CHALLENGES FOR IMPLEMENTING ASSET MANAGEMENT SYSTEMS IN MEXICO

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ABSTRACT

A discussion of the main challenges for implementing asset management systems in Mexico is presented in this paper together with some proposals to address those challenges. First, the national road network is described broadly in order to put the discussion in context. Next, the prevalence of the conception of a management system as a computer program and the lack of interest in developing management systems for asset classes other than pavement are emphasised. Later in the document, actions are identified to develop a national culture of asset management that helps overcoming the existing conceptual limitations. The structure of the entity responsible for the operation of the federal road network is described in section 3 showing the obstacles that such an organisational arrangement implies for the application of asset management and thus proposing an alternative structure. In the final part, the paper discusses further limitations related to standards, technology use and training of human resources, and point out possible contributions of the Mexican Transport Institute to meet the challenges identified.

1. BACKGROUND

Mexico owns a vast road network whose length exceeds 360,000 km, from which 35% (just over 127,000 km) corresponds to paved roads and the remaining 65% (about 233,000 km) to unpaved roads [1]. About 48,000 km of paved roads make up the federal road network, which extends throughout the national territory structured around 19,000 km of trunk corridors [2] and is the most important component of the national network (Figure 1). Another substantial part of the paved network refers to state roads of regional and local relevance whose length amounts to 74,000 km [1]. From all paved roads, 91% (115,600 km) are two-lane roads and the rest (11,600 km) multi-lane roads.

84% of the total length of the federal paved network (40,600 km) consists of toll-free roads, which are mostly operated directly by the Secretariat (Ministry) of Communications and Transport (SCT), though a growing part of this network is being concessioned to the private sector under various schemes.

The remaining 16% of the federal paved network (7,700 km) corresponds to toll roads whose operation and maintenance, for the most part, are performed by the government agency "Federal Toll Roads, Bridges and Complementary Services (CAPUFE)" although also in this case the participation of the private sector has been increasing.

With respect to state paved roads, almost all of them are toll-free roads operated by state governments.

Today, Mexico faces tremendous challenges for preserving, upgrading and expanding its road assets. It is estimated that these activities, for the federal network only, require annual investments totalling around U.S. $ 5 billion [3], which can not be made only through public funds. Given the above, the latest federal administrations have been promoting an increasing participation of the private sector in road programmes.

Figure 1 - Trunk corridors of the federal road network.

Meanwhile, at the global level, road asset management has been consolidating as the most appropriate framework to face challenges related to the preservation and development of road networks [4]. In this regard, while a number of initiatives has been promoted in Mexico for implementing road infrastructure management systems with mixed results, to date there are no projects involving the formal application of asset management, and the arising of such projects is restricted by several methodological, organisational, technological and standards shortcomings including: i) Prevalence of the misconception of a management system as a computer program, ii) Lack of interest in developing management systems for asset classes other than pavements iii) Existence of organisational structures inadequate for implementing management systems; iv) Deficiency of standards for orienting the use of measuring equipment and the integration of road databases v) Insufficient local experience in the application of some of the various technologies involved in road infrastructure; vi) Lack of academic programmes specifically designed for training human resources in asset management.

A discussion of the above limitations is developed in the following sections along with specific proposals for promoting the development of asset management in the country. Likewise, the role that the Mexican Institute of Transport (IMT) could play in implementing those proposals is pointed out.

2. THE CONCEPT OF A MANAGEMENT SYSTEM AND ASSET MANAGEMENT

2.1. Management systems and computer programs

The application of a road infrastructure management system involves processing large datasets as well as using computational algorithms that can be very complex. Therefore, since its inception, the analytic tools of management systems have been implemented through computer programs, which explains the long-accepted notion of a management system being a software package. Although the formalisation of the conceptual framework of asset management has led in several countries, especially in developed countries, to change the conception of management systems to a set of institutional processes, information and analysis tools, the former notion still prevails in Mexico.

