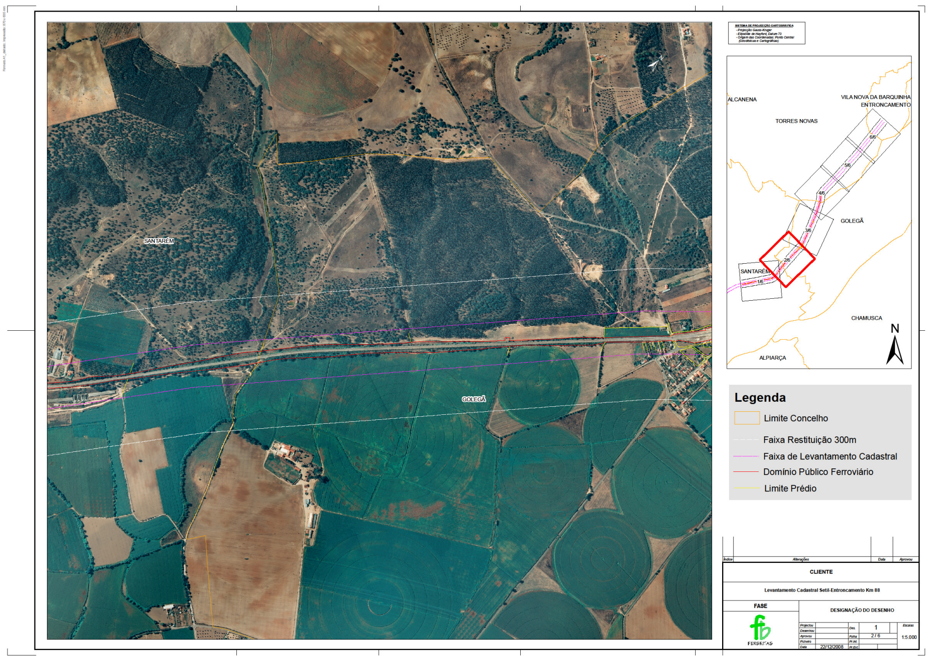


Figure 3.3 - Cadastral Survey support map.

3.2.3.2 *Sub-step 1.2: Cadastral field survey*

Cadastral survey is compose by a series of initial field based operations later complemented in office whose workflow, as depicted in initial FBSIC project meetings, is presented in Figure 3.4.

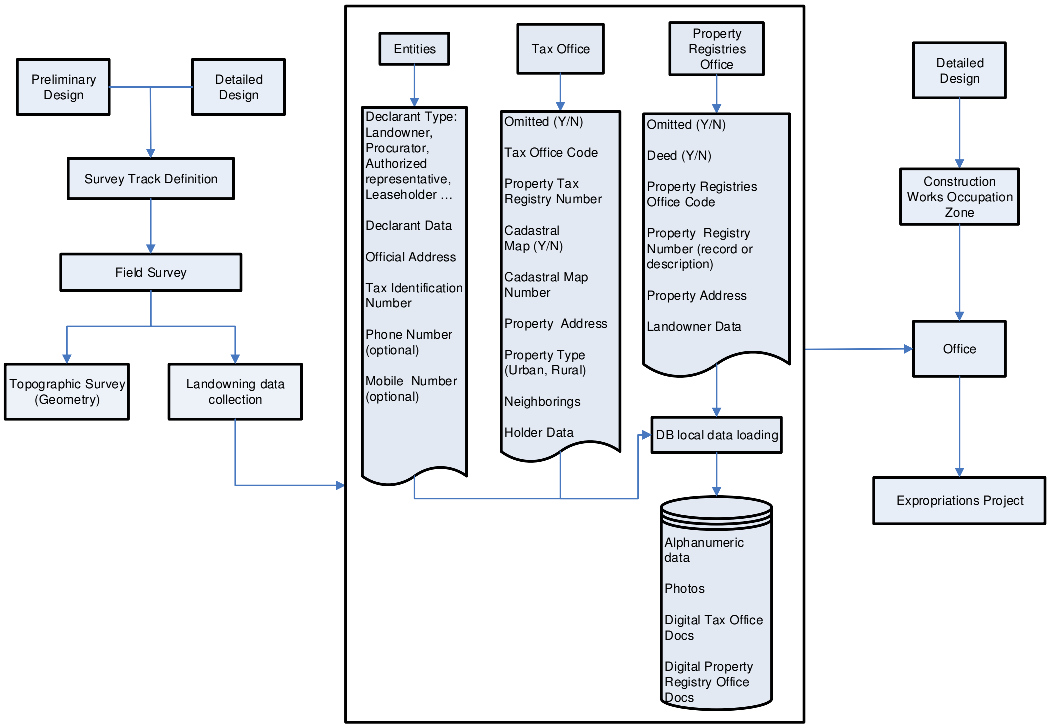


Figure 3.4 - Cadastral Survey workflow

Additionally, is presented in Figure 3.5, in first place, an example of a Cadastral Survey Map (produced with GIS support) and afterwards (Figure 3.6) its related Cadastral GIS workflow.

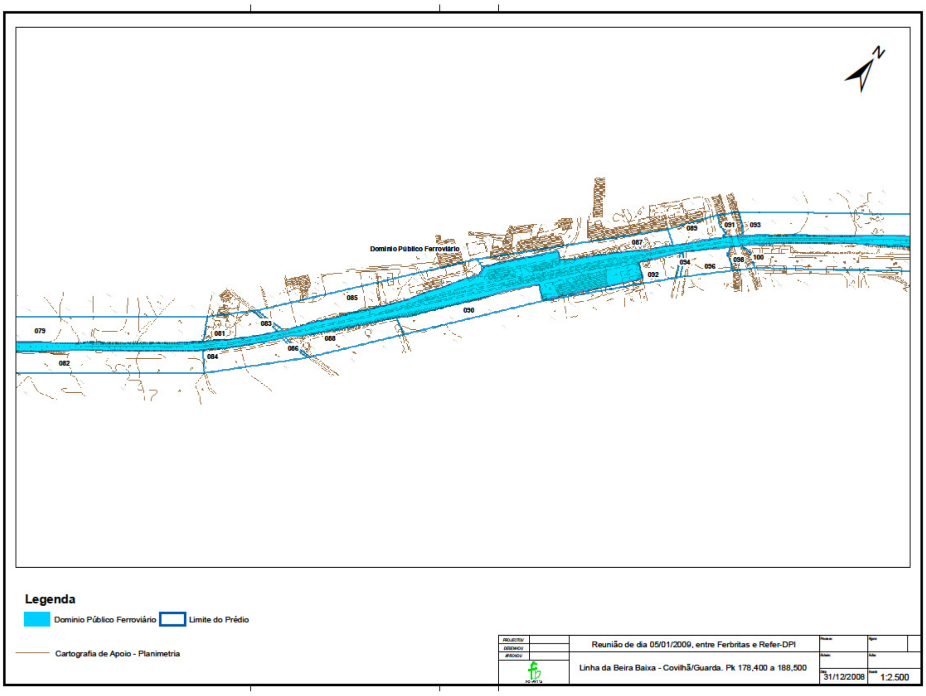


Figure 3.5 - Cadastral Survey Map

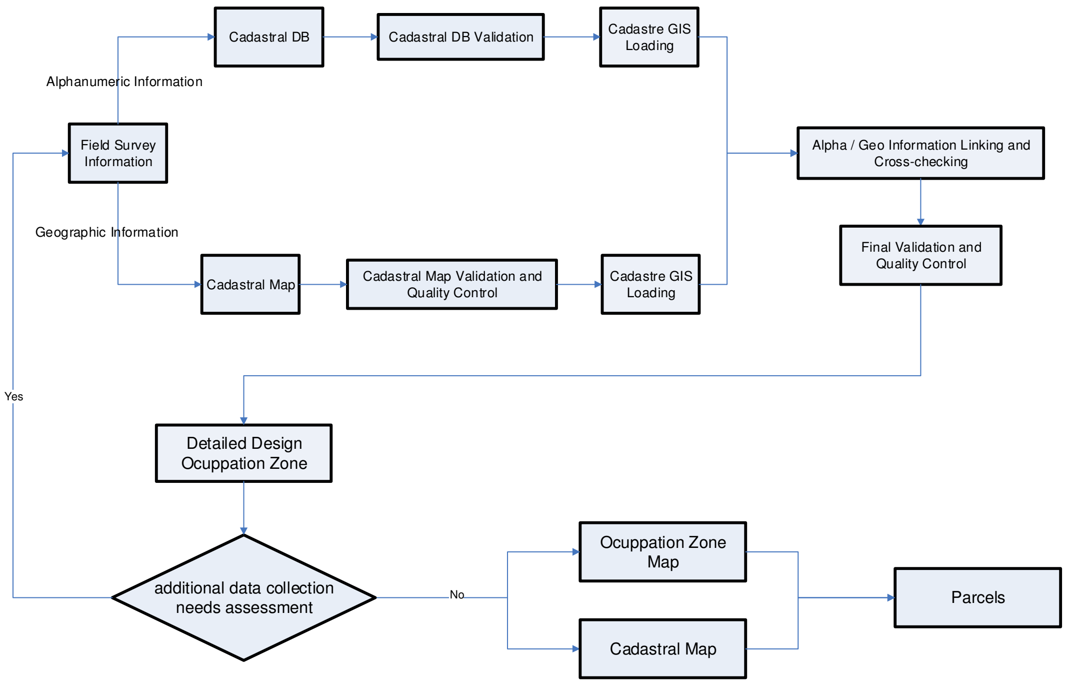


Figure 3.6 - Cadastral GIS workflow

3.2.3.3 *Step 2: Expropriations Project*

Expropriations Project is compose by several office based operations whose workflow, as depicted in initial FBSIC project meetings and is presented in Figure 3.7.

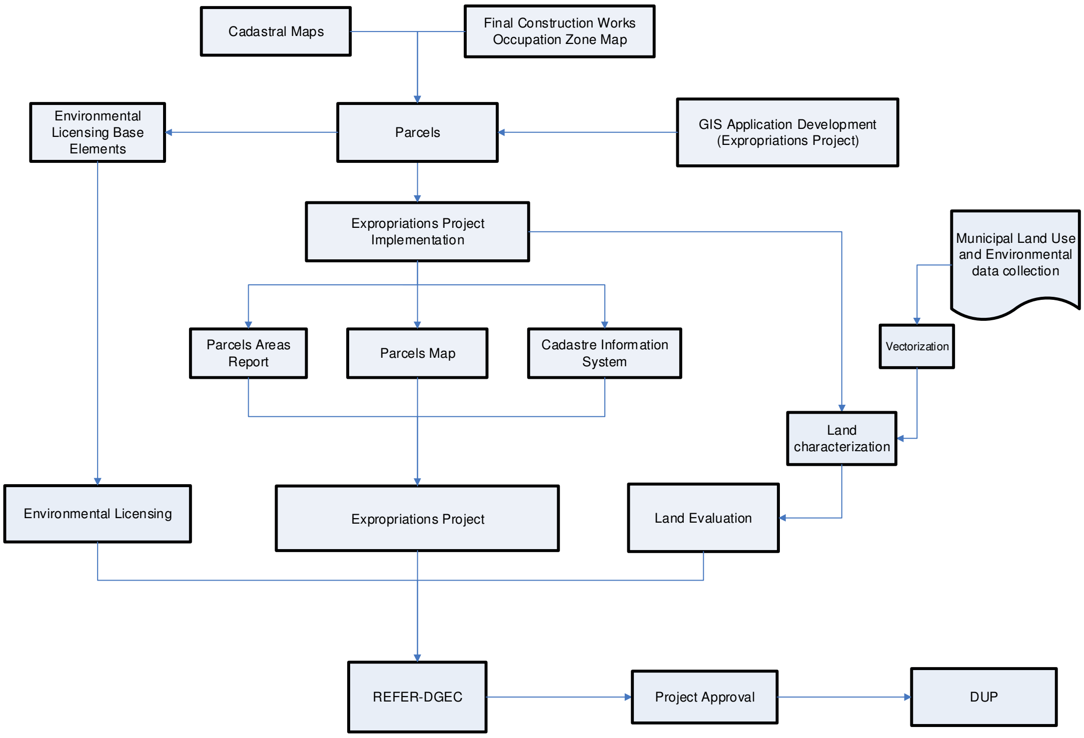


Figure 3.7 - Expropriations Project workflow.

Finally, is presented below (Figure 3.8) an example of an Expropriations Project Map (produced with GIS support).

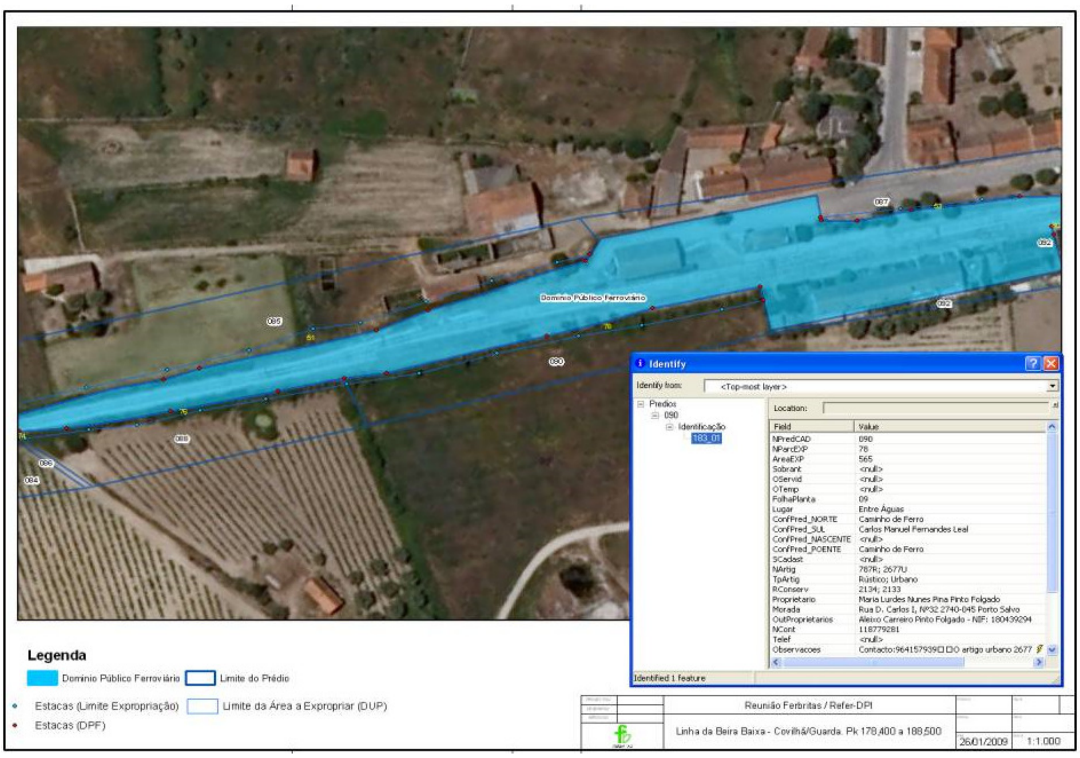


Figure 3.8 - Example of an Expropriations Project Map

Annex 4 - FBSIC project's overview

I present in Table 4.1 a global overview of Ferbritas Cadastre Information System (FBSIC) projects, which covered about a four years period, between October 1, 2008 and October 12, 2012, and production stages (June 1, 2009 to July 27, 2013); in addition with their main activities list.

PROJECT STAGE	MAIN ACTIVITIES
FBSIC Preliminary stage (October 1, 2008 to January 4, 2009)	• Recruiting the project manager; • Eliciting the true needs of clients (internal and external); • Documenting the internal and external client's needs; • Negotiating with the clients about how those needs will be met; • Writing a document describing the project; • Gaining senior management approval to plan the project.
FBSIC Planning stage (January 5, 2009 to May 7, 2009)	• Three year plan comprising hardware, software, software development services and training acquisition; • Overall Procurement Management definition: – Contractor solicitation (Tender); – Contractor evaluation; – Contractor selection; – Gaining senior management approval to launch the project; – Contractor contracting (contract award); – Contractor management.
FBSIC Phase 1 - FBSIC Prototype (May 8, 2009 to August 11, 2009)	• FBSIC Prototype Procurement; • FBSIC Prototype project: – Kick-Off; – GIS Infrastructure (hardware and software) set-up and install; – Requirements gathering; – Functional Analysis and Technical Design Report; – Tests Reports; – Implementation; – Acceptance Tests; – Final deploy; – FBSIC (Web ADF) requirements gathering; – Meetings; – Project Closure.

<table>
<tr><th>PROJECT STAGE</th><th>MAIN ACTIVITIES</th></tr>
<tr><td>FBSIC Phase 2 - FBSIC Web ADF (September 15, 2009 to October 4, 2010)</td><td>• FBSIC Web ADF Procurement;
• FBSIC Web ADF project:
– Kick-Off;
– Functional Analysis and Technical Design Report;
– Tests Reports;
– Implementation:
o Data Migration Module;
o Field Module;
o Information Processing Module;
o Central Module;
o Backoffice Module;
o Approval Module;
o Public Domain Management Module.
– Acceptance Tests;
– Final deploy;
– FBSIC phase 3 requirements gathering;
– Meetings;
– Project Closure.</td></tr>
<tr><td>FBSIC/FBX integration (January 3, 2011 to May 18, 2012)</td><td>• FBSIC/FBX integration Procurement;
• FBSIC/FBX integration project:
– Requirements gathering;
– Functional Analysis and Technical Design Report;
– Tests Reports;
– Implementation;
– Acceptance Tests;
– Final deploy;
– Project Closure.</td></tr>
<tr><td>REFER Domain Module and Final Expropriation Parcels Drawings Generation Component implementation (January 3, 2011 to May 31, 2012)</td><td>• REFER Domain Module Procurement;
• REFER Domain Module project:
– Requirements gathering;
– Functional Analysis and Technical Design Report;
– Tests Reports;
– Implementation;
– Acceptance Tests;
– Final deploy;
– Project Closure.</td></tr>
</table>

PROJECT STAGE	**MAIN ACTIVITIES**
2011 FBSIC upgrading and corrective maintenance (October 6, 2011 to April 5, 2012)	• 2011 FBSIC Upgrading Procurement; • 2011 FBSIC Upgrading project: – Requirements gathering; – Functional Analysis and Technical Design Report; – Tests Reports; – Implementation activities scope: o Technological developments: to update the technology base that supports FBSIC. One example: Ferbritas GIS Infrastructure update to a more current version of the platform technology (Database, Operating System, GIS platform , ...); o New features evolution or creation. Some examples listed below: ▪ GUI additional fields display; ▪ Validation algorithm determination for one value entered; ▪ Automation implementation in order to speed-up or ease the use; ▪ Additional pre-defined research implementation. o Existing features changing. Some examples of this intervention are listed below: ▪ Process flow diagram or states redefining; ▪ Objects association and their handling logic resetting; ▪ GUI objects redistribution; ▪ Print layout or its support logic resetting. – Acceptance Tests; – Final deploy; – Project Closure.
Ferbritas GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration (February 2, 2011 to January 13, 2012)	• Ferbritas GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration Procurement; • Ferbritas GIS Infrastructure and FBSIC migration project: – Requirements gathering; – Functional Analysis and Technical Design Report; – Tests Reports; – Implementation activities scope: o FBSIC ArcGIS support platform upgrade (test and production environments) ; o GIS infrastructure applications migration (Central Module, Approval Module, Migration Module, etc.); o Functional, integration and performance tests; o Production environment applicational update; o Migration management (end-to-end).

