

Long Term Warranty Provisions for Sustained Preservation of Pavement Networks

Ralph Haas

Center for Pavement and Transportation Technology
Department of Civil and Environmental Engineering
University of Waterloo
haas@uwaterloo.ca

Susan Tighe

Center for Pavement and Transportation Technology
Department of Civil and Environmental Engineering
University of Waterloo
sltighe@uwaterloo.ca

John Yeaman

Chairman, Pavement Management Services Pty
Sydney, Australia
jyeaman@pavement.com.au

Lynne Cowe Falls

Schulich School of Engineering
University of Calgary
lcowefal@ucalgary.ca

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ABSTRACT

The use of long term warranty or performance based contracts (PBC's) for periods of 10 years or more has proven to be an effective means for sustained preservation of pavement networks. A transfer of risk to the contractor is involved, but there is also increased potential for innovation.

There are several keys to maximizing benefits to both the agency and the contractor in long term PBC's and they range from commitment by both parties to objectively based, measurable performance criteria or warranties to harmonized measurement methods. As well, it is important that the agency has established realistic policy objectives which can be linked to performance indicators and in turn to implementation targets/warranties.

A real world network example from the June 2008 International Conference on Managing Pavement Assets in Calgary provides a comprehensive set of policy objectives – performance indicators – implementation targets and demonstrates that they can in fact be achieved.

Another example from a 10 year PBC shows that the original pre-contract targets for network roughness, rutting, cracking and structural adequacy were realistic in that they were met or exceeded at the end of the contract period.

These examples, and other evidence, clearly demonstrate that long term performance based contracts for pavement networks can provide significant benefits to all stakeholders and that well founded realistic warranties/implementation targets are key to success.

INTRODUCTION

The pioneering work on long term warranty or performance based contracts for pavements was initiated on a network in New South Wales, Australia, in 1995(1). It involved a period of 10 years, 2115 lane-km, 185 bridges and 672 traffic signals. The key performance indicators (KPI's) were grouped into Safety, Serviceability and Sustainability, with specific KPI's being objectively based, measurable and being assigned defined intervention levels and/or levels of service criteria. Preservation of the assets was an overriding objective. While the contract approach was termed performance specified maintenance, it should be noted that it comprised all expenditures (eg. capital, such as rehabilitation, plus preventive and corrective maintenance).

Another approach to warranty based contracts, often within public-private-partnerships ("P3's"), involves concessions, for periods of up to 30 years or more. This approach has seen widespread use in South America, Central America, some Asian countries, Europe and North America. Concessions have often involved toll roads, or "shadow tolls" and specific highway links or routes rather than networks.

It is contended, however, that the value of long term performance based warranty contracts can be more fully realised on pavement networks and thus the focus herein is on networks.

The overall purpose of this paper is to discuss the scope and basic characteristics of long term performance or warranty based network contracts, and to provide examples. More specifically, the objectives are to:

- Describe a context and framework for long term, network contracts, including categories of contracts, relative degree of risk, assets involved and keys to maximizing benefits.

- Present a set of suggested policy objectives linked to performance indicators which are linked in turn to implementation targets/ criteria/ warrants, and to provide a case example comparison from a large size pavement network.
- Present an additional example set of (pre-contract) warranty/ performance guarantees from a 10 year performance based contract for some 2,000 km of roads, and an assessment of whether the warranties were realistic in terms of actually being achieved at the end of the contract period.

CONTEXT AND FRAMEWORK FOR LONG TERM NETWORK CONTRACTS

The traditional models for road network maintenance have ranged from carrying out the work in-house to private sector contracts for routine maintenance on a schedule of rates basis. In the past two decades, several other models have evolved; they are categorised, with examples and discussion of their pros and cons, in Ref (2), as follows:

- Privatized or outsourced road maintenance- generally refers to contracts of 5 yrs, sometimes renewable, for preventive, corrective and emergency maintenance work.
- The pioneering authority in Canada is British Columbia, starting in 1987 with all 28 districts and a network of 42,000 km of roads and over 2,800 bridges. In fact, a comprehensive World Bank review of performance based contracting gave considerable attention to the B.C initiative (3).
- Competitive highway maintenance – refers to the private sector and the public agency maintenance forces competing for the work. This is not a common approach but has apparently seen some success in Massachusetts, starting in the mid 1990's (2).
- Legislated competitive maintenance – refers to a mandated percentage of the maintenance work to be awarded to the private sector. Again, this is not a common approach, but Texas legislation, starting in 1989 and updated in 1997, illustrates the approach (2)
- Privatised highway asset management and maintenance – the state of Virginia, starting with 250 center line miles of Interstate highways in 1996, a contract period of five and a half years and the contractor bearing full risk (4), is an excellent example of this approach.
- Long term performance based maintenance – has primarily been defined by initiatives in Australia and New Zealand where the term maintenance is all encompassing. In other words, it involves emergency, corrective, preventive and rehabilitative maintenance (there is no separate capital budget for rehabilitative work, as in all the others noted above). Moreover, long term means up to 10 years or more (1,2)

Figure 1 is a schematic illustration of the relative degrees of risk for the foregoing categories of network contract approaches. The in-house approach is included for comparative purposes, and because it is an alternative.



Figure 1 Relative Degree of Risk for Various Categories of Contract Approaches

The most comprehensive, current context and examples for world wide warranty contracts, using the term “Performance Based Contracts” (PBC’s) is available from the World Bank’s “Resource Guide for Performance-Based Contracting” (<http://www.worldbank.org/transport/roads/resource-guide/index.html>). Included are (Feb., 2008), power point presentations by Dr. Cesar Queiroz on U.S. Case Studies and various other information on PBC’s. it is noteworthy that an essential component of the PBC’s is performance assessment and the key performance indicators (KPI’s)/ criteria/ standards involved.