Thus, decisions regarding the implementation of a management system remain in many cases restricted to the acquisition, adaptation or development of specific software. Moreover, these decisions are often made by professionals not knowing in detail the operation of road management software, which prevents them from assessing properly the following:

a) Present and future information requirements as well as the necessary organisation technical and financial capabilities to meet those requirements.
b) Costs additional to initial investment arising from the licensing schema involved and from getting product updates.
c) Additional software tools that might be required for data pre- and post-processing and for road inventory management.
d) Personnel availability and training needs related not only to operating the computer program, but also to making a productive use of it.
e) Correspondence between the program information flows and those of the established institutional procedures for road infrastructure management.
f) Applicability of the assumptions underlying the models implemented through the software.
g) Relevance of the computer program results for decision making.
h) Organisation ability to disseminate the generated information among all actors involved in the management process.

Clearly, if the above issues are not taken into account the selected computer program may be abandoned prematurely leading to conclusions such as the software is inadequate “per se” or management systems are useless.

2.2. Measuring equipment and software

In that concerning pavements, the growing availability of high performance measuring equipment in the country (Figure 2) along with the level of sophistication recently achieved in the development of software for pavement management, has made some professionals think that equipment and software, as a high technology package, bring together everything they need to implement a pavement management system. It is true that, on one hand, high performance equipment allow for getting information on road condition expeditiously and, on the other hand, last generation pavement management software have capabilities for processing that information quickly and displaying it through views designed to simplify decision making. However, turning this technology package into an actual pavement management system requires both ensuring that software results are relevant for the organisation and obtaining the institutional commitment necessary to update data regularly and consistently, incorporate the information flows into the

organization internal processes, allocate human resources for operating the system and provide them with adequate training to achieve the institutional assimilation of technologies.

Figure 2 - Deflection measurements using a falling weight deflectometer in the federal network.

Given the above, pavement management systems projects based exclusively on the implementation of a "measuring equipment + software" technology package are also at risk of being abandoned if the aforementioned issues are not taken into account.

2.3. Management systems for pavements and other asset classes

Pavements are the most important road infrastructure assets given the economic resources involved in their construction and maintenance, among other reasons. This explains why management systems as a concept and the software developed to ease their implementation have been originally designed to streamline pavement maintenance, and why applications for pavements have been prevailing since then. In this sense, Mexico has not been an exception and, indeed, virtually all national experience concerning management systems refers to pavements.

However, while the interest in developing management systems for other asset classes as well as integrated management systems has grown in other countries, in Mexico this interest remains insignificant mainly because of the existence of unfinished pavement management systems projects, which have prevented projects for other assets from being initiated. Perhaps, this lack of interest has also resulted from an insufficient emphasis in technical literature and academic forums about the benefits of management systems that may result from the better performance of the various assets, the cross-optimisation of the available resources and, ultimately, the overall level of service offered to the user.

2.4. Towards the development of an asset management culture

The problems described above are some of the limitations existing in Mexico to promote projects based on the asset management conceptual framework. Since these limitations are due mainly to the lack of an asset management culture, they may be overcome through actions encouraging the development of this culture, some of which may be:

a) Hold an event to disseminate the basic principles of asset management among managers of organisations that operate roads.
b) Hold an international seminar or conference where professionals from the most advanced countries in this subject share their experiences with local specialists.

c) At meetings of the Mexican members of PIARC technical committees, the integration of national committees homologous to those of the association has been proposed. In this context, encouraging the integration of the national committee for Road Infrastructure Asset Management by convening representatives of stakeholders is highly recommended.
d) Promote the establishment of a professional association specialised in asset management.
e) Incorporate asset management topics into road engineering graduate curricula and design courses for continuing education programmes at universities. The issue of asset management training is taken up in paragraph 4.3.
f) Disseminate papers on asset management written by national and international authors through the space provided by national technical journals.

3. ORGANISATIONAL ISSUES

3.1. The Secretariat of Communications and Transport

As mentioned earlier in this document, the Secretariat of Communications and Transport operates directly the toll free federal network (more than 40,000 km), which is one of the most important components of the national road network. This secretariat is responsible for other key functions related to the federal network: i) Planning; ii) Preparation of the annual budget expenditure; iii) Management of projects for the construction of new roads; iv) Tendering of contracts for the operation of roads through public-private partnerships.

