THE HYBRID PERFORMANCE BASED PAVEMENT MANAGEMENT STRATEGY

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ABSTRACT

Hybrid performance based road management and maintenance contracts were introduced in the North Canterbury State Highway Network in October 1999. This concept introduces outcome-based contracts for both the Consultant and Contractor. These are performance based 5-year lump sum contracts, which require the Consultant, Contractor, and the road controlling authority form a network team, responsible for network control and road maintenance activities on the state highway.

This discussion paper explains the hybrid pavement management strategy and describes methods to optimise maintenance performance delivery.

1 OVERVIEW

The longest running full hybrid maintenance contracts in New Zealand commenced in North Canterbury on 1 October 1999.

The roads in this area have been subject to performance related pavement management strategies for over three years. This discussion document has been developed following observation reviews by Opus International Consultants during that period. In particular the issues discussed are focused on the resulting pavement condition and performance outcome in respect to traditional expectations.

The key issues discussed are:

a) Pavement management strategy development in respect to the current hybrid physical works document.

b) Hybrid physical works documentation improvements.

The issues discussed do not necessarily apply to Hybrid Contractors operating in the North Canterbury area.

2 DEFINITION OF TERMS

KPM - Key Performance Measures reflect the overall condition of both the primary (pavement) and secondary assets (bridges, drainage and minor structures, carriageway lighting, etc) and the overall safety performance of the maintained network.

Level of Service - The defined service quality for a particular activity (ie. roading) or service area (i.e. street lighting) against which service performance may be measured. Service levels usually relate to quality, quantity, reliability, responsiveness, environmental acceptability and cost.

Maintenance - All actions necessary for retaining an asset as near as practicable to its original condition, but excluding rehabilitation or renewal.

Fixed interval maintenance is used to express the maximum interval between maintenance tasks.

Maintenance Plan - Collated information policies and procedures for the optimum maintenance of an asset or group of assets.

MPM - Management Performance Measures reflect the service providers performance in the management of the contract and delivery of professional services. MPM's cover reporting and communications, quality systems, management plans and the delivery of professional services including asset management, planning, and network controls.

OPM - Operational Performance Measures reflect the road users expectation about the networks daily serviceability. For each OPM, the contract standard and response time specified must be achieved.

RAMM - The Road Assessment Maintenance Management system (RAMM). The computerised road maintenance management software system developed by Transit New Zealand for use nationally by all New Zealand road asset managers.

Service Potential - The total future service capacity of an asset. It is normally determined by reference to the operating capacity and economic life of an asset.

Strategic Plan - A plan containing the long-term goals and strategies of an organisation. Strategic plans have a strong external focus, cover major portions of the organisation and identify major targets, actions and resource allocations relating to the long-term survival, value and growth of the organisation.

3 HYBRID PAVEMENT MANAGEMENT STRATEGY MODEL

The pavement maintenance strategy required by the hybrid document is generally implied by regular reference to the Transit New Zealand C specifications. These specifications are generally method based with indicative outcome standards in terms of required levels of service. Furthermore the hybrid document includes a series of pavement related key performance measures (KPM's), operational performance measures (OPM's), and management performance measures (MPM), which define the contractual requirements. This paper focuses entirely on the pavement, where the outcome requirements are defined in terms of OPM's and KPM's.

a) OPM Management (condition) – This requirement governs the pavement condition standards and residual life required by the contract. Treatment generally involves any maintenance activity that maintains the pavement to the required condition, while maintaining the remaining life. Maintenance includes routine repairs such as pothole repairs, localised digouts, crack sealing, pavement drainage and major interventions including area wide treatments, and resealing.

b) KPM Management (LOS) – This requirement generally reflects the standard of ride and surface safety standards in terms of a specified level of service. The intention is to target a level of service appropriate to road user expectations, while balancing the costs. Levels of service could improve, be maintained, or decrease to specifically meet the demands. Improvements to service levels are typically specified by annually reducing the length of deficiency outside the target KPM level. Pavement KPM's generally include roughness, skid resistance, and surface texture.

This pavement management philosophy is illustrated in **Figure 1**, where the overall level of service (LOS) is increased over time depending on the KPM targets prescribed by the contract. Generally either the maximum limit for each KPM is reduced over time or the length outside the target is reduced over time. With either method, the outcome increases the LOS provided.

