

Evaluation, Comparison, and Improvement Recommendations for Caltrans Financial Programming Processes and Tools

Wenbin Wei, PhD

Nigel Blampied, PhD

Raajmaathangi Sreevijay



Mineta Transportation Institute

Founded in 1991, the Mineta Transportation Institute (MTI), an organized research and training unit in partnership with the Lucas College and Graduate School of Business at San José State University (SJSU), increases mobility for all by improving the safety, efficiency, accessibility, and convenience of our nation's transportation system. Through research, education, workforce development, and technology transfer, we help create a connected world. MTI leads the [Mineta Consortium for Transportation Mobility \(MCTM\)](#) funded by the U.S. Department of Transportation and the [California State University Transportation Consortium \(CSUTC\)](#) funded by the State of California through Senate Bill 1. MTI focuses on three primary responsibilities:

Research

MTI conducts multi-disciplinary research focused on surface transportation that contributes to effective decision making. Research areas include: active transportation; planning and policy; security and counterterrorism; sustainable transportation and land use; transit and passenger rail; transportation engineering; transportation finance; transportation technology; and workforce and labor. MTI research publications undergo expert peer review to ensure the quality of the research.

Education and Workforce

To ensure the efficient movement of people and products, we must prepare a new cohort of transportation professionals who are ready to lead a more diverse, inclusive, and equitable transportation industry. To help achieve this, MTI sponsors a suite of workforce development and education opportunities. The Institute supports educational programs offered by the

Lucas Graduate School of Business: a Master of Science in Transportation Management, plus graduate certificates that include High-Speed and Intercity Rail Management and Transportation Security Management. These flexible programs offer live online classes so that working transportation professionals can pursue an advanced degree regardless of their location.

Information and Technology Transfer

MTI utilizes a diverse array of dissemination methods and media to ensure research results reach those responsible for managing change. These methods include publication, seminars, workshops, websites, social media, webinars, and other technology transfer mechanisms. Additionally, MTI promotes the availability of completed research to professional organizations and works to integrate the research findings into the graduate education program. MTI's extensive collection of transportation-related publications is integrated into San José State University's world-class Martin Luther King, Jr. Library.

Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the information presented herein. This document is disseminated in the interest of information exchange. MTI's research is funded, partially or entirely, by grants from the California Department of Transportation, the California State University Office of the Chancellor, the U.S. Department of Homeland Security, and the U.S. Department of Transportation, who assume no liability for the contents or use thereof. This report does not constitute a standard specification, design standard, or regulation.

Report 22-61

Evaluation, Comparison, and Improvement Recommendations for Caltrans Financial Programming Processes and Tools

Wenbin Wei, PhD

Nigel Blampied, PhD

Raajmaathangi Sreevijay

February 2023

A publication of the
Mineta Transportation Institute
Created by Congress in 1991

College of Business
San José State University
San José, CA 95192-0219

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. 22-61	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Evaluation, Comparison, and Improvement Recommendations for Caltrans Financial Programming Processes and Tools		5. Report Date February 2023	
		6. Performing Organization Code	
7. Authors Wenbin Wei, PhD (https://orcid.org/0000-0001-9813-7555) Nigel Blampied, PhD (https://orcid.org/0000-0001-8597-6691) Raajmaathangi Sreevijay		8. Performing Organization Report CA-MTI-2058	
9. Performing Organization Name and Address Mineta Transportation Institute College of Business San José State University San José, CA 95192-0219		10. Work Unit No.	
		11. Contract or Grant No. 65A0660	
12. Sponsoring Agency Name and Address U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology University Transportation Centers Program 1200 New Jersey Avenue, SE Washington, DC 20590		13. Type of Report and Period Covered	
		14. Sponsoring Agency Code	
15. Supplemental Notes			
16. Abstract The California Transportation Improvement Program System (CTIPS) is the main tool used by Caltrans' Division of Financial Programming to support the business of transportation programming. It is a multi-agency joint-use project programming database system applied to develop and manage various state and federal transportation programming documents. The goal of this project is to evaluate CTIPS and explore various new options that will maintain the current functionality of CTIPS, meet legislative guidelines for ADA compliance, ensure security of the system, and have sufficient scalability and capabilities for integration with other systems in the future. The research is based on the review of current and historical documents, interviews, and surveys of the customers of the Division of Financial Programming; the survey of programming systems used by the other 49 states and District of Columbia (DC) in the U.S.; an interview with the CTIPS service support provider; and interviews and surveys of the software companies that provide services and products similar to CTIPS. This research identifies risks associated with CTIPS and opportunities for improvements; compares the processes in California with currently recognized best practices and with those used in the other states in the U.S.; and makes recommendations for the improvement of CTIPS. Research results could help Caltrans better capture current data needs and future analytics requirements and make an informed decision about modernizing and upgrading an essential programming database.			
17. Key Words California Transportation Improvement Program System (CTIPS), Processes and tools, ADA compliance, Security of the system, Evaluation, Comparison and improvement recommendations	18. Distribution Statement No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161.		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 130	22. Price

Copyright © 2022
by **Mineta Transportation Institute**

All rights reserved.

DOI: 10.31979/mti.2023.2058

Mineta Transportation Institute
College of Business
San José State University
San José, CA 95192-0219

Tel: (408) 924-7560
Fax: (408) 924-7565
Email: mineta-institute@sjsu.edu

transweb.sjsu.edu/research/2058

ACKNOWLEDGMENTS

The authors acknowledge the valuable assistance provided by the personnel from the Caltrans Division of Financial Programming who were members of the combined Caltrans and San José State University (SJSU) project team: Muhaned Aljabiry, Jordan Leung, Hai Nam Bui, Heather Loeb, Scott Williams, Dae Yoo, John Hedges, Shalini Chandra, and Ebtesam Hazbavi.

Special thanks are due to Muhaned Aljabiry and Jordan Leung who submitted edits and additions to the questionnaires, and Caltrans Division Chief for Transportation Planning, Marlon Flournoy, who contacted the members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Planning to publicize the questionnaire for Chapter 3 and encouraged participation.

For Chapters 2 and 4, the authors express gratitude to representatives of Regional Transportation Agencies, California Department of Transportation (Caltrans) Districts, and Caltrans Headquarters Divisions who responded to two questionnaires relating to transportation project programming in California, and who participated in meetings on this subject. Their insights contributed significantly to those two chapters.

For Chapter 3, the authors express similar thanks to representatives of the Departments of Transportation (DOTs) across the United States who responded to the questionnaire that forms the basis of that chapter.

Dr. Lisa Blampied very kindly reviewed and commented on the draft report.

CONTENTS

Acknowledgments	vi
List of Figures.....	ix
List of Tables.....	x
Executive Summary	1
1. Introduction.....	4
1.1. Background, Motivation, and Goal of the Project.....	4
1.2. Organization of this Report	6
2. Overview of Caltrans Current Financial Programming Process and Tools.....	7
2.1 Perspective on Caltrans Financial Programming.....	7
2.2 Caltrans Program Components.....	10
2.3 Best Practices: Portfolio Management	16
3. Synthesis of Programming Systems in the United States	25
3.1 Overview of Programming Systems	25
3.2 Research Method for Programming Systems	28
3.3 Results and Discussions of Programming Systems	28
3.4 Findings Regarding Programming Systems	42
4. Recommendations for Caltrans Financial Programming Processes.....	44
4.1 Overview of these Recommendations	44
4.2 Sources	44
4.3 Enumerated Recommendations	45
4.4 Reconciliation to Sources.....	60

5. Risks, Opportunities, and Recommendations of Improvement for Caltrans Financial Programming Tools.....	63
5.1 Introduction and Background	63
5.2 Risks of the Current Financial Programming Tools, i.e., CTIPS.....	66
5.3 Opportunities for Improvement of the Financial Programming Tools, i.e., CTIPS.....	70
5.4 Recommendation for improvement of the financial programming tools, i.e., CTIPS.....	76
6. Summary & Conclusions	83
Appendix A. Text of the Online Questionnaire	85
Appendix B. Recommendations and Requirements as they Appear in the Sources.....	90
Bibliography	114
About the Authors.....	119

LIST OF FIGURES

Figure 1. Overview of the Caltrans Financial Programming Process	7
Figure 2. Broad Categorization of the Caltrans Budget for Fiscal Year 2021–2022	10
Figure 3. Program Components of Caltrans State Highway Expenditures in 2020–2021.....	11
Figure 4. Program Components of Caltrans State Highway Expenditures in 1990–1991.....	12
Figure 5. Annual Count of Papers in Scopus that Refer to “Project Portfolio”	24
Figure 6. Use of In-House Versus Commercial Systems for Managing the STIP.....	29
Figure 7. Correlation between in-House versus Commercial Systems for Managing the STIP versus their Location	31
Figure 8. Correlation Between Security Practices for the STIP versus their Location	32
Figure 9. Project Phases Managed in the DOT’s STIP Programming System	32
Figure 10. Responses to the Question “Does the System Reconcile the Authorized Funding with Actual Expenditures to Show the Balance of Funds Remaining?”	33
Figure 11. Responses to the Question “Does the System Interface with the Agency’s Accounting System for Purposes of Expenditure Authorization?”	34
Figure 12. Illustration of a Problem in Tracking of Costs from Programming to Completion of Construction	35
Figure 13. Responses to the Question “Does the System Have a Method for Tracking Situations Where a Single Environmental Document Provides Environmental Clearance for Multiple Sets of Plans, Specifications, and Estimates?”	37
Figure 14. Responses to the Question “Does the System Generate Data or Forms for Federal Authorization?”	38
Figure 15. Systems with which the Dots’ STIP Programming Systems Interface	39
Figure 16. Input Methods Permitted in the DOTs’ STIP Programming Systems.....	41
Figure 17. Responses to the Question “Does the System Track Each Project’s Expected Contribution to the State’s Performance Targets Under MAP-21?”	42

LIST OF TABLES

Table 1. Program Components of Caltrans State Highway Expenditures in 1990–1991 and 2020–2021	13
Table 2. Mapping of California Project Portfolio Responsibilities to the ANSI Performance Domains.....	20
Table 3. List of Related Studies	27
Table 4. Comparison of Software Types Used for Project Management Versus STIP Programming	30
Table 5. Reconciliation of Recommendations to Sources	61

Executive Summary

The Division of Financial Programming in Caltrans is responsible for the programming of state and federal funds for surface transportation projects in California. The Division defines its work, “Financial Programming,” as “the commitment of transportation funds to be available over a period of several years to particular projects.” The Financial Programming Division’s activities are directed by both state statutes and federal regulations. The Division develops and manages the department’s multi-year capital programs, maintains records of funding decisions, and acts as Caltrans’ liaison to support other state and local agencies responsible for transportation funding and projects. The Financial Programming Division’s work involves the exchange of project financial information with several other Caltrans divisions, Caltrans districts, and the public. The involved Caltrans divisions include Accounting, Budgets, Local Assistance, Rail and Mass Transportation, Project Management, Construction, and Right of Way. The Division of Financial Programming also serves as an interface with the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) responsible for approvals and record keeping of federal funding.

The California Transportation Improvement Program System (CTIPS) is the main tool used by Caltrans’ Division of Financial Programming to support the business of transportation programming. It is a multi-agency joint-use project programming database system, which is applied to develop and manage various state and federal transportation programming documents as required under state and federal laws.

Specifically, CTIPS is used to capture STIP (State Transportation Improvement Program) and SHOPP (State Highway Operation and Protection Program) documents in an automated repository, which would be used to generate the FTIP (Federal Transportation Improvement Program) and FSTIP (Federal Statewide Transportation Improvement Program) documents. Data from CTIPS are interfaced with other project management and budgetary databases within Caltrans. CTIPS is accessible on the internet to over 1,000 users and provides a common database shared by Caltrans’ headquarters and district offices, MPOs, RTPAs, the CTC, the FHWA, the FTA, the EPA (Environmental Protection Agency), and local agencies. CTIPS will also receive Project Programming Requests (PPR) documents for projects that have been adopted by CTC, from CALSMART, in the near future. Overall, CTIPS is the main tool and database system used by these agencies to manage the programming and allocation of funds for STIP, SHOPP, and local projects. Many MPOs use CTIPS as their sole FTIP database system. Other MPOs use in-house database systems and electronically import data from FTIP into CTIPS.

CTIPS is a programming database that was originally developed in-house in a FoxPro environment. To keep the database with the more advanced and modern information technology, it was converted to an Oracle database and Java interface as an interim solution. The conversion was not a standard process and was done using Legacy Conversion, which makes it hard to implement any changes or updates to its code as it currently exists. For example, the current user

interface of CTIPS is not compliant with the Americans with Disability Act's (ADA) requirements, and the system, including the web interface, has security vulnerabilities.

The efforts to make CTIPS ADA compliant have been unsuccessful due to the database's complex structure. Currently, there is also an important need to add more project data, such as benefits/outcomes, to the CTIPS database. Therefore, Caltrans is interested in exploring an upgraded or overhauled database system for growing programming needs, including data storage, data integration, reporting analytics, and other reporting needs required by California.

The goal of this project is to evaluate the current financial programming processes and tools, i.e., CTIPS, and explore various new solutions and options which will maintain the current functionality of CTIPS, meet legislative guidelines for ADA compliance, ensure the security of the system against attacks, and also have sufficient scalability and capabilities for integration with other systems that share CTIPS data and enhancement for the future.

To achieve the goal of this project, we have completed the following tasks: identified the risks associated with the current financial programming processes and tools, i.e., CTIPS; identified opportunities for improvements to the financial programming processes and tools, i.e., CTIPS; compared the processes in California with currently recognized best practices as well as with the processes and tools used in the other 49 states in the United States; and made recommendations for the improvement of the financial programming processes and tools, i.e., CTIPS.

We provide an overview of the current Caltrans financial programming processes and tools and analyze and assess the existing financial programming business processes. This is based on the review of current and historical documents, interviews, and surveys of the customers of the Division of Financial Programming. This will help Caltrans and others understand better the expectations of the Division's customers, the outcomes that the customers desire from the financial programming processes, and the expectations of stakeholders.

We research the national market for programming systems as used by the Departments of Transportation (DOTs) of the fifty United States and the District of Columbia (DC). This is based on a survey and investigations of the processes and approaches used by the states and DC to perform functions similar to the processes in California. The survey covers a variety of questions and areas, such as whether there is a dominant commercially available system; security practices; programmatic usage; financial interfaces; other interfaces; and input methods. It is concluded that there are no dominant commercial systems in the market for DOT STIP programming, although there is one product that is used by six of the seventeen DOTs that utilize commercial systems. A clear majority of DOTs use their own in-house systems, and most DOT STIP programming systems appear to have room for improvement in their financial interfaces.

We recommend mid-level business-based requirements for a future CTIPS replacement system and associated processes. Our recommendations spread across a variety of areas, such as automation and workflow; batch upload; Caltrans IT strategy; compliance and audits; custom

reports and information for RTPAs, MPOs, and Caltrans units; data storage, dates, and milestones; data validation and integrity; federal processes and systems; Geographic Information System interface; hand entry of data; interfaces with Caltrans systems; interfaces with RTPA and MPO systems; notifications and alerts; replacement of existing systems; security; splits and combines / project identification; statewide reports and reports to the CTC; training, coordination, and information sharing; and use of funds. We note that this is the fifth time that Caltrans has investigated the possibility of replacing CTIPS over a span of 22 years. The previous four efforts have not led to a replacement system. The requirements, however, have remained fairly constant over these 22 years.

We identify the risks associated with the tools used by the current financial programming processes, i.e., CTIPS, identify opportunities for improvements to CTIPS, and then make recommendations for the improvement of CTIPS. Our recommendations cover 11 different areas, such as hosting environment; vendor selection; ADA compliance; security improvements; scalability and flexibility; database and user access; ML/AI and data analytics features; procurement platform; product license and price; migration plan; and project management. We find that it would almost certainly be cheaper, and less risky, to replace CTIPS rather than attempting to recode the existing system.

It is expected that our research results will help Caltrans better capture the current data needs and future analytics requirements and enhancements, and develop a comprehensive plan for the next steps involved, so that Caltrans can utilize resources more efficiently, make the reporting process more effective, and improve the department's transparency in communicating about the cost, scope and benefits of current and planned projects. Our research project will help Caltrans make an informed decision about modernizing and upgrading an essential programming database and obtain a comprehensive picture of the unbiased options that can help structure the existing functions and potential upgrades to CTIPS.

1. Introduction

1.1 Background, Motivation, and Goal of the Project

1.1.1 Financial Programming and CTIPS

Several government agencies in California share the responsibility for allocating state and federal funds to transportation projects, including California Department of Transportation (Caltrans), California Transportation Commission (CTC), Metropolitan Planning Organizations (MPOs), and Regional Transportation Planning Agencies (RTPAs). The Division of Financial Programming in Caltrans is responsible for the programming of state and federal funds for surface transportation projects in California. The Division defines its work, “Financial Programming,” as “the commitment of transportation funds to be available over a period of several years to particular projects.” The Financial Programming Division’s activities are directed by both state statutes and federal regulations.

The Division of Financial Programming develops and manages the department’s multi-year capital programs, maintains records of funding decisions, and acts as Caltrans’s liaison to support other state and local agencies responsible for transportation funding and projects. The Division’s work involves exchanging project financial information with several other Caltrans divisions, Caltrans districts, and the public. The involved Caltrans divisions include Accounting, Budgets, Local Assistance, Rail and Mass Transportation, Project Management, Construction, and Right of Way. The Division also serves as an interface with the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) responsible for the approvals and record keeping of federal funding.

Historically, Financial Programming was a manual paper process that tracked project funding, amendments, allocations, additions, and deletions. In late 1998, The California Transportation Improvement Program System (CTIPS) was created to electronically integrate the various state and federal transportation programming documents, which contained more than 10,000 planned improvements worth billions of dollars funded with state and/or federal funds along with legislative mandated changes in the state of California.

Currently, CTIPS is the main tool used by Caltrans’s Division of Financial Programming to support the business of transportation programming. It is a multi-agency joint-use project programming database system, which is applied to develop and manage various state and federal transportation programming documents as required under state and federal laws.