Taking into account the importance of the SCT and the federal network, the discussion about the institutional limitations for implementing asset management systems in Mexico will be carried out taking the roads division of this Secretariat as reference. In any case, the proposals presented at the end of this section may also be relevant to other road organisations in the country.

The SCT is an extremely complex organisation whose duties extend far beyond the development and preservation of the federal road network and include planning, development and regulation of the various transportation modes and telecommunication services at the national level. This large concentration of functions could be considered the first organisational limitation for implementing road asset management systems since it can disturb the vertical flow of information given the amount and diversity of issues that should be addressed at the highest management level of the Secretariat. In fact, on several occasions it has been advised splitting the SCT into two separate Secretariats, one for Communications and one for Transport.

To perform the duties outlined above the SCT is organised into the following main units [5]:

- Sub-secretariat of Infrastructure.
- Sub-secretariat of Transport.
- Sub-secretariat of Communications.
- Coordination for Ports and Merchant Marine.
- General Coordination for SCT Centres (state representations of the secretariat).

3.2. Sub-secretariat of Infrastructure

The functions of the SCT concerning the preservation and development of the federal road network are performed within the Sub-secretariat of Infrastructure (SI). In fact, almost all work carried out within this sub-secretariat is related to the federal road network, so that SI

could be renamed as "Sub-secretariat of Federal Roads". Figure 3 shows the structure of the SI.

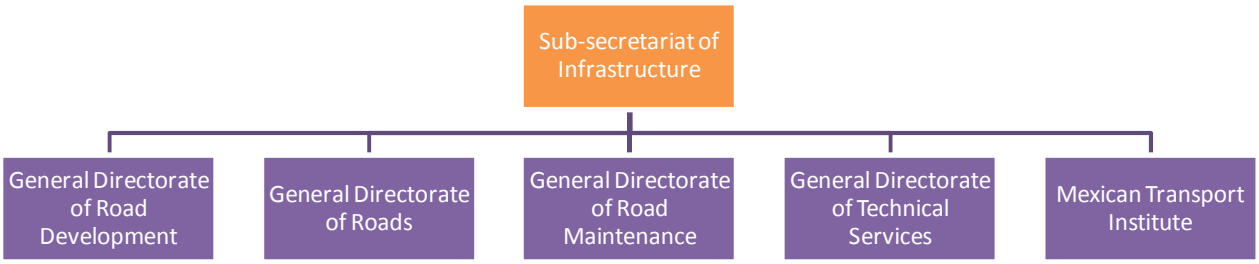

Figure 3 - Units composing the Sub-secretariat of Infrastructure of the SCT.

The following summarises the main functions of the areas illustrated in Figure 3 [6]:

General Directorate of Road Development: Planning the strategic development of the network, monitor the performance of toll roads and tender contracts for granting new concessions.

General Directorate of Roads: Managing projects for constructing new sections of the federal paved network as well as for constructing and maintaining local roads.

General Directorate of Road Maintenance: Maintaining the federal toll-free network.

General Directorate of Technical Services: Providing technical support services to the road sector in planning, carrying out studies, projecting, constructing, maintaining and operating roads.

Mexican Transport Institute: Developing projects for research, technological innovation and formulation of technical standards, as well as collaborating in activities related to basic training, updating and specialisation of human resources in the transportation sector.

3.3. Background and current profile of the SI entities

The background of several of the entities within the current structure of the SI dates to the period in which the expansion of the road network for integrating the national territory was the top priority of road development. This period began in 1925 and lasted almost until 1980, when the federal network reached a length of 43,500 km and the entire network 240,000 km [7].

In 1960, when the federal network was 24,500 km in length, the General Directorates of Construction and Maintenance of Federal Roads were established. These are direct precursors of the General Directorates of Roads and Road Maintenance depicted in Figure 3. In the beginning, the work of these units was mainly operational and even included the direct execution of road works. Technical personnel of both directorates were highly specialised.

