Performance-Specified Maintenance Contracting: The New Zealand Approach to Pavement Preservation

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ABSTRACT

Performance-specified maintenance contracting (PSMC) for pavement preservation it is used routinely by international roading agencies with much success. PSMC changes the definition of pavement preservation and maintenance success from “minimize cost” to “maximize value.” This paper reviews the PSMC experience found in New Zealand and compares it to the US experience. It finds that the US is handicapped by the federal funding delineation between construction and maintenance versus New Zealand’s holistic approach to pavement preservation that does not differentiate between the two. The paper details two variations to the New Zealand PSMC and finds that the hybrid PSMC model is very similar to Construction Manager/General Contractor project delivery in the US and might furnish an attractive structure to pilot a US project that bridges the construction and maintenance line.

INTRODUCTION

The philosophy that led to the success of the New Zealand Transport Agency’s (NZTA) performance-specified maintenance contracting (PSMC) is summed up neatly by the following quotation from one of its PSMC contractors:

“Our approach to a performance-based contract is to meet or exceed the Project Objectives and Project Outcomes, as measured by the various Performance Measures, in accordance with the specified Risk Profile, for the tendered Lump Sum. We adopt a “best for road” approach...Our methodology is based on identifying the risks to achieving each of the performance measures, and then determining a methodology to minimize, isolate or eliminate the risks to provide the client with a high level of confidence that the specified Performance Measures will be met or exceeded. To successfully meet the performance measures, we adopt a robust systems approach underpinning a comprehensive risk-based Contract Quality Plan” (Rainsford & Hunt 2006).
The authors of that quote work for Fulton Hogan, Ltd., a general contractor based in Christchurch, New Zealand. Most Americans will read the quote and think that this is just a marketing pitch, but most Americans are unaware of the fact that the performance of Fulton Hogan’s PSMC work is measured by over 200 performance measures that range from physical parameters such as pavement macrotexture and skid resistance to pavement condition-related crashes and the social costs generated by those accidents (Tighe 2007). Australia and New Zealand having been assigning contractors the responsibility to manage and maintain road networks for a fixed period at a lump sum for over ten years (Manion & Tighe 2007). The PSMC contract value covers the total cost of maintaining the network to the required level of service by NZTA with in-house forces. The term “maintenance” extends beyond the classic US definition to include highway and bridge rehabilitation and upgrades as well as other roadway improvement projects.

The salient issue with implementing performance-based maintenance contracts in the US is the risk the contractor must assume for the condition of the road network at the time the contract is awarded. The assumption that industry can reasonably estimate maintenance costs for a facility that it did not build is faulty. Plus, US agencies do not have the sophisticated deterioration modeling for highway pavements and structures that are available overseas. Hence, asking for maintenance services that are beyond vegetation control, litter pickup, and snow removal sheds a massive amount of risk and literally asks industry to furnish a lump sum for a multi-year contract to maintain a highway based solely on its visible condition. The impact of shedding this amount of risk was quantified when several US state maintenance contracts were not awarded due to unexpectedly high bids (Ribreau 2003). The scale required to make such a maintenance contract attractive also increases the variation from contract conditions and further reduces the agency’s ability measure from established benchmarks. The level of effort required to set those benchmarks prior to advertising the contract is also often prohibitive (Virginia 2001). In fact, the probability of the US agency even being able to enforce its contract performance criteria is questionable as was shown in the Oklahoma DOT experience (Segal & Montague 2004). Therefore, the fundamental issue in the US is to redefine the distinction between maintenance and construction as defined by the FHWA. In NZ, the PSMC will often schedule the contractor to rebuild sections of the road that are in bad condition before requiring it to be maintained. This effectively solves the issue of setting enforceable benchmark criteria against which the project’s performance can be measured.

INTernational PerforMance-BASEd CoNTRACTS

Various types of performance-based highway contracts have used for several decades in many European and Australasian countries (DeWitt et al 2005). The structural difference with the US system is the lack of separation between design and construction as well as between construction and maintenance. The international model views the process of project delivery as continuous rather than the US vision which is subdivided with hand-offs interrupting the progress from one phase of the project to another. The international approach permits the contractor to develop its own long-term risk management plan by participating in the design and completing the construction for a facility for which it will take long-term performance responsibility. There are many variations on this theme, ranging from privatizing infrastructure assets to public-private partnerships. Two more recent project delivery methods are alliancing (DeWitt et al 2005) and early contractor involvement (ECI) (Highways 2004). Both these methods bring the contractor on board the project in some capacity at a very early phase of the project and keep it on board for a term long enough to qualify as a “strategic relationship” (DeWitt et al 2005).

