HAL open science

Managing the national road network maintenance in Spain

Victor Gomez Frias, Teresa Sánchez Chaparro

To cite this version:

Victor Gomez Frias, Teresa Sánchez Chaparro. Managing the national road network maintenance in Spain. European Transport Conference 2008. Seminar "Roads Policy, Delivery & Operation", Oct 2008, Amsterdam, Netherlands. hal-00405473

HAL Id: hal-00405473

https://hal.science/hal-00405473v1

Submitted on 21 Jul 2009

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

MANAGING THE NATIONAL ROAD NETWORK MAINTENANCE IN SPAIN

Víctor Gómez Frías
GETINSA (Spain), vgomez@getinsa.es
Teresa Sánchez Chaparro
ANECA (Spain), tsanchez@aneca.es

ABSTRACT

The Spanish Ministry of Public Works manages the National Road Network, which consists in 27,000 km. In 1992, the average age of pavements was 7.2 years, whereas at present it has increased to 9 years. The great heterogeneity of pavements, the constant increase in the network length and its gradual aging demand important budgets but also agile technical, economic and administrative management models.

The Subdirectorate of Maintenance and Operation is responsible of management systems for this network, now helped by the engineering consultancy GETINSA. This communication shows the actual state of the pavement management that consists in an Integrated Database System comprising many parameters both about technical values and administrative follow-up of actions. It is connected to various pavement evolution models that allow managers to predict the future state of the roads, then to establish a maintenance policy. Finally, the Management System calculates a maintenance plan, detailing actions to be done in each section in a multi-year scenario, so that the investment and the road quality are optimised.

The Management System software combines analytical formula with geographical information, used for representing results as well as part of the forecast and optimisation models, using the modern technology of “dynamic segments”. Attention has been paid to conciliate the operational organisation of maintenance works with the fact that optimal needs are detailed for each road section in too short distances to be executed separately.

The communication starts analysing other existing Pavement Management Systems, then describes the Spanish situation and justifies which Pavement Management System is needed. The body of the text covers the description of the functionalities and design assumptions of the new System. Finally, the conclusions present some future evolutions for the Spanish Management Systems and the possibility to generalise its use to other road networks, either for pavement or other assets.

1. INTRODUCTION

A Pavement Management System is a support system to the decision making, in the field of highways maintenance, to systematize the collection, storage and later

© Association for European Transport and contributors 2008

analysis of the information relative to pavements. For Lopez et al. (2004) the Pavement Management Systems (PMS) must be designed to provide a structured and comprehensible approach to the management of pavements. Its function consists in attending the agents in charge of the decision process to find strategies that help to maintain the pavements in suitable conditions during a certain period of time of the most efficient way from an economic point of view.

In order to understand the importance and difficulty that presents in Spain the development of a system with these characteristics, it is necessary to take care of several questions. On the one hand, the construction of a wide net of transportation infrastructures carried out in the last years. Generally, these policies are based in Territorial Plans that they try to assure the connections between cities by a system of highways that guarantees the suitable conditions of speed, economy of transport and security. Nevertheless, recent studies as those of Martinez Lainez and Pérez Jiménez (2006) emphasize how the paradigm of the construction of new road infrastructures is opening the way, in most developed countries, to the paradigm of the maintenance of these infrastructures.

On the other hand, the support to the geographic or space decision is, in Spain, an area of research still relatively new but that, due to the fast development of the Information Technologies, has grown fast in the last years. This expansion, as they point Sanchez and Torrecillas (2002), has not only as main users the public administrations, but also the infrastructures companies or the commercial distributors. In any case, this technological height is suffering a bottle neck, due to the insufficient availability of data. The Infrastructures of Spatial, according to these authors, could play a decisive role to unblock this situation.

In this article, among the varied functions that are derived from the Planning of a Territory, we emphasize those that have to do with the design and elaboration of information instruments to support the strategic road infrastructure planning. In particular, the case in which the objective of the planning is to support the strategic programming and the management of the pavements in highways.

2. STATE-OF-THE-ART

In the national and international bibliography, the problem of the management of pavements has been studied, in the last years, from quite diverse optical. Some look to the engineering of the problem; others put their focus in the state of present development of the PMS in the different administrations of highways and some are centered in the technological aspects for the development of the system.

Among the first, it is possible to emphasize the text of Ruotoistenmäki (in Martinez Lainez and Perez Jiménez, 2006) that, from an operative point of view, it suggests three levels, differentiated clearly, in the Pavements Management. That is to say: a first level or Level of Network; a second level or Level of Project, and a third level or

© Association for European Transport and contributors 2008

Level of Works or Maintenance Works in the Network. These three levels, although strongly related, represent instances of decision clearly differentiated: from most global or strategic, represented by the Level of Network, to local, represented by the Level of Maintenance Works.

