ROLE OF WEIGH-IN-MOTION IN PERFORMANCE-BASED CONTRACTS

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Abstract
This paper investigates the role of using Weigh-In-Motion (WIM) systems to monitor and enforce traffic load spectra on highways in support of performance-based contracts. In particular, the role and benefits that WIM data collection and enforcement can have to ensure contractual obligations of long term performance based contracts and the financial objectives of the interested parties are presented.

Keywords: Public-private partnerships, Performance Specifications, Data collection, Alternative Funding Mechanisms, Weigh-In-Motion

Abstrait
Cette article étudie le rôle d'employer des systèmes de “Weigh-In-Motion” pour surveiller et imposer des spectres de charge de la circulation sur des omnibus à l'appui des contrats exécution-basés. En particulier, le rôle que la système de collection et l'application de données du Weigh-In-Motion peuvent devoir s'assurer des engagements contractuels des contrats basés par l’exécution à long terme et les objectifs financiers des ayants droit sont presenter.

Mots-clés: associations publique-privées, caractéristiques d'exécution, collecte de données, mécanismes de placement d'alternative, “Weigh-In-Motion”

En lo Abstracto
Este documento investiga el papel que juegan los sistemas de Pesaje-En-Movimiento (WIM), usados para supervisar y aplicar la ley en todos los espectros de tráfico de carga en las carreteras, en el suporte a contratos basados en el desempeño. En particular, el papel que la recolección de datos y la aplicación de la ley usando WIM pueden tener para asegurar que las obligaciones contractuales en contratos basados en el desempeño a largo plazo y los objetivos financieros de las partes interesadas, se logren.

Palabras Claves: sociedades público-privadas, Especificaciones de Desempeño, Recolección de Datos, Mecanismos de Fondo de Alternativa, Pesaje-En-Movimiento

1. Background

In North America, most road transport infrastructure assets have traditionally been publicly funded. Public road agencies, in turn, have been responsible to construct, maintain and preserve road transport assets. However, recent increased demands on road transport systems have, in some cases, exceeded traditional public funding capabilities required to provide the necessary rate of infrastructure expansion to meet growing user demands in a timely manner, and to maintain an acceptable level of service across existing road infrastructure assets. As a result, public road agencies are encountering limitations in funding infrastructure preservation and expansion through conventional public funding mechanisms. Road agencies are therefore investigating alternative financing mechanisms to provide and sustain transportation infrastructure.

The most common alternative funding mechanism used to facilitate road transport infrastructure assets has been user pay-as-you-go tolls. Public and private toll facilities have been successful in many regions of the world as an effective means to finance road infrastructure facilities including initial capital costs, as well as expenditures for preservation and maintenance. However, tolling typically requires multi year financing schemes to generate the magnitude of funding required to repay the significant accelerated investment in the infrastructure. Growth of toll roads has resulted in the development of intelligent toll systems. These advanced tolling systems provide the ability to implement a wide range of financing recovery regimes based on system capacity and demand. However, tolling of roads can be politically sensitive in some regions, and may be difficult to establish public acceptance to pay tolls because of the public's perspective of "free public access" to roads already paid for through public taxation.

An alternative funding source to tolling for financing road transportation infrastructure is through public-private partnerships. A public-private partnership establishes cooperation between public and private sector entities with shared interests in the financial benefits, as well as the mutual sharing of risks associated with large public infrastructure projects. Public-private partnerships are intended to provide increased financial resources through available private sector capital as well as provide equitable risk allocation between the participating public and private sectors. Public-private partnerships have been implemented globally to provide road infrastructure facilities and fill growing "infrastructure gap" between transportation user needs and limited public resources.

One of the benefits of private financing of transportation infrastructure is the accelerated investment in road transport infrastructure with non-deficit off balance sheet financing. Private financing therefore enables more projects to be undertaken sooner than would be possible with limited public resources, which often accelerates development of transportation dependent economies such as manufacturing, resource expansion and agriculture. In addition, private funding of transport infrastructure allows public agencies to divert resources to other public initiatives, including those with less ability to attract private financing, but are essential to social needs. For the private sector, investing in transportation infrastructure projects is a potentially attractive use for large blocks of capital and the traveling public gains access to a higher level of transport service and a more efficient transportation system (Black and Blunden, 1988). However, private sector investors typically require guarantees such as minimum future profit

gained to mitigate the threat of changes in future public policy and/or political direction which may have a significant negative affect on future cash flow for the private investor.

There are several types of public-private partnerships that have been used to privately fund public infrastructure. These agreements include: BOO (Build-Own-Operate), BOT (Build-Own-Transfer), LIO (Lease-Improve-Operate), BTO (Build-Transfer-Operate), and more recently public shadow toll mechanisms. With the surging need for accelerated road infrastructure maintenance, the use of performance based contracts to implement public-private partnerships are becoming increasingly popular.

Performance based contracts are emerging as an innovative option for tendering privatized contracts. As opposed to the traditional tendering process where specific construction techniques and materials are outlined, a performance based contract allows the contractor greater flexibility to use innovative methods, new technology and/or techniques that provide greater efficiencies and thereby greater profitability to achieve the end result. Public-private partnerships typically employ performance based specifications to ensure a sustainable level of service throughout the contract term and salvage value at the time of transfer. A performance based contract shifts the responsibility from the person managing road maintenance to the person designing and constructing the infrastructure. As a result, the contractor will try to minimize the amount above the minimum level of service required as the cost of over-designing will reduce profitability.

Although certain types of traffic data collection and enforcement is beneficial in routine public agency preservation and planning of infrastructure, in the case of performance based contracts, traffic data collection and enforcement is critical to ensure minimum performance levels are sustained throughout the contract. As a result, in order to effectively manage performance based contracts, data collection including traffic volume information, vehicle classification, traffic flow patterns, highway and pavement performance, environmental conditions and commercial truck traffic data and weight are important. Accurate traffic usage and monitoring enforcement is the basis for effective asset management, and facilitate better decisions to be made to protect the private investment.

2. Traffic Data Collection

Traffic data collection commonly used in the management of road infrastructure assets include: traffic types and volumes, environmental conditions and information dissemination systems. Generally, private vehicles cause congestion, while heavy commercial vehicles cause permanent distresses in the pavement.

In addition, to effectively preserve the highway infrastructure as an operating network system, truck weight information and weight management is required for both main highway routes as well as surrounding lower volume routes as an integrated system. An effective network system based weight management program is necessary to avoid costly damage to highway and bridge infrastructure assets. This is especially true for roads because they can exhibit relatively high increases of inelastic damage behavior under minimal increases in traffic loading compared to other engineered structures. Figure 1 demonstrates the increase in road related damage relative to an increase in traffic loads, showing a Fourth Power exponential relationship between the two.

By monitoring the traffic loads, preventative maintenance can be performed before structural failure occurs, thereby avoiding costly rehabilitation.

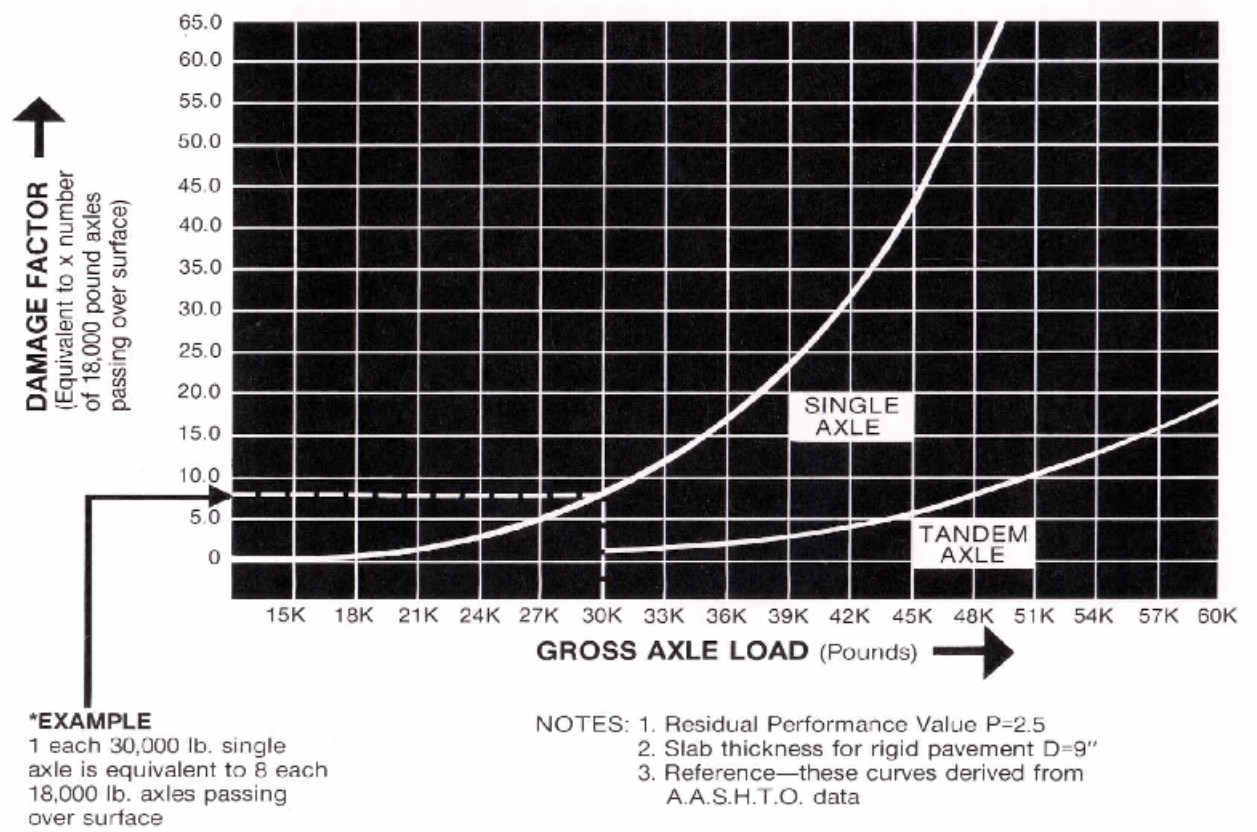

Figure 1: Fourth Power Law Damage Relationship

As a result, in order to accurately quantify load related damage inflicted onto road structures, vehicle weight, vehicle configuration, dynamic loading, tire type, tire pressure, environmental conditions, specific road materials and the road structure all influence the impact traffic loading has on the whole road structure performance. Similarly, spatial and temporal traffic load spectra is required to accurately measured to accurately quantify the impact that different truck loadings will have on the whole life performance of road structures.

3. Role of Weigh-In-Motion

Weigh–In-Motion (WIM) has been commonly used to quantify spatial and temporal axle loads to support performance based mechanistic-empirical performance prediction calculations. By employing WIM, actual load profiles in the field can be accurately quantified. An advantage to using WIM is that it is well established as a road management tool for traffic planning data collection, and commercial vehicle enforcement. As a traffic planning data collection tool, WIM has been used to provide traffic information needed to support future road infrastructure planning

decisions. As a weight enforcement tool, WIM is used to sort trucks prior to entering a weigh station either on the mainline traveling at highway speeds or on off-ramps at reduced speed. Where truck volumes are low, static scales provide sufficient capacity to weigh most trucks passing through the facility. However, many weigh stations experience such high truck traffic that they do not have the capacity to weigh all trucks statically. In these cases, trucks that the WIM identifies as near the allowable weight limits are directed to the static scales, while all other trucks are allowed to bypass. Given the road industry's move towards mechanistic-empirical road modeling techniques with such initiatives as the Strategic Highway Research Program (SHRP) and the proposed AASHTO 2002 design guide, WIM is also well suited to provide a field data collection tool that directly quantifies load state profiles in the field to support performance based mechanistic-empirical road design and analysis methods. To illustrate, SHRP Long Term Pavement Performance (LTPP) employ WIM systems to quantify traffic loading on LTPP pavement test sections throughout North America.

Several types of different WIM scales are currently available and have been widely implemented throughout North America including: single load cell scales; bending plate scales; and piezoelectric, quartz and fiber optic sensors (portable and permanent). The accuracy and costs of the different WIM systems range from a few thousand dollars per lane to several tens of thousand dollars per lane, as can be seen in Table 1. As a result, the type of WIM system appropriate for the specific application will depend on the specific needs of the road agency and the sophistication of the road modeling capability.

Table 1- WIM Scale Comparison

Type of Sensor	Accuracy	Cost	Speed
Piezoelectric	ASTM Type II GVW ±15% (@2s)	Low	30-100 mph
Bending Plate and Quartz	ASTM Type I GVW ±10% (@2s)	Medium	10-100 mph
Single Load Cell	ASTM Type III GVW ±6% (@2s)	High	10-100 mph

Note: GVW – Gross Vehicle Weight
@2s – at 2 standard deviations

Effective weight monitoring not only provides benefits for road planning, but also for enables more efficient enforcing of regulations. Weight monitoring and enforcement on the complete road network, as opposed to simply the primary highways, is now possible with Remote and Virtual Weigh-In-Motion sites.

At a Remote WIM site, existing weigh stations can be controlled and operated from a central location using web-based communication. The benefits of increasing the operation of a wide range of weight enforcement systems are far reaching. Data collection, road preservation, employee efficiency and operational savings are just some of the traditional problem areas that will improve from increased weight enforcement with a Remote WIM site.

A Virtual WIM site uses WIM in a similar manner to the Remote WIM site, in that it utilizes an existing or new weigh-in-motion data collection site. The data collected for each vehicle, which may include vehicle classification and weight along with an image, is then transmitted to an enforcement officer with a personal computer downstream of the Virtual WIM. If a vehicle is overloaded, the enforcement officer will have an image, along with vehicle weight, and he or she can pull the vehicle over for further inspection. Pre-weighing the trucks in advance allows enforcement officers to concentrate on potential violators, instead of detaining all trucks. A Virtual WIM system complements permanent weigh stations (typically located on main highway routes with higher traffic volumes), as they can be located between permanent facilities, or on known bypass or secondary highways.

3.1 Benefits of WIM Data Collection to Stakeholders

The incorporation of WIM into the monitoring of performance based contracts can satisfy the interests of several different stakeholders, including highway agencies, financiers and contractors. WIM data provides the basis for facility optimization, revenue generation and payment verification.

Highway agencies typically want to maximize the serviceability of the road. Data collected from the WIM system is used to strategically determine the appropriate time when road maintenance and repairs must be done in order to ensure at least the minimum level of serviceability. The data is also used to predict future road planning issues along the highway, such as traffic volume and distribution, as well as to evaluate the occurrence of overweight vehicles and the effectiveness of regulatory efforts.

The information collected by the WIM is vital for financial agencies to monitor their highway investments and to ensure a suitable return on investment. The information is also valuable in that it establishes a steady revenue stream based upon truck traffic, both empty and loaded, as loaded commercial trucks imply high economic activity. The data will also assist in asset management to avoid a high level of depreciation.

The ultimate goal of a contractor involved in road construction and repair is to optimize costs. In the case of a shadow toll public-private partnership, the WIM data allows for a detailed analysis of road usage and performance, thereby enabling the contractor to evaluate the necessary preservation measures to be taken in order to avoid severe road deterioration and failure.

In many cases, it is the public road agency that initiates traffic policies and weight limits, as well as determines the level of weight enforcement on the road. If the vehicle weights on the roadway are not properly enforced or policies are changed, premature structural damage may occur, leaving the private contractor responsible for the increased damage and resulting costs in order to maintain the required level of service. As a result, accurate traffic data collection, specifically vehicle weight monitoring, will not only benefit the public road agencies for planning purposes, but will also provide the road contractor with evidence of such overloading, in the case of premature structural failure.

4. Monitoring Performance Based Contracts

Due to public resistance to toll roads in some regions, shadow toll mechanisms are emerging as an effective mechanism to monitor a performance based contract when road construction and management are handled through a public-private partnership. Shadow Tolling allows for the construction of new sections of highways, or to contract the maintenance and service of existing highways, with payment based upon traffic volume or road usage. A Shadow Toll System also enables operation of the highway and monitoring of roadway performance without actually imposing monetary tolls on motorists. The system continuously collects data on road usage that is used to audit the performance of the road management contractor and acts as the basis for payment to the contractor. In the case of a performance based contract, the traffic data collected provides a mechanism to monitor usage of the assets, the performance of the investment, the effectiveness of the private contractor, and validates the financial models.

A Shadow Toll System uses WIM and will provide key information to optimize the quality of road management and maintenance practices. The information collected by the system is vital for financial agencies to monitor their highway investments and to ensure a suitable return on investment, especially as highway agencies consider new ways of financing highways. The technologies used are reliable and proven in practice through thousands of applications throughout the world, in all-climatic conditions and are cost effective. Shadow Toll Systems provide the data required to validate business models used in today's road financing environment and to audit the performance of the road management contractor.

Conclusion

Public authorities are encountering increasing limitations in funding infrastructure preservation expansion with conventional public funding mechanisms. As a result, road agencies are investigating alternative private based financing mechanisms to expand and sustain transportation infrastructure to meet growing user demands.

An alternative funding mechanism now being used for road transportation infrastructure are public-private partnerships. Public-private partnerships provide the advantage of increased financial resources being made available early in the project and provide equitable risk allocation between the participating public and private sectors. With the surging popularity of these innovative mechanisms as a method of financing road infrastructure rehabilitation and the privatization of maintenance of existing roadways, the use of performance based contracts are becoming increasingly popular.

The performance based contract requires all participants of the contractual parties to take a broader, longer-term view of their contractual obligations. The road contractor/operator has a contractual obligation to maintain the pavement infrastructure to a specified minimum level of performance during the term of the contract. From the public agency's perspective, the contractor or operator must ensure delivery of their performance obligations, including maintaining the roadway in the condition specified in the contract. Further, at the end of the contract period the contractor must assure that the roadway is returned at or above the minimum

specified salvage value requirements. The financiers are interested in ensuring a continuing stream of revenue without disruption due to performance issues.

In the privatized road market, having access to reliable traffic loading data helps the public road agency to correctly plan maintenance activities and rehabilitative measures to ensure the prolonged integrity of a road. Weigh–In-Motion (WIM) can be used to assist in the prevention of road damage from overloaded trucks and to monitor the performance based contract. Similarly, accurate vehicle weight information will provide the road contractor with evidence of overloading if premature structural damage occurs, thereby enforcing the public road agency's responsibility of effective weight enforcement.

Shadow Tolling has proven to be a successful mechanism for facilitating these performance based contracts. A Shadow Toll System enables operation of the highway and monitoring of roadway performance without actually imposing monetary tolls on motorists. Shadow Toll Systems provide the data required to validate business models used in today's road financing environment and to audit the performance of the road management contractor.

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