Specifically, CTIPS is used to capture STIP (State Transportation Improvement Program) and SHOPP (State Highway Operation and Protection Program) documents in an automated repository, which would be used to generate the FTIP (Federal Transportation Improvement Program) and FSTIP (Federal Statewide Transportation Improvement Program) documents.

Data from CTIPS are interfaced with other project management and budgetary databases within Caltrans. CTIPS is accessible on the internet to over 1,000 users and provides a common database shared by Caltrans headquarters and district offices, MPOs, RTPAs, CTC, FHWA, FTA the EPA (Environmental Protection Agency), and local agencies. CTIPS will also receive Project Programming Requests (PPR) documents for projects that have been adopted by CTC, from CALSMART, in the near future. Overall, CTIPS is the main tool and database system used by these agencies to manage the programming and allocation of funds for STIP, SHOPP, and local projects. Many MPOs use CTIPS as their sole FTIP database system. Other MPOs use in-house database systems and electronically import data from FTIP into CTIPS.

1.1.2 Goal and Tasks of the Project

CTIPS is a programming database originally developed in-house in a FoxPro environment. To keep the database with the more advanced and modern information technology, it was converted to an Oracle database and Java interface as an interim solution. The conversion was not a standard process and was done using Legacy Conversion which makes it hard to implement any changes or updates to its code as it currently exists. For example, the current user interface of CTIPS is not compliant with the Americans with Disability Act (ADA) requirements, and the system, including the web interface, has security vulnerabilities.

Efforts to make CTIPS ADA compliant have been unsuccessful due to the database's complex structure. Currently, there is also an important need to add more project data, such as benefits/outcomes, to the CTIPS database. Therefore, Caltrans is interested in exploring an upgraded or overhauled database system for growing programming needs, including data storage, data integration, reporting analytics, and other reporting needs required by California.

The ultimate goal of this project is to explore various solutions and options, including off-the-shelf and custom products available, which will not only maintain the current functionality of CTIPS, but also meet legislative guidelines for ADA compliance and ensure security of the system against attacks. In addition, the new system should have sufficient scalability and capabilities for integration with other systems that share CTIPS data and enhancement due to future needs.

To meet the goal of the project, we need to first evaluate the financial programming processes and their associated risks, and compare them with currently recognized best practices as well as with the processes and tools used in the other 49 states in the United States. We need to identify opportunities for improvement, and also provide a set of recommendations for the changes in the Division's financial programming processes and tools, i.e., CTIPS, that are expected to decrease its risks in various areas and improve its ability to serve its customers in the CTC, MPOs, RTPAs, FHWA, Caltrans divisions and districts, and the public.

Based on the project's goals, we need to complete the following tasks for this project: (1) identify the risks associated with the current financial programming processes and tools, i.e., CTIPS; (2) identify opportunities for improvements to the financial programming processes and tools, i.e.,

CTIPS; (3) compare the processes in California with currently recognized best practices as well as with the processes and tools used in the other 49 states in the U.S.; and (4) finally make recommendations for the improvement of the financial programming processes and tools, i.e., CTIPS.

The research project will help Caltrans, especially the Financial Programming division, obtain a comprehensive picture of the unbiased options that can help structure the existing functions and potential upgrades to the CTIPS database. It is expected that our research results will help Caltrans better capture the current data needs and future analytics requirements and enhancements; make an informed decision about modernizing and upgrading an essential programming database; develop a comprehensive plan for the next steps involved, so that Caltrans can utilize resources more efficiently rather than depending on solutions from vendors with vested interests, and eventually make the reporting process more effective as well as improve departments transparency in communicating about the cost, scope, and benefits of current and planned projects.

1.2 Organization of this Report

In Chapter 1, we introduce this research project and its report, which includes the background, motivation, goals, tasks, and also organization of the report.

In Chapter 2, we provide an overview of current Caltrans financial programming processes and tools, and analyze and assess the existing financial programming business processes. This is based on the document review, stakeholder interviews, and investigation of financial programming processes and tools. This will help Caltrans and others better understand the expectations of the Division's customers, the outcomes that the customers desire from the financial programming processes, and the expectations of stakeholders.

In Chapter 3, we research the national market for programming systems as used by the Departments of Transportation (DOTs) across the U.S. and the District of Columbia (DC). This is based on a survey and investigations of the processes and approaches used by the fifty states and DC to perform functions similar to the processes in California.

In Chapter 4, we recommend mid-level business-based requirements for a future CTIPS replacement and associated processes. We point out that this is the fifth time that Caltrans has investigated the possibility of replacing CTIPS over a span of 22 years. The previous four efforts have not led to a replacement system. The requirements, however, have remained fairly constant over these 22 years.

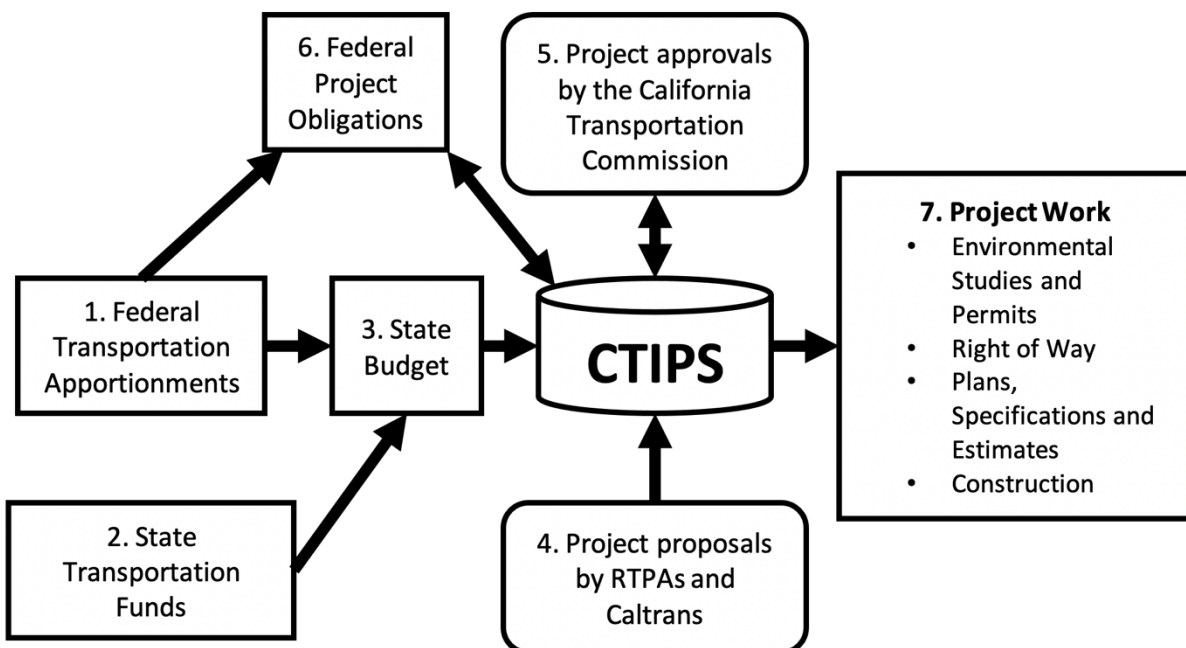
In Chapter 5, we identify the risks associated with the tools used by the current financial programming processes, i.e., CTIPS, identify opportunities for improvements to CTIPS, and then make recommendations. We find that it would almost certainly be cheaper, and less risky, to replace CTIPS rather than attempting to recode the existing system. In Chapter 6, we conclude this report with a summary of our research.

2. Overview of Caltrans Current Financial Programming Processes and Tools

2.1 Perspective on Caltrans Financial Programming

Caltrans defines “Financial Programming” as “...the commitment of transportation funds to be available over a period of several years to particular projects,”¹ and assigns responsibility for coordinating this commitment to the Division of Financial Programming. Figure 1 illustrates the Division’s duties and the relationship of CTIPS to the funding of transportation projects in California. A generic description of the process follows.

Figure 1. Overview of the Caltrans Financial Programming Process



Beginning at the left of Figure 1, the U.S. Congress (Congress) apportions transportation funds to the states. Since 1916, Congress has at regular intervals passed laws to provide federal aid for the construction of transportation facilities.² This aid has normally been apportioned to each state through formulas established by Congress.

¹ “Financial Programming” accessed May 19, 2022, <https://dot.ca.gov/programs/financial-programming>.

² The first federal aid highway act was the *Rural Post Roads Act* of 1916, Public Law 64-156. The most recent revision is the *Infrastructure Investment and Jobs Act* of 2021, also known as the *Bipartisan Infrastructure Law*, Public Law 117-58. Other major modifications in federal transportation funding include the *Fixing America’s Surface Transportation Act* (FAST) of 2015, Public Law 114-94; the *Moving Ahead for Progress in the 21st Century Act* (MAP-21) of 2012, Public Law 112-141; the *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users* (SAFETEA-LU) of 2005, Public Law 109-59; the *Transportation Equity Act for the 21st Century* (TEA-21) of 1998, Public Law 105-178; and the *Intermodal Surface Transportation Efficiency Act* (ISTEA) of 1991, Public Law 102-240.

In California, the state raises transportation funds through a variety of measures established in state law. Section 2.2 of this report provides a description of these state funds.

The state and federal funds are appropriated by the California State Legislature (the Legislature) in its annual state budget. State law requires that federal funds be included in the state budget so that the Legislature will be cognizant of them. Thus, in California, the federal funds discussed above cannot be used by state agencies until provision has been made for their use by the Legislature, which does not normally appropriate funds on a project-by-project basis but rather appropriates annual amounts of money to categories (“program components”) of projects. Project-by-project approval is made later by the California Transportation Commission (CT1C).

The program components are discussed in greater detail in Section 2.2.

Under the guidance of the Department of Finance, Caltrans estimates expected multi-year transportation revenues and submits a “Fund Estimate” to the CTC for approval. This fund estimate process is prescribed in state law.³ The 2020 Fund Estimate identified more than \$28 billion in State and Federal funds to be committed (“programmed”) to projects over a six-year period.⁴

Under the direction of the CTC, the estimated funds are apportioned to the counties and to Caltrans using state-wide priorities and formulas established in state law.

Local transportation priorities for each county are set by an RTPA, with some RTPAs serving multi-county areas.⁵ The RTPAs and Caltrans propose projects based on their priorities, subject to state law, and their proposals are stored in CTIPS. To comply with state law, the proposals are divided into four “phases”: Environmental Studies and Permits; Right of Way; Plans, Specifications and Estimates; and Construction.⁶ The Right of Way and Construction phase are

³ The Fund Estimate requirement is in Government Code 14525, which was added by the *Alquist-Ingalls Act*, Chapter 1106 (AB 432), Statutes of 1977, which also created the CTC and several program components (see later discussion).

⁴ California Department of Transportation. *2020 State Transportation Improvement Fund Estimate* adopted by California Transportation Commission, August 14, 2019. (Sacramento, CA: Caltrans), 1 & 2.

⁵ RTPAs are defined in Government Code 29532, which was added by Chapter 1400 (SB 325), Statutes of 1971. Every county in California is served by an RTPA. One sometimes also hears the collective term “RTPAs and MPOs.” Metropolitan Planning Organizations (MPOs) are defined in Federal Law, 49 US Code 5303 (b) 2), which was added by Public Law 103-272 in 1994. Only some areas of California are served by MPOs.

⁶ The phases are cited in several places in California State Law, using slightly different terms. In CTIPS it appears that the various terms are assumed to be equivalent. In Government Code 14526.5 (c) (1), relating to the SHOPP, the phases are listed as (A) Project approval and environmental documents, support only. (B) Plans, specifications, and estimates, support only. (C) Rights-of-way. (D) Construction. In Government Code 14529 (b) relating to the STIP, they are (1) Completion of all permits and environmental studies. (2) Preparation of plans, specifications, and estimates. (3) The acquisition of rights-of-way, including, but not limited to, support activities. (4) Construction and construction management and engineering, including surveys and inspection. In Government Code 14556.13. (b) relating to the TCRP, they are (1) Studies, environmental review, and permits. (2) Preparation of project plans and specifications. (3) Right-of-way acquisition. (4) Construction or procurement. In Article XXII of the Constitution, relating to architectural and engineering services, they are permitting and environmental studies, design phase services, rights-of-way services, and construction phase services.

further subdivided into “Support” and “Capital/Local Assistance” elements.⁷ The CTC approves or disapproves proposed projects, by phase. These CTC actions are recorded in CTIPS.

The federal apportionments discussed above are large sums allocated to the states and, like state appropriations, are not normally made on a project-by-project basis.⁸ Once a project receives approval, it needs to be submitted to the responsible federal agency to obtain a project-specific “obligation” which recognizes the commitment of the U.S. government to provide a part of the apportionment to a specific project. The responsible federal agency is either the FHWA or FTA.

Once a project is approved by the CTC and the FHWA or FTA, project work may commence. A variety of agents perform the project work: Caltrans; private consultants and contractors hired by Caltrans; cities, counties, and transit districts; and private consultants and contractors hired by cities, counties, transit districts, and Regional Transportation Planning Agencies.⁹ Project work funded by state or federal funds may not commence until CTC, FHWA, and FTA approval is recorded in CTIPS.

U.S. law requires each state to submit a multi-year transportation program to the FHWA and the FTA, and then to have each project in that plan approved (or “obligated”) project-by-project by the FHWA or FTA. CTIPS is the source from which California draws its data for the multi-year federal program and in which California records Federal obligations.

CTIPS thus plays a pivotal role in the provision of public roads and transportation services to the people of California and, through California, to the western U.S.

⁷ The separation between support and capital/local assistance is needed to comply with California state budgeting rules. “State operations (support), local assistance, and capital outlay” are the three “characters of appropriation” (COA) in the California State Budget (*State Administrative Manual* (SAM), Section 6806, accessed on May 21, 2022 <https://www.dgs.ca.gov/Resources/SAM/TOC/6000/6806>). Each item in the California State Budget is identified first by a COA. The three COA’s are defined in Section 3.00 of the annual budget and expanded in SAM Section 6806.

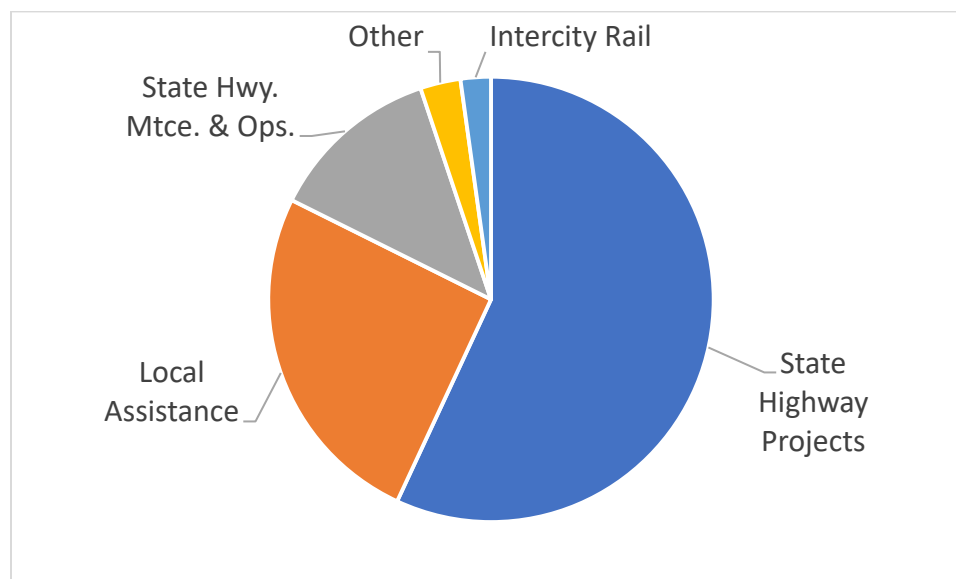
⁸ On occasion, however, state and federal laws assign funds to specific projects, a practice that is sometimes referred to as “earmarking.”

⁹ Government Code 4529.11, which was added by Proposition 35 in November 2000, includes a provision that allows local agencies to take responsibility for hiring the consultants on some State Highway projects: “The sponsoring governmental entity shall have the choice and the authority to contract with qualified private entities for architectural and engineering services. For projects programmed and funded as regional improvements, the sponsoring governmental entity shall be the regional or local project sponsor. For projects programmed and funded as interregional improvements, the sponsoring governmental entity shall be the State of California, unless there is a regional or local project sponsor, in which case the sponsoring governmental entity shall be the regional or local project sponsor.” This provision overrode Government Code 14520.3 (b) and (c) which had been enacted by SB 45 of 1997 (see note below). These sections read, and continue to read: “(b) The department is responsible for the planning, design, construction, maintenance, and operation of the state highway system and Senate Bill 45 is not intended to alter that responsibility. (c) In addition to other responsibilities established by law, the department is the responsible agency for performing all state highway project components specified in subdivision (b) of Section 14529 of the Government Code except for construction.”

2.2 Caltrans Program Components

As noted in the discussion of Figure 1, state and federal funds are budgeted by the Legislature. The Caltrans budget consists of many line items. For instance, for Fiscal Year 2021–2022, Caltrans has 160 line items in the budget.¹⁰ Figure 2 summarizes them in five broad categories.

Figure 2. Broad Categorization of the Caltrans Budget for Fiscal Year 2021–2022



The five broad categories are:

1. State Highway projects, which account for most of the Caltrans budget;¹¹
2. Local Assistance, the second-largest category. This refers to funds that pass through the Caltrans accounting system to local government agencies;¹²
3. State Highway maintenance and operations, the third largest category;¹³
4. Interregional Passenger Rail, the smallest of the five categories;¹⁴ and
5. “Other” a catch-all for the remaining line items in the budget.

¹⁰ State of California. *Budget Act of 2021*, Chapter 21 (AB 128), Statutes of 2021, June 28, 2021. (Sacramento, CA: Secretary of State), Items 2660-001-0001 to 2660-399-0890, 157-202.

¹¹ State Highway Projects refers to the sum of Capital Outlay, Capital Outlay Support, and Major Maintenance and comprises portions of 45 line items in the *Budget Act of 2021*.

