Future Prospects for Pavement Management

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ABSTRACT: Pavement management is a process used worldwide. Its success has been achieved through continuing advancements and innovation, commitment, the ability to serve users at all levels and its importance as a key component system of overall road asset management. There are also continuing improvement needs, however, and they can be categorized as: technical, economic and life-cycle and institutional. A corresponding set of future prospects for meeting these needs are suggested in the paper, ranging from the development and tie in between policy objectives, measurable performance indicators and implementation targets to comprehensive knowledge management/succession planning involving people, information and technology. It is also suggested and demonstrated in the paper that long-term, public-private-partnership contracts for road networks offer significant potential in accelerating these future prospects. Finally, it is concluded that the process and practice of pavement management does indeed have a promising future.

KEY WORDS: Pavements, management, future, prospects

1 INTRODUCTION

Pavement management evolved from a concept in the 1960’s to initial applications in the 1970’s to the situation today where federal, state and local agencies worldwide have some sort of operational pavement management systems. In fact, some early technical articles in the late 1960’s, and the first books in the mid 1970’s (CGRA, 1977, Haas and Hudson, 1978), provide a good historical record of this era, and they provided a valuable foundation for the vast amount of ensuing development and applications of pavement management systems (PMS).

The questions for the future of pavement management, however, are that of whether or not additional major development work needs to be carried out, and/or whether the issues of an institutional, technical, economic and life cycle sense have been adequately addressed. It is the premise of this paper that these questions have not been sufficiently answered and that a lot of additional work is both necessary and justified.

More specifically, the purpose of the paper is to first highlight some of the key achievements in pavement management and why it is essential to develop a “culture” of continuing advancements and innovations over time. Success factors and the driving forces behind the future of pavement management systems, including their context within the broader area of asset management, are identified. Improvement needs in technology such as those related to longer lasting, better quality pavements and to economic, environmental and resource consideration factors are described. As well, institutional improvement needs, such as knowledge management and adapting PMS to Public-Private-Partnerships (“P3’s”) are discussed.

Future prospects and expectations for PMS, including quality of service, safety goals, asset valuation and preservation of investment, productivity and efficiency, communication, integration with asset management and the importance of measureable performance indicators are addressed. Finally, the scope and key elements of the ideal PMS of the future are suggested.

2 TOWARD A CULTURE OF CONTINUING ADVANCMENTS AND INNOVATIONS

A historical perspective on pavement management would suggest that there has been an inherent culture of continuing advancements and innovations. While numerous specific examples could be cited, a few but certainly not exhaustive highlights are:

- An all encompassing framework (including planning and priority programming in-service monitoring and evaluation, design of new pavements and rehabilitation, construction and maintenance), which was defined early (eg. In the 1970's) and has sustained for over four decades
- Major technology advancements in high speed, automated methods and equipment for pavement surveillance and data acquisition; also, availability of web-based performance data.
- Two decades of long term pavement performance (LTPP) data from the Strategic Highway Research Program (SHRP); this constitutes an enormous repository of information for pavement management (TRB, 2009).
- Integration of pavement management, as a major component system, within broadly based asset management at the strategic, network/system wide and project/site specific levels, and recognition of asset valuation as a key element.
- Advancements in pavement design, including the current AASHTO "Mechanistic-Empirical Pavement Design Guide"
- Widespread incorporation of life-cycle analysis in pavement design and management
- Recognition of the value of preventive and rehabilitative maintenance in pavement preservation.
- Worldwide growth in P3, long term performance based contracts.

2.1 Success Factors and Driving Forces Behind the Future of Pavement Management Systems

A recent, invited presentation on the future of PMS identified several major success factors which were relevant in the past and should continue to be so in the future (Haas, 2007)

- Clear context as a primary component management system within the broader base of asset management
- Commitment at all levels of the organization
- Ability to serve users promptly and reliably at all application levels
- Understanding the technology, plus its limitations, underlying the PMS
- A robust, reliable, up-to-date database
- Succession planning for not only people but also technology and information
- Adequate resources, including financial

The first success factor, context of pavement management within a broader asset management system for roads, can be illustrated by the framework of Figure 1. It indicates that the general principles of asset management apply to all levels, and that a decision support process plus training and knowledge management/succession planning functions should be included. Moreover, all the items and elements within the framework also apply to pavement management. Thus, generically, there should be a seamless integration.

