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PRSM REVIEW

YEAR 1 REPORT PART A

Review of PRSM Use at Caltrans

A Research Report from the University of California Institute of Transportation Studies

Nigel Blampied, UC Berkeley

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25 September 2017
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16. Abstract
The California Budget Act of 2016 included a provision to “complete a post-implementation review of the Project Resourcing and Schedule Management (PRSM) information technology system upgrade completed by the Department of Transportation.” The PRSM system referenced is Commercial-Off-The-Shelf (COTS) software deployed at Caltrans in 2014 and intended to enable Caltrans to effectively plan State employee and consultant time spent on activities related to projects in its Capital Outlay Support (COS) program. In this Part A report, the researchers studied PRSM as implemented and in practical use, based on a Caltrans document review and interviews conducted with sample groups of Caltrans staff. The result is this factual, non-judgmental description of how PRSM is used and what it is used for. The researchers’ initial sense from the PRSM review meetings is that over the course of three years of deployment, PRSM has become a well-established project management system for approximately 3,000 Caltrans users with read/write access and many others with read-only access, yet PRSM is not yet fully living up to its title. While PRSM is an acronym for “Project Resourcing and Schedule Management,” Caltrans is only using it for project resourcing, especially for annual budgeting, and is not using PRSM’s scheduling functions to their potential.
About the University of California Institute of Transportation Studies (ITS)

The University of California Institute of Transportation Studies (ITS) is a network of faculty, research- and administrative staff, and students dedicated to advancing the state of the art in transportation engineering, planning, and policy for the people of California. Established by the Legislature in 1947, ITS has branches at UC Berkeley, UC Davis, UC Irvine, and UCLA.

About the Project production Systems Laboratory (P2SL)

The Project Production Systems Laboratory (P2SL) at UC Berkeley is a research institute dedicated to developing and deploying knowledge and tools for project management. The Laboratory is housed under the umbrella of the Center for Information Technology Research in the Interest of Society (CITRIS).

Projects are temporary production systems. P2SL is dedicated to developing and deploying knowledge and tools for the management of project production systems and the management of organizations that produce and deliver goods and services through such systems. Project production systems include for example construction, product development, software engineering, air and sea ship building, work order systems, job shops, performing arts productions, oil field development, and health care delivery.

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PRSM REVIEW
YEAR 1 REPORT PART A
Review of PRSM Use at Caltrans

UNIVERSITY OF CALIFORNIA INSTITUTE OF TRANSPORTATION STUDIES

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25 September 2017
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EXECUTIVE SUMMARY

The California Budget Act of 2016 included a provision (Item 6440-001-0046 provision 2 (b) (2)) to “complete a post-implementation review of the Project Resourcing and Schedule Management (PRSM) information technology system upgrade completed by the Department of Transportation.” The PRSM system referenced is Commercial-Off-The-Shelf (COTS) software deployed at Caltrans in 2014 and intended to enable Caltrans to effectively plan State employee and consultant time spent on activities related to projects in its Capital Outlay Support (COS) program.

Tasked with responding to this provision, the Institute of Transportation Studies at the University of California designated a team of researchers in the Engineering Project Management Program at UC Berkeley to conduct this review, phased over multiple years. For year 1 of this research, the team defined the scope of work as comprising three parts, each one documented correspondingly in Part A, B, and C, that in combination make up the Year 1 Report. Leveraging the findings from their Year 1 Report, the team then defined the subsequent research and scope of research for year 2 to respond to the aforementioned provision. This document presents Part A of the Year 1 Report.

In Part A, the researchers studied PRSM as implemented and in practical use, based on a Caltrans document review and interviews conducted with sample groups of Caltrans staff. The desired outcome of this part was to produce a factual, non-judgmental description of how PRSM is used and what it is used for. The researchers’ initial sense from the PRSM review meetings—to the extent that conclusions are possible at this early stage of the review—is that over the course of three years of deployment, PRSM has become a well-established project management system for approximately 3,000 Caltrans users with read/write access and many others with read-only access, yet PRSM is not yet fully living up to its title. PRSM is an acronym for “Project Resourcing and Schedule Management.” Caltrans is using it for project resourcing, especially for annual budgeting, but is not using PRSM’s scheduling functions to their potential.

In Part B, the researchers (1) conducted an overview of software available on the market today, akin to various degrees in functionality and use to PRSM; (2) surveyed other state departments of transportation on their agency-wide use of software to perform functions that are similar to those Caltrans performs in PRSM; and (3) interviewed managers at a select number of design and engineering firms in private practice, performing similar functions. The desired outcome of this part is to shed light on the state-of-practice of design and engineering project management and software use in public and private organizations, so that PRSM can be reviewed in this context.

In Part C, the researchers present developments in project management theory and practice in organizations other than Caltrans. In particular, since the PRSM Feasibility Study Report (FSR)
was written in 2000, such developments include the publication of several national and international standards; the growth in worldwide interest in portfolio management; the spread in adoption of Lean, Agile, and other innovative practices in project management; and new thinking that falls under the broad umbrella of “Management of Projects.” The desired outcome of this part is to describe the insights that these developments provide for Caltrans practices and, where appropriate, recommended changes in Caltrans practices.

Parts A, B, and C combined into the Year 1 Report will inform the subsequent years’ research to respond to the California Budget Act provision.
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This study was made possible through funding received by the University of California Institute of Transportation Studies from the State of California’s Public Transportation Account. The authors would like to thank the State of California for its support of university-based research, and especially for the funding provided in support of this project.
1. INTRODUCTION

1.1 Context and Background of Review of PRSM Use at Caltrans

The Institute of Transportation Studies (ITS) at the University of California's Berkeley (its.berkeley.edu), Davis (its.ucdavis.edu), Irvine (www.its.uci.edu), and Los Angeles (www.its.ucla.edu) campuses was tasked with responding to the provision in the California Budget Act of 2016 that stated:

“At a minimum, the funds shall be used to complete a post-implementation review of the Project Resourcing and Schedule Management (PRSM) information technology system upgrade completed by the Department of Transportation.” (California State Legislature 2016)

Accordingly, ITS designated a team of researchers in the Engineering Project Management Program at UC Berkeley to conduct this review and report on their findings. This team comprises two internationally-recognized experts in engineering project management, an additional student researcher, and a staff member. Appendix I presents their credentials.

The PRSM system referenced in this provision is Commercial-Off-The-Shelf (COTS) software deployed at Caltrans in 2014 and intended to enable Caltrans to effectively plan State employee and consultant time spent on activities related to projects in its Capital Outlay Support (COS) program. This program “funds environmental studies, design services, construction engineering and right-of-way acquisition services for State Highway projects” (Caltrans 2005). For fiscal year 2017-18, COS funding amounts to about $1.8 billion-per-year, which is half as much as the $3.6 billion-per-year funding Caltrans receives for the Capital Outlay program itself. The COS program is for about 90% staffed by state employees (about 8,200 people) and for the remaining 10% by consultants.

The provision left it up to the researchers to determine the specifics of the review, so the researchers considered post-implementation reviews of PRSM that Caltrans had already conducted in-house (Caltrans 2014, 2015:2, 2016:1) and then defined their scope and approach. Accordingly, this review focuses on how Caltrans is using various PRSM software capabilities in their specific implementation setting, how PRSM enables Caltrans staff to realize their project management workflows (processes), and what—if any—other, new project management practices Caltrans might consider for future implementation in an effort to drive continuous performance improvement within their organization.
This document presents Part A, the first of three Parts that in combination will make up the Year 1 Report. Leveraging the findings from their Year 1 Report, the researchers will then define the subsequent research and scope of work for year 2 to respond to the aforementioned provision.

Part A of the Year 1 Report reviews the history and intended use of PRSM at Caltrans. It presents the researchers’ observations of PRSM as implemented and in practical use, based on a Caltrans document review and interviews they conducted with sample groups of Caltrans staff. The desired outcome of this part of the review is to produce a factual, non-judgmental description of how PRSM is used and what it is used for. Part A offers no specific recommendations for improvement of PRSM use or project management practice at Caltrans. The researchers will provide such recommendations in follow-on Part C of their Year 1 Report, after they have summarized current best practices, standards, literature, and research on project management with an eye on articulating opportunities for improvement of Caltrans project management processes. Research into the possible pursuit of such opportunities will be explored with Caltrans personnel and will then be conducted in year 2.

Part B of the Year 1 Report first will offer a high-level overview of software available on the market today, that is akin—to various degrees—in functionality and use to PRSM. This review will be based on information publicly available on the internet and market surveys. Second, Part B will present and interpret data the researchers obtained by administering a survey to other state departments of transportation on their agency-wide use of software to perform functions that are similar to the functions Caltrans performs in PRSM, and, in general terms, how other agencies use their software. Last, Part B will summarize data the researchers obtained by conducting telephone interviews with engineers and managers at a select number of engineering and design firms in private practice. The desired outcome of this part of the review, comprising high-level market-scan, survey, and telephone interview data from these three sources, is to shed light on the state-of-practice of design and engineering project management and software use in public and private organizations, so that PRSM can be reviewed in this context.

Part C of the Year 1 Report will present developments in project management theory and their use in practice in organizations other than Caltrans. In particular, since the PRSM Feasibility Study Report (FSR) was written in 2000, such developments include the publication of several national and international standards; the growth in worldwide interest in portfolio management; the spread in adoption of Lean, Agile, and other innovative practices in project management; and new thinking that falls under the broad umbrella of “Management of Projects.” The desired outcome of this part of the research is to describe the insights that these developments provide for Caltrans practices and, where appropriate, to recommended changes in Caltrans practices.
1.2 Research Methodology and Work Plan for Year 1 Report Part A

The methodology followed to conduct the research for this Part A included reviewing PRSM-related documents produced in-house by Caltrans, gathering data on PRSM use in meetings with Caltrans and PRSM software-development staff, describing observations, and then obtaining feedback from Caltrans on these observations to ensure their factual correctness prior finalizing this document.