However, the routine pavement management is fundamental to maintaining the pavement condition in perpetuity. On this basis, routine maintenance takes priority over work to improve the level of service. Through strategic pavement management, routine maintenance efforts will contribute to an improvement in KPM's, however this outcome should not become the focus of the pavement management strategy. Any intended improvements to the KPM's should be considered secondary (**see Figure 2**).

Should the specified KPM targets not be achieved through routine pavement maintenance, then specific treatment will be necessary.

3.1 OPM Management (condition)

Pavement Maintenance

Routine pavement management strategies are focused on maintaining the current integrity of the pavement in the long term. Strategies are based on whole of life analysis where the asset is maintained in perpetuity (ie. minimal pavement defects). This theory relies on the combined efforts of the hybrid Network Contractor and hybrid Network Consultant to provide a balanced treatment programme, which considers both the immediate future and longer-term pavement condition. Joint driveovers combined with practical experience, pavement deterioration reports, and capital project knowledge is expected to produce a robust and optimised forward work programme (**see Figure 3**).

Contract specified response times, to pavement defects, generally ensure the pavement is maintained in a safe condition, however the aim is to ensure the greatest quantum of maintenance work is planned (cf. reactive).

The hybrid document specifies underpinned quantities, based on traditional treatment quantities, which provides a base quantum of work. While a consistent quantum of annual physical work is expected, the Contractor may need to complete additional work to ensure that all routine pavement needs are met. Condition and service level drivers can change during the contract period.

Treatment types can be traded annually to suit the pavement condition demands. Furthermore, the hybrid Contractor has the opportunity, if economically justifiable, to explore alternative pavement treatment options. This exercise involves the consultant who ensures that the best intervention is adopted as opposed to the cheapest option. The development of the forward works programme is critical to ensuring that the Contractor's short-term vision is combined with the Consultant's long-term interest. For example, seal widening treatment may be more economic, for the Contractor, compared to regular edge break repairs. These cost saving solutions need to be considered in respect to:

a) The best economic window of opportunity for the Contractor exists in the first part of the contract period, where the return period (ie. remaining contract period) is the greatest. The financial benefit to the Contractor is increased when longer return periods are considered. Capital outlays to save maintenance cost are not likely in years 4 or 5.

b) The Contractor prefers to spread maintenance costs over the contract period, by undertaking routine maintenance, to better suit the fixed monthly revenue. Capital outlays need to be considered against the revenue stream.

c) There is a limited time for the Contractor to collect the necessary knowledge (maintenance needs) required to justify larger treatment options. As knowledge increases, the remaining investment return period decreases. While historic maintenance costs are provided in RAMM, these do not always reflect the future costs needed to maintain the asset.

d) There is risk to the Contractor associated with capital outlays, where justification is marginal. For this reason the Contractor is likely to be conservative in the justification analysis.

Pavement investment by the Contractor also needs to be balanced with remaining life (**see Figure 4a & Figure 4b**). The Road Controlling Authority does not want the remaining life consumed, solely because the Contractor can economically justify early maintenance. All benefit assessments need to consider both current and future remaining lives, resulting from area wide maintenance treatment. Treatment applied at the wrong sites will compromise the ability for the Contractor to meet the routine pavement maintenance requirements.

Road Safety Maintenance

Safety maintenance, in the context of pavement management, refers to pavement and surface related hazards. These hazards are typically in the form of surface skid resistance, texture deficiencies, ride and, pavement defects. Like all road maintenance procurement types, the hybrid physical works document requires that the road pavement and surface be free from hazardous defects at all times. Table 1 identifies how common pavement hazards are managed.