These levels also are gathered in Bartholomew (1999), who denominates Management Level to the Level of Network and Level of Analysis or Study to the Level of Maintenance Works, and considers that a same system of taking of data cannot satisfy all the levels since they present/display sensibly different ranks of decision.

Originally (Races Lopez et al., 2004), the management of pavements in the network level followed a model denominated “from the bottom to the top” in which the best possible design of the pavements for each project was determined, and later all the projects of every year were gathered. This model required very important budgets. From the 70’s, as a result of the budget limitations, this model evolved to another denominated “from the top to the bottom”, in which they considered the set of solutions that provided better results at network level, being possible that they were not the optimal ones in the level of individual section. This model is the one that prevails in our days.

Among the bibliography that studies the present development of PMS, it is possible to emphasize the work of Sanmartin (2003), that makes a comparative test of the application of the Management Pavement Systems in Europe, in particular, the German and Spanish administration, emphasizing the detected deficiencies. Hereu Ferrer (2006) exposes the precise experience of the Generalitat de Catalunya and emphasizes the difficulties that the introduction of new methodologies of work imply, along with the intervention of the managers in charge of the decision making.

Among those who approach the subject of the Pavement Management from a more technological perspective are remarkable, in the international panorama, authors like the following ones: Neelam et al. (2003); Peled et al. (1996); Espinosa (2001) and Tornes et al. (2004). They focus almost all attention on the technological component and, particularly, in component of Geographical Information Systems (GIS), of the PMS. This is not surprising considering that the GIS are relatively new technologies, in any case later to the development of PMS (the Pavement Management in the network level began in the middle of the 60’s, and are in constant evolution.

Also Bham et al. (2001) describe the development of a Pavement Management System for the State of Illinois, based on a commercial GIS. This author documents, briefly, the models used and illustrates some of the interfaces developed in the PMS. In the same line, N. Hans et al. (1997) describe the development of a PMS based on a GIS for the State of Iowa (U.S.A.). In Spain, many PMS structure now their technological component around the GIS (Elvira and Herrera, 2006; Alder grove et al., 1999; Crossbowmen, 1999; Bartholomew, 1999).

© **Association for European Transport and contributors 2008**

As a conclusion, considering all the references, the objectives of a PMS, in the network level, are the following ones: to compile information on the state of the road network; to facilitate the evaluation of pavements maintenance; to asses the approximate cost of the maintenance works for necessary maintenance; and to help to optimize the use of the available budgets, using maintenance strategies. Therefore, the incorporation of the Information Technologies and, in particular, of GIS, will contribute to attain these objectives.

3. CONCEPTUAL FRAME FOR THE DEVELOPMENT OF A PMS

3.1. Components of a Pavement Management System

From a conceptual point of view, the components of a Pavement Management System are the following ones: the inventories of data; the models of follow-up and analysis; and the models of optimization and planning. In general, the different inventories have as objective a catalogue, description and quantification of the different variables that constitute the supply, as has been done in Spain in a systematic way since 1960 (Gallant, 1999).

The models of evolution and prediction of the behavior of the pavements are useful (Carreras Lopez et al., 2003), in the level of network, for the election of the optimal strategies of maintenance; in the project level, they are used to design pavements, to make analysis of cost of the service life of the pavements, to select the optimal design with minimum cost and to determine the best moment and state of the pavements with the purpose of carrying out the maintenance work. Finally, the planning models are used to evaluate different strategies from maintenance of the set of the network, before identifying projects or precise maintenance works.

3.2 Geometric inventory

If we considered like geometric inventory the geometry base of the road network to be maintained, in Spain we are dealing with a length of more of 40,000 km, including the National Road Network (Red de Carreteras del Estado, RCE) and the First Class Regional Network (Comunidades Autónomas). If we extended the view, according to Gallant (1999) in 1998, there were 535,000 km in the interurban network, of which 23,842 km belonged to the RCE and the rest to the Comunidades Autónomas, and local areas. In addition, they had inventoried 130,000 km of highways that constituted the urban roadway. According to this author, it is possible to assume that in the interurban network a progressive degree of lack of information exists, and is more important when we go from to the RCE down to the network of the City Councils.

This indicates that a major contribution of a PMS is the knowledge, as most detailed as possible, of that network. This step is doubtlessly a help for two factors: the

© Association for European Transport and contributors 2008

existence of data or information that describe that network and the existence of technologies that allow exploring those data. Both factors find at present a solution in the scope of the Information Technologies.

3.3 Inventory of indicators, parameters and maintenance works

This section describes (Table 1), on the one hand, the resulting data of the auscultation of the road network; then those referred to sections of the network in which rehabilitation projects have been carried out. Finally, the information processed, according to diverse models, from the data previously mentioned. All this information, of eminently alphanumeric character, has a space component that is specified by means of its location in the Network.