Several driving forces are relevant to the future of pavement management systems, as schematically portrayed in Figure 2. Complementary to this is a definition of the future timelines involved, as suggested in Figure 3. Note that the captions at the top of this figure are meant as humour. Nevertheless it is not unreasonable to have a short term timeline of 10-30 years, medium of 30 to 70 years, and long term of 70 to 100 years plus, especially in view of a trend to long life pavements and to very long term life cycle analysis.

3 IMPROVEMENT NEEDS AND SHORT TERM FUTURE PROSPECTS

Improvement needs in pavement management are represented to a large degree by a myriad of research problem statements and ongoing research initiatives. For example, the Office of Asset Management of the U.S. Federal Highway Administration (FHWA) launched a project in late 2009 titled "Development of a Pavement Management Roadmap" (see FHWA Contract No. DTFHG1-07-0-00029). The intent is to provide direction for future research, development and technology transfer activities through identifying focus areas (eg., data collection, system performance, decision support, etc., etc.) and the gaps or needs that have to be addressed within these areas. Regional workshops scheduled for early 2010 will develop specific needs and problem statements within these focus or topic areas. Certainly the outcomes should provide the foundation for substantive advancement in the technology and practice of pavement management.

While the foregoing outcomes are still to be realized, it has been suggested that pavement management system improvement needs can be categorized as follows (Haas, 2007):