The research work plan included the following steps:

1. Meet with Caltrans Headquarters project management staff and with PRSM staff.
2. Conduct interviews with PRSM users in selected Districts.
3. Review Caltrans in-house documents pertaining to PRSM, and other relevant literature.
4. Prepare draft Year 1 Report Part A.
5. Circulate a draft Year 1 Report Part A to Caltrans managers for their input into the observations made to-date and direction for the follow-on research.

1.3 Outline of Year 1 Report Part A

Shedding light on how the PRSM software is currently used at Caltrans, this Year 1 Report Part A has 6 sections and 3 appendices. Section 2 gives an overview of project management at Caltrans. Section 3 presents a history of software use at Caltrans that informed the request for proposals for project management software that ultimately resulted in the selection and deployment of PRSM. Sections 4 and 5 summarize PRSM-user reported successes and challenges of the PRSM software and current project management practices at Caltrans. Section 6 offers a summary of the review of PRSM use at Caltrans, though defers spelling out specific recommendations to Caltrans as these can be offered at their fullest only after completion of on Parts B and C of the review. Appendix I gives the researchers’ credentials and standard of ethical conduct, Appendix II abbreviations and acronyms, and Appendix III references.
2. Overview of Project Management at Caltrans

A review of the use of project management software in an organization must be grounded in that organization’s project management needs, practices, culture, and context. These evolve to address the complexities of the projects being delivered by the organization and the socio-technical context in which the projects unfold (e.g., reflecting advances in computational hardware and software). In addition, project management success depends on the extent to which people in the organization have management knowledge and skills as needed to address the complexities of the projects they engage in. Recognizing the need for grounding the ideas presented, while this document focuses on the use of the PRSM software by Caltrans, this Section provides an overview of the Caltrans organization and project management practices of its Capital Outlay Support (COS) staff.

2.1 Caltrans Organization: Functional- vs Project-based Structure

The projects that Caltrans manages in its COS program comprise distinct elements. In accordance with Federal Highway policies, these elements distinguish between “preliminary engineering,” that starts at project initiation and ends with the award of a construction contract, and “construction engineering” that starts at contract award and consists of the management of construction contractors through the completion of construction (FHWA 2015). Until 1989, Caltrans made a clear distinction in the management of these two elements. The project engineer managed preliminary engineering, and then handed the project over to a resident engineer who managed construction engineering. The project management literature describes an organization that is structured in this way as a “functional organization” (PMI 2013). A functional organization can reap the benefit of specialization within disciplines (e.g., bridge design), however, it may encounter challenges when delivering projects because the priorities of the functional organizational structure may be in tension with those of the project. Many organizations that deliver projects, including Caltrans, adopt some matrix form of organization, somewhere in-between the spectrum ranging from purely functional- to purely project-based organization.

In 1989, Caltrans Director Robert Best announced that Caltrans would be adopting “project management,” in which a single designated project manager would manage each project from “cradle to grave,” including both preliminary engineering and construction engineering (Caltrans 2017). This demarcation of the project as a larger whole, elevates the locus of power and control to a higher level so that management can aim for more comprehensive, broadly optimal project delivery.
The current Caltrans conceptualization of project delivery of all state highway projects comprises 5 components (Figure 1): (1) Project Initiation Document (PID), (2) Project Approval and Environmental Document (PA&ED), (3) Plans, Specifications, and Estimate (PS&E), (4) Right of Way, and (5) Construction.

Figure 1: Project Component Lifecycle
(Source: “Project Component Lifecycle” tab in Microsoft Visio file “2011-6-21 PRSM Capital Outlay Support Business Processes 3.0”)

Caltrans differs from most state departments of transportation (DOTs) in the US in that the preponderance of its preliminary and construction engineering is performed by state employees; most other US state DOTs hire private engineering firms as consultants to perform a large part of this work. A significant effort of Caltrans project management therefore goes into managing in-house resources involved in preliminary and construction engineering; whereas other US state DOT’s management focuses more on managing external consultants.

Caltrans is geographically organized in 12 Districts, each one staffing and managing its own projects, though (on occasion) staff in one District could be working on a project in another District. The Caltrans Headquarters are located in Sacramento and of course serve the entire state.
The Caltrans Project Management Handbook (Caltrans 2007) describes project management roles and responsibilities. Project managers are generally assigned to all major capital projects, including the following:

- State Transportation Improvement Program (STIP), State Highway Operation and Protection Program (SHOPP), seismic, locally funded, and toll projects,
- Projects with multiple functional unit involvement, and
- Projects with a significant amount of local or private entity involvement.

Caltrans’ current organization is described in project management literature as a “weak matrix” (PMI 2013). This means that, although each project has a project manager with overall responsibility for the project, project managers must negotiate with organizational unit supervisors for staff to perform work on projects. At the planning stage of a project, deciding on hours needed to deliver that project is done in a bottom-up fashion (as the researchers were told while interviewing users of PRSM) with functional units estimating the numbers of hours (by job title or named individual) they anticipate needing to deliver the project at hand. This project management practice builds responsibility and accountability as those involved in estimating also are involved in execution with PRSM being used to track expenditures by project. The alternative approach, top-down estimating, e.g., using a (resource-loaded) schedule and a cost template based on a historic project database (which may serve in conceptual estimating), may not provide the custom-tailoring needed to address the specifics of the project and leaves those responsible for execution potentially less committed to meeting the estimate that isn’t theirs.

Caltrans uses three terms to denote project management roles (Caltrans 2000:3, 2007):

- **Project Manager (PM):** the individual responsible for managing a project.
- **Functional Manager (FM):** the immediate supervisor of the staff who work on a project.
- **Task Manager (TM):** an individual who is delegated the responsibilities of both the Project Manager and the Functional Manager for the production of particular elements of the project Work Breakdown Structure.

Caltrans staff in these roles are the key users of the PRSM system. About 3,000 Caltrans staff read/write PRSM data for their management decision making. Anyone with a Caltrans Intranet account has read-only access, even if they do not play any of these roles.

“In the early 1990s, several task forces and Peer Reviews recommended that the Department establish a modern project management process and develop the tools to help improve the Department’s project delivery. Caltrans issued the first version of the Department’s Capital Outlay Support (COS) [Work Breakdown Structure] WBS in July 1994.” (Caltrans 2016:2 p. 1)
standard has been updated numerous times to address deficiencies and changing practices; Caltrans issued the current Version 11.2 in 2016.

A Work Breakdown Structure (WBS) is a tool used in project management for planning and controlling work. PMI (2006) states “The WBS organizes and defines the total scope of the project. The WBS subdivides the project work into smaller, more manageable pieces of work, with each descending level of the WBS representing an increasingly detailed definition of the project work.” A WBS focuses on deliverables and who is responsible for them, usually not on sequencing of work.

Caltrans uses its WBS to enumerate presumably every deliverable type that its employees might need to produce on a State Highway Project (Figure 2). It mandates that project managers detail their projects to at least Level 5 by task name as illustrated, and leaves the use of levels 6, 7, and 8 as optional. The Caltrans WBS serves as the backbone for reporting and tracking project data in PRSM.
2.2 Project Management Competence Development

Caltrans has structured its organization according to regionally-distributed functional units to meet the needs of the projects it delivers. In addition, it has created a Division of Project Management (www.dot.ca.gov/projmgmt/) and put a project management backbone in place, i.e., the Caltrans (2016:2) Workplan Standards using a WBS. Finally, Caltrans continues to encourage individual staff to engage in professional development of their project management competence so as to increase the organization’s capacity and capability to deliver State Highway Projects. E.g., Caltrans (2007 p. 53) promotes staff certification as Project Management Professional (PMP):
“The Project Management Institute’s (PMI) PMP certification is widely recognized and accepted throughout the world as evidence of a proven level of education, knowledge and experience in project management. The Division of Project Management encourages qualified Project Delivery staff to pursue their PMP and provides a course that includes intensive on-line review and the PMP exam.”

With this foundation for practicing project management outlined, the next Section presents the processes and computational support that Caltrans has been deploying and improving over the years.
3. PRSM Predecessors and History

In the 1970s, Caltrans staff began to develop and use software systems to support their organizational practices. The early, mainframe systems had to be programmed in-house as no commercial programs existed to suit Caltrans needs; over time, commercial off-the-shelf (COTS) systems on desktop computers have become increasingly available and versatile, and thus potentially suitable for use by Caltrans. Caltrans workflows accordingly have evolved thanks to better definition of their project management requirements in combination with increasing capabilities of computing and communication hardware and software to support them, not in the least the flourishing of the Internet.

3.1 Caltrans Project Management Software Prior to PRSM

Caltrans made decisions in specifying the requirements for PRSM and its implementation, informed by how it used its predecessor systems. PRSM was to maintain some prior system functions (“received tradition”) while also offer new capabilities.

3.1.1 PMCS and PYPSCAN

Caltrans employees created the Project Management Control System (PMCS) database on the Department’s mainframe computer and started using it to manage their projects in 1976 (Caltrans 2017). Although Caltrans has since introduced newer project management systems, namely XPM in 1994 and PRSM in 2014, these did not fully replace PMCS. PMCS continues to be a source of data for several legacy systems in Caltrans, including the Project Information and System Analysis (PISA) software that also dates back to the 1970s.

