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ASSET MANAGEMENT: TECHNICAL INPUTS TO DECISION MAKING

R. SOLORIO, P. GARNICA, R. TÉLLEZ, R. AGUERREBERE, R. HERNÁNDEZ
Mexican Transport Institute, San Fandila, Querétaro, Mexico
rsolorio@imt.mx, pgarnica@imt.mx, rtellez@imt.mx, raguerrebere@imt.mx,
rihernan@imt.mx

ABSTRACT

A general description concerning the current use of technical information in Mexico as an input to the decision making processes related to roads preservation and improvement is presented in this paper. The first part of the document provides a background on the main activities carried out by road authorities and other actors to promote the deployment of infrastructure management systems. In this section, particular attention is paid to those projects undertaken by the Transport and Communications Ministry (SCT) leading to systematically analyse the maintenance and upgrading needs of the federal trunk network. The role played by the Mexican Transport Institute (IMT) in supplying guidelines for systems development, offering training activities and providing consultancy services is also addressed. IMT is a transportation research centre dependent on SCT. Subsequent sections of the document present the results of an opinion survey conducted among road officials in order to bring together their perceptions about topics such as technical data being acquired by their organizations, relevance attributed to that information as part of decision making, deployed management systems, preferred approaches for road maintenance and institutional provisions required for systems implementation. Background information, in conjunction with that collected by means of the opinion survey, is then used to discuss the integration of technical inputs into the decision processes of road organizations in the country. Final sections are dedicated to present the conclusions and references of this work.

1. BACKGROUND

Mexico's national road network has a total length of approximately 350,000 km, including 48,000 km (14%) of paved trunk roads administered by the federal government through the Transport and Communications Ministry (SCT), 74,000 km (21%) of secondary roads managed by state governments, 160,000 km (46%) of low-volume rural roads managed mainly by SCT and 67,000 km (19%) of improved breaches (Martínez, 2000). 14% of trunk roads (almost 7,000 km) correspond to toll motorways and 81% (60,000 km) of state roads are paved.

Road infrastructure management systems have been a matter of interest for Mexican road authorities, operators, consultants and researchers for more than 15 years. The Mexican Transport Institute (IMT), a research centre dependent on SCT, has carried out since its creation in 1987 a number of studies on the subject, including the development of methodologies and software that have been incorporated into products such as the Mexican Pavement Management System (SIMAP) (Téllez, 1990), SIMAP Economic Analysis (Solorio, 1993) and Geographic modules (García, 1997), the Pavement Evaluation System (Téllez, 2002), the Bridge Management System (Barousse, 1997) and the Accident Data Acquisition and Management System (SAADA) (Uribe, 2000). All these efforts resulted in working tools, though its main purpose has been to provide road organizations and consultants with some guidelines to undertake their own developments.

In addition to the above projects, IMT have offered through the years a number of training courses in various topics related to road management, including conceptual issues, data acquisition procedures and equipment, pavement condition assessment, project evaluation, planning and programming. HDM-III and HDM-4 models, as well as the specific tools developed by IMT, have also been covered in these courses.

The SCT being the main responsible for the federal network administration, its work on road management accounts for the most significant part of the country actual experience on this discipline. In 1993, SCT started using the Road Maintenance Strategies Simulation Model (SISTER) to support the planning and programming of road maintenance and rehabilitation activities. This model, developed by an external consultant, allows for conducting straightforward comparisons of maintenance policies without requiring large amounts of information to describe pavement attributes (Escalante, 2002). SISTER inputs include data on road geometric design, drainage condition, topographic features, traffic levels, climate zones and pavement damage. The model analyses this information in conjunction with user-defined strategies to construct several pavement behaviour scenarios dependent of the level of funding associated with each strategy.