¹² Local Assistance comprises 33 line items in the *Budget Act of 2021*, numbered 2660-101-0042 through 2660-130-0001.

¹³ State Highway Maintenance and Operations comprises portions of 13 line items in the *Budget Act of 2021*.

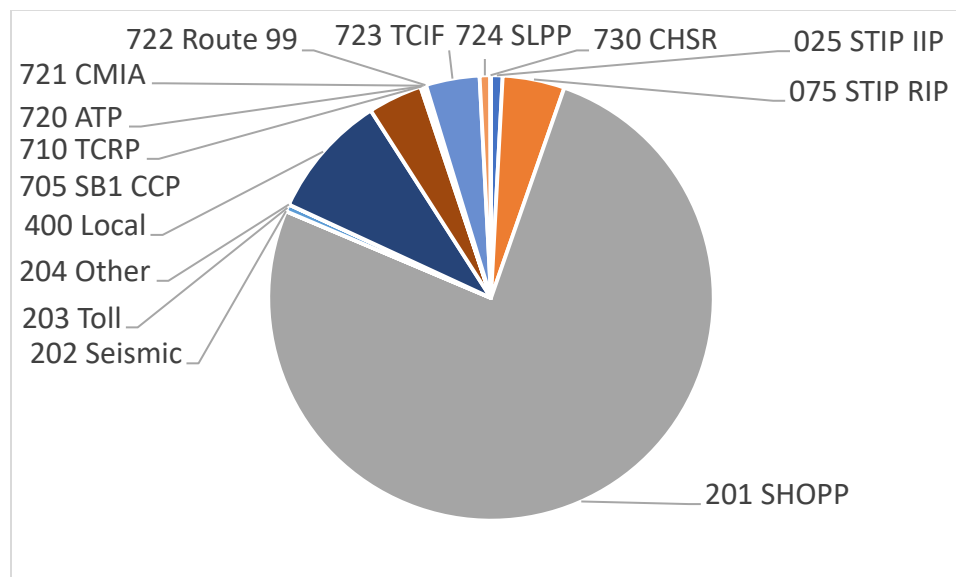
¹⁴ Intercity Passenger Rail comprises portions of 16 line items in the *Budget Act of 2021*.

As noted, State Highway projects account for more than half of the Caltrans budget. In addition, Local Assistance and Interregional Passenger Rail consist in large part of projects. Therefore, projects together make up a preponderance of the Caltrans budget.¹⁵ Most of the funds for those projects are approved, by project and project phase, by the CTC and recorded in CTIPS.

To further illustrate the role and purpose of CTIPS, Figures 3 and 4 provide a more detailed look at the “State Highway projects” portion of Figure 2. Figure 3 shows the distribution by program component of all State Highway project expenditures recorded in the Caltrans accounting system from July 1, 2020 to June 30, 2021. Figure 4 shows the same distribution, but for expenditures 30 years earlier, from July 1, 1990 to June 30, 1991.

The 2020–2021 year is chosen because it is the most recent completed year, while 1990–1991 is chosen as a contrast because it is both separated by a round number and also illustrates the changes in program components over the years.

Figure 3. Program Components of Caltrans State Highway Expenditures in 2020–2021



¹⁵ “Projects” are understood here as the sum of the four phases listed in Government Codes 14526.5 (c) (1); 14529 (b); and 14556.13. (b), quoted above.

Figure 4. Program Components of Caltrans State Highway Expenditures in 1990–1991

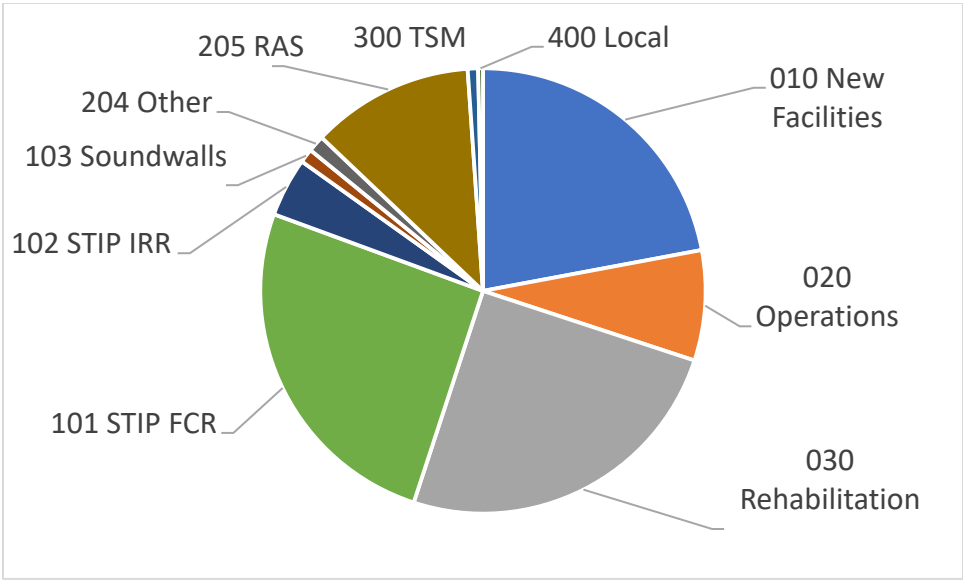


Table 1 provides the data for Figures 3 and 4 in tabular form, along with a fuller name for each program component, the year in which the component was introduced, and the percentage of the annual expenditures accounted for by each program component. Percentages are rounded to the nearest whole number except in cases where a program component accounted for less than 0.5%. In those cases, decimals are added to ensure that at least one significant digit appears.

Table 1. Program Components of Caltrans State Highway Expenditures in 1990–1991 and 2020–2021

Program Component	Short title	Introduction	1990–1991	2020–2021
010 HE New Facilities	010 New Facilities	1977 ¹⁶	22%	-
020 HB Operational Improvements	020 Operations	1977	8%	-
025 STIP Interregional Improvement	025 STIP IIP	1997 ¹⁷	-	1%
030 HA Rehabilitation	030 Rehabilitation	1977	25%	
075 STIP Regional Improvement	075 STIP RIP	1997	-	5%
101 STIP Flexible Congestion Relief	101 STIP FCR	1990 ¹⁸	26%	-
102 STIP Interregional Improvement	102 STIP IRR	1990	4%	-
103 Soundwalls	103 Soundwalls	1990	1%	-
201 State Hwy. Op.& Protect. Prog. ¹⁹	201 SHOPP	1997	-	76%

¹⁶ Program components 010 (HE), 020 (HB), and 030 (HA) were established in response to Streets and Highways Code 167, which was enacted by the *Alquist-Ingalls Act*, Chapter 1106, (AB 432), Statutes of 1977. Although Streets and Highways Code 167 was amended by SB 300 of 1989 (see note below), the HA, HB, and HE program components are still cited in some Caltrans documents, such as Chapter 4, “Programming,” of the *Project Development Procedures Manual*, accessed May 20, 2022, <https://dot.ca.gov/-/media/dot-media/programs/design/documents/pdpm-chapter4-a11y.pdf>.

¹⁷ Program components 025 (the Interregional Transportation Improvement Program, IIP), and 075 (the Regional Transportation Improvement Program, RIP), together make up the State Transportation Improvement Program, which is governed by Government Code sections 14526, 14527, 14529, and 14530. The IIP and RIP were established by Chapter 622 (SB 45), Statutes of 1997. They replaced the FCR, IRR, Soundwall program, and Other Highway Construction programs that had been established by the *1989 Blueprint* (see next note).

¹⁸ Program components 101 (the Flexible Congestion Relief, FCR), 102 (Interregional Improvement, IRR), 103 (Soundwalls), 204 (Other Highway Construction), 205 (Rehabilitation and Safety, RAS), and 300 (Traffic System Management, TSM) were established as a result of the *Kopp-Katz-Baker Transportation Blueprint for the Twenty-First Century (1989 Blueprint)* that was created by SCA1, which the voters approved as Proposition 111 in June 1990; and several Statutes of 1989: Chapter 105 (SB 300); Chapter 106 (AB 471); Chapter 107 (AB 680); Chapter 108 (AB 973); and Chapter 109 (AB 2218).

¹⁹ Program components 204 (Other Highway Construction) and 205 (Rehabilitation and Safety, RAS) constituted the “highway systems operation and protection plan” (HSOPP) established by SB 300 of 1989, part of the *1989 Blueprint*. This was renamed the State Highway Operation and Protection Program (SHOPP) in Chapter 1177 (SB 1435), Statutes of 1992. SB 45 of 1997 eliminated the 204 and 205 components. The SHOPP is governed by Government Code 14526.4 and 14536.5.

Program Component	Short title	Introduction	1990– 1991	2020– 2021
202 Phase 2 & Toll Bridge Seismic ²⁰	202 Seismic	1998	-	0.005%
203 Toll Bridges ²¹	203 Toll	1998	-	1%
204 Other Highway Construction	204 Other	1990	1%	0.0005%
205 Rehabilitation and Safety	205 RAS	1990	12%	-
300 Traffic System Management	300 TSM	1990	1%	-
400 Locally Funded Projects ²²	400 Local	1990	0.3%	9%
705 SB1 Congested Corridors ²³	705 SB1 CCP	2017		4%
710 Traffic Congestion Relief ²⁴	710 TCRP	2000	-	0.1%
720 Active Transportation ²⁵	720 ATP	2016		0.1%
721 Corridor Mobility Improvement	721 CMIA	2006 ²⁶	-	0.2%
722 Proposition 1B Route 99	722 Route 99	2006	-	0.1%
723 Trade Corridor Improvement	723 TCIF	2006	-	4%

²⁰ Program component 202 (Phase 2 and Toll Bridge Seismic), officially “The Seismic Retrofit Bond Fund of 1996” resulted from a \$2 billion bond measure passed by the voters as Proposition 192 of 1996. It was placed on the ballot by Chapter 310 (SB 146) Statutes of 1995.

²¹ Program component 203 (Toll Bridges) was established in response Chapter 328 (SB 226), Statutes of 1997, which created the Bay Area Toll Authority to manage the state-owned toll bridges of the San Francisco Bay Area.

²² Program component 400 (Locally Funded Projects) was an indirect result of the *1989 Blueprint*, even though the large-scale investment of local funds in state highways originated from Chapter 446 (SB 2117) Statutes of 1984, which permitted voters of Santa Clara County to pass a local sales tax for transportation, Measure A. Prior to 1990, Locally Funded State Highway programs were assigned to HA, HB, or HE program components (mainly HE).

²³ Program component 705 (The Solutions for Congested Corridors Program) was established in response to provisions in Chapter 5 (SB 1), Statutes of 2017. It is governed by Streets and Highways Code 2390 and following.

²⁴ Program component 705 (Traffic Congestion Relief) was established in response to provisions in Chapter 91 (AB 2928) Statutes of 2000. It is governed by Government Code 14556 and following.

²⁵ Program component 720 (Active Transportation) was established in response to Chapter 359 (SB 99) Statutes of 2013. It is governed by Streets and Highways Code 2380 and following.

²⁶ Program components 721 (Corridor Mobility Improvement), 722 (Proposition 1B Route 99), 723 (Trade Corridor Improvement), and 724 (State Local Partnership), resulted from a \$19.9 billion bond measure passed by voters as Proposition 1B of 2006. It was placed on the ballot by Chapter 25 (SB 1266) Statutes of 2006.

Program Component	Short title	Introduction	1990– 1991	2020– 2021
724 State Local Partnership	724 SLPP	2006	-	1%
730 Calif. High Speed Rail ²⁷	730 CHSR	2009	-	0.1%

Although some of the percentages in Table 1 are quite small, this is not an indication that the specific program components always contributed small amounts to the overall state highway project expenditures. Programs such as 202, Phase 2 and Toll Bridge Seismic and 204, Toll Bridges, each accounted for large percentages of the total expenditures at their peak.

Key principles illustrated by Figures 3, 4, and Table 1 are:

1. There are many program components.
2. Program components change. Components are added by the Legislature, and they cease after the Legislature deletes their enabling legislation. However, each component persists in the accounting system for several years after the legislation is deleted because contracts that were awarded with funding from former components often take years to complete.²⁸
3. Each program component results from actions taken by the Legislature. (The endnotes provide the supporting documentation for each of the program components in Figures 3, 4, and Table 1.)
4. Each program component has its own goals and rules, established by the Legislature, often with additional details added by the CTC.

The key impact for CTIPS is that the design of the system must be sufficiently flexible to accommodate new components as they are added, and to permit Caltrans and the CTC to comply with the rules that the Legislature establishes in the future. The differences between 1990–1991 and 2020–2021 illustrate that every component will eventually be removed from the California statutes and cease to exist, and that the Legislature will add new components.

²⁷ Program component 730 (California High Speed Rail), resulted from a \$9.95 billion bond measure passed by the voters as Proposition 1A of 2008. It was placed on the ballot by Chapter 267 (AB 3034) Statutes of 2008.

²⁸ Once funds are encumbered for a contract, they remain available for expenditure for several years, in accordance with Government Code 16304.

2.3 Best Practices: Portfolio Management

As noted in Section 2.2, most of the Caltrans budget is dedicated to projects, and each of these projects falls into a “program component” established by the Legislature. When establishing such components, the Legislature normally includes statements about the purpose of the component and the objectives that it is intended to achieve. In the broader community outside of the California State Government, the American National Standards Institute (ANSI) and the International Standards Organization (ISO), have adopted and defined the term “portfolio” to describe collections of projects similar to what Caltrans refers to as a “program component.” ANSI defines a “portfolio” as follows:

Portfolio. A collection of projects, programs, subsidiary portfolios, and operations managed as a group to achieve strategic objectives.²⁹

The international definition is essentially identical to the ANSI definition, although it consists of a primary definition followed by a secondary definition of one of the words within the primary definition.³⁰

Portfolio. collection of portfolio components grouped together to facilitate their management to meet strategic objectives.³¹

Portfolio component. project, programme, portfolio, or other related work.³²

Virtually every organization has strategic objectives and a portfolio of projects, whether or not it uses those terms. The portfolio consists of all the actions that the organization undertakes, or intends to undertake, to bring about changes that it hopes to make.

In addition to an overall project portfolio, organizations often have sub-portfolios. For instance, the totality of all Caltrans projects is a portfolio, each of the components listed in Table 1 is a sub-portfolio, and each Caltrans district has a portfolio and sub-portfolios of projects.

Some key features of a portfolio include:

- Each portfolio includes multiple projects.

²⁹ ANSI/PMI. *The Standard for Portfolio Management* – Fourth Edition. ANSI/PMI 08-003-2017. (New Town Square, PA: Project Management Institute, 2017).

³⁰ For full disclosure: co-author Dr. Nigel Blampied, representing the United States, was one of the three principal editors of the 2021 revision of the International Standard for Portfolio Management, along with the leaders of the French and Dutch delegations to the responsible international committee, ISO Technical Committee 258 for Project, programme and portfolio management.

³¹ International Organization for Standardization. *Project, programme and portfolio management—Vocabulary*. ISO/TR 21506:2018. (Geneva: ISO, 2018), 3.42.

³² International Organization for Standardization. *Project, programme and portfolio management—Vocabulary*. ISO/TR 21506:2018. (Geneva: ISO, 2018), 3.43.

- The projects are selected with the intent that they will help the organization to achieve its strategic objectives.
- While individual projects have planned start and end dates, the organization's portfolio has no planned ending. For as long as the organization exists, it will have strategic objectives and, therefore, will have a portfolio of projects. As projects are completed, new projects will be added to the portfolio.
- The addition of new projects generally occurs at regular intervals.

The ANSI and ISO term, “portfolio,” is well known in Caltrans. For instance, the following examples appear on the Caltrans website:

- The Caltrans Division of Project Management “is responsible for the management and delivery of the California Department of Transportation's portfolio of transportation improvement projects”³³ and has a duty to “Monitor and report on the delivery status of the portfolio of projects.”³⁴
- The Division of Financial Programming “has primary responsibility for planning, developing, managing and reporting the four-year SHOPP portfolio of projects.”³⁵
- The Asset Management Office issued a performance report on “the 2016 SHOPP project portfolio.”³⁶
- Each Caltrans district has a portfolio of beautification projects.³⁷

Having established that Caltrans, just as virtually every other organization, has a project portfolio, one can search for best practices in project portfolio management and consider how they might apply to Caltrans. The ANSI Standard provides a framework for this consideration. It describes portfolio management as consisting of six “performance domains” interacting with a central “portfolio life cycle.”

The portfolio life cycle follows the process by which projects are identified, selected, planned, managed, developed, and completed. The life cycle often follows a fixed cadence, with projects added to the portfolio at specific intervals, often in groups that may be referred to as tranches.

³³ “Project Management” accessed May 19, 2022, <https://dot.ca.gov/programs/project-management>.

³⁴ “Major Projects” accessed May 19, 2022, <https://dot.ca.gov/programs/project-management/major-projects>.

³⁵ “State Highway Operation and Protection Program (SHOPP) and Minor Program” accessed May 19, 2022, <https://dot.ca.gov/programs/financial-programming/state-highway-operation-protection-program-shopp-minor-program-shopp>.

³⁶ “Asset Management Performance Report” accessed May 19, 2022, <https://dot.ca.gov/programs/asset-management/guidelines-phase-1-plan>.

³⁷ “Clean California Beautification Projects” accessed May 19, 2022, <https://cleancalifornia.dot.ca.gov/projects>.

The six performance domains are:

- **Portfolio governance.** Sets the rules and procedures for the portfolio, which control the life cycle and the other five domains.
- **Strategic management.** Identifies changes that the organization needs to make in its strategies to respond to emerging issues and trends.
- **Stakeholder engagement.** Works with stakeholders to achieve the goals of the portfolio. Stakeholders include executive leaders, managers, those who work on projects, and project customers.
- **Capacity and capability management.**
 - Capacity. Identifies the types and quantities of resources needed by the portfolio, when needed, and how to obtain them. Resources include people, funding, equipment, and intellectual property.
 - Capability. Validates that the needed resources are available and ensures that they are capable of performing the required functions.
- **Value management.** Identifies the value-adding outcomes expected from the projects, adjusts the project selection to obtain the desired outcomes, and increases the return on investment, as measured by the desired outcomes.
- **Risk management.** Considers and responds to risks that may hinder the organization's ability to achieve the expected value, and opportunities that may enhance value achievement.