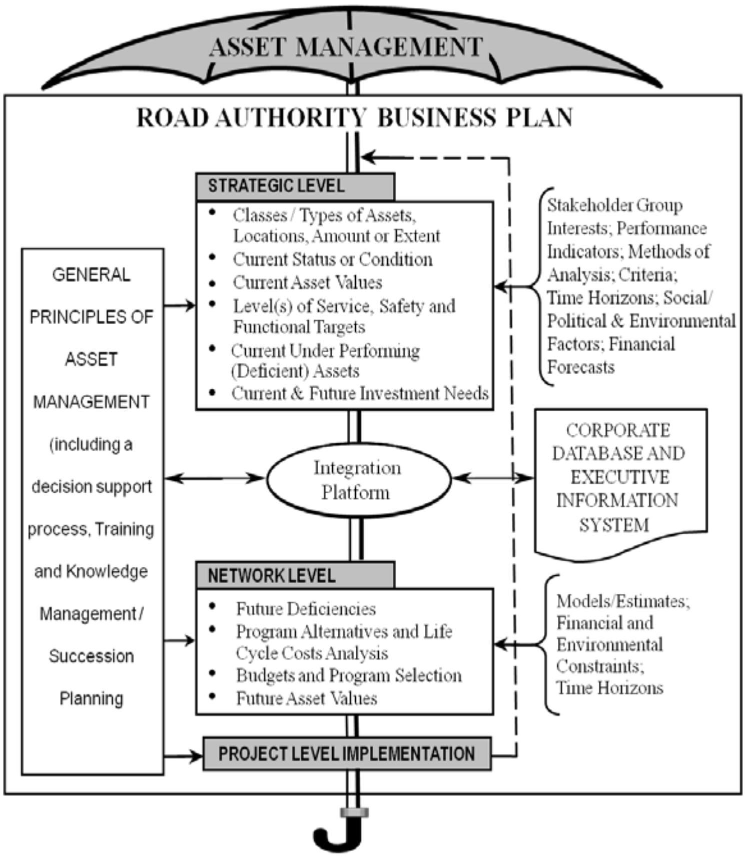

Figure 1: Overall Framework for Road Asset Management

Figure 2: Driving forces behind the future of pavement management systems

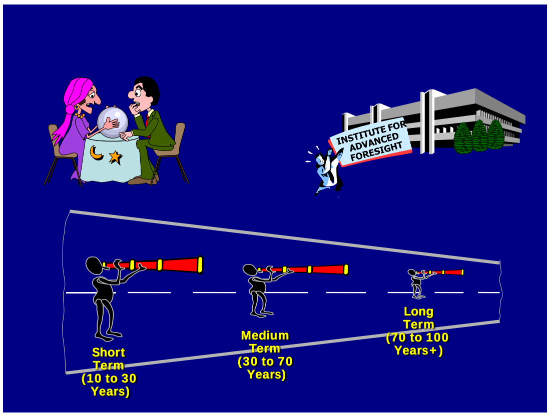

Figure 3: Time horizons for the future

Prospect	Likely	Uncertain	Wishful Thinking
• More P3's in long term network contracts	Yes	Yes	No
• Explicit policy objectives tied to measurable performance indicators and implementation targets	?	Yes	No
• Comprehensive integration platform tying "silos" together	?	Yes	No
• Extensive web-based availability of data and information	Yes	No	No
• Explicit requirements for reporting asset value	Yes	No	No
• Incorporating climate change, resource conservation, noise, etc. into PMS	?	Yes	No
• Substantive technical advances ("Smart pavements, nanotech applications, etc.)	Yes	No	No
• Widespread protocols for valuing PMS's, data bases, risk exposure, etc.	No	Yes	?
• Comprehensive succession planning (people, knowledge and technology)	No	Yes	Yes
• Adequate research funding to advance PMS	No	Yes	Yes
• Clear recognition and encouragement of the leaders of tomorrow	No	Yes	?

Figure 4: Example short term future prospects for advancements in pavement management

- Technical improvement needs, such as:
  - Longer lasting better quality pavements
  - Seamless interfacing of the strategic, network and project levels
  - Performance models which separate traffic and environmental effects
  - Making effective use of the long term pavement performance (LTPP) database (TRB, 2009)
  - Establishing data integration protocols
  - Establishing risk exposure procedures in assessing strategy alternatives
  - "Re-integrating" pavement preservation into pavement management
- Economic and life-cycle improvement needs, such as:
  - Quantifying the benefits of PMS and of component activities like data collection
  - Very long-term life cycle analysis protocols
  - Quantifying the benefits, or extra costs, of varying risk exposure
  - Incentive programs for improving PMS processes and application in both private sector and Public-private-Partnership (P3) contracts
- Institutional improvements needs, such as:
  - Guidelines for knowledge management and succession planning involving people, technology and information
  - Overcoming the challenges of institutional inertia (eg. barriers) to change
  - Seamless integration of PMS with asset management
  - Adapting PMS to P3's, particularly in long term network contracts
  - Establishing and integrating agency policy objectives with measurable performance indicators and realistic implementation targets

These example needs are the basis for further example future prospects in pavement management, as listed in Figure 4, which are to a large part the opinion of the author of this paper. The author has also taken the liberty of assigning a subjective likelihood rating to each prospect, ranging from likely to uncertain to wishful thinking.

The first two prospects in Fig. 4, more P3's in long term network contracts and policy objectives tied to measurable performance indicators and implementation targets have particularly high potential and are further discussed in the next section.

4 LONG TERM NETWORK CONTRACTS AND WARRANTY PROVISIONS

A general short term time horizon of 10 to 30 years has been suggested in Fig. 3. In the case of network P3 contracts involving pavements, however, ten years has been considered long term (Yeaman, 2007; Stankevich, et al, 2005; Haas, et al, 2008). There are few exceptions, with the extreme being a 99 year concession on the express toll road bypass of Toronto, Canada (ETR 407) in 1999 (Mylvaganam and Borins, 2004). Institutional barriers, financing aspects and service life considerations for pavements are certainly factors in determining the life of a P3 contract.

A key objective in P3 contracts should be to maximize benefits to both the agency and the contractor. Table 1 provides fifteen such items relevant to the key objective.

Table 1: Keys to Maximizing Benefits in Long Term Performance Based Contracts

Key Item	Applicable to			
	Pre Contract	Ongoing	Agency	Contractor
1. Obtain clear and unequivocal commitment of senior agency staff	√	√	√	
2. Review the experience of others including frank disclosures of what went right and wrong	√		√	√
3. Establish rigorous, objectively based pre-qualification criteria	√		√	
4. Define the work and/or performance requirements in clear, objective terms	√	√	√	√
5. Perform an accurate inventory of the assets and assessment of their condition	√			
6. Don’t mix end-result requirements with performance requirements	√	√	√	√
7. Understand and define the relative assumptions of risk involved in the contract	√	√	√	√
8. Utilize any existing agency management systems (bridge, pavement, sign, etc.) as possible	√	√		√
9. Utilize any “surplused” personnel from the agency who bring appropriate skills and knowledge		√		√
10. Provide on-line access for agency to contractor data base	√	√		√
11. Develop a reward procedure for innovation	√	√		√
12. Develop a clear, well defined dispute resolution procedure	√	√	√	√
13. Clearly understand the political climate and motivations	√	√	√	√
14. Harmonize the agency and contractor ongoing performance measurement method and procedures	√	√	√	√
15. Realistic policy objectives on the part of the road authority which are linked to performance indicators and implementation targets	√	√	√	√