The major elements of a strategy decision framework to adopt a long term performance based contract approach for road networks are shown in Figure 2, from the owner/ agency perspective. Asset management and delivery on the contractor’s part are not shown (the World Bank’s website previously noted provides comprehensive sample contract details). While the focus in this paper is on pavements, a road network, performance based contract would likely include fixed assets within the Right-of -Way (ROW), fixed and unfixed assets outside the ROW and possibly other non-physical assets outside the ROW, as subsequently listed and described in Ref (2).

The driving forces or rationale behind the strategy decision could include: (a) increasing public agency commitment to outsourcing, (b) performance or warranty specifications as a preferred means of service delivery, (c) increased assumption of technical expertise on the part of the private sector, (d) desire on the part of public agencies to reduce their risk exposure, and (e) lack of interest on the part of policy makers for involvement in technical matters and developments (2,5)

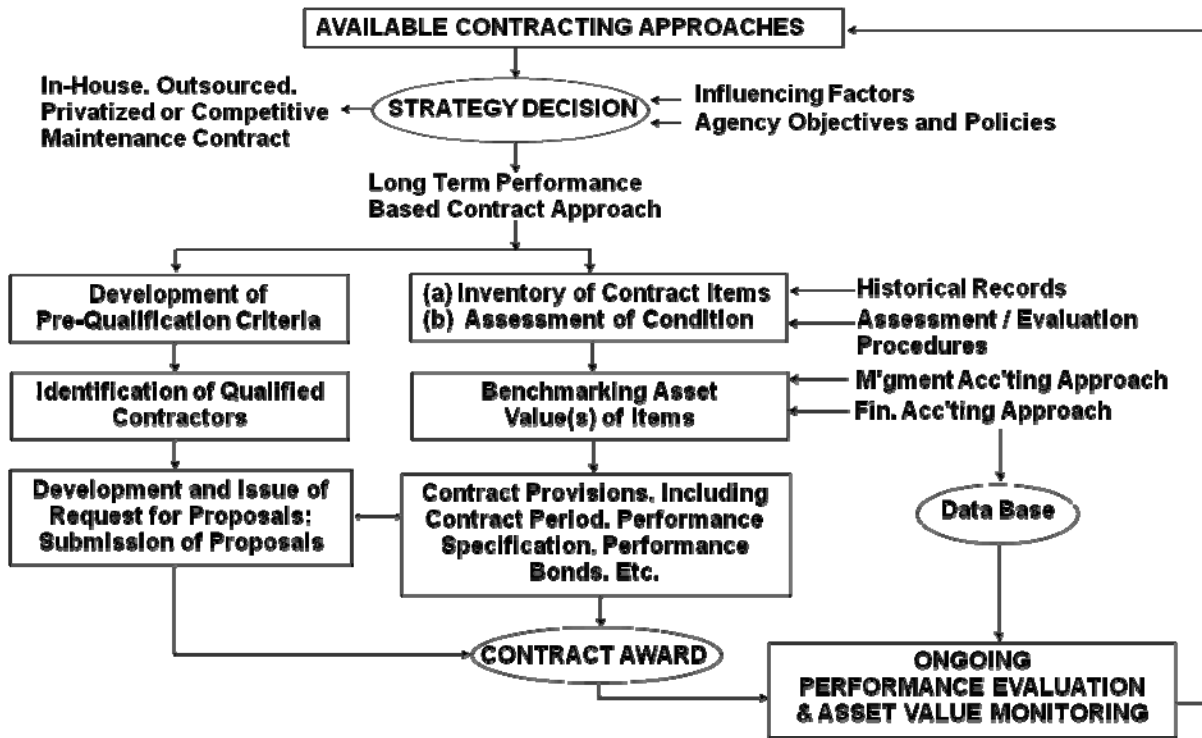


Figure 2 Major elements of a Strategy Decision Framework to Adopt a long Term Performance Based Contract Approach for Road Networks.

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Assets Included in Warranty/Performance Based Contracts

While this paper focuses on pavements, contracts which are warranty/performance based would normally include a suite of asset categories and component types. Table 1 provides a sample list, which indicates whether the asset is likely to be included in the contract. Land, including right-of-way (ROW), or outside the ROW, can be a large component of an agency's total asset base, and may actually appreciate in value, unless it becomes a liability because of clean up or site remediation costs.

Keys to Maximizing Benefits in Long Term Performance Based Contracts

There are keys to the success and maximization of benefits to both the public sector and agency and the contractor in the long term performance or warranty based contracts. Table 2 lists a suggested set of such key items and their applicability.