The researchers discussed these domains with Caltrans personnel, both in the Division of Financial Programming and in other Caltrans divisions, and attempted to identify how work in each of the six domains is accomplished in Caltrans. Caltrans has managed its project portfolio since the founding of its first predecessor agency, the Bureau of Highways, in 1895,³⁸ and the Caltrans procedures for portfolio management have evolved over many decades. In fact, many Caltrans procedures in this regard were developed long before the Project Management Institute (PMI) and ANSI adopted the first American National Standard for project portfolio management in 2006³⁹ and before ISO adopted the first International Standard for project portfolio management in 2015.⁴⁰ These standards developed as part of a rapid increase in interest in the topic following

³⁸ R. Forsyth and J. Hagwood, *One Hundred Years of Progress: A Photographic Essay on the Development of the California Transportation System* (Sacramento, CA: California Transportation Foundation, 1996), 11.

³⁹ Project Management Institute. *The Standard for Portfolio Management*. ANSI/PMI 08-003-2006. (New Town Square, PA: PMI, 2006).

⁴⁰ International Organization for Standardization. *Project, programme and portfolio management—Guidance on portfolio management*. ISO 21504:2015. (Geneva: International Organization for Standardization, 2015).

its first mention in an ANSI standard in 2000, when the ANSI standard for project management first alluded to the fact that there was, within the world of project management, a concept called “project portfolio management.”⁴¹

The development of national and international guidance on project portfolio management provides Caltrans and similar organizations with the opportunity not only to consider their processes in the light of recognized best practices, but also to work on improving those processes. While improvement of the processes is beyond the scope of this report, this report can, and does, offer an initial mapping of the organizations responsible for the different performance domains in California’s transportation project portfolio. This initial mapping is summarized in Table 2, which can almost certainly be improved with further discussion and elaboration.

⁴¹ “Project portfolio management refers to the selection and support of projects or program investments. These investments in projects and programs are guided by the organization’s strategic plan and available resources.” A Guide to the Project Management Body of Knowledge, Second Edition, ANSI/PMI 99-001-2000. (New Town Square, PA: Project Management Institute, 2000), 10.

Table 2. Mapping of California Project Portfolio Responsibilities to the ANSI Performance Domains

	Life cycle Management	Governance	Strategic Management	Stakeholder Engagement	Capacity Management	Capability Management	Value Management	Risk Management
Legislature and Congress		✓	✓					
CTC	✓	✓	✓	✓				
Caltrans Asset Management	✓		✓				✓	✓
Caltrans Financial Programming	✓			✓				
Caltrans Accounting and Local Assistance	✓							
RTPAs	✓						✓	✓
Caltrans Planning	✓						✓	✓
Local Sponsors	✓			✓	✓	✓		✓
Caltrans Districts	✓			✓		✓		✓
Caltrans Project Management	✓				✓	✓		
Caltrans Budgets	✓				✓			
Caltrans Environmental Analysis, Design, Right of Way, Construction, and Engineering Services	✓					✓		

	Life cycle Management	Governance	Strategic Management	Stakeholder Engagement	Capacity Management	Capability Management	Value Management	Risk Management
Caltrans Procurement and Contracts	✓					✓		
Caltrans Human Resources						✓		

As noted above, the **portfolio life cycle** is central to portfolio management. In California’s case, the biennial fund estimate drives the life cycle of the state transportation project portfolio. Every two years, the fund estimate leads to:

- an apportionment of funds to each program component, in some cases further sub-apportioned to RTPAs and Caltrans Districts;
- the identification and selection of projects;
- approval of projects and project phases by the CTC;
- the commencement of project work;
- the performance of that work; and
- the ultimate completion of projects.

Each biennial fund estimate therefore normally leads to the approval and development of a tranche of new projects or project phases.⁴² Individual projects normally take longer than two years to complete and therefore run through several cycles of the portfolio life cycle.

Apart from Congress and the Legislature, all but one of the organizations listed in Table 2 play roles in the project portfolio life cycle. The one exception is Caltrans Human Resources, which plays an essential role in the acquisition of resources to deliver the projects in the portfolio, but does not itself perform activities on individual projects. Of the remaining listed organizations,

⁴² This is “normally,” but not always, true. In periods of economic downturn, the projected income is sometimes sufficient only to continue the funding of existing projects, perhaps delayed, with no funds being available to add new projects.

some are involved in projects from the initial identification all the way through to completion, while others are involved in only some phases of projects.

Briefly, the roles of the organizations listed in Table 2 in the six performance domains are:

- **Portfolio governance and Strategic management.** As noted in the first row of Table 2, Congress and the Legislature establish the goals and rules governing each program component and enact them as laws, as discussed in Section 2.1. The CTC then adopts resolutions which provide detailed directions for carrying out the laws. Two distinctions differentiate the roles of Congress and the Legislature on one hand from the CTC's role on the other. First, CTC resolutions provide more detail than the laws and, second, the CTC deals with individual projects, and project phases. In contrast, Congress and the Legislature provide broader guidance and do not normally address individual projects.

Caltrans normally advises the CTC, and may draft CTC resolutions, but its responsibility is primarily to carry out the strategic direction provided by Congress, the Legislature, and the CTC. Caltrans plays a role in strategic management, especially in reporting and analysis, but it requires approval from the CTC, the Legislature, or Congress if it wishes to change the goals or funding of any program component.

- **Stakeholder engagement.** The CTC and the Division of Financial Programming have the primary responsibility for stakeholder engagement at the portfolio level, i.e., they are responsible for ensuring that the various stakeholders understand their roles in the portfolio life cycle. At the project level, stakeholder engagement is the responsibility of the project manager, who is employed either by a Local Sponsor or by a Caltrans District.

All the other organizations in Table 2 are stakeholders, but do not carry the primary responsibility for ensuring that stakeholders are engaged.

- **Capacity and capability management.**
 - Capacity. Some state-funded projects in California are developed by Local Sponsors, which are then responsible for identifying the resources needed for those projects.⁴³ Resources include:
 - staffing for Environmental Studies and Permits; Right of Way Operations; Plans, Specifications and Estimates; and Construction Engineering; and
 - funding for Right of Way Capital and Construction Capital.

Caltrans develops the remaining projects, and for them the Division of Project Management identifies the staffing needs. The Division of Budgets works with the

⁴³ See the note 9 about Proposition 35 of 2000.

Department of Finance and the Legislature to obtain funding for the staffing,⁴⁴ capital, and local assistance needs.

- **Capability.** The responsible Local Sponsors or Caltrans also ensure that the staff assigned to projects are capable of performing the work. They do this through hiring, training, coaching, and supervision. Hiring includes the procurement of consultants or contractors to perform work. Local Sponsors, Caltrans Districts, the Division of Engineering Services, and the Division of Procurement and Contracts have the primary duty of performing this capability management work. Caltrans Headquarters Divisions establish standards and develop training materials. The Divisions of Project Management and Construction also work with industry associations to ensure that there are firms in the marketplace that have the needed capabilities.
- **Value management** in transportation agency portfolios has become a more formal process than it might have been before due to changes in U.S. law as a part of the MAP-21 legislation of 2012.⁴⁵ This requires each state to develop a transportation asset management plan (TAMP) which includes performance measures and performance targets to address this requirement. Caltrans has established an Office of Asset Management which has the responsibility for leading and coordinating the agency's TAMP and performance measurement effort.

The Office of Asset Management mainly uses the State Highway Operation and Protection Program (SHOPP, program component 201) to accomplish the performance targets. In addition to the Office of Asset Management, RTPAs share a responsibility for value management through the selection of projects for the Regional Improvement Program (RIP, program component 075), as does the Caltrans Division of Transportation Planning through the selection of projects for the Interregional Improvement Program (IIP, program component 025).

- **Risk management** at the portfolio level is closely associated with value management. Portfolio risk management consider both risks that may hinder the organization's ability to achieve the expected value, and opportunities that may enhance value achievement. These considerations are usually discussed in the TAMP.

At the project level, there are normally some risks that are unique to each project, and others that are part of the portfolio-level risks. Project risk management is the responsibility

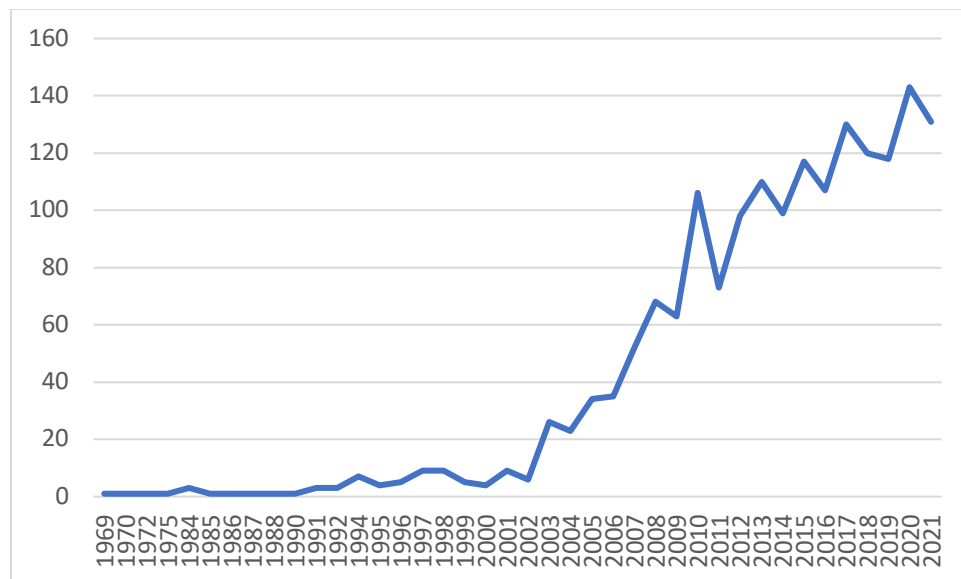
⁴⁴ "Staffing" is used here as a substitute for the California State Budgeting term "Support." See the note 7 about the three "characters of appropriation" (COA) in the California State Budget. Support consists almost entirely of state employee salaries and costs that relate to them, such as building rental and maintenance, utilities, and supplies. The term "staffing" is used here because it is commonly understood, whereas "support" has a meaning that is unique to California State Budgeting and is not widely understood outside California State Government.

⁴⁵ United States Congress, Public Law 112-141, *Moving Ahead for Progress in the 21st Century Act* (MAP-21), enacted on July 6, 2012.

of the project manager, who is employed either by a Local Sponsor or by a Caltrans District.

A major goal of American National (ANSI) and International (ISO) Standards is to establish a common lexicon so that people throughout the U.S. and worldwide will have the same understanding when they use words in a particular context. The development of the ANSI and ISO standards for project portfolio management has led to an explosion of research and writing on this topic, as illustrated in Figure 5. This chart shows the annual output of papers referenced in the Scopus database of academic research that use the exact phrase “project portfolio.”

Figure 5. Annual Count of Papers in Scopus that Refer to “Project Portfolio”



As previously noted, Caltrans uses some of the standard terminology regarding project portfolios. The common usage of these terms opens the possibility for Caltrans to apply, and benefit from, the growing body of research in project portfolio management. This study has begun documenting the relationship between Caltrans practices and organizational units and practices worldwide. Future research could expand upon this work and potentially help Caltrans improve its processes by identifying and applying lessons that have been learned by other organizations.

3. Synthesis of Programming Systems in the United States

3.1 Overview of Programming Systems

3.1.1 Background

Federal law in the U.S. requires each state, the District of Columbia, and Puerto Rico to both prepare a statewide transportation improvement program (STIP) covering a period of at least four years and to update it at intervals of no more than four years.⁴⁶ There are thus 52 such STIPs, which “shall provide for the development and integrated management and operation of transportation systems that will function as an intermodal transportation system for the State and an integral part of an intermodal transportation system for the United States.”⁴⁷

In standard project management terms, as used by the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO), the STIP is a portfolio of projects.⁴⁸ ANSI defines a portfolio of projects as “A collection of projects, programs, subsidiary portfolios, and operations managed as a group to achieve strategic objectives.”⁴⁹

Every organization that works systematically to achieve strategic objectives must, by the ANSI definition, have a portfolio of projects, whether or not it uses the term “portfolio.” A factor that sets the STIPs apart from organizations in general is that the STIPs offer 52 versions of a relatively standard portfolio developed by large government agencies. This permits comparative studies between the 52 STIPs, enabling agencies to learn from each other and revealing lessons that can potentially be applied more widely by other organizations with portfolios of projects.

As part of the evaluation of the processes and tools that Caltrans uses in its STIP preparation, the researchers were tasked with gathering data on the tools used by other agencies that develop STIPs. To this end, the researchers developed an online questionnaire and contacted states in the last week of May 2021, asking them to complete it. By the end of December 2021, all 50 states and the District of Columbia had completed the questionnaire. The questionnaire is provided in Appendix A.

This report provides the results from the questionnaire. The researchers found considerable interest among the respondents from the states, and several states indicated that they had been considering doing a similar study. Based upon this interest, the researchers hope that this report

⁴⁶ United States Congress, 49 U.S.C. 5304(g), enacted by *Public Law 103-272*, Statutes 745, on July 5, 1994.

⁴⁷ United States Congress, 49 U.S.C. 5304(a)(2).

⁴⁸ International Organization for Standardization, *Project, Programme and Portfolio Management – Guidance on Portfolio Management*. ISO 21504:2022. (Geneva: ISO, 2022).

⁴⁹ Project Management Institute, *The Standard for Portfolio Management*, Fourth Edition. ANSI/PMI 08-003-2017. (New Town Square: PMI, 2017), 3.

will be beneficial to many of the 52 Departments of Transportation (DOTs) as well as to other organizations that manage project portfolios.

3.1.2 Prior studies

A search of the Transportation Research Board's (TRB's) Transportation Research International Documentation (TRID) database found a handful of similar studies. In 2016, the FHWA conducted a review of all 52 STIPs and not only identified three models for STIP development—connective, collaborative, and graduated—but also suggested a possible model for STIP evolution.⁵⁰ The Minnesota DOT published a review of STIP and TIP amendment procedures in 2013.⁵¹ In 1997, the TRB published a synthesis of capital programming and project selection,⁵² and in 1978, the TRB published a synthesis of priority programming and project selection.⁵³ The present study adds to this accumulated body of work by considering the systems used in STIP programming and the functions of those systems.

In addition to the above studies relating to programming, there have also been studies of project management in DOTs across the U.S. The management of individual projects is a subset of the work performed to manage a portfolio, although it could be argued that project management is more likely to be studied than programming because project management has the goal of efficiency in project delivery whereas programming has to do with the assignment of funds.

The most recent project management study appears to be Tommelein and Blampied's work in 2018, commissioned by the California State Legislature.⁵⁴ In 2017, the Utah DOT commissioned a study of project management practices in U.S. state DOTs.⁵⁵ The Montana DOT conducted a study of state construction program tracking, monitoring and software in 2013,⁵⁶ the AASHTO Task Force on Pre-Construction Engineering Management conducted a survey of state project management practices in 2003,⁵⁷ and the Arizona DOT commissioned a study of best practices in project management in 2003.⁵⁸ Table 3 summarizes the prior studies.

⁵⁰ K. McCoy, A. Ingles, and W. Lyons, *STIP State of the Practice Review: Development and Use of Statewide Transportation Improvement Programs*. (Washington: Federal Highway Administration, 2016).

⁵¹ Minnesota Department of Transportation, *STIP and TIP Amendment Procedures: A Review of State and MPO Practices*. (St. Paul: MNDOT, 2013).

⁵² L. A. Neumann, NCHRP Synthesis 243: *Methods for Capital Programming and Project Selection*. (Washington: Transportation Research Board, 1997).

⁵³ Transportation Research Board, NCHRP Synthesis 48: *Priority Programming and Project Selection*. (Washington: TRB, 1997).

⁵⁴ I. D. Tommelein, and N. Blampied, *Review of the Project Resourcing and Schedule Management (PRSM) System used by Caltrans*. (Berkeley: University of California Institute of Transportation Studies, 2018).

⁵⁵ C. F. Cline, *Transportation Engineering Project Management: Survey of Practice Prepared for the Utah Department of Transportation Research Division*. (Madison: CTC & Associates, LLC, 2017).

⁵⁶ Montana Department of Transportation, *Survey of Capital PPM in DOTs*. (Helena: MTDOT, 2013).

⁵⁷ American Association of State Highway and Transportation Officials, *State of the Practice in Preconstruction Engineering Management*. Unpublished survey. (Washington: AASHTO, 2003).

⁵⁸ Dye Management Group, *Best Practices in Project Management*, Final Report 511. (Phoenix: Arizona Department of Transportation, 2003).

Table 3. List of Related Studies

Year	Sponsor	Topic
2022	Caltrans	STIP programming systems (This report)
2018	California Legislature	Project management systems ⁵⁹
2017	Utah DOT	Project management practices ⁶⁰
2016	FHWA	STIP development models ⁶¹
2013	Minnesota DOT	STIP amendment procedures ⁶²
2013	Montana DOT	Construction program systems ⁶³
2003	AASHTO	Project management practices ⁶⁴
2003	Arizona DOT	Best practices in project management ⁶⁵
1997	TRB	STIP project selection ⁶⁶
1978	TRB	STIP project selection ⁶⁷

3.1.3 Confidentiality

The researchers consulted with the SJSU Human Subjects Institutional Review Board (IRB) and obtained an IRB exemption for the research. This was granted under Section 46.104(d)(2ii) of Title 45 of the Code of Federal Regulations, which reads "Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil

⁵⁹ Tommelein and Blampied, *Review of the Project Resourcing and Schedule Management (PRSM) System used by Caltrans*.

⁶⁰ Cline, *Transportation Engineering Project Management*.

⁶¹ McCoy et al., *STIP State of the Practice Review: Development and Use of Statewide Transportation Improvement Programs*.

⁶² Minnesota Department of Transportation, *STIP and TIP Amendment Procedures*.

⁶³ Montana Department of Transportation, *Survey of Capital PPM in DOTs*.