Table 1 : Road Safety Maintenance

Defect		**Action**	**Responsible**
Skid Resistance	Below investigation level, but above intervention level	Monitor, with view to treating site in the near future	Hybrid Contractor
	Below intervention level	Immediate Treatment	Hybrid Contractor
Texture	Below standard	Immediate Treatment	Hybrid Contractor
Pavement	Failures	Hazardous failures to be treated within response times specified.	Hybrid Contractor
Surface Shape	Hazardous	Immediate local reshaping	Hybrid Contractor
	Below geometric standard	Correct in conjunction with an area wide treatment	Hybrid Contractor
		Capital Project	Transit
Alignment	Below geometric standard	Capital Project	Transit

The hybrid Contractor needs to allow, within the lump-sum, sufficient funds to allow safety maintenance items to be addressed as they are identified. The Contractor is responsible for ensuring that response times are met when managing these issues.

3.2 KPM Management (LOS)

Levels of Service

The KPM's specified in the physical works document could either decrease or increase the current level of service depending on the road controlling authorities objective. Generally the KPM's increase the level of service to the road user during the contract period. Recent hybrid contracts require the Contractor to specify a realistic annual target. Either way, there is an intention that the level of service will be managed over time. This is typically specified by reducing the target length of road outside the required performance threshold level (Table 2).

Table 2 : KPM Threshold Levels

Key Performance Measure	Measure	Threshold Level
Roughness	NAASRA	150 counts
Texture	MPD	0.5 mm
Skid Resistance	SCRIM	Various depending on site category

The resulting performance profile can be illustrated (**see Figure 5**), where the region below the target LOS represents the reducing length of road outside the KPM targets.

This strategy may result in the following observations:

a) Roads in very good condition are likely to exhibit a LOS exceeding the specified minimum target level. These lengths may not be maintained, allowing the current LOS to deteriorate with time back to the target service level. [a]

b) Defective lengths of road will be treated to increase the road condition (LOS) above the minimum LOS specified in the physical works document. [b]

c) The net difference will eventually yield a pavement condition, which follows the target condition.

d) The pavement and surface performance will become more consistent, as the achievements are optimised through planned pavement management strategies.

e) The KPM achievements become the driver for developing the pavement management strategy. Contractor performance is measured through analysis of the high-speed data measures. Too much investment by the Contractor may cause an over achievement in KPM outcomes, thereby compromising potential profit.

High Speed Data

Analysis of the high-speed data provides:

a) KPM achievement for assessing Contractor performance
b) Sites where the KPM achievements were unacceptable (ie. below the target LOS)
c) Physical measurements to confirm field observation
d) Prediction of future KPM achievements based on the recent pavement management strategy

High-speed data analysis is typically presented in the form of a data plot (**see Figure 6**), allowing unacceptable KPM achievements to be clearly identified. Unacceptable measures are then subject to reactive treatment options, which is not desirable for the following reasons:

- The road controlling authority has exposed its road users to unnecessary risk by providing inappropriate measures.

- The quantum of treatment work required to manage the deficiencies identified may exceed the Contractors treatment programme. The Contractor is required to accept this risk.

- Identified deficiencies may suggest that the maintenance strategy is not appropriately focused on the network needs. Care must be taken in the assessment to consider varying deterioration rates across the network, which effect predictive treatment options.

These sites require attention if the accumulated length exceeds the target achievement length. This exercise can only be performed prior to pavement treatment, therefore skilled predictive analysis is required. Other issues such as deterioration and KPM measurement repeatability also need to be considered in order to determine the optimal amount of work to meet the specified KPM targets.

Advanced analysis (**see Figure 7**) includes the identification of marginal KPM achievements. These sites are also considered for treatment as determined by potential future deterioration.

4 ADDED VALUE

Added value is simply an assessment of the increase in asset value resulting from the maintenance investment. Let’s consider the two key aspects of pavement management.

4.1 OPM Management (Condition)

Extending the asset remaining life increases asset value. In essence, the service life cycle is extended, which subsequently increases the depreciated replacement value.

Simply,

$$\text{Deprec Replace Value (DRV)} = \frac{\text{Replace Cost (RC) x Remain Life(RL)}}{\text{Base Life (BL)}}$$

Table 3 presents some examples, which show the affect of extending the remaining life (Ext).

Table 3 : Depreciated Replacement Value

Component	**RC**	**BL**	**Age**	**RL**	**DRV**	***Ext***	***BL+***	***RL+***	**DRV+**
Surfacing	$ 10,000	8	7	1	**$ 1,250**	2	10	3	**$ 3,000**
Pavement	$ 10,000	20	10	10	**$ 5,000**	5	25	15	**$ 6,000**

Increase in value

Remaining life can be extended by:

a) improved maintenance strategies, which maintain the asset condition through early intervention.

b) using improved materials, which exhibit longer life.

c) area wide maintenance treatment (eg. Reseal, Area Wide Treatment).