PROJECT STAGE	MAIN ACTIVITIES
	– Acceptance Tests; – Final deploy; – Project Closure.
FBSIC production support tools and procedures (December 15, 2011 to October 12, 2012)	• FBSIC production support tools and procedures Procurement; • FBSIC production support tools and procedures project: – Requirements gathering; – Functional Analysis and Technical Design Report; – Tests Reports; – Implementation activities scope: ○ Geographic database compress automatic daily procedure implementation (production); ○ Interface for process / service delivery creation development; ○ Interface for map index information creation and loading; ○ Interface for parcels grouping; ○ Geographical and alphanumeric features linking automation; ○ Cadastral parcels, Expropriation parcels and Entities delete feature availability (Central Module - Flex); ○ Geographic feature editing Flex availability; ○ Central Module Flex migration, including multi language support structure; ○ Expropriation parcels automatic numbering. – Acceptance Tests; – Final deploy; – Project Closure.
2012 FBSIC upgrading and corrective maintenance (February 21, 2011 to October 12, 2012)	• 2012 FBSIC upgrading and corrective maintenance Procurement • 2012 FBSIC upgrading project: – Requirements gathering; – Functional Analysis and Technical Design Report; – Tests Reports; – Implementation activities scope: ○ Auditing and information quality check tool; ○ Operation Key Performance Indicators (KPIs) calculation tool; ○ Quick reference map tip tool, including analysis, implementation, testing and deployment of quick reference map tip pop-up; ○ Objects identification within project validation; ○ Global Improvements; ○ Legend lateralization. – Acceptance Tests;

PROJECT STAGE	MAIN ACTIVITIES
	– Final deploy; – Project Closure.
FBSIC production stages (June 1, 2009 to July 27, 2013)	• Context information definition, migration and FBSIC loading; • Cadastral and Expropriations Projects data and official rules preliminary analyses; • Cadastral and Expropriations Projects data migration strategy, and existing data standardization definitions; • Processes documentation; • Production teams training; • Alphanumeric, and geographic work packages definition, distribution, monitoring and auditing with task workflow control tool support; • Global migration of Cadastral and Expropriations Projects (alphanumeric, geographic information and documents) into FBSIC; • Migration of existing data to the geospatial database quality control; • Alphanumeric, geographic and documents data loading quality control; • Automatic quality control procedures definition; • Automatic quality control checks with quality control dashboards (project and infrastructure) support.

Table 4.1 - FBSIC projects and production stages main activities global overview

Annex 5 - FBSIC project phase 2 diagrams

5.1 Introduction

In this annex I present, in first place, a global overview of Ferbritas expropriations project high level workflow as it was depicted in Ferbritas Cadastre Information System (FBSIC) project requirements.

As a result of FBSIC analysis, Ferbritas expropriations project was decomposed in seven phases, listed below and presented in Figure 5.1 (with reference to each phase main outputs, and snapshots):

1. Cadastral Survey Preparation;
2. Cadastral Survey;
3. Cadastral Survey Internal Validation;
4. Expropriations Project;
5. Expropriations Project Internal Validation;
6. REFER Validation; and
7. Public Use Declaration (DUP).

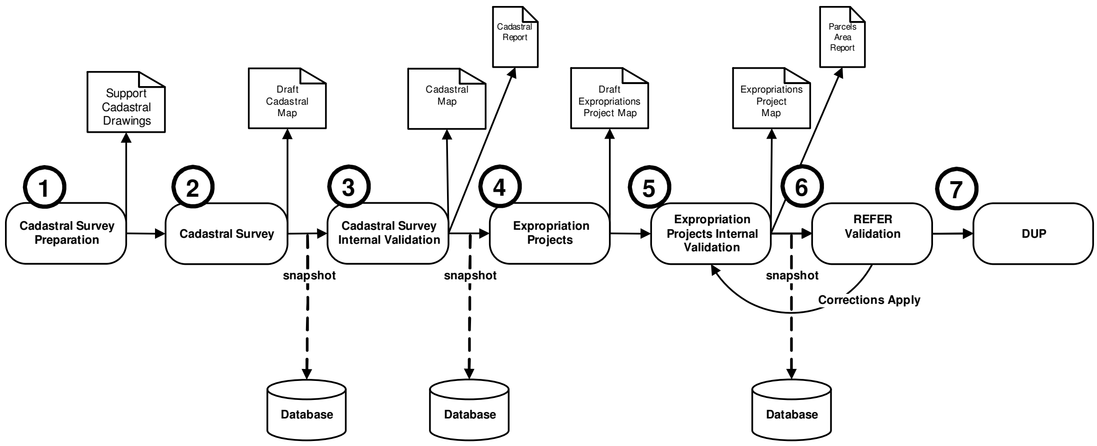


Figure 5.1 - Cadastre Information System Phases Workflow (Ferbritas, 2010a)

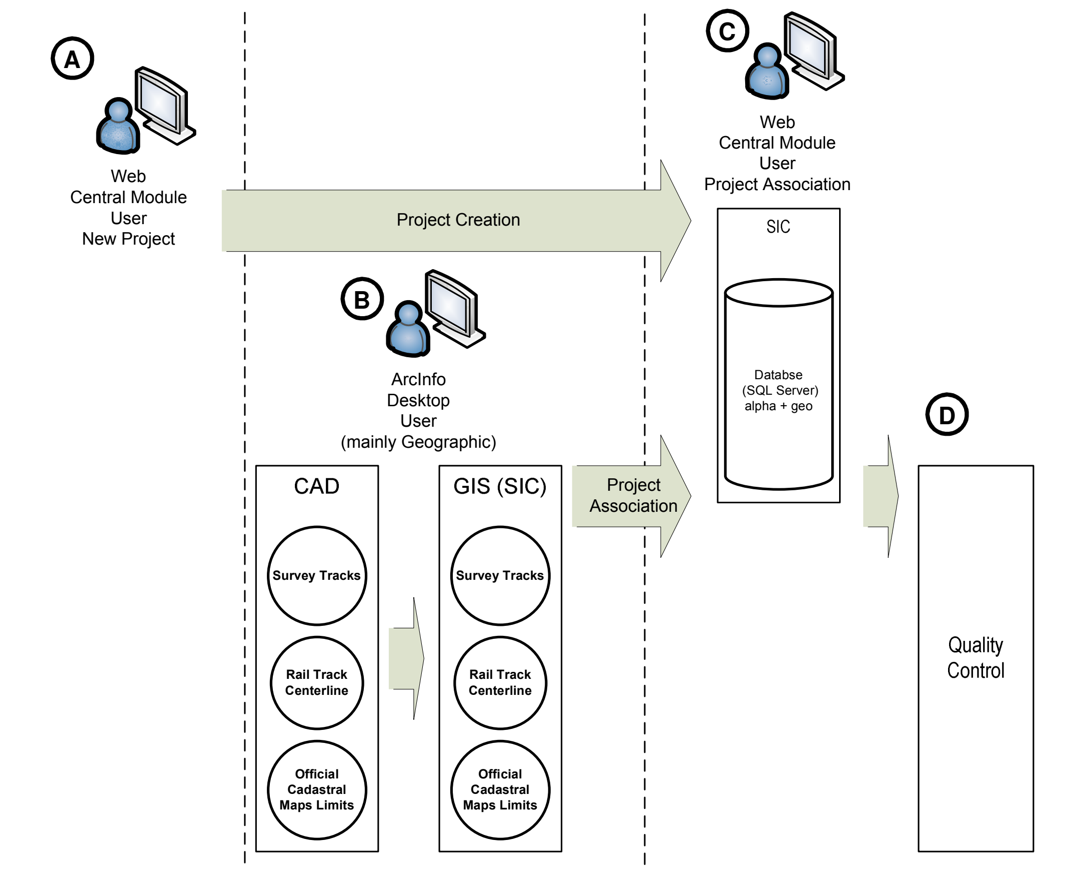
Afterwards, Ferbritas expropriations project phases were transposed to FBSIC where they have a direct correspondence with the corresponding phase of FBSIC life cycle.

5.2 FBSIC phases description

In next tables (Table 5.1 to Table 5.6), I present a brief description of FBSIC first six previously referred phases' main features comprising the following items: phase, code, description, last phase, next phase, input, output, next phase change requirements, diagram and legend.

PHASE:	**1 - CADASTRAL SURVEY PREPARATION**
Code:	FASE_SIC_PREP_LEV_CADASTRAL
Description:	Project internal Work Number, and Name; Railway Line and Line Segment are database loaded. Moreover, Survey Track, Rail Track Center Line, Official Cadastral Maps geographical information (after CAD/GIS conversion) and Ortophotomaps, Official Cadastral Maps images and Project Cartography are also database submitted.
Last Phase:	-
Next Phase:	Cadastral Survey
Input:	• Project localization and designation; • Intervention geographical area (vector + raster)
Output:	• Project available in the system • Support Cadastral Drawings and Cadastral Report paper printouts.

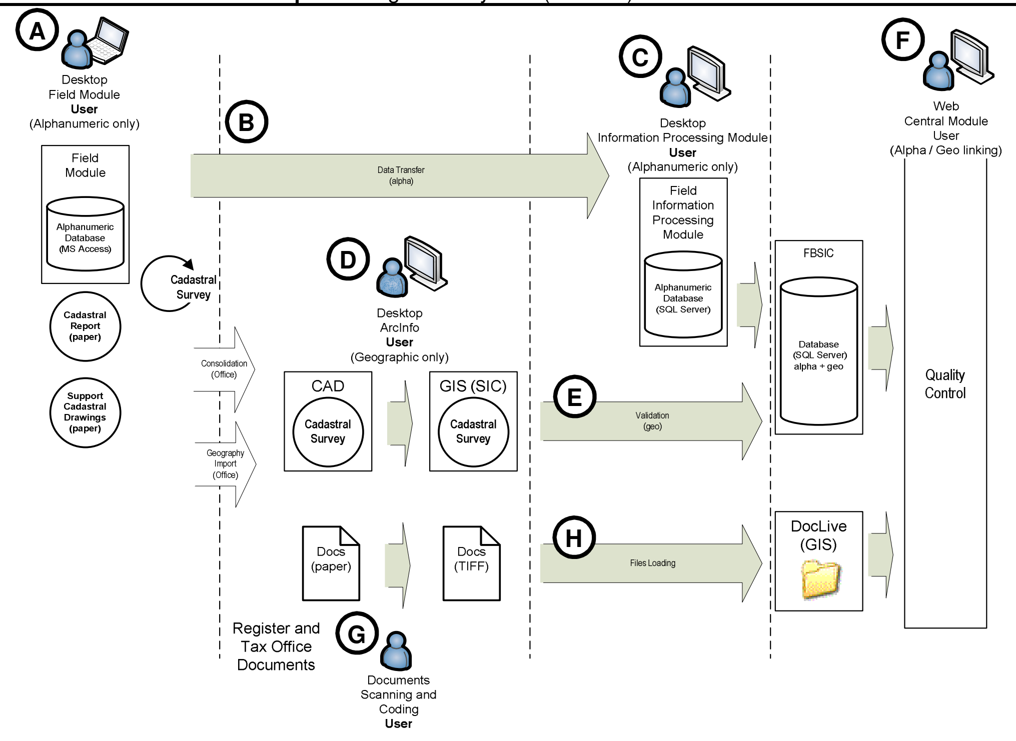
Next phase change requirements:	✓ Project information is complete (Name, Work Number, Railway Line and Segment);
	✓ Mandatory project associated base information:
	  ✓ Survey Track;
	  ✓ Rail Track Center Line;
	  ✓ Official Cadastral Maps (Geometric Cadastre Municipalities only);
	  ✓ 300 m (or 150m) Buffer;
	  ✓ PKs and HMs;
	  ✓ Support Cartography;
	  ✓ Official Administrative Boundaries (CAOP);
	  ✓ Cadastral Map index.



Legend:	A. Central Module New Project creation; B. CAD / SIG geographical information conversion; C. Data loading and project association D. Loaded information Quality Control

Table 5.1 - FBSIC Phases Diagrams. Cadastral Survey Preparation (Ferbritas, 2010a)

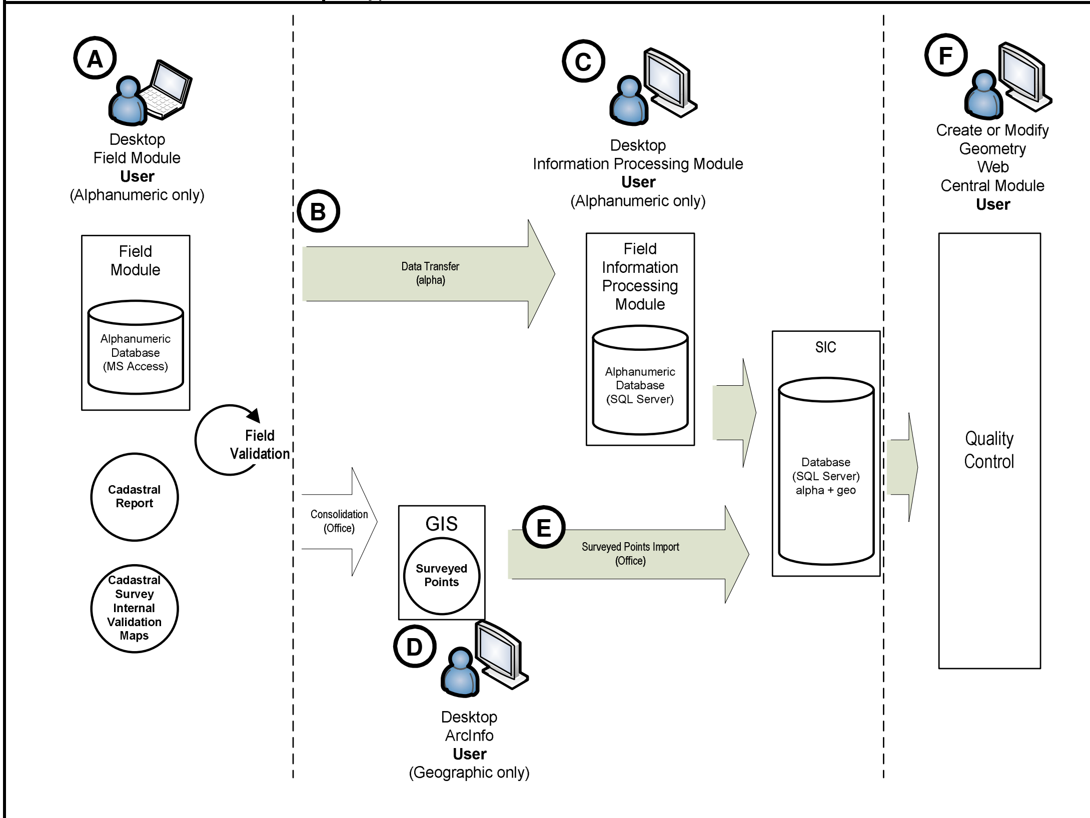
PHASE:	**2 - CADASTRAL SURVEY**
Code:	FASE_SIC_LEV_CADASTRAL
Description:	Cadastral Survey is executed in this phase, being composed by alphanumeric and geographic information. It's a massive information collection process that becomes the expropriations project foundations until its last step (Public Use Declaration (DUP) delivery).
Last Phase:	Cadastral Survey Preparation
Next Phase:	Cadastral Survey Internal Validation
Input:	• Field collected alphanumeric information. • Cadastral parcels geographic information.
Output:	• Cadastral parcels Map and Cadastral Report (initial versions)
Next phase change requirements:	✓ Last phase validations must be fully verified; ✓ There must be at least one Cadastral Parcel associated to the project; ✓ All project Cadastral Parcels must have a Field Cadastral Parcel Number; ✓ All project Cadastral Parcels alphanumeric information must be error free; ✓ All project Cadastral Parcels must have their neighbouring's correctly fulfilled; ✓ All project Cadastral Parcels must have geographic information associated; ✓ All geographic information must comprise project defined topological rules; ✓ All project Cadastral Parcels with "Collected Documents" records must have at least one document linked and loaded in the Document Management System (DocLive).



Legend:	
	A. Field Module cadastral alphanumeric information field collection with paper printed support cartography. B. Central system transfer of field collected information, after returning to office. C. Information Processing Module central database information insert and validation; D. CAD to GIS geographic information conversion; E. Central database geographic information insert; F. Alphanumeric / geographic information matching and linking (inserted in steps B and D), and cadastral parcels correspondence with Land Property and Tax registers and documents association. G. Land Property and Tax registers paper documents scanning (TIFF or PDF); H. Document Management System information storing (DocLive);

Table 5.2 - FBSIC Phases Diagrams. Cadastral Survey (Ferbritas, 2010a)

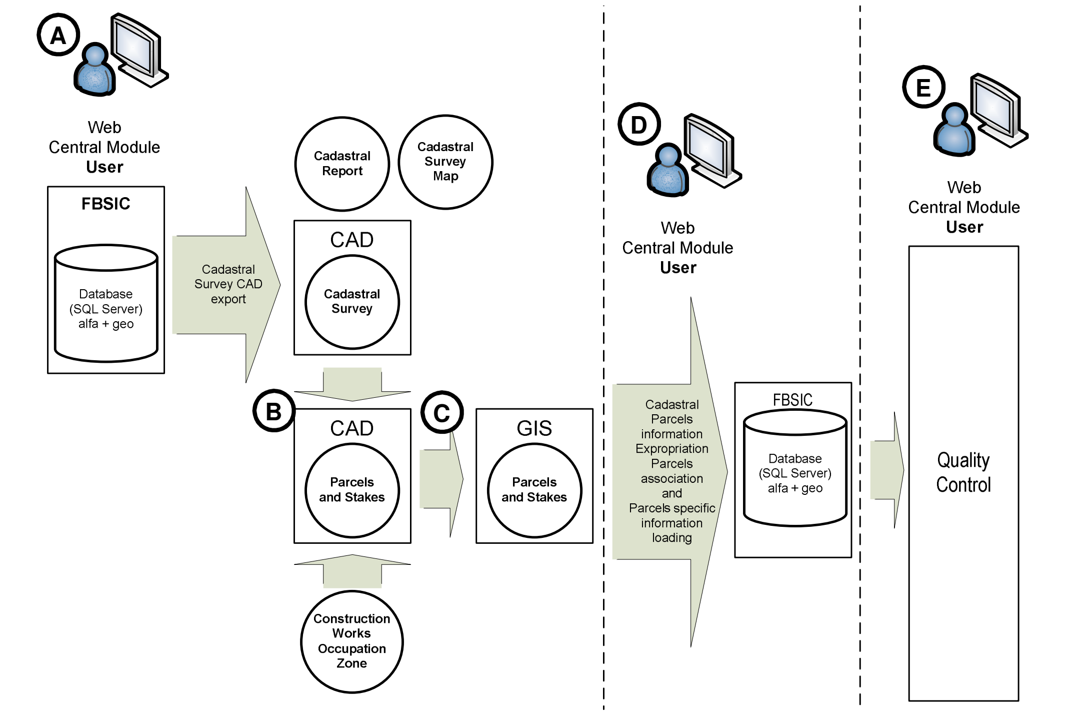
PHASE:	**3 - CADASTRAL SURVEY INTERNAL VALIDATION**
Code:	FASE_SIC_VALID_INT_LEV_CADASTRAL
Description:	Field information previously loaded is validated in this stage. Eventually can be made some alphanumeric and/or geographic corrections or new data inserts. All information is loaded in central database after surveys team field returning.
Last Phase:	Cadastral Survey
Next Phase:	Expropriations Project
Input:	• New or updated alphanumeric or geographic data.
Output:	• Cadastral parcels Map and Cadastral Report (final version with new or updated data)
Next phase change requirements:	✓ Last phase validations must be fully verified; ✓ All project Cadastral Parcels must have a Cadastral Parcel Number; ✓ All pre-defined action dates must be filled (recognized, surveyed, drafted, validated and verified dates, all of each must stand between initial and final Project dates); ✓ All Projects Cadastral Map Index and Cadastral Map sheet must have Ferbritas and REFER numbering; ✓ There must exist at least one tax registry and one land property registry record for each cadastral parcel, but either one of them can be of omitted type.