⁶⁴ American Association of State Highway and Transportation Officials, *State of the Practice in Preconstruction Engineering Management*.

⁶⁵ Dye Management Group, *Best Practices in Project Management*.

⁶⁶ Neumann, *NCHRP Synthesis 243*.

⁶⁷ Transportation Research Board, *NCHRP Synthesis 48*.

liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation."

Notwithstanding the exemption, and in an abundance of caution, the researchers decided to present the report in such a manner as to avoid identifying the specific responses provided by any one DOT. Readers who are familiar with a given DOT might guess at the answers provided, but this report neither confirms nor refutes those guesses.

In any given DOT there are only a handful of people, sometimes only one or two, who have the knowledge needed to respond to the questionnaire. The identity of a given DOT's respondent cannot, therefore, be protected. What is protected is the knowledge of how they responded. This protection was provided both to encourage honest answers and to protect the respondents in case their managers might object to any response.

Please note that Section 3.3.1 adds a consideration of a special case of confidentiality, with regard to commercial systems, which is discussed in that section.

3.2 Research Method for Programming Systems

The researchers developed a questionnaire and published it online. This questionnaire built upon the researchers' understanding of the STIPs, experience in developing and managing databases, and feedback and advice from the Caltrans sponsors, who also tested the questionnaire and were the first respondents. In the hope of achieving a high level of participation, the questionnaire was kept short, used multiple choice questions where possible, and had no mandatory questions.

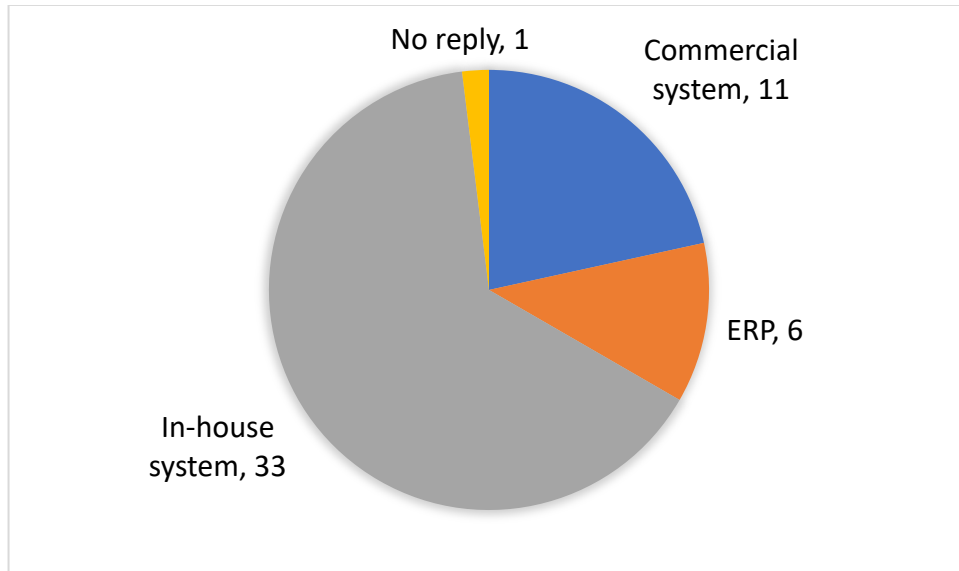
The researchers then searched the websites of each of the remaining 51 agencies that develop STIPs to identify who in each agency would be best qualified to respond to the questionnaire. The researchers went through several rounds of attempting to contact respondents in each of the 51 agencies. The first round of contacts was through email or the agency's online contact forms. The second round, a week later, was principally by telephone. Reminder emails and telephone calls drew further responses, and the process was aided by an email from the Caltrans Division Chief for Transportation Planning to the members of the AASHTO Committee on Planning.

3.3 Results and Discussions of Programming Systems

3.3.1 Is there a dominant commercially available system?

Fifty DOTs answered a question about whether they use a commercial or in-house system to manage their STIP. Among these respondents, thirty-three used in-house systems, eleven used commercial systems, and six used a modified enterprise resource planning (ERP) system, as illustrated in Figure 6. One DOT did not answer this question. There was no dominant player among the commercial systems, although one firm's product is used by six DOTs. No other single product is used by more than two of the responding DOTs.

Figure 6. Use of In-House Versus Commercial Systems for Managing the STIP



The identities of the commercial systems and ERPs is not provided in this report because the authors do not intend to endorse, or suggest any endorsement, of any product. The identities of the systems are known to the authors, however, and will be provided to DOTs upon request to help in their searches for new systems. Only the names and contact information for these systems will be provided. DOTs may elicit further information directly from the producers of the commercial systems, subject to the procurement rules of each DOT.

In 2018, Tommelein and Blampied conducted a similar study to this one, but for project management systems rather than STIP programming systems. They found that 22 of 31 responding DOTs used commercial off-the-shelf project management systems, six used in-house systems, and three used adapted versions of well-known ERP products.⁶⁸ Table 4 compares the 2018 and 2021 studies, albeit for different functions.

⁶⁸ Tommelein and Blampied, *Review of the Project Resourcing and Schedule Management (PRSM) System used by Caltrans*, 46-49.

Table 4. Comparison of Software Types Used for Project Management Versus STIP Programming

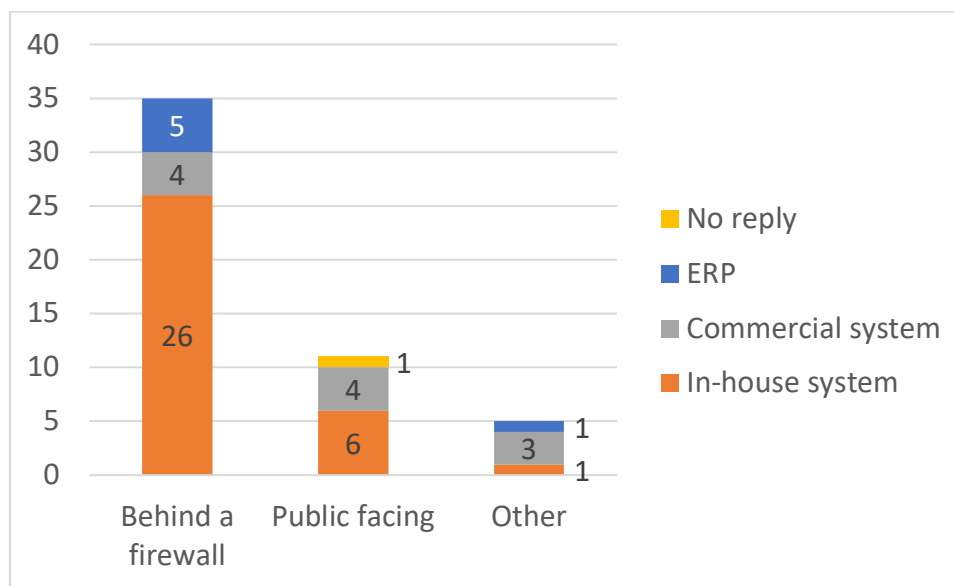
	2018 Project Management	2021 STIP Programming
Commercial system	22 (71%)	11 (22%)
Adapted ERP	3 (10%)	6 (12%)
In-house system	6 (19%)	33 (66%)

Table 4 indicates that commercial off-the-shelf products have penetrated the STIP programming sphere to a far lesser extent than they have penetrated DOTs' project management functions. There are, however, some purpose-built commercial systems for STIP programming on the market. Commercial systems used for project management also have portfolio management modules that could, conceivably, be adapted to STIP programming.

One explanation for this difference in penetration might be the fact that most STIP programming systems are located in the DOT's intranet, behind a firewall, and are not directly accessible to those outside the DOT. This is illustrated in Figure 7, where the commercial systems are almost as prevalent as in-house systems when only public-facing systems, on the internet, are considered. (In the one "no reply" instance, the DOT did not indicate what type of system it uses.)

The question that generated Figure 7 included an "other" option for DOTs whose systems did not fit the standard choices. A similar "other" option was provided for most questions. It was qualified with a statement that the researchers might follow-up to clarify. Such a follow-up has not been done because the "other" responses were few in number, and the researchers did not expect to find significant insights from pursuing greater clarity on these responses. Follow-ups on these questions could be pursued if they were of interest to DOTs, however.

Figure 7. Correlation between in-House versus Commercial Systems for Managing the STIP versus their Location (behind a firewall in the intranet, or public-facing on the internet).

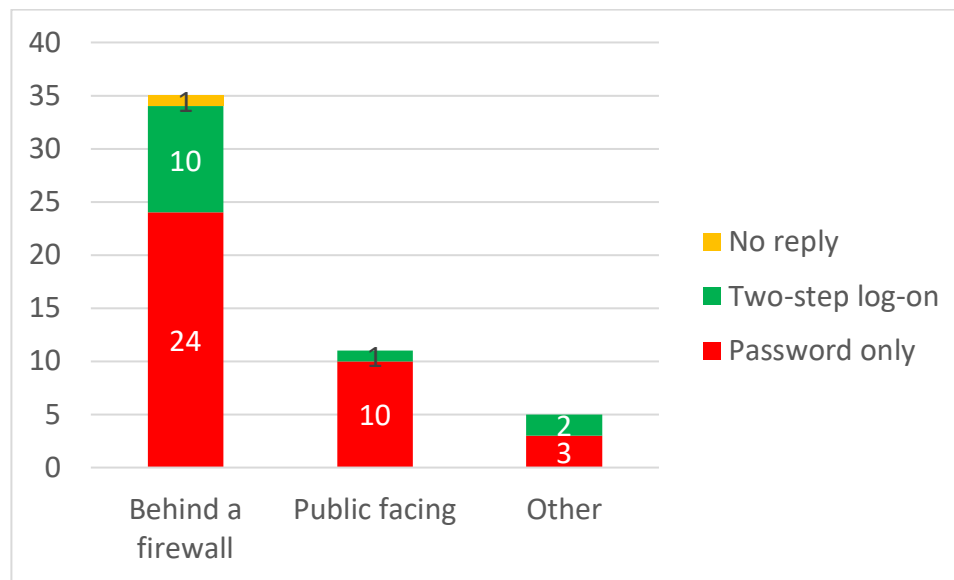


With 52 potential customers, it seems likely that one or more market leaders will emerge and that states will start migrating their STIP programming to those products. This appears to be the business plan of at least two purpose-built commercial systems. With growing concerns about cyber security, it is unlikely that state DOTs, especially those with public-facing systems, will be able to keep their systems current with the rapidly changing best practices in security without assistance from the private sector. Security practices are discussed in greater detail in the following section.

3.3.2 Security Practices

The questionnaire includes a question relating to the security of the current systems. An emerging best practice in security is to use two-step authentication. Agencies, and computer systems, have used passwords for several decades but it is now widely believed that a password alone is insufficient security, which has led to the introduction of a second step at log-on. Such second steps include having a code sent to an email address or cell phone, using a security token such as a USB stick, asking a challenge question, using a biometric identification such as an iris scan or fingerprint, and using a third-party authenticator. Figure 8 illustrates the fact that several states use two-step authentication to permit access to their intranets, but only one of the public-facing STIP solutions uses such two-step authentication. In the one "no reply" instance, the DOT did not indicate what type of security approach it uses.

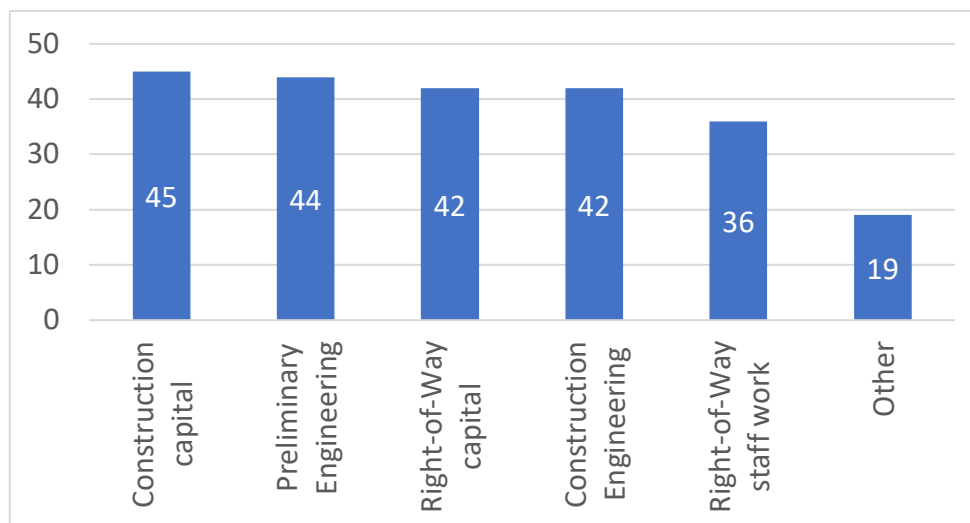
Figure 8. Correlation Between Security Practices for the STIP versus their Location (behind a firewall in the intranet, or public-facing on the internet).



3.3.3 Programmatic usage

The questionnaire asked which project phases each DOT's STIP system is used to manage. Most states responded that they manage all phases in their system, as shown in Figure 9. This is the core function of and purpose of the STIP system.

Figure 9. Project Phases Managed in the DOT's STIP Programming System

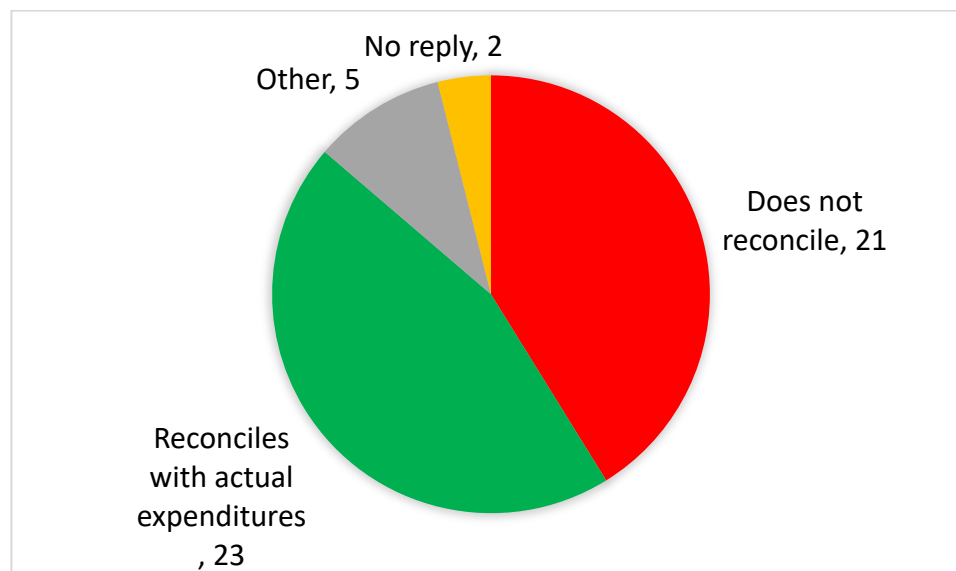


3.3.4 Financial Interfaces

Questions relating to financial interfaces formed a central core of the questionnaire.

The first financial interface question yielded mixed results. It asked whether the STIP system reconciles the authorized funding with actual expenditures to show the balance of funds remaining. This is a standard budgetary requirement—the DOT needs to determine what funds remain at the end of the project, enabling those funds to be de-obligated and potentially assigned to other projects. Management would also typically want progress reports of expenditures against budget. Figure 10 shows the responses to the question, “Does the system reconcile the authorized funding with actual expenditures to show the balance of funds remaining?”

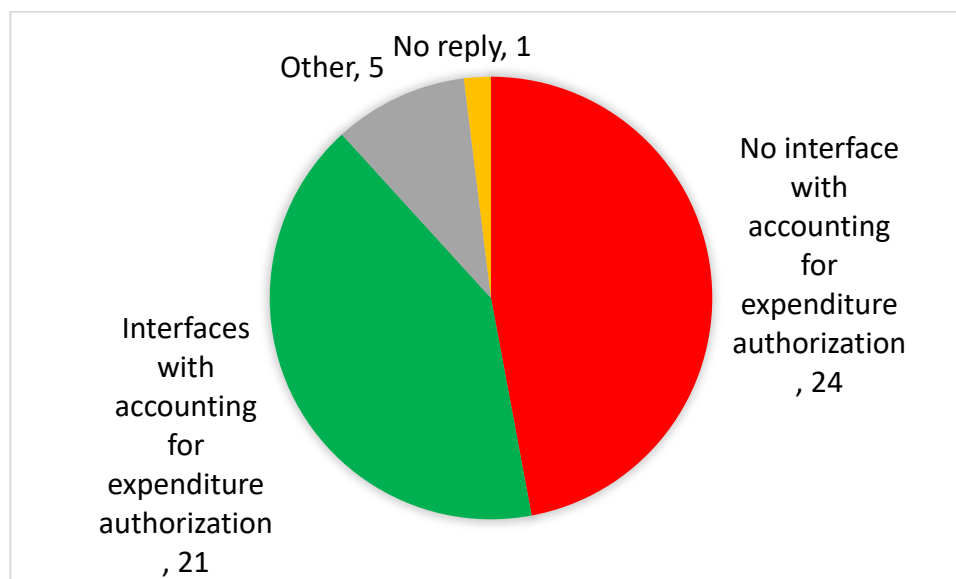
Figure 10. Responses to the Question “Does the System Reconcile the Authorized Funding with Actual Expenditures to Show the Balance of Funds Remaining?”



Twenty-one DOTs reported that their STIP systems do not do this reconciliation, and seven DOTs responded "other" or did not respond to this question. As of the writing of this article, those seven responses have not been followed-up on. As a financial reconciliation is ultimately essential, it must be performed somewhere, if not in the STIP system then in another system or through project-by-project calculations by hand. Those 28 responses may be a useful area of further research as these states may have interesting methods of reconciliation.

Figure 10 shows the responses to a question about reconciliation between authorized funding and actual expenditures, a process which has to take place after the expenditures are incurred. By contrast, another survey question related to the authorization of expenditures before they are incurred. This question asked whether the STIP system interfaces with the DOT’s accounting system for purposes of expenditure authorization. Figure 11 shows the responses to the question, “Does the system interface with the agency’s accounting system for purposes of expenditure authorization?”