Table 1: Subdivision of Road Assets After Ref (6)

Category	Asset Type	Likely to be Included in Privatized Maintenance or Long Term Performance Based Contracts
Fixed Assets (Within R.O.W.)	Pavement	Yes
	Bridges	Yes
	Drainage Structures	Yes
	R.O.W (land & landscaping/ vegetation)	Yes
	Grading (Cut/Fill)	Yes
	Signs	Yes
	Signals and Loop Detectors	Yes
	Monitoring Equipment (Cameras, RWIS, etc)	Yes
	Guide Rail and Barrier Wall	Yes
	Fences and Noise Barrier	Yes
	Culverts	Yes
	Pavement Markings	Yes
	Lighting	Yes
	Sidewalks (including bike paths)	Yes
	Curb and Gutter	Yes
	Utilities (Cable, Hydro, Gas, Phone, Water)	Possibly
Weigh Scales and Weigh in Motion Devices	Possibly	
Unfixed and Fixed Assets (Outside R.O.W.)	Quarries and Pits	Available for Use
	Yards etc. (e.g. Regional or District Buildings, Salt Sheds, Fuel Tanks, etc.)	Possible transfer/ sale
	Buildings (Central Offices)	No
	Material Stockpiles	Available for use
	Laboratories	Possible transfer/ sale
	Communication Equipment	Possible transfer/ sale
	Computer Hardware	No
	Vehicles and Equipment	Possible transfer/ sale
	Parts Inventory	Possible transfer/ sale
Other Assets (Non-Physical)	Human Resources	Possible hiring clause
	Intellectual Property (software, libraries, guidelines, methods, procedures, and data)	N/A
	Organization/ Management Structure	N/A
	Image/ Goodwill	N/A
	Cash/ liquidity	N/A

Table 2 Keys to Maximizing Benefits in Long Term Performance Based Contracts

Adapted from Ref 2

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.) is 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	√	√	√	√

The first item on commitment is self evident. If this does not exist, and/or if it changes with changes in government or senior staff, then either the process will be diluted or the implementation will not occur.

The experience of others, item 2, can be beneficial to an agency when starting out with long term performance based contracts. Disclosures of what went right, and wrong, are important.

Pre-qualification criteria, the third item in Table 1, protects both the agency and the potential contractors in that the risk of not being sufficiently knowledgeable or having the necessary resources, on the part of the contractor, are minimized.

Item 4, on clearly defining the work and/or performance requirements is an absolutely necessary element for success, including application of the asset management system (AMS).

An accurate inventory of the assets and assessment of their condition, item 5, is also absolutely necessary to a proper start of the contract, and again to successful application of the AMS.

Item 6, is directed to letting the contractor do and manage the work. The contractor is responsible for the end result and all the agency should be concerned with is that the performance requirements are met.

Relative assumption of risk, item 7, must be understood and defined. For example, in the Tasmanian contract in Australia (2), the contractor assumes the risk for flood damage, landslides, etc. This requires a long term contract so that yearly variations may be evened out.

Item 8, utilizing any existing agency management systems, can be particularly valuable to the contractor. Some agencies have well established pavement and bridge management systems, for example, and the contractor may adopt these as is or modify as needed.

Any privatization or outsourcing will result in a reduction in agency personnel. If most or all have to be absorbed by the contractor, this can be particularly constraining. However, a wise strategy on the part of the contractor would be to hire a significant portion of the “surplused” personnel (item 9) because of their skills and knowledge base.

Providing on-line access for the agency to the contractor data base, item 10 not only keeps the agency current but also is a convenient mechanism for reducing their QA requirements.

A reward procedure for innovation (item 11) would also be a beneficial part of any long term performance contractor’s strategy. The opportunities for innovation are higher than in the other contract approaches and staff should be encouraged to be as innovative as possible.

Any contract will from time to time incur disputes. If a well defined dispute resolution procedure exists (item 12), then this should be of major benefit to both parties.

A clear understanding of the political climate and the motivating forces (item 13), whether one agrees with it or not, can also contribute substantially to a smoothly functioning contract.

The agency and contractor should be using the same ongoing performance measurement methods and procedures (item 14). Otherwise, they are highly likely to get different numbers on the same items.

Finally, it is important that the agency has established realistic policy objectives which are linked to performance indicators and in turn to implementation targets (item 15) as further discussed in the example of the next section.

EXAMPLE: THE “CHALLENGE”

A major part of the 7th International Conference on Managing Pavement Assets, Calgary, June 2008 is “The ICMPA Investment Analysis and Communication Challenge for Road Assets” (www.icmpa2008.com). It involves 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 Challenge¹ include a comprehensive, long term data base, plus, for the pavement network portion, the following:

- Highway number and type, section identifier, chainage, 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

Responses to the Challenge have been international in extent and have come from consultancies, public agencies and academic institutions. The Challenge has proven to be just that for the first two types of respondents but also for graduate projects and courses in academic institutions in that it represents a comprehensive real world situation.

Developing Policy Objectives, Performance Indicators and Implementation Targets

The Challenge has 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 3, 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 (6), as subsequently described in the following.