The UK Highways Agency has used ECI as a means to bring constructability expertise and real-time cost estimating to the project at its conception (Highways 2004). The fundamental concept is to begin the process
pragmatically and avoid wasting planning and design effort developing design solutions that are ultimately not implementable due to cost or other factors that are best known by the construction industry. It also serves to create “a sense of ownership” for the design by the builder which discourages disputes in later phases of the project (Molenaar et al 2007). ECI’s major culture shift is that the contractor comes to the project before the designer. The Utah DOT recognized the potential value of this change in its analysis of its Construction Manager/General Contractor (CM/GC) program when it posed a need to alter the timing of CM/GC selection: “[the timing] needs to be developed in a way that allows us to select the contractor earlier in the process even as soon as the design consultant. This will enable contractor input at the beginning of the design process before too many design decisions are made” (Alder 2007). Figure 1 shows the differences between international project delivery and US project delivery from a global perspective.

The international forms of project delivery shown in Figure 1 are essentially variations on the US ones. Alliancing is a form of public private partnership where the owner, designer and contractor form a legal consortium to deliver a given project. “Design and build” is equivalent to the US design-build project delivery method. The main difference is that the proposal process is both extensive and expensive. The preproposal process is aimed obtaining the owner’s concurrence with the design before awarding the final contract. This process is in some ways like the US “bridging” design-build method. Public tender equals US design-bid-build. Finally, the reader must know that the figure is purely conceptual and not an attempt at a precise definition of each possible variation on the project delivery theme. The point is to show how the US system has no project delivery tool that involves its industry partners in the project planning process and only one (PPP) that extends across the construction-maintenance boundary.
International Performance Specified Maintenance Contracts

Figure 1 shows two of the common types of PSMC found internationally (Porter 2001). “Pure PSMC” functions much like an alliancing scheme that extends into the maintenance period. A consortium is formed by a design consultant and a construction contractor to design, build, and maintain all the required facilities on a given highway network. Construction usually falls in the realm of rehabilitations, upgrades, and small projects. These are often called “asset management contracts” (Manion & Tighe 2007). Quality assurance is performed by a “network board” monitors key performance measure (KPM) outcomes and makes payments to the PSMC consortium based on the success rate of meeting or exceeding specified performance criteria. In the “hybrid PSMC” the owner retains control of the design contract but allows the PSMC contractor to make significant input to the design of project it will construct. This is done by requiring the design consultant to generate several design alternatives for each major feature of work and allowing the PSMC contractor to propose on the alternatives that it will warrant (Porter 2001). This functions somewhat like a US CM/GC contract with a follow-on maintenance period. The hybrid PSMC will be discussed in detail in the NZ case study analysis.

The Canadian province of British Columbia was the first to out-source its highway rehabilitation and maintenance using PSMC in 1988 and was followed by the provinces of Alberta and Ontario shortly thereafter. Australia tried its first PSMC in New South Wales in 1995 to maintain urban roads in Sydney and since then three other states adopted the “pure” and “hybrid” approaches as well (Zeitlow 2004). At present, 15% of New Zealand’s national network is covered under this type of contract (Stankevich, Qureshi, & Queiroz, 2005). The developing world, specifically Latin America, has developed and adopted their own PSMC models. Argentina introduced PSMCs, which cover 44% of its national paved network (Liaustaud 2004). In the mid nineties Uruguay, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico and Peru all shifted to a performance-based approach for infrastructure delivery and maintenance. South Africa uses PSMCs on 100% of its national roads. Other developed and developing countries like the UK, Sweden, Finland, Netherlands, Norway, France, and Estonia, have since adopted the PSMC contract. Table 1 shows the equivalent US project delivery methods that are in use within international PSMCs and illustrates the ability to use PSMCs with virtually all forms of project delivery.

