

Performance Based Lifecycle Management of Highway Assets

Chin Chi Haw, Alvin Chang and Shahdee Ahmad

Abstract

Significant highway transportation assets are being developed, procured, and managed amongst a variety of procurement models. An important feature of these contemporary projects is the emphasis on sustainability of functionality.

Under such evolving practices, prerequisites, comprising a combination of output and outcome based parameters, are key deliverables. These parameters form the basis of performance measurements as key indicators that the asset is appropriately preserved and its functionality sustained throughout its lifecycle. Increasingly, these emerging contract models expands the role of the private sector, from the simple execution of works to the management and conservation of road assets and clearly defines the stewardship and governance responsibilities of the road agencies for the administration of these contracts.

This paper describes the concepts behind such Output and Performance-Based Long Term Road Contracts that embraces the principles of Total Asset Management. Details of key aspects are explained and references from latest developments are provided to give a clear understanding on the manner such performance measures are applied to ensure the physical condition of the roads under contract is adequate for the need of road users, over the entire period of the contract which is normally several years.

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Introduction

Internationally there is a strong trend towards outsourcing of highway maintenance. However the majority of these contracts still primarily placed emphasis on the activity of maintenance and the cost per activity of maintenance. Bills of quantities and schedule of rates are thus usually common features in these types of contracts with a set of workmanship specifications that will determine the quality of the output product. Although there is some flexibility, there is very little leeway for the outsourced service provider to intrinsically determine the manner that the works or products are designed, prepared or scheduled for completion.

The premise of this type of outsourcing is thus focussed on the exact activity to be performed (what), frequency of activity (when) and at a certain (worth) price. These detailed output based contracts are sometimes manifested into smaller works packages and given misnomers such as "Work Orders", "Job Sheets", and "Procurement Orders", where the principles for implementation are basically the same.

As road authorities progress and recognise the need to drive better value for money spent and demanded better services, the contract specifications started to evolve towards defining output and performance expected from the highway assets rather than the specific activity and costs per activity of maintenance.

Output-Performance Based Philosophy

The inclusion of performance based measures together with the output specifications provides significant advantages to the asset owners (which may be the road authorities or concessionaires depending on the form of partnership collaboration) and ultimately to the end user.

The specifications of performance measure in such contracts means that the service provider needs to ensure that the works on the assets or services provided will be able to meet the functionality or levels of service set while the assets are under their tenure and upon handover. Solutions that reduce 'whole of life' costs will become the focus of the service provider and hence the road authorities and asset owner will also inherit the cost savings. In addition, as such output – performance based contracts are on considerable time period tenures (some 10~15years), this arrangement focuses the parties to clearly identify the risk and cost-benefit issues, which needs be addressed under long term aspects. The tenure also

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allows ample opportunity during the tenure to assess the condition of the asset to reduce the risk of defect inheritance to the road authorities-asset owners.

The output-performance specifications of such contracts circumscribe the outcomes expected from the asset and consequently define the level of service required. Typically, such contracts comprise different categories of Performance Measures and Criteria underpinning the required project outcomes (Figure 1). These measures and criteria are ultimately to achieve the goals or objectives of the road authority.

Areas of Improvements

Thus, the contracts give rise to a few areas of improvements. These are summarised in Table 1.

Output Based	Output and Performance Based
<ul style="list-style-type: none"> Finished works according to specified profile, roughness and texture as per design specification by consultants. 	<ul style="list-style-type: none"> Ride quality for road users, resulting in reduction in quantifiable road user costs. (economic) Reduced accident rates, as per accident statistics. (social) Noise and dust control, no of complaints from affected community. (environment) Savings to the owner in terms of providing the right type of work at the right time and the right price. (economic)
<ul style="list-style-type: none"> Activity driven – what and when to perform tasks 	<ul style="list-style-type: none"> Level of Service – e.g. Road Usability, Road User Service & Comfort Measures, Durability, Road Furnitures’ Performance Measures
<ul style="list-style-type: none"> Does not Promote Innovation 	<ul style="list-style-type: none"> Proactive Innovation – Contractors’ are incentivized to innovate to save costs in order to participate in the sharing of the cost savings
<ul style="list-style-type: none"> Work driven 	<ul style="list-style-type: none"> Promotes Optimisation – Level of Service vs Cost of Service:- <ul style="list-style-type: none"> Avoids “overkill” Encourages strategic trade-offs and management of priorities
<ul style="list-style-type: none"> Payment for inputs or physical works (which they undoubtedly have to carry out) 	<ul style="list-style-type: none"> Payment for output & performance e.g. rehabilitation to pre-defined standards

Table 1: Input based vs Output & Performance based

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Figure 1: Performance Measures & Criteria

Management Performance Measures

(MPM) - provide principle outcomes in the management of the contract and delivery of professional services across key performance areas. They are a set of outcome criteria, which the service provider's performance is measured against and include measures relating to the management of the contract and delivery of asset management related services. The service provider is required to develop and implement asset management practices to limit the extent

of asset consumption, while achieving the other performance measures.

