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A PROPOSED METHODOLOGY FOR THE MANAGEMENT OF LOW-VOLUME ROADS IN SPAIN

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Abstract. Low-volume roads play an essential role in the development of rural areas in Spain, yet most are in a poor condition since hardly any money is designated for their upkeep. This work proposes a management system for the Spanish low-volume road system based on an analysis of the present management of the country's road and low-volume road networks, the methodologies used in the inspection and evaluation of the latter's condition (designed by the authors), and on data from other countries. The proposed plan involves the stages of implantation, execution and monitoring, each one with its own objectives. The possible sources of funding for such a management system – vital if its future is to be ensured – are also discussed.

Keywords: low-volume roads, planning, condition, management, finance, methodology.

1. Introduction

Low-volume roads play an essential role in developed countries. Their main function is to facilitate access to farms and fields (Jaarsma, van Dijk 2002). However, they also perform a social function by allowing the activities that permit local people to enjoy a standard of development – and thus standard of living – similar to that enjoyed by the rest of a country. According to *Europe's Agenda 2000. Strengthening and Widening the European Union*, they therefore help in the achievement of one of the EU's priority goals: rural development. Low-volume roads are also commonly used as communication routes between populations, they allow the access of emergency services (Gallego *et al.* 2004), and are of great importance from an environmental point since they make up an ecosystem in their own right (Lugo, Gucinski 2000). They also allow knowledge of the environment to be gained and provide access to leisure areas – ever more in demand by city dwellers. These reasons highlight how the adequate maintenance of the low-volume road system would improve the quality of life of the society. Certainly, the repair of these roads would improve the safety of those who travel upon them, as well as reduce the cost of vehicle operation.

In Spain, much of the low-volume road system was constructed between 1960 and 1980 (Gallego *et al.* 2006), and its fate has been the same as that of similar systems in other countries: subjection to traffic intensities and loads much greater than those for which they were designed (Hough *et al.* 1996a; Jaarsma 1997; Pauwels, Gulinck 2000; Prater 1998). This has had negative environmental consequences (Jaarsma 1997; Gulinck, Wagendorp 2002; Jaarsma, Willems 2002). The increased traffic density is owed in part to the economic activities of the rural areas served by these roads, but also to the fact that they are often used as alternative transport routes (Hough *et al.* 1997). These negative factors, plus a general lack of upkeep, have led to their rapid deterioration (Ayuga, Dal-Ré 2004).

Following recommendations of the *Organization for Economic Co-operation and Development (OECD)* in the document entitled *Road Maintenance and Rehabilitation: Funding and Allocation Strategies* of 1994, proper maintenance of the low-volume road system would facilitate its management, maximise the quality of service it provides,

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and contribute to the improvement of the environment. In earlier work (Gallego *et al*. 2008a, 2008b), the authors proposed methods of inspection and evaluation of low-volume roads in Spain with the aim of estimating their needs and delaying their deterioration. However, a good management plan should also take into account the cost of its own implementation (Talvitie 2000), an essential aspect of any maintenance program. The literature reveals the scarcity of low-volume road maintenance plans defining the funding mechanisms that might be used; the major exceptions are those mentioned for the countries of Latin America and the Caribbean (Zietlow 2001), and for The Netherlands (Jaarsma, van Dijk 2002).

The present work proposes a management plan for the low-volume roads of Spain and defines the objectives of the implantation, execution and monitoring stages of which it is composed. In addition, it proposes a methodology specifically adapted to low-volume roads in order to classify them. Finally, this paper discusses the possible sources of financing the management plans focusing on the Spanish framework.

2. Background

2.1. Road management systems

Despite their differences, rural and general road systems may share certain characteristics, such as the management mechanisms involved in their maintenance. This is possible since both types of roads are linear elements that form networks, and both have common components such as side ditches and pavements. Therefore, the maintenance and repair work they undergo may also be similar.

Road management plans have now been put into action in all developed and some developing countries. However, it was not until 1962, with the publication of *The AASHO Road Test: Report No. 7* by the Highway Research Board of the NAS-NCR Division of Engineering and Industrial Research, that maintenance became a recognised stage in prolonging the useful life of roads. The administrative division of Spain into *Comunidades Autónomas* (Autonomous Communities), of which there are 17 in all, and the progressive transfer of power to these from central government (including the ownership and management of many roads) has led to marked setbacks in the implantation of road maintenance plans in recent years. This tendency has been made worse by the fact that many *Comunidades Autónomas* are further divided into smaller units (Provinces) which on occasion take on the responsibility of road maintenance. The condition of the local road network can therefore vary greatly from one area to another (Sastre 2001), a situation that the state road network does not suffer. The latter is kept in good repair and is the regular recipient of maintenance contracts.

The different authorities in Spain generally choose mixed road management systems – basically they reserve for themselves the tasks of management and monitoring, and contract out the actual work of road maintenance and repair to specialised firms. However, these authorities may, on occasion, take on the full responsibility of road upkeep; only in rare instances do they contract out all management and maintenance tasks.

At the national level, the *Ministry of Public Works and Transport* has attempted to create 150 operating and maintenance sectors, each acting as a fundamental management cell headed by a qualified technician, as exposed at the *5th Workshop for Road Maintenance. Preservation Contracts* held in Madrid (Spain) and organized by the World Road Association (PIARC) in 1995. Maintenance contracts in each sector are adjudicated via public tender, and the firm awarded a contract is bound to meet a series of requirements. The State, for its part, is obliged to make a series of annual payments for work undertaken. The pertinent authorities then monitor the road condition to guarantee that the work contracted meets the objectives set out in the contract.

Fig. 1 shows the general format of road maintenance plans. The 1st stage involves determining the methodology to be used and the definition of the object to be maintained. This requires the production of a roadwork inventory, the drawing-up of a corresponding maintenance plan, and the production of manuals required for its application. In this 1st stage the authorities may condition the actual writing up of the maintenance plan since they are responsible for establishing the goals to be achieved. The preparation of the plan therefore commonly means it is subordinate to the needs of the authorities.

The network inventory can be completed using the means at the disposal of the authorities (although this is not usually the case), or by contracting private firms. Finally, the authorities fix the guidelines to be followed in the drawing-up of the manuals required, although the contract-winning firms are usually asked to write the finished product. These manuals should clearly explain how the road is to be inspected, how data are to be collected and processed, how the different maintenance work should be performed, and how monitoring should be undertaken.

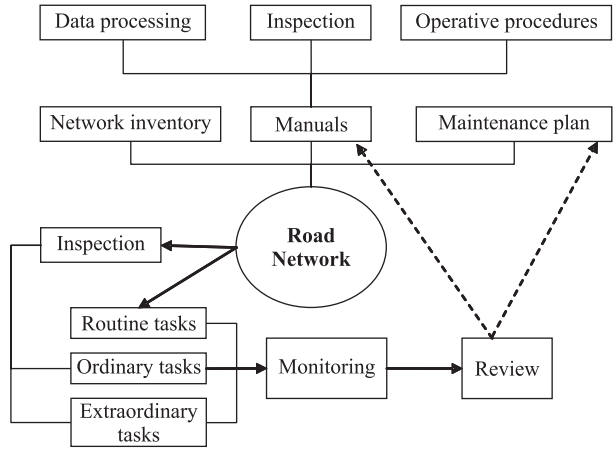

Fig. 1. General organisation of the road maintenance plan

Finally, the execution phase involves carrying out the actual maintenance tasks, which fall into three groups: routine, ordinary and extraordinary tasks. The differences among them are based on the frequency they must be performed with and the nature of the tasks themselves.

The importance of periodic inspections aimed at guaranteeing adequate road maintenance cannot be understated. Given that the economic resources destined for road maintenance are limited, the early detection of problems may lead to important savings.

Owing to the complexity of the organization of road maintenance plans – an outcome of both the large number of agents usually involved and the number of tasks to be completed – good understanding between all those involved is vital (Hough *et al.* 1996b; Zietlow 2001).

The great diversity of roads means that no single management system is the most efficient. Systems should be adapted to the funds available (Lepert *et al*. 2001), the characteristics of the road in question, and the objectives set.

2.2. Low-volume road management mechanisms

2.2.1. The international perspective

Low-volume road networks present some common characteristics that may explain the difficulty in finding the funding necessary to maintain them, and therefore, the lack of asset management systems (Schliessler, Bull 1994) or maintenance operations undertaken, as explained at the *International Road Maintenace Handbook. Practical Guidelines for Rural Road Maintenance*, reported by AIPCR (1994). They usually represent a great percentage of the overall road network in a country, but they are usually placed in rural areas, forming dense but isolated networks. In addition, they are usually designed to support low vehicle flows and to minimise the construction costs by using inexpensive techniques: reduced earth movements, longitudinal slopes adapted to the original terrain as much as possible or the use of local gravel materials for the pavement. So, it is difficult and very expensive in comparison to highways to collect and update data about all low-volume roads in a country with an adequate frequency in order to properly adopt maintenance decisions about them. Some information on the condition of the low-volume roads system appears (Watanatada *et al*. 1998) with respect to work performed by the World Bank in developing countries. International aid and donations from different institutions made possible the construction of a great length of low-volume roads in Africa over the last 50 years. However, the funds necessary for their maintenance have not been available, which has led to the premature decline of the roads (Malmberg Calvo 1998). A similar situation is now seen in many parts of Eastern Europe following the break-up of the communist block. In Latin America and the Caribbean the situation is not much better. The financial resources available have been mainly destined for the reconstruction of roads rather than periodic maintenance. In this sense, it is important to provide recommendations for the reconstruction of low-volume roads that allows optimising the investments made (Gintalas 2010). The use of resources is therefore not optimised, although this behaviour is justified by the ease with which international loans are secured for financing road reconstruction compared to road maintenance (Zietlow 2001).

Some asset management systems have been proposed for the last years in several countries (Pidwerbesky *et al.* 2007; Skrinskas, Domatas 2006; de Solminihac *et al*. 2007) but all of them are adapted to local conditions and circumstances. For example, the Lithuanian Gravel Road Paving Programme was implemented to minimise maintenance costs. A cost/benefit analysis was conducted by using data of *AADT* (annual average daily traffic in vpd), road pavement roughness, vehicle operating costs or time savings to study the feasibility of upgrading the pavement. It was concluded that paving many gravel roads was economically justified even for low-volume roads (Skrinskas, Domatas 2006).

The proposal conducted by Abat-Bangasan (2006) should also be mentioned. The author developed a low-volume road maintenance management system for the Philippines based on that carried out in New Zealand. The model was applied to three pilot projects. Because of the differences between both countries, the advantages and the drawbacks derived from the application of this management plan were considered in this study. The experience obtained could serve the Philippines road authorities to implement future long-term performance-based maintenance contracts on national roads and, possibly, to apply the same to low-volume roads.

It is very interesting to analyse the Swedish experience in the management of low-volume road networks. Private Road Associations (PRA's) manage 2/3 of the road network in Sweden (Malmberg Calvo, Ivarsson 2006). There are thousands of PRA's in Sweden, most of them being responsible for the management, inspection and maintenance of small low-volume road networks. The sizes of these PRA's may vary widely, but most of them manage less than 100 km of roads. The Swedish government provides grants from 40% to 80% of the funding required for the maintenance of the low-volume roads managed by each PRA, while the owners of the roads (members of the PRA) assume the remaining costs. The calculation of the grants provided by the government depends on several factors, like the type of settlements along the roads, the road type or the public services accessed by the roads.

A notable exception is a pilot scheme undertaken in Holland (Jaarsma, van Dijk 2002), where, in 1993, two Dutch water boards developed a model of finance that would guarantee the maintenance of low-volume roads. The model is still in use today. In addition, a law passed in Honduras in 1993, which covered the constitution of a fund for maintaining low-volume roads, deserves mention. This model foresees the contracting out of all services to the private sector, and gives priority to the paved road system over the unpaved system. The positive re-

sults obtained have led other countries such as Guatemala (1996), Costa Rica (1998), Nicaragua and El Salvador (2000), and four states of Brazil (between 1999 and 2001) to follow the suit. The conclusion (Zietlow 2001) from the results of these experiments was that the creation of funds for road maintenance is easier in small countries with bad roads than in large countries with road systems in a good condition.

Other interesting aspects studied at international level have been related to the strategies for optimising the investments destined for maintaining rural roads in minimally acceptable conditions (Hough *et al.* 1997), for deciding whether new roads are more desirable from an economic point of view (Thomas 1998), and the determination of the sums to be invested in different stretches of road when working to a fixed budget (Sánchez-Silva *et al.* 2005).

2.2.2. The situation in Spain

The majority of low-volume roads in Spain date from around 1960–1980 and were built to meet the demands of that time. However, as in other European countries and the USA, agricultural practices have changed, and the use of these roads is quite different to that for which they were originally designed (Pauwels, Gulinck 2000; Prater 1998). The vehicles that use these roads are now much heavier, and the almost complete lack of maintenance of these roads now requires that plans be approved for their upkeep.

Traditionally, the small amounts of money that public authorities had to spend have been used for the construction of low-volume roads rather than for their upkeep. Since the majority of these roads fall under the authority of small administrative units (mostly town and provincial councils; Fig. 2), maintenance work is usually sporadic. Sometimes the users of these roads themselves undertake this kind of work, with the corresponding lack of control over what occurs. The official choice of the roads to be repaired is commonly based on political, economic and social reasons rather than technical considerations. It should be mentioned that many of the public works undertaken on important low-volume roads are financed by EU Development Funds, which clearly influences the roads that are marked for repair.

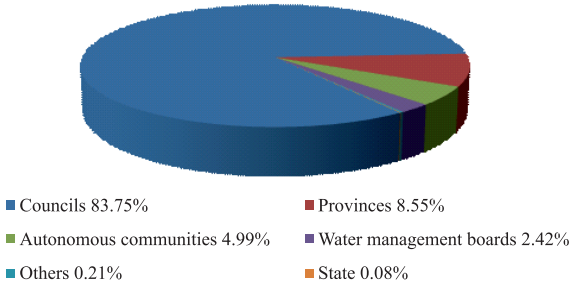

Fig. 2. Distribution of the Spanish low-volume road system according to governing authorities

Some of the maintenance work performed in Spain has, however, been the subject of better planning; that deriving from the agreement made between the *Junta de Castilla y León* (the Castilla y León Regional Government) and the *Diputación Provincial de Soria* (the Soria Provincial Authority) for the repair and upgrade of the Soria Province's road system deserves special mention.

Given the administrative decentralization undertaken in Spain in recent years, a number of *Autonomous Communities* have developed their own road laws, such as Aragón, Andalusia and the Canary Islands, although all adhere to State road law 25/1988 (29th July).

Although no national road inventory exists, figures published by the *General Roadways Authority of the Ministry of Public Works and Transport* at the *Roads of Municipal Dependency* (2004) estimate the length of the National Low-volume roads Network to be some 431 651 km for a total national extension of 504 800 km² (density = 0.85 km/km²). The magnitude of this figure is best understood in the light of the fact that the entire national road system has a length of 664 852 km; low-volume roads therefore make up 64.9% of the entire network. Nonetheless, the discrimination suffered by low-volume roads is made manifest in most recent laws: only the *Autonomous Community of Extremadura* has a specific law governing low-volume roads (Ley 12/2001). All other State and *Autonomous Community* laws regarding roads make only small reference to low-volume roads, in which they are generally considered as simple service routes to farmland. Only a few laws mention their function as service routes to populations or as satisfying the needs of traffic.

3. Proposed low-volume road system management plan

The management system proposed in this work involves three clearly differentiated stages: implantation, execution and monitoring (Fig. 3).

3.1. The implantation stage

This stage requires the completion of an inventory of the roads that make up the network to be managed. The length

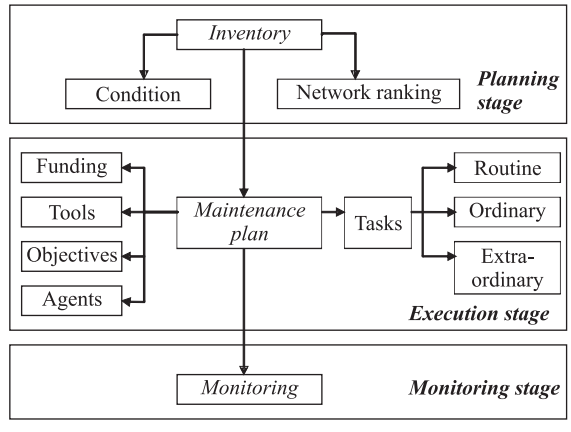

Fig. 3. Proposed low-volume road management system

of provincial low-volume road networks is usually very large. So, it would be suitable that the competent authorities define some criteria to select the part of the road network which is to be managed. In addition, the procedures that will be used in road inspection and evaluation should be defined. These methodologies should be developed by the firm responsible for the maintenance process, although the competent authority should review and approve them. The end sought is the determination of the road condition and an assessment of their relative importance within the network.

Among the agents who should be involved in this stage are the *Autonomous Communities* and the *Provincial Deputations*, who must assume the largest role in terms of the costs involved. However, in regions taking part in rural development programs promoted by the EU (LEADER programs), local action groups should be involved, as should town councils and any other interested and able institution, including water boards and irrigation groups.

3.2. Inventory production, inspection and evaluation

Given the characteristics of the low-volume roads system, it is essential to produce an inventory that includes all the elements of the network that should be objects of management. Only in this way can the full dimension of the low-volume road network and its current condition be understood. Without this information no maintenance strategy can be proposed.

In Spain, the majority of regions have no such low-volume road inventory; the production of these documents is therefore a priority. Several techniques can be used in this. For example, when a network is small and covers a small number of municipalities, maps at an adequate scale could be used to represent the roads. However, if the network is larger, say at provincial scale, the detection of roads in ortophotographs using computers would be more advisable. Once the inventory is complete, each road should be inspected to determine its main characteristics. This will allow the road condition to be evaluated. The inspection and evaluation methodologies (Gallego *et al.* 2008a, 2008b) could be used for this purpose.

3.3. Hierarchy of low-volume roads

Given the budgetary limitations constraining the upkeep of low-volume roads, repair and maintenance priorities should be appointed, bearing in mind that many low-volume roads are currently in a state of abandon and cannot be used for their design purposes. With the aim of optimising the use of financial resources, the present work proposes a method for classifying low-volume roads. This should help assign funds to roads that still perform important functions yet are in a precarious condition.

3.3.1. Criteria

The proposed methodology requires a numerical value be given to each low-volume road using the criteria shown in Table 1.

Table 1. Criteria and subcriteria used to classify low-volume roads

Criteria	Max value of the criterion	Subcriteria	Max value of the subcriterion
Design	15	Main low-volume road	15
		Secondary low-volume road	10
		Tertiary low-volume road	5
Functions performed	40	Economical	22
		Social	18
Road condition	30	Very poor	30
		Poor	24
		Average	18
		Good	12
		Very good	6
Traffic	15	Class D	15
		Class C	12
		Class B	7
		Class A	2
Total	100		

3.3.1.1. Design

Following the classification system proposed (Dal-Ré 2001), three types of low-volume road exist – main, secondary and tertiary – according to the service they provide. On many occasions the belonging of a road to one of these categories will depend on the economic importance of the land to which it provides access, and its connection with population nuclei etc. There should be defined technical criteria to decide to which category a road should belong. The classification of low-volume roads can be adapted to local types in each country (Vorobjovas 2011).

3.3.1.2. Road functions

Low-volume roads have two main function types, one economic and the other social. These functions can be classified into different categories as shown in Table 2.

Table 2. Max values assigned to economic and social functions in the classification of low-volume roads with respect to their function(s)

Function	Subcriteria	Max value of the subcriterion
Economic	Agroindustrial farm	22
	Agricultural use	
	– irrigated	16
	– rain-fed	10
	Stock raising	16
	Forestry	5
	No use	0
Social	High	18
	Medium	12
	Low	6
	None	0

A road's social function should be considered of high importance when it provides access to facilities such as hospitals, old people's homes, clinics or recreational/tourist areas belonging to the national heritage system, or when it facilitates the activity of emergency services. Its social function should be considered of medium importance when it provides access to recreational/tourist areas of lesser interest, and to farmland or other farms of economic importance (farms, agroindustrial plants, intensive rain-fed or irrigated land etc.). A road should be considered of low social importance when it serves common land or plots devoted to less intense agricultural activity.

When a road is associated with economic activities of different type or performs different social functions along its length, only the most important should be taken into account.

3.3.1.3. Road condition

The Road Condition Index (RCI) classifies the road condition as very good, good, average, poor and very poor (Gallego *et al.* 2008b), and assigns a max value to each of these categories. These indices are later used to select the roads that will undergo repair.

3.3.1.4. Traffic volume

This is determined by calculating the average daily traffic (*ADT* in vpd) of vehicles using the road. This can be done using any valid technique, although here the method (Heras 1981) – which is simple – is suggested:

$$HIC = \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} adt \right]^{2.5} (t_2 - t_1),$$

$$ADT = \frac{K}{500} QS\sqrt{E}, \quad (1)$$

where Q – annual production of the area, t/ha; S – total area served, ha; E – number of different farms served; K – a coefficient, the value of which depends on the type of road considered: 1 – if the road is classed as terminal, 1.3 – for roads that connect two others, 1.5 – for those that connect to a population nucleus.

Once the *ADT* has been calculated, the road should then be classified according to the categories listed in Table 3 (i.e. with respect to the number of industrial vehicles of over 1.5 t that use it). If any of the data required for the above calculation are missing, it is recommended that experts on the area in question be asked to estimate the road's *ADT*. The greater the traffic volume, the higher the upkeep priority the road should be given.

3.3.2. Classification of low-volume roads

According to the methodology proposed, each road is evaluated according to the criteria and max values laid out in Table 1. Therefore, the max number of points a road can be assigned is 100, and the min 13. Once this value is known the road can be classified by calculating the two indices shown in Table 4. Index 1 is the sum of the points awarded according to the criteria of design and functions performed. Index 2 is the sum of all four criteria studied.

Table 3. Classification of low-volume roads according to *ADT*

Category	*ADT*[1], vpd
A	≤ 15
B	16–45
C	46–150
D	151–450

Note: 1 – average number of vehicles that use the road every day.

Table 4. Classification of low-volume roads in terms of indices 1 and 2

Category	Index 1[1]	Index 2[1]
1st	> 35	> 70
2nd	–	> 40
3rd	–	≤ 40

Note: 1 – valuation of design criterion plus valuation of function criterion, 2 – all criteria.

As shown in the above table, low-volume roads can be classified as 1st order (when their permanent upkeep is obligatory), 2nd order (when possible but not obligatory), or 3rd order (when not assigned to any permanent maintenance program whether funds exist for this or not). It should be clarified that 2nd order roads should be included in any permanent maintenance program if sufficient funds exist. 3rd order roads will receive only occasional upkeep attention.

As can be appreciated in Table 4, 2nd and 3rd order roads must reach set thresholds with respect to index 2, while 1st order roads must also meet a threshold with respect to index 1. For the latter, it is sufficient that either the index 1 or 2 thresholds be met.

3.4. Execution phase

This stage sees maintenance tasks take on a priority role; it is now when the firm performing the work should be careful to take into account the objectives set out in the maintenance contract signed with the management agency. The definition of the maintenance work to be carried out should be the joint responsibility of the financing body and the contracted maintenance firm (always keeping within budget), while the latter should decide upon the programming of these tasks.

According to some authors (Hough *et al.* 1996b; Zietlow 2001), the involvement of all interested agents is essential if a management plan is to be successful, and it is recommended to define the role of each. It should be the role of the competent authorities to see that the maintenance work is carried out and to evaluate the degree to

which set objectives has been achieved. The maintenance firm should be responsible for correctly performing its work within the timeframe agreed. Finally, the management authorities should make the plan known to society, especially the most direct users of the roads in question, since they are the main beneficiaries. This is important for them to become aware of the essential role they play in terms of facilitating information regarding road maintenance.

The tools used in the management of low-volume roads should reflect the dimensions of the network they are to serve. Since large quantities of information are handled in this type of work, the use of computers is particularly recommended. Commercial programs for the management of roads are available, but geographical information systems (GIS) are becoming even more popular for such management. Thanks to these it is possible to associate geographically referenced graphical data for an area with a database that includes information on the stretches of road managed, including the design characteristics of the road, relative importance in the network, its condition, and the maintenance tasks programmed for it etc. GIS greatly increase the capacity of analysis available, and help enormously in the comprehension of information and the monitoring of management plans. The research group the authors belong to has successfully undertaken such work (López Casares 2003).

The maintenance tasks marked out in the proposed plan can be categorised as routine, ordinary or extraordinary. Routine tasks are those that should be performed annually along the entire road, independent of its condition. Their function is to slow the process of deterioration and delay the need for repairs. Such tasks might include the cleaning out of ditches and the inspection of the road. The importance of safety is sometimes underestimated in low-volume roads because of the reduced traffic flows. So, the inspection of the road may also help to detect obstacles and possible deficiencies in some elements of the road that negatively affect the driver safety (Dell´Acqua, Russo 2010; Vorobjovas 2011; Vorobjovas, Žilionienė 2008). Ordinary tasks are those such as the repairs made to restore functional capacity lost through the normal use of the road. No set frequency for such tasks can be set; these should be performed when the road has deteriorated to previously determined levels. Such tasks might include reasphalting or ripping, etc.

Extraordinary tasks are those performed exceptionally due to the appearance of anomalies or imperfections of unforeseen cause. These tasks might include the replacement of factory-produced elements damaged by flooding or the replacement of traffic signs damaged in an accident.

The importance of routine tasks should be emphasised since these can prevent the deterioration of a road and reduce the costs of its maintenance by delaying repairs (ordinary tasks).

Table 5 lists the jobs that might be undertaken under these different task categories, according to whether the road is asphalted or has a granular surface.

Table 5. Types of maintenance task required depending on the type of low-volume road surface

Surface type	Type of task	Maintenance tasks
Granular	Routine	Monitoring of road condition
		Ditch cleaning
		Cleaning of factory-made elements
		Antidust watering
	Ordinary	Monitoring of road condition
		Surface ripping
		Provision of materials
		Surface levelling
		Watering and compaction
	Extraordinary	Ditch reparation
		Replacement of traffic signs
		Repair of factory-made elements
		Repair of ditch bridges
		Placement of geotextiles
Paved	Routine	Monitoring of road condition
		Ditch cleaning
		Cleaning of factory-made elements
	Ordinary	Monitoring of road condition
		Reconstruction of the surface
		Elimination of excess binding material
		Patching
		Sealing of cracks
	Extraordinary	Ditch reparation
		Sweeping of surface
		Replacement of traffic signs
		Repair of factory-made elements
		Repair of ditch bridges
		Placement of geotextiles

It is recommended that a timetable be drawn up (representing all seasons of the year) for maintenance work. Since several areas will probably be attended to simultaneously, this will help avoid misunderstandings and prevent the overlapping of an excessive number of tasks. The assignment of tasks to the most appropriate time of year will also help optimise the use of the resources available.

3.5. Monitoring stage

The monitoring of the management plan is essential if it is to be successful. The contracted maintenance firm should make sure that all work is correctly executed, and the competent authorities should ensure that all the objectives set out in the contract are achieved.

Road users can participate in the monitoring process via their comments and suggestions, and by providing information on their degree of satisfaction with the plan and the improvements made. Such information more easily allows the identification of areas that need attention or the need for certain tasks to be undertaken. It can be gathered by questionnaires, personal interviews, or by selecting a

panel that represents different user collectives. The method to follow should be decided upon depending on the information required and the funds available. It is recommended that a monitoring committee be created, made up of representatives of all the agents involved in the upkeep process, including the contracted maintenance firm.

It would be required to collect data about *ADT*, pavement roughness and traffic composition in test sections of some of the low-volume roads of the managed network. In addition, some studies should be conducted to establish vehicle operation costs. These data could be used later to conduct cost/benefit analysis in order to consider an upgrading of the pavement as a suitable strategy to minimise maintenance costs for unpaved roads.

4. Finance mechanisms

Like other countries (Jaarsma, van Dijk 2002; Zietlow 2001), Spain suffers from the lack of economic resources destined for the maintenance of the low-volume road system. This is made worse by the fact that taxes are not paid for specific purposes – all tax moneys go into the same pot from which funds are taken as required. Authorities therefore find it hard to establish a fixed budget for the upkeep of low-volume roads, despite their importance.

The EU places great importance on agriculture and rural areas, and wishes to favour their development as stated at *Europe's Agenda 2000. Strengthening and Widening the European Union*. Adequate maintenance of the low-volume road system would favour this as well as help protect the environment. It is therefore recommended that the EU assign funds for the maintenance of the low-volume road network. In fact, many of the repair projects currently underway in Spain are financed by the *Provincial Deputations* via European Rural Development Funds. However, this contribution is insufficient to completely finance the management plan proposed, and it is recommended that town councils (the main governors of low-volume road networks) take on a funding role – although this is difficult given the precarious financial states of many of these institutions. It would therefore appear necessary that the *Autonomous Communities* and the State, the most powerful authorities, become involved.

Some authors (Jaarsma, van Dijk 2002; Schliessler, Bull 1994) propose that the users of these roads should contribute directly in the funding of their upkeep. It is interesting to remark the Swedish experience, where most part of the low-volume road networks is owned and managed by PRA′s (Malmberg Calvo, Ivarsson 2006). The funding required for the maintenance is partially provided by the Swedish government and the remaining costs are assumed by the owners. In this scheme, a careful and continuous inspection of the roads is made by the owners. However, the success of this system may be explained due to the tradition of community road management and the rural structure in Sweden. Nevertheless it does not seem to be feasible that this model could be generalised for Spain. Along these lines it would be desirable that Spain use a system of financing similar to that adopted by a Dutch pilot project (Jaarsma, van Dijk 2002). This would sensitise users to use roads carefully. However, certain doubts exist over the economic and legal viability of such a venture: economically because in Spain there are few areas where users could take on charges for road maintenance, and legally because this would require the approval of this special tax. In addition, the *Autonomous Communities* are taking on taxation responsibilities at different speeds, and therefore the situation differs around the country. However, the Andalusian Regional Government has recently put a pilot scheme in place in which users pay up to 10% of low-volume road reparation costs, although it is too early to reach any conclusions.

If a tax were imposed to finance the low-volume road system, its fair distribution would have to be implemented. Since the population that most uses low-volume roads would be that which would most benefit, it would not seem fair to simply apply the same tax rate to the entire population of the country.

Finally, agreements could be signed between town councils and private agents, such that the ownership of roads passes from the former to the latter, with the latter promising to undertake the necessary repairs. However, this would seem largely unviable since, in many cases, low-volume roads are considered to be inalienable public property and cannot be sold.

Some changes should be carried out to guarantee a good condition for low-volume roads. The major authorities, the State and the *Autonomous Communities*, should provide the most part of the funding for maintenance. However, a special tax should be approved to get the public awareness of road users. Nevertheless, this tax should not affect the total Spanish population but those actually using low-volume roads for different purposes.

5. Conclusions

In Spain, according to the trend followed in other European countries as well as in the USA, low-volume roads play a vital social role and contribute to increase the life quality of people living in rural areas, which is nowadays one of the goals of the EU. Although these roads were initially designed for other purpose, changes in the agricultural practices have led to use heavier vehicles than those originally considered. As a consequence, most of low-volume roads are in a bad condition, and therefore maintenance plans must be approved for their upkeep.

Since the low-volume road system in Spain represents 64.9% of the entire Spanish Road System, it would appear to be fully justifiable that an adequate maintenance and management system be put in place. Currently Spain has no such system because of legal and financial problems and because the characteristics of these networks make this difficult.

The present work proposes a system adapted to the peculiarities of Spanish low-volume roads and the social

and legal framework, takes into account the fact of limited financial resources, and suggests a hierarchy that reflects the importance of each road in a network. It also suggests different maintenance strategies that might be adopted and possible sources of financing for its implantation.

The low-volume road system management plan proposed in this work should be tested to validate its use; this would allow the possible shortfalls to be detected. The contracted maintenance firm should make sure that all work is correctly executed, whereas the authorities should ensure that all the objectives set out in the contract are achieved. In addition, road users should participate in this process via their comments and suggestions.

Finally, if a management system with the proposed characteristics were put into operation, it would be advisable to undertake studies to determine the costs faced by vehicles using low-volume roads. In addition, data about *ADT*, traffic composition and pavement roughness should be collected. This would help to propose other maintenance strategies, e.g. the upgrading of pavement in unpaved roads, and reveal the economic impact made on rural society. Therefore, investments made in low-volume roads could be optimised.

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