TECHNOLOGICAL UPGRADING OF THE GEOGRAPHIC INFORMATION SYSTEM FOR THE ANDALUSIAN ROAD NETWORK (SPAIN)

Carmen Velilla Sánchez
Consejería de Obras Públicas y Transportes (Department of Public Works and Transport)
Charles Darwin S/N
41071 Sevilla
mariac.velilla@juntadeandalucia.es

Moisés Barea Solís
Consejería de Obras Públicas y Transportes (Department of Public Works and Transport)
Charles Darwin S/N
41071 Sevilla
moises.barea@juntadeandalucia.es

Javier Lamela Jiménez
ISOTROL
Avda. Diego Martínez Barrio 4, planta 8, módulo 2A
41013 Sevilla
javier.lamela@isotrol.com

ABSTRACT

INTRODUCTION
Although there is already an Information System for the Andalusian Road Network which plays an essential role in the management of the regional network of roads and adequately covers current demand, the Junta de Andalucía (The Andalusian Regional Government), and particularly the Department of Public Works and Transport, are making efforts to upgrade their information systems and adapt them to the latest technologies. This is therefore a process of technological evolution.

OBJECTIVES
The aim of the project is to develop a new *Information System for the Andalusian Road Network* which takes advantage of the latest technologies and standardisation trends in the field of geographical information systems. The idea is thus to switch from localised systems to a broader approach so as to offer more versatility and accuracy in our information.

METHODOLOGY

The functional analysis was based on exhaustive research of requirements and needs. In terms of the functional requirements, the current system was used as a reference point, identifying its limitations and the necessary areas for improvement. Non-functional requirements were also included, such as those which enable the upgrading of the system to incorporate the latest technological advances and improve accessibility.

After the document outlining the requirements was approved, a technical viability analysis was performed to validate the technological options being considered (moving from proprietary platforms to others based on free software, or a mixture of the two). A series of variables was also assessed to select the most suitable option by analysing the current situation from all points of view.

It was finally decided to opt for a technological solution based on an Oracle Spatial (SDO_GEOMETRY) repository which is compliant with OGC specifications and ensures inter-operability with other systems. The internal exploitation of the information was based on proprietary software, but structured in such a way to permit progressive migration to free software (which is one of the objectives of the project). The external exploitation of the information was based on WMS services.

Once the functional analysis was validated and the technological platform selected, the system design and construction phases could safely go ahead whilst maintaining an uninterrupted service to users.

RESULTS

The result of the project is a new Information System for the Andalusian Road Network which covers all the current functional objectives whilst complying with the requirement to incorporate the latest technological advances and disseminate the geographical information generated.

As a result, the geographical information is now contained in one single corporative repository which benefits from the synergies generated by other areas.

The data model was also re-engineered, eliminating previous defects, such as redundant information, and introducing new features like double calibration in a single SDO_GEOMETRY- based layer.

The internal operational system consists of a web-based map viewer which complies with all the functional requirements whilst ensuring both efficient dissemination and good accessibility. The system uses both self generated information and data provided by external OGC services.

The relevant WMS services were also integrated for both the dissemination of the geographical data produced and its integration into the appropriate Spatial Data Infrastructures.

CONCLUSIONS

The overall objective of the project was therefore to maximise the possibilities of both proprietary and free software. Furthermore, thanks to the OGC services we are able to successfully update, distribute, and post the information in its relevant location.

The project is part of a general effort to promote internal modernisation and communication. As a result we can now use the standard services available and provide information in the same manner, thus contributing to the linking up of services whilst enhancing the dissemination of public information.

PAPER

INTRODUCTION

The areas of competence of the General Directorate for Road Infrastructure include: conducting studies and implementing road and infrastructure schemes for the autonomous region which are based on the principles of sustainability, accessibility, and intermodality; developing rules and regulations concerning the projection, construction, conservation and exploitation of roads; developing the annual programme of investments, surveys, projects and road works, (although the final coordination of economic and financing activity is supervised personally by the deputy head of the department); constructing, preserving and exploiting the network of roads which are under the jurisdiction of the Regional Government; protecting and managing public roads, and preparing reports on specific sectors for plans, surveys and projects which affect public roads; preparing, reviewing and updating the catalogue of the Andalusian Road Network; preparing reports on road surveys, schemes and projects which affect the Autonomous Region; assessing and monitoring the activities which are the responsibility of GIASA, in accordance with the guidelines set out by the Head of the Department, independently of the coordination role which is the responsibility of the Deputy Head of the Department. Likewise, this Administrative Centre is also responsible for the areas of competence outlined in Decree 208/1995, of September 5, which establishes the areas of responsibility of the different Bodies of the Department in the field of roads.