Caltrans uses PISA to manage its construction Capital Outlay program, which accounts for the largest slice of their budget, about $3.6 billion in fiscal year 2017-18, vs. PRSM to manage its Capital Outlay Support (COS), which is about half in size. PISA has four subsystems (Figure 3):

1. Basic Engineering Estimating System (BEES) to estimate construction costs.
2. Bid Opening System (BID) to manage the process of analyzing construction bids.
3. Bridge Bid Analysis System (BBA), supplementing BID with a focus on structures.
4. Construction Administration System (CAS) to manage finances and track awarded construction contracts, including monthly payment to construction contractors.
After developing PMCS, Caltrans staff developed an automated project planning system, called Person-Year Project Scheduling and Cost Analysis (PYPSCAN), and placed it in service in 1980 (Caltrans 2017). PYPSCAN addressed Caltrans’ resource forecasting and allocation problem, as described by McManus (1981):

“Once a year, a gigantic manpower intensive effort was launched statewide for from one to two months when all the manpower estimating was tied to project schedules. Under the decentralized process of that time, this effort was undertaken in eleven District offices and numerous headquarters units. Between redundancy on the one hand and omissions on the other, the whole exercise was suspect—and this became the base of the Governor’s Budget. Manpower allocations were transmitted six months later and were pitifully out of date with everything. When all this was loaded into the computer, we were able to produce beautiful management reports fraught with totally incredible information.”

Figure 4 illustrates the Caltrans process for project resourcing and schedule management using PMCS and PYPSCAN from 1980 onward. This process consisted of 9 steps:

1. Project Events: Events occurred, whether or not according to plan, given the reality that:
   - Plans are forecasts, and forecasts are always wrong,
   - The further out in the future we plan, the more wrong we are, and
   - The greater detail at which we plan, the more wrong we are.

2. Negotiations: As events deviating from the plan occurred, they were made known to project team members who discussed and negotiated their responses to them. The forum for such negotiations was the monthly project status meeting, but meetings, discussions, and negotiations could be held at any time.
3. Status: Agreed project milestones were recorded as the “status” in PMCS, which had fields for standard project status milestones. Relative to a given reporting date, actual dates of milestones accomplished in the past were recorded in mm/dd/yy format, and those in the future or milestones not yet accomplished in mm/__/yy format. Target dates, appearing below status dates, were recorded in mm/yy format; they could not, and did not, include a specific day of the month. For example, Figure 5 shows, relative to the “LAST PYPSCAN” date of 10/30/80, status dates immediately below each milestone: “BEG STDY” started 08/16/78 (a date in the past) whereas “RW&SITE” was to start in 04/ /81 (April 1981, a date in the future) and has a target date of 12/81 (December 81).

To view PMCS data, Caltrans staff required a UserID and password. These were issued to many, although their availability fluctuated as managers decided who had a “need to know.”
4. “What if” Target: The user could run PYPSSCAN (step 6), starting from a selected start date, to generate a so-called “average” schedule and person-year (PY) resources based on the actual performance of projects deemed similar, selected from a database of over 12,000 previously-completed Caltrans State Highway projects. The PY resources were distributed between milestones based on PYPSSCAN algorithms (Caltrans 1992).

Figure 5 shows a “What if” output. It begins the schedule from the submittal of the project report (SUBM PR) in September 1979 and generates an average schedule that is expected to run through June 1985 (FNL RPT). This provides the PY resource estimate for fiscal years 1979-80 through 1984-85 that appear in the upper part of the screen.

However, Figure 5 shows an advertisement date of February 1985 (02/__/85) rather than the PYSCAN-generated October 1983 (10/83). When overriding the PYPSSCAN schedule with their Status schedule, PY resources were kept constant in total, but got redistributed by fiscal year in accordance with the new milestone dates. Users in the Districts could see the changes on their screens, but could not save them.

5. Paper copy: Upon completing the “What if” analysis, and before leaving the screen (Figure 5) the user would print a copy of the screen showing the desired milestones, and consequent PY distribution by fiscal year.

6. PYPSSCAN calculated an average project milestone schedule and PY resource needs based on:
   o Project Type: each project in a database of over 12,000 projects was identified as having a project type; each project could have only one project type (Caltrans 1992). The original
The database had 107 project types (McManus 1981) and this number increased to 119 by 1992 (Caltrans 1992).

- Weather zone: one of five, ranging from Zone 1 (the driest), to Zone 5 (the wettest).
- Location: Urban or Rural.
- Environmental type: one of the three standard types of environmental document in Federal and State law respectively (NEPA and CEQA): (1) Environmental Impact Statement /Environmental Impact Report (EIS/EIR), (2) Finding Of No Significant Impact / Negative Declaration (FONSI/ND), and (3) Categorical Exclusion / Exemption (CE).
- Function: For PYPSCAN purposes, PY resources were calculated for six “functions”: (1) highway preliminary engineering (or “project development,” PJD), (2) right of way (RWO), (3) structures design (STD), (4) structures construction (STC), (5) highway construction (CON), and (6) day labor (D/L) (but this D/L formula was later dropped from PYPSCAN) (McManus 1981 compared with Caltrans 1992).
- Capital Cost: Three capital costs were considered (adjusted for inflation using the Caltrans Construction Cost Index): (1) total construction cost, (2) right of way capital, and (3) structures construction cost. A specific capital costs was used for each phase. PJD, CON and D/L used total construction cost; STC and STD used structures construction cost; and RWO used right of way capital.
- Right of way information, including numbers of appraisals, acquisitions, utilities, relocation assistance cases, demolitions, railroad agreements, and condemnations.

The typical PYPSCAN formula had the form:

\[ P = a X^b \]

where

- \( P \) is the PY resources
- \( a \) is a constant
- \( X \) is the applicable capital cost, and
- \( b \) is a constant such that \( 0 < b < 1 \)

This produced a possible 12 separate formulae for each of 119 project types (6 for PJD: 2 location types * 3 environmental types STD, STC, and CON). A single formula, regardless of project type, was developed for RWO based on the number and complexity of the Right of Way parcels that were affected. This produced a possible \((12 \times 119 + 1) = 1,429\) formulae. Each formula was developed by regression analysis of projects from the database that matched the particular combination of factors. In practice, fewer than 1,429 formulae were in use because some project types could not include structures and most had only one possible environmental type.
Separately, PYPSCAN calculated an average project milestone schedule that used the same factors as the resource estimates, plus weather zone (which affected only the construction-phase milestones).

7. Project Change Request (PCR): If the project team, with approval of District management, wanted to permanently change the target milestones and distribution of PY resources, they would submit a project change request to headquarters. This was accompanied by the paper copy of the desired target milestones and resource distribution (step 5).

8. Hand entry in headquarters: If the PCR was approved, headquarters staff would enter the new target milestones into PMCS, run PYPSCAN, and save the resulting data. Only certain headquarters account-holders had the ability to save the target milestones and consequent PY distributions.

9. Target: The target milestone schedule was the headquarters-approved schedule. PY resources were distributed, through PYPSCAN, to match this target schedule. If the status milestone for the end of the project was later than the target, Caltrans nevertheless received a PY budget that was based upon the target, and no resources were provided beyond the target end date. Likewise, if the status date was earlier than the target, Caltrans received the resources based upon the target and thus, to an extent, after they were actually needed. If they chose, project team could address these discrepancies, with District management approval, by submitting a new PCR.

The target milestones were used in making commitments to the CTC, and the PYPSCAN PYs distributed between those milestones were used for the annual budget request to the Legislature. The Caltrans commitments and budget requests were in sync.

Because target milestones could be changed only through a PCR, the intensive process described by McManus was eliminated. Districts could run reports on their multi-year expected budgets at any time and plan for upcoming work accordingly. Caltrans could also provide the Legislature with multi-year project-by-project budget projections, e.g., Figure 5 shows a six-year budget plan from 1979-80 to 1984-85. A project’s year-by-year numbers could be changed only through a PCR. If a number changed, there would always be a PCR that documented the reasons for the change.

3.1.2 XPM

Recognizing limitations of their existing systems, the 1980s hardware revolution from mainframe computers to client-server configurations leveraging the availability of desktop computers, as well as Caltrans’ desire to enable PMs and first-line supervisors to manage their projects at a detailed
level (with resources provided in person-hours to each organizational unit for each task), Caltrans arranged for series of demonstrations and ended up procuring the XPM project management software in 1994. It was soon found that XPM was cumbersome in use: only a handful of employees in each District could have direct XPM access and it was impossible to provide direct access to every PM and supervisor. As the company that produced XPM went bankrupt (certainly before 1999), Caltrans received no upgrades nor support. Caltrans was the only known user of XPM when the PRSM FSR was written in 2000.

This situation required that project teams work outside of XPM to address project changes. Figure 6 illustrates the process that developed, consisting of 7 steps:

1. Project events: These continued to occur as described for PMCS and PYSCAN.

2. Personal files: Because direct access to XPM was not possible, employees in the Districts developed a variety of tools on their desktops to manage project events, such as e-mails and

Figure 6: Project Resourcing and Schedule Management Process with XPM

1. Project events: These continued to occur as described for PMCS and PYSCAN.

2. Personal files: Because direct access to XPM was not possible, employees in the Districts developed a variety of tools on their desktops to manage project events, such as e-mails and
spreadsheets. Some Districts addressed the problem of access to project data by building so-called “shadow systems” which all their employees could see on the Caltrans Intranet. Data from XPM was downloaded to the shadow systems, together with cost data from the Caltrans accounting system, and programming data from Transportation Programming. Due to the difficulties with XPM, arrangements were made to directly upload data from the shadow systems to XPM, avoiding almost all needs for hands-on access to XPM.