Table 1. Summary of International PSMC Practices (after Pakkala 2005)

<table>
<thead>
<tr>
<th>Country</th>
<th>DBB</th>
<th>DB</th>
<th>CM/GC</th>
<th>DBOM or DBFO</th>
<th>PPP</th>
<th>Alliance or ECI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td></td>
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<td>X</td>
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<tr>
<td>Australia</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>Canada</td>
<td></td>
<td>X</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>Finland</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Netherlands</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td>New Zealand</td>
<td>X</td>
<td></td>
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<td>X</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

DBB: Design-Bid-Build; DB: Design-Build; DBOM: DB-Operate-Maintain; DBFO: DB-Finance-Operate; PPP: Public Private Partnership
As is the case throughout the world with procurement systems, PSMCs have many different names in the literature, and this proliferation of terminology is confusing. They are often termed “output-based” or “outcome-based” contracts. The World Bank designates them “performance-based contracts for management and maintenance of roads” (PMMR) or “output- and performance-based road contracts” (OPCR) (World 2005). PSMCs within the highway sector can be either “pure” or “hybrid”. Hybrid PSMCs combine features of both method- and performance-based contracts. Some services are paid on a unit rate basis, while others are linked to meeting performance indicators or KPMs. Australia and New Zealand use this term. While the UK refers to PSMCs as a “managing agent contracts” (MAC), they are called “area maintenance contracts” in Finland. Finally, Argentina refers to it as CREMA, which stands for “contract for rehabilitation and maintenance” (‘Contrato de Recuperación y Mantenimiento). Thus, the reader must take great care to understand the meaning of the various technical terms and acronyms before making judgments about their applicability to the US environment.

The Argentine CREMA requires the contractor to rehabilitate and subsequently maintain a sub-network of roads under a lump sum contract for a total period of five years. The system applies to a paved sub-network which needs to be rehabilitated over a part of its length and subsequently maintained over the whole of its length. Rehabilitation works range from resurfacing with slurry seals and surface-dressing to overlays to complete reconstruction of the base and surface course. These works are carried out during the first year of the contract and maintenance activities are undertaken throughout the contract period. The contract specifies the sections that need rehabilitation as well as the acceptable minimum solution (i.e. overlay thickness) that is required. After award, the CREMA contractor carries out detailed engineering design and is free to propose, on the basis of his own risk assessment, any rehabilitation solution above the minimum threshold defined in the contract. One of the conclusions of Liautaud (2004) was that the risk of unsatisfactory quality in the capital (rehabilitation) works was greatly reduced by the obligation of the CREMA contractor to maintain the roads over a five-year period. Also, in Argentina consideration is given to extending the contract period from 5 to 7 or 10 years. This system is very similar to the hybrid PSMCs used by Australia and New Zealand.

New Zealand Hybrid PBC Case Study

New Zealand’s PSMC program for highway construction and maintenance services is mature (Porter 2007; Rainsford & Hunt 2006). NZTA utilizes pure PBC, hybrid PBC, and what it calls “conventional” PSMC contracts. The latter is merely a PSMC contract where the scope of work is limited to a few work items like litter control, vegetation control, and snow removal. The hybrid PSMC contract model is shown in Figure 2. NZTA holds both a design and a construction/maintenance contract and uses an auditor as an arbiter of outcome achievement for payment purposes. These contracts are typically 5 or 10 year terms. The agency has an option to extend the contract if the contractor exceeds certain predefined quality outcomes as measured by the contract KPMs. This feature “provides very positive incentives for quality within the contract” (Porter 2007).
Compendium of Papers from the First International Conference on Pavement Preservation

Figure 2. New Zealand Hybrid PSMC Contract Model

**PSMC Key Performance Measures**

NZTA has various approaches for specifying performance outcomes tailored to each contract’s environment, level of traffic, etc. but most hybrid PSMCs define performance outcome target for:

- “roughness profiles
- texture profiles
- surface skid resistance profiles
- rutting profiles.” (Porter 2007)

They also contain the following metrics that are based on deterioration models:

- “measures to assess the residual surfacing life,
- measures to assess on the residual pavement life,
- response times in emergencies/adverse weather,
- minimum levels of reflectivity for signs and delineation marking,
- minimum condition profiles for stormwater channels and structures, street furniture and lighting” (Porter 2007).
The contract tender and payment structure involves a lump sum bid for routine maintenance work and a schedule of unit prices for the construction features that are scheduled within the period of the contract. Hence, NZTA and its PSMC contractor negotiate the cost of the construction projects (called “periodic maintenance” in NZ) in much the same manner as a US CM/GC guaranteed maximum price. Part of this process involves the contractor proposing the conceptual design for the construction projects in the same manner as CM/GC makes input to design in the US. The consultant and the agency then review and approve the concept with the consultant taking the concept and producing the construction documents necessary to complete the project. While any type of project is theoretically possible under this arrangement, most are overlay, reseal, upgrade, or rehabilitation type projects. Additionally, NZTA uses these contracts to complete most of its major drainage works for the contract area of operations.