4.2 KPM Management (LOS)

Added value, in terms of the KPM targets is assessed in terms of Table 4.

Table 4 : KPM Targets and Achievements

KPM Targets	Added Value	
	Contract Evaluation	**Contractor Performance**
Document Specified	Where Contractor undertakes to improve targets specified	Assessment of KPM achievement relative to document KPM targets. Nominated targets must be used where Contractor undertakes to improve the document targets.
Contractor Nominated	Assessment of KPM improvement relative to current KPM level of service.	Assessment of KPM achievement relative to nominated KPM targets.

5 FIELD OBSERVATION

Field observation of hybrid pavement management strategies has identified:

a) KPM Focus

Because the KPM achievement currently represents 50% of the Contractor performance score, Contractors are more focused on KPM management rather than routine pavement maintenance. There are currently no contract performance measures for ensuring that the adopted routine maintenance strategy is appropriate. Deterioration modelling provides an indication of long-term affect, but again this is not reflected in any Contractor performance measures.

b) KPM Targets

The required level of service is generally specified in terms of annual KPM targets. These are focused at improving service levels by reducing the deficiency above the required level. There is currently no consideration for the annual distribution of measures. For example, Roughness above 150 NAASRA counts, over a fraction of the network, is eliminated, but the average roughness across the network may have increased. Either a distribution of KPM's or KPM statistics (average, max, standard deviation) are specified as the annual targets.

c) Tendered Quantities

Tendered quantities are being used solely to achieve the specified KPM targets as opposed to manage the OPM's. The Contractors performance appraisal is largely based on their ability to meet the KPM's, therefore this measurement aspect has become the focus. This practice is compromising the Contractor's ability to manage the routine pavement maintenance, causing some parts of the network to appear neglected. Area wide treatment has sometimes been applied to rough sections of road to improve roughness, as opposed to providing the least cost option for wide spread pavement failure.

d) Pavement Deterioration

Good lengths of road, which exhibit a high level of service, are generally receiving no attention allowing deterioration back to specified service levels. This practice is causing a general perception that the road network is in poorer condition than at contract start, despite the worst sites being improved.

e) Frequency of High Speed Data Measures

Currently high-speed data is collected once annually. This infrequent measurement is considered insufficient to ensure that some of the specified KPM's are actually being achieved, particularly with the variable measures such as roughness. Repeatability of the measures has also been questioned and whether the single 'snap shot' measure provides a representative result for a 12-month period.

e) Timing of High Speed Data Measures

Because of the timing of the data collection, a potion of the annual quantum of work is completed after the measure, making data analysis difficult. Consideration needs to be made for the effect of treatment not yet complete, particularly for performance appraisal purposes. The resets considered are not confirmed until the following year.

f) Asset Consumption

Currently there is no accurate method for assessing the remaining pavement life. Pavement deterioration models (ie. dTIMs) provide an indication, however are dependant on the accuracy of many pavement performance inputs. As these models evolve and develop, their output combined with valuation processes may provide sufficient information to assess the asset life or value consumed during the contract period.

6 KEY REQUIREMENTS

The following suggestions are recommended to improve the current hybrid maintenance document:

a) Documentation has emphasis on the expected outcome of routine pavement maintenance. The Road Controlling Authority expectations, regarding level of service, needs to be clearly specified rather than requesting the Contractor to nominate target levels.

b) Routine pavement maintenance measures be established and be integrated into the Contractor performance appraisal score. Measures may include asset value or remaining life on a component basis assessed annually.

c) The KPM targets require review in respect to the level of service Transit want to provide. This LOS needs to be balanced against the cost.

d) Provisions are specified to ensure that safety issues relating to KPM's are addressed immediately regardless of current KPM achievement and target levels.

e) The high speed data is captured at least twice a year to provide increased assurance that KPM's are being met. Data results apply only on the day of measure yet because of a single measure are extended to represent a 12 month period. Costs needs to be balanced with the benefit of an additional annual survey.

f) All critical MPM's and OPM's need to be measured and incorporated into performance reports.

g) KPM targets need to be either specified in terms of a distribution curve or statistical output (average, max, standard deviation) across the network.

h) Residual life analysis may provide an assessment of asset life consumed during the contract period. In particular, the difference between the remaining life at contract start and contract end should equal the contract period if the pavement asset is properly maintained. Alternatively the asset value could be assessed during the contract period.