4.1 Developing Policy Objectives, Performance Indicators and Implementation Targets

A major part of the 7th International Conference on Managing Pavement Assets, Calgary, June 2008, “The ICMPA Investment Analysis and Communication Challenge for Road Assets” (www.icmpa2008.com) involved a network of:

- 1293 pavement sections in two road classes, 3240 center line km in length and varying in traffic use, surface age and condition
- 161 bridges of two basic types
- 356 culverts
- 45 major signs

Terms of reference for the Challenge included a comprehensive, long term data base, plus, for the pavement network portion, the following:

- Highway number and type, section identifier, drainage, width, pavement and base type and thickness, year of construction and last rehabilitation or preventive maintenance treatment, current condition (including IRI) and distress data, and estimated needs/trigger year
- List of rehabilitation and preventive maintenance treatment options, and a decision tree for selection for various combinations of factors
- Unit costs, expected service lives, improvement in IRI for implementation of each treatment- road type combination and annual rate of increase of IRI for each combination
- Five vehicle types, AADT for each type for each road section, ESAL estimates
- Vehicle operating costs vs. IRI relationships

The Challenge provided an opportunity to develop realistic policy objectives, performance indicators and implementation targets. In turn, these provide the basis for long term performance based or warranty based contracts.

The framework is hierarchical, as schematically illustrated in Figure 5, where the policy objectives should be derived from the agency's mission statement and a range of relevant factors including stakeholder considerations. In fact, stakeholder considerations are also directly relevant to development of policy objectives, performance indicators and implementation targets, as subsequently described in the following.

Figure 5: Hierarchical Structure for Development of Operational Warranty/Performance

The development of realistic policy objectives for road asset management, including pavement networks, should be focused on the following main aspects:

- Consider the interests of stakeholders and other relevant factors
- Use quantifiable performance indicators for controlling the quality of service delivered to the user
- Establish achievable implementation targets

Examples of policy objectives, performance indicators and implementation targets are listed in Table 2. These have been adapted from the "Investment Analysis and Communication Challenge for Road Assets" in the 7th International Conference on Managing Pavement Assets (Haas, 2008).

The "Challenge" contains a real life data base for two classes of highways, interurban and rural. It presents an opportunity to compare, for example, the implementation target of quality of service to users in terms of smoothness in Table 2. Figure 6a shows that the interurban network, consisting of freeways and major arterial highways has more than one third as excellent ($IRI \leq 1.0$), about one quarter as good ($1.5 \geq IRI > 1.0$), one fifth as fair ($2.0 \geq IRI > 1.5$) and less than 10% as poor. Thus, the target of having 90% of the network in fair or better condition with regard to smoothness (Table 2) is met by the interurban network.

Table 2: Suggested Institutional Policy Objectives, Performance Indicators and Example Implementation Targets

Police Objectives	**Performance Indicators**	**Implementation Targets**
1- Quality of Service to Users	• Network level of service (smoothness, functionality and utilization) - % good, fair and poor • Provision of mobility (average travel speed by road class) • Annual user costs ($/km)	• Maintain Network at 90% or greater in Fair or Better Category ($IRI \leq 2$) • Greater than 50% of speed limit • Total user costs/total network km increase at no more than CPI
2- Safety Goals	• Accident reductions (%)	• Reduction of fatalities and injuries by 1% or greater annually
3- Preservation of Investment	• Asset value of road network ($)	• Increase (written down replacement cost) annually of 0.5% or greater
4- Productivity and efficiency	• Cost effectiveness of programs (ratio) • Annual turnover (%)	• 1% or greater annual increase • 5% or less annually
5- Cost recovery ($)	• Revenues	• Annual increase at no less than rate of inflation
6- Research and Training	• Expenditures (% of budget)	• Annual commitment of 2.5% of total program budget