Road data needed by SISTER is gathered through SCT state offices which have allocated specialised technicians to perform annual visual surveys of sections under their respective jurisdictions. This national organization for road monitoring is one of the most remarkable accomplishments of SISTER implementation. As part of annual surveys, pavement condition is rated using a “quality note” for structural adequacy and a “roughness note” for ride comfort. Both notes represent somehow subjective measures which are obtained by evaluators following a standardised procedure that takes into account existing pavement distresses, among other factors, and are two of the most influential parameters involved in SISTER methodology. Local surveyors also provide SISTER operators with estimates of pavement maintenance and rehabilitation requirements, which are used as basis for delineating the strategies to be evaluated.

During the last 13 years, SCT has been using the SISTER model to improve the toll-free federal subnetwork maintenance planning and programming, to present and justify funding needs to political authorities and, as a result, improve gradually the overall condition of this part of the national network. According to SCT (DGCC, 2006), in the 1994-2005 period the percentage of federal toll-free roads in good to fair condition increased from 43 to 79% and, correspondingly, poor condition roads have passed from 57 to 21%.

In 2001, SCT decided to start a process for discontinuing SISTER use in favour of PIARC HDM-4 model. Reasons for making such a decision include the following: a) Overcoming licensing limitations that prevent SISTER from being applied directly by SCT state offices; b) Taking advantage of modern high performance equipment to obtain pavement condition indicators; c) Replacing subjective measures such as the quality and roughness notes with worldwide accepted pavement response parameters, e.g. the International Roughness Index (IRI), rut depth and pavement deflections. As part of this process, a database system for managing the information needed by HDM-4 has been developed.

In the course of 2006 SCT granted several contracts to private consultants in order to collect IRI and deflection data throughout the toll-free trunk network which, complemented with pavement distress information coming from the visual inspections of state offices, will allow for preparing the first HDM-4-based programme for this entire subnetwork and compare it to this year SISTER’s results.

SCT has also made efforts to apply systematic management techniques to other components of road infrastructure maintenance and operation. The Mexico’s Bridge System (SIPUMEX), a bridge management system based on Danish DANBRO system, has been used since 1992 to assist the Ministry in performing tasks such as bridge inventory, routine inspection, load-bearing capacity calculation and bridge rehabilitation design. Likewise, SCT state offices have been using SAADA to organize and exploit information about accidents occurring in the federal network.

“Caminos y Puentes Federales de Ingresos y Servicios Conexos” (CAPUFE) is an agency of the federal government responsible for operating the largest portion of the 7,000 km constituting the federal toll roads subnetwork. In the late nineties, CAPUFE carried out projects to develop pavement and bridge management systems respectively adapted from IMT SIMAP and SIAP. Though full-featured software tools resulted from these projects, which allowed for collecting and analysing initial datasets, no institutional provisions were made to ensure continuous monitoring of network condition and, therefore, use of these systems were finally discarded.

In 2004, CAPUFE required IMT technical assistance to design and develop an integrated road management system built upon the principles of transportation asset management. As a result, an agreement was signed to conduct a pilot study for initially setting up a pavement management system based on Geographic Information Systems (GIS), dynamic segmentation of roads for condition assessment and the use of the HDM-4 model. Although the scope of the study was constrained to pavement management, the addition of modules for managing bridges, signs and other infrastructure components, as well as operational issues such as accidents, was taken into account in system design. Network length covered in the study included approximately 400 km corresponding to the three most important motorways operated by the agency.

IMT specifically supported CAPUFE in gathering information stored in documentary sources, preparing detailed specifications for pavement condition evaluation using high performance equipment, overseeing field studies, implementing system database and software tools and running the HDM-4 model.

By mid 2006, the pilot study described above produced its first results, basically a HDM-4-generated maintenance programme for the three motorways addressed in the study. The accuracy and consistency of this programme is currently being evaluated by CAPUFE, which is also taking steps to get the necessary funds for continuing system development, extending its coverage and reorganising the administrative areas involved in its application.

At the same time, there is evidence of CAPUFE regional offices asking contractors to justify their proposed maintenance and rehabilitation solutions through HDM-4 project analyses based on pavement condition surveys. Even though this practice is not linked to the application of the HDM-4-based pavement management system being developed jointly with the IMT, it reflects the concerns of local officials about adopting a more rational approach to pavement preservation and upgrading.