AUTHOR BIOGRAPHY

Travis Gilbertson [NZCE (Civil), BE (Civil)(Hons), MIPENZ, Reg Eng] is a Principal Engineer with Opus International Consultants Ltd. He has 17 years experience with civil engineering, predominantly in roading design and road asset management. Travis specialises in asset management practices, valuations, information systems, and strategic management planning for road maintenance. He is also a computer software developer and is recognised as a systems specialist with skills in process mapping, service performance measuring, analysis, and reporting.

Travis is the Manager for the road asset management group in Christchurch, comprising professional engineers and road maintenance practitioners. He is also consultancy team leader for the management of the North Canterbury State Highway network.

Figure 1 : PMS Strategy (Improving LOS)

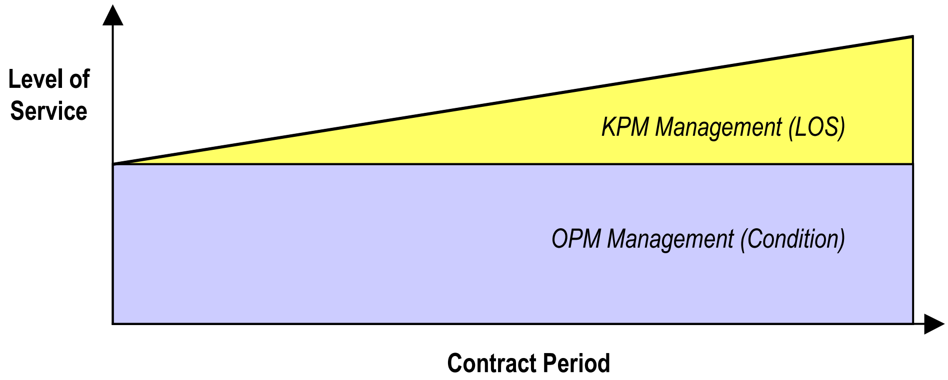

Figure 2 : Hybrid PMS Process

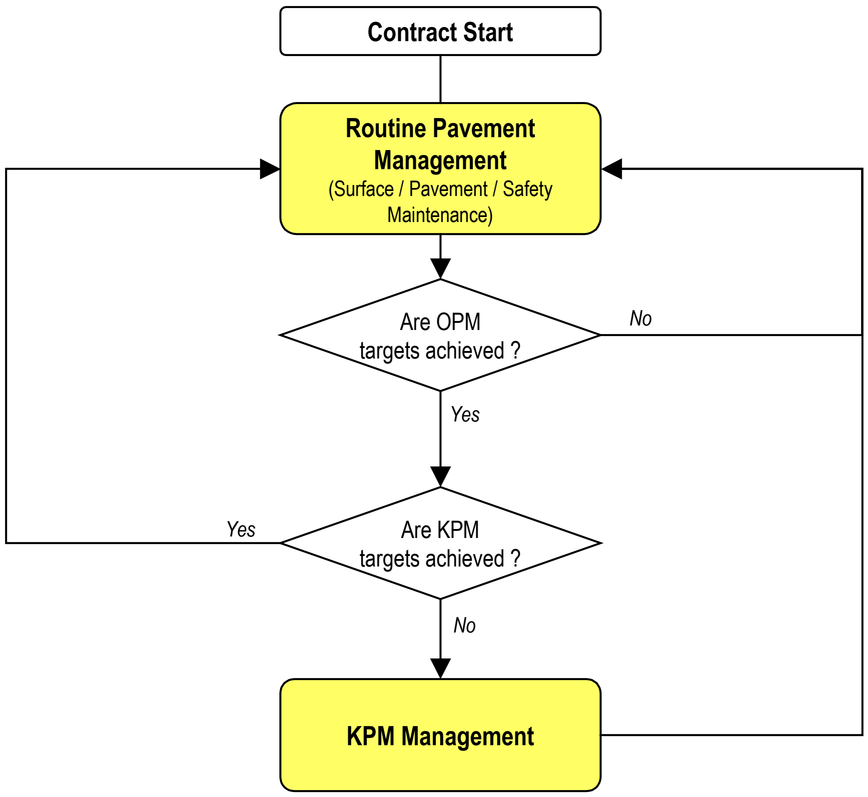

Figure 3 – Routine Pavement Management

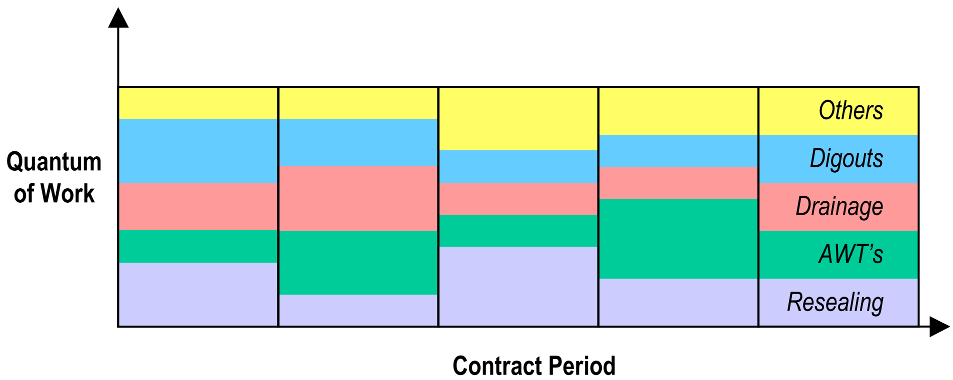

Figure 4a : Remaining Life Analysis (network wide)

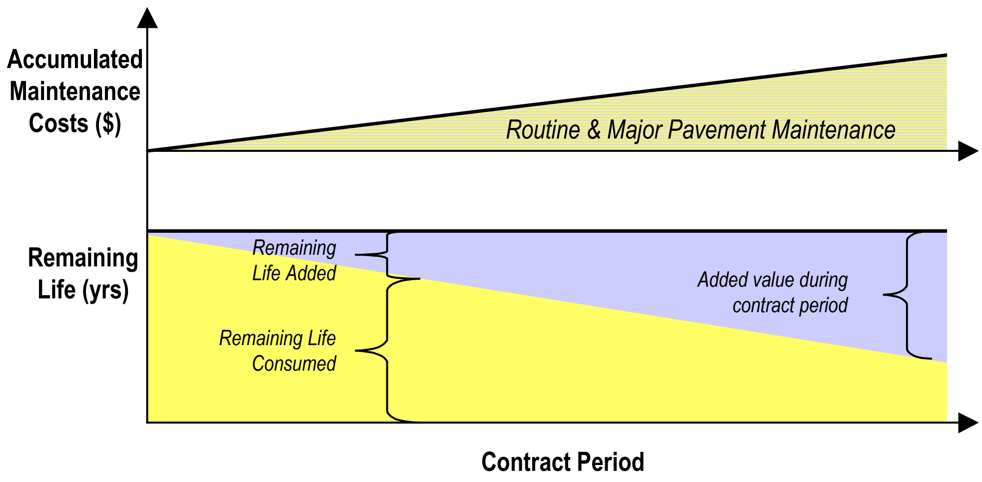

Figure 4b : Remaining Life Analysis (individual treatment length)