¹ Available upon request from haas@uwaterloo.ca

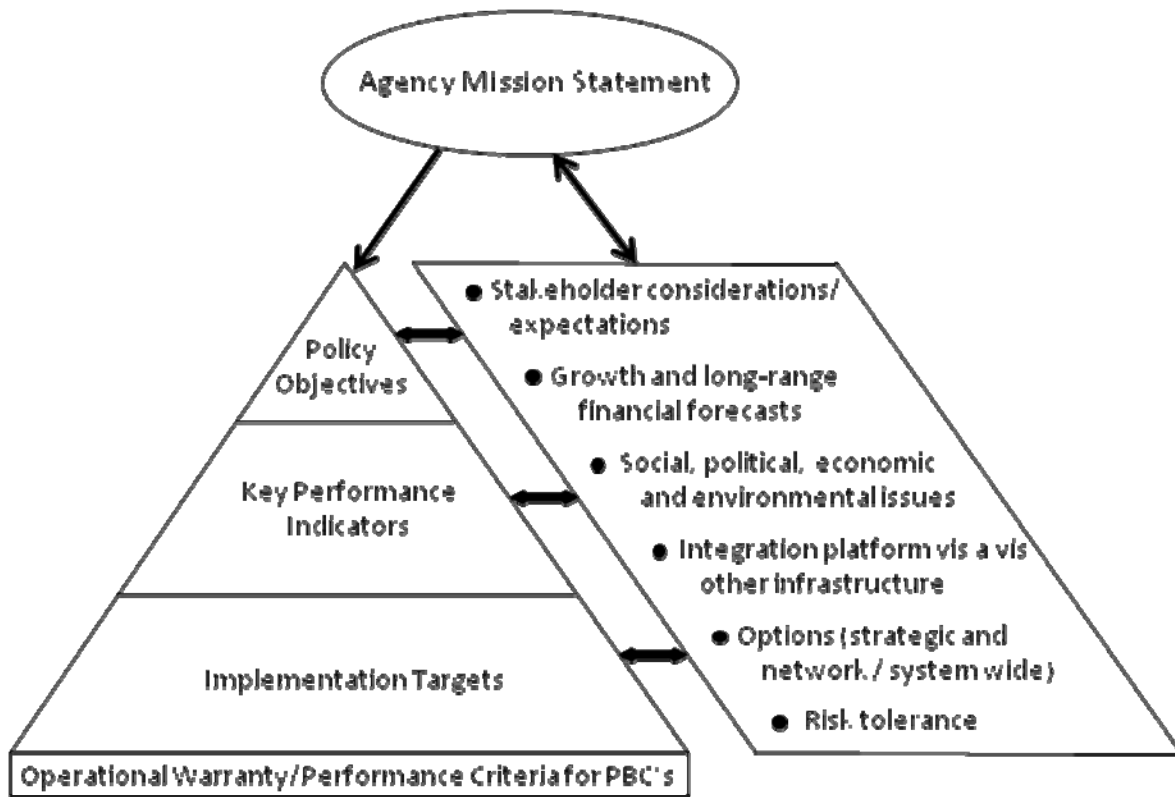


Figure 3 Hierarchical Structure for Development of Operational Warranty/ Performance Criteria for Performance Based Contracts (PBC's)

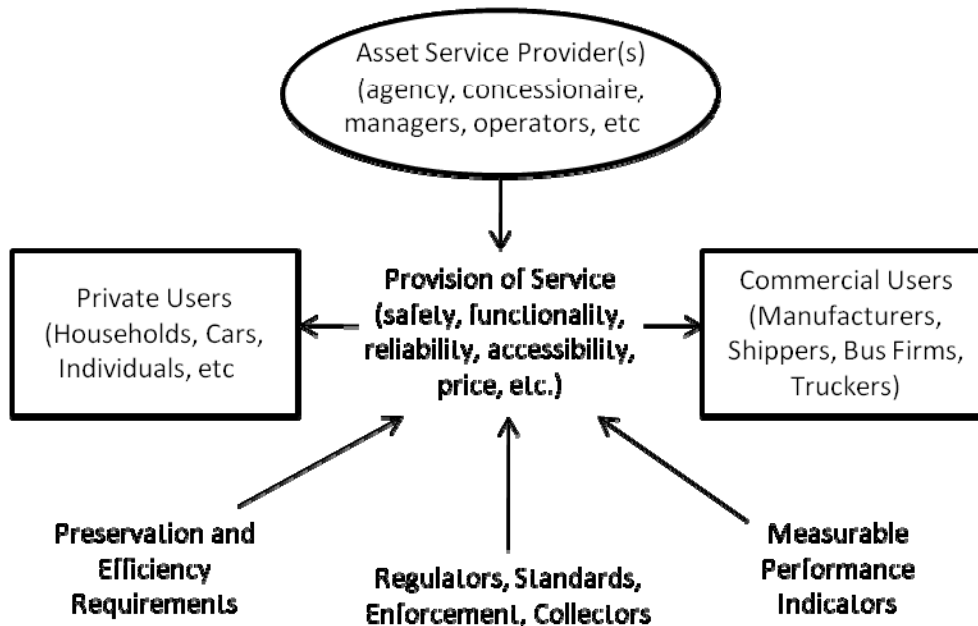


Figure 4 Stakeholder Groups, Provision of Service Expectations and Related Factors

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

Stakeholders may be classified into different groups: private road users, commercial road users and service providers. Figure 4 shows the groups and the provision of service as a main objective.

Provincial or State, federal and municipal road agencies have different objectives or targets. User service quality is usually based on the road classification. In most cases, available resources have the most important influence on limiting user service quality. These aspects influence and limit the user expectations and constitute the main reason for establishing policy objectives and achievable implementation targets.

Effective asset management requires measures or indicators of performance, which should be objectively based, consistent and quantifiable (2). The performance indicator set should incorporate institutional, economic, environmental, safety, user's expectations and technical and functional considerations. It is important that an underlying rationale exists and that objectivity and consistency have been achieved (7). Figure 4 shows the role of performance indicators on provision of service quality. Performance indicators should be understood by users and enable the following:

- A monitoring mechanism for assessing policies, and a tool for resource allocation
- Provision of information to users or customers
- Provision of data to track condition, costs, safety ,etc., and use as a diagnostic tool
- Pavement preservation and provision of adequate friction and structural life
- Adequate drainage, signs, markings, aesthetics, vegetation control and litter management
- Bridge safety and adequate remaining life
- Assessment of institutional effectiveness: asset value, program delivery and productivity
- Assessment of operational effectiveness (response time to incidents or complaints/inquiries
- Assessment of mobility

Individual road agencies might use only a subset of indicators, depending on their resources, size, location and specific conditions or requirements. Successful implementation of performance targets require adequate skills and expertise within the road agency and the level should be matched to the level of agency involved (3).

Table 3 Suggested Institutional Policy Objectives, Performance Indicators and Example Implementation Targets (Modified from Ref (10))

Police Objectives	Performance Indicators	Implementation Targets
1- Quality of Service to Users	<ul style="list-style-type: none"> • 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) 	<ul style="list-style-type: none"> • Maintain at 90% or greater of Network 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	<ul style="list-style-type: none"> • Accident reductions (%) 	<ul style="list-style-type: none"> • Reduction of fatalities and injuries by 1% or greater annually
3- Preservation of Investment	<ul style="list-style-type: none"> • Asset value of road network (\$) 	<ul style="list-style-type: none"> • Increase (written down replacement cost) annually of 0.5% or greater
4- Productivity and efficiency	<ul style="list-style-type: none"> • Cost effectiveness of programs (ratio) • Annual turnover (%) 	<ul style="list-style-type: none"> • 1% or greater annual increase • 5% or less annually
5- Cost recovery (\$)	<ul style="list-style-type: none"> • Revenues 	<ul style="list-style-type: none"> • Annual increase at no less than rate of inflation
6- Research and Training	<ul style="list-style-type: none"> • Expenditures (% of budget) 	<ul style="list-style-type: none"> • Annual commitment of 2.5% of total program budget
7- Communication with stakeholders	<ul style="list-style-type: none"> • Satisfaction survey sampling (%) 	<ul style="list-style-type: none"> • Greater than 75% of respondents satisfied or very satisfied
8- Resource conservation and environmental protection	<ul style="list-style-type: none"> • Recycling of reclaimed materials (asphalt, concrete, etc) - % • Monitoring of emissions 	<ul style="list-style-type: none"> • Maintain at 90% or greater • Maintain at levels < 90% of standards
9- Bridges	<ul style="list-style-type: none"> • Remaining life (years) • Safety 	<ul style="list-style-type: none"> • No bridge with remaining life less than 5 years • Comprehensive programme of periodic inspections to identify any risk

Example of Policy Objectives, Performance Indicators and Implementation Targets

Examples of policy objectives, performance indicators and implementation targets are listed in Table 3. These have been adapted from the “Investment Analysis and Communication Challenge for Road Assets” in the 7th International Conference on Managing Pavement Assets (9). These match large road network service providers and apply primarily to the North American situation.

Table 4 list four objectives with correspondent performance indicators and implementation targets that better match small and medium road network service providers, where there is a relative lack of resources.

The implementation targets presented in Table 3 and 4 should be considered as examples, not a set of universally applicable targets. They are based largely on current practice and to a degree on the experience and opinion of the authors.

Table 4 Suggested Institutional Policy Objectives, Performance Indicators and Example Implementation Targets for Medium and Small Network Providers (Adapted from Ref 1,3 and 10)

Police Objectives	Performance Indicators	Implementation Targets
1- Quality of Service to Users	<ul style="list-style-type: none"> • Network level of service (smoothness)- % good, fair and poor • Surface Distress (potholes) • Rut Depth (mm) 	<ul style="list-style-type: none"> • Maintain at 90% or Greater of Network in Fair or Better Category ($IRI \leq 3$) • No potholes on Paved Roads with $AADT \geq 1,000$ • Rut Depth ≤ 12mm
2- Safety Goals	<ul style="list-style-type: none"> • Accident Reduction (%) 	<ul style="list-style-type: none"> • Reduction of Fatalities and Injuries by 1% or Greater Annually
3- Research and Training	<ul style="list-style-type: none"> • Expenditure (% of Budget) 	<ul style="list-style-type: none"> • Annual Commitment of 1% of Total Program Budget
4- Bridges	<ul style="list-style-type: none"> • Remain Life (years) • Safety 	<ul style="list-style-type: none"> • No bridge with remaining life less than 5 years • Comprehensive programme of periodic inspections to identify any risk

EXAMPLE COMPARISON WITH AN IMPLEMENTATION TARGET

The “Challenge” (8) 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 smoothness in Table 3 (Figure 5a and 5b). From Figure 5a, it is clear that 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 3) is met by the interurban network.

Figure 5b 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.

Safety goals should be among the top priorities in any set of policy objectives. Perhaps no area of the highway field has received more attention than safety. Safety continues, however, to be treated largely as an area separate from the other management systems, partially because it is impacted by many external factors like weather, visibility, vehicle characteristics, driver behaviour and capabilities, highway geometrics, speed, etc, and often interactions of these factors. That is why Tables 3 and 4 suggests an implementation target of 1% or greater annual reduction of fatalities and injuries, rather than targets for individual factors.

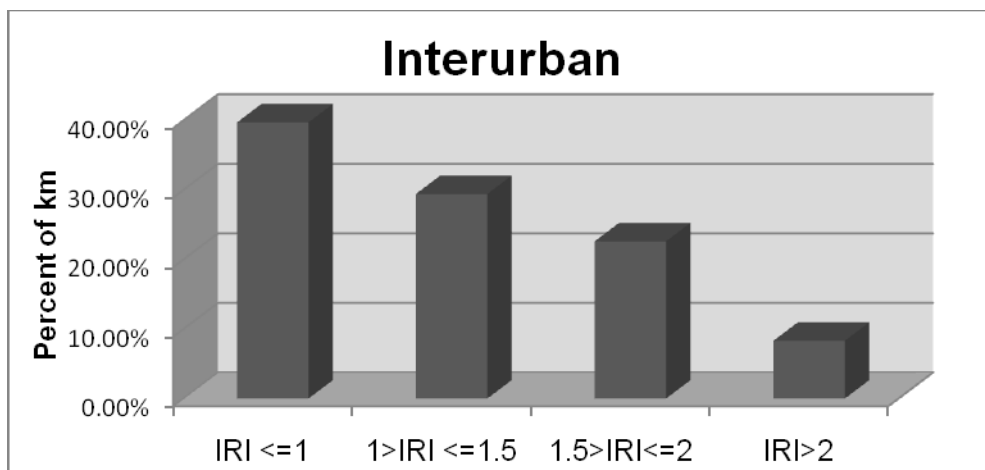


Figure 5a Distribution of IRI Values from the “Challenge”: Interurban Sections Derived from Ref. (8)

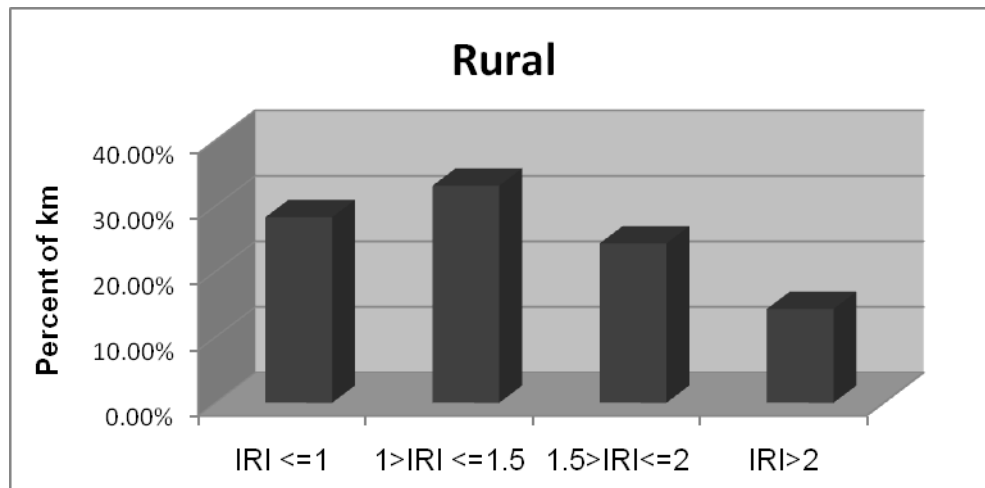


Figure 5b Distribution of IRI Values from the “Challenge”: Rural Sections Derived from Ref. (9)

EXAMPLE WARRANTY/ PERFORMANCE CRITERIA

Table 2 has provided example implementation targets associated with performance indicators (often termed performance measures, especially in Canada – see Ref. 11) and basic policy objectives. The implementation targets suggested may also be considered as warranty provisions or performance criteria. It is thus useful to now examine some operational or working criteria, which are also sometimes referred to as outcome measures (11).

The first performance based contract (PBC) for road maintenance occurred in British Columbia in 1988, involving all 28 Districts and a first round period of 3 years for routine maintenance, at a total cost of about \$250 million/year. Further extensions and/or renewals have been awarded since then, to the current time (12). Also, over the past two decades, a considerable amount of PBC work has occurred in Canada, as referred to in a performance measures survey by TAC in 2006 (11)

In the United States, Virginia passed a Public- Private Transportation Act in 1995 to facilitate design, build, maintain and operate roads. The first contract involving 250 center-line miles of Interstate Highways and a total price of \$131.6 million for a period of 5 ½ years was awarded in 1996. The contractor and state agreed on performance standards for each asset in 7 groups, with a tolerance level of acceptance. A unique aspect in this privatization is that the contractor functions like a mini or surrogate road authority in that it does the asset management with all the work being carried out through sub contracts. Currently, Virginia’s “Turnkey Asset Management Services” (TAMS) contract, for about 320 km of interstate highways, for a period of 5 years beginning in April, 2008, involves 12 groups of assets and includes the following performance criteria for pavement surfaces (www.virginiadot.org/projects/constSTAN-181-overview.asp):

Concrete	Asphalt
<ul style="list-style-type: none">• Outcome: safe, durable, smooth• Target: 95%• Criteria: no potholes, <10% area with cracks > ½ in. wide, <25% area with spalling 1 in. deep, <25% of joint material missing• Timelines: temporary repair to potholes immediately, permanent repairs within 30 days, removal of safety hazard obstructions immediately	<ul style="list-style-type: none">• Outcome: safe, durable, smooth• Target: 95%• Criteria: no potholes, patches < ¼ in. higher or lower than surface• Timelines: temporary repairs to potholes immediately, all other repairs within 2 days, permanent repairs within 30 days, removal of safety hazard obstructions immediately.

Various other countries have developed operational performance criteria/ standards/ targets. Examples from around the world can be obtained from the World Bank (3, 10 and www.worldbank.org/transport/roads/resource-guide/Docs)

The Australian and New Zealand experience, starting in the mid 1990’s, has shown that realistic criteria/ targets are achievable for network wide PBC’s (1), as subsequently described. For example, the original New South Wales (NSW) 10 year contract involved the following basics for the pavement part of the network (13):

1. General
 - 2115 lane-km, 60% flexible and 40% rigid and composite

- Maintenance includes: (a) repairs, (b) corrective maintenance, (c) preventive maintenance and rehabilitative maintenance including reconstruction where appropriate
 - Asset value, written down replacement cost basis, \$700 million Australian, in 1996
 - Pre-contract benchmark measurements included video log record of entire network, roughness, skid, rutting and surface distress survey, deflection survey on 80 lane-km of most badly cracked sections and structural thickness from the Road Transport Authority Records (in 1995)
2. Periodic Data Collection by the Contractor's Engineering Consultant
- Benchmark measurements noted above
 - Roughness, video log and surface distress in 1996 and annually thereafter
 - Skid measurement spot checks only in 1996 and thereafter
 - Deflection only for project level design after the benchmark measurements
 - Equivalent Single Axle Load (ESAL) estimates calculated from AADT, % commercial vehicles and truck factor

The contractor's warranties, termed performance guarantees in the 1995 NSW contract, included the following:

- Annual increase in asset value (up to 4%)
- No flexible section with an International Roughness Index (IRI) of greater than 4.5 and no rigid/composite section with an IRI greater than 5.5
- At the completion of the contract, not more than 10 % of Class 1 & 2 links (arterials and collectors) in the network would have more than 10% fatigue cracking, and not more than 15% of Class 3 links would have more than 10% fatigue cracking.
- No arterial section with greater than 12 mm rut depth and no collector section with greater than 15 mm rut depth
- No section with less than 10 years of remaining structural life at the end of year 10.

ACTUAL ACHIEVEMENT OF WARRANTY/ PERFORMANCE CRITERIA: 10 YEARS LATER

The success of what were considered in 1996 to be realistic performance criteria can be assessed by whether they were actually achieved. For example, in the NSW 10 year contract preciously noted, the weighted network roughness decreased from an IRI of 2.57 in 1996 to 2.52 in 2006(1). This would indicate a small but still an increase in asset value. In a more detailed sense, there were substantial improvements in rutting, cracking and structural capacity, described further in the following.

Figure 6 shows the rutting distribution (processed in 25m intervals) over the last 3 years of the contract. The level of rutting in the 10-20 mm bin, for example, has decreased to 4.5% in 2006, and the critical bin rutting, greater than 20mm, is down to 0.6% of the network. In essence, rutting is being maintained at low levels, and thus the original targets or performance guarantees can be considered as realistic.

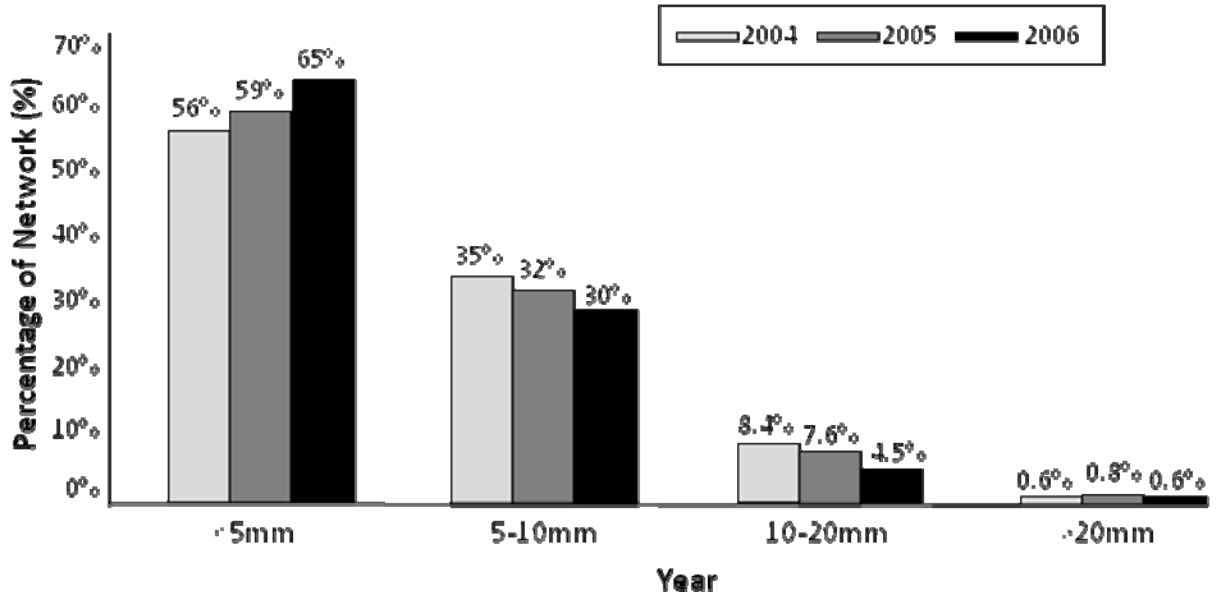


Figure 6 Rutting Distribution for the Network, Last 3 Years

After Ref. (1)

Figure 7 shows the historical trend cracking for the network's Class 1 and 2 links. It is obvious that the target of 10% maximum fatigue cracking was quite achievable, and in fact total cracking has declined over the 10 years from about 1/3 of the network to just over 10%. In essence, cracking is under control and has been managed over the life of the contract and beyond.