With respect to state and municipal road administrations, despite that they have repeatedly expressed varying levels of interest in adopting or developing road management systems, few of them have undertaken specific projects, being the shortness of funding and the lack of technical expertise the main reasons exposed to postpone studies related to field data acquisition or systems implementation. However, there are some remarkable efforts in place, for instance, a multiyear project performed by the state of Guanajuato, with the support of the local university, to integrate a pavement management system also relying in the HDM-4 model. According to the state government, this project has an overall progress of 60%.

As a result of the rising demand of road authorities to conduct automated field surveys, in recent years the number of contractors offering data collection services based on equipment such as laser profilometers, falling weight deflectometers, vehicle-mounted digital cameras and ground penetrating radars have been steadily increasing, though national availability of this equipment is still marginal when compared to the potential demand.

2. MANAGERS SURVEY

In order to collect the current perceptions of decision makers about the topics this document deals with, a questionnaire for managers was prepared and distributed among a number of SCT, CAPUFE and state and municipal officials. Questions covered information being gathered, systems in use, relevance attributed to both information and systems, and decision makers perceptions about the implications of management systems in the operations of their organizations.

A total of 45 questionnaires were sent, comprising 4 to SCT headquarters, 31 to SCT state offices, 2 to CAPUFE and 8 to state and municipal governments known to have some specific work in progress about road management systems. 3 answered questionnaires came back from SCT headquarters, 21 from SCT state offices and 4 from state and municipal governments (28 in total). Replaying SCT central offices were specifically the following: a) Road Preservation Head Office (DGCC), responsible of SISTER operation and HDM-4 implementation; b) Road Development Head Office (DGDC), which monitor toll road operators performance, among a variety of other functions; c) Technical Services Head Office (DGST), an area specialised in providing highway engineering services to the entire road sector of the federal government, particularly in those aspects related to evaluating the technical feasibility of new construction and reconstruction projects. Local representations of DGCC and DGST exist in each of SCT state offices.

It must be noted that, according to the above figures, most of the questionnaires were sent to and answered by both central and regional offices of SCT. Thus, information resulting from this opinion survey largely reflects the current practice of road maintenance management concerning the federal free-toll network, which is administered by SCT, as stated before.

The next sections are devoted to presenting and discussing opinions pulled together.

3. ISSUES RELATED TO TECHNICAL INFORMATION BEING COLLECTED

The conducted survey included questions intended for verifying road components involved in data acquisition initiatives, identifying the specific indicators of pavement condition being measured and assessing the perceptions of inquired managers about technical information relevance. Answers to these questions are summarised in Figures 1 to 3.

