Data Collection Needs for Public-Private Highway Facilities

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Prepared for presentation at the
**"Finance/Design/Build/Operate/Maintain –
The Canadian Experience"** Session
of the 2001 Annual Conference of the
Transportation Association of Canada
Halifax, Nova Scotia

August 2001

Abstract

Innovative roadway financing and BOT (Build-Operate-Transfer) projects are becoming an increasingly popular means for providing accelerated investment in road transport infrastructure. Typically, these public-private partnerships involve a number of contractual parties, each required to take a broad, long-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 owner'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.

These public–private partnerships are creating a new way of investing in public infrastructure without public agencies having to incur on-balance sheet debt. There is usually a positive public perception of these relationships, as the public expects improvements to be made and view efficiencies by private sector entities to be higher than public sector agencies.

Shadow Tolling is becoming a common tool in the operation and financing of road infrastructure, where traditional toll collection is replaced with payments by government agencies on behalf of the users.

In this regard, this paper has three objectives;

First, the paper will present the different levels of data required by the stakeholders involved in Public-Private partnership, and the technology available to collect it.

Second, the paper describes the technology available to operate a Shadow Toll, citing references to the system currently deployed on the Fredericton-Moncton highway in New Brunswick.

Third, the paper will describe how accurate and reliable traffic data directly supports whole life asset management of a facility, and provides the basis for modern, mechanistic pavement design, pavement and bridge management, and policy and enforcement strategies.

Background

In Canada, most road transport infrastructure assets have traditionally been publicly funded. In addition, public road agencies have also been responsible to maintain and preserve the same road assets. However, recent increases on the demands placed on road transport systems have exceeded the traditional funding methods' ability to provide the necessary level of service and infrastructure expansion. As a result, public authorities are now encountering limitations in funding infrastructure preservation expansion with conventional public funds and road agencies are investigating alternative financing mechanisms to provide and sustain transportation infrastructure.

The most common private sector funding mechanism used to facilitate road infrastructure has been user pay-as-you-go tolling. Public-private toll facilities have been successful as an effective means to raise the necessary capital to construct and maintain the facility, while at the same time provide the required revenue to recover the initial capital investment. Many bridges across Canada were built in this manner with Federal and Provincial input. Growth of public-private toll roads has resulted in the development of intelligent toll systems with the ability to implement variable toll regimes based on the system capacity and demand. However, tolling is a politically sensitive issue and in some regions, is difficult to acquire public acceptance to pay tolls because of the necessary paradigm of traditional "free public access" to all roads.

Another alternative funding source for road transportation infrastructure is through public-private partnerships. A public-private partnership is a cooperation between public and private sector entities with shared interests and risks in a specific project. 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. There are several types of public-private partnerships, ranging from complete privatization to specified term commercialization of assets under privatization including: BOO (Build-Own-Operate), BOT (Build-Own-Transfer), LIO (Lease-Improve-Operate), BTO (Build-Transfer-Operate), and more recently publicly owned shadow toll mechanisms.

With the surging popularity of BOT (Build-Operate-Transfer) projects 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 owner'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. A Facilities Management Partnership Agreement using a Shadow Toll system is a beneficial mechanism to efficiently manage a Performance Based Contract.

Certain types of data collection are always beneficial in order to maintain infrastructure, however in the case of a public-private partnership, the role of data collection is deemed to be very important as private money is at stake. Traditionally, performance based contracts are based mainly on safety and pavement condition. Pavement condition data is generally collected to

monitor road deterioration, including rutting and cracking, which then enables optimization and scheduling of roadway maintenance. However, in order to effectively manage performance based public-private partnerships from a road contractor's point of view, it is more beneficial to monitor loading, damage and more advanced pavement condition data (including Ground Penetrating Radar and other non-destructive methods). This data is the basis for asset management, and will allow better decisions to be made to protect the private investment before pavement failure occurs.

Data Collection

Data collection plays an important role in the management of road infrastructure. Field data collection is important because it supports various highway performance and financial models that are vital to monitor highway investments and ensure a suitable return on investment over the life cycle of the asset.

While it is generally agreed that good data is required to properly manage a road, there is debate over what constitutes good data. Generally, the more complete and accurate the data, the more expensive it is to obtain that data. However, it can be shown that in the case of highway asset management, it is always good practice to collect complete accurate data as the costs are always a fraction of the potential loss.

Traditionally, it is generally acceptable to monitor pavement distresses as they occur, such as roughness, rutting and cracking. Although this provides the necessary data to optimize and schedule maintenance, it is a reactive technique. Alternately, by monitoring loading, volumes, and the environment, the inputs to the mechanistic damage model can be determined. Testing will verify the road designs, and the cost of changes in traffic volume and weights, due to circumstances beyond the road contractor's control, can be then be quantified.

Traffic Volume and Loading Data

To effectively preserve the highway infrastructure, truck volume, classification and weight information is required for both main highway routes as well as surrounding by-pass routes. By monitoring the loading over the life of the asset, one can know what stresses have been applied which can help to validate the pavement design. In the event of public policy changes which allow larger truck volumes and weights on privatized highways under performance based contracts, for example, collection of traffic data can help the private contractor identify this and preventative measures can be taken early on in the life of the asset. As well, having access to traffic data also gives the private contractor a defense mechanism in the event of premature failing as a result of policy changes.

Traffic weight management protects the pavement from damage due to over-weight trucks to achieve the design life of the highway and protects the return to the investors. An effective weight management program is necessary to avoid costly damage to the highway and bridge infrastructure. In the privatized road market, truck weight is a critical input for the protection of the investment in the asset, for life cycle costing and to assess pavement performance. Traffic data collection is also important as primary input information into a mechanistic based performance prediction model. This is especially true for road structures because they can exhibit a relatively high degree of inelastic deformation and fracture behavior under minimal increases in traffic loading compared to other engineering structures. As a result, in order to accurately quantify the inelastic behavior of road structures, vehicle weight, vehicle configuration, dynamic loading, tire type, tire pressure, environmental conditions and the specific road materials comprising the road structure influence the impact traffic load profiles have on the road structure.

In order to accurately predict traffic load related damage inflicted onto a road structure, spatial and temporal traffic load spectra is required to be accurately measured in the field for different truck loadings and road structures.

There are generally three primary categories of traffic data that are required, all incrementally more complete in the type of data provided, as can be seen in Table 1:

Table 1: Primary Types of Traffic Data

Data Type	**Use/Value**
Traffic Volume Spectra	General high level planning including geometrics and lane use. Simple traffic counting is the lowest cost data element, and should be deployed widely to ensure that original volume estimates are in line with the actual volumes and growth.
Traffic Classification Spectra	The acquisition of classification data is becoming quite cost effective, and it is generally recommended that all data collection include at least classification data. Classification data can provide better insight into lane capacity and use, and can provide general information on truck volumes and truck volume growth trends. Given that there is accurate truck and truck type information, safety and exposure analysis is possible.
Traffic Weight Spectra	Weigh spectra data is important in the continued management of pavement assets. Weight spectra information is important to validate original pavement design loading assumptions, and to continuously monitor pavement performance given the loading spectrum. Weight spectra data can allow effective and pro-active use of maintenance efforts and can be used to mitigate sudden and unexpected pavement deterioration due to increased volumes or loading patterns.

In this context, following are the key components for modern performance based contracts.

Weigh–In-Motion (WIM) is uniquely capable of quantifying spatial and temporal axle loads to support performance based mechanistic-empirical load equivalency calculations. By employing WIM, the actual load state profiles experienced in the field can be quantified based on the actual traffic loading spectrum in the field. An advantage to using WIM is that it is well established as a road management tool in two traditional capacities: 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. WIM data collection systems are often used to provide traffic stream volumes, vehicle speeds, axle weights, and vehicle configuration. 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.

Specifically in data collection, WIM systems located on the mainline continuously collect valuable data on truck weights, speeds, time of travel, axle configurations, and volumes. This information can then be used for statistical analysis of road usage, road wear, truck overloading, and vehicle configurations both for the planning of new roadways and for the management of existing roadways. This provides the most unbiased data since most illegally operating carriers avoid weigh stations, or travel when weigh stations are closed, thereby, artificially skewing the figures to indicate a lower frequency of overweights. WIM systems record all traffic information, even when weigh stations are closed. WIM data can be used to accurately predict future traffic volumes for planning of new construction, management of maintenance activities, to identify if overloading problems exist, and to evaluate the performance of pavements. Furthermore, when maintenance activities are mistimed due to inaccurate traffic loading estimates due to lack of reliable information, or overloading, it can mean the degradation of a road.

Several types of WIM systems 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 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.

Environmental Data

Monitoring environmental conditions enables a private contractor to relate the information to the pavement design in order to prevent premature failing of the road. For example, if unusual heat is experienced for a significant amount of consecutive days or months, data collected will help the road contractor to perform preventative maintenance before premature failure occurs. This information will also assist in future road design in the area.

Environmental data collection is also an effective tool for detecting adverse weather conditions, as the system can relay this information to radio stations or changeable message signs to alert road users to take caution, thereby increasing the safety of the road. In the same manner, road sensors can detect the presence of water and/or ice on the pavement in specific areas, thereby increasing the effectiveness of maintenance measures such as sanding. This not only reduces the wasting of materials, but increases the safety on the road.

Lastly, environmental sensors can be used to assist in flex shadow tolling. If the sensors detect large amounts of snow on the road, for example, then the rate charged per vehicle can be increased for a period of time to give the road contractor an incentive to quickly clear the road.

Pavement Condition Evaluation

Traditional data collection for pavement condition evaluation includes distress surveys involving observations of rutting, cracking, and roughness, for example. Although these are good indicators of damage, by the time they can be measured, the damage has progressed significantly, often beyond repair. As a result, new methods of data collection include non-destructive testing methods such as Ground Penetrating Radar (GPR) and Falling Weight Deflectometer (FWD) are currently being used. These new methods allow for detection of surface and sub grade problems before the distresses appear on the surface, allowing the road contractor to perform necessary maintenance procedures early on in the life of the asset, in order to comply with performance standards under the performance based contract. In most cases, early detection of possible distress significantly reduces the cost of maintenance and repair.

Road asset management includes monitoring the usage of the road assets and with regards to the types of vehicles to ensure that the initial design assumptions and pavement performance predictions are both accurate and reliable. By collecting real time traffic, pavement temperature, and weather information and applying modern pavement condition and highway performance models, highway managers can monitor their investment and predict future performance needs. This information can also be used to forecast maintenance and major rehabilitation requirements of the facility, help manage resources such as roadway signing, provide data for models that attribute road condition to road usage, develop new highway management practices and properly plan for future needs.

Facilities Management Partnerships

With limited budgets for road infrastructure, the use of a Facilities Management Partnership allows the public entity to receive all of the benefits of the road infrastructure immediately without the initial capital and start-up costs. As well, immediate deployment of data collection equipment will assist in the protection of the infrastructure and increase safety on the roads. By monitoring and controlling truck weights, the public entity can significantly decrease costly damage and deterioration to highway infrastructure from overweight trucks, as well as delay and reduce the major costs of highway refurbishment.

With a Facilities Management Partnership, the public entity will operate the facility, while the private company will be responsible for financing, design, supply, installation, maintenance and any upgrades of the weigh station.

The concept of “Shadow Tolling” is becoming a common tool in the operation and financing of road infrastructure, where traditional user-pay-as-you-go toll collection is replaced with payments by government agencies on behalf of the users. An example of a Shadow Toll partnership is portrayed in the Fredericton-Moncton Highway Project. In this particular project, a private company, Maritime Road Development Corporation (MRDC), is responsible for financing, building and maintaining the road to specified performance levels. The New Brunswick Department of Transportation (DOT) is the owner of the road and is responsible for payment to MRDC based on the amount of vehicles detected on the road. International Road Dynamics Inc. (IRD) forms the bond between the two, collecting the necessary information for billing purposes. The Shadow Toll partnership, in its simplest form, collects the number of vehicles and their respective classification. Two classifications are currently being used, the first being either a car or light truck, while the second classification is for commercial trucks. The details of this partnership can also be enhanced to accommodate the vehicle weights, if desired. The aforementioned partnership can be seen in Figure 1.

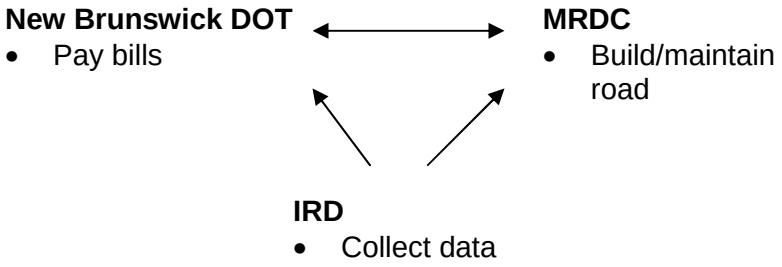

Figure 1: Fredericton-Moncton Highway Project Partnership

Shadow Toll can be used by highway agencies when road construction and management are handled through a public-private partnership. Shadow Tolling also allows for the construction of new sections of highways, or 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. The data collected provides a solid indication of the performance of the investment, effectiveness of the road management contractor, and validates the financial models.

The Shadow Toll System will provide key information to improve 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.

Stakeholders

The incorporation of public-private partnerships into the preservation and operation of roads can involve the interests of several different stakeholders, including highway agencies, financiers and contractors. Data collected provides the basis for optimization, revenue generation and payment verification.

Highway agencies want to maximize the serviceability of the road. Data collected can be used to 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 can also be used to look at 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 shadow toll system is vital for financial agencies to monitor their highway investments and to ensure a suitable return on investment. 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 minimize costs. In a shadow toll public-private partnership, the 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.

Conclusion

Public authorities are now encountering limitations in funding infrastructure preservation expansion with conventional public funds and as a result, road agencies are investigating alternative financing mechanisms to provide and sustain transportation infrastructure.

The most common private sector funding mechanism used to facilitate road infrastructure has been user pay-as-you-go tolling. However, tolling is a politically sensitive issue and in some regions, is difficult to acquire public acceptance to pay tolls because of the necessary paradigm of traditional "free public access" to all roads.

Another alternative funding source for road transportation infrastructure is through public-private partnerships. A public-private partnership is a cooperation between public and private sector entities with shared interests and risks in a specific project. 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.

Data collection plays an important role in the management of road infrastructure. Field data collection is important because it supports various highway performance and financial models that are vital to monitor highway investments and ensure a suitable return on investment over the life cycle of the asset. Traditionally, it has been generally acceptable to monitor pavement distresses as they occur. Although this provides the necessary data to optimize and schedule maintenance, it is a reactive technique. In many cases, distresses resulting in pavement reconstruction can be prevented if certain data is collected, including traffic volume, classification, truck and axle weight monitoring, environmental monitoring and information systems. In the privatized road market, having access to reliable traffic loading data helps the road owners to correctly plan maintenance activities and rehabilitative measures to ensure the prolonged integrity of a road. Weigh–In-Motion (WIM) systems can be used to assist in the prevention of road damage from overloaded trucks.

With the surging popularity of public-private partnerships, the use of a Facilities Management Partnership allows the public entity to receive all of the benefits of the road infrastructure immediately without the initial capital and start-up costs. Shadow Tolling has proven to be a successful mechanism for facilitating these Facilities Management Partnerships.