7- Communication with stakeholders	• Satisfaction survey sampling (%)	• Greater than 75% of respondents satisfied or very satisfied
8- Resource conservation and environmental protection	• Recycling of reclaimed materials (asphalt, concrete, etc) - % • Monitoring of emissions	• Maintain at 90% or greater • Maintain at levels < 90% of standards
9- Bridges	• Remaining life (years • Safety	• No bridge with remaining life less than 5 years • Comprehensive programme of periodic inspections to identify any risk

Figure 6b shows the distribution of IRI for the rural network, consisting of lower volume arterial and collector highways. It may be inferred that about one quarter is excellent, one third good, one fifth as fair and a little more than 10% as poor. Also it is slightly below the target of 90% of the network being in fair or better condition.

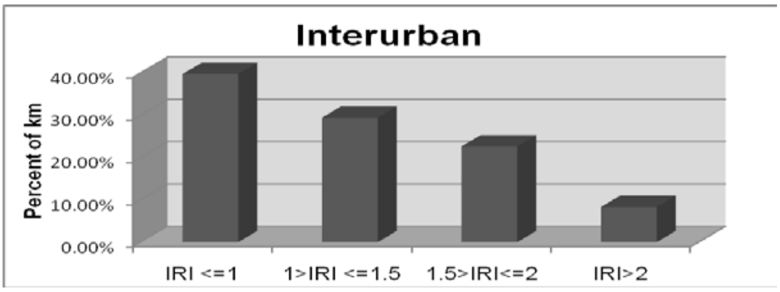

Figure 6a: Distribution of IRI Values from the “Challenge”: Interurban Sections

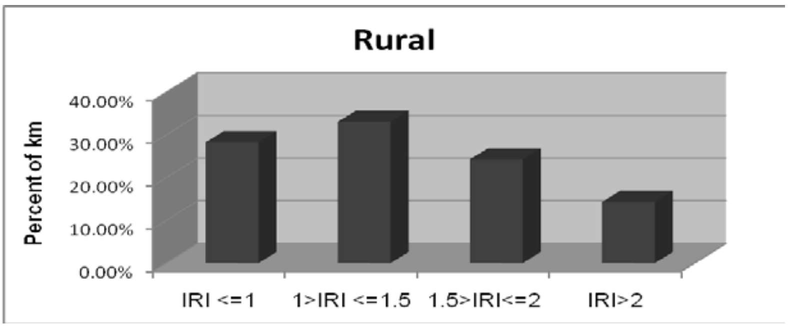

Figure 6b Distribution of IRI Values from the “Challenge:: Rural Sections

5 CONCLUSIONS AND IDEAL PMS OF THE FUTURE

Pavement management has evolved to a widely applied process worldwide. There is every reason to expect that the future will see advances and continued application as a key component of overall road asset management. Realization of this future will depend in large part on commitment, on technical, economic and institutional improvements and on adequate resources. Long-term, public-private-partnership (P3's) contracts for road networks offer a high degree of potential for accelerating these improvements. Finally, based on evolution and successful application of the pavement management, and on realistic future prospects, it is entirely reasonable to expect a promising future for pavement management, with an ideal PMS of the future suggested in Figure 7.

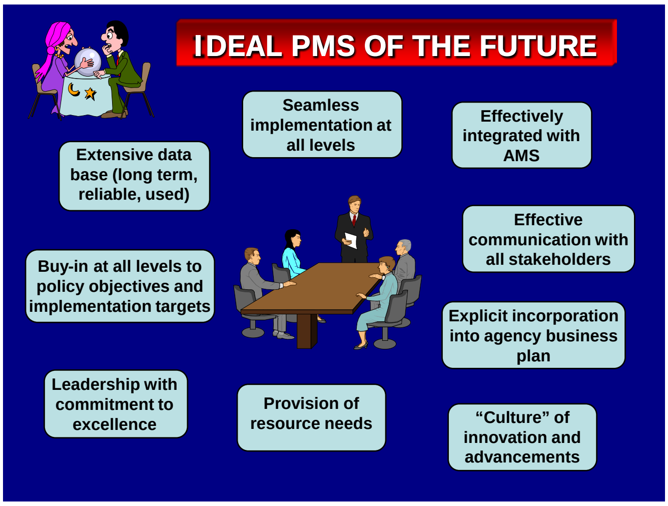

Figure 7: Key Elements of an Ideal PMS of the Future

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