Legend:	
	A. Alphanumeric cadastral information field validation using Field Module, with paper support cartography. This activity implies previous laptop database project loading from central database. B. Central system validated information transfer, after field team's office return. C. Information Processing Module central database information load and validation; D. Surveyed points and / or new cadastral parcels loading; E. Central database geographic information import; F. Geometry creation or modify. **Notes:** If there'll be new cadastral parcels loading, according to last phase, alphanumeric and geographic information must be validated and link together (loaded in steps B and D). The same procedure must be adopted relating Land Property and Tax registers documents (loaded as in last phase steps G and H) and Cadastral parcels association.

Table 5.3 - FBSIC Phases Diagrams. Cadastral Survey Internal Validation (Ferbritas, 2010a)

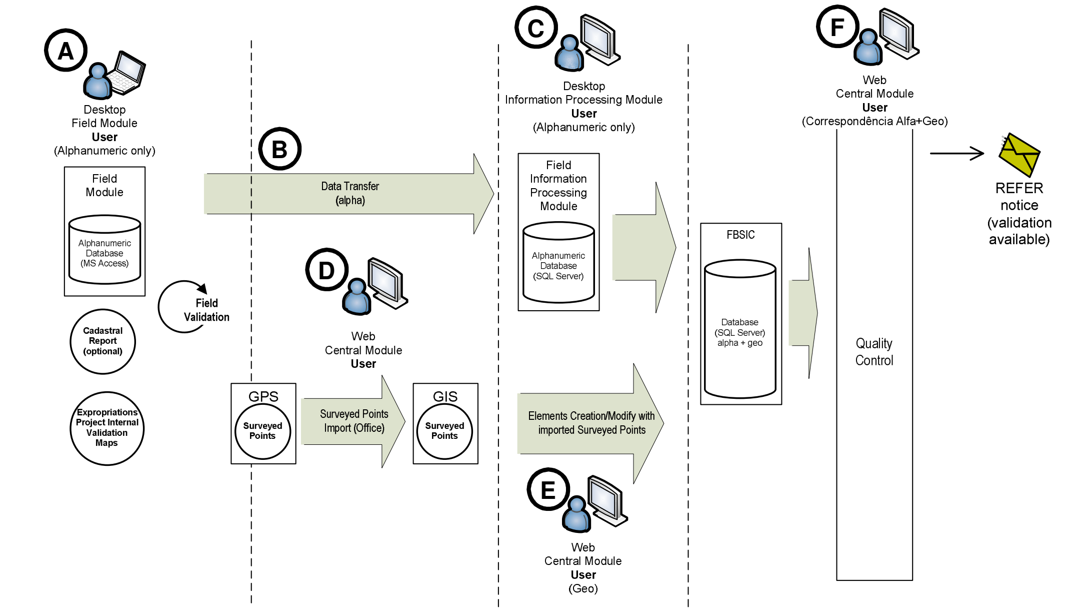
Phase:	**4 - Expropriations Project**
Code:	FASE_SIC_PROJ_EXP
Description:	Expropriations Project is executed in this phase, being composed by alphanumeric and geographic information. Parcels to be acquired and related entities full identification is made in this phase, according to Construction Works Occupation Zone and local Railway Public Domain.
Last Phase:	Cadastral Survey Internal Validation
Next Phase:	Expropriations Project Internal Validation
Input:	• Cadastral Survey Construction Works Occupation Zone, Railway Infrastructures Project. Note: Sometimes the Cadastral Survey is made right before Expropriations Project within the same project.
Output:	• Expropriations Project Map and Parcels Area report (1st version)
Next phase change requirements:	✓ Last phase validations must be fully verified; ✓ All projects must have a construction works occupation track associated; ✓ Parcels (to use and remaining terrains) and stakes created; ✓ All project parcels must have alphanumeric information associated; ✓ All project parcels must have a parcel code number; ✓ All project parcels must have correct neighbouring's; ✓ All project parcels must have geographic information associated; ✓ All project parcels must have DPF Stakes and Expropriation Vertices associated; ✓ All DPF Stakes and Expropriation Vertices associated must be numbered; ✓ There is a Expropriations Project Map Index within the Construction Works Occupation Zone.



Legend:	A. GIS -> CAD export B. CAD information consolidation, parcels and stakes design; C. Geographic information CAD to GIS export; D. Cadastral Parcels information Expropriation Parcels association and Parcels specific information loading; E. Validation. **Notes:** If there'll be new cadastral parcels loading, according to last phase, alphanumeric and geographic information must be validated and link together (loaded in steps B and D). The same procedure must be adopted relating Land Property and Tax registers documents (loaded as in last phase steps G and H) and Cadastral parcels association

Table 5.4 - FBSIC Phases Diagrams. Expropriations Project (Ferbritas, 2010a)

PHASE:	**5 - EXPROPRIATIONS PROJECT INTERNAL VALIDATION**
Code:	FASE_SIC_VALID_INT_PROJ_EXP
Description:	Field information previously loaded is validated in this stage. Eventually can be made some alphanumeric and/or geographic corrections or new data inserts. All information is loaded in central database after surveys team field returning.
Last Phase:	Expropriations Project
Next Phase:	REFER Validation
Input:	• Expropriations Project Map and Parcels Area report (1st version)
Output:	• Expropriations Project Map and Parcels Area report (final version)
Next phase change requirements:	✓ Last phase validations must be fully verified; ✓ All pre-defined action dates must be filled (recognized, surveyed, drafted, validated and verified dates, all of each must stand between the initial and final Project dates); ✓ All project Cadastral Parcels with Parcels to expropriate must be valid; ✓ All project Parcels to expropriate must be valid; ✓ All Map Indexes, Expropriations Project Map A1 sheet and Expropriations Project Single Parcel Map A4 sheet must have Ferbritas and REFER numbering; ✓ There must exist at least one tax registry and one land registry records for each cadastral parcel, but either one of them can be of omitted type.



Legend:	A. Alphanumeric cadastral information field validation using Field Module, with paper support cartography. This activity implies previous laptop database project loading from central database. B. Central system validated information transfer. C. Information Processing Module central database information load and validation; D. Surveyed points and / or new cadastral parcels/parcels loading; E. Central database geographic information import; F. Validation. <u>**Notes:**</u> If there'll be new cadastral parcels and /or parcels loading, according to last phase, alphanumeric and geographic information must be validated and link together. The same procedure must be adopted relating Land Property and Tax registers documents and Cadastral parcels association

Table 5.5 - FBSIC Phases Diagrams. Expropriations Project Internal Validation (Ferbritas, 2010a)

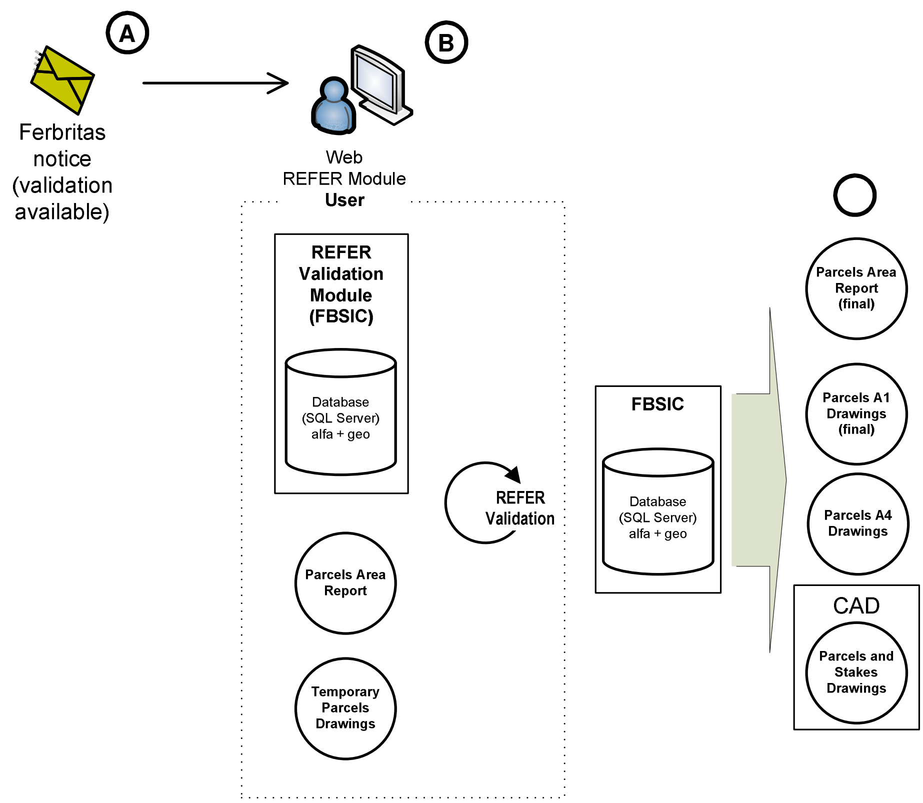
PHASE:	6 - REFER VALIDATION
Code:	FASE_SIC_ VALID_REFER
Description:	Expropriations project previously loaded is validated in this stage. Eventually can be made some alphanumeric and/or geographic corrections or new data inserts.
Last Phase:	Expropriations Project Internal Validation
Next Phase:	-
Input:	• Final Expropriations Project (version with new and revised data)
Output:	• Expropriations Project Map A1 Drawings (final version), Expropriations Project Single Parcel Map A4 Drawings, e Parcels Area Report (final version)
Next phase change requirements:	✓ Last phase validations must be fully verified; ✓ REFER Expropriations Validated Project (final version with new and revised data) ✓ DUP phase move
	
Legend:	A. REFER receives Ferbritas notification; B. Expropriations Project Validation (Cadastral Parcels, Parcels, Stakes, Owners, etc); C. Final documents production after validation process ending.

Table 5.6 - FBSIC Phases Diagrams. REFER validation (Ferbritas, 2010a)

Annex 6 - FBSIC upgrading and corrective maintenances (2011-2012)

6.1 Introduction

Between January 2011 and October 2012 occurred several FBSIC software developments integrated in the application upgrading and corrective maintenances cycle that will be briefly explained in the next chapters, comprising the following six main implementations:

- FBSIC integration with Ferbritas Enterprise Service Bus (FBX);
- REFER Domain Module and Final Expropriation Parcels Drawings Generation Component implementation;
- 2011 FBSIC upgrading and corrective maintenance;
- Ferbritas GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration;
- FBSIC Production support tools and procedures;
- 2012 FBSIC upgrading and corrective maintenance.

6.2 FBSIC integration with Ferbritas Enterprise Service Bus (FBX)

This intervention occurred between January 3, 2011 and May 18, 2012, was comprised by FBSIC integration with Ferbritas Enterprise Service Bus (FBX) software.

The developed system aimed cadastral information availability assurance to expropriations project stakeholders, ensuring required rigor and real-time updated knowledge and information. Among the benefits achieved, I highlight the following:

- Ambiguities decrease and cadastral information processes significantly quality improvement;
- Easier and quicker information access (relevant, complete and timely information);
- Controlled information access with authentication processes;
- Service-oriented architecture (SOA) integration based to reach robustness, scope, openness, scalability and adequate reliability levels.

6.3 REFER Domain Module and Final Expropriation Parcels Drawings Generation Component implementation

This intervention occurred between January 3, 2011 and May 31, 2012, was comprised by REFER Domain Module and Final Expropriation Parcels Drawings Generation Component implementation.

This application was framed in the added value services strategy that Ferbritas provided to REFER, in order to ensure theirs real estate integrity and availability. With REFER Domain Module and Final Expropriation Parcels Drawings Generation Component Ferbritas optimizes processes and transactions associated with cadastral recovery and REFER follows the evolution and state of the corresponding asset register thus facilitating Railway Public Domain updating.

The services acquired included REFER Domain Module and Final Expropriation Parcels Drawings Generation Component Specification, Analysis, Design, Implementation, Testing and Validation. This solution operation entry allowed to serve cadastral recovery process actors (Ferbritas and REFER) by providing information that enabled REFER railway real estate characterization, in a intelligible and updated way. It was intended thereby to facilitate railway public domain management and rail infrastructure improving investments decisions.

The user access to this module is made through Windows Integrated Authentication, combined with central database profile information and module functionalities access authorization definitions.

This solution is based on and integrated with FBSIC infrastructure with Ferbritas and REFER users having different levels of use.

6.4 2011 FBSIC upgrading and corrective maintenance

This intervention occurred between October 6, 2011 and April 5, 2012, was comprised by 2011 FBSIC upgrading and corrective maintenance which intended to ensure Ferbritas GIS platform updating.

Cadastral Information System (FBSIC) production entry resulted in processes and information work significant quality increase. Now there is more integration, consolidation, rigor, accreditation and monitoring of all information contained herein. These changes have resulted, of course, in new work processes and business requirements system adaptation needs. This needs arise too from application processes optimization and new features creation. Along with this evolution comes another related to support technology evolution that opens up new horizons in business performance and services creation. FBSIC enables simultaneously more information and new services availability that also benefit other Ferbritas business areas, increasingly widening organization's GIS platform scope, thus leveraging return on investment increasing.

Project development activities scope were grouped into three intervention types:

- Technological developments are intended to update the technology base that supports the Cadastral Information System. Ferbritas GIS Infrastructure update to a more current version of the platform technology (Database, Operating System, GIS platform , ...), is an example of this technological developments;
- New features evolution or creation - the creation of new features aimed at responding to new opportunities to create services for the development of Ferbritas business, below there are some examples listed:
  - GUI additional fields display;
  - Validation algorithm determination for one value entered;
  - Automation implementation in order to speed-up or ease the use; and
  - Additional pre-defined research implementation.

- Existing features changing - Changes to existing features, result of business areas requests and essentially aims to increase operational efficiency. It is understood by the evolution of features, the situations in which the feature was initially set to a certain behaviour, and using or later Thus, there can be extended, returning additional results to the user. It is understood by modifying an existing functionality, in which it was initially set to a certain behaviour, but with the use or later assessment it should be changed, returning results more oriented than initially intended by the user. Examples of this intervention are listed below:
  - Process flow diagram or states redefining;
  - Objects association and their handling logic resetting;
  - GUI objects redistribution; and
  - Print layout or its support logic resetting.

6.5 Ferbritas GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration

6.5.1 Introduction

This intervention occurred between February 2, 2011 and January 13, 2012, was comprised by Ferbritas GIS Infrastructure and FBSIC ArcGIS 10 (SP2) migration software development activities proceeded to base technology update (that supported Ferbritas GIS Infrastructure and FBSIC components). In next points, will be highlighted the most relevant aspects of the following main interventions:

- FBSIC ArcGIS support platform upgrade (test and production environments) ;
- GIS infrastructure applications migration (Central Module, Approval Module, Migration Module, etc.);
- Functional, integration and performance tests;
- Production environment applicational update; and
- Migration management (end-to-end).

6.5.2 Esri components migration

Development and tests environments, and later on, production environment were upgraded in order to support ArcGIS version 10 (SP2), thus upgrading the platform that supports FBSIC, including:

- ArcGIS Server and Image Server;
- ArcSDE;
- ArcGIS Desktop and extensions; and
- ArcGIS for AutoCAD.

6.5.3 GIS infrastructure applicational migration

The activities comprised in GIS infrastructure applicational migration, included technical aspects evaluation and FBSIC applications migration.

In what concerns, the technical aspects were evaluated the following:

- Cartography usage;
- Database access;
- Flex API usage;
- Database domains usage;
- Web services call-up; and
- Measure tools usage.

In what concerns, FBSIC applications migration, the interventions focused in the following components

- Field module;
- Information Processing Module;
- Geographic Migration Module;
- Central Module;
- Approval module;
- REFER Module;
- Backoffice; and
- Geographic web services.

6.5.4 Testing

Testing activities were comprised by the following tasks:

- Functional tests
  - Navigation;
  - Query;
  - Printing;
  - On-the-fly projections;
  - Editing.
- Integration tests
  - Geographic web services
  - AutoCAD2010 (files import and export)
- Performance tests
  - Cartography access;
  - Imagery access;
  - Simultaneous access user number.
- Acceptance tests and noncompliance issues correction

6.5.5 Production GIS infrastructure upgrading

The production GIS infrastructure upgrading was comprised by support technologies upgrade and FBSIC applications new version install.

Support technologies upgrade interventions occurred in the following main components:

- ArcGIS;
- Flex; and
- Windows, SQL Server, others service packs install;

In the other hand, the following listed FBSIC applications were upgraded with a new version install:

- Field module;
- Information Processing Module;
- Geographic Migration Module;
- Central Module;
- Approval module;
- REFER Module;
- Backoffice; and
- Geographic web services.

6.6 FBSIC Production support tools and procedures

6.6.1 Introduction

This intervention occurred between December 15, 2011 and October 12, 2012, was comprised by FBSIC production support tools and procedures implementation, which activities are listed below and will be described in detail in next points:

1. Geographic database compress automatic daily procedure implementation (production);
2. Interface for process / service delivery creation development
3. Interface for map index information creation and loading
4. Interface for parcels grouping
5. Geographical and alphanumeric features linking automation
6. Cadastral parcels, Expropriation parcels and Entities delete feature availability (Central Module - Flex)
7. Geographic feature editing Flex availability
8. Central Module Flex migration, including multi language support structure
9. Expropriation parcels automatic numbering

6.6.2 Geographic database compress automatic daily procedure implementation (production):

Compress process to be performed daily and automatically, in order to enable geographic data performance optimization and information consolidated access.

6.6.3 Interface for process / service delivery creation development

Graphical user interface (GUI) implementation to process / service delivery creation, and user data input smoothing.

6.6.4 Interface for map index information creation and loading

Graphical user interface (GUI) implementation to imported CAD map index configuration.

6.6.5 Interface for parcels grouping

Graphical user interface (GUI) implementation to parcels group, for data entry assistance.

6.6.6 Geographical and alphanumeric features linking automation

Graphical user interface (GUI) implementation and process relationship establishing between geographic (from CAD) and alphanumeric components (obtained in the field) of cadastral parcels and expropriation parcels within an expropriations project.

6.6.7 Cadastral parcels, Expropriation parcels and Entities delete feature availability (Central Module - Flex)

Graphical user interfaces (GUI) implementation for cadastral parcels, expropriation parcels and entities controlled records deleting. This feature usage must be authorized via backoffice and should only be attributed to editor profiles.