Hybrid PSMC Model

The model has two major advantages over the conventional and pure PSMC models. First, it requires much less data be made available during the procurement phase as the construction projects are defined in terms of lengths of overlay, total area of sprayed seals, etc. These form the estimated quantities against which the contractor will develop its unit prices. The hybrid’s second advantage is they don’t need a “robust definition of long term outcomes” as “residual pavement life is not as big an issue because the client is protected by the underlying quantities” (Porter 2007). From 1995 to 2001, cost savings in the range of 25% using the hybrid PSMC were realized by NZTA (Porter 2007). The contract procedures proceed according to the process chart shown in Figure 3. Figure 3 was developed from a paper written by a NZTA hybrid PSMC contractor and describes how this firm executes the contract it holds in the province of Canterbury (Rainsford & Hunt 2006). Its most striking feature is the level of integration between the owner, the consultant, and the contractor. It also clearly shows the long-term strategic approach taken to completing this contract.

The authors of the paper stress the requirement for a high level of integration both vertically and horizontally. “It is important to link all 3 levels of programming – daily and weekly programming, monthly programming and annual programming, to provide holistic and value-based programming…[Figure 3] outlines this process, but is also aligned with the programming and delivery of works within the Pavement Management Strategy” (Rainsford & Hunt 2006). It is interesting that the contractor in this case uses the word “strategy” to describe the pavement management planning and programming system. They use it again when they state: “the Maintenance Intervention Strategy selected for each treatment length will provide economic control of the works to ensure the correct repairs are undertaken for the programmed treatment year.” In this citation they link strategy to “maintenance intervention” to convey the meaning that while the system provides a mechanism for reactive maintenance that must inevitably occur on road networks of this scale, the intent from the beginning is to intervene at appropriate points in time to prevent local failures and to preserve the pavement’s structural integrity. This fits nicely with the FHWA definition of “pavement preservation” which is work to which the FHWA will contribute funding (Washington 2008). The salient point to be drawn from this case study is that PBC in New Zealand treats the requirement to furnish a desired level of service “holistically” and “strategically.” Both of these values are ones expressed in the previously referenced the US report by DeWitt et al. (2005).
New Zealand PSMC Experience

Now that one model for implementing PSMC has been presented, it is important to show the change in the level of service that result from making this culture shift. PSMC focuses on outcomes rather than input (Manion & Tighe 2006). “Government should not pay for inputs, nor processes, nor activities, nor outputs, but for outcomes” (Behn & Kant 1999). PSMC is predicated on performance, capacity, and real-time sharing of project information. It contains contractual content to share the risk and possibly share the benefits of exceeding performance criteria in a meaningful way through incentives. The ultimate result of this method is changing the agency maintenance/preservation decision criterion from “minimize cost” to “maximize value” by focusing the effort on measured performance rather than specification compliance (Manion & Tighe 2006). It is also based on creating the design and construction capacity that matches a given agency’s requirements both in terms of technical sophistication and robust, flexible financial ability. The PSMC contract formally leverages the technological advances in design, management, and project controls technology to share information in real-time among all the project stakeholders. PSMC fosters long-term, multi-project strategic partnerships between the project stakeholders that last long enough that mutual trust and respect can grow and be used to leverage the value of the capital, creativity, and technical abilities of each party to the benefit of the traveling public. Highway agencies who see the risk of awarding a project to an incompetent or recalcitrant designer or contractor drop to nearly zero are the prime beneficiaries. The designers and builders also accrue benefits in an enhanced familiarity with the owners’ requirements that allows them to design and build projects with
increased confidence that they will be promptly paid for their efforts without having to resort to the legal system. The ultimate end-users of the constructed product also accrue benefits from decreased life cycle costs, earlier service delivery, and efficient use of public monies.

**PSMC Performance Measures**

KPMs are established for PSMCs in five different areas. Table 2 lists the major categories and subcategories used in a typical PSMC. For the case study presented above there were over 200 KPMS that were tracked over the course of the 5 year contract (Tighe 2007).

<table>
<thead>
<tr>
<th>Major Category</th>
<th>Subcategory</th>
<th>Example KPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement</td>
<td>– Structure</td>
<td>– Deflection FWD &lt; STD</td>
</tr>
<tr>
<td></td>
<td>– Pavement cracking</td>
<td>– High Speed Vehicle data measures</td>
</tr>
<tr>
<td></td>
<td>– Surface remaining life</td>
<td>– Deterioration model output</td>
</tr>
<tr>
<td></td>
<td>– Roughness</td>
<td>– NAASRA count &lt; STD</td>
</tr>
<tr>
<td></td>
<td>– Rutting</td>
<td>– Rut depth &lt; STD</td>
</tr>
<tr>
<td></td>
<td>– Surface texture</td>
<td>– Macrotexture &gt; STD</td>
</tr>
<tr>
<td></td>
<td>– Surface skid resistance</td>
<td>– Skid number &gt; STD</td>
</tr>
<tr>
<td>Drainage Systems</td>
<td>– Pits (detention swales)</td>
<td>– % Original depth</td>
</tr>
<tr>
<td></td>
<td>– Culverts</td>
<td>– % Blocked</td>
</tr>
<tr>
<td>Traffic Facilities</td>
<td>– Traffic Signs</td>
<td>– Reflectivity &gt; STD</td>
</tr>
<tr>
<td></td>
<td>– Road Marking</td>
<td>– Visibility &gt; STD lane-kilometers</td>
</tr>
<tr>
<td></td>
<td>– Barriers</td>
<td>– % &gt; STD</td>
</tr>
<tr>
<td></td>
<td>– Lighting</td>
<td>– % Operational &gt; STD</td>
</tr>
<tr>
<td>Visual Amenity</td>
<td>– Litter control</td>
<td>– # Notices</td>
</tr>
<tr>
<td></td>
<td>– Grass cutting</td>
<td>– % On scheduled time</td>
</tr>
<tr>
<td>Management</td>
<td>– Reporting</td>
<td>– Timeliness</td>
</tr>
<tr>
<td>Performance</td>
<td>– Response times</td>
<td>– % &lt; max allowable time</td>
</tr>
<tr>
<td></td>
<td>– Safety</td>
<td>– % Crashes &lt; STD</td>
</tr>
</tbody>
</table>
| STD = Contract standard for given KPM

**Example Record of PSMC Performance**

Attempting to summarize a measurement and compliance program as robust as the one shown in Table 2 is impossible. However, three examples are presented to demonstrate the impact of implementing PSMC on a road network’s level of service. NZTA’s first PSMC was selected as the example for three reasons. First, it has been in force for the majority of its 10-year contract period and thus, gives the clearest indication of potential benefits. Secondly, it is a “pure PSMC” and furnishes an example of the difference between this model and the previous one. Finally, it shows that NZTA “got it right the first time.” Intuitively one would expect that the first iteration of a new pavement preservation paradigm would be rife with difficulties and that it might take several iterations before the agency reached the top of the learning curve for the new form of project delivery. While PSMC 001 was certainly not perfect and NZTA and its contractor both learned valuable lessons that were included into subsequent contracts, the overall result was very positive. As such the three examples are diverse. The first example is shown in Figure 4.
This example is a global measure of network roughness as measured by the National Association of Australian State Roading Authorities (NAASRA) roughness count. This index is a description of ride quality defined by the movement of a point on the body of a special purpose vehicle in relation to its rear axle while travelling at a predetermined speed. The NAASRA count increases as roughness increases. Counts less than 40 are rated as excellent. “Good” runs 40 to 80, and “fair” value ranges from 80 to 110. Counts above that are considered either “poor” or “very poor.” Typical KPMs are usually set based on a road’s current condition and will vary based on pavement type, age, and level of traffic. In PSMC 001, the contract was divided into four separate networks on this basis. Figure 4 shows the change in roughness over time for nine contract years on three of the four networks.

Figure 4 shows how the actual performance is measured against the performance measure set for each network. It shows that all three networks exceeded their individual mean roughness KPM for each of the 9 years under contract. In fact, all three showed continuing improvement for the majority of the period. One would expect that at some point in the PSMC period that this measure would rebound and start getting worse as the rehabilitated road nears the end of its service life. While, this is observed in the Northern and Southern Networks, the values still exceed the KPM.

Figure 5 moves the same road system from the macroscopic to the microscopic scale by looking at skid resistance measured by a High Speed Data Measurement Vehicle. The performance criterion is to keep 99.5%
of the network at skid measurements greater than the standard shown in the figure. This particular criterion allows that standard to slip 1% before disincentives kick-in. Again one can see that the contract mechanisms in place created an incentive which led the contractor to literally keep the entire network above the standard for three straight years. This makes a powerful argument for the paradigm shift from “minimize maintenance cost” to “maximize pavement preservation value.” This is a particularly important illustration in that a structurally sound pavement could become unsafe due to aggregate polishing alone necessitating remedial action to raise the microtexture. In the US, that would be a microsurfacing, a chip seal, or an overlay. Thus, this is an instance where PSMC directly contribute to pavement preservation by modifying contractor and agency behavior.

Figure 5. Example PSMC Network Skid Resistance Experience Over Time – First Five-Year Period Report (Inroads 2007)

Figure 6 takes the engineering measurement in Figure 5 and translates it to a measured criterion for highway safety and holds the PSMC contractor responsible for providing a level of service that includes safety. In this case, the performance measure is a comparison with the national safety record and is quantified as 90% of the national average of crashes attributed to unsafe road conditions. These relate not only to the skid resistance measured in Figure 5, but also to the categories shown in Table 2 such as the condition of signs, road markings, lighting, and barriers.

NZ has a methodology to measure the actual costs of vehicle accidents. This furnishes a measure of the severity of the accidents that do occur. The government, as opposed to private insurance companies, actually furnishes insurance for all accidents and as a result has direct access to this data (Oliphant 2007). In this contract, the KPM was set 95% of the national average for NZ Accident Compensation Corporation payments. Once more the PSMC contractor was able to exceed the KPM in this category.

In summary, the review of PSMC 001, a pure PSMC contract, showed that the results of implementing this method to preserve and maintain highways and can be positive from the very first project if the agency
invests the necessary effort to develop appropriate KPMs and realistically relate them to the condition of the existing roads. It also shows how allowing the contractor to “make its own bed” by including rehabilitation in the PSMC alters the agency’s risk for the current condition of its roads in a manner that leads to improved levels of service and increased safety. The hybrid PSMC case study demonstrated an alternate model to deliver a robust program of pavement preservation and maintenance. The case showed that the “construction” features of the PSMC contract can be separated from the preservation/maintenance activities in a manner that is less drastic than privatizing the entire network. This model would make a good starting point for a US DOT interested in piloting a PSMC.

The bottom-line is that the road to successfully implementing PSMC in the US has already been mapped by the international roading community. The steps to implementation are evident. First, the legal ground must be prepared to create an environment where long term strategic partnerships can be established. Next, a holistic strategy to delivering the required level of service should be developed that no longer differentiates between the construction and maintenance. It must also allow the funding of outcomes rather than inputs. Research must be accomplished to determine practical tools to measure outcomes, eliminating the input-driven culture from this form of infrastructure delivery. Contractual instruments that create a high level of integration between the three stakeholders in the project must be developed to fit the US public works environment. Finally, programs like Highways for Life and SEP 14 (SAIC 2006) could be used to pilot the proposed forms of PSMC to gain insight and lessons learned. The US’s ability to implement this form of project delivery will be greatly influenced by the two barriers cited above. However, the documented benefits accrued internationally provide the necessary incentive to overcome these barriers and add another tool to the highway agency’s project delivery toolbox.
CONCLUSIONS

This study shows that while the US has experimented with forms of PSMC, the results are not altogether positive. The US attempts were not as broad as those implemented in other parts of the world. Five conclusions are drawn from the above analysis:

1. Both the pure and hybrid forms of PSMC are successful in fulfilling pavement preservation objectives. As this process effectively blurs the lines between construction, maintenance and preservation, it makes an ideal tool for keeping good roads good and making bad roads better inside a single contract.
2. PSMC must be implemented in a manner that allows long-term strategic partnerships to form and mature.
3. PSMC should span the design, construction, and maintenance phases of a highway project's life cycle to permit a holistic, value-based execution.
4. To be successful, PSMC demands a high level of integration in its execution.
5. The true benefit of PSMC project delivery is in shifting from a “minimize cost” culture to a “maximize value” culture by focusing the effort on measured performance outcomes rather than specification compliance inputs.

The conclusions lead to the idea that implementing PSMC is worth pursuing. As such, two recommendations with regard to future implementation of PSMC are made:

1. The NZTA hybrid PSMC model is a very likely candidate for pilot projects. It is contractually structured like CM/GC, a project delivery method used by a number of DOTs. Thus, the foundation those agencies have built to implement CM/GC can be leveraged to build a PSMC model that could be used in a pilot project.
2. Research should be done to synthesize international PSMC experience and provide information to US project delivery method decision-makers to be able to determine if this approach is attractive in their areas of responsibility.

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