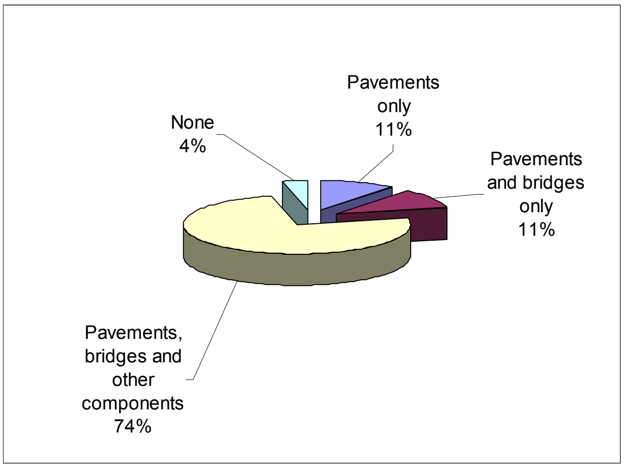

Figure 1 - Road components involved in data acquisition initiatives

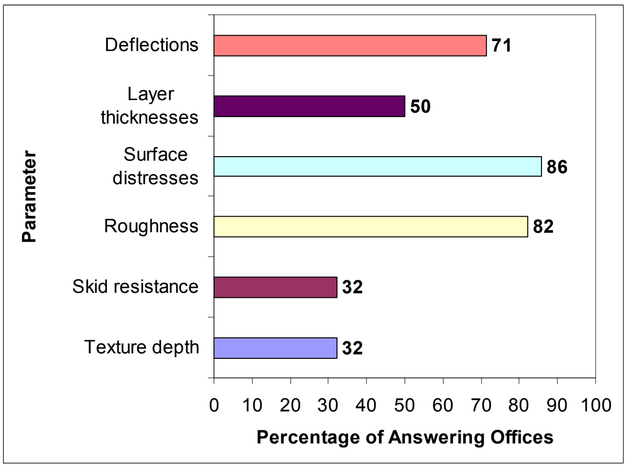

Figure 2 - Indicators of pavement condition being measured

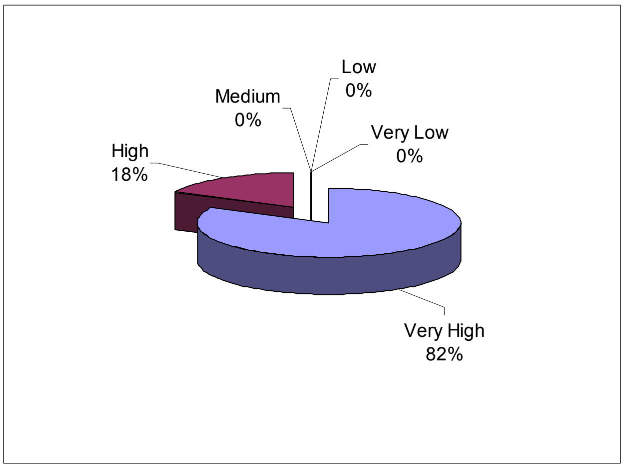

Figure 3 - Importance assigned to information as an input to decision making.

As illustrated in Figure 1, 74% of managers reported that their offices are collecting information about pavements, bridges and other infrastructure components. This percentage includes DGCC, DGST, 18 of the 21 responding SCT state centres and one local government. The remaining answers showed that 3 SCT centres are gathering data for pavements and bridges only, and that road monitoring activities of DGDC and two other local governments comprise only pavements. A single “none” answer came back from a municipal agency.

With reference to Figure 2, replies about the indicators of pavement condition being collected allow to state the following:

a) 82% of answering offices have measurements being made for IRI and 86% for surface distresses. Four SCT state centres and one municipal agency are not conducting roughness surveys, whereas DGDC and DGST, along with a single SCT centre and the same municipal agency, do not perform surface distress appraisals.

b) 71% are acquiring pavement deflection data. This percentage includes DGCC, DGDC, DGST, 16 SCT local centres and a state agency.

c) 12 SCT local centres and 2 state governments (50% of responding offices) reported that they are determining the thicknesses of pavement layers.

d) 32% are assessing skid resistance and texture depth. The first parameter is being measured by DGST and 8 SCT state centres, while 9 of these centres were the only offices reporting texture depth being monitored.

Finally, according to Figure 3, significance of technical information as an input to decision making was considered "very high" by 82% of replying officials and "high" by the remaining 12%.

In summary, answers to questions related to technical information evidence that, on the one hand, road condition surveys for the toll-free federal network have an adequate level of coverage to support the planning and programming of maintenance activities and, on the other hand, managers of federal, state and municipal offices involved in road preservation and upgrading generally regard technical data as a very important input to the decision making processes.

4. PERCEPTIONS ON ASSET MANAGEMENT SYSTEMS IMPLEMENTATION

The remaining questions included in the survey comprised various aspects of asset management systems. Firstly, officials were asked what road components and operational issues are being managed with the aid of systems, and what priority level would they assign to systems implementation. Answers to these questions are depicted in Figures 4 and 5.

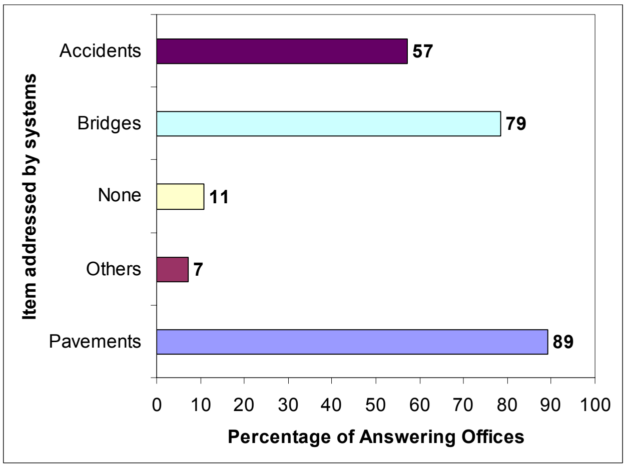

Figure 4 - Systems in operation for specific road components or operational issues.

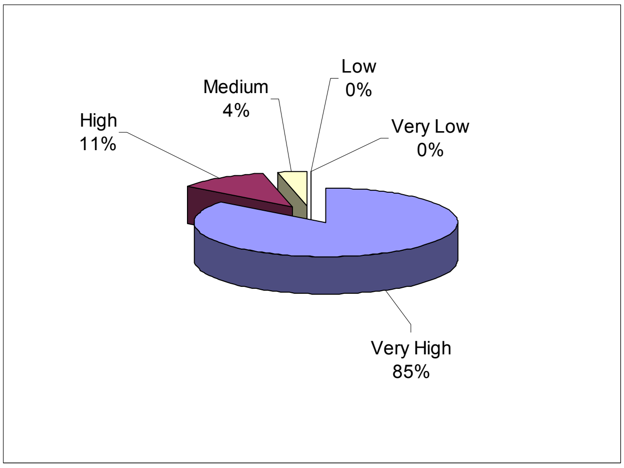

Figure 5 - Priority assigned to systems implementation

Figure 4 essentially represents the current use of infrastructure management systems throughout SCT national organization, as described in section 2 with respect to SISTER, HDM-4, SIPUMEX and SAADA. The "other" category refers basically to systems used by DGST to process traffic-related data, including volume, vehicle composition, origin-destination and weights and dimensions. With reference to systems implementation priorities, as shown in Figure 5, the vast majority of inquired managers considered this activity must be assigned "very high" (85%) or "high" (11%) levels of priority. 4% of answers assigning a "medium" level actually correspond to a single response coming from a municipal government.

Several questions attempted to find out managers conceptions about various asset management issues, including those referring to what the scope of systems application should be, the proposed approach to deal with road management and the institutional provisions that must considered when implementing systems.

In this part of the questionnaire, decision makers were asked to select among the ensuing options the definition of a pavement management system (PMS) that best matches their related perception: a) A computer system for evaluating technically and economically project alternatives and long-term policies for pavement preservation and improving; b) A set of institutional procedures and tools for planning and programming pavement preservation and improvement. The chart in Figure 6 portrays answers gathered for this question. The “b” option, intended to express currently accepted asset management principles, was the preferred option. Still, almost half of the answers (46%) corresponded to the more traditional view of a PMS as a mere computing tool.

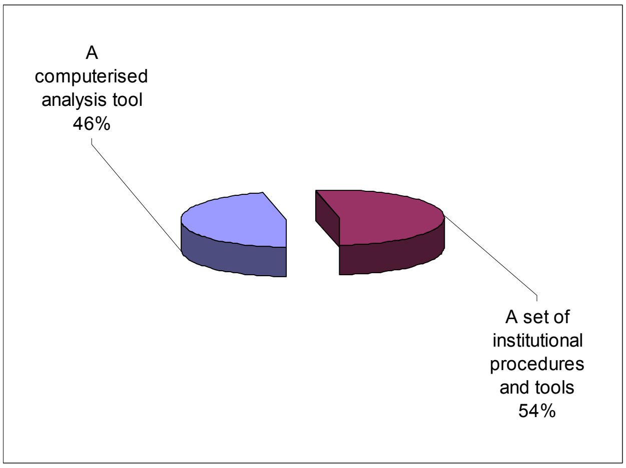

Figure 6 - Selected definition for a Pavement Management System

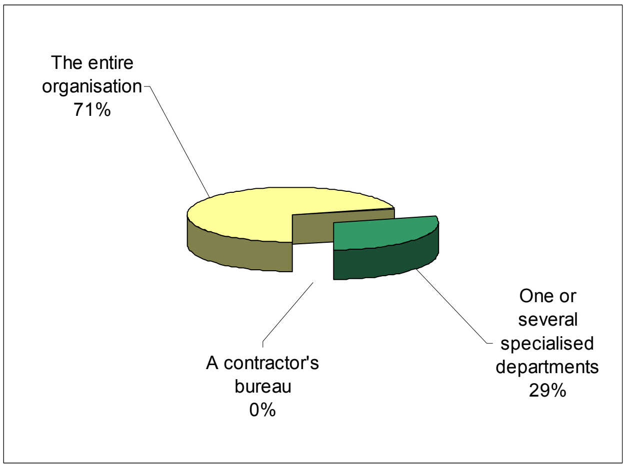

Figure 7 - Choices for the scope of systems application.

Regarding the possible scope for systems application, inquired officials were given the following options: a) The entire organization; b) One or several specialised departments; c) A contractor’s bureau. In accordance to Figure 7, all responding managers believe systems must be applied inside the road agency, with 71% considering their use should span to the entire organization and 29% that systems must be run by specialised departments. Again, the latter reflects a conservative view about the potential role of road management systems.

The next question was aimed at learning how various alternative approaches to road preservation and improvement would be rated by consulted executives. Options put into consideration were: a) Analysing requirements derived from the deterioration of each road component separately; b) Examining simultaneously requirements derived from the deterioration of all components; c) Addressing concurrently requirements derived from the deterioration of all infrastructure components alongside those concerning operational problems. As shown in Figure 8, the most favoured approach was to conduct a fully integrated analysis of road maintenance and improvement needs, which contrasts with the more conventional opinions expressed in the preceding answers.

Additionally, in order to capture perceptions about the institutional commitment involved in systems implementation, a list of specific provisions that might be made by organizations during this process was presented to managers. This list consisted of the following items: a) Personnel hiring for system operation; b) Computer equipment purchasing; c) Software acquisition; d) Contracting of condition surveys; e) Contracting of technical assistance services; f) Training; g) Organization reengineering. Figure 9 summarises the obtained answers. According to this Figure, the most selected item was training, with 96% of responding executives choosing it. Prevalent options also included condition surveys contracting (82%), software acquisition (71%) and computer purchasing (61%). Organization reengineering is one of the given options that more strongly relates to modern asset management principles. Since rating for this particular option was relatively low, an overall inclination of decision makers taking part in the survey towards a more traditional approach to road management could be confirmed.

A final question was posed as regards to survey participants' awareness of the currently accepted paradigm for transportation asset management. A single participant claimed to have a detailed understanding of this paradigm. For the other proposed knowledge levels, i.e. "on its most relevant issues", "superficial", and "none", incidence was respectively 32%, 25% and 39%. These answers, depicted in Figure 10, convey an overall level of knowledge on asset management principles that can be considered as inadequate.

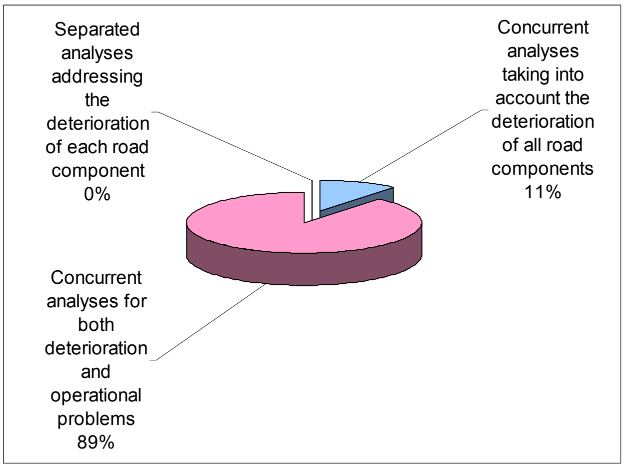

Figure 8 - Executive's preferred approaches for road preservation and upgrading

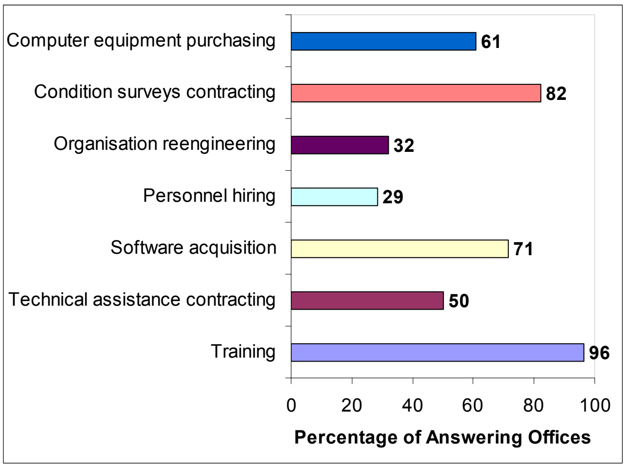

Figure 9 - Institutional provisions for systems implementation

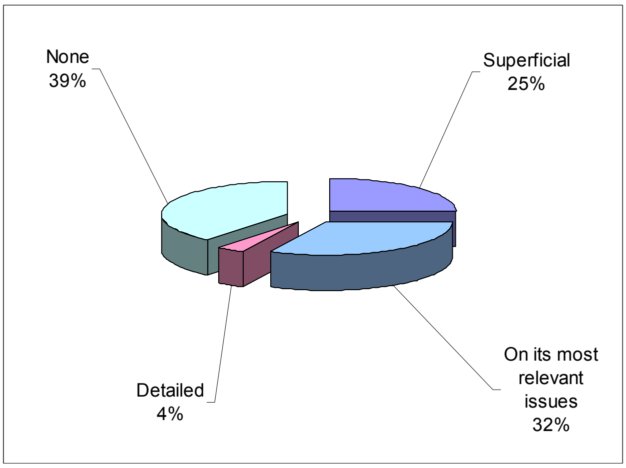

Figure 10 - Managers awareness of the asset management paradigm

5. INTEGRATION OF TECHNICAL INPUTS INTO THE DECISION PROCESS

Available documentary sources about the implementation of management systems in Mexico (Escalante, 2002), along with information obtained as part of IMT research and consultancy projects and data gathered through the managers survey described above, allow to state that technical information definitely plays a role in the decision processes linked to the federal trunk roads maintenance and upgrading. There is no evidence of this being the case for other components of the national network.

As mentioned in section 2, for the last 13 years SCT has been using the SISTER model to present and justify funding needs to political authorities and, as a result, gradually improve the overall condition of the federal toll-free network. Likewise, activities related to bridge maintenance has been systemised through the use of SIPUMEX, while additional efforts are in place to organize and exploit data on accident occurrence in the same network. In the latter case, ways to ease information flow and timely generate reports specifically designed to support decision making need still to be defined.

Concerning the federal toll network, it must be mentioned that roughness data annually collected by SCT Road Development Head Office is routinely used by the Ministry to evaluate the performance of operators including CAPUFE and some private firms to whom concessions have been granted. As for CAPUFE, the integrated road management system currently being developed jointly with IMT is intended to become the main source of information for decision making in the forthcoming years.

Although works in progress represent noticeable advances towards implementing decision making processes fully supported on technical information, some adverse factors exist that might prevent current initiatives to consolidate as part of modern asset management systems.

On the one hand, as illustrated in **Figure 6**, a significant portion of inquired managers (46%) consider pavement management systems as plain computer programmes, evidencing a misleading perception of software tools as the most important part of road management systems, which might considerably limit the impact of projects undertaken. On the other hand, according to results depicted in **Figure 7**, one third of consulted officials believe systems must be run inside specialised organization departments, thus overlooking the need of reviewing the current practices for the whole agency as part of systems implementation. This perception was further validated by findings about institutional provisions shown in **Figure 9**, particularly with respect to organization reengineering, acknowledged only by 32% of answering executives.

There is also a potential limitation of technical data currently being collected which refers to its accuracy, since no standard procedures have been defined to verify that measurement equipment used by contractors complies with road agencies specifications, especially those related to calibration. To overcome this limitation, an agreement has been made between SCT and IMT to have measurement equipment verified at IMT's facilities every time a contract is to be granted by the Ministry, CAPUFE or by other national road agencies.

Additionally, in accordance to system descriptions presented so far, the implementation of road management systems in the country has been accomplished using mainly a subsystems approach, that is, developing or adapting systems for each infrastructure component or operational issue (pavements, bridges, accidents and so on) separately without considering any interaction between them (De Solminihac, 2001). This practice reflects that the corresponding planning and programming processes are still being conducted independently. As is internationally recognised today, the integration of these processes is required to ensure the improvement of roads as a whole.

Undoubtedly, technical information is increasingly been used by road agencies managers as a support for selecting and assigning priorities to road projects. However, perhaps this information is still not reaching top level authorities within road organizations nor decision makers at the government institutions responsible of assigning and distributing funds. Furthermore, these officials seem to share the perception of management systems as computer programmes, so that funding requirements for continued road condition monitoring, information systems development, technology transfer and organization restructuring, are frequently regarded as excessive.

Finally, it must be pointed out that, as shown in **Figure 10**, knowledge of asset management principles assessed through the managers survey appear to be insufficient. Therefore, a national campaign to massively divulge such principles among transportation officials throughout the country should be recommended.

6. CONCLUSIONS

The following conclusions can be drawn from the brief discussion presented in this paper about road management systems in Mexico and from the survey conducted among road officials:

a) In the last decades, infrastructure management systems have been a matter of interest for Mexican road authorities, operators, consultants and the academia, bringing about a number of research projects, training efforts and systems deployments within road organizations.

b) Federal government agencies such as the Transportation and Communications Ministry (SCT) and toll roads operator CAPUFE are supporting the application of infrastructure management systems. In fact, through the use of PMS technology, in recent years SCT has managed to present and justify annual funding requirements to political authorities and to apply strategies that are producing a gradual improvement of the federal toll-free network. Hence, at least for that concerning the federal network, technical information is certainly being taken into account for decision making.

c) Despite that state and municipal road administrations have repeatedly shown interest in applying road management systems, there is little evidence of actual projects being developed.

d) Road agencies increasing initiatives to conduct automated road surveys are resulting in a rising number of contractors offering data collection services based on high performance equipment, though availability of this equipment is still limited when compared to the roads length that could be subject to this sort of surveys annually.

e) In general, transportation officials rate technical information as a high relevance input to decision making. Likewise, they consider that the implementation of asset management systems should be a matter of the highest priority for road organizations.

f) According to the conducted survey, some traditional views about asset management are still common, namely the following: i) Understanding road management systems as computing tools; ii) Restricting the scope of systems application to specialised departments; iii) Discarding organization reengineering as one of the institutional provisions that should be pondered by road agencies when considering systems implementation. These views might limit the outcome of projects undertaken.

g) Implementation of road management systems in Mexico has been accomplished using a subsystems approach, which reflects that the corresponding planning and programming processes are still being performed independently.

h) Although technical information is doubtlessly being used by road officials to support decision making, this information could be still not reaching top level authorities, thus limiting access to funds required for improving road condition and deploying systems.

i) Further actions by road authorities may be required to ensure that measurement equipment used by contractors is always properly calibrated when conducting field surveys.

j) Road management in Mexico could greatly benefit from a national campaign aimed at divulging current asset management principles along with worldwide actual experiences related to the application of information technology for supporting road management systems implementation.

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