6.6.8 Geographic feature editing Flex availability

Graphical user interface (GUI) implementation to enable geographic information editing. This functionality is restricted to make (not creating) shape or position changes in the spatial objects, and does not keep their form or previous position history. This feature usage must be authorized via backoffice, and should only be attributed to editor profiles.

6.6.9 Central Module Flex migration, including multi language support structure

Central Module Flex migration, standardizing and review of all remaining modules. Simultaneously, it was defined and implemented the data structure that allowed FBSIC install in a different language from the original (Portuguese).

6.6.10 Expropriation parcels automatic numbering

Graphical user interface (GUI) and project expropriation parcels automatic numbering process implementations.

6.7 2012 FBSIC upgrading and corrective maintenance

This intervention occurred between February 21, 2012 and October 12, 2012, was comprised by a set of software development activities intended to FBSIC evolution and Ferbritas business areas operational efficiency increase, which are listed below and described in detail in the following points:

1. Auditing and information quality check tool
2. Operation Key Performance Indicators (KPIs) calculation tool
3. Quick reference map tip tool, including analysis, implementation, testing and deployment of quick reference map tip pop-up.
4. Objects identification within project validation.
5. Global Improvements

6. Legend lateralization

6.7.1 Auditing and information quality check tool

Analysis, implementation, testing and installation of automatic mechanism for data quality auditing. It can be launch with a chosen periodicity (daily, weekly or monthly), through all database records, to detect field data omissions critical to FBSIC proper functioning. Detection can be performed on criteria, allowing user to select projects by Project Phase, Project Status, Start Date, End Date, Project Number, Railway Line and Railway Segment. This mechanism can also run on demand or at previous audit expiration validity date, and it can be run for a single project. Since this process demands heavy computational resources, it is recommended to be run outside normal operation hours. At process ending is generated a "noncompliance" report (with details for each occurrence), allowing information administrator to act correctively. This tool usage is restricted and always accompanied by user, date, time and summary results log. Examples of “non-conformities” to detect:

a. Cadastral parcels, Map indexes and expropriation parcels alphanumeric records without associated geographic pair (and vice versa);
b. Cadastral parcels and expropriation parcels without identification code (Field Number);
c. Expropriation parcels not associated with Cadastral parcels; and
d. Entities (Owners, etc.) without Portuguese Tax Identification Number (NIF).

The previous list may be complemented with new validations anytime in the future, making the audit process more robust. In the projects list it’s registered when the last audit is considered expired.

Evolution analysis and dashboard visualization, impose that Warnings, Severe Warnings and Errors registers must be persistently database stored and accounted.

6.7.2 Operation Key Performance Indicators (KPIs) calculation tool

Analysis, implementation, testing and installation of automatic mechanism for operating performance indicators calculation. This mechanism, aims project status analysis and classification can be run periodically (daily, weekly or monthly), through all database records, to calculate a group of indicators and thus characterizing project state. Detection can be performed on criteria, allowing user to select projects by Project Phase, Project Status, Start Date, End Date, Project Number, Railway Line and Railway Segment. This mechanism can also run on demand or at previous audit expiration validity date, and can be directed to a specific project. Since this process also demands heavy computational resources, it is recommended to be run outside normal operation hours. In the end, is generated a report showing each indicator value, allowing the infrastructure information administrator or the project manager, to analyse and possibly act correctively on the relevant records. This mechanism is use restricted and always accompanied by user, date, time, and summary of results log. Examples of indicators to account are:

a. Number of unresolved issues identified by project number;
b. Percentage of corrections identified vs rectified within a project ;
c. Number or percentage of expropriation parcels in a given state ;
d. Number or percentage of expropriation parcels without associated Owner ;
e. Number or percentage of cadastral parcels without associated deed; etc.

KPIs values must be persistent in order that their value changes over time can be displayed on the dashboard.

6.7.3 Quick reference map tip tool, including analysis, implementation, testing and deployment of quick reference map tip pop-up.

This pop-up immediately displays the object attributes with “no need" to database access by simply moving the mouse cursor over the object in question (expropriation parcel or cadastral parcel). Database access is not necessary since all objects information was passed to the pop-ups on project loading. This feature is geared to anticipate “at hand” information availability, being immune to resulting traffic network latencies. The display fields are configurable in Backoffice, also with the ability to include hyperlinks to documents.

6.7.4 Objects identification within project validation.

In the project validation phase is provided a tool that allows to filter multiple detail columns of error and submit reports (statistics) on top of the window. Additionally is provided an error / warning linking option, i.e. a link to the GUI object that originated the issue, thus streamlining the errors correction procedure.

6.7.5 Global Improvements

This work package comprised executing an additional set of specific changes:

a. Sorting results contemplating the multicolumn tables option (datagrid);
b. Other Base Map selection besides the initially defined set;
c. Context data migration from Datum73 to ETRS89;
d. Advanced Edition ("snapping") between layers;
e. "Milestone Checklist Manager";
f. Historical information log and query.

6.7.6 Legend lateralization

Legend lateralization to the right side of the application window using the browser space throughout its height, avoiding the need for user scrolling. To activate legend display, simply hover the mouse over a central point on the right side of the screen. It’s possible to fix the legend in the open position, if is intended by the user while performing other actions on the map. It also has dynamic configuration, i.e., it display only the defined TOC active layers (including their level of transparency).

Annex 7 - FBSIC v3.0.3 functionalities matrix

7.1 Introduction

Cadastre Information System (FBSIC) is a tool that works with very unique and distinctive features among others:

- Brings together a multitude of use cases in pre-defined formats and streamlined immediately to the user;
- Integrates standardized and normalized information produced by third parties (Courts, Land Property Registries and Financial Services, Postal codes, etc.).
- Focuses on the user's perspective;
- Allows integrated and multidisciplinary uses within an enterprise or institution;
- Adds accuracy, efficiency and effectiveness of action;
- Ensures changes traceability;
- Exports to other information technology platforms, including SAP;
- Provides a platform for information and knowledge, a valuable asset in itself;
- Adds immediate value in a trend that grows exponentially over time, as the database is being enriched.

FBSIC is supported by a scalable architecture, standards-based information technology and communication, and interoperability, ensuring a high sustainability of long-term application. Allows geographic and alphanumeric viewing and editing and documental information.

Has a modular character comprising seven modules, which main features and interfaces will be presented in next chapters:

- Data Migration (geographic and alphanumeric data import with feature integrated validation);
- Field (information gathering activities support);
- Information Processing (field data import and validation);
- Central (geographic, alphanumeric and document information load and edit; project phases and transitions (workflow) quality monitoring; maps and formal documents print; among many other features);
- Approval (expropriation data approval cycle before final client delivery);
- Domain Management (management of expropriation parcels life cycle till their acquisition and integration in railway public domain by national authorities);
- Backoffice (system administrator support).

7.2 Data Migration Module

Data Migration Module is an ArcGIS ArcEditor/ArcInfo (v 10.0) extension comprised by four toolbars: import structure, CAD/GIS import, project features class creation, and information synchronize. Below, in Table 7.1, are presented its main features divided between preparation, import, validation and upload sections.

Data Migration Module
Description: Spatial data import (AutoCAD dwg)
Type: Desktop based (ArcGIS Extension)
Technology: ArcGIS Desktop, .Net (C#)

	Extranet access	Configured user access	Logged user actions
Preparation			
Work coordinate system selection		•	
Staging databases creation (personal geodatabase)		•	
CAD / GIS layers mapping (cartography data)		•	
CAD / GIS layers mapping (cadastre data)		•	
Layers mapping templates reuse		•	
New layers adding (if necessary)		•	
Feature classes naming and structure normalization		•	
Import			
Staging database cartography CAD data (dwg) import		•	
Staging database cadastre CAD data (dwg) import		•	
Import errors log		•	
Validation			
Imported feature classes (intermediate) topological validation		•	
Automatic polygon creation (line based import)		•	
Attribute validation (alphanumeric information quality checks)		•	
Annotation feature association		•	
Final dataset feature classes creation (points, lines, polygons and annotation)		•	
Upload			
Final feature classes topological validation		•	•
Central geographic database final feature classes upload		•	•
Wide feature data logs (user, date and time)		•	

Table 7.1 - Data Migration Module main features

In the following figures (Figure 7.1 and Figure 7.2) I present two examples of this module interfaces, comprising the main interface (four toolbars) and the cartography mapping table interface (from import structure toolbar).

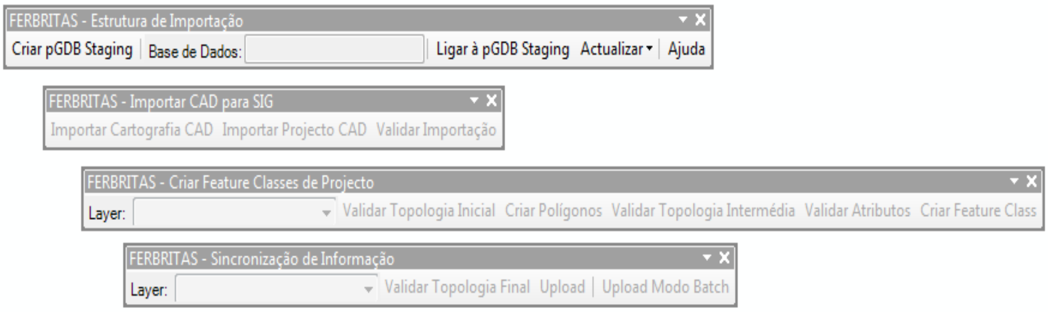


Figure 7.1 - Data Migration Module toolbars interfaces (Ferbritas, 2012d)

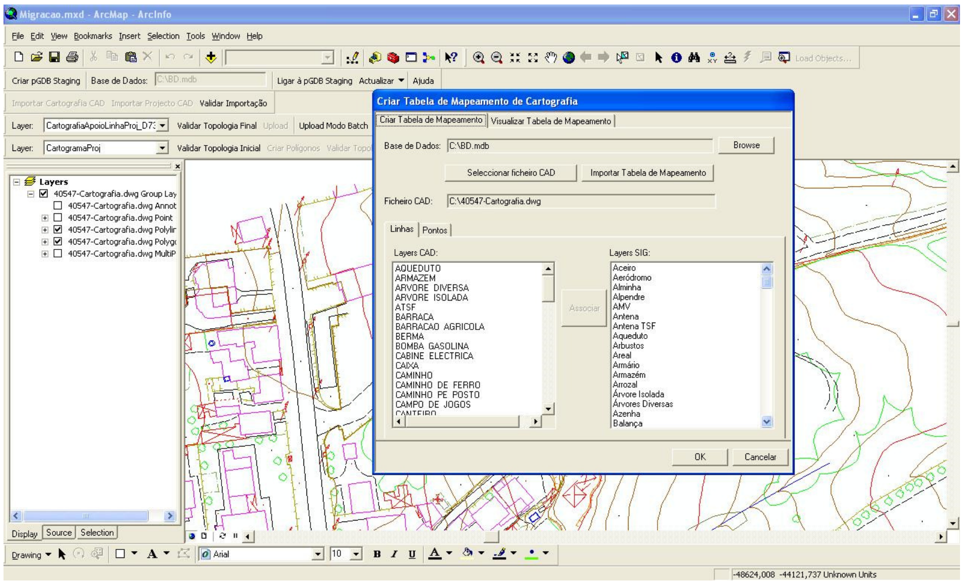


Figure 7.2 - Import structure toolbar: cartography mapping table interface (Ferbritas, 2012d)

7.3 Field Module

Field Module is a desktop application with intranet and internet user authenticated access and a compact interface comprised by the following sections: cadastral project, cadastral parcels, expropriation parcels, entities, tax and land property registries. In brief, its main features are: user authentication, access restrictions on a user base, secured access via intranet/extranet to download and upload data; data insert, edit and query (cadastral parcels, expropriation parcels, entities, tax and land property registers); addresses validation according to Portuguese postal address format; data validation (format and completeness) for cadastral parcels and cadastral project; warnings and errors log for performance quality metrics; data validation before submission to the central database; and operation autonomy in offline mode. Below, in Table 7.2, are presented its main features divided between preparation, operation and upload sections.

Field Module *Description: field information collection* *Type: Desktop based* *Technology: .Net (C#), SOA*	Extranet access	Configured user access	Logged user actions
Preparation			
Internet secure access	•	•	
User, project and phase data access restriction	•	•	
Base data availability: Postal codes, Land Property Registers, Tax Offices, Municipalities	•	•	•
Project data availability: Cadastral and Expropriation parcels, Entities, etc.	•	•	•
Central database project base data download	•	•	•
Operation			
User authentication (single sign on)		•	•
User access restrictions		•	•
Intranet based data download / upload secured access	•	•	•
Data insertion: Cadastral and Expropriation parcels, Entities, Tax and Land Property registers, etc.		•	•
Data editing: Cadastral and Expropriation parcels, Entities, Tax and Land Property registers, etc.		•	•
Single and multi-criteria queries: Cadastral parcels, Entities, Land Property registers, etc.		•	•
Portuguese postal address format validation		•	•
Global data validation: type, format and completeness		•	•
Warnings and errors log form		•	•
Warnings and errors log export		•	•
Data quality metrics and performance indexes		•	•
Offline mode operational autonomy			
Upload			
Internet secure access	•	•	•
Central infrastructure data backup loading	•	•	•
Central database on submission data validation		•	•
Central database validated data upload	•	•	•

Table 7.2 - Field Module

In the following figures (Figure 7.3 and Figure 7.4), firstly I present an example of this module interface, comprising user authentication and cadastral parcel section, and after an illustration of field module's operation cycle.

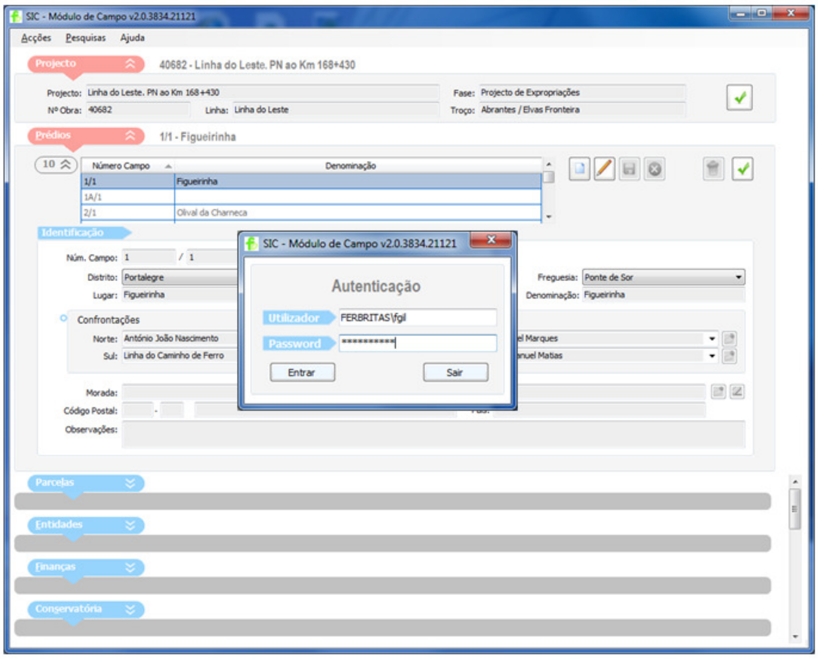


Figure 7.3 - Field module interface (user authentication and cadastral parcel section) (Ferbritas, 2012d)

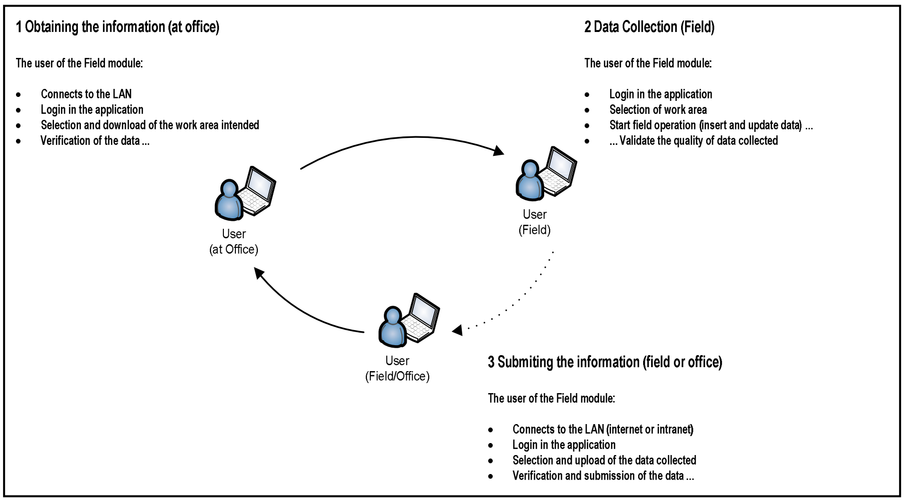


Figure 7.4 - Field module's operation cycle (Ferbritas, 2012d)

7.4 Information Processing Module

Information Processing Module is an office desktop application with user authenticated access and an interface comprised by the following sections/tabs: cadastral parcels, entities, tax registries, land property registries and expropriation parcels. In brief, its main features are: user authentication, secured access via intranet to download and upload data, validation and acceptance of data (cadastral parcels; entities; tax and land property registers; expropriation parcels), recording of the work session (save my work), and submission to the central database. Below, in Table 7.3, are presented its main features relating to operation section.

Information Processing Module

Description: central database field data upload, validation and import

Type: Desktop based

Technology: .Net (C#)

	Extranet access	Configured user access	Logged user actions
Operation			
User authentication		•	•
Field Module data download with internet secure access		•	•
Data validation and acceptance:		•	•
Cadastral parcels		•	•
Expropriation parcels		•	•
Entities		•	•
Tax registers		•	•
Land Property registers		•	•
Work session recording (save my work)		•	•
Warnings and errors log form		•	•
Warnings and errors log export		•	•
Central database validated data upload		•	•

Table 7.3 - Information Processing Module

In Figure 7.5, I present an example of this module interface, comprising cadastral parcels, entities, tax registries, land property registries and expropriation parcels tabs (sections).

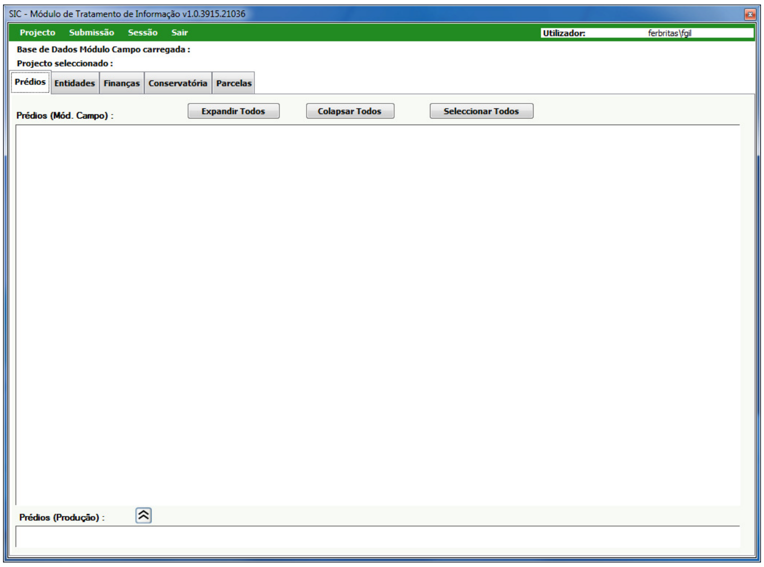


Figure 7.5 - Information processing module interface (Ferbritas, 2012d)

7.5 Central Module

Central Module is a web application with intranet and internet user authenticated access with an interface comprised by the following tools: navigation bar, map, identify, search, create, business objects, print, audit and quality, table of contents, imagery, about, and map symbology. In brief, its main features are: user authentication; data access restrictions for profile / user; data insert, edit and query (cadastral parcels, expropriation parcels, entities, tax and land property registers); addresses validation according Portuguese postal address format; integration of geographic and alphanumeric information, imagery and documents; workflow control of the project phases; query and generation of snapshots; documents generation (cadastral parcels draft report (.pdf), cadastral parcels report (.pdf), expropriations parcels areas report (.xls), easy print map (.pdf), cadastral parcels map (.pdf), expropriations project map (.pdf), expropriations project single parcel map (.pdf)); and Document Management System integration (land property and tax registry documents). Below, in Table 7.4, are presented its main features relating to navigation, measurements, searches, edits, quality, documents, print, export, and tools sections.

