*Proposal (revision)*

# CA4PRS Software Enhancement

(Manual, Version 1.5 and 2.0)

Pooled Fund Sponsored by
Federal Highway Administration (FHWA) for
4-State DOT Pavement Technology Consortium
(CA, MN, TX, and WA)

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## Summary of Enhancement Costs and DOT Contribution

(Unit: $1,000)

| Cost Item | OPTION 1 (Version 1.5 Only) | OPTION 2 (Version 1.5 and 2.0) |
|---|---|---|
| Manual | 35 | 45 |
| Training | 30 | 60 |
| Version 1.5 development | 145 | 110 |
| *Sub-total* | *210* | *215* |
| Version 2.0 development (with Caltrans Contribution) | N/A | 10.5 |
| ***Total*** | ***210*** | ***320*** |
| DOT Contribution (for 2 fiscal years) | CA=MN=TX=WA=52.5 | MN=TX=WA=53.75<br>CA=5.375+10.5=158.7 |

## Cost Estimate Assumption

If only CA4PRS version 1.5 is developed without version 2.0 enhancement, its enhancement cost goes up due to the university overhead policy, contracting cost, and no package-discount, compared to the case of both V1.5 and 2.0 enhancements.

The enhancement cost estimate was based on the following two options:

- ***Option 1: Only Version 1.5 is developed.***
  4 DOTs will share the cost ($210,000) with the same contribution.

- ***Option 2: Both Version 1.5 and 2.0 are developed.***
  4 DOTs will share the 1.5 enhancement cost ($215,000), in addition Caltrans would like to allocate more pooled fund to bear the V2.0 enhancement cost of $105,000.

## 1. CA4PRS VERSION 1.0

In a national-wide perspective, the majority of urban highway pavements have been rendered obsolete due largely to the fact that the majority of these infrastructures have been explicitly exposed to heavier volumes and loads of traffic than those for which they were originally estimated and designed. In responding, the current version (V1.0) of CA4PRS software was developed by the Institute of Transportation Studies in the University of California at Berkeley with the pooled fund sponsored by the 4-State DOT (CA, MN, TX, and WA) Pavement Technology Consortium. It was designed to help road agencies, pavement contractors, and engineers plan and conduct pavement rehabilitation and reconstruction projects efficiently.

## 2. FEATURES OF CA4PRS V1.0

CA4PRS estimates the maximum and/or range of amounts (distance) of pavement that can be rehabilitated or reconstructed under differing traffic closure strategies within a given set of project constraints. It is a knowledge-based computer simulation model that allows evaluating what-if" scenarios with respect to rehabilitation productivity by comparing the following input variables (alternatives):

- ***Rehabilitation strategy****:* Portland Cement Concrete (PCC) reconstruction, crack and seat PCC and asphalt overlay (CSOL), or full-depth asphalt concrete replacement (FDAC).
- ***Construction window****:* nighttime closures, weekend closure, continuous closure, or combinations of the above.
- ***Lane closure tactics****:* number of lanes to be closed for rehabilitation (i.e., partial or full closures).
- ***Material selection****:* mix design and curing time for concrete or cooling time for asphalt.
- ***Pavement cross section****:* thickness of new concrete or asphalt concrete.
- ***Pavement base types****:* lean concrete base (LCB) or asphalt concrete base (ACB).
- ***Contractor's logistical resources****:* location, capacity, and numbers of rehabilitation equipment available (batch plant, delivery and hauling trucks, paving machine).
- ***Scheduling interfaces****:* mobilization/demobilization, traffic control time, and activity lead-lag time relationships and buffer sizes.

A total of 9 one-day training classes with the CA4PRS software V1.0 for about 80 end users in 4-State DOT were delivered in the summer and fall of 2003. More intense 4-day training class to educate in-house trainers so that they can train their own users in the 4-State DOT was provided in March 2004. A technical report summarizing all analysis logics and processes of the CA4PRS model was developed and submitted to the 4-state DOT at the beginning of 2004. CA4PRS has been successfully used for several long-life pavement rehabilitation projects in California. Caltrans has used the software on the I-710 Long Beach AC Long-life Project (Caltrans D7) and on the I-15 Devore PCC Long-life project (Caltrans D8) to develop construction and traffic management plans.

## 3. NEED OF CA4PRS ENHANCEMENT

First of all, the development of a user's manual is urgently needed according to comments from the members of the training classes. The manual will help the user understand the background logics, analysis process, and relationship of the input variables in the CA4PRS software. The limitation of the V1.0 training manual provided during the training classes is only to demonstrate

the examples of the software application with graphic screen shots without textual explanations. The user needs more specific description and definition of input variables and their impacts on outputs to use the software more accurately.

The current CA4PRS model (V1.0) is not only limited to the production analysis from the scheduling aspect of pavement rehabilitation to determine maximum, optimal production capability, but also focused mainly on specific pavement (particularly long-life project in urban areas) construction scenarios within limited reconstruction options such as two truck lane rehabilitation strategy on the fixed four-lane per direction freeway in the urban area.

To overcome these limitations, the current CA4PRS model needs to be upgraded as a major enhancement. Interim version 1.5-a will improve user friendliness and input interfaces for user convenience. In addition, the software upgrade will be done concurrently in two main enhancement schemes, named as CA4PRS version 1.5-b and version 2.0. For the upgrade of the version 1.5, some input parameters and construction alternatives will be expanded to cover more rehabilitation strategies, and to improve the user friendliness, and to add more powerful and accurate constructability analysis features.

In the update for version 2.0, the CA4PRS model updated will be integrated with traffic delay analysis based on demand-capacity model (Highway Capacity Manual) to calculate road user delay in the construction workzone, and to estimate agency cost (construction and traffic handling cost). Eventually, the concept of the total cost (as the sum of the agency and road user cost) based on the scheduling, traffic, and cost analyses will be provided to select the most economical construction scenarios.

The same programmer (Siva) will be hired as the programmer for both the V1.5 and V2.0 enhancements with EB Lee's coordination.

The 4-state DOTs will have the free and unlimited license for the CA4PRS software V1.5 and V2.0, although the UC Berkeley will keep the ownership, the same as for V1.0.

# 4. SCOPE OF ENHANCEMENTS

## 4.1 CA4PRS Version 1.0 Manual

- **Objective: The manual (V1.0) will guide the user in how to use the software accurately**

  The manual for V1.0, after being developed, will be updated for V1.5 and V2.0 accordingly. The manuals will developed by EB Lee, as a consultant with a separate contract.

## 4.2 CA4PRS Version 1.5-a

- **Objective:**
  - **Improve user friendliness and input interfaces**
  - **Improve the MS Access based CA4PRS stability with minimum crash**
  - **Use more generic terminology rather than California terms**

| Item | Feature | Remark |
|---|---|---|
| **1** | Put the “unit” button to Resource and Analysis window in addition to the existing on Project window only. | |
| **2** | SI unit = “tonne”, Imperial unit = “ton” rather than SI = ton and Imperial = lb | |
| **3** | Use “single lift” for cooling time analysis rather than using “MultiCool” | Asphalt |
| **4** | Trucks/hour → truck loading or truck discharge/hour. | |
| **5** | “Total demolition truck” in output should take account of crew number. | |
| **6** | SBT → HMA delivery truck. EDT → concrete delivery truck, demolition hauling truck. | Asphalt |
| **7** | Box “additional depth” for demolition in the FDAC analysis. | FDAC |
| **8** | Box the user defined inputs of cross-section in the PCCP analysis | PCC |
| **9** | Link the “Road User Cost” calculation spread sheet. | |
| **10** | “Continuous closure/24-hr operations”<br>“Continuous closure/shift operations” | |
| **11** | Demobilization = curing time/cooling time + minimum x hours. | |
| **12** | Tab key → next cell highlight. | |
| **13** | Show all CSOL closure/work methods. | |
| **14** | Nighttime closure limits too tight on working hours. | |
| **15** | Show centerline-km in the Comparison table. | |
| **16** | Objective in Project window → total rehabilitation distance. | |
| **17** | More clear function of the time-lags in the sequential method in the PCCP schedule | |
| **18** | Input # of hours of CW in continuous closure/24-hr operation in stead of # days. | |

### 4.3 CA4PRS Version 1.5-b

- **Objective: Add more rehabilitation strategies and features and various types of highways (urban and rural (2-lane-by-2lane)) could be analyzed**

| Item | Feature | Remark |
|---|---|---|
| **1** | Add an option to analyze "**mill and fill AC"** rehabilitation. | |
| **2** | Add an option to analyze "**CRCP** (Continuous Reinforced Concrete Pavement)" rehabilitation | |
| **3** | Add a new rehabilitation option to analyze "**dowel bar retrofitting"** and diamond grinding of existing lanes. | Option |
| **4** | Adding the "completely sequential method" to the existing "concurrent" and "hybrid sequential" methods. | PCC |
| **5** | Input existing cross section and new cross section.<br>- Higher final elevation, Additional demolition | |
| **6** | Select resource input from the list number. | |
| **7** | Separate input of nighttime resource and schedule. | |
| **8** | Show the reasonable range of input as reference information. | |
| **9** | Enhance PCCP rehabilitation to include the use of **AC Base** or CTB (LCB) base with AC bond-breaker. | |
| **10** | Add ability to specify **two different types of concrete mix** for PCCP | |
| **11** | Add **Gantt charts** and enhance existing linear scheduling charts for deterministic analysis. Add **CPM schedule** to results display. | |
| **12** | Add ability to analyze roadways with **any number of lanes** instead of the fixed 4-lane per direction (to rebuild up to 2 lanes) configuration currently available for PCCP and Full-depth AC replacement options. Especially to include an ability to analyze the 4-lane (2x2) highways. | |
| **13** | Add ability to determine the **optimum number of hours** required for rehabilitation given project length. | |
| **14** | Consideration of **simultaneous or pre-paving of shoulders** for PCCP and Full Depth rehabilitation. Types of shoulder rehabilitation will include cold plane and overlay and full depth ACP. | |
| **15** | Add an option of including the **new base** (e.g. Aggregate Base) under PCCP or Full-depth AC to replace to poor sub-soil condition. | |
| **16** | Adjust and improve the existing **time lead-lag relationships** for PCCP between demolition-base paving-slab paving operation activities. | |
| **17** | A tech note (online and offline) for the "Summary of changes" in the 1.5 enhancement | |
| **18** | Re-organize the menu trees according to the revised rehabilitation strategy hierarchy | |

### 4.4 CA4PRS Version 2.0

- **Objective: Add Traffic and Cost analysis modules and contracting schedule baseline**

| Item | Feature | Remark |
|---|---|---|
| **1** | Incorporate total cost analysis that will aid in comparing two or more rehabilitation alternatives.<br><br>**Road User Cost** – Incorporate user delay time and costs due to construction activities. The analysis will consider traffic impacts due to reduced speed and queuing caused by construction activity. Traffic impacts will be characterized by vehicle-hour delay and increase in vehicle-operating costs. This analysis will utilize demand capacity models from the Highway Capacity Manual 2000 and analysis procedures described in FHWA Interim Technical Bulletin on Life-Cycle Cost Analysis in Pavement Design. | |
| **2** | **Agency Cost** – Incorporate construction costs and traffic handling costs. Both material and resource costs will be considered.<br>**Total Cost** – Total cost of a rehabilitation option will be in terms of agency cost and factored road user cost.<br>**Risk Analysis and Incentives contract** – Provide a monetary baseline for the incentives/disincentives and cost (A) + schedule (B) contract considering the rehabilitation closure schedule and its impact of road users and agency cost | |
| **3** | **Comprehensive online-help**<br>A tech note (online and offline) for the "Summary of changes" in the 2.0 enhancement.<br>Embed the user manual on the online help. | |

### 4.5 Future Development (Not included in the enhancement scope yet)

| Item | Enhancements | Remark |
|---|---|---|
| **1** | Add option to analyze PCCP rehabilitation with **pre-cast concrete** slabs. | |
| **2** | Add option to analyze "lane addition or roadway widening" to the reconstruction of existing lanes. | |
| **3** | Add ability to include the rehabilitation of approach slabs to the bridges simultaneously within the closure. | |
| **4** | Rehabilitation with recycling of existing pavement structure. | |
| **5** | Develop methodologies and procedures for interaction of CA4PRS with pavement design, LCCA, and macro/microscopic traffic simulation analyses. | |

## 5. TRAINING WORKSHOPS FOR V1.5 AND V2.0

The training workshops for the CA4PRS version 1.0 were held for the 4-State DOT engineers (about 160 trainees) in summer 2003. According to the evaluations (survey) of the trainees for the workshops, in general they agreed that the software would be a capable tool to be applied for their pavement projects. The evaluation also showed that the hand-on training workshop was very helpful in understand the background and application of the software, especially to avoid "Garbage-in and Garbage-out". The feedback from them indicated that they would like to see some improvement/enhancements and continuous upgrade efforts for the software.

Two-day, hands-on training workshop, (which is more comprehensive than the CA4PRS V1.0 training) will be provided for each DOT at the end of V1.5 and V2.0 development, respectively:
- Version 1.5 Training Workshop: 2-day Training Class x Total 4 (one class for each DOT)
- Version 2.0 Training Workshop: 2-day Training Class x Total 4 (one class for each DOT)

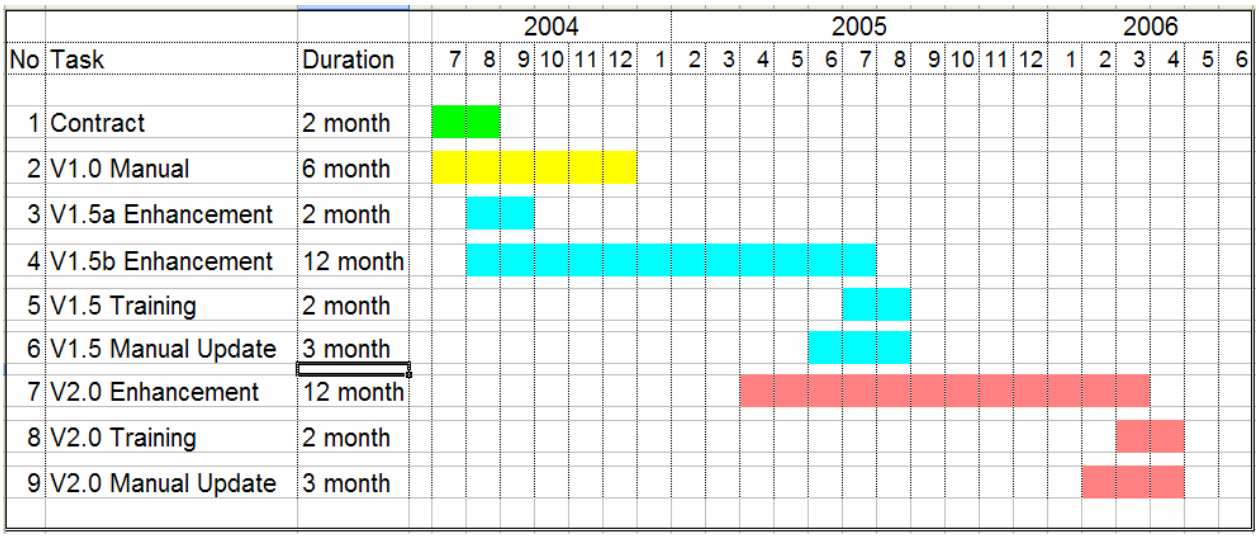
A series of a short "Tech Note", briefly describing the changes in the version upgrade and how it can be used, will be delivered along with each version upgrades.

The training workshop classes for V1.5 and V2.0 will be provided by EB Lee, as a consultant with a separate contract.

## 6. DEVELOPMENT SCHEDULE

The enhancement (manual and Version 1.5 and 2.0) is scheduled to take about 24 months by starting work on V2.0 before the completion of V1.5 with a four month overlap to save time and cost.. But the three versions should be developed with one contract to coordinate a lot of interfaces between the three versions. For the DOTs' convenience, the release of the development in V1.5-a and V1.5-b, and V2.0 will be incremental, if possible. Especially some enhancement such as "Mill and Fill AC Strategy" will be delivered as soon as it is completed (as long as it is independent module).

**CA4PRS Enhancement Development Schedule (V1.5 and 2.0 together)**




| No | Task | Duration |
|---|---|---|
| 1 | Contract | 2 month |
| 2 | V1.0 Manual | 6 month |
| 3 | V1.5a Enhancement | 2 month |
| 4 | V1.5b Enhancement | 12 month |
| 5 | V1.5 Training | 2 month |
| 6 | V1.5 Manual Update | 3 month |
| 7 | V2.0 Enhancement | 12 month |
| 8 | V2.0 Training | 2 month |
| 9 | V2.0 Manual Update | 3 month |

### 6.1 Development Schedule: Total net 20 months

Manual development (V1.0) = 6 months (July 2004 – December 2004)

Version 1.5 = 1 year (July 2004 – June 2005), if developed with V2.0

Version 2.0 = 1 year (March 2005 – February 2006)

### 6.2 Training Class Schedule

Version 1.5 Training = Spring 2005

Version 2.0 Training = Spring 2006

## 7. COST ESTIMATE

### 7.1 Manual Development Cost

Manual for V1.0 = $25,000

Manual Update for V1.5 = $10,000

Manual Update for V2.0 = $10,000

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***Sub-total = $45,000***

**7.1 Enhancement Cost**

Version 1.5 = $145,000 (if only V1.5 is developed) or $110,000 (if V1.5 is developed with 2.0)

Version 2.0 = $105,000 (Assuming Caltrans contribution)

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***Sub-total = $215,000 (V1.5 and 2.0)***

**7.2 Training Cost**

Version 1.5 Training = $30,000

Version 2.0 Training = $30,000

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***Sub-total = $60,000***

**7.3 Total Cost for Manuals, Enhancements, and Trainings**

**Please refer to the cost summary table on page 2.**

**Total Cost = $35,000 + $145,000 + $30,000 = $210,000 (V1.5 enhancement only)**

**Total Cost = $45,000 + $215,000 + $60,000 = $320,000 (V1.5 and 2.0 together)**