It is clear that this administrative centre has always needed a Geographic Information System which supports its functions. As a result, an Information System for the Andalusian Road Network aimed at providing essential support in the management of

the region's roads was put in place in 2000. This system, which is located in the central services of the Department for Public Works and Transport, serves the eight provincial branches.

Following the publication of the 20007/2/EC European Directive which establishes an infrastructure for spatial information in the European Community (Inspire), we were required to publish our data on the Internet using standard map services. Inspire is the European initiative which regulates Spatial Data Infrastructures within the European Union. The directive was finally approved on the 21st of November 2006 and its definitive text was subsequently published in the Official Journal in April 2007. As a result, we proposed a different approach to our information system so as to make our data available not only to the experts working for public authorities but also to the public in general.

CONTENT OF THE POSITION PAPER

Objectives

The existing Information System for the Andalusian Road Network was aimed at providing support for the basic management of the region's entire network of roads, and was generally adequate in terms of its functional needs.

Nevertheless, the development technology had become obsolete because the system was originally developed in Visual Basic for Windows and the geographic functionality was supported by ESRI's family of MapObjects components. Furthermore, the geographic information was set out in layers in SHAPE format.

As a result of this situation the performance of the application was not as optimum as could be expected, especially for complex tasks, and the storage format and structure made the distribution of information a costly process. Furthermore, interoperability with other related systems was almost non-existent, access to the application was restricted to a reduced number of users, and the maintenance of the system was both costly and complex.

In fact the Junta de Andalucía, and particularly the Department of Public Works and Transport, had already begun the process of upgrading and adapting their information systems with the latest innovations.

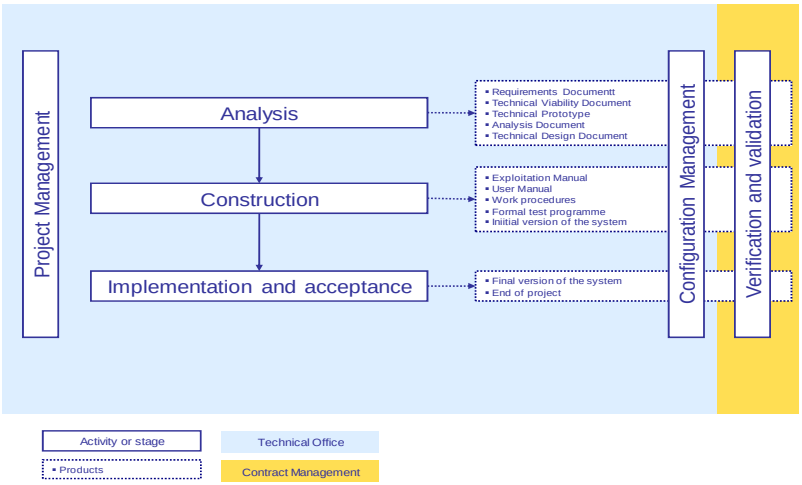
Given the situation as a whole, it was clear that the system needed to be upgraded to incorporate the latest technologies so as to meet both functional and non-functional needs.
Consequently, the objective of the project was defined as follows:

...to develop a new Information System for the of Andalusian Road Network which is compatible with the latest technologies and standardisation trends currently in use in the field of geographic information systems
The resulting design will satisfy the needs for the successful management, exploitation and dissemination of information concerning the Andalusian Road Network under the jurisdiction of the General Directorate for Roads of the Junta de Andalucía's Department of Public Works and Transport.

This target was further developed in the objectives outlined in the catalogue of requirements, which included the following:
Modern technology. The system will be developed in accordance with the latest technological and standardisation trends;
Information concerning Andalusian Roads. The system will contain and manage updated information about the Andalusian Road Network, and include data compiled by a range of different inventory procedures. Additional complementary information may be used but will not be managed;
Dissemination of information: The system will be designed in such a way that the information is made accessible to anyone to whom it might be of interest;
Improved functionality. The system must offer functional solutions for current requirements, whilst incorporating functional features which were not available in previous versions and eliminating inherited functions which have become obsolete.

Methodology

A classic process methodology was developed, making the three main procedures (Analysis, Construction and Implementation) compatible with the horizontal management processes (Project Management, Configuration Management and Verification).