3. Negotiations: These continued to occur as they had with PMCS and PYPSCAN. Districts that had built shadow systems frequently used those systems to facilitate negotiations.

4. XPM: Project milestones and tasks were loaded into XPM along with the units that would work on each task, the estimated hours required to perform the task, the average cost per hour of the staff in each unit, and the consequent estimated support dollar cost of each project.

Access to XPM required that this software be loaded onto the user’s computer and that the user have a UserID. Only a few such computers were available in each District, and the software was not widely available. Users of XPM were normally rank-and-file workers; in contrast, first-line supervisors were not “users” in that they did not have the software on their personal computers.

5. Project Change Request (PCR): If the project team, with approval of District management, wanted to permanently change the target milestones and estimated cost of a project phase, they would propose a PCR and submit it on paper to headquarters.

6. Headquarters baseline: If approved, the PCR data were recorded by headquarters using a desktop system that was accessible only to headquarters staff, in much the same was as District staff was performing work in systems that were not broadly visible. The headquarters data was provided to the CTC as the Caltrans commitments.

7. January 9 file: PMCS and PYPSCAN continued to be used to develop the annual budget until the 1996-97 Fiscal Year. In 1997, the budget began to be downloaded from XPM. This was done on January 10 of each year, with Districts given until January 9 to update their data in XPM. The intent of that date was to give District staff a full week in January to update files and avoid requiring intense work over the holidays. In practice, the updating took more than a week. Caltrans returned to the practice described by McManus (see Section 3.1.1.). Some Caltrans staff refer to this period in November and December as “the Fall Classic.”

On January 9, XPM data was downloaded to an Excel spreadsheet, named the “Delta File,” and sent to the Districts for review. In due course, the updated “Delta File” provided the resource needs that Caltrans submitted to the Legislature as the “May Revise” of the annual budget.
The XPM process meant that there was no correlation between the annual budget submitted to the Legislature and the commitments made to the CTC. Using XPM, Caltrans submitted annual projects budgets to the Legislature, that could, when accumulated over the years of a project’s life, be considerably larger or smaller than the life-of-project support budget that Caltrans submitted to the CTC.

The Districts and Caltrans had no way to do reliable multi-year project-by-project planning because XPM plans changed without clear consistent documentation.

### 3.2 Feasibility Study Report for PCSM and PRSM

PCSM and PRSM came about in response to a business process review by Bein et al. (1996). This review informed and was informed by the Statewide Project Management Improvement Team (SPMIT), comprising more than 100 Caltrans employees, divided into sub-teams that considered Caltrans project management processes and proposed improvements. SPMIT members had experience in Caltrans processes together with formal training in project management. Some improvements were implemented immediately; others required the development of a statewide project management system. The PCSM Feasibility Study Report (FSR) was written to provide that system.

In 2000, Caltrans developed a FSR for a project management software system to be named “Project Cost and Schedule Management (PCSM)” (Caltrans 2000:1). PCSM was to address three business requirements:

1. Project Initiation and Tracking
2. Project Programming and Functioning
3. Project Resourcing and Scheduling

The Department of Finance (DOF) rejected the PCSM FSR and instructed Caltrans to return with a downscoped FSR. In response, Caltrans submitted to DOF soon thereafter (Caltrans 2000:2) the PRSM FSR that addressed only the third one of PCSM’s business requirements. PRSM had ten objectives:

1. Meet the reporting requirements of SB45 for 100% of the State Transportation Improvement Program (STIP) projects.
2. Provide project status data such as: plan vs. actual, earned value, cost performance indexing, etc. to transportation partners on a near-time basis.
3. Realize efficiencies associated with entering initial workload estimates by WBS into an integrated, validating scheduling tool.
4. Reduce the manual effort required to compile information for the Program Resource Management semi-annual reviews.
5. Provide an enterprise scheduling tool to reduce the need for various shadow systems.
6. Provide project and functional manager desktop access to a statewide resource and scheduling tool to plan and status projects at WBS level 7.
7. Provide a tool that allows project team members to continually forecast and optimally commit resources.
8. Provide supervisors with current critical path and individual prioritized task information in order to reduce project completion times.
9. In order to utilize fixed cost resources more effectively, ensure that the staff with the most relevant skill-set is assigned to the right task.
10. Provide the required numbers of software licenses and system security

3.3 PRSM Timeline

PRSM had an eventual 15-year procurement and delivery timeline (Figure 7):
Figure 7: PRSM Procurement and Delivery Timeline
• April 14, 2000: Caltrans submits the PRSM FSR and receives approval on June 7, 2000. Total project cost $13.4 million.
• July 14, 2000: Department of General Services (DGS) issues an “Invitation to Partner.” Two firms respond: (1) Niku (later renamed CA Clarity, and now named CA PPM) and (2) Primavera (now Oracle Primavera).
• May 2002: Caltrans submits a Special Project Report (SPR) reflecting an increased cost. Total project cost $26.1 million. Some increased costs are attributed to a lack of competition (there was only one finalist vendor, Primavera), increased vendor rates, increased COTS software cost, a requirement for new hardware, and a longer time required for development.
• March 17, 2004: After several rounds of discussion, DOF instructs Caltrans to carry out an eight-step process that includes a Value Analysis and a Market Analysis.
• July 2, 2004: Caltrans submits the Value Analysis Report.
• December 31, 2004: DGS publishes a Request for Qualifying Information. Twelve firms respond, all are invited to make a 2-day scripted presentation and six firms make presentations.
• March 24, 2005: Caltrans submits the Market Analysis Report.
• October 13, 2005: Caltrans submits a draft Request for Proposals (RFP) to DGS.
• March 28, 2006: DGS publishes the RFP for PRSM.
• June 23, 2006: Three firms submit draft proposals for discussion with Caltrans.
• September 15, 2006: Two firms submit final proposals: (1) SAIC using Planisware and (2) Bearing Point using CA Clarity. The third proposer, Deloitte using Primavera, had withdrawn.
• January 29, 2007: DGS instructs firms to submit new final proposals.
• April 25, 2007: Teams submit second final proposals.
• July 31, 2007: DGS and Caltrans select Bearing Point, using CA Clarity.
• November 2007: DGS approves Bearing Point contract.
• February 8, 2008: Award to Bearing Point rescinded, notice of intent to award the contract to SAIC using Planisware.
• March 5, 2009: Contract signed with SAIC, using CA Clarity, with implementation to be completed within 18 months.
• April 2012: Delay of 21 months authorized to allow PRSM to interface with Caltrans new accounting system eFIS / AMS.
• May 2014: Roll-out delay of 4 months authorized.
3.4 PRSM Process Model as Designed

The PRSM RFP issued in March 2006 included technical requirements that expanded on the ten objectives in its FSR. Caltrans maintained a traceability matrix to show how every technical requirement was rooted in the FSR. Each bidder’s proposal described how they would satisfy the technical requirements through the use of their proprietary software; the exact methods varied from one bidder to another.

The CA solution, selected by Caltrans, was a suite comprising Clarity custom-tailored to Caltrans needs and augmented by Open Workbench (OWB, which functions like, e.g., Microsoft Project). This suite allows anyone within Caltrans with Intranet access to download PRSM data to OWB, run what-if analyses, and share analysis files with others.

Figure 8 illustrates the steps of the Project Resourcing and Schedule Management process designed for CA Clarity (since renamed CA PPM), the software tool that is now PRSM. In the following description, active verbs refer to steps that Caltrans staff are currently taking, whereas “would” and “could” describes steps that reflect the PRSM design but are not (yet) taken:

1. Project Events occur as described for PMCS/PYPSCAN and XPM.

2. Plan of Record (more appropriately called “project status”): As events occur, project team members notify others on the team to take care of “action items.” Team member actions result in changes in the “Plan of Record.”

    PRSM plans are visible to any employee with access to the Caltrans Intranet, using generic internet browsers that are loaded as a standard practice on Caltrans computers, and without needing special software or permissions.

3. Auto schedule: At appropriate times, the PM can select “Auto schedule” to create a new “Tentative Schedule.”

4. The Tentative Schedule is a copy of the project plan that is used to discuss how to address the action items. Anyone can download this schedule to the OWB desktop application for manipulation and exploration of what-if alternatives. The OWB file can be sent to team members by e-mail and they can view the Tentative Schedule directly. Note that only the PM can upload data back from OWB to PRSM; if the PM downloads a project to OWB, the project in PRSM is frozen until the PM uploads the OWB file back to PRSM.
5. Negotiations: These occur with transparency as all team members can view the Tentative Plan, Plan of Record, and Baselines (see later steps regarding baselines). Changes are made in the Tentative Plan.

6. Publish and Baseline: When the PM is satisfied with the Tentative Plan, they can select “publish” and “baseline.” The Tentative Plan then overrides the Plan of Record and automatically becomes the new Project Baseline.

7. Project Baseline: Each Project Baseline is saved as a new file, providing an audit trail for the project if needed. The most recent Project Baseline is the PM’s current plan. It should represent the most recent agreement within the project team. The Project Baseline is analogous to the negotiated “status” in PMCS, but it has considerably more detail than the milestone-only status that was found in PMCS.
PRSM / CA PPM provides tools to enable project team members to compare any baseline with the Plan of Record and to compare any baseline with any other baseline.

8. Project Change Request (PCR): As events transpire and are addressed, almost certainly the Project Baseline will begin to deviate from the Headquarters Baseline (see next step). If the project team, with approval of District management, wanted to permanently change the approved project plan, they would submit a PRC to headquarters. The PCR would request that the current Project Baseline be copied and saved as a new Headquarters Baseline.