Asset Preservation Performance Measures (APPM) - define the minimum performance criteria for individual assets during the contract term, with which the service provider must comply at all times. The overriding requirement is achieving asset preservation that ensures individual assets are maintained to the desired levels of service and achieve/exceed their design life expectations. The APPM's reflect the overall condition of the assets of the maintained corridor and are based on delivering current levels of service, as determined from road asset condition assessments, performance monitoring, delivery methodologies, and management functions within infrastructure management systems.

In a typical outcome or performance based road maintenance contract, key APPM's are collected in a periodic (usually annual) cycle. The collection of this APPM data are targeted at network level, which typically requires network wide measurements such as high speed mechanised data collection in conjunction with more conventional manual collection methods. This data is classified and reported against functional (road user) and structural (durability) criteria. Key APPM report the functional aspect of pavement performance including the International Roughness Index (IRI), which is collected on a high speed laser profiler. This performance measure has been gaining worldwide acceptance as the best indicator of level of service offered to the road user in terms of operating savings in Road User Costs (RUC). Common to most outcome and performance based road contracts is the measurement of pavement residual life. Residual life describes the structural or durability aspects of the pavement and typically derived from measuring the deflection bowl produced when a specified load is applied onto the pavement in a Falling Weight Deflectometer (FWD) test.

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Operational Performance Measures (OPM) - define the minimum performance criteria for individual assets in terms of day-to-day operations and maintenance standards.

For an output and performance based road contract, this measure defines the required level of service to be achieved by the service provider. This includes works management, information management, responsiveness to incidences, efficiencies in monitoring and reporting to Client and environmental and safety legislative compliance.

End of Term Requirements (EOTR) - specify the condition state for various major assets at time of hand back to the road authority. These requirements are intended to protect the owner from asset consumption during the contract term. The service provider must demonstrate throughout the contract term, via the submitted asset management plan and quality management plan that they will achieve or exceed the End of Term Requirements.

The most common requirement in the case of output and performance based contracts is the expected residual life of assets. Conventionally, the residual life of a pavement asset can be defined in terms of Million of Equivalent Standard Axles (MESA) that the asset is expected to withstand before reaching the design life capacity. In this case, comprehensive data collection on traffic volume and axle loading will be required. The lack of historic traffic and axle load data in many cases can be augmented from FWD load deflection test, using mechanistic (stress and strain onto pavement layers) derivation of structural strength of pavement layers.

Case Study

As an example, a road authority's goal is the provision of a safe and efficient road transport system. Over the past several years through a series of studies, it determined that to progress up the value chain, it will implement Output and Performance based Road Contracts (OPRC) for a portion of their road network to assess the benefits from this approach to the management of its highway assets.

The linkage of the various project parties involved in the development of this work is illustrated in Figure 2.

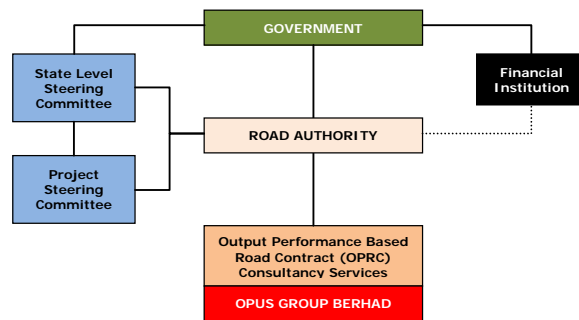


Figure 2: Linkages of various parties

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The project seeks to improve management of the network's infrastructure such that the **desired level of service** is delivered for the **least cost** to the agency **over the whole life** cycle of the asset.

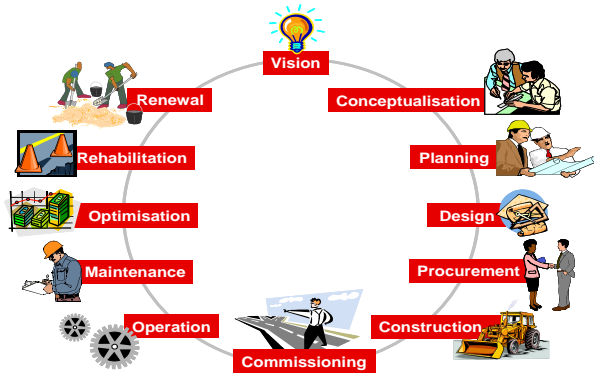


Figure 3: Stages in the Life Cycle of an Asset

The life cycle of an asset can be schematically depicted in Figure 3.

The cycle repeats itself at the renewal stage if an upgrading or expansion in capacity is planned at the end of the initial lifecycle.