One of the significant sub-processes undertaken was a Technical Viability Analysis which compared the current situation of the system and the stated requirements as a basis for studying the range of technological options which could be valid for the development of the new system. These technological possibilities were translated into various different system architectures.

Technical Viability Analysis

The first task of the analysis was to use documental references to demonstrate the technical viability of the architecture. Once the architecture was validated, compliance with the requirements outlined in the "requirements document" was ensured, particularly in terms of elements related to the "technological environment", such as: concurrence of updating accesses; versions of the information (long transactions); topology of the network; linear geometries with (calibrated) measurements; support based on SHAPE layers; scalability; interoperability; technological restrictions of the IT service.

The next step of the analysis consisted of assessing and justifying a series of variables which were deemed necessary or helpful in terms of defining the most suitable option. These included:

Difficulty in migration. An assessment of the degree of difficulty of transferring existing information to the new system from the old one.

In this respect, the following factors were taken into account:

1. The difficulties associated with the development of migration procedures.
2. The difficulties associated with the application of migration procedures.
3. Losses of information.

Use of free software: the Junta de Andalucía has been promoting the dissemination and use of free software. This was one of the main focus points of Decree 72/2003, of March 18, which established Measures for the Development of an Information Society in Andalusia. This variable assessed the degree of compliance of the analysed option in terms of the promotion of the application and use of free software.

The following factors were assessed:
1. Importance of free software in the architecture.
2. Future adaptability.

Cost of licences: this assessed the economic cost involved in the acquisition of the necessary user licenses required to implement the solution.

Maintenance cost: this evaluated the possible future difficulties involved in adapting to the new requirements, as well as the upgrading of the basic software to future versions.

Support: measuring the efficiency and suitability of software support mechanisms, expressed in terms of support equipment, technical forums, updated documentation, resolution of detected errors, etc.

Degree of compliance with the requirements of the technological environment or ease of attaining them: this is an assessment of a previous analysis of compliance with the technological requirements. The result of the technical viability analysis led to the choice of the most suitable technological option based on an overall assessment of each of the relevant variables.

Three possible technological options were considered:
The free software option: this option is solely based on the use of free software, i.e., software which can be used, copied, studied, modified and redistributed without restriction;
The Oracle option: in which the information support is Oracle based, although access to the information is via free software;
ESRI option: option in which the information support is still Oracle based but access is via ESRI products.
An overall assessment of the various different variables determined that Oracle was the most suitable technological solution, and as such it was the one selected.

Re-engineering of the data model
One of the problems of the previous system was the difficulty in maintenance of road information. One element contributing to this was the fact that different layers of information had been generated for different data needs. Thus, there was a layer for each of the different road networks depending on the responsible authority or body; a layer in which the different sections of the network were adapted to the inventory

information; a layer calibrated according to the distance from the point of origin; a layer calibrated according to kilometre signs, etc.

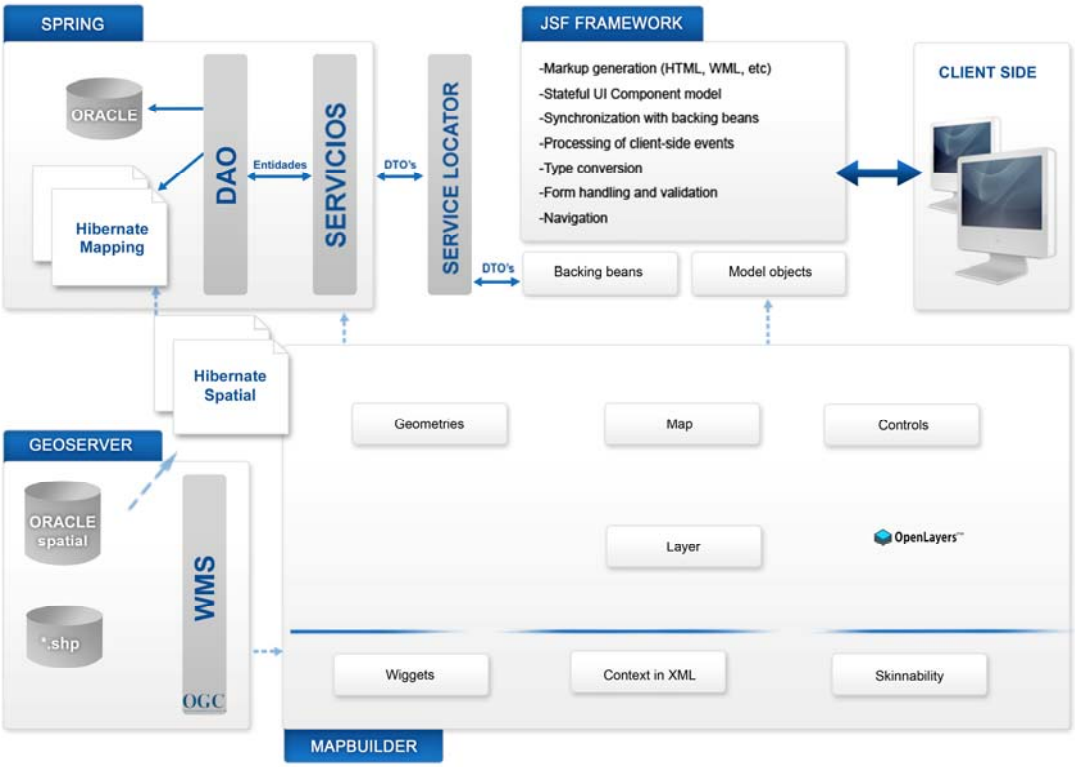
The inherent difficulties of using all these different layers generated problems which are typical in these cases: difficult maintenance: any small modification in layout made it necessary to repeat the updating process in multiple layers, each with their own characteristics; probability of errors: redundant information could end up being incoherent between the different layers.