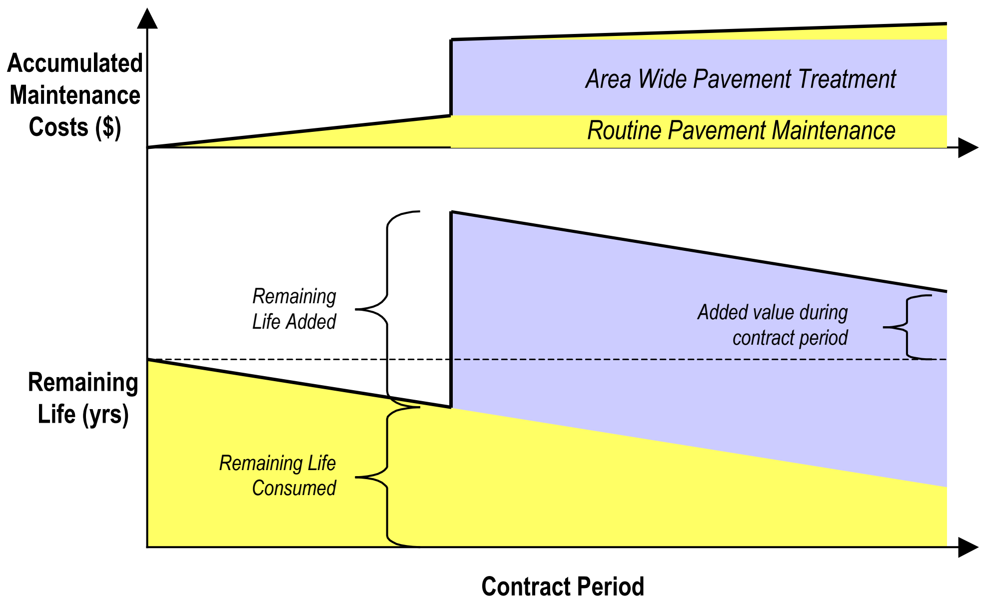

Figure 5 – Improving LOS Profile

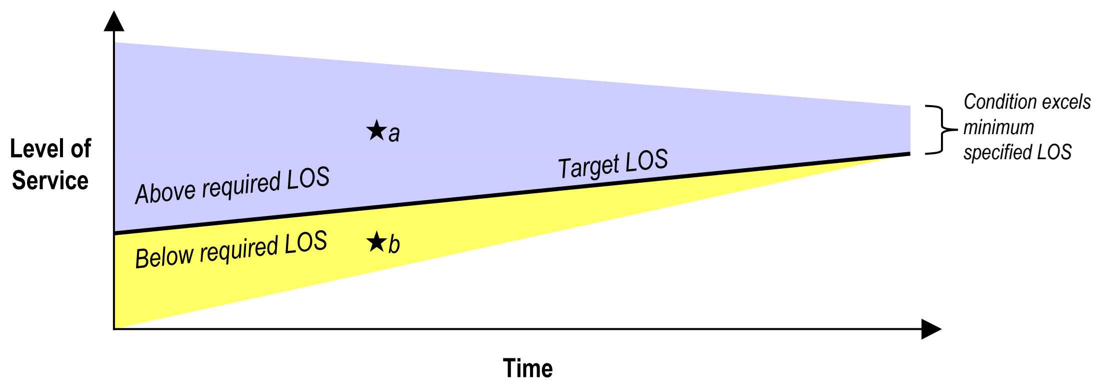

Figure 6 – KPM Analysis

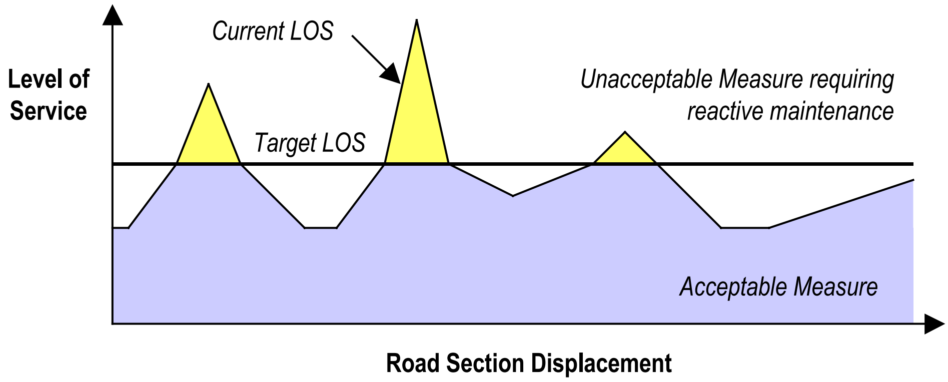

Figure 7 – Advanced KPM Analysis