Denomination	Type	Description
IRI	Indicator	Index of Structural Regularity. Related to the security and the comfort.
CRT	Indicator	Coefficient of Cross-sectional Friction. It is an indicator of the state of the adhesion between the tire and the pavements, that is to say, of the security.
Deflections	Indicator	Measure the elastic deformation of a pavements to the passage of a load. Related to the structural state of the pavements.
ADT	Parameter	Average Daily Traffic. Represents the loads due to the traffic
Type of Pavement	Characteristic	Defines the characteristics of the material that composes the pavements.
Texture	Characteristic	Determines the drainage capacity and the noise. It is related with the security and the comfort.
Maintenance works		Projects of rehabilitation or improvement of the pavements. They inform into the modifications made on the original characteristics of the pavements.

Table 1. Indicators, parameters, characteristics and maintenance works.

A step that must be considered at the time of developing a PMS is, indeed, the one that leads to the knowledge, as most detailed as possible, of the behavior of these indicators, characteristics, parameters and maintenance works on the Network study object. It is shown, therefore, the narrow limit that exists between these data and the geometric inventory. Therefore, the quality of this knowledge helps to a great extent conditional the quality of the geometric inventory. An aspect that is also due to consider is that the relation between this inventory and the geometric one is dynamic. That is to say, there are not only relations of space nature but also of time.

© Association for European Transport and contributors 2008

3.4 Models of evolution

Once the state the network is known, it is necessary to anticipate how it is going away to tolerate aging. Suitable models are developed for the behavior of the road network. These models are based on the existing relation between the modeled indicators and other parameters measured on the network. The execution of these models allows to know the behavior the pavements in certain climatic circumstances and traffic; the forecast of degradation in pavement and its evolution; the conception of maintenance strategies. In the network level, these models are used for: the election of the optimal strategies of maintenance; the optimization of budgets in short and long term; preparing the inspection calendar that allows evaluating the pavements deterioration.

3.5 Optimization models and consequences analysis

Basically, these models try to distribute the cost of existing budgets, in a program of maintenance works for a certain period of planning. They try to establish where, when and how it must be acted in the network to optimize a precise criterion of maintenance satisfying certain limitations. For their development, the minimum functional conditions consider, the minimum structural conditions and the costs and benefits.

4. METHODOLOGY

We present a practical case of PMS, developed by the consulting company GETINSA for the Spanish Ministry of Public Works. We show the structure of the GIS in relation to the rest of components of the PMS and the benefits obtained in the management process itself. The basic architecture of the system consists of a data set, measured in different periods, on road network. The data measured in the auscultations is stored in a relational database and the data of the geometric inventory in a GIS. The operation, the analysis and the management of the information, as well as the generation of scenes and the put into operation of the models of evolution and optimization are made by means of a set of ad hoc developments that take advantage of the functionalities of the GIS and the relational database. The system has a modular conception in the sense that, using like structural axis the dynamic segmentation, the geometric inventory and the rest of the inventories and exits of the models like two parts differentiated clearly have been considered.

The objective of this conception is to equip with flexibility the system with the aim of making possible the compatibility with new geometric inventories or modifications at the moment in use. Thus, we also diminished the potential impact that could be produced as a result of changes in the technologies of collection of data. In effect, at present, the Ministry of Public Works carries out an Inventory of geometric characteristics and equipment of the RCE (Ministerio de Obras Públicas, 2005).

Figure 1. Pavement Management System developed by GETINSA for the Spanish Ministry of Public Works.

Figure 1 shows the Presentation of the Pavement Management System developed by GETINSA for the Spanish Ministry of Public Works. At present, the basic network in the system is elaborated by the Ministry of Public Works on 1:1.000 scale and inventories of indices and parameters are the corresponding ones to the auscultations made between years 1995 and 2005. Between the basic functionalities of the developed prototype one is: Within the Module of management of alphanumeric information: The Consultation of Indicators and Parameters and Administrative Management of the maintenance works Within the Module of management of space information: The visualization and consultation of the inventories on the road network. Inside the Module of management of models: the space and temporary analysis of the existing data with the objective to develop to models of evolution or prediction of the behavior of the pavements, using the different Indices and inventoried parameters; The support to prioritize and to plan the maintenance maintenance works that must be adopted; Thematic maps, obtained like exits of the GIS, that represents the made maintenance works of maintenance on the road network. The generation of scenes of future based on the taken measures to palliate the deficiencies identified in the highways.

5. CONCLUSIONS

Geographic Information Systems facilitate the preparation, the analysis and the management of the inventories of pavements. They are formed like a geographic support that facilitates and improves the knowledge of the network to be managed and its decision making. GIS technology represents an improvement, in all the aspects, of the process of Pavements Management, since this technology seems to be the logical form to relate the diversity of data that are handled in the Pavement Management System. In addition, it equips the Pavement Management System with capacities of visualization, analysis and update of the data more efficient than those conferred ones by other technologes.