9. Headquarters Baseline: The most recent Headquarters Baseline would be identical to the Project Baseline that was in use when the most recent PCR was approved. It would be the approved project plan and have all the details of that Project Baseline, including actual expenditures, actual milestone completion dates, start and end dates of completed tasks, as well as future milestone and task dates together with the estimated costs of each task by unit expressed in both dollars and hours.

   The Headquarters Baseline milestones would be used in making commitments to the CTC and the approved hours for each task for the annual budget request to the Legislature. Accordingly, Caltrans commitments and budget requests would be in sync.

   Because the Headquarters Baseline could be changed only through a PCR, this eliminates the intensive “Fall Classic” process described by McManus. Districts could run reports on their multi-year expected budgets at any time, based on the Headquarters Baselines, and plan for their upcoming work accordingly. Caltrans could also provide the Legislature with multi-year project-by-project budget projections. The year-by-year numbers for any project could be changed only through a PCR. If a number for a particular project for a particular year changed from one year to the next, there would always be a PCR that documented the reasons for the change. For each detailed change, at the unit and task level, the documentation would include what change was made, when it was made, its magnitude, who requested the change, who approved the change, when it was requested, and when it was approved.

3.5 Comparison of PMCS/PYPSCAN, XPM, and PRSM Processes

In practice today, Caltrans is not using the PRSM process model as designed but, rather, a variation of the XPM process. XPM has now been replaced by the Plan of Record in PRSM, which has two advantages:

1. Unlike XPM, the Plan of Record can be viewed by any person with Caltrans intranet access. Information about the Plan of Record is readily available to those who need it.
2. Availability of the Plan of Record reduces the need to maintain data on individual desktops and reduces the need for shadow systems.

With this background in mind, on project management practices at Caltrans (Section 2) and the history of the determination of PRSM software capabilities and vendor selection (Section 3), PRSM has been deployed agency-wide at Caltrans since 2014 and now counts on the order of 3,000 users. The following two sections present input from a selected group of current users, who were asked by the researchers to comment on successes and challenges in using PRSM. This input points at successes and challenges either in implementing the project management workflows that Caltrans has established or in using specific features and the capabilities of the PRSM software.
4. **User-reported PRSM Successes**

During data-gathering meetings with the researchers, Caltrans PRSM users reported satisfaction (as stated by users or as interpreted by the researchers) in performing a number of functions for project resourcing and schedule management.

Note that the list of functions called-out here may be augmented or corrected for the Year 1 Report, in light of Caltrans management feedback and findings in forthcoming Parts B and C of that Year 1 Report.

**4.1 Bottom-up Estimating and Annual Budgeting**

Before the adoption of PRSM, Advanced Planning units in the Districts included support cost estimates in the Project Initiation Documents (PIPs) without consulting the responsible functional units and, indeed, the PIDs did not differentiate support costs by functions. These estimates were submitted to the CTC for programming. As a result, after the project was programmed several Caltrans staff reported contention when Task Managers (TMs) and Project Managers (PMs) found themselves trying to reconcile their needs to the PID estimate that had been developed without their participation and buy-in.

A major departure from pre-PRSM practices is that first-line supervisors (i.e., TMs), are actively engaged in estimating the hours required for their units’ work from the inception of each project. This reflects both a change in project management workflow and the fact that this new workflow is effectively supported by PRSM. “Bottom-up estimating” ensures that TMs know before programming how many hours they will be allocated to complete each task (for the project as a whole, but also for each annual slice of hours that is incorporated into the yearly budget request) and it promotes accountability.

In keeping with generally accepted professional practices, TMs estimate their units’ effort on each task in hours, usually not by named individual. These hours are then converted to a dollar estimate using each unit’s average cost per hour. That average cost reflects the mix of civil service classes of the employees in a particular unit (units with a larger percentage of people in higher-paid classes have a higher average hourly cost). The cost averages are derived from actual employee data in the Caltrans accounting system eFIS (an acronym for “electronic Financial Information System” that was used during the procurement of the commercial AMS Advantage software, referred to as “AMS”) and recalibrated each year based on that data.

Caltrans staff use PRSM to track resource needs at an aggregate District level, for individual units, and for the collections of units that make up the different levels of the District hierarchy. The
Deputy District Director for Design, for instance, can obtain reports for the District Design organization which, depending on the District, may encompass many units.

### 4.2 Data Accuracy and Reliability

PRSM receives actual expenditure data, in both hours and dollars, from a weekly automatic downloaded from the Caltrans accounting system eFIS. The researchers learned during interviews with Caltrans staff that staff believe that this expenditure data is accurate and reliable. This reliability is borne out by audits conducted in 2015 and 2016 by the Caltrans Office of Audits and Investigations (Caltrans 2015:2, 2016:1). It is of utmost importance, indeed, that Caltrans staff be vigilant in ensuring only quality data gets entered into their systems.

PRSM provides a central and common source of data for resource planning at all levels in the Caltrans organization, including offline discussions of resources and resource needs.

PRSM is integrated not only with AMS, but also with the Caltrans employee system called Staff Central that uses Oracle’s PeopleSoft software. PRSM receives employee information from Staff Central so that work can be assigned in PRSM to named individuals. PRSM also passes work assignments to Staff Central where Caltrans employees report their time. The PRSM feed enables Staff Central to prevent employees from reporting that they performed work on an assignment that is not listed in PRSM (i.e., TMs open and close tasks for charging).

This is a change in workflow from the pre-PRSM era, when employees could charge time to any open project, and that change was recorded if it was approved by a supervisor.

In addition to the interfaces with accounting and staff, PRSM provides an interface to the Caltrans Standard Tracking Exchange Vehicle for Environmental (STEVE). Environmental permits are recorded in PRSM and passed to STEVE, so that Caltrans employees can ensure that they keep the Department’s environmental commitments. Although such commitments may be made in the early stages of a project, they can continue for decades after the project has been completed.

On a somewhat related note, PRSM provides a document management feature that allows Caltrans employees to upload project documents, such as reports and Project Change Requests, to PRSM. It was not clear to the researchers to what extent Caltrans staff use this feature to support their workflows.

PRSM addresses some of the weaknesses of XPM and replaces some residual functions of PMCS, by including fields that did not exist in XPM but did in PMCS. Example fields are the estimated construction capital cost, and the legislative and congressional districts, so that PRSM staff can use these to extract and sort data as needed to compile their reports.
Accessibility to the software together with the reliability of data make PRSM a valuable source of information.

Caltrans staff involved in PRSM deployment studied reports used by staff in Caltrans Districts state-wide and, based on those, standardized on a limited number of them. Inevitably, some reporting needs (e.g., reports that managers developed prior to PRSM) cannot be satisfied by standard reports and people may, in any case, be reluctant to adopt a standard. Managers develop affinities for reports that they have become accustomed to seeing, and the ability to download data from PRSM enables them to continue to create those reports. The standard reports, however, remain the official data and any custom reports must reconcile with the standard reports.

Some of these custom reports might give the appearance of the *shadow systems* that were developed in the XPM area, and they could even re-use some of the shadow system code, but they are not, in fact, shadow systems because they do not upload data back to PRSM.

**4.3 Display Customizability**

PRSM offers the ability to customize screens; any user can select the fields they wish to see. This enables each user to focus on those aspects of the overall portfolio of Caltrans projects within their workflow and responsibility (portfolio management will be addressed in greater detail in Year 1 Report Part C).

This ability to customize screens allows staff to manage the hours and schedules for which they are responsible and to gain a perspective on the forthcoming work of their units.

Note that PRSM is used not only for the management of work by state employees but also the work of the consultants that Caltrans employs to assist on state highway projects. Districts and the Division of Engineering Services can add consultants to the project team and report their planned hours. Since October 2014, actual hours worked by consultants have been hand-entered into the AMS accounting system and uploaded to PRSM (Caltrans 2014).

The Division of Engineering Services indicated that it is having some success in getting project manager rights for its Project Liaison Engineers who assist in keeping project data up to date.

**4.4 Cultural Assimilation of PRSM**

As a result of the use and availability of PRSM, Caltrans supervisors and managers are now far more conscious of the hours needed and consumed to complete each project task. The use of bottom-up estimating, where individual supervisors provide estimates of hours, has greatly
improved accountability from the situation before PRSM, when supervisors had no input, and little consciousness of the cost of tasks.

4.5 Increased Accountability and Awareness

Along with the increased awareness of the hours needed to complete tasks, PRSM has enabled Caltrans to place controls on the charging of unplanned activities. PRSM controls have brought a focus to, and provided a solution for, charging problems that were known to exist in the past, but for which Caltrans had no effective solution in their pre-PRSM workflow.

The first time that a task is charged, that charge is passed to PRSM, and PRSM records the date of the charge as start date of the task. When the task is closed in PRSM, employees get a ten-day grace period to record their time. After ten days, PRSM accepts no further charges to the task.

PRSM passes authorized tasks, by unit, to Staff Central where Caltrans employees enter their time. If an employee enters a charge for a task and unit that is not currently authorized for charging, the system will immediately inform the employee that the charge is unauthorized.

This process is generally controlled by unit, allowing all employees who charge to that unit to make charges against the task. It can also be controlled at a more granular level in PRSM, by named employee, so that only they can charge time to the task.

PRSM has processes to allow TMs to open and close tasks for charging, update the percent complete for each task, and add units to the task (i.e., allow them to work on the task). More than one unit can be assigned to a task, with each unit having its own start and end date for its work on the task.