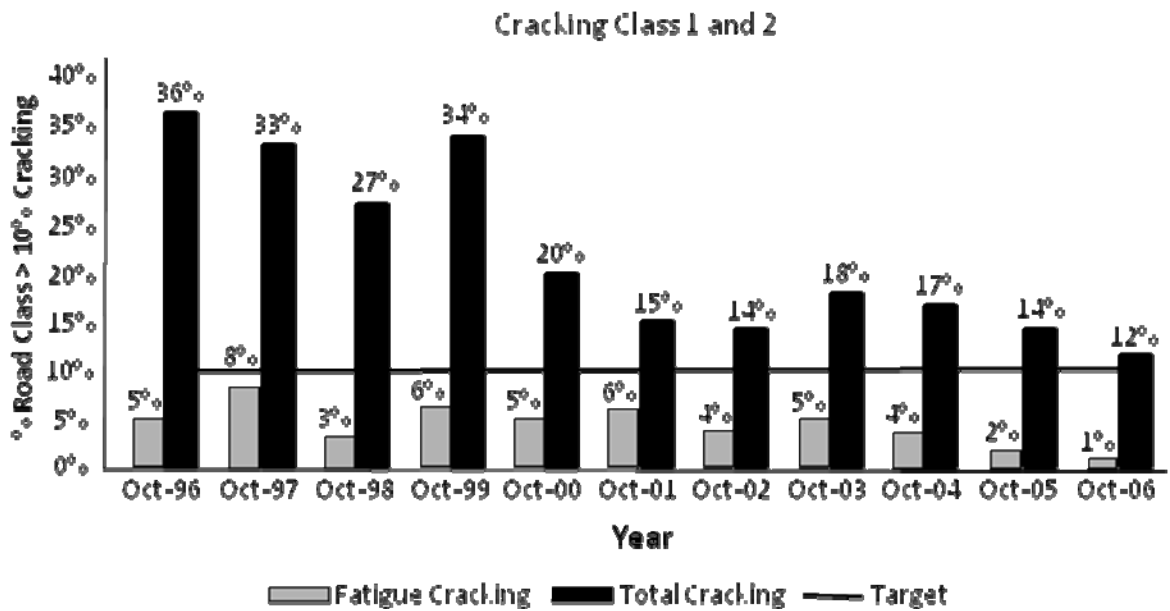


Figure 7 Historical Trend of Cracking for Class 1 and 2 Links of the Network

After Ref. (1)

To assess the structural life criterion, a methodology was developed of 12 test points (Falling Weight Deflectometer, FWD, based) per link, selected at random by lane and chainage, with a pass or fail regime. This regime stated that no more than 30% of points tested within a link shall have less than 10 years remaining life.

Figure 8 shows that at year 10, 93.6% of the links tested have greater than 10 years remaining life. The 6.4% of the links below 10 years remaining life are scheduled for structural rehabilitation. This is what might be expected if a typical 20 year design life is adopted; e.g., 5% of the network will “retire” structurally every year. The conclusion from this is that structural adequacy is a fundamental consideration for any forward works program.

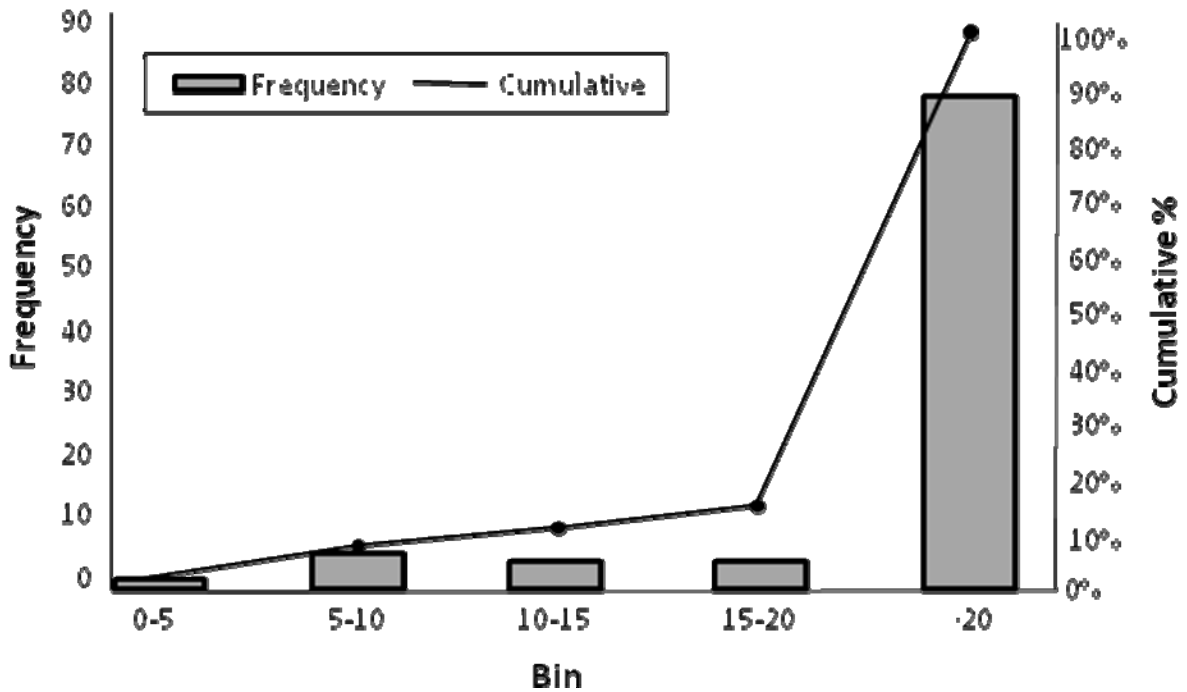


Figure 8 Structural Life Frequency Distribution for the Network at Year 10 After Ref. (1)

CONCLUSIONS

The following conclusions are based on the content of the paper:

- Long term performance based contracts are applicable to pavement networks, they offer major benefits for both the road authority and the contractor, and they are directly applicable to sustained preservation of the networks.
- Examples demonstrate that with realistic policy objectives defined by the road authority, linked to key performance indicators which are in turn linked to implementation targets/ warranties/ performance guarantees, it is possible to actually achieve expected outcomes at the end of long term contract periods.

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