This aspect was taken into account in the reengineering process so as to integrate all the information needs associated with roads into one single network, thus avoiding redundancy. This makes maintenance significantly easier and avoids potential management errors.

This network has the following characteristics: it encompasses all the target roads of the system, regardless of their competent authority or hierarchical importance; it is divided into different sections, i.e. different sections are defined with unique global identifiers which will be of interest for all the different users of the road network; it is a network calibrated according to distance to point of origin, taking maximum advantage of field inventory information; it is topologically-connected, thus ensuring the geometric quality of the system. The implementation of different visual criteria for the road network was based on Oracle views. Thus, different views were implemented for each of the networks according to their competent authority; views incorporating the layouts of the different roads without cutting them into sections, etc.

Technical design of the system

The main data storage of the system uses the corporative geo-database of the Department of Public Works and Transport of the Junta de Andalucía. This repository is an Oracle SGBD 9i version 9.2.0.6, and includes the Oracle Spatial complement. The management of the geographic information is performed using Oracle's native capacities, as well as Oracle native data types (SDO_GEOMETRY). The persistence of objects is implemented via Hibernate and Hibernate Spatial. Maps are served as WMS by means of Geoserver. The map client is based on Mapbuilder (Openlayers). Java Server Faces was used as development pattern.



Interoperability and integration with other systems

The selection of the Oracle Spatial platform as support, together with SDO_GEOMETRY data, ensures interoperability, due to their compatibility with OGC specifications. External dissemination of information is possible thanks to the definition of Web Map Services (OGC WMS) which are integrated into local Spatial Data Infrastructures. In general we are referring to sensitive information, and therefore access is restricted.

Due to increasing availability and dissemination needs, metadata for each of the managed data sets was defined. The field structure established for metadata from IDEAndalucía was followed. This is basically an adaptation of the Núcleo Español de Metadatos (NEM) for the IDEE (Spanish Spatial Infrastructure Data) with a series of additional characteristics which are specific to Andalusia. The following standards were applied:

- ISO 19115 Standard: Geographic Information Metadata
- ISO 19115-2 Standard: Metadata for Imagery and gridded data
- ISO 19139 Standard: Geographic Information Metadata – Schema implementation
- National profile, Núcleo Español de Metadatos

- Decree 141/2006: Annex (BOJA 154, 9th of August 2006)
- Plan Cartográfico de Andalucía 2009 – 2012 (Andalusian Mapping Programme 2009-2012)

Functional interoperability in Service Oriented Architecture mode (SOA) was initially proposed so that both the information and functionality can be provided as loosely coupled interoperable services but its implementation was subsequently ruled out.

CONCLUSIONS

The project presented here successfully implemented the technological upgrading of a SIG which was already in operation. The new system is more accessible, flexible, scalable and maintainable.
Furthermore, more information can now be disseminated and integrated with other related geographic sources, thus maximising the benefits of synergies and improving its overall operational possibilities.

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Decree 141/2006, of July 18, which regulates the mapping activities within the region of Andalusia.