Network surveys and actual loads per vehicle were collected and used to develop estimates of future traffic loads. This information has been consolidated up and

used to categorise future traffic loads on the Network. In this case, 3 design groups were assumed based on a recommended pavement design along typical categories as follows:-

Group 1 Roads: Future traffic up to 20MSA

Group 2 Roads: Future traffic up to 50MSA

Group 3 Roads: Future traffic up to 100MSA

Based on a review of the current condition data and the quality achieved on recent contracts, the proposed Levels of Service (LOS) and performance criteria for the network were then determined. The setting of "fit-for-purpose" service levels is pivotal to the whole OPRC exercise. The measurement of LOS has been grouped in to the following 3 headings:-

Management Performance Measures (MPM's)	<ul style="list-style-type: none"> • Set of performance criteria that reflect the Contractor's ability to successfully manage the physical works contract and to provide information to the Client e.g. final Annual Programme, Rolling 3-Year Programme, Report Submission Deadlines
Road User Service & Comfort Performance Measures (RUS&CPM's)	<ul style="list-style-type: none"> • Set of performance criteria that reflect the Contractor's ability to successfully complete routine maintenance activities • E.g. No more than 2 potholes within continuous 1km center line length with a diameter greater than 150mm. The maximum diameter of any single pothole shall be 300mm. No pothole shall be more than 50mm in depth.

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Road Durability Performance Measures (RDPM's)	<ul style="list-style-type: none">• Set of performance criteria that reflect the Contractor's ability to successfully manage the pavement and surfacing asset for the future and protect it from consumption over the duration of the contract.• E.g. roughness level – IRI
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Taking into account the inventory and the assessment of the road condition, the quantum of measures necessary to ensure that the proper level of service can be adequately defined to meet the objectives of the road authority and realize the appropriate benefits to the road users were then formulated. The quantum varies according to project size and for this example the typical road networks have the scope of measures as follows: -

Management Performance Measures (MPM)	11
Road User Serviceability & Comfort Performance Measures (RUS&CPM)	34
Road Durability Performance Measures (RDPM)	9
	54

Within the definition of the LOS, it have been endeavoured to avoid the use of response time based measures wherever possible. This is because not only are response time based measures more difficult to audit but they also reduce some of the pressure on the service provider to manage the asset to avoid defects – by instead allowing them to rectify once they occur or are identified by others.

In this regard, objective type definitions had to be set for the description of the performance measures and level of services. Hence, in setting the performance measures, amongst the key principles were along the following criteria: -

- **Repeatable** – measured with appropriate accuracy
- **Reproducible** – by different operator or equipment
- **Cost Effective** – in comparison to contract value
- **Manageable** – able to be influenced by contractor
- **Enforceable** – reasonably enforced with penalty/bonus
- **Predictable** – possible to model future outcomes
- **Safe to Measure** – practically requires high speed data

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Typical measures for the difference performance measures are as follows:-

Nomenclature	Management Performance Measure (MPM)
MPM-1	Quality Assurance System
MPM-2	Contracting Entity's Programmes
MPM-3	Emergency Works Reporting
MPM-4	Treatment Design
Road User Service and Comfort Performance Measures (RUS&CPM)	
RUS&CPM-1	Pavement Surface Repairs
RUS&CPM-2	Ponding of Water on the Pavement Surface
RUS&CPM-3	Signs Maintenance - General
RUS&CPM-4	Pavement Marking
Road Durability Performance Measures (RDPM)	
RDPM-1	Average Roughness
RDPM-2	Pavement deflection – contract area
RDPM-3	Construction Standards

Table 2: Examples of Performance Measures

Intrinsic to this project, was the recognition that it is almost impossible to have a conforming network 100% of the time. An innovative administration mechanism was thus introduced where non-conformance will be managed through a **“non-conformance bucket”**.

Non-Conformance Bucket is akin to a bucket of water where within any time period, as long as the prescribed Non-Conformance is not overflowing the bucket no penalty will be imposed (refer Figure 4).



Figure 4: Non-Conformance Bucket

Over time the bucket will be reduced when the contractors begin to appreciate the network and gain efficiency and effectiveness in carrying out the works (refer Figure 5).



Figure 5: Reducing Non-Conformance Bucket over time

Inter related with the development of the starting “bucket size” as well as the speed and quantum of progress over time are the **local market development** and **staged improvement** - criteria and objectives that the Client intend to achieve.

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Summary

Output & Performance-based Road Contracts (OPRC) embraces the concept of Total Asset Management i.e. the Whole Life Cycle of an Asset. Based upon such outlook, it directly relates the aspects of performance to cost, i.e. the aspects of cost of service to level of service. This balancing act provides a transparency to the aspects of service delivery by the service provider and to the road authority in owning the asset. Hence it enables all parties to appreciate the value for money aspects on an objective basis.

It is recognized that OPRC are relatively more complicated to administer initially but the benefits far out-weigh the initial complications. The aspects of sharing is intrinsic to such contracts, as the parameters when appropriately set is primarily objective in nature and hence any variation or 'requests' for supplemental or complementary requirements can be administered based on a clear-cut set of criteria. This will forge the alliance attitude very early on the in contract relationship and hence it will be true partnership seeking win-win solutions in addressing issues rather than the traditional client-contractor positioning.

OPRC contracts are a journey rather than a destination. It promotes innovation, as evident from contracts of such nature in many jurisdictions where 2nd to 3rd generation versions are now being implemented, i.e. New Zealand, Australia, United Kingdom, Canada. This will in turn support evolution of local practices, encourage higher standards and improvement of more rigorous performance measures over time. This can only benefit the road authority and users, including the service provider in its skills and knowledge development for business expansion.

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About Opus Group Berhad

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