From its origins through the mid 90's the General Directorate of Road Maintenance (DGDC) dealt with the maintenance of the toll-free federal network using the traditional approach based on the previous behaviour of road sections and the experience of technical staff. By 1994, the network showed a high degree of deterioration (almost 60% in unacceptable condition), which led this directorate to start a formal planning process for maintenance based on a pavement management system. As part of this process, specific

targets for network recovery were defined, working groups were integrated and procedures for achieving the defined objectives were designed. In addition, DGCC implemented a French computer program for the evaluation of maintenance strategies called SISTER (acronym for Simulation de Stratégies d'Entretien Routier) and a bridge management system called "SIPUMEX." These initiatives enabled the DGCC to reverse the deterioration of the network so that the length in unacceptable condition has been reduced since then to 20%. Currently, a pavement management system based on HDM-4 is used, and DGCC is one of the few road organisations in the country that has successfully implemented road management systems, aligned them with its business processes and kept them running permanently.

Another unit with a remote history is the General Directorate of Technical Services (DGST), which was established back in the mid 50s. For a long time, this Directorate concentrated the execution of all material testing required by road projects and works nationwide. At the same time, the Directorate became a technical support unit for the road sector as a whole. DGST still plays this role, particularly in that concerning the reviewing of construction and rehabilitation projects for the SCT and CAPUFE.

The General Directorate for Road Development (DGDC) emerged in the late 90s as the "Toll Roads Unit" with the purpose of monitoring the performance of an important group of more than 20 motorways whose length totalled approximately 3,000 km [8]. These motorways had been operated by private operators under concession, but concessions were terminated by the federal government since traffic flows did not reach the forecast levels, which was linked to expensive tolls. At the same time, the unit was assigned the task of identifying new schemes for the involvement of private resources in financing road projects. The implementation of these new schemes had to be necessarily placed in a general planning framework of the network, which led to the transformation of the toll roads unit into the DGDC.

Finally, with regard to the Mexican Transport Institute (IMT) it should be noted that an important part of its projects focus on the road system, which explains why the Institute began depending on the Sub-secretariat of Infrastructure some years ago. In 2001, the IMT encouraged the integration of a research group dedicated to road infrastructure management, which is currently one of the country’s few groups that specialises in this area.

3.4. Organisational limitations for implementing an asset management system within the SI

The following limitations can be identified in relation to the origins and current profile of the units making part of the Sub-secretariat of Infrastructure:

a) According to the previous paragraph, in their origins a number of units of the SI had an operational profile which included carrying out studies, projects and works directly. The rapid growth of the network caused this profile to become unsustainable and entities to reorient their functions towards planning, management and supervision tasks while transferring all operational duties to private companies. However, since this change was not planned, entities did not completely acquire the required organisational scheme to respond efficiently to the new requirements. At the same time, job profiles became confusing between the purely technical knowledge that needed to be kept and the additional skills required to perform the new duties. The existence of vague job profiles not only affected units created in the past, but also the Sub-secretariat as a whole.

b) The ensemble of directorates operate under a stovepipe scheme, i.e. horizontal communication is scarce thus preventing the integration of institutional information sources and analysis tools that allow for comparing projects generated by the various units in their areas of competence, analysing development strategies thoroughly and expeditiously for the network as a whole or benchmarking technically and economically the performance of sections operating under different regimes.
c) Several aspects of the federal network operation such as accident reporting or incident clearing are under the responsibility of the General Directorate of Federal Motor Carriers, which is not dependent on the SI, but on the Sub-secretariat of Transport. This makes it difficult to coordinate actions for the generation of programs aimed at improving the service level of federal roads in a comprehensive manner.
d) As in any other country, construction and upgrade programmes for trunk roads have a great deal of political significance. Therefore, the work of the DGDC and SI are always subject to an enormous pressure from various stakeholders who require projects to be put into operation quickly. In this context it is very difficult to get receptivity for projects concerning the implementation of asset management systems, which do not produce results in the short-term especially in a complex environment.
e) Recent federal administrations have promoted the downsizing of government agencies through voluntary retirement programs and job cancelling. In general, these programs have not been accompanied by actions aimed at restructuring agencies, which has led to lose all kinds of personnel including technical staff. At the same time, the salaries of all employees have been suffering a gradual deterioration. For the SCT both problems have resulted in a gradual decrease of its technical capacity.
f) The current role of DGST can be explained in terms of the problems in job profiles that have arisen from vocation changes in the units of the Sub-secretariat of Infrastructure and the technical capacity loss mentioned above. However, the current size of the network and its impact on the number of studies and projects that are being generated suggest that the concentration of technical support services in a specific unit of the sub-secretariat could become unsustainable in the near future.