In the case of the Pavement Management System, developed by GETINSA for the Ministry of Public Works, the incorporation of a GIS to the system has facilitated to a great extent, even in the initial phases of the development, the knowledge of the present state of the road network, the development of proposals and selection of solutions in the level of network and the generation of predictive models of the behavior of the pavements.

BIBLIOGRAPHY

Aliseda Pérez de Madrid, Pedro; Crespo del Río, Ramón; Yarza Álvarez, Pedro; (1999). Sistemas de Información Geográfica aplicados a carreteras, en ATC (Ed.). *Jornadas sobre auscultación y toma de datos para planificación y gestión de carreteras,* diciembre 1999 .Cáceres, pp 657-672.

Bartolomé Marín, Carlos (1999). Recopilación de la información. Bases de datos de carreteras, en ATC (Ed.). *Jornadas sobre auscultación y toma de datos para planificación y gestión de carreteras*, diciembre 1999 .Cáceres, pp 639-649.

Carreras López, Juan; de Oña López, Juan; Martínez Montes, Germán (2004). Revisión del estado del arte en los sistemas de gestión de firmes, en ATC (Ed.): *IX Jornadas de Conservación de Carreteras,* junio de 2004. Salamanca.

Elvira Huse, Francisco Javier; Herrera Valencia, Juan Ignacio (2006). Elementos multicriterio SIG de Carreteras, en Departament de Política territorial i Obres Públiques, Generalitat de Catalunya - Asociación Española de la Carretera (Ed.): *Jornadas sobre Optimización en la Planificación y Gestión de Carreteras.* Barcelona, pp 317 –329.

Bartolomé Marín, Carlos (1999). Recopilación de la información. Bases de datos de carreteras, en ATC (Ed.). *Jornadas sobre auscultación y toma de datos para planificación y gestión de carreteras*, diciembre 1999. Cáceres, pp 639 – 649.

ESRI (2003). Linear Referencing in ArcGIS: Practical Considerations for the Development of an Enterprisewide GIS. **ESRI Technical Paper, april 2003**. Redlands, Ca., 18 pp.

Galán Bueno, Pedro Manuel (1999). Los inventarios. El inventario de características geométricas y de equipamiento del Ministerio de Fomento, en ATC (Ed.). *Jornadas sobre auscultación y toma de datos para planificación y gestión de carreteras*, diciembre 1999 .Cáceres, pp 45 – 56.

Gould, Michael D. (1993). Uso de los SIG contra los desastres petrolíferos, en AESIG (Ed.): *2º Congreso Los Sistemas de Información Geográfica en el umbral del siglo XXI,* junio 1999. Madrid, pp 257-265.

Hereu Ferrer, Antonio (2006). La gestión de la conservación en Cataluña. Implementación y desarrollo de sistemas de gestión, en Departament de Política territorial i Obres Públiques, Generalitat de Catalunya - Asociación Española de la Carretera (Ed.): J*ornadas sobre Optimización en la Planificación y Gestión de Carreteras* .Barcelona, pp 171-188.

H. Bham, Ghulam; G. Gharaibeh, Nasir; I. Darter, Michael (2001). Development of GIS-Based Illinois Highway Pavement Management System, en Esri (Ed.): *ESRI User Conference*, July 9-13th, 200., San Diego, California.

Neelam, Jain; Nanda, P.K.; Durai, B.K.; Prasada, Rao (2003). Geographical Information System for Pavement Management System, en development.net (Ed.). *Map Asia Conference 2003*, Transportation. Kuala Lumpur, Malaysia.

N. Hans, Zachary; G. Smadi, Omar; H. Maze, Tom; R. Souleyrette, Reginald; L. Resler, Jon (1997). I*owa´s Pavement Management Program Database: Issues and Design Considerations*. En Iowa State University (Ed.): Eight AASHTO/TRB Mainenance

Management Conference. Saratoga Springs, N.Y., July 1997. Sánchez Díaz, F. y Torrecillas Lozano, C. (2002): Estrategia para una infraestructura de Datos Espaciales en Andalucía. *II Jornadas sobre Sistemas de Información Geográfica.* El Escorial. Madrid: Universidad Politécnica de Madrid. 18 y 19 de Noviembre 2002.

Sanmartin Calzada, Miguel (2003). *Comparación entre los sistemas de mantenimiento de carreteras en España y Alemanía.* Universidad Politécnica de Valencia – Technische Universität Berlin. Trabajo Fin de Carrera.

Skowronek, M. (2003). Dyn Seg for Pavement Management. Metropolitan *Transportation Commission GIS Users Group Meeting,* Oakland, CA , February, 27, 2003.