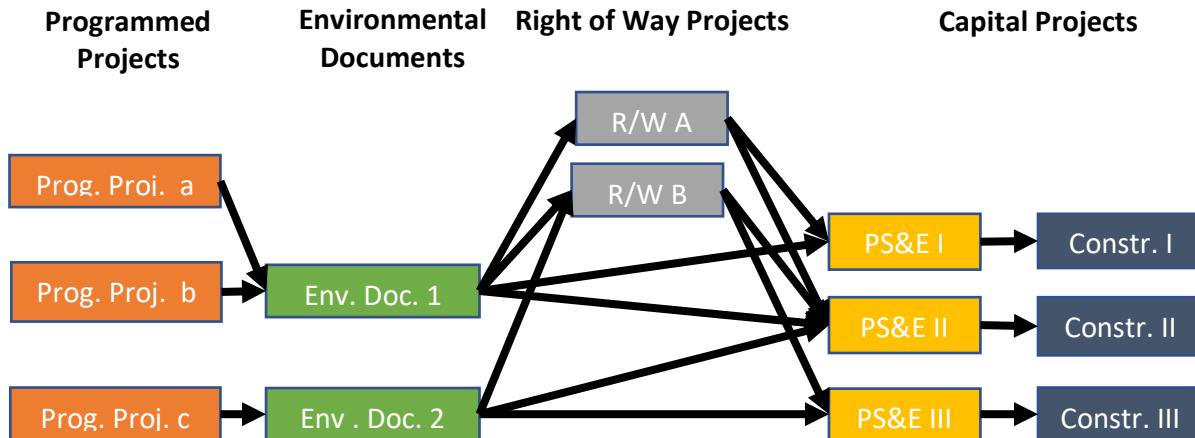
Figure 11. Responses to the Question “Does the System Interface with the Agency’s Accounting System for Purposes of Expenditure Authorization?”



Twenty-four DOTs reported that their STIP systems do not include this interface, and an additional six DOTs either responded "other" or did not respond to this question. Those six responses have not been followed-up on. It is a generally accepted principle that no expenditure should be incurred without prior authorization. If there is no interface between programming and accounting with digital rule enforcement, then there would likely need to be a manual process for authorizing expenditures, probably through a paper form and likely with several signatures. Methods of interface may be a useful area of further research.

The questions regarding accounting interfaces were followed by a broader question that relates to traceability of costs. This question asked “Does the system have a method for tracking situations where a single environmental document provides environmental clearance for multiple sets of plans, specifications, and estimates?” The problem that this question seeks to explore is illustrated in Figure 12, which shows five relationships with rules governing each relationship.

Figure 12. Illustration of a Problem in Tracking of Costs from Programming to Completion of Construction



1. *Programming to Environmental Documents (Env.Doc.).* Figure 12 begins with the requirement that each programmed project will require an Env.Doc. before it can proceed. FHWA regulations require each Envir.Doc. to encompass a segment that “shall connect logical termini and be of sufficient length to address environmental matters on a broad scope;” and “have independent utility or independent significance.”⁶⁹ The funding available for programmed projects in a single programming cycle will often be insufficient to fund the totality of work encompassed in an Envir.Doc., and funding would need to be spread over multiple programming cycles. There could, then, be multiple programmed projects for one Envir.Doc.
2. *Environmental Documents to Right of Way (R/W) projects.* An Env.Doc. must be completed before commencing work on R/W acquisition, except in cases of hardship acquisition. There are instances in which R/W parcels or utilities are needed for the work described in more than one Envir.Doc. This is illustrated by R/W project B in Figure 12, which serves both Env.Doc. 1 and Env.Doc. 2. In practice, this two-to-one relationship is likely to be ignored. That is, R/W project A will be considered to be the R/W project for Env.Doc. 1 and R/W project B will be considered to be the R/W project for Env.Doc. 2.
3. *Environmental Documents (Env.Docs.) to Plans, Specifications, and Estimate (PS&E) sets.* As with R/W projects, an Env.Doc. must be completed before commencing work on PS&E. Envir. Docs. have a many-to-many relationship to PS&Es:

⁶⁹ Federal Highway Administration, *NEPA Implementation: The Development of Logical Project Termini*. (Washington: FHWA, November 5, 1993). https://www.environment.fhwa.dot.gov/legislation/nepa/guidance_project_termini.aspx.

- a. As with programmed projects described above, several PS&Es may be required to complete all the work within the logical termini encompassed by an Envir.Doc.
 - b. In some cases, work that was initially envisaged as separate PS&Es, each with its own Envir.Doc. is combined into a single PS&E. For instance, a pavement rehabilitation project that has a Categorical Exclusion may be combined for construction with a widening that has a Finding of No Significant Impact.
4. *Right of Way (R/W) projects to PS&E sets.* Due to the relationships described above between Envir.Docs. and R/W projects, and between Envir.Docs. and PS&Es, R/W projects have a many-to-many relationship to PS&Es:
 - a. Utility relocations and properties acquired through more than one R/W project may end up being needed for a single PS&E.
 - b. Utility relocations and properties acquired through a single R/W project may end up being needed for more than one PS&E.
5. *PS&E sets to Construction contracts.* Provided that one is using the design-bid-build process that is most common in public works in the U.S. and most of the world, there is a one-to-one relationship between PS&Es and Construction contracts. A set of plans, specifications, and an estimate are assembled and advertised for construction, leading to a single construction contract. If multiple different sets of PS&E are assembled, they would each lead to a separate Construction contract.

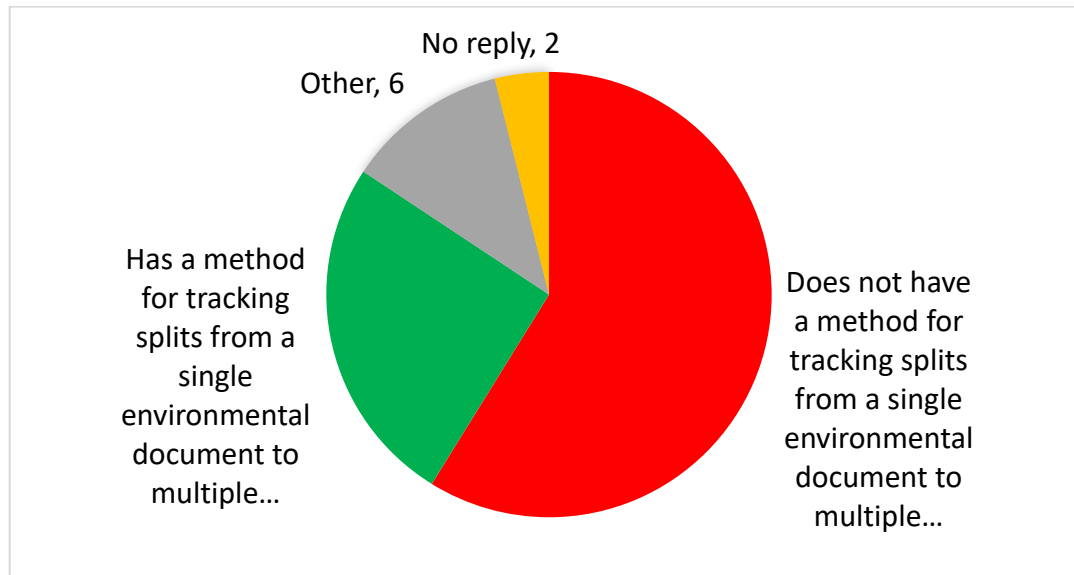
The authors believe that the exact situation illustrated in Figure 12 is unusual, however, and that most projects have a one-to-one relationship throughout, i.e., one programmed project has one Envir.Doc., one exclusive R/W project, and one exclusive combination of PS&E and Construction contract. Nevertheless, the situation illustrated in Figure 12 does sometimes occur. Indeed, in some cases, far more complex versions of Figure 12 apply. Also, the larger the proposed improvement, the more likely that such a complex situation will pertain. This is owing to the fact that it is difficult to obtain funding for very large improvements and that complex funding packages and stages will need to be arranged.

The relationships illustrated in Figure 12 are peculiar to public infrastructure projects that require environmental documents, acquire their real estate through eminent domain, and select construction contractors through a “lowest qualified bidder” process, also often referred to as “design-bid-build.” Nevertheless, comparable relationships are commonplace in the project portfolios of large organizations because organizations have plans for development that exceed their current funding capacity. They must therefore split their planned development into multiple projects. There are also instances when organizations find that they can achieve economies of scale by combining several projects into one.

Caltrans refers to the situation illustrated in Figure 12 as “splits and combines,” and it has struggled to manage these since the introduction of its Person Year Project Scheduling and Cost Analysis (PYPSCAN) software in 1980. Caltrans has commissioned several studies to address the problem of splits and combines, the most recent completed in 2021.⁷⁰ A similar study was undertaken by Taylor and Billings in 2001,⁷¹ and further inconclusive studies were conducted in later 2001 and in 2002.

To explore the scenario illustrated in Figure 12, respondents were asked “Does the system have a method for tracking situations where a single environmental document provides environmental clearance for multiple sets of plans, specifications, and estimates?” The responses are summarized in Figure 13.

Figure 13. Responses to the Question “Does the System Have a Method for Tracking Situations Where a Single Environmental Document Provides Environmental Clearance for Multiple Sets of Plans, Specifications, and Estimates?”



Only 13 DOTs indicated that their STIP programming system incorporated such a method. The remaining 38 indicated either that their systems did not include such a feature, that they had some other response, or did not reply to the question. In these 38 DOTs, reconciliation across the various many-to-many and other relationships must therefore be done in another system or by hand.

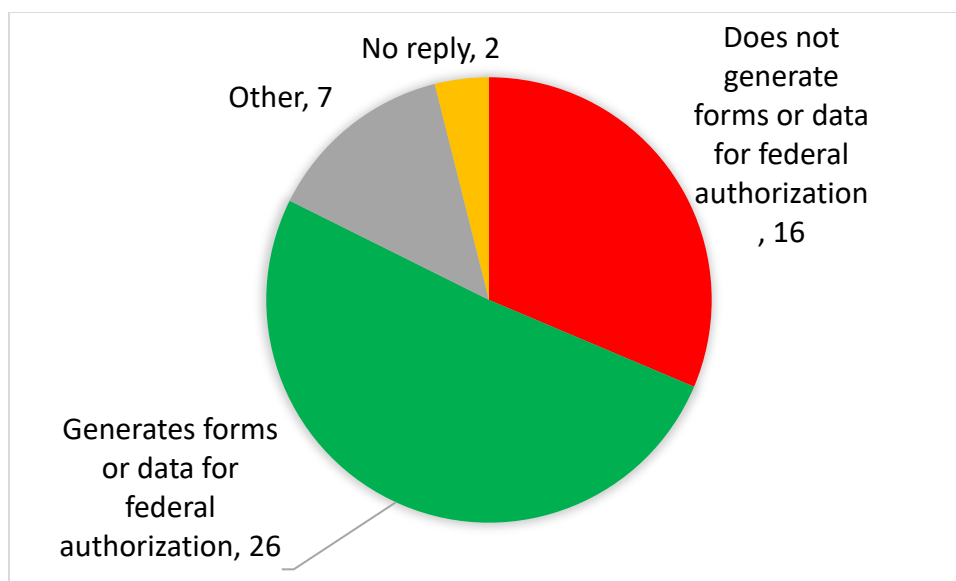
Methods of reconciliation is probably a useful area of further research. Pending that research, however, Section 4.3.16 of this report offers a widely accepted portfolio management solution.

⁷⁰ California Department of Transportation. *Project Delivery Quarterly Report Process*. Caltrans Lean 6-Sigma project. February 8, 2021. (Sacramento, CA: Caltrans).

⁷¹ R. Taylor and M. Billings. *RTC Universal Transportation Project Identifier (UTPI): Final Project Report*. June 28, 2001. (Sacramento CA: Renée Taylor Consulting).

The final financial interface question concerns federal authorization. It asks “Does the system generate data or forms for federal authorization?” Here, it was found that most STIP programming systems do generate such forms, as illustrated in Figure 14.

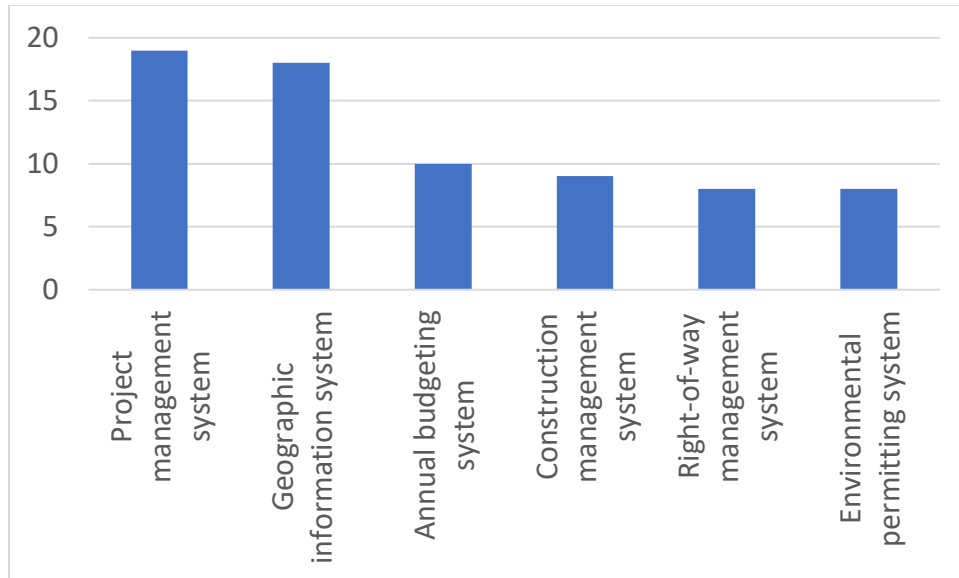
Figure 14. Responses to the Question “Does the System Generate Data or Forms for Federal Authorization?”



3.3.5 Other Interfaces

In addition to the accounting interfaces discussed in relation to Figures 10 and 11, the questionnaire asked about interfaces to non-financial systems. Thirty-nine DOTs answered this question, and their responses are summarized in Figure 15.

Figure 15. Systems with which the Dots' STIP Programming Systems Interface



- Project management system:* The most common non-accounting interface is to the DOT's project management system. Nineteen of the thirty-nine respondents indicated that they had such an interface. In their study in the opposite direction, Tommelein and Blampied found in 2018 that fourteen of twenty DOT project management systems interfaced with programming.⁷² An interface to programming was the most common interface for a DOT project management system. Referring to Figure 12, the project management system would typically be used to manage the work involved in Envir.Docs., R/W, PS&E, and possibly some of the work in Construction. That is, the project management system is used to manage some aspects of virtually all the work to the right of programming in Figure 12.
- Geographic information system:* Most DOTs also provide an interface from programming to a geographic information system. Tommelein and Blampied explain the benefits of such an interface as "users typically begin by mapping the start- and end- post miles of the project to the GIS system, enabling the production of a locality map showing the project in its geographic context. This use can then be expanded to allow users to select an area on a map and view all projects within that area. A GIS can also be used to produce maps of the projects, perhaps of a particular type or delivery year, within the boundaries of a county, city, school district, or legislative district. It may also be used to identify utilities, environmentally sensitive areas, property zoning, types of agriculture, and a vast array of other data that could be relevant to the project and influence the project's outcome."⁷³

⁷² Tommelein and Blampied, *Review of the Project Resourcing and Schedule Management (PRSM) System used by Caltrans*, 53.

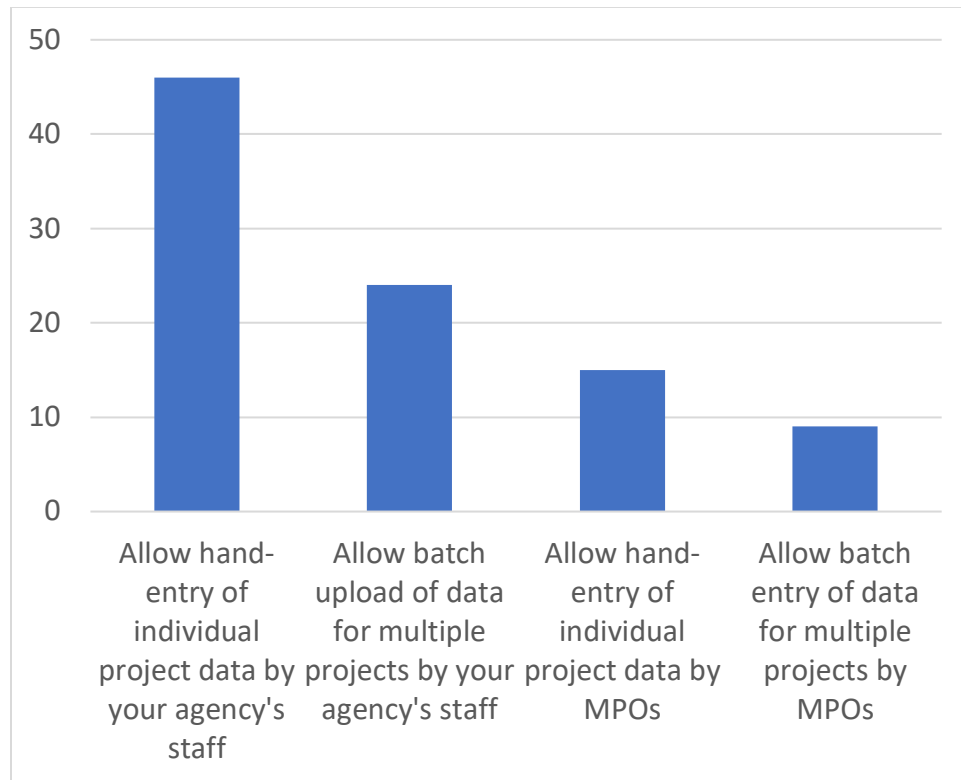
⁷³ Tommelein and Blampied, *Review of the Project Resourcing and Schedule Management (PRSM) System used by Caltrans*, 55.