Overcoming the above limitations is a huge challenge that must necessarily go through a re-engineering process of the Sub-secretariat of Infrastructure whose conception, albeit initial, far transcends the scope of this work. Nevertheless, some ideas that might be useful for a preliminary discussion of the changes required by the SI in order to facilitate the implementation of asset management are presented in the next paragraph.

3.5. Elements for the transformation of the SI

Overall, the transformation of the Sub-secretariat of Infrastructure of the SCT in order to strengthen the use of a business approach for the operation, preservation and development of the federal network and, as part of it, implement road asset management systems would require actions such as:

a) Recognise that roads' level of service is influenced not only by programmes related to maintaining them in good condition and increasing their coverage, but also by those addressing operational problems such as accidents, congestion and violations to the regulations of weights and dimensions. Thus, operational issues should be always taken into account when formulating new road projects, upgrade projects and annual work programmes, as well as for supervising private operators.
b) Recognise the relevance for the national road system of the planning functions that have been being performed by DGCC, by raising the status of this directorate to a “staff" position within the Secretariat and reassigning its functions related to tendering and supervision of road operation contracts to other units.

c) From the above proposal, create a new Directorate, the "General Directorate of Concessions," which would be in charge of managing road operation contracts granted to private operators under different models of private involvement. Specifically, the Directorate would be responsible for activities such as formulating reference projects, tendering and awarding new contracts and monitoring the performance of contractors during the concession term. Additionally, this Directorate would continue supervising the operation of those motorways whose concession failed in the 1990s.
d) Widen the scope of DGCC functions to incorporate the management of operational issues. To reflect this change, it is proposed to change the entity's name to "General Directorate of Operation and Maintenance." It is also proposed to insist in transferring the jurisdiction of secondary federal roads to state governments (a project started in the recent past) in order to streamline the operation of the entire national road network. With this measure and the gradual transfer of the operation and maintenance of the primary network to private operators, the Directorate would tend to reduce substantially its size in the future or even disappear.
e) Reassign the technical oversight functions of the General Directorate of Technical Services to the units that generate projects. Relocate DGSCT personnel to these units and strengthen their technical capacity through training and education programmes.
f) Define rigorously detailed job profiles for each of the job positions allocated to the sub-secretariat.
g) Develop a short-term project for integrating a road database for the federal network common to all areas of the sub-secretariat, as well as a set of institutional analysis tools.

The diagram in Figure 4 illustrates the organisational structure that would result from implementing the proposed actions. In this Figure, the name of the sub-secretariat has been changed to "Sub-secretariat of Federal Roads" so that the scope of the sub-secretariat functions is stated clearly. Likewise, the current Directorate of Roads has been renamed as "General Directorate of New Projects" in order to reflect more accurately the main function of this directorate, which consists essentially in managing projects for constructing new road sections, including those pertaining to local unpaved networks. The maintenance of some sections of the unpaved roads network is also considered part of the duties of this unit, though it is recommended that this particular role is transferred to state governments.

Although much of the Mexican Transport Institute activities are oriented towards the road sector, the Institute has also developed highly relevant projects related to the infrastructure and operation of other transportation modes. Thus, maybe the IMT should depend on the Secretary’s office or on any other office that is more representative of the transport sector as a whole.

4. OTHER LIMITATIONS

The lack of standards for pavement measuring equipment and other aspects of infrastructure management, an experience that has proven insufficient for the application of certain technologies and the absence of academic programs for training specialists are all additional limitations for the implementation of asset management in the country. The most relevant aspects of these limitations are presented in the paragraphs that follow.

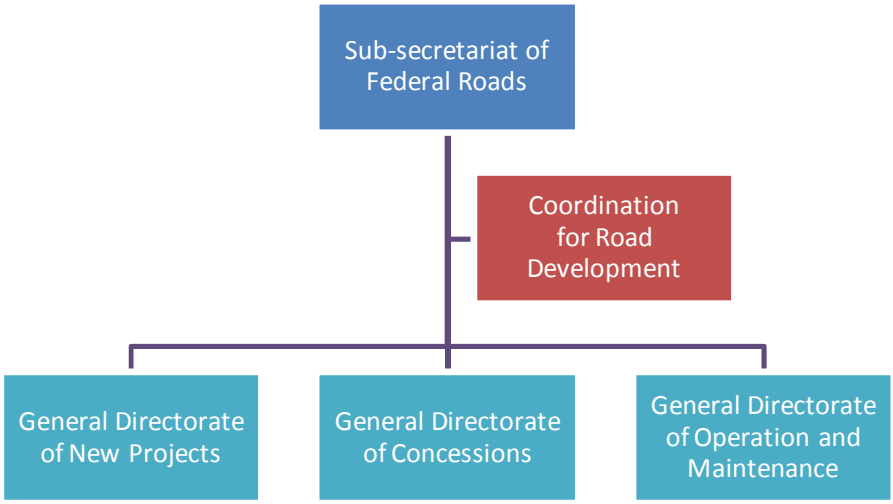

Figure 4 - Basic structure proposed for the current Sub-secretariat of Infrastructure.

4.1. Standards Issues

The use of high performance equipment for obtaining indicators of the condition of pavements has become common practice in the country since it has gained acceptance as a valid information source for the following processes or tools: i) Pavement management systems; ii) Studies for pavement rehabilitation or upgrade; iii) Feasibility analysis for granting new concessions; iv) Supervision of concessions already granted.

The parameters most commonly measured include the following (shown in parentheses is the equipment usually used for each parameter):

- International Roughness Index or IRI (laser profilometer).
- Rut depth (laser profilometer).
- Pavement deflections (falling weight deflectometer).
- Friction coefficient (Mu Meter).
- Surface distresses (digital cameras).
- Thickness of pavement layers (ground penetrating radar).

Mexico has a comprehensive set of road standards in which, nonetheless, the management subject is virtually absent. Currently, this set only includes standards for measuring smoothness using California profilographs and friction coefficient using Mu Meters, both as part of procedures for the acceptance of new construction or maintenance works.

Consequently, at best, units contracting measurement services refer to foreign standards for general use, particularly the ASTM standards, which sometimes lead to misinterpretation due to the detail in which equipment and processes are described and the variants considered in these standards.

Thus, the measurement of pavement condition data would be highly benefited from standards on this subject specifying:

a) Equipment acceptable for measuring each parameter of interest and characteristics of each equipment class.
b) Verification or validation procedures to be carried out on equipment before, during and after the provision of services.

c) Specific parameters to be measured and measuring interval.
d) Provisions for the acceptance or rejection of the measured data based on verification procedures.
e) Definition of aggregate indicators and thresholds for characterising the condition of road sections based on each parameter, including sections length.

Closely linked to data collection, another task that has become common is storing the gathered information in spreadsheet and databases files. Since neither the SCT nor the state governments have implemented standards for road inventories to date, field information often has inconsistencies that hamper the integration of data collected by different service providers in a single measurement campaign or the preparation of historical series. At the same time, entities generally do not provide contractors with templates indicating the required data fields and their corresponding data types. Therefore, information processing has become a task that requires a great deal of effort to eliminate inconsistencies and put the data in the proper format for being used as inputs to analysis tools.

In the same vein, it has also become common practice to obtain the geographical representation of road sections along with pavement condition data, using GPS devices. In this regard, there are no conventions on the required degree of precision, geographical projection, number of lanes to survey or file format for storing the information, all resulting in a limited usefulness of data collected.

In light of the problems described, it has become increasingly necessary to:

a) Integrate institutional road inventories for the federal and state networks whose use for storing road condition data is mandatory.
b) Develop reference standards for storing road condition data specifying the minimum set of fields to include for each information category and the data type for each field.
c) Develop reference standards for conducting GPS surveys on road sections aimed at representing geographically road characteristics and condition. These standards should specify aspects such as lanes to be surveyed, level of precision required, projection to be used and format of the computer files used to store the information.

Evidently, standards for data collection and storage for other asset classes are also required. However, being the practice of asset management for asset classes other than pavements actually scarce, the discussion about these standards would be at this time somewhat premature.

4.2. Technological limitations

Asset management is a multidisciplinary practice and, therefore, involves the use of diverse technologies. In our environment, there are limitations regarding the use of technologies such as:

a) Software and information tools: database systems, geographic information systems (GIS), computer networks, multimedia and software for processing technical information.
b) Road technology: deterioration models and assessment condition procedures for asset classes other than pavements.
c) Tools for economic evaluation and prioritisation.
d) Risk management.

With respect to software and information tools, though the degree of development of the information technology in Mexico is comparable to that of any other country in the world, the actual assimilation of this technology within the road sector is still at an early stage. Hence, those responsible of making decisions about database or GIS systems tend to leave entirely in the hands of specialists the development of the required products, without involving in these projects the technical staff that later will act as users. This may lead to products not modelling adequately the organisation information and processes or not meeting expectations in terms of functionality.

Moreover, as already mentioned, some of the road management software currently available implement a set of graphical, geographical and multimedia views that usually result very attractive for road managers, and lead them to make decisions about purchasing the software without assessing adequately the extent to which it will support business processes or the additional costs that may generate from the collection of data required by the software, among other issues.

From the above, the inclusion of topics such as databases, geographic information systems and analysis tools for management systems in the training programmes for the personnel involved in making decisions about developing or purchasing information tools, has arisen as a need not only to support the acquisition or development processes, but also to facilitate the operation of the selected tools.

In relation to road technology for management systems, Mexican practice exhibit limitations in some important aspects such as:

a) Pavement distresses. The various surface distresses affecting pavements are well-known in Mexico. However, a distress catalogue that can be used for management purposes has not been integrated yet. The increasing use of HDM-4 in the country has caused many of the conducted distress surveys to be adapted for meeting the requirements of that model, thus neglecting the collection of some distress modes whose measurement is essential for selecting appropriate treatments.
b) Deterioration models. Local experience regarding the development of pavement deterioration models is practically nonexistent. The advisability of setting up test sections to observe the progress of various pavement condition indicators over time has been stressed for several years, but no initiative has taken shape to date. Not even the applicability of relations such as those of HDM-4 has been formally analysed, and calibration exercises for relations like such are very limited. Damage appraisal for other asset classes has only been addressed as an important issue in academic forums.
c) Assessment condition procedures for asset classes other than pavements. Regarding this topic, in the case of bridges formal inspection procedures have been established and even been implemented through bridge management systems such as SIPUMEX. Although similar procedures have been developed for drainage or signs, in these cases the results have only been used for rating the overall condition of road sections. For the remaining asset classes the lack of assessment condition procedures constitutes a further limitation of management systems in the country.

Concerning tools for economic evaluation and prioritisation, the use of life-cycle and benefit/cost procedures are common practice though their application is observed more frequently in project feasibility studies than in medium-term programme analyses or in the identification of strategies for a longer time horizon. Additionally, the aggregation level of available data for some applications is not always the most appropriate.

A significant shortcoming related to economic evaluation and prioritisation is the lack of methods for optimal resource allocation across different asset classes or across roads belonging to different road networks.

Finally, with regard to risk analysis, although this procedure has started being used in developing reference projects for bidding on road concessions, it is usually not considered a formal stage in the road management process, which sometimes causes failure of programmes in scenarios such as budget cuts, increased costs or administrative or legal complications.

4.3. Lack of Education Programmes

In Mexico, road asset management is virtually absent from the undergraduate and graduate civil engineering curricula, which can be explained in terms of a weak demand for professionals in this area. In turn, this is due to the lack of a culture of asset management, thus creating a vicious circle from this problem.

In fact, civil engineering programmes from major universities offer limited coverage in road engineering courses, making interested candidates choose one of the few master's degrees available in the country. Understandably, these programmes rather address traditional topics of roads engineering, as illustrated in Figure 5.

Master's Degree in Terrestrial Ways	
COMPULSORY CORE SUBJECTS	**COMPULSORY SUBJECTS**
TRANSPORT ENGINEERING	PLANNING AND PROJECT EVALUATION
STATISTICAL QUALITY CONTROL	GEOTHECNICS I
APPLIED MATHEMATICS	GEOMETRIC DESIGN OF TERRESTRIAL WAYS
TRAFFIC ENGINEERING	PAVEMENT DESIGN
SURFACE AND DRAINAGE HYDROLOGY	GEOTHECNICS II
	AIRPORT PLANNING AND DESIGN
	SEMINAR ON RESEARCH METHODOLOGY
	ELECTIVES
	SYSTEM ANALYSIS
	BRIDGE ANALYSIS AND DESIGN
	TUNNEL ENGINEERING
	WORKS ASSESSMENT AND MAINTENANCE TECHNIQUES
	WORKS PROGRAMMING AND CONTROL
	BRIDGE INSPECTION AND ASSESSMENT

Figure 5 - Master's degree programme in Road Engineering.

Programme in Figure 5 includes only three subjects directly related to road asset management: "Planning and Project Evaluation, Works Assessment and Maintenance Techniques" and "Bridge Inspection and Assessment". From these only the first listed is compulsory.

On the contrary, in recent years the demand for courses on software tools for pavement management has increased, in line with the growing interest of road organizations in these tools. The challenge, then, is to reorient this interest towards asset management courses and specialisation and graduate programmes so that demand for a more formal education on asset management starts growing.

5. ROLE OF THE MEXICAN TRANSPORT INSTITUTE

Derived from its functions, the Mexican Transportation Institute could play an important role in addressing the challenges that our country is currently facing in implementing asset management systems. In this sense, some activities that could be performed by the IMT in the near future are:

a) Organise the dissemination event on basic principles of asset management for managers and the seminar on international experiences suggested in paragraph 2.4. The latter could be organized as a PIARC seminar in 2012.
b) Encourage the integration of the national committee for asset management homologous to the PIARC technical committee, share within this committee the experiences related to asset management gained through the various projects developed in this area and participate in designing solutions to the problems posed by the implementation of asset management in the country.
c) Propose and participate in specific projects that address the challenges faced by the Secretariat of Communications and Transport in implementing this framework and in integrating institutional information systems and analysis tools.
d) Integrate working groups to develop standards for using pavement evaluation equipment and creating road databases.
e) Propose and participate in projects aimed at overcome the existing limitations in using the various technologies involved in asset management.
f) Include permanently in its training programme courses that address topics of this area.
g) Promote the offer of continuing education and graduate programmes in asset management within universities and collaborate with them in the design of these programmes.

The IMT's infrastructure management working group is a very small group so, in several cases, it will only be able to act as a promoter until bigger groups can be integrated.

6. CONCLUSIONS

The following conclusions can be obtained from the discussion in previous sections:

a) The implementation of asset management dissemination campaigns together with the promotion of academic programmes could contribute to the development of an asset management culture among Mexican road engineers, which, in turn, might help overcome the existing confusion about the concept of a management system and raise awareness about the importance of the organisational aspects of asset management.
b) The roads entity within the Secretariat of Communications and Transport has a structure in which coexist areas whose origins date back to the period of greatest expansion of the road network and others created to face the current challenges of the federal network development. This organisational arrangement creates obstacles for the formal application of asset management that might only be eliminated through a re-engineering process of this entity.
c) Other challenges related to asset management include the following: formulate standards for the use of high performance equipment and the integration of road databases; have the technical staff involved in the development of information systems so that the organisation business rules are adequately modelled; overcome shortcomings related to the characterisation and modelling of deterioration for pavement and other asset classes; develop or adapt formal methods for resource

allocation across asset classes or roads belonging to different road networks; incorporate risk analysis as a formal step in infrastructure management.

d) Taking into account its functions, the Mexican Institute of Transport could collaborate in several of the actions required to promote the development of asset management in Mexico.

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