These controls and workflows based on PRSM have vastly improved the accountability of Caltrans employees in managing and recording their time.
5. User-reported PRSM Challenges

During data-gathering meetings with the researchers, Caltrans PRSM users reported challenges in performing a number of functions. These tend to be more project-management workflow related rather than stemming from PRSM software limitations.

Note that the list of functions called-out here may be augmented or corrected when Parts A, B, and C get integrated into the Year 1 Report.

5.1 Task Management

Task management appeared to have both project-management workflow as well as PRSM software support challenges. A recurring theme in meetings with Caltrans staff was that the process for updating the TM’s estimate of hours to complete a task is challenging when TMs submit their changes through a “bolt-on” java portlet or “custom object” that is not part of the CA PPM software. After these changes are submitted, the PM may or may not approve them for inclusion into the Plan of Record.

Data the researchers obtained from Caltrans indicates that nine of the twelve Districts are making little use of the applet and a question is whether this applet is of value at all. TMs in these nine Districts appear to be submitting their changes directly to the PM or assistant PM, who can directly change the Plan of Record.

An additional challenge is that, because changes are processed through this external portlet, PRSM receives them as coming from a single external source and does not have a record of the name of the requester.

This external applet appears to have been developed with a goal of using PRSM as a direct substitute for XPM, following the process shown in Figure 6. In that process, the apparent intent is to use the Plan of Record as the Project Baseline (compare with Figure 8). The applet controls the Plan of Record, but because changes must be approved by the PM, direct recording of the actual unapproved events as they occur is inhibited. Actual events, by their nature, are seldom pre-approved.

The Plan of Record in CA PPM, which Caltrans uses as the principal element of PRSM, records two sets of hours for each combination of task and unit: (1) the actual hours expended to date and (2) the estimate to complete (ETC). As costs are incurred and hours recorded, the ETC is decremented down to 0; by definition it cannot take on a negative value. For example:
• If the original estimate for a unit to complete a task is 100 hours, the ETC will be 100 hours before the task begins.
• After 40 hours of work is performed, the actual cost will be recorded as 40 hours, with the ETC being the balance of 60 hours.
• When 100 hours have been performed, the actual cost will be recorded as 100 hours, with the ETC being the balance of 0 hours.
• When 120 hours have been performed, the actual cost will be recorded as 120 hours, with the ETC still being 0 hours.

A task management challenge occurs when tasks are reassigned from one unit to another. In an 8,000-person organization—in particular one with many specialists as is the case for Caltrans—some units inevitably will have an overload at any given time while other units will have a shortage of work. In order to balance workload, work must be shifted from one unit to another. This requires a change in PRSM to show the new unit responsible for the work, and to permit the newly-assigned unit to charge time to the project task. Some TMs use the aforementioned cumbersome portlet to perform this vital task; alternatively a PM could handle a TM’s request to make such changes.

Another challenge comes as the ETC reaches 0. The researchers heard that some managers want to block further charges to a task when that is the case, as an ETC of 0 means that all hours estimated for a unit to complete their task have been used up. Several people also expressed concern that they lose the ability to track their original budget request after the ETC reaches 0. Indeed, PRSM’s display shows the total hours consumed-to-date (irrespectively of the value of ETC) but not the budgeted hours that were approved. If a TM thinks more hours will be needed to complete the task, they must ask their PM to approve additional hours. Upon approval these extra hours will be reflected in an updated ETC in PRSM.

Several respondents described experiencing difficulties in updating the Plan of Record and having developed work-arounds to address these difficulties. This led to an inconsistency between Districts, and from one PM to another, in giving right to add new units to projects in the Plan of Record to TMs and Project Liaison Engineers. In several Districts, TMs ask PM Support staff to enter their data into PRSM rather than trying to deal with the “custom object.”

The researchers also heard about occasional tensions between TMs and PMs. TMs expressed concerns about their estimated hours being changed by the PM without their knowledge and PMs feared losing control.

Concerns were expressed that resource estimates were required during the PID phase, many months before the work was required. Such early estimates are likely to be inaccurate.
The researchers also heard about difficulties in updating detailed milestones, especially the structures-specific milestones. A significant number of the issues raised are to be addressed in Caltrans project management workflows, irrespectively of whether or not PRSM is used.

5.2 Limited Schedule Management

PRSM is being used effectively for project resourcing, namely the entering of estimated resources and provision of data for the annual budget requests. However, it is not being used as effectively for schedule management (e.g., activities in PRSM have long durations but may require an allocated resource for only part of that duration, thus not allowing for intermediate controls). The root of this problem lies in the fact is related to project-management workflow: most projects are planned only to Level 5 of the standard Caltrans WBS (Figure 2) and not with greater breakdown detail.

In Caltrans’ WBS, Level 4 is the project phase, and the project phases match the phases, or components, that are specified by the Legislature (in Government Code 14526 (c), 14526.5 (c), 14527 (g), 14529 (b), and 14529.4) namely:

- Phase K: Project Study Report, also referred to as a Project Initiation Document
- Phase 0: Completion of all permits and environmental studies.
- Phase 1: Preparation of plans, specifications, and estimates.
- Phase 2: The acquisition of rights-of-way, including, but not limited to, support activities.
- Phase 3: Construction and construction management and engineering, including surveys and inspection.

Breakdown to a more detailed level requires that the collective elements of the more detailed level contain the entirety of the less detailed, or summary, level (they must be mutually exclusive and collectively exhaustive). Figure 2 shows that WBS Level 5 is a first breakdown of each of the phases shown in WBS Level 4. The number of Level 5 elements varies from one phase to another, e.g., Phase K, the project initiation document, has only 2 possible Level 5 elements, the fewest among the phases, whereas Phase 1, for “Plans, Specifications and Estimates,” has 10, the most.

Although Caltrans projects must be and most projects are planned to Level 5, its WBS can support workflows that involve planning to Level 8 so the WBS can be used to plan in far more detail than what is being done at present.

To improve understanding of the data available in PRSM, the researchers took a snapshot of the tasks that were scheduled in PRSM as “active” on January 31, 2017. A “task” is an assignment to an organizational unit to complete all or part of a WBS element. An “active task” in this context
is a task started on or before the selected date but not yet completed by that date. On the said date, PRSM had:

- 3,265 active projects
- 19,758 active WBS elements, i.e., an average of 19,758/3,265 = 6.1 active WBS elements per project
- 154,573 active tasks, i.e., an average of 154,573/19,758 = 7.8 organizational units with assigned work on each WBS element

The data indicated that the average duration of an “active task” is 845 calendar days or about 28 months (assuming ~30 days/month). Figure 9 illustrates the distribution of task durations, rounded to the nearest month. Not shown are the 1,616 tasks with durations in excess of 120 months.

![Figure 9: Distribution of Active Tasks in PRSM on January 31, 2017 (truncated at 120 months duration)](image)

The researchers also considered the work effort associated with each task. This is the amount of time that employees or consultants are expected to work on each task. Work effort may be expressed in, e.g., person-years, person-days, etc. The data indicates that the average work effort estimated for each task is 19.5 person-days. Figure 10 illustrates the distribution of work effort per task, rounded to the nearest person-day. Not shown are the 10,874 tasks with an estimated effort in excess of 40 person-days.
Figure 10: Distribution of Work Effort of Active Tasks in PRSM on January 31, 2017 (truncated at 40 person-days)

Although most tasks are spread over several months, the work effort per task is relatively small – most tasks have estimated efforts of less than 3 person-days. PRSM’s default setting is to spread work evenly over the life of the task. At the average of 19.5 person-days with a 845 calendar day duration, PRSM would show 15 person-minutes (sic) for the task on every working day for 28 months.

A project management question is: At what level of granularity should work be planned and for what planning purpose? PRSM data indicates unevenness in the granularity of tasks. Table 1 categorizes active tasks in PRSM: 49% involved less than 20 person-hours of effort, and 21% involved more than 80 person-hours of effort.
Table 1: Distribution of active tasks and effort in PRSM

<table>
<thead>
<tr>
<th>Person-hours of Effort</th>
<th>Number of Tasks</th>
<th>Percentage of Tasks</th>
<th>Total Person-hours of Effort</th>
<th>Percentage of Total Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>75,927</td>
<td>49%</td>
<td>530,358</td>
<td>2%</td>
</tr>
<tr>
<td>20-80</td>
<td>46,166</td>
<td>30%</td>
<td>1,836,260</td>
<td>8%</td>
</tr>
<tr>
<td>&gt; 80</td>
<td>32,480</td>
<td>21%</td>
<td>21,710,618</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Column Total</td>
<td>154,573</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although they accounted for almost half of the tasks, the tasks involving fewer than 20 hours of effort accounted for only 2% of the total effort of the active tasks. Tasks with more than 80 person hours of effort accounted for 90% of the total effort. Table 2 displays the active PRSM tasks according to the average weekly effort per task.

Table 2: Distribution of Active Tasks and Effort in PRSM by Average Weekly Effort

<table>
<thead>
<tr>
<th>Average person-hours per week</th>
<th>Number of Tasks</th>
<th>Percentage of Tasks</th>
<th>Total Person-hours of Effort</th>
<th>Percentage of Total Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>118,979</td>
<td>77%</td>
<td>2,921,442</td>
<td>12%</td>
</tr>
<tr>
<td>1-10</td>
<td>30,868</td>
<td>20%</td>
<td>7,861,585</td>
<td>33%</td>
</tr>
<tr>
<td>11-40</td>
<td>3,827</td>
<td>2%</td>
<td>5,948,010</td>
<td>25%</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>899</td>
<td>1%</td>
<td>7,346,199</td>
<td>31%</td>
</tr>
<tr>
<td></td>
<td>Column Total</td>
<td>154,573</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Column Total</td>
<td>24,077,236</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data row at the top shows that 77% of the active tasks (12% of the total effort of all active tasks) in PRSM were distributed across such a long duration that their effort on average was less than 1 person-hour per week.
The data row at the bottom (next-to-last row) shows that 899 tasks involve an average of more than 40 person-hours per week, i.e., more than one person full time for the entire duration of the task. This is less than 1% of the tasks, but it accounts for 31% of the total effort.