- *Construction management system.* The construction management system typically records details about the payments made on construction contracts, contract amendments, supplemental work, and often the records kept by the construction inspectors as well. These are details that would not appear in the project management system. Slightly fewer than half of the DOTs have interfaces between their programming and construction management systems. Referring to Figure 12, the construction management system lies at the extreme right of the figure and has the most intermediate steps from programming. Construction management does, however, manage the largest dollar volume among the systems referenced in Figure 15.
- *Annual budgeting system.* Approximately one third of DOTs have interfaces between programming and the annual budget system. In Figure 12, annual budgeting would lie to the left of programming, outside the figure.
- *Right of way management system.* The R/W management system typically records information about individual land parcels and utilities and the acquisition of those parcels or relocation of utilities. These are details that would not appear in the project management system. R/W lies between the Envir.Docs. and PS&Es in Figure 12, and approximately one quarter of DOTs have interfaces between programming and their R/W management system.
- *Environmental permitting system.* The permitting system typically records the commitments that the DOT has made during the environmental clearance process. It is used to both monitor those commitments and ensure that the DOT carries them out. Like the R/W data, these are details that would not appear in the project management system. Envir.Docs. follow immediately after programming in Figure 12.

3.3.6 Input Methods

Figure 16 illustrates the answers that DOTs gave to a question about the permitted input methods for their STIP programming systems.

Figure 16. Input Methods Permitted in the DOTs' STIP Programming Systems



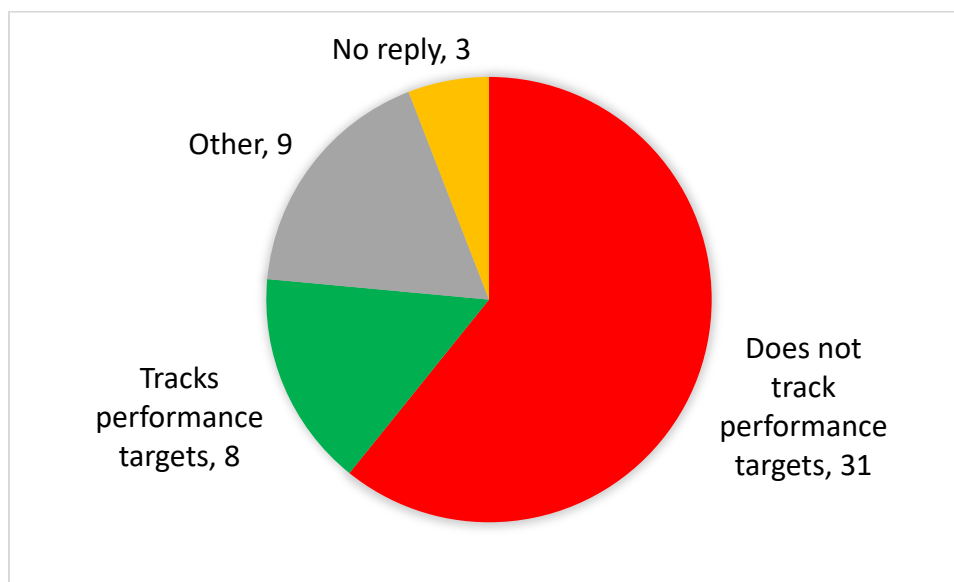
All responding DOTs allow for the hand-entry of project data by DOT staff, referred to in the questionnaire as "your agency's staff." Many DOTs allow batch entry, and fewer allow Metropolitan Planning Organizations (MPOs) to enter data directly. Four DOTs did not reply to this question.

3.3.7 Performance Targets

The last structured data-gathering question in the questionnaire asked about the use of the STIP programming system to track the achievement of the state's performance targets under the 2012 Federal Surface Transportation Reauthorization Act, known as MAP-21.⁷⁴ This requires states to establish performance measures and set targets for improving its performance against each measure. To meet the federal requirements, projects in the STIP would need to be selected strategically to achieve the desired targets. As shown in Figure 17, most states do not use their STIP programming systems to track the expected achievement of performance targets on a project-by-project basis. They must use another method of keeping track of the targets.

⁷⁴ United States Congress. *Public Law 112-141, Moving Ahead for Progress in the 21st Century, MAP-21*, 126 Statutes 405, enacted July 6, 2012, amending 23 United States Code.

Figure 17. Responses to the Question “Does the System Track Each Project’s Expected Contribution to the State’s Performance Targets Under MAP-21?”



The MAP-21 performance targets are a relatively new phenomenon in DOTs, and the AASHTO Committee on Performance-Based Management has engaged in an extensive program of research on performance measurement. The study of how states record and track their performance measures may be a useful part of or supplement to that research.

3.4 Findings Regarding Programming Systems

Analysis of the responses to the questionnaire yielded the following findings, analysis, and recommendations for further research.

Contrary to the researchers’ expectations, the survey results indicate that the market for DOT STIP programming is not dominated by a small number of commercial systems. However, there is one product that is used by six of the seventeen DOTs that utilize commercial systems. Instead, a clear majority of DOTs each use their own in-house system, which may relate to the fact that most STIP programming systems are behind firewalls, accessible only by DOT employees.

Importantly, but not surprisingly, most STIP programming systems are used to manage all project phases.

Most DOT STIP programming systems appear to have room for improvement in their financial interfaces. A small majority of systems do not reconcile with accounting for actual expenditures (Figure 10), most do not interface with accounting for expenditure authorization (Figure 11), and most do not have processes for tracking the many-to-many relationships illustrated in Figure 12 and discussed with Figure 13. These are all necessary functions that are well within the capability of modern data management systems. If these

functions are not automated and regulated by machine-verified rules, they involve error-prone and costly human calculations. Further research is needed to establish how states do, in fact, perform these necessary functions. That research would seek to determine whether these functions are accomplished in other systems than STIP programming, or performed by hand.

In addition, the opportunity for further research into how states record and track their performance measures could supplement or be a part of the research initiated by the AASHTO Committee on Performance-Based Management (see the discussion of Figure 17).

In summary, there are opportunities for improvement to DOT STIP systems through the introduction of rule-based interfaces that reduce hand work, increase data reliability, and improve timeliness. The increasing focus on data security in the world of information technology is likely to drive change, especially in public-facing systems on the internet. It will be difficult for many DOT information technology divisions to keep abreast of the changing security demands. Like their private sector counterparts, some will turn to commercial firms with state-of-the art security operations to provide their systems.

In conclusion, if past trends in information technology are indicators of future change, it seems likely that a few dominant commercial players will emerge to provide STIP programming systems to the DOTs.

4. Recommendations for Caltrans Financial Programming Processes

4.1 Overview of these Recommendations

The recommendations that follow in Section 4.3 respond to a request for an evaluation, a comparison, and improvement recommendations for Caltrans financial programming processes and tools. At first glance, these recommendations may seem excessive, but one should keep in mind that most organizations perform many functions that are often not well documented. Viewed in that light, these recommendations are concise. When the time comes for Caltrans to replace CTIPS, considerably more detail will be needed, since computer systems, after all, perform only the functions that they are programmed for, and desired functions must be documented if they are to be included in the system.

4.2 Sources

The recommendations derive from seven sources:

1. A 2000 Feasibility Study for a *Project Cost and Schedule Management System*. This system would have included modules for “Project Initiation and Tracking” and “Project Programming and Funding,”⁷⁵ and these modules would have replaced CTIPS.
2. A 2004 Division of Programming Business Process Review.⁷⁶
3. A 2012 Caltrans Business Case Analysis of Transition into the CTIFS Solution,⁷⁷ that led to
4. A 2013 Feasibility Study for a California Transportation Infrastructure Funding System (CTIFS)⁷⁸ that would have replaced CTIPS.
5. A 2021 “Statewide Agencies” transportation programming survey of Caltrans Headquarters Divisions and Federal Agencies, followed by interviews and email exchanges with some of the respondents. The survey asked four questions:
 - i. “What information do you give to the Caltrans Division of Financial Programming?”

⁷⁵ California Department of Transportation. *Project Cost and Schedule Management Feasibility Study Report*. January 24, 2000. (Sacramento, CA: Caltrans).

⁷⁶ California Department of Transportation. “Appendix 3 – Division of Programming (CTIFS)”. *Caltrans Integration Study Business Process Review*. June 1, 2004. (Sacramento, CA: Caltrans).

⁷⁷ California Department of Transportation. *Divisions of Local Assistance, Budgets & Transportation Programming Business Case Document: Analysis of Transition into the CTIFS Solution*. October 23, 2012. (Sacramento, CA: Caltrans).

⁷⁸ California Department of Transportation. *California Transportation Infrastructure Funding System (CTIFS)*. Project Number 2660-505. Feasibility Study Report. June, 2013. (Sacramento, CA: Caltrans).

- ii. “What information do you receive from the Caltrans Division of Financial Programming?”
- iii. “What additional information would you like to receive from the Caltrans Division of Financial Programming?”
- iv. “With regard to the information that you give to the Caltrans Division of Financial Programming, do you obtain it from one or more databases? If so, what database(s), and is there a possibility of automating the process to avoid hand-entry and to keep data more current?”

These questions were intended to elicit facts about actual and desired data flows and about potential system interfaces.

1. A 2021 “Local and Regional Agencies” transportation programming survey of Caltrans Districts, RTPAs, and California MPOs. This survey asked the first three questions in the “Statewide Agencies” survey, but the fourth question was not asked because the researchers believed that separate custom interfaces for each local agency or district would not be feasible.
2. A review of some relevant literature sources.

As this source list suggests, the present study is the fifth study of financial programming that Caltrans has conducted since 2000. Previous studies were conducted in 2000, 2004, 2012, and 2013. Some issues have persisted throughout this time, with problems identified in 2000 continuing to be raised in 2021–2022.

Between them, these seven sources provided 278 possible requirements or recommendations, which are listed in Appendix B.

Upon consideration, only 224 of the 278 possible requirements or recommendations were identified as possible recommendations for Caltrans Financial Programming or a CTIPS replacement. These were grouped to limit duplication or repetitiveness, leading to the 19 recommendations that are listed alphabetically in Sections 4.3.1 through 4.3.19.

4.3 Enumerated Recommendations

It should be noted that these recommendations do not all recommend change. Many of them are documentation of existing processes that will need to be accommodated in any system that replaces CTIPS.

For convenience, the recommendations are phrased as requirements for a CTIPS replacement system, as they might be phrased in a requirements document. This phrasing is intended to assist Caltrans in developing the necessary documents when the time comes to replace CTIPS.

4.3.1 Automation and Workflow

The CTIPS replacement system should include electronic workflow⁷⁹ that enables users to move through the following processes smoothly and with a minimum of error, duplication, or revision, including electronic performance of the review steps, obtaining signatures and approvals electronically, and posting approved changes. This encompasses the generation of requests by Caltrans Districts, RTPAs and MPOs that can then be approved by Caltrans headquarters and CTC personnel as appropriate. It also includes tracking the author of each change, the date and time of the change, and the identification of the computer from which the change was made. This workflow incorporates:

- a process for non-attainment areas receiving and programming CMAQ projects and the ability to click a box and open a new tab to enter emissions reductions requirements;
- approvals signaling any negotiated conditions approved by the FHWA and FTA;
- an automated process for gathering CTC Book items data and attachments;
- an automated review of Vote boxes and Vote lists by impacted stakeholders;
- an automated routing of the CTC Agenda including Book items with attachments for review;
- federal and state requests;
- initial allocations, adjustments, authorizations, obligations, apportionments, and expenditures;
- iterative refinement and finalization of Statewide Programming lists by Program type, District, Region, and Agency;
- an iterative review of data including the ability to electronically approve or reject transactions at agreed upon authorization points at the Program and/or project levels;
- an iterative review of E-76s;

⁷⁹ “The sequence of steps involved in moving from the beginning to the end of a working process” Merriam-Webster.com dictionary.

- the processing of official CTC transactions electronically and their transmittal to the CTC;
- program applications and calls for projects, including input from required stakeholders;
- project amendments including, but not limited to, SHOPP Project Change Requests (PCR) and STIP amendment requests;
- a project close-out;
- project fund allocations, including delegated project allocations, and the outcomes of CTC decisions;
- subvention fund management;
- support for the development and management of the Interregional Transportation Improvement Program (ITIP) List;
- time extension requests;
- transmittal of CTC actions to all impacted stakeholders;
- automatic creation of FTIP amendments and electronic routing of the requests to MPOs upon approval of a STIP or SHOPP amendment; and
- verification that requests have funding and come from authorized requesting agencies.

4.3.2 Batch Uploads

In addition to the hand entry noted elsewhere, the CTIPS replacement system should permit authorized users, including those in Caltrans Districts, RTPAs, and MPOs, to enter multiple projects into the system from a spreadsheet, comma-separate value file, or other similarly approved format. The upload should include security checks to ensure that batch uploaders enter data only for projects that are within their areas of jurisdiction. Data uploads include:

- agreement processing;
- candidate data;
- existing project change transactions related to Scope, Cost, and Schedule;
- FTIP information;
- fund allocation transactions;

- milestone data;
- new transportation projects;
- nomination data;
- other project data; and
- supplemental fund transactions.

4.3.3 Caltrans Information Technology (IT) Strategy

The CTIPS replacement system should establish the IT infrastructure and technical foundation for future business improvement. The system should meet current state software requirements, such as those of the *Americans with Disability Act*,⁸⁰ and should be adaptable to address changing requirements (i.e., it should use current "state of the art" technology and be as adaptable as other leading systems currently on the market, as determined or approved by the Department of Technology and specified by the Department of General Services).

4.3.4. Compliance and Audits

Upon implementation, the CTIPS replacement system should increase the capability for stakeholders to ensure accountability for federal and state funds for Caltrans and local projects. This includes:

- allowing users to check fund accounts to ensure funds are available and, when funds are unavailable, not allowing authorization requests to continue;
- automatically calculating and ensuring that obligation funds do not exceed available federal funds;
- complying with control agency regulations (e.g., AB 1012⁸¹ and MAP-21⁸²);
- increasing project monitoring capabilities designed to increase project delivery compliance with federal and state regulations; and
- providing the capability for a project- and document-level audit trail.

⁸⁰ U.S. Congress. *Americans with Disabilities Act*. Public Law 101-336, 104 Statutes 327, enacted July 26, 1990, codified at 42 United States Code Chapter 126 (sections 12101 to 12213).

⁸¹ Chapter 783 (AB 1012) Statutes of 1999.

⁸² See MAP-21 note above.

4.3.5 Custom reports and Information for RTPAs, MPOs, and Caltrans Units

The CTIPS replacement system should provide the ability for RTPAs, MPOs, and Caltrans units to produce and print reports, and download the report data. This includes:

- additional project and phase details for the annual CMAQ-specific obligation/de-obligation reports including the project sponsor, the phase of work, and the total cost of the project/phase being obligated/de-obligated;
- annual obligation transactions including: all federal programs, CMAQ-specific transactions, and CMAQ-specific transfers to FTA;
- annual programs of projects for Caltrans and CTC managed programs including: 5310, 5311f, Statewide ATP, HBP, HSIP, Railway-Highway Crossings (Section 130), Recreational Trails Program, SHOPP, and the Tribal Transportation Program;
- backup lists (detailed listings) for local grouped projects such as HBP, HSIP, etc. and providing for batch-entry or transfer of data for the FTIP;⁸³
- “canned reports” based on existing reporting needs of all stakeholders;
- complete funding picture of programmed projects;⁸⁴
- drafts of action items for the CTC agenda prior to finalization so errors can be caught and corrected. It should also provide confirmation of what action was taken by CTC;
- Fund Code and Program ID assignments for new programs and cycles of programming;
- funding and programming details on programmed projects;
- grouped project listings (from other databases such as HBP, HSIP, and SHOPP) that are transferred automatically into CTIPS. It should also satisfy reporting requirements such as Performance Measures and emissions reporting requirements for CMAQ, as examples;
- lists of potential projects for ITIP consideration and PPRs for those projects;

⁸³ This responds to a note from a local agency “I have to manually enter into CTIPS and manually enter a financial spreadsheet and submit to Caltrans. Way too much hand-entry. Caltrans controls the apportionments and, in many cases, the projects which are selected for grant funding such as HBP and HSIP. They enter and control their SHOPP projects, control the STIP... etc., manual entry into the FTIP does not make sense.”

⁸⁴ This responds to a note from a local agency “At this time, federal, local, and other non-State funds committed on programmed projects are not always included in the CTIPS database. For these funds to be included, someone has to make the request, which doesn't always happen. For this reason, some projects do not have a complete funding picture.”

- lists of toll credit balances. Further, the list should include a summary of what regions are generating the toll credits and what regions are using the toll credits;
- milestone data available to meet needs of internal and external customers;
- performance reporting requirements such as PM1, 2, or 3;
- PPNO and federal project numbers as soon as they are created for various programs. Including but not limited to: SCCP, TCEP, LPP-F, LPP-C, ATP, and STIP;
- Program Supplements;
- project information for the FTIP including backup lists (detailed listings) and amendment update requests as well as apportionment levels and RTIP PPRs;
- project lists identifying funding sources to program in the FTIP. For example, new Active Transportation Program projects awarded or new apportionment distributions issued;
- proposed and adopted transportation programming documents with project listings for multiple programs such as State Transportation Improvement Program (STIP), FTIP, Highway Bridge Program, and the Highway-Railway Crossing Program with documentation of votes, awards, and amendments;
- semi-annual list that highlights the list of investments going to the NHS;
- standard and ad hoc reports for functional and project managers at various levels of detail. The reports should include fixed and user-definable formats;
- standard reports based upon pre-determined conditions;
- support on the ITSP development and the preparation of the ITIP Scoring Criteria forms. Also, information on the funding status of projects being considered for ITIP and those partially funded through ITIP; and
- updated forms, program/programming changes, and information.