Central Module *Description: Data creation, query, view, maintain, report, map and export* *Type: Web based* *Technology: ArcGIS Server, Flex, .Net (C#), SOA*			
	Extranet access	Configured user access	Logged user actions
Active Directory based single sign-on authentication	•	•	•
Profile / user data access restrictions	•	•	
Navigation			
Geographic, alphanumeric, imagery and documents information integration	•	•	
Pan, Zoom In, Zoom Out, Zoom to Extent, Zoom Previous tools	•	•	
Table of Contents and Map Symbology	•	•	
Bookmarks	•	•	
Multiple layers identify (with point, line or polygon)	•	•	
Pre-defined and graphic scale	•	•	
Geographic features related pop-ups display	•	•	
Measurements			
Measurement units selection	•	•	
Assisted measurement assessment of areas, lengths and points coordinates	•	•	
Location coordinates determination	•	•	

Central Module (cont.)

Description: Data creation, query, view, maintain, report, map and export

Type: Web based

Technology: ArcGIS Server, Flex, .Net (C#), SOA

	Extranet access	Configured user access	Logged user actions
Searches			
Single or multi-criteria searches:	•	•	•
District	•	•	•
Municipality	•	•	•
Parish	•	•	•
PKs (kilometric distance)	•	•	•
Train stations	•	•	•
Map indexes	•	•	•
Railway lines	•	•	•
Railway line segments	•	•	•
Expropriation Projects	•	•	•
Cadastral parcels	•	•	•
Project cadastral parcels	•	•	•
Expropriation parcels	•	•	•
Entities	•	•	•
Administrative Expropriation Processes	•	•	•
Provision of Services	•	•	•
Tasks			
Search results export (xls or csv formats)	•	•	•
Search results map location	•	•	•
Project historical data log access	•	•	•
Cadastral parcel status	•	•	•
Expropriation parcel status	•	•	•
Edits			
Records creation and editing:	•	•	•
Provision of Services	•	•	•
Expropriation Projects	•	•	•
Cadastral parcels	•	•	•
Project cadastral parcels	•	•	•
Expropriation parcels	•	•	•
Entities	•	•	•
Administrative Expropriation Processes	•	•	•
Civil Registry	•	•	•
Tax Registry	•	•	•
Commercial Registry	•	•	•
Geographic edition	•	•	•

Central Module (cont.) *Description: Data creation, query, view, maintain, report, map and export* *Type: Web based* *Technology: ArcGIS Server, Flex, .Net (C#), SOA*	Extranet access	Configured user access	Logged user actions
Edits (cont.)			
Project cadastral parcels	•	•	•
Expropriation parcels	•	•	•
Expropriation Stakes and Vertices	•	•	•
Construction works occupation track	•	•	•
Other elements	•	•	•
Quality			
Portuguese postal address format validation	•	•	•
Global data validation (type, format and completeness)	•	•	•
Expropriation Projects	•	•	•
Cadastral parcels	•	•	•
Project cadastral parcels	•	•	•
Expropriation parcels	•	•	•
Entities	•	•	•
Administrative Expropriation Processes	•	•	•
Validation log export (*.xls)	•	•	•
Quality dashboards: project and global	•	•	•
Documents			
Document generation:	•	•	•
Cadastral Parcels map (.dwg, .pdf)	•	•	•
Expropriations Project map (.dwg, .pdf)	•	•	•
Expropriations Project single parcel map (.dwg, .pdf)	•	•	•
Cadastral and Expropriation Map Sheets (.dwg, .pdf)	•	•	•
Expropriations parcels area report (.xls)	•	•	•
Cadastral parcels report (.pdf)	•	•	•
Cadastral parcels draft report (.pdf)	•	•	•
Land Property and Tax registers documents and Cadastral Parcels information report	•	•	•
Document Management Systems support and integration	•	•	
Print			
Simple map prints (easy print map)	•	•	•
Pre-defined map print templates (A4 to A1 formats; portrait or landscape)	•	•	•

Central Module (cont.) *Description: Data creation, query, view, maintain, report, map and export* *Type: Web based* *Technology: ArcGIS Server, Flex, .Net (C#), SOA*	Extranet access	Configured user access	Logged user actions
Export			
Export to CAD (.dwg)	•	•	•
Cadastral Project	•	•	•
Cadastral and Expropriation Projects map sheet(s)	•	•	•
Expropriation Parcels	•	•	•
Export to geodatabase	•	•	•
Provision of Services (global or partial)	•	•	•
Tools			
Cadastral / Expropriation Parcels, Expropriation Vertices / Stakes assisted numbering	•	•	•
Geographic and alphanumeric information integration:	•	•	•
Cadastral Parcels alpha/geo matching	•	•	•
Expropriation Parcels alpha/geo matching	•	•	•
Map Indexes alpha/geo matching	•	•	•
Entities integrated management	•	•	•
Cadastral / Expropriation Parcels, and Expropriation Vertices / Stakes project move	•	•	•
Expropriation Project phases workflow control	•	•	•
Expropriation Project global snapshots generation and query	•	•	•
Global release notes log search and display	•	•	

Table 7.4 - Central Module

In the following figures (Figure 7.6 to Figure 7.15), first I present an example of this module interface (initial screen), and afterwards I present a group of FBSIC outputs namely:

- Cadastral parcels report;
- Land Property registry document;
- Tax registry document;
- Cadastral parcels map;
- Expropriations Project map;
- Expropriations Project single parcel map (A4 format);
- Expropriations Project single parcel map (A3 format);
- Expropriations parcels area report; and
- Easy print map.

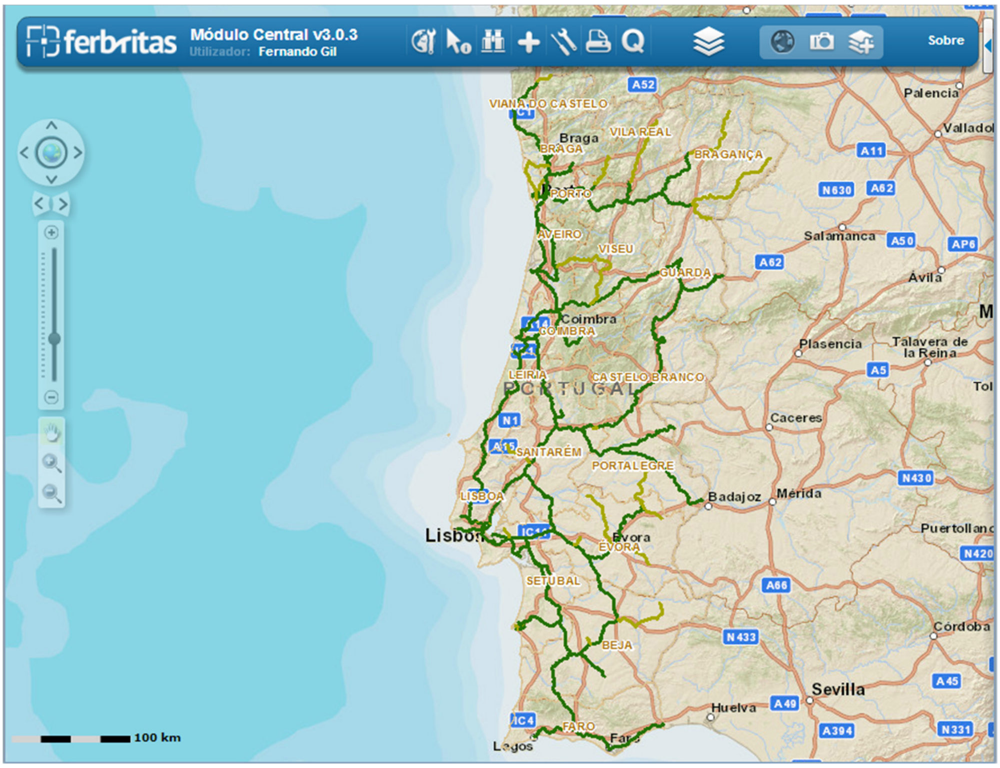


Figure 7.6 - FBSIC initial screen (Ferbritas, 2012d)

ferbritas

Ficha de Identificação Cadastral

Variante de Santarém

REFER EPE

Linha do Norte
Lisboa Santa Apolónia / Porto Campanhã

Nº Prédio Cadastro: 1

Identificação do Prédio

Lugar:	Paúl de Malpique	**Distrito:**	Santarém
Freguesia:	Vila Chã de Ourique	**Concelho:**	Cartaxo
Observações:			
Denominação:			

Confrontações

Norte:	Domínio Público Ferroviário
Sul:	José
Nascente:	
Poente:	Domínio Público Ferroviário

Finanças

Artigo Rústico:

Artigo Urbano:

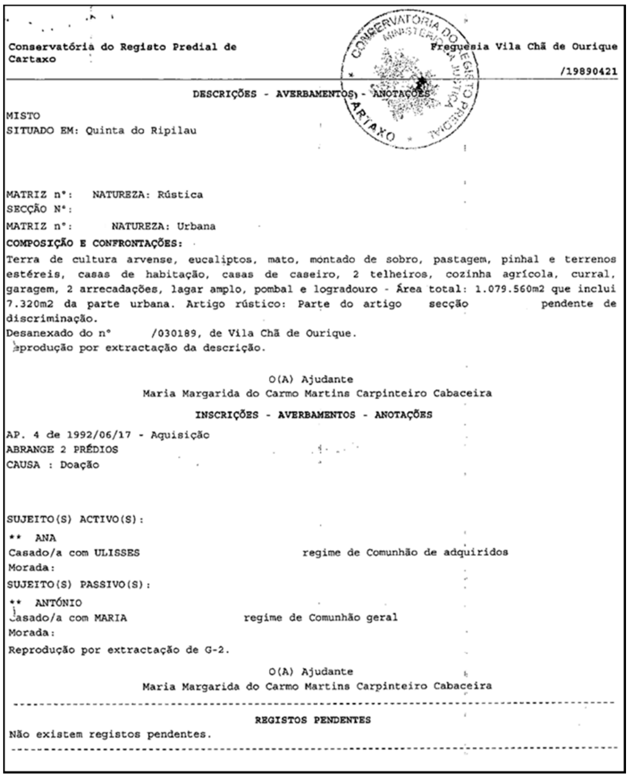
Registo da Conservatória

Registo Predial Conservatória: /19890421

Proprietários

Nome:	Ana		
Morada:	Rua		
Telefone:		**NIF/NIPC:**	
Observações:			

Figure 7.7 - Cadastral parcels report



Conservatória do Registo Predial de Cartaxo — Freguesia Vila Chã de Ourique — /19890421

CONSERVATÓRIA DO REGISTO PREDIAL — MINISTÉRIO DA JUSTIÇA — CARTAXO

DESCRIÇÕES - AVERBAMENTOS - ANOTAÇÕES

MISTO
SITUADO EM: Quinta do Ripilau

MATRIZ nº: NATUREZA: Rústica
SECÇÃO Nº:
MATRIZ nº: NATUREZA: Urbana

COMPOSIÇÃO E CONFRONTAÇÕES:

Terra de cultura arvense, eucaliptos, mato, montado de sobro, pastagem, pinhal e terrenos estéreis, casas de habitação, casas de caseiro, 2 telheiros, cozinha agrícola, curral, garagem, 2 arrecadações, lagar amplo, pombal e logradouro - Área total: 1.079.560m2 que inclui 7.320m2 da parte urbana. Artigo rústico: Parte do artigo secção pendente de discriminação.
Desanexado do nº /030189, de Vila Chã de Ourique.
Reprodução por extractação da descrição.

O(A) Ajudante
Maria Margarida do Carmo Martins Carpinteiro Cabaceira

INSCRIÇÕES - AVERBAMENTOS - ANOTAÇÕES

AP. 4 de 1992/06/17 - Aquisição
ABRANGE 2 PRÉDIOS
CAUSA : Doação

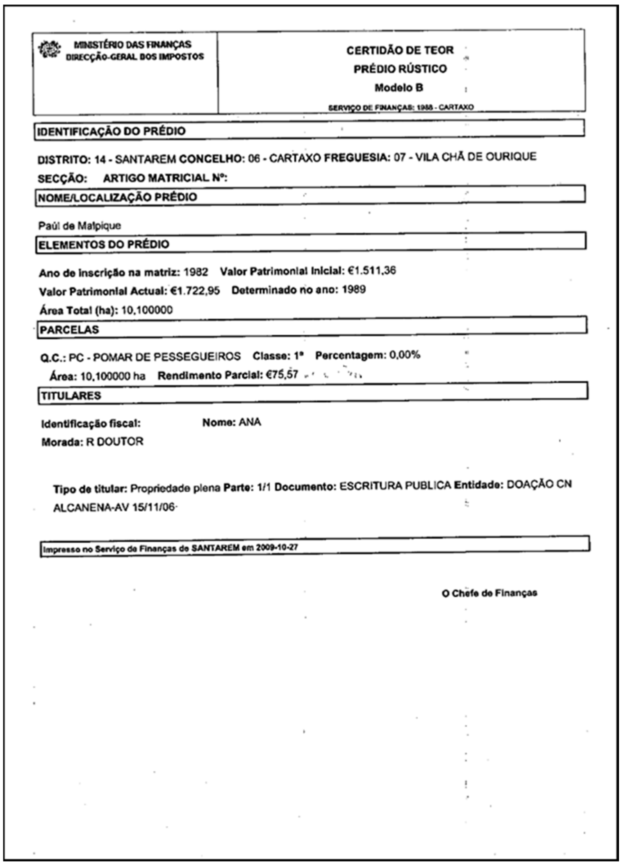
SUJEITO(S) ACTIVO(S):
** ANA
Casado/a com ULISSES regime de Comunhão de adquiridos
Morada:
SUJEITO(S) PASSIVO(S):
** ANTÓNIO
Casado/a com MARIA regime de Comunhão geral
Morada:
Reprodução por extractação de G-2.

O(A) Ajudante
Maria Margarida do Carmo Martins Carpinteiro Cabaceira

REGISTOS PENDENTES

Não existem registos pendentes.

Figure 7.8 - Land Property registry document



MINISTÉRIO DAS FINANÇAS
DIRECÇÃO-GERAL DOS IMPOSTOS

CERTIDÃO DE TEOR
PRÉDIO RÚSTICO
Modelo B
SERVIÇO DE FINANÇAS: 1988 - CARTAXO

IDENTIFICAÇÃO DO PRÉDIO

DISTRITO: 14 - SANTAREM **CONCELHO:** 06 - CARTAXO **FREGUESIA:** 07 - VILA CHÃ DE OURIQUE
SECÇÃO: ARTIGO MATRICIAL Nº:

NOME/LOCALIZAÇÃO PRÉDIO

Paúl de Malpique

ELEMENTOS DO PRÉDIO

Ano de inscrição na matriz: 1982 **Valor Patrimonial Inicial:** €1.511,36
Valor Patrimonial Actual: €1.722,95 **Determinado no ano:** 1989
Área Total (ha): 10,100000

PARCELAS

Q.C.: PC - POMAR DE PESSEGUEIROS **Classe:** 1ª **Percentagem:** 0,00%
Área: 10,100000 ha **Rendimento Parcial:** €75,57

TITULARES

Identificação fiscal: **Nome:** ANA
Morada: R DOUTOR

Tipo de titular: Propriedade plena **Parte:** 1/1 **Documento:** ESCRITURA PUBLICA **Entidade:** DOAÇÃO CN ALCANENA-AV 15/11/06

Impresso no Serviço de Finanças de SANTAREM em 2009-10-27

O Chefe de Finanças

Figure 7.9 - Tax registry document

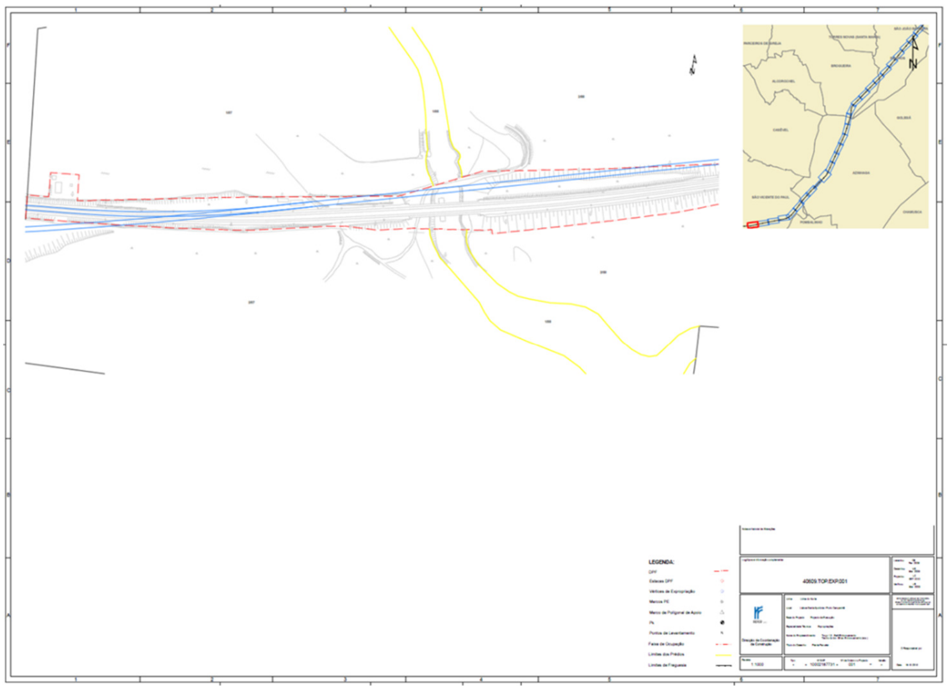


Figure 7.10 - Cadastral parcels map

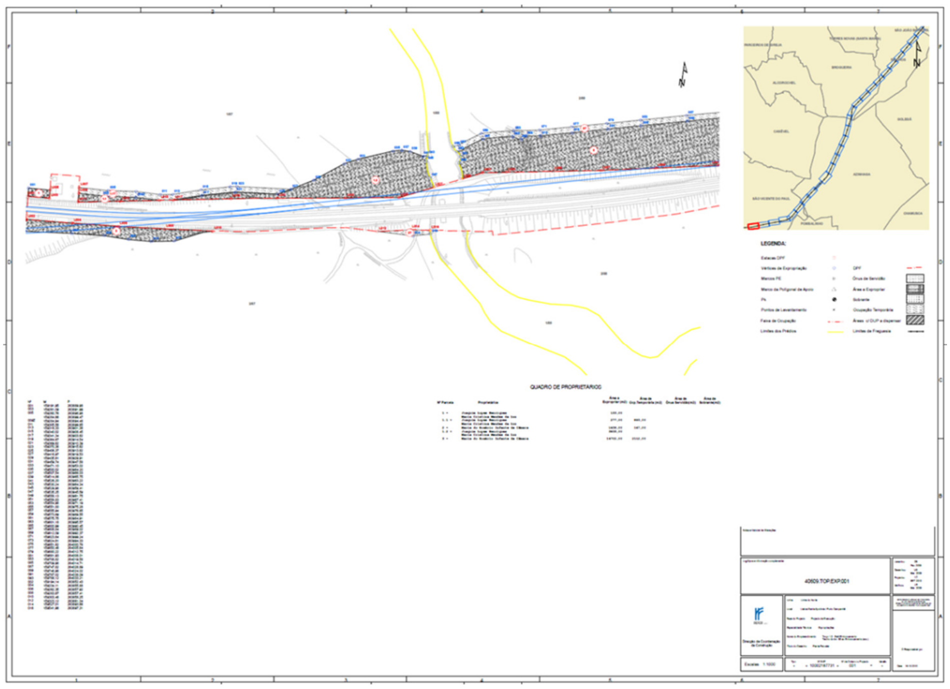


Figure 7.11 - Expropriations Project map

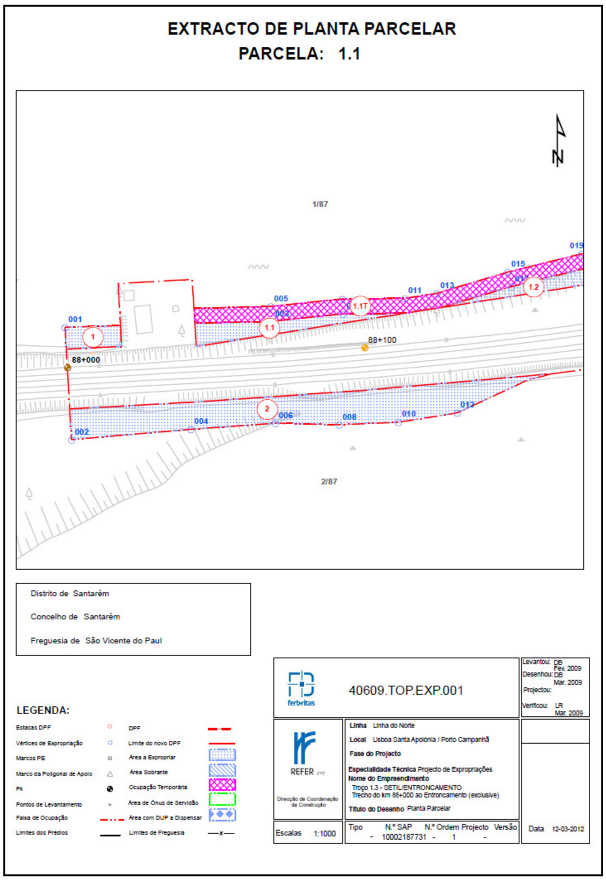


Figure 7.12 - Expropriations Project single parcel map (A4 format)

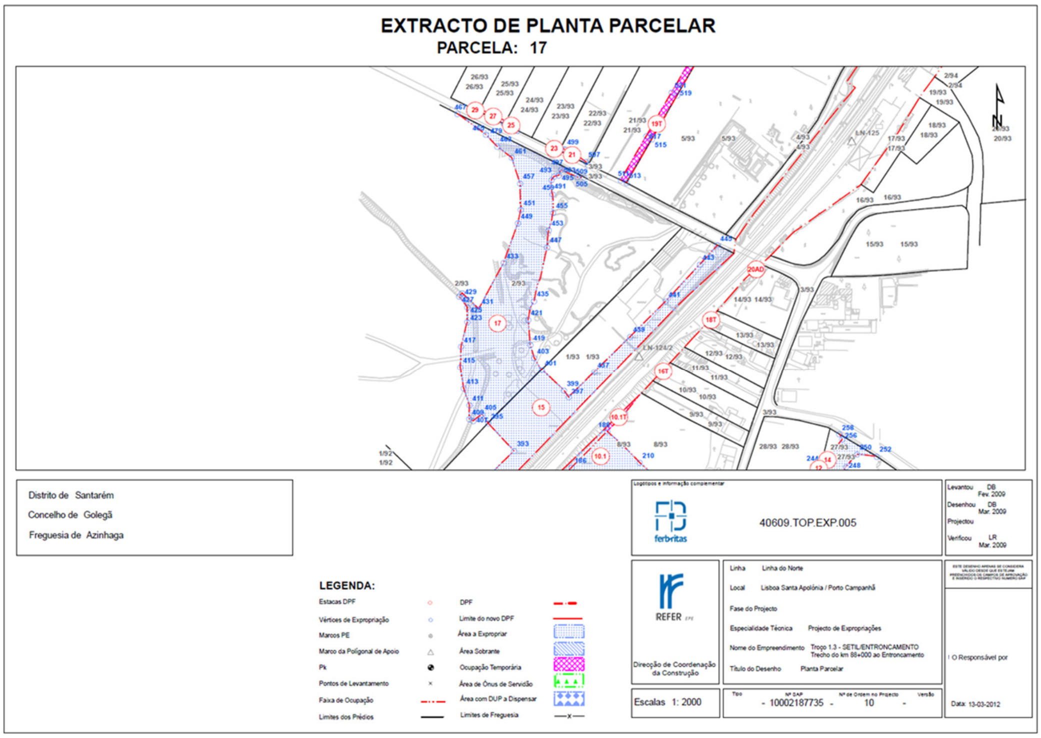


Figure 7.13 - Expropriations Project single parcel map (A3 format)

Mapa de Áreas

Projecto de Expropriações

Linha do Norte

Linha do Norte. Subtroço 1.3 – Setil / Entroncamento. Trecho do km 88+000 ao Entroncamento (Exclusive).

Distrito: Santarém
Concelho: Santarém
Freguesia: São Vicente do Paul

Data: 12-03-2012

NÚMERO PARCELA EXPROPRIAR	PROPRIETÁRIOS	ÁREA A EXPROPRIAR (m2)	SOBRANTE EVENT. A EXPROPRIAR	OCUPAÇÃO TEMPORÁRIA	DUP A DISPENSAR	REFERÊNCIAS – FINANÇAS	REFERÊNCIAS – REGISTO PREDIAL	CONFRONTAÇÕES	NÚMERO DESENHO
1	Maria Rua da e cônjuge Joaquim Rua da	133				Rústico	/20001018	Norte : Próprio Sul : Domínio Público Ferroviário Nascente : Domínio Público Ferroviário Poente : Próprio	10002187731
1.1	Maria Rua da e cônjuge Joaquim Rua da	277		893		Rústico	/20001018	Norte : Próprio Sul : Domínio Público Ferroviário Nascente : Próprio Poente : Domínio Público Ferroviário	10002187731
1.2	Maria Rua da e cônjuge Joaquim Rua da	3835				Rústico	/20001018	Norte : Próprio Sul : Domínio Público Ferroviário Nascente : Rio Alviela Poente : Próprio	10002187731
2	Maria Quinta Arrendatário: Joaquim Tojeiro, Joaquim Tojeiro, Manuel Tojeiro	1436		147		Rústico	/20080415	Norte : Domínio Público Ferroviário Sul : Próprio Nascente : Próprio Poente : Próprio	10002187731

São Vicente do Paul | Azinhaga | Brogueira | Riachos | São João Baptista

Figure 7.14 - Expropriations parcels area report

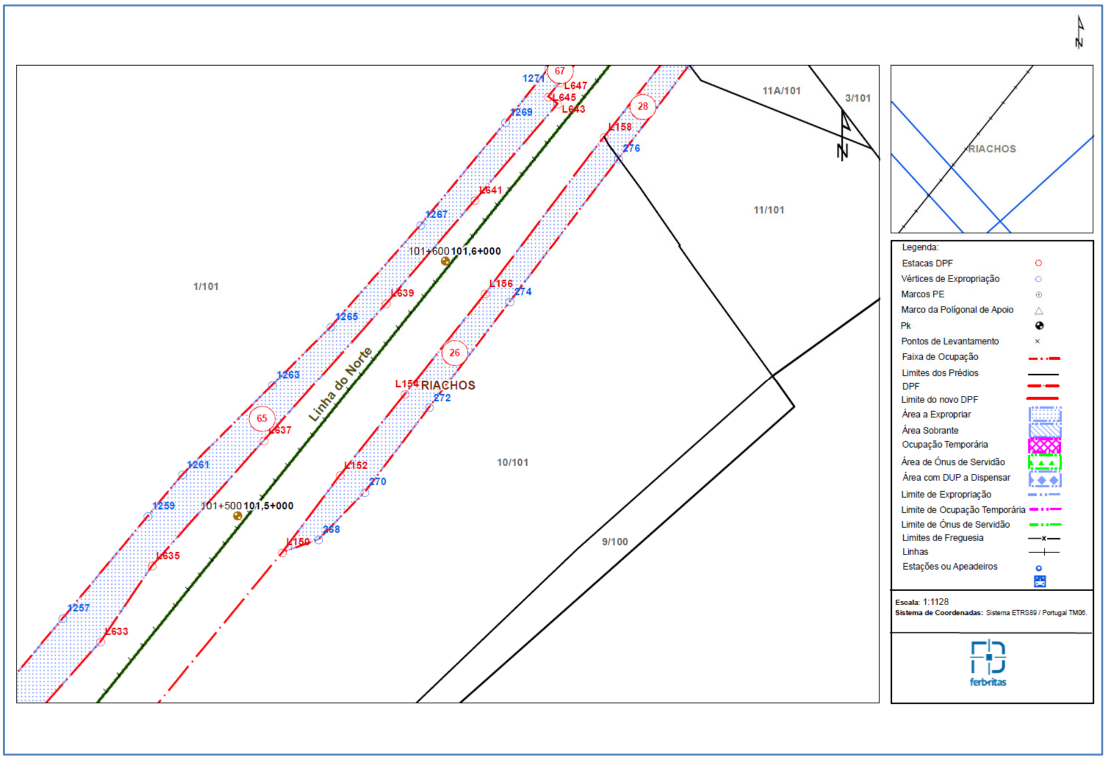


Figure 7.15 - Easy print map

7.6 Approval Module

Approval Module is a web application with intranet and internet user authenticated access Flex technology based. In brief, its main features are: user authentication; data access restrictions for profile, user, phase and project; project navigation; cadastral and expropriation parcels information analysis (geographic and alphanumeric); annotation and / or correction events notes insertion into data in analysis; information visualization to support analysis; Railway Engineering Project information integration; measurement tools availability; search tools availability; analysis and validation track log (what, who and when); search by analysis state. Below, in Table 7.5, are presented its main features relating to navigation, measurements, searches, event identification and resolution, and print sections.

Approval Module

Description: Quality control and final acceptance

Type: Web based

Technology: ArcGIS Server, Flex, .Net (C#), SOA

	Extranet access	Configured user access	Logged user actions
Active Directory based single sign-on authentication	•	•	•
Profile / user data access restrictions	•	•	
Navigation			
Geographic, alphanumeric, imagery and documents information integration	•	•	
Pan, Zoom In, Zoom Out, Zoom to Extent, Zoom Previous tools	•	•	
Table of Contents and Map Symbology	•	•	
Bookmarks	•	•	
Multiple layers identify (with point, line or polygon)	•	•	
Pre-defined and graphic scale	•	•	
Geographic features related pop-ups display	•	•	
Measurements			
Measurement units selection	•	•	
Assisted measurement assessment of areas, lengths and point coordinates	•	•	
Location coordinates determination	•	•	
Searches			
Single or multi-criteria searches:	•	•	•
Cadastral parcels	•	•	•
Project cadastral parcels	•	•	•
Expropriation parcels	•	•	•
Entities	•	•	•
Expropriation Projects	•	•	•
Administrative Expropriation Processes	•	•	•

Approval Module (cont.) *Description: Quality control and final acceptance* *Type: Web based* *Technology: ArcGIS Server, Flex, .Net (C#), SOA*	Extranet access	Configured user access	Logged user actions
Searches (cont.)			
Provision of Services	•	•	•
Search results export (xls or csv formats)	•	•	•
Search results map location	•	•	•
Historical log access:	•	•	•
Cadastral parcel status	•	•	•
Expropriation parcel status	•	•	•
Administrative expropriation processes status	•	•	•
Event Identification and Resolution			
Support analysis information visualization (criteria)	•	•	
Cadastral and Expropriation parcels information analysis (geographic and alphanumeric)	•	•	
Data annotations insert (observations and/or corrections)	•	•	
Search tools availability	•	•	
Railway engineering projects vectorial information integration	•	•	
Log analysis and validation history (what, who and when)	•	•	
Search by analysis status	•	•	
Print			
Simple map prints	•	•	
Pre-defined map print templates (A4 to A1 formats; portrait or landscape)	•	•	

Table 7.5 - Approval Module

In the following figures (Figure 7.16 and Figure 7.17), first I present an example of this module interface (initial screen), and afterwards I present the Approval Module’s operation life cycle.

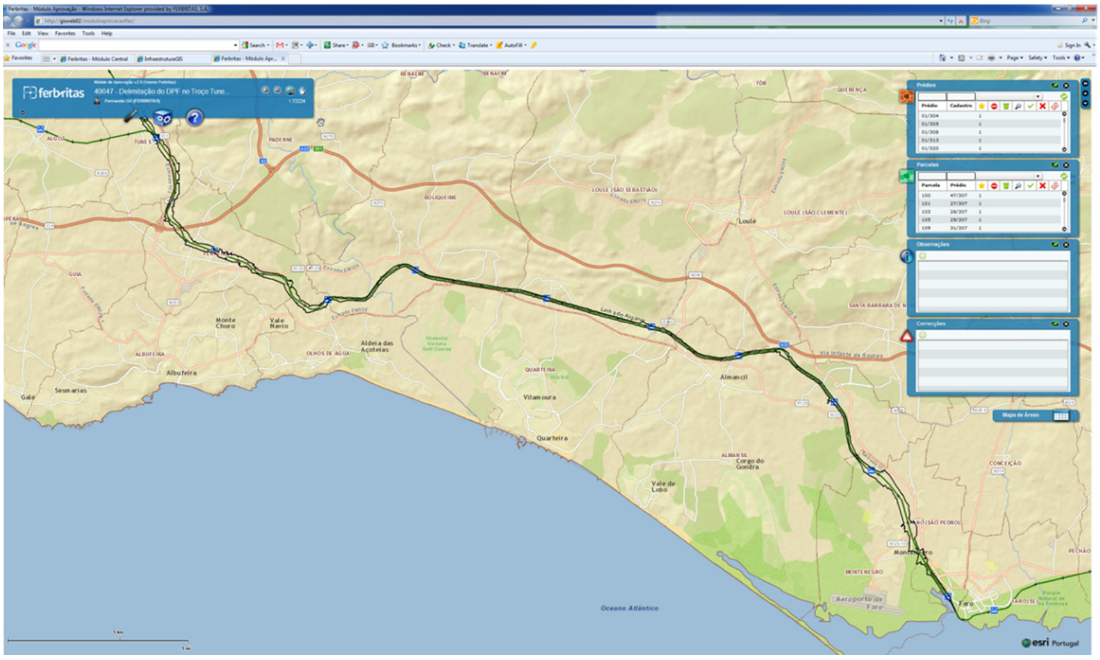


Figure 7.16 - Approval module initial screen

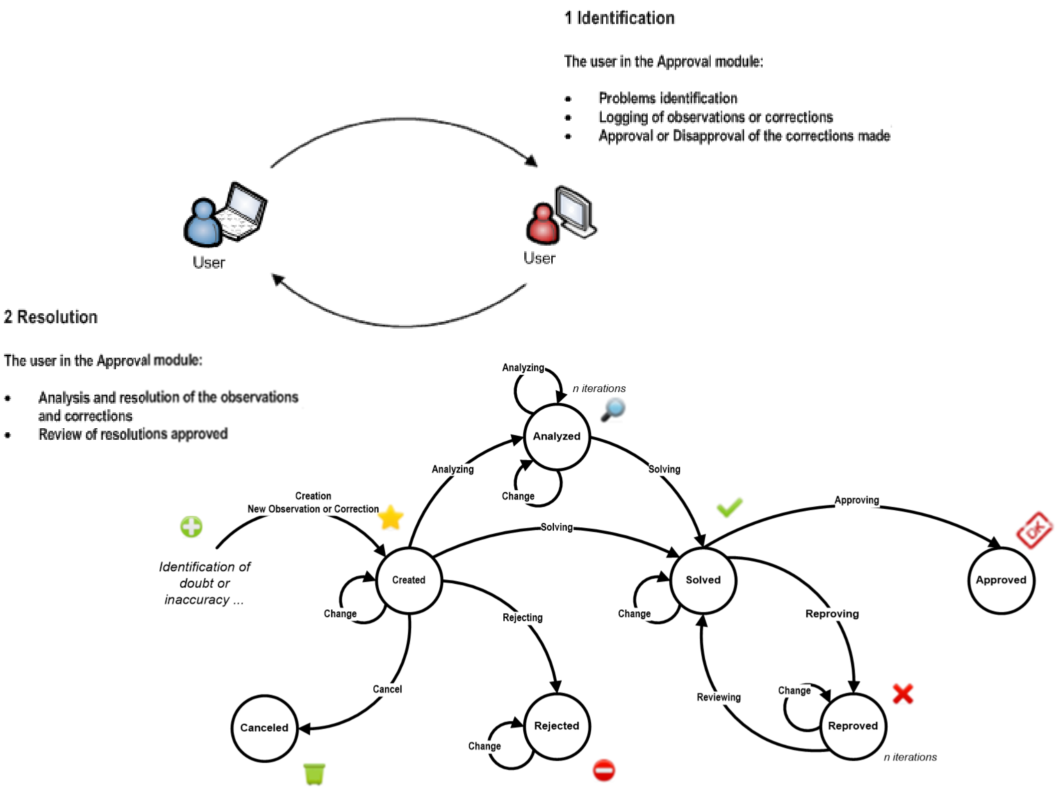


Figure 7.17 - Approval module operation life cycle (Ferbritas, 2012d)

7.7 Domain Management Module

Domain Management Module is a web application with intranet and internet user authenticated access Flex technology based. In brief, its main features are: access to data with user restrictions; Expropriations Projects, Cadastral Parcels, Expropriation Parcels, Railway Lines, Railway Line Segments and KPs query; integration between of geographic and alphanumeric cadastral information; context geographic information visualization (orthophotos, military and street maps); expropriation parcels process state control; Railway Public Domain automatic update after an expropriation parcel acquisition; parcel status log view; official documentation generation (Cadastral Parcels and Expropriations Project maps, Expropriations Project single parcel map, Cadastral Parcels report, and Expropriations parcels area report); Document Management System integration; alphanumeric and geographic data and related documents export. Below, in Table 7.6, are presented its main features relating to sections navigation, measurements, searches, edit, documents, print, and export. In Figure 7.18 is presented the Domain Management module search screen.

Domain Module *Description: Railway Domain data creation, query, view, maintain, report, map and export* *Type: Web based* *Technology: ArcGIS Server, Flex, .Net (C#), SOA*			
	Extranet access	Configured user access	Logged user actions
Authentication single sign-on Active Directory based	•	•	•
Data access restrictions for profile / user	•	•	
Navigation			
Integration of geographic and alphanumeric information, imagery and documents	•	•	
Pan, Zoom In, Zoom Out, Zoom to Extent, Zoom Previous	•	•	
Table of Contents and Map Symbology	•	•	
Bookmarks	•	•	
Identify of multiple layers (with point, line or polygon)	•	•	
Pre-defined and graphic scale	•	•	
Pop-up of the alphanumeric information associated with a geographic element	•	•	
Measurements			
Selection of units of measurement	•	•	
Assisted assessment of areas and lengths	•	•	
Location coordinates determination	•	•	

Domain Module (cont.) *Description: Railway Domain data creation, query, view, maintain, report, map and export* *Type: Web based* *Technology: ArcGIS Server, Flex, .Net (C#), SOA*			
	Extranet access	Configured user access	Logged user actions
Searches (cont.)			
Project cadastral parcels	•	•	•
Expropriation parcels	•	•	•
Entities	•	•	•
Expropriation Projects	•	•	•
Administrative Expropriation Processes	•	•	•
Provision of Services	•	•	•
Search results export (xls or csv formats)	•	•	•
Search results map location	•	•	•
Historical log access:	•	•	•
Cadastral parcels and Expropriation parcels	•	•	•
Edit			
Expropriation parcels management status	•	•	•
Railway Public Domain automatic update after a expropriation parcel acquisition			
Documents			
Official documentation generation:	•	•	•
As-built Expropriations Project map (.dwg, .pdf)	•	•	•
Final Expropriation Parcels Area Report (.xls)	•	•	•
Cadastral Parcels Report (.pdf)	•	•	•
Cadastral Parcels Draft Report (.pdf)	•	•	•
Cadastral Parcels Report (including related documents) (.pdf)	•	•	•
Document Management Systems support and integration	•	•	
Print			
Simple map prints	•	•	•
Pre-defined map print templates (A4 to A1 formats; portrait or landscape)	•	•	•
Export			
Export to CAD (.dwg)	•	•	•
Cadastre Project	•	•	•
Cadastre Project drawing sheet(s)	•	•	•
Expropriation parcels	•	•	•
Export to geodatabase	•	•	•
Provision of Services (global or partial)	•	•	•
Alphanumeric, geographic data and documents export	•	•	•

Table 7.6 - Domain Management Module

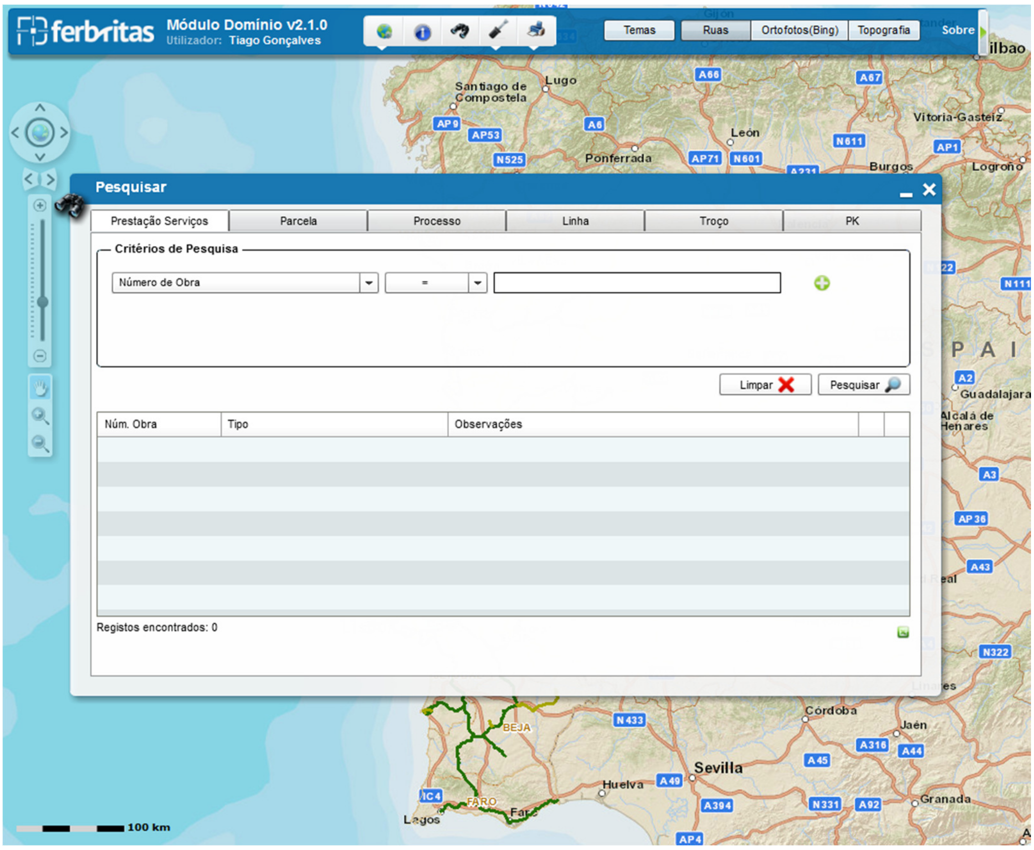


Figure 7.18 - Domain management module search screen (Ferbritas, 2012d)

7.8 Backoffice Module

Backoffice Module is a web application with intranet and internet user authenticated access. In brief, its main features are: user authentication; profile / user data access restrictions; users definition; user profile definition; profile functionality definition; profile user association; module/application access restriction; project and phase access restriction (Field Module); Active Directory integration; expropriations projects creation, copy and maintenance. Below, in Table 7.7, are presented its main features relating to users, projects and infrastructure.

Backoffice *Description: Infrastructure administration support* *Type: Web based* *Technology: ArcGIS Server, .Net (C#)*	Extranet access	Configured user access	Logged user actions
Authentication single sign-on Active Directory based		•	•
Data access restrictions for profile / user		•	•
Users			
Users definition		•	•
Profile definition		•	•
Profile functionality access definition		•	•
Profile user association		•	•
Application access restriction		•	•
Project and phase access restriction (Field Module)		•	•
Application parameters configuration		•	•
Projects			
Project creation, copying and maintenance		•	•
Infrastructure			
Multilingual use settings		•	•
System parameters configuration		•	•

Table 7.7 - Backoffice Module

7.9 Solution Detailed Functionalities

In Table 7.8, are presented FBSIC solution detailed functionalities.

Tools	Description
1. General Tools	
Navigation	
	Navigation panel, zoom slider, mouse wheel support
	Zoom in, zoom out, pan, continuous zoom, full extent
	Discrete scales list, zoom to a given scale
	Dynamic zoom scale and extent display for exact map navigation
Selection	
	Point selection
	Rectangle (box) selection
	Line selection
	Polygon selection
	Multiple layers selection
	Snap selection
	Selection clear
Map Tip	
	Layer specific map tip on point / line / polygon objects with display of object geometry and attribute data
	Identified objects add to current selection
	Map tip window images and hyperlinks display
	Map tip on multiple layers (drill down)
	Map tip minimum and maximum scale
	Map Tip permanently active optional configuration
Labelling	
	Point, line and polygon objects support for of any vector layer. Object selection with a map click
	One or multiple labelling configurations support
	Label print
Drawing	
	Points drawing
	Lines drawing
	Areas drawing
	Digitized text placing on the map
	Text colour, size, font and background colour definition
	Measure tool features
email map	
	Current map email (including extent, layer visibilities, drawings, measured objects, labelled objects)
Search Coordinates	
	Coordinate search and location display map centred
	Coordinates entered in a given Projected Coordinate System or in geographic coordinates
	Coordinates on-the-fly projection according to the main map service
	Coordinates map display

Tools	Description
1. General Tools (cont.)	
Map overlay	
	Dynamic overlay of current map with another map view
	Overlay size and transparency level adjustment
Snapping	
	Map vector layers (vertex, edge, ….), and measuring and selection functions feature snap
	Existing measuring / drawing objects snap (optional)
	Multiple group layers snap definition in snap profiles
Online Help	
	Online help
2. Map Tools	
Spatial Bookmarks	
	Create bookmark (to identify a particular geographic location for later reference)
	Zoom to / Pan to a saved bookmark location in the map
Measure	
	Point coordinates measurement with optional snap
	Distance measurement with optional snap
	Area measurement with optional snap
	Feature measurement with optional snap
	Perpendicular distances measurement with optional snap
	Graphic colour, line width, area fill colour and transparency level setting
	Measured object move (point, line, polygon, ...)
	Results obtained in several units
	Snapping functions use while measuring
3. Identify Tool	
Feature Selection	
	Identify objects on a specific layer
	Identify objects on multiple layers (drill down)
	Identify with: point, line and polygon
	Object browser for processing drilldown results
	Access to all selected objects from one layer
	Access to specific objects in the object browser
	Map display of all selected objects from multiple layers at once

Tools	Description
4. Search Tool	
Search tool	
	Query builder
	Powerful queries combining
	Powerful queries and spatial selectors combining
	Support for advanced search operations in multiple steps
	Default values for search fields
	Full text search (suggestion for search fields)
	Hierarchical search
Search results	
	Multiple result views for one query
	Show all objects
	Select all objects
	Show selected objects in current map extent
	Show previous/next object
	Zoom to previous/next object
	Remove selected object from selection
	Export selected objects into Excel (xml)
	Excel (xml) export configuration available
	Layer specific print templates available
	Sorting on any column
	Columns repositioning
	Object detail view
5. Business Entities	
Creating	
	Entity
	Cadastral Parcel
	Provision of Services
	Expropriation Project
	Administrative Expropriation Process
	Map Index
Editing	
	Point, line and polygon feature classes web based editing
	Edit tools configuration: create, copy, edit, delete and split.
	Edit mode configuration: 'geometry only', 'attributes only', 'attributes and geometry'
	Attribute data edit form validation
	Snapping functions use in editing mode
	Support for ESRI domains (lookup tables for input fields)
	Support for hierarchical dependencies in input fields
	'Edit object' tool available in context menu

Tools	Description
5. Business Entities (cont.)	
	Support for client-based data editing
	Flip function (lines or polygons)
	Features merging
	Edit layer configurations optimized input forms
Construction	
	Constructions tools for creating objects:
	-Square construction tool for line and polygon feature class
	-Circle construction tool for line and polygon feature class
	-Orthogonal construction tool for line and polygon feature class
	Constructions tools for adding/editing object vertex points:
	-Alignment
	-Intersection of two lines
	-Circular intersection
	-Construction by distance and/or angle
6. Business tools	
	Alphanumeric / Geographic data matching:
	-Cadastral Parcels,
	-Expropriation Parcels, and
	-Map sheets
	Expropriation Parcel Grouping
	Entities Manager
	Map Indexes Parameters Manager
	Provision of Services Parameters Manager
	Features automatic numbering (cadastral and expropriation parcels, stakes)
	Field Module database submissions Manager
	Cadastral Parcels Project Move
	Authentication
	Vector data export tool (Personal GDb and AutoCAD dwg)
7. Print tool	
	Print output in file formats supported by ESRI ArcGIS
	Print output available in several resolutions
	Multiple print templates available
	Default templates A4 portrait/landscape to A1 included
	Print output rotation tool
	Print extents preview
	Print output selected objects attribute data display - simple map plots
	Selected objects attribute data display, including a detailed map for each selected object
	Predefined function fields for dynamic population of print header with several metadata
	Generic function fields for dynamic population of print header
	Logo fields for logo images display

Tools	Description
7. Print tool (cont.)	
	North arrow rotation function field (for display of a correctly rotated north arrow symbol when using rotated plots)
	High resolution prints using map cache
	Full support for internationalization and multilingual print output
	Server resources optimization for Print function (centralized print service)
	Multiple maps plots optimization and acceleration
	Different map plan type printing relating a map view to a print template.
8. Quality	
	Cadastre Information System Audit tool
	Project Summary
	Project Tasks Definition
9. Maps	
	Map collection: Ordered set of maps
	Support for ArcGIS Server Internet map service (cached or dynamic), ArcGIS Image Server Image service, and OGC WMS / WFS map services
	Support for ESRI MSD - MXD hybrid scenarios for fast and high quality map rendering (MSD) and full search, selection and legend functionality (MXD)
Caches	
	Full support for cached ArcGIS Server Internet map services (integrated by administrator)
	Full support for multiple caches blending on client side (each of them with optional transparency level)
Display / Elements	
	North arrow
	Scale bar
	Copyright text
Selection display	
	Support for symbology specified selection in ArcMap layer properties
	Support for dynamic specified selection display
Rotated Maps	
	Support for data frames rotation (for non-north oriented maps)
WMS Services	
	OGC WMS services integration
ArcGIS Server Services	
	ArcGIS Server Internet services integration
	Combination of any layer group or layer visibility settings based on all map collection
	Transparency level configuration for each map services included in map view
	Metadata short description and metadata detail description reference
	Overruling of layer groups respectively layer attributes

Tools	Description
10. Table of contents	
	Layer navigation based on ArcMap Table of Contents
	Prepared legend images using
11. Image Services	
	Support for ArcGIS Online Image Services
	Dynamic on-the-fly projection and transformation to the user specific geographic projection system
	Dynamic rescaling to the user specific scales
	Support for map rotation in client side and in plot printing
12. About	
	About Form with links to application versions log and application manual
13. Legend	
	Table of Contents: ArcMap legend dynamic display
	Multilanguage support for dynamic legend display

Table 7.8 - Tools listing and description

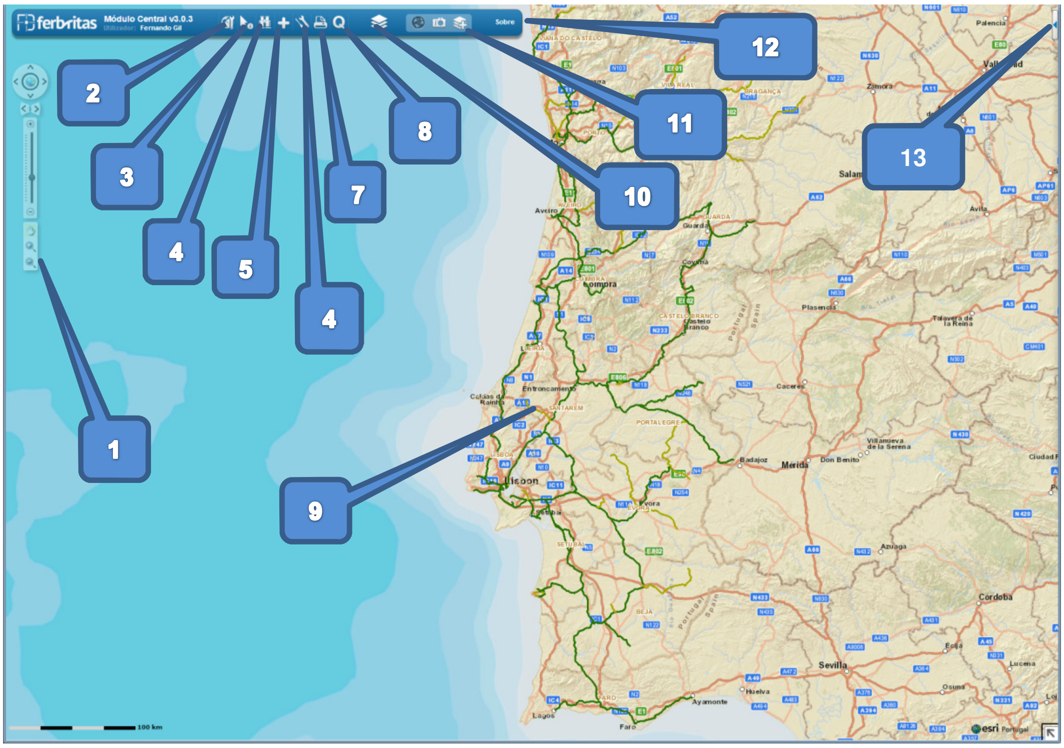


Figure 7.19 - Central Module interface main features

In the following points, I will present Central Module tools list, whose numbering relates to Figure 7.19:

1. Navigation bar
2. Map Tools
    a. Bookmarks;
    b. Measures;
    c. Geographic Edit (base elements, expropriations parcels and cadastral parcels);
    d. Layer move;
    e. Address search (Portuguese postal addresses format search, or European addresses free format search).
3. Map Objects Identify (point, line, polygon)
4. Search Tool
5. Create Tool (Railway line, Provision of services, Expropriations project, Cadastral parcel, Expropriation process, Entity, Map index)
6. Business objects tools
    a. Project cadastral parcels alpha/geo matching;
    b. Expropriation parcels alpha/geo matching;
    c. Map index alpha/geo matching;
    d. Parcels grouping;
    e. Authentication;
    f. Automatic numbering (stakes, expropriation vertices, cadastral and expropriation parcels)
    g. Repeated entities management;
    h. Map index configuration;
    i. Provision of services configuration;
    j. Field Module data submissions management;
    k. Project cadastral parcel move.
7. Print Tool
    a. As-built (final) Expropriations Project map;
    b. Expropriations Project single parcel map;
    c. Easy print;
    d. Geodatabase parcels export;
    e. Expropriations Project map;
    f. Cadastral Project map;

g. Expropriations Project parcels areas report;
h. Project cadastral parcels report;
i. Project cadastral parcels draft report;
j. Snapshot management.

8. Quality
   a. Global FBSIC database audit;
   b. Projects summary;
   c. Projects tasks.
9. Maps
10. Table of contents: project and context layers, and military base maps.
11. Imagery: world street map; world imagery; world topography; and world shaded relief.
12. About: Versions log; and User's manual
13. Map symbology

In the following points I will present FBSIC Central module search tool 16 theme listing, signalling alphanumeric themes with (a), geographic themes with (g), and alphanumeric and geographic themes with (a/g), and afterwards, in Figure 7.20 I present the search theme's navigation flows:

1. Railway Lines (g)
   a. Base Data
      - Edit
   b. Expropriations Projects (10)
   c. Railway Segment (2)
2. Railway Line Segments (g)
   a. Base Data
      - Edit
   b. Expropriations Projects (10)
   c. Project Cadastral Parcels (12)
   d. Expropriation Parcels (13)
3. Kilometer Posts (g)
4. Train Stations (g)
5. District (g)
6. Municipality (g)
7. Parish (g)

8. Tasks (a)
9. Provision of Services (a)
    a. Base Data
    b. Expropriation Parcels (13)
10. Expropriations Projects (a)
    a. Base Data
        - Validate
        - Edit
        - Delete
    b. Cadastral Parcels (11)
    c. Project Cadastral Parcels (12)
    d. Expropriation Parcels (13)
    e. Annotations
    f. Other Annotations
        - Project Cadastral Parcels (12)
        - Expropriation Parcels (13)
    g. Indicators
        - KPIs (table/graphic)
        - Objects Totals (graphic)
        - Activity Totals (graphic)
        - Validation Totals (graphic)
    h. Tasks
11. Cadastral Parcels (a)
    a. Base Data
        - Validate
        - Edit
        - Delete
    b. Addresses
    c. Land Property Registers
    d. Land Property Inscriptions
    e. Tax Registers
    f. Related Entities
        - Cadastral Parcel Related Entities (14)

g. Project Cadastral Parcels (12)
h. Expropriation Parcels (13)

12. Project Cadastral Parcels (a/g)
    a. Base Data
        - Validate
        - Edit
        - Delete
    b. Related Entities (14)
    c. Expropriation Parcels (13)
    d. Annotations

13. Expropriation Parcels (a/g)
    a. Base Data
        - Validate
        - Edit
        - Delete
    b. Provision of Services (9)
    c. Expropriation Processes (15)
    d. Cadastral Parcels (11)
    e. Tax Registers
    f. Related Entities
        - Cadastral Parcel Related Entities (14)
        - Expropriation Parcel Related Entities (14)
    g. Parcel Status Log
    h. Annotations

14. Entities (a)
    a. Base Data
        - Validate
        - Edit
        - Delete
    b. Addresses
    c. Entities Registers
    d. Related Entities
        - Entity related Entity (14)

- Relation related Entity (14)

e. Cadastral Parcels (11)

f. Project Cadastral Parcels (12)

g. Expropriation Parcels (13)

15. Expropriation Process (a)

a. Base Data

- Validate
- Edit
- Delete

b. Expropriation Parcels (13)

16. Map Index (a/g)

a. Base Data

- Validate
- Edit
- Delete

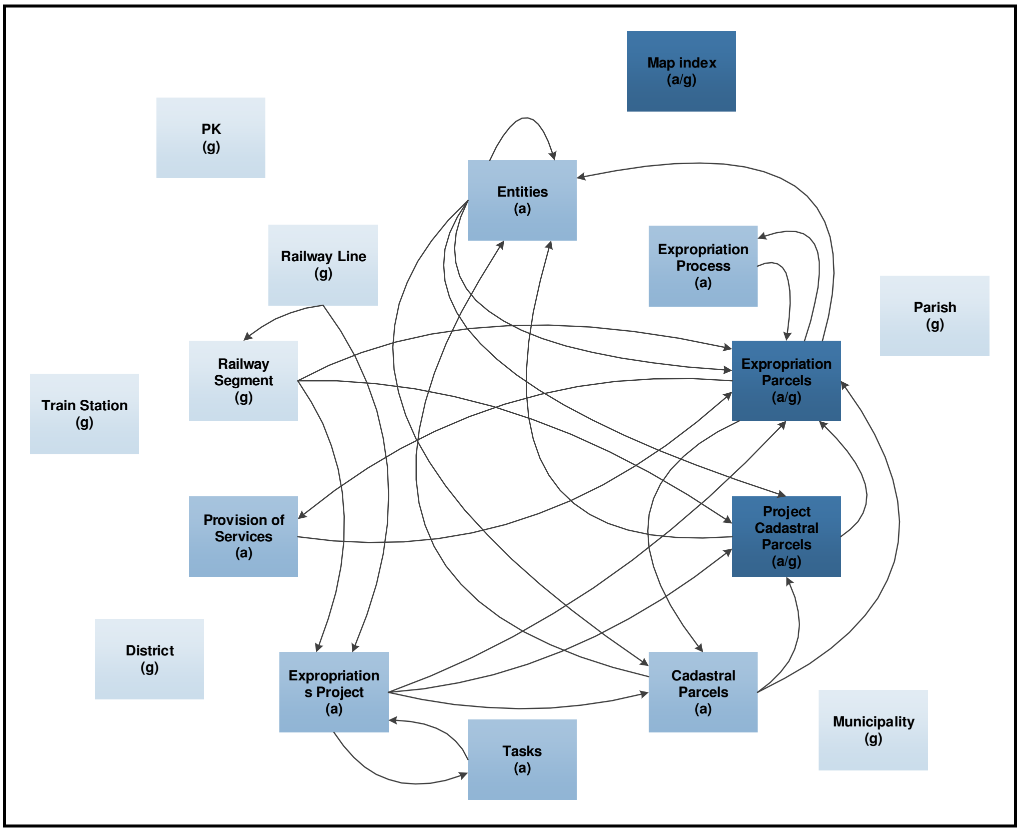


Figure 7.20 - FBSIC Search Tool theme navigation flows (a: alphanumeric; g: geographic; a/g: alphanumeric and geographic)

7.10 Solution Global Features

In Table 7.9, are presented FBSIC solution global features.

Features	Description
General Features	
	Easy-to-use user interface (maximum three mouse clicks for display the data/object needed in a fast map rendering environment)
	New intuitive concepts concerning search and results display
	Quick switch between different map displays with map views
	Document creation with one mouse click from a selected object
	Optimized search form for small, medium and large queries
	Support for static legend display
User Interface	
	Flexible windows interface: - windows free positioning - windows minimize / maximize - windows docking / fixing - windows undocking
	Centralized server side user interface for enabling specific client layouts
	Navigation control with Zoom In, Zoom Out, Pan, Zoom to Last Extent, Zoom to Next Extent, Zoom to Full Extent and Zoom Slider bar
	Rotation control for dynamically rotating the current map
	Toolbar ribbon like style makes user understanding faster and easier
Multi-language support	
	Availability of specific language information as a resource bundle file for easy translation
	OEM delivery of resource bundles (including user interfaces) in Portuguese and English
	Full translation support for all relevant metadata (layer names, field names, map service names etc.)
	Full translation support for Multilanguage projects
	Multilanguage support for lookup tables
Administration	
	Logging Settings: log level for each module
	System runtime information
	Current log file open and display
	Status page for live database connections
	Map services tab - detailed ArcGIS Server map service information (service type, projection etc.)
	Project access statistics tab: simple numerical access statistics and graphical diagrams
	Application access statistics dashboard: project start requests, prints, user login, search requests, data filtering based on user login
	Application access statistics interactive filtering on daily and on user basis graphical display (access statistics diagrams)

Features	Description
User access logging and statistics	
	User access logging (date and time, user, IP, project, request type, used resources, access duration) for user access statistics log and tracking (which user accessed which resource on a certain date / time)
	Statistics log stored on daily basis. Optional "HOUR" parameter for peak load analysis (system dimensioning)
Access control management	
	Support for User Management database role based rights control
	User group role based right and access control on applications, projects and tools
	User group profiles configuration
	Logged in user persistent display in any client side windows
Identity check	
	Support for Microsoft Active Directory authentication system
	Support for single sign on (SSO) in selected scenarios
	Support for anonymous log in without password
Systems integration	
Database	
	Search on tables/views (MS SQL Server 2008 R2)
	Support for display of related data (Join table to table or layer)
	Support for display of related data (Relate table to table or layer)
	Form grid display for query results with filtering, sorting, column width, and excel export (xml) record capabilities
	Multi-level object relations for navigating through a data model. Navigation view and detail view
	Support for lookup tables in tabular queries and results
Doc. Management System	
	Direct support for EMC Documentum
	Support for other systems DMS granted on demand.
ArcGIS Server Internet-Services	
	ArcGIS Server internet services administrator integration
	ArcGIS Server internet services user dynamic adding
ArcGIS Support	
	Support for ArcGIS Server 10 SP 2
Windows 2008 Server R2	
	Support for Windows 2008 Server R2

Table 7.9 - Solution Global Features listing and description

Annex 8 - FBSIC Central Module 2011 and 2012 versions log

FBSIC Central Module 2011 and 2012 versions log is presented in Table 8.1 covering two major software releases (versions 2.0 and 3.0) and sixteen minor versions, between September 1, 2011 and December 19, 2012.

Version	Date and Description
v3.0.3	**December 19, 2012**
	✓Several tooltips correction
	✓New column in train stations search
v3.0.2	**October 9, 2012**
	✓Search tool correction: using <>" operator with values list
	✓KPI's form data XLS export
	✓Spouse address copy and insert
	✓Geographic editing : points creation by coordinates insertion
	✓Several corrections
v3.0.0	**September 24, 2012**
	✓New icons and layout.
	✓Project cadastral parcels, expropriation parcels, DPF stakes and expropriation vertices automatic numbering
	✓Geographic editing of objects without alphanumeric component (DPF stakes, Vertices, etc.).
	✓Project cadastral parcels and expropriation parcels work environment geographic editing
	✓Project cadastral parcels and expropriation parcels layer change
	✓Cadastral and expropriations parcels map indexes printing multiple choice
	✓Entities search by telephone number
	✓Map index geographic zoom
v2.6.3	**July 3, 2012**
	✓Entity creation: civil persons gender insertion became obligatory
	✓Entity creation: civil person default selected
	✓Matching forms: object detail and "Zoom to" navigation tools implementation
	✓Esri base maps loading
	✓Several corrections
v2.6	**May 15, 2012**
	✓ Project tasks new form
	✓Tasks management / editing new project form tab
	✓Address builder form modification
	✓Auditing form: record absence indication, when the user tries to access to an object that no longer exists

Version	Date and Description
v2.5.5	**May 9, 2012**
	✓Project Summary form: project search with Auditing criteria added ✓Error correction: annotations date insert ✓Date colour correction in a 'disabled' type field. ✓New tool: Addresses geographic locator - Geolocator
v2.5	**April 16, 2012**
	✓Error correction: entity birth date insert ✓Geographic editing ✓External aplicational access through a specific URL ✓Error correction: FBDOC document access
v2.4.3	**March 9, 2012**
	✓Error correction: Parcel symbology in parcel map printing ✓Error correction: phone and electronic addresses insert ✓Cadastral parcel tax register "not defined" (omitted) type insert or update ✓Error correction: outputs generation when a project is loaded ✓Error correction: postal address visualization and update ✓Parcels area type search tool
v2.4.2	**February 24, 2012**
	✓Duplicated entities automatic search by initiating naming letters interval ✓Error correction: old data visualization in cadastral maps selection
v2.4.1	**February 20, 2012**
	✓Annotation text fill aiding with normalize predefined phrases ✓Project form correction: forms overlap error ✓Entity form correction: data refreshing error ✓In project, entity, cadastral parcels, project cadastral parcels, and expropriation parcels forms, when a form is refreshed it maintains the working tab opened
v2.4.0	**February 17, 2012**
	✓Annotation tool integrated in project, project cadastral parcels and expropriation parcels forms, allowing corrections/observations visualization/management/insertion in each referred object ✓Annotation log list and counters by project cadastral parcels and expropriation parcels within a given project ✓Projects, project cadastral parcels or expropriation parcels annotation attributes querying ✓New functionalities: project cadastral parcels moving between projects and expropriation parcels moving between cadastral parcels

Version	Date and Description
v2.3.3	**February 7, 2012**
	✓Resolution of a crash associated with navigation in projects with cadastral parcels or expropriation parcels defined with polyline segments (with the installation of ArcGIS Server 10 SP2) ✓Land Property registry save restriction and validation taken back when an acquisition document doesn't have description ✓Error issue corrected: message "SOAP Response cannot be decoded. Raw response: null" was associated to browser timeout default definition ✓After an entity search with no results the user is asked if a new entity (with the search criteria) should be created ✓Cadastral parcel form: "Record type" selection blocks data loading in other specific fields depending of the selected type ✓Project cadastral parcel validation added to avoid duplicated field numbers ✓Project cadastral parcel form: parcels association non visualization correction ✓Base data district, county and parish assumed in initial land property and tax register creation ✓Search form: closed at Central Module initial display ✓ Entity form: Place of birth text box cleaning made possible. ✓Object to entity consecutive associations without form closing ✓Land Property register insertion correction ✓Several improvements and corrections
v2.3.0	**January 30, 2012**
	✓Map Index new form ✓New objects creation tool: cadastral parcels, project cadastral parcels, entities, map indexes, expropriation parcels, railway lines and railway segments.
v2.2.1	**January 2, 2012**
	✓Services provision printing parameters new form ✓Relating Entities new tab in project cadastral parcel form ✓Entity relating Entity new functionality in cadastral parcel and project cadastral parcel forms ✓Project cadastral parcel detail shortcut button after Identify ✓Temporary cadastral parcels maps printing (cadastral parcel and project cadastral parcel prints)
v2.2.0	**December 22, 2011**
	✓Cadastral parcel new form and tabs: land property register, land property inscription, tax register, entities and addresses ✓Project cadastral parcel new form ✓Railway line new form ✓Railway segment new form ✓Entities new form ✓Map index printing parameters new form ✓Repeated entities management new form ✓Cadastral parcels maps and documents printing (cadastral parcel and project prints) ✓Temporary cadastral parcels maps printing

Version	Date and Description
v2.0.1	**September 19, 2011**
	✓Expropriation process unloaded if a loaded expropriation parcel was not in a services provision
	✓Project uploading, editing and creation tools available
	✓Project validation functionality created
	✓XLS lists export
	✓Add and remove expropriation parcels specific tokens created within services provision and expropriation processes forms
	✓Previous search criteria is saved in current searches
	✓Expropriation process validation available
	✓District, County and Parish searches available
	✓Cadastral parcels and expropriation parcels maps printing available
	✓Query based business objects search available
v2.0	**September 1, 2011**
	✓Flex Central Module first version release

Table 8.1 - FBSIC Central Module 2011 and 2012 versions log (Ferbritas, 2013a)

Annex 9 - FBSIC main results complements

9.1 Main Presentations List

Below is presented FBSIC main presentations list between 2010 and 2012, which the author authored or co-authored, and presented:

- Sistema de Informação Cadastral – Reunião de Encerramento do Projecto, Ferbritas, 2012/10, Lisbon – Portugal;
- Cadastre Information System - GWF 2012, 2012/04, Amsterdam – Netherlands, (Gil & Mata, 2012b)[2];
- FBSIC: uma solução sete módulos - Esri Portugal EUE 2012, 2012/03, Lisbon – Portugal, (Gil & Mata, 2012a)[2];
- Sistema de Informação Cadastral - Esri Portugal EUE 2012, 2012/03, Lisbon – Portugal, (Gil & Mata, 2012) (Ferbritas, 2012)[2];
- Sistema de Informação Cadastral – FLAD e-Planning Journeys, 2011/12, Lisbon – Portugal, (Gil & Mata, 2011d);
- Cadastre Information System - Esri MEA 2011, 2011/11, Beirut – Lebanon, (Gil & Mata, 2011c) (Ferbritas, 2011c)[2];
- Cadastre Information System - Esri EUC 2011, 2011/10, Land Track + Transports Track, Madrid – Spain, (Gil & Mata, 2011b)[2];
- Cadastre Information System - 1st Esri North American GIS Rail Summit, 2011/10, Omaha – NE, USA, (Gil & Mata, 2011a)[2];
- Cadastre Information System - Esri IUC 2011, 2011/07, San Diego – CA, USA, (Gil & Mata, 2011)[2];
- Sistema de Informação Cadastral - Esri Portugal EUE 2011/03, Lisbon – Portugal, (Gil, 2011)[2];
- Cadastre Information System (FBSIC) - Esri EMEA 2010/10, Rome – Italy, (Gil, 2010b) [2];
- Cadastre information system for the Portuguese railway infrastructure manager (REFER) – 1st European Rail GIS Summit, UIC 2010/06, Paris – France, (Gil & Mata, 2010);
- Sistema de Informação Cadastral – FCUL 2010/05, Lisbon – Portugal, (Gil, 2010a);
- Sistema de Informação Cadastral - Esri Portugal EUE 2010/03, Lisbon – Portugal, (Gil, 2010).

[2] Available at conference site and/or at http://www.slideshare.net/FernandoGil

9.2 FBSIC poster example

I present in this section one FBSIC poster example in Figure 9.1.

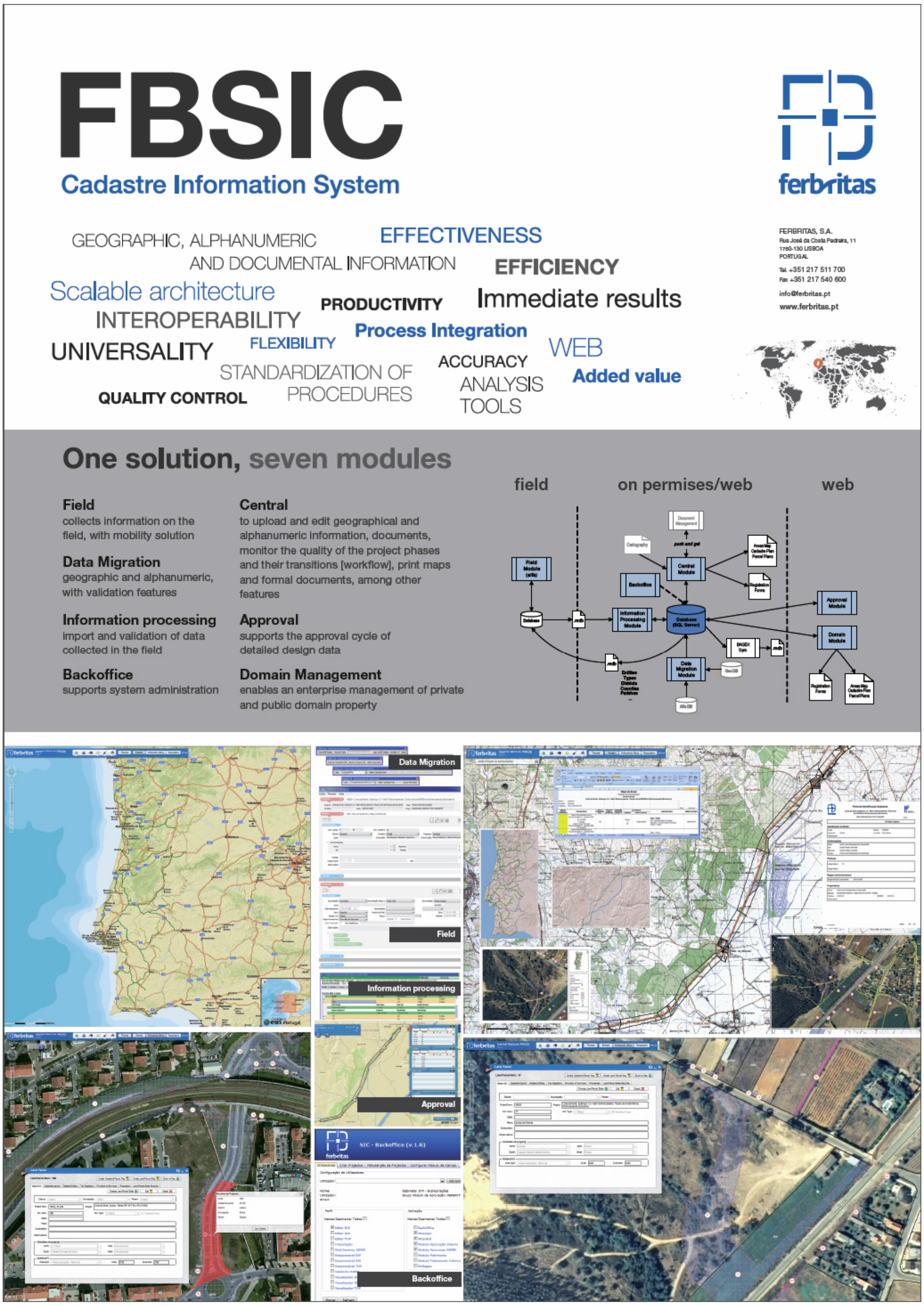


Figure 9.1 - FBSIC Poster (2012) (Ferbritas, 2012b)

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