Although Table 2 shows an average number of hours per week, actual work performed varies from one week to the next. For example, focusing on one specific task in the PRSM system, completed in the period from June 2016 to March 2017, Figure 11 depicts the hours billed in each week to that task. Although the average weekly charges were 385 hours, they fluctuated between a high of 503 hours and a low of 81 hours. On smaller tasks, one would expect to find many weeks with no charges at all.

![Figure 11: Hours billed per Week on a Specific Task Completed between June 2016 - March 2017](image)

This unevenness in durations of tasks, hours estimated, and hours billed, indicates that Caltrans project management practices vary. More consistent breakdown and tracking of work in greater detail would benefit project management.

### 5.3 Reporting

The researchers heard several concerns about the types of reports available from PRSM. On the one hand, the reports they saw in District visits seemed to consist largely of tables of numbers with little summary data and little in the way of graphics. On the other hand, the reports they saw at headquarters depicted a greater amount of management-friendly summary information. Then,
when the researchers spoke to CA Technologies, they were treated to “dashboards” of management data, with numerous charts and graphs. The researchers do not know whether the distinctions are rooted in inadequacies of the CA reports of which they are unaware, difficulties in developing the CA-type reports, Caltrans choices, lack of training, or in something else.

District staff expressed dissatisfaction with the PRSM reporting capabilities, particularly in areas such as:

- Comparison of Budget (Baseline) to actual expenditures.
- Inadequate summary-level reports for organizational units at any level.
- Inability to view summary data for multiple projects rather than one project at a time.
- Lack of graphical displays on reports.

They acknowledged, however, that 8,000 Caltrans employees have access to PRSM data and have the ability to customize their preferred data screens.

It appears to be common practice to download PRSM data and then display reports in tools that are preferred by District staff. These tools may be shared applications that display data on the Intranet, or desktop tools such as Excel for use in analyzing and drawing charts and graphs. Such downloads afford any of the 8,000 users customization to individual preferences and specific needs that cannot be met by a corporate system.

5.4 "Out of the Box" CA PPM Functionality

The researchers met with CA Technologies, the producer of the software system CA PPM that forms the core of PRSM. CA PPM offers visual tools including out-of-the-box dashboards to report on project status. These are customizable. Caltrans might benefit from discussing these reporting tools with CA and possibly deploy them effectively.

Other tools that could be of benefit to Caltrans include the CA PPM elements that support planning, programming, portfolio management, and program management. The researchers will discuss portfolio management, and program management in more depth in Year 1 Report Part C, a document separate from this Year 1 Report Part A. As Caltrans considers these aspects of their management, it would then be useful to explore to what extent the CA PPM tools could be helpful to them.

CA PPM also has tools such as “story-boards,” which have developed as part of the move toward “Agile” project management, and the CA Productivity Accelerator, a tool for just-in time training and assistance with compliance to standards. These appear to have potential uses in Caltrans.
The review team discussed the concept of “Software As A Service (SAAS)” with CA Technologies. In this model, CA would host the PRSM application on their “cloud” computers and be responsible for maintaining and upgrading the PRSM core software. Upon discussion with Caltrans, it was found that this had been discussed and considered at length by Caltrans and CA, and that Caltrans had found that CA was either not able or not willing to support in the cloud the Caltrans approach to PRSM in its current configuration. Despite this current finding, a move toward SAAS may be viable now and it may be inevitable in the future.

CA indicated that Caltrans is currently using an outdated version of CA PPM and advocated that Caltrans upgrade to the current version.

5.5 Participation with CA

During the procurement process, Caltrans had to maintain an arms-length relationship with CA Technologies to avoid favoritism. That has now changed. Caltrans has purchased CA PPM and it now needs to get the maximum benefit from its purchase. Caltrans must see CA as a partner, not an arms-length contractor, especially as it seems unlikely that Caltrans will abandon CA PPM in the foreseeable future (see Year 1 Report Part B, a document separate from this Year 1 Report Part A).

The researchers’ discussed three venues for partnership with CA Technologies:

1. CA PPM has a user community (communities.ca.com) that any Caltrans employee can join. Joining would enable the employee to learn more about the capabilities of CA PPM and to comment on possible upgrades to the software.

   CA generally introduces twice-yearly upgrades to CA PPM. Priorities for the upgrades are driven in large part by feedback from the user community. Active participation by a large number of Caltrans employees would help to ensure that Caltrans needs, and especially the needs of front-line Caltrans users, are heard and receive adequate priority from CA.

   E.g., an enhancement that Caltrans staff suggested for consideration by CA PPM is integrating the Caltrans Outlook calendaring system with PRSM, to enable PRSM assignments to appear on employee calendars as tasks to be performed.

2. CA PPM hosts a “Big Room,” a gathering of major users of CA PPM who meet with CA leadership and help them decide on software upgrades. A Caltrans seat in the “Big Room” would provide a slightly different voice than that of other users, which would benefit both CA and Caltrans. This is true even if the California State Chief Information Officer (CIO) has a seat in the “Big Room,” since most users of CA PPM are drawn from the information
technology sector, which is well represented by the CIO. Caltrans PRSM is a tool for the design-bid-build construction industry which has different needs from information technology.

3. The CA PPM Sacramento user community, promoted by the information technology division at the California State Teachers’ Retirement System (CalSTRS), could be one for Caltrans employees to participate in, even though that group is unlikely to have a design-bid-build construction industry perspective and the vast majority of PRSM users are not located in Sacramento.

5.6 Training

PRSM users mentioned the need for continuing training in PRSM. Headquarters staff has performed valiantly in providing vast amounts of start-up training, but training cannot stop. In order to address incoming staff needs (due to attrition and turn-over of staff) training in PRSM’s technical capabilities must be provided on an on-going basis to District staff.

In particular, it appears that Caltrans staff are not using the CA PPM software to its potential. The headquarters trainers appear to understand the software better than the District staff, and CA demonstrated features that the researchers had not seen demonstrated by anyone in Caltrans.

5.7 Construction Management System

Although the following observation deviates from the PRSM review, the researchers did hear concerns about the fact that the Construction Management System (CMS) has not yet been replaced. Caltrans continues to use PISA with its four sub-systems (see Section 3.1.1.), to manage the construction Capital Outlay program. A project to replace PISA with a new CMS has been in process at least since 2005. The researchers did not follow up on this issue, but the outdated PISA system is an area of concern to them and, doubtless, of concern to Caltrans management as well.
6. YEAR 1 REPORT Part A FINDINGS

This Year 1 Report Part A presented a description of project management practices at Caltrans, a historic overview of supporting work processes using a progression of software systems, ending with the most recent deployment of PRSM in 2014, and observations recorded by the researchers from interviews conducted with sample groups of Caltrans staff. The researchers’ desired outcome was to produce a factual, non-judgmental description of how PRSM is used and what it is used for. As observed, Caltrans is using PRSM for project resourcing, especially for annual budgeting, but is not using its scheduling functions to their potential.

PRSM in used throughout all Caltrans Districts. It is customizable for use by all staff within Caltrans to meet their needs. Most notably, it enables Caltrans to align Headquarters Baseline milestones commitments to the CTC and budget requests to the Legislature.

The herewith provided factual, non-judgmental description of how PRSM is to be reviewed by Caltrans and corrected where needed. Caltrans staff have far greater understanding of their processes than the researchers do, and the intent at this point is to validate or correct the facts.

The researchers have received feedback on a draft of this Part A from people designated by Caltrans management and corrected this document accordingly prior to including it in the Year 1 Report.

The researchers’ initial sense from the PRSM review meetings, to the extent that conclusions are possible at this early stage of the research, is that over the course of three years of deployment, PRSM has become a well-established project management system for about 3,000 Caltrans users with read/write access and many more with read-only access, yet PRSM is not yet fully living up to its title. PRSM is an acronym for “Project Resourcing and Schedule Management.” Caltrans is using it for project resourcing, especially for annual budgeting, but does not appear to have project management workflows in place to use PRSM’s scheduling functions to their potential.
APPENDIX I: RESEARCHER CREDENTIALS AND ETHICAL CONDUCT

I.1 Biographies and Credentials of Research Team Members

The four-person research team that conducted the PRSM review and wrote this document comprises two internationally-recognized experts in engineering project management, affiliated with UC Berkeley’s Project Production Systems Laboratory (P2SL – p2sl.berkeley.edu), as well as a third researcher from UC Berkeley/P2SL and a staff member from UC Berkeley’s Partners for Advanced Transportation Technology (PATH – path.berkeley.edu) program.

Iris D. Tommelein
Professor in the Civil and Environmental Engineering Department
Director, Project Production Systems Laboratory
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tommelein@berkeley.edu
faculty.ce.berkeley.edu/tommelein

Professor Iris D. Tommelein, the Principal Investigator, teaches, consults, and conducts research to develop and advance the theory and principles of project-based production management, applied—but not limited—to the Architecture-Engineering-Construction (AEC) industry, what is termed “Lean Construction.”

Professor Tommelein directs the Project Production Systems Laboratory at UC Berkeley (P2SL - p2sl.berkeley.edu), a research laboratory dedicated to developing and deploying knowledge and tools for project management, as well as a learning lab for the Northern California construction industry. She is active in the International Group for Lean Construction (IGLC - www.iglc.net) and serves on the Board of Directors of the Lean Construction Institute (LCI - www.leanconstruction.org). She served 4 years on the Executive Committee of the Technical Council on Computing and Information Technology (TCCIT) of the American Society of Civil Engineers (ASCE - www.asce.org), and is a member of the Construction Research Council of ASCE’s Construction Institute.

In 2002, Professor Tommelein received ASCE’s Walter L. Huber Civil Engineering Prize “for her research on civil engineering computing for managing project-based production systems in the engineering-architecture-construction industry,” and in 2014 ASCE’s Peurifoy Construction Research Award “for her contributions in developing Lean Project Production theory, methods and tools, and for successfully disseminating these theories, methods and tools into multiple large, complex projects in the US and worldwide.” Last but not least, she received the Lean Pioneer Award 2015 from LCI, recognizing an individual (or organization) who has moved the design and
construction industry forward in embracing and implementing Lean tools and techniques on capital projects.

Professor Tommelein earned a 5-year Civil Engineer-Architect degree from the VUB in Belgium, where she is a Professional Engineer, and three graduate degrees (MS in Civil and Environmental Engineering (Construction Engineering & Management), MS in Computer Science (Artificial Intelligence), and PhD in Civil Engineering) from Stanford University.

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Nigel Blampied is a Doctoral student and P2SL researcher at UC Berkeley. He retired in 2011 from the position of Division Chief for Project Management and BATA Support in the Caltrans office in Oakland (District 4). Before his assignment in Oakland, he was project manager for PRSM from 2003 to 2008 and he played a significant role in writing the PRSM specifications.

Mr. Blampied has extensive experience in writing national and international project management standards. He was secretary of one of the three working groups that wrote the International Standard on Project Management, ISO21500. Since 1998 he has been active in writing American National Standards for project management and he also co-authored the American Association of State Highway Officials (AASHTO) Guide for Consultant Contracting. Mr. Blampied led the team that wrote PMI’s Government Extension to the PMBOK® Guide; which appears to be the first book ever published specifically about project management in government (as opposed to project management in general, the private sector, or in a specific government agency). He has served on the editorial and drafting committees for the PMBOK® Guide, Practice Standard for Work Breakdown Structures, and the Construction Extension to the PMBOK® Guide.

For his work in project management standards, PMI recognized Mr. Blampied with its Distinguished Contribution Award. In the 26 years since this 473,000-member organization began making this award, it has been given to only 102 people.

Mr. Blampied earned a BScEng degree in Civil Engineering from the University of Natal, a BA in Economics and Geography from the University of South Africa, an MA in Cross-Cultural Studies from Fuller Theological Seminary, and an MS in Civil Engineering from the University of California, Berkeley. He is a candidate for the PhD in Civil Engineering (Engineering and Project Management) at Berkeley. He is a registered Professional Engineer in California and South Africa.
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Master’s Student in the Engineering and Project Management Program (2016-17)  
Civil and Environmental Engineering Department  
University of California, Berkeley, CA 94720-1712  
eshanjayamanne@berkeley.edu

Mr. Eshan Jayamanne Mohottige Don is a Master’s student in the Engineering and Project Management Program in the Civil and Environmental Engineering Department at UC Berkeley. He holds a BS degree in Civil Engineering from the University of Texas, San Antonio. He has been conducting research on workforce planning in engineering and design companies.

Benjamin McKeever  
California PATH Program Manager  
University of California  
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Ben McKeever is a Program Manager at California Partners for Advanced Transportation Technology (PATH) within the Institute for Transportation Studies at UC Berkeley. He is responsible for the development and growth of a robust and coherent program at PATH in the area of Connected and Automated Vehicle (CAV) research.

Prior to joining PATH, Mr. McKeever acquired over 18 years of experience working in both the private and public sector to deliver intelligent transportation system (ITS) solutions to improve safety and mobility on our transportation network. Most recently, Mr. McKeever served as Team Leader at the FHWA Turner-Fairbank Highway Research Center in the Office of Operations R&D where he led a team of research engineers focused on developing and testing transformative safety, mobility and environmental applications in the area of CAV. Mr. McKeever is currently focused on advancing CAV technology and applications from research to deployment throughout the US.

Mr. McKeever holds a BS degree in Applied Mathematics from the University of Virginia and a MS degree in Civil Engineering from the University of Texas, Austin. He is a registered Civil Engineer in California and Missouri.

I.2 Ethical Conduct

UC Berkeley has Standards of Ethical Conduct that are “a statement of our belief in ethical, legal and professional behavior in all of our dealings inside and outside the University” (UCB 2016). These state that “University community members who have certain professional or financial interests are expected to disclose them in compliance with applicable conflict of interest/conflict of commitment policies. In all matters, community members are expected to take appropriate steps,
including consultation if issues are unclear, to avoid both conflicts of interest and the appearance of such conflicts.”

A perception may exist that researchers on the team potentially have conflicts of interest in conducting the research as described because of their current or past employment funded by Caltrans.

- Iris Tommelein is Principal Investigator on a research project with the University of California Center on Economic Competitiveness in Transportation (UCCONNECT - ucconnect.berkeley.edu) supported by Caltrans funds (Contractor agreement 65A0529 with UC Berkeley). This project titled “Mapping and improving the Delivery Process of Highway Pavement Rehabilitation Projects” was awarded a budget of $ 81,074 for the term May 1, 2016 through April 30, 2017. Nigel Blampied served as the Graduate Student Researcher on this research. Both Prof. Tommelein and Mr. Blampied were paid using these UCCONNECT funds.
- Nigel Blampied retired from Caltrans in 2011.
- Ben McKeever is a Program Manager with PATH. His salary is paid with PATH funds that originate from various sources including Caltrans-funded research projects.

In September 2016, prior to team members accepting to engage in this PRSM review research, Thomas West, Director of California PATH at UC Berkeley, consulted with Caltrans and concluded that no conflict of interest situation existed to prevent any team members from conducting the research in an ethical fashion.
## Appendix II: Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>ASCE</td>
<td>American Society of Civil Engineers</td>
</tr>
<tr>
<td>Caltrans</td>
<td>California Department of Transportation</td>
</tr>
<tr>
<td>CEQA</td>
<td>California Environmental Quality Act</td>
</tr>
<tr>
<td>CITRIS</td>
<td>Center for Information Technology Research in the Interest of Society, at UC Berkeley</td>
</tr>
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<td>CTC</td>
<td>California Transportation Commission</td>
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<tr>
<td>DOF</td>
<td>California Department of Finance</td>
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<tr>
<td>ETC</td>
<td>Estimate To Complete</td>
</tr>
<tr>
<td>FM</td>
<td>Functional Manager</td>
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<tr>
<td>FSR</td>
<td>Feasibility Study Report</td>
</tr>
<tr>
<td>IGLC</td>
<td>International Group for Lean Construction</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ITS</td>
<td>Institute(s) of Transportation Studies (institutes at UC Berkeley, UC Davis, UC Irvine, and UC Los Angeles)</td>
</tr>
<tr>
<td>LCI</td>
<td>Lean Construction Institute</td>
</tr>
<tr>
<td>NEPA</td>
<td>National Environmental Policy Act</td>
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<td>P2SL</td>
<td>Project Production Systems Laboratory (a research laboratory at UC Berkeley, housed under the umbrella of CITRIS)</td>
</tr>
<tr>
<td>PATH</td>
<td>Partners for Advanced Transportation Technology (a center within ITS at UC Berkeley)</td>
</tr>
<tr>
<td>PCC</td>
<td>California Public Contract Code</td>
</tr>
<tr>
<td>PCSM</td>
<td>Project Cost and Schedule Management (a software system that was proposed in 2000)</td>
</tr>
<tr>
<td>PM</td>
<td>Project Manager</td>
</tr>
<tr>
<td>PMI</td>
<td>Project Management Institute</td>
</tr>
<tr>
<td>PRSM</td>
<td>Project Resourcing and Schedule Management (a software system)</td>
</tr>
<tr>
<td>PY</td>
<td>Person Year</td>
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<tr>
<td>SHOPP</td>
<td>State Highway Operation and Protection Program</td>
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<tr>
<td>SPMIT</td>
<td>Caltrans Statewide Project Management Improvement Team</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>--------------</td>
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<tr>
<td>SSTI</td>
<td>State Smart Transportation Initiative (an institute at the University of Wisconsin that is sponsored by several states, including California)</td>
</tr>
<tr>
<td>STIP</td>
<td>State Transportation Improvement Program</td>
</tr>
<tr>
<td>TM</td>
<td>Task Manager</td>
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<td>University of California</td>
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<td>UCB</td>
<td>University of California, Berkeley</td>
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<td>UCCONNECT</td>
<td>University of California Center on Economic Competitiveness in Transportation (a center within ITS, supporting research at UC Berkeley, UC Irvine, UC Los Angeles, UC Riverside, UC Santa Barbara, and California Polytechnic State University at San Luis Obispo)</td>
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<tr>
<td>UCTC</td>
<td>University of California Transportation Center</td>
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<tr>
<td>US</td>
<td>United States (ISO standard two-letter country code)</td>
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<tr>
<td>WBS</td>
<td>Work Breakdown Structure</td>
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</tbody>
</table>
APPENDIX III: REFERENCES


California State Legislature (2016). *Budget Act of 2016* (Chapter 23, California Statutes of 2016; Senate Bill 826), Sacramento, CA.