4.3.6 Data input, Storage, Dates, and Milestones

The CTIPS replacement system should store the information that is currently provided in the systems it replaces. The following data, which might or might not be in the existing systems, should be included in the new system:

- an ability to develop, edit, and generate non-STIP/SHOPP projects that are programmed in non-MPO areas;

- an archive project history including scanned attachments and uploaded files;
- a Caltrans-wide project inventory containing information at each key point in a project including transportation improvement needs, a region/district's candidate projects, and projects that are approved by the California Transportation Commission (CTC);
- each project's expected contribution to the state's performance targets under MAP-21;
- a funding-program specific eligibility criteria;
- the implementation of agreed-upon system validation and security rules to ensure consistent state-wide data management for impacted stakeholders;
- internal and external stakeholder project notes;
- ITIP data including "scratchpad," historical, and future cycle data;
- milestones based on user data entry;
- module data entry managed by required stakeholders based on agreed-upon business rules;
- a project inventory containing information at each key point in a project including transportation improvement needs, a region/district's candidate projects, and projects that are approved by the California Transportation Commission (CTC);
- project notes and other miscellaneous data;
- system management and maintenance of data for 10-year biennial SHOPP Plan;
- system management and maintenance of data for 4-year biennial SHOPP Plan;
- the dates of approval of future consideration of funding resolutions;
- the Environmental Certification date, Right of Way Certification date, type of Right of Way Certification, and funding request from the Basic Engineering Estimating System;
- fillable PDF files that accommodate different programs, including PPM;
- the type of environmental document and resolution numbers;
- time extensions and supplemental votes and Greater than 120s data for both the SHOPP and the STIP side (informants say that this data is currently gathered for the STIP but not the SHOPP);

- upon implementation, the ability for external partners to directly input information electronically to Caltrans (reports, electronic signature, project invoices, applications, and attachments, etc.) where feasible;
- Vote Box data for CTC transactions; and
- Vote Box lists and attachments, based upon agreed business rules.

4.3.7 Data Validation and Integrity

The CTIPS replacement system should define and isolate project data to a single data source/system to promote data ownership and enforce referential integrity. It should implement agreed upon system validation based upon business and security rules to promote consistent state-wide understanding and use data. It should:

- automatically populate as many data fields as possible based on demographic, boilerplate, template, and existing stakeholder data;
- automatically update all impacted system modules with CTC transactions and data updates; and
- update existing applications and interfaces to strengthen data integrity.

4.3.8 Federal Processes and Systems

The CTIPS replacement system should provide the data needed for federal Fiscal Management Information System (FMIS) reporting. It should provide for FMIS responses to be electronically processed and sent back to Caltrans with real-time transmittal capability to stakeholders. It should also interface with external systems as appropriate to transmit necessary funding data for projects (FADS, FMIS, etc.). It should:

- allow MPOs to record their boards' approvals via electronic signature, and automatically route the FTIP to Caltrans for review and approval;
- automatically update Obligation Authority funds based on FHWA approvals for E-76 transactions;
- electronically process and automate the FHWA FMN-76 (E-76);
- electronically transfer in "real-time" project E-76 information to the FHWA (via the FMIS system);
- enable FMIS response data to be disseminated to accounting systems;

- enable reviewers to insert comments and provide the capability to route E-76 along with comments back to lower review levels for rework;
- implement validation parameters on the E-76 process to error check prior to submission to Caltrans;
- interactively access the Federal Resources data (FADS v.2.0) to verify current funding status and availability prior to E-76 transaction approvals;
- permit the online “real-time” editing of E-76s to ensure accuracy and completeness of data;
- provide Caltrans Local Assistance with FSTIP amendments that are applicable to the projects that they provide oversight for;
- provide Caltrans Local Assistance with the data needed for any programs that are receiving FSTIP amendments, and on any FSTIP amendment; and
- provide requests for approvals of both FTIPs, FSTIP, and associated amendments.

4.3.9 Geographic Information System Interface

The CTIPS replacement system should include location data for each programmed project that permits each project's location to be identified in the Caltrans-approved geographic information systems.

4.3.10 Hand entry of Data

In addition to the batch entry noted elsewhere, the CTIPS replacement system should allow hand-entry of individual project data by designated Caltrans headquarters, Caltrans districts, RTPA, and MPO employees for projects within their jurisdiction only.

4.3.11 Interfaces with Caltrans Systems

All data in the CTIPS replacement system that duplicates information in other Caltrans systems should either obtain the data from the other system or feed the data to the other system, so that there is a single agreed original source for each data element. This original source should be documented, and the system should point users to the source in the event that they want to change the data. Possible duplicative sources include, but are not limited to:

- Accounting (CGI Advantage);
- Construction Management;
- FADS;

- Local Programs Accounting and Management System (LPAMS);
- LP2000;
- Multimodal Operational Transportation Equity Report (MONSTER);
- ODIS;
- Project Management (PRSM); and
- Right of Way Management.

4.3.12 Interfaces with RTPA and MPO Systems

The CTIPS replacement system should enable those RTPAs that use their own internal systems for project nomination development to:

- upload and import data so that “Programming Lists,” and project nomination data populate the new system module with relevant project information from the FASS system;
- store approved “Programming Lists,” including archives and new cycles;
- receive live database access by regional and federal agencies; and
- electronically move operational data between Caltrans and the regional and local agencies.

4.3.13 Notifications and Alerts

The CTIPS replacement system should:

- inform Caltrans Budgets if a SHOPP project’s support phases 0, 1, 2, 3 is to be rescinded, to permit Caltrans Budgets to de-allocate the budget from their financial database, AMS Advantage (BQ94);
- issue alerts to internal and external stakeholders on an upcoming project’s specific deadlines, report on performance measures, and monitor control agency transactions;
- issue notifications for agreement processing to impacted stakeholders at review and approval stages;
- issue project closeout automatic notification to all impacted stakeholders;
- issue alerts on amendment submittals;

- issue alerts on changes to APL including project details and milestones;
- issue alerts on CTC actions;
- issue alerts on Document Review/Approval;
- notify impacted stakeholders of CTC transactions;
- provide annual apportionment amounts (and estimates) for federal programs including: RSTBG (STP), CMAQ, HIP, and CRRSAA;
- provide approval emails for FTIP Updates and Amendments;
- provide notifications for any programming actions to be taken by RTPAs, MPOs, and Caltrans districts;
- route FMIS response via auto alerts to impacted stakeholders in “real-time;”
- send lists to MPOs if there are any lapsing funds that need to be obligated; and
- show how much time is needed past 6 or 72 months for timely use of funds.

4.3.14 Replacement of Existing Systems

The CTIPS replacement system should incorporate the features of, and replace, the following current systems:

- CalSmart;
- CMAQ database;
- CTIPS;
- Federal Aid Data System (FADS);
- Transportation performance management database; and
- VIPER.

4.3.15 Security

For sign-on, the CTIPS replacement system should use a two-step process or other advanced security currently considered to be “state of the art,” and should be adaptable to address changing requirements (i.e., it must be as adaptable as other leading systems currently on the market, as

determined or approved by the Department of Technology and specified by the Department of General Services). There should also be different levels of security access with clear areas of responsibility and appropriate access to user groups.

4.3.16 Splits and Combines / Project Identification

The CTIPS replacement system should address the problem of “Splits and Combines” which is created by the many-to-many relationship from programmed projects listed in CTIPS to project codes listed in CGI Advantage. The problem is illustrated in Figure 12 and discussed there in relation to that figure.

To address the “Splits and Combines” problem, Caltrans should adopt these business rules:

- For each program-element-component-task combination (PECT) in CGI Advantage, the Division Chief for Financial Programming should determine whether projects, by phase, using that PECT require CTC-approved programming. If this requirement exists, it should be noted in the definition of the PECT in the *Caltrans Coding Manual*. If only some projects, by phase, using a particular PECT require CTC-approved programming, the Division Chief for Financial Programming should establish criteria for when CTC-approved programming is required, and those criteria should be noted in the definition of the PECT in the *Caltrans Coding Manual*.
- Program codes used in the CTIPS replacement system should be only the PECT codes listed and defined in the *Caltrans Coding Manual*. The Division Chief for Financial Programming should have the authority to define new PECT codes and have them added to the *Caltrans Coding Manual*.

In addition, the CTIPS replacement system should:

- assign a unique “programmed project” identifier to each project that receives CTC-approved programmed amounts. This identifier should not be the same as the project code in CGI Advantage because: (a) one CTC-approved programmed amount can be split between more than one project code in the CGI Advantage, and (b) one project code in the CGI Advantage can combine amounts from more than one CTC-approved programmed project;
- record CTC-approved programmed amounts for these phases within each project: (1) Environmental Studies and Permits, (2) Plans Specifications and Estimates, (3) Right of Way Administration (a.k.a., Right of Way Support), (4) Construction Engineering (a.k.a., Construction Support), (5) Right of Way Capital, (6) Construction Capital and (7) any other phases that the Legislature, CTC, or Department of Finance choose to require;

- provide the capability to split the funding of any phase of any programmed project between an unlimited number of PECT codes; and
- include workflow with CGI Advantage for PECT combinations that require CTC-approved programming, so that each new project phase established in CGI Advantage identifies which specific CTC-approved programmed project phase, by PECT, correlates with the new project phase in CGI Advantage. This should include a split between the CTC-approved programmed project phases, by PECT, if more than one CTC-approved programmed project phase correlates with a single project phase in CGI Advantage.

4.3.17 Statewide Reports and Reports to the CTC

The CTIPS replacement system should provide the ability to generate Program Fund Lists (STIP, FSTIP, FTIP, SHOPP, RTIP, ITIP, RCL, and Approved Program Lists (APL)) documentation directly from the ITIP and RTIP data in the system along with entire list of amendments. The system should also:

- create summary information for CTC agenda and book items electronically based on agreed upon business rules;
- calculate the ITIP formula including project splits (i.e., North, South, Urbanized, etc.);
- maintain an “application status” screen that is viewable by impacted stakeholders with real-time milestone tracking;
- create “real-time” CTC summary reports for stakeholders; and
- increase project monitoring capabilities designed to increase project delivery compliance with federal and state regulations.

4.3.18 Training, Coordination, and Information Sharing

The Caltrans Headquarters Division of Financial Programming should provide training and information to key stakeholders (Districts, Programs, RTPA, and MPOs) and should partner with the key stakeholders in the development of the CTIPS replacement system. Training and information include:

- a master calendar, which includes information about Federal programs like CARES, federal transportation bills, etc. Where these are on the calendar;
- coordination of CFPG and biennial TIP update workshops;
- formula funds appropriations and forecasts;

- fund estimates for CTC-managed programs including STIP and ATP;
- guidance for programming new fund types;
- information about funding awards and updated project lists for Caltrans funded projects (for amendment purposes), communication of needs to be passed along to CFPG members from third parties (i.e., FHWA, FTA), updates on programming requirements, meetings, and workshop invitations;
- information from CFPG meetings, procedures for FTIP amendments, program funding allocation estimates and final amounts, reminders for obligating program awards or new CTC voted projects etc.;
- instructions for how to complete the correct forms for programming;
- meeting notices for CFPG meetings;
- more documents on the Caltrans financial programming website;
- pertinent information such as schedules, "nuts and bolts" of programming, and any updates to assist with FTIP Adoption submittals, FTIP Amendment, and Administrative Modification submittals;
- programming information and requests, updates on transportation/air quality through CFPG meetings, recommendations of approval of FTIP formal amendments, training workshops on FTIP development every two years, RSTP/CMAQ, and HIP apportionments, responses to inquiries, etc.;
- project data for grouped listings of projects, apportionment levels, PPRs for inclusion in the Federal TIP;
- reviews and approvals of TIP amendments and adoptions;
- semi-annual summary reports of state only funds balances from around the state, specifically for programs funded with both state and federal funds like the ATP;
- state program listings (HBP, HSIP, SHOPP, etc.);
- support for the ITSP development and the preparation of the ITIP Scoring Criteria forms together with information on the funding status of projects being considered for ITIP and those partially funded through ITIP;
- training and information on the STIP process (including the Fund Estimate), FTA formula grants for urbanized areas less than \$200,000, local TDA apportionments, etc.;

- training materials and instructions for the CTIPS replacement system with examples, and with dummy instance of the database for use in training;
- training, orientation, or FAQ for new programming staff;
- updates on performance measures; and
- updates to programming guidelines/procedures, and interpretation/advice on federal regulations.

4.3.19 *Use of Funds*

The CTIPS replacement system should enable Caltrans to comply with Government Code sections 14525.6 and 14526.6 (a) and (b),⁸⁵ both of which require reports of costs programmed projects listed in CTIPS rather than for project codes listed in CGI Advantage (see the discussion of “Splits and Combines” following Figure 12 and in Section 4.3.16). To this end, the CTIPS replacement should:

- compare the CTC-approved programmed amounts with the actual and planned expenditures by project and phase from PRSM and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual and planned expenditures. (This may be accomplished by requiring that PRSM use only project identifiers from CGI Advantage—see the requirement for reconciliation with CGI Advantage.) 4.3.16;
- compare the CTC-approved programmed amounts with the actual and planned expenditures by project and phase from the Caltrans right of way management system and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual expenditures. (This may be accomplished by requiring that the right of way management system use only project identifiers from CGI Advantage—see the requirement for reconciliation with CGI Advantage.) 4.3.16;

⁸⁵ 14525.6. Not later than November 15, 2014, and annually thereafter, the department shall, as part of the project delivery report required pursuant to Section 14525.5, report on the difference between the original allocation made by the commission and the actual construction capital and support costs at project close for all state transportation improvement program projects completed during the previous fiscal year. (Added by Stats. 2012, Ch. 272, Sec. 1. (SB 1102) Effective January 1, 2013).

14526.6. (a) The department shall report to the commission quarterly, for projects which complete construction in the previous quarter, on the information outlined in subdivision (b) for all major state highway operation and protection program projects, as defined by the commission pursuant to subdivision (f) of Section 167 of the Streets and Highways Code.

(b) The department shall report to the commission on the approved capital and support budgets compared to expenditures at contract construction acceptance for all projects included in subdivision (a). (Added by Stats. 2014, Ch. 917, Sec. 8. (SB 486) Effective January 1, 2015).

- compare the CTC-approved programmed amounts with the actual and planned expenditures by project and phase from the Caltrans construction management system and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual expenditures. (This may be accomplished by requiring that the construction management system use only project identifiers from CGI Advantage.);
- compare the CTC-approved programmed amounts with the actual expenditures by project and phase from CGI Advantage and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual expenditures;
- provide Caltrans Budgets with programming information related to allocations; and
- relate each programmed project to the Caltrans environmental permitting system and show which permits are required for each programmed project. (This may be accomplished by requiring that the environmental permitting system use only project identifiers from CGI Advantage.).

4.4 Reconciliation to Sources

Table 5 provides a count of the recommendations or requirements from the sources listed in Section 4.1. Although Section 4.1 lists seven sources, the three sources that derive from the present 2021–2022 study are shown together as a single source in Table 5. As noted in Section 4.1, the sources provide a total of 278 recommendations or requirements. Appendix B provides the full list of recommendations or requirements. There, again, the three 2021–2022 sources are combined.

Table 5. Reconciliation of Recommendations to Sources

Row Labels	2000 Feasibility Study Report	2004 Business Process Review	2012 Business Case	2013 Feasibility Study Report	2021– 2022 Study	Total
Automation and workflow	2	3	21	5	1	32
Batch uploads			3		3	6
Caltrans IT Strategy				1		1
Compliance and audits	1		2	3		6
Custom reports	6		3		17	26
Data input, storage, dates, and milestones	1		11	2	5	19
Data validation and integrity			2	1		3
Federal processes and systems			11	1	4	15
GIS					1	1
Hand entry of data					3	3
Interfaces with Caltrans systems	1		7	3	1	12
Interfaces with RTPA and MPO systems	2		3			5
Notifications and alerts			10	1	8	19
Replacement of existing systems	3	1	2		3	9
Security			3		2	5
Splits and combines/Project identification	4		5		5	14
Statewide reports and reports to the CTC			15			15

Row Labels	2000 Feasibility Study Report	2004 Business Process Review	2012 Business Case	2013 Feasibility Study Report	2021– 2022 Study	Total
Training, coordination, and info. sharing		1			22	23
Use of Funds			1	1	7	9
Exclude from the recommendations	2	12	39	1		54
Total	22	17	138	19	82	278

The final category in Table 5 is listed as “Excluded from the recommendations.” This refers to the 54 recommendations or requirements listed in one or more of the four prior studies that the authors of the present study chose to exclude from the recommendations in the present study, thereby reducing the number of recommendations to 224, which were then grouped into the 19 recommendations in Sections 4.3.1 through 4.3.19. The excluded recommendations fall mainly into two sub-categories:

- Recommendations for organizational changes made in the 2004 Business Process Review. If the recommended organizational changes have still not been implemented 18 years later, the authors of the present study assume that the change has been considered and rejected.
- Recommendations from the 2012 Business Case that relate primarily to the Caltrans Division of Budgets or the Caltrans Division of Local Assistance. The 2012 study was intended to address the needs of those two divisions and of the Division of Financial Programming. The present study, however, has a mandate only to consider financial programming.

5. Risks, Opportunities, and Recommendations of Improvement for Caltrans Financial Programming Tools

5.1 Introduction and Background

5.1.1 Brief Introduction of CTIPS

The California Transportation Improvement Program System (CTIPS) is a web application that is used by the stakeholders to support the business of Financial Programming, California Department of Transportation (Caltrans), the lead transportation agency for the State of California. The CTIPS is built on an Oracle database. The Division of Transportation Programming conducts the preparation, management, and administration of project “Programming” documents required under State and Federal statute. Major “Programming” documents include the State Transportation Improvement Program (STIP), State Highway Operation and Protection Program (SHOPP), and the Federal Transportation Improvement Program (FTIP)/Federal State Transportation Improvement Program (FSTIP). The application is used to get STIP and SHOPP documents generated from the data stored in the database of the CTIPS application, which is used to generate Federal Transportation Improvement Program (FTIP) documents and the Federal Statewide Transportation Improvement Program (FSTIP). CTIPS provides a common database shared by Caltrans District Offices and Headquarters, Regional Transportation Planning Agencies (RTPAs), the Federal Highway Administration (FHWA), and the Metropolitan Planning Organizations (MPOs). Various predefined and ad hoc reports can be produced through CTIPS. Caltrans has the responsibility to deliver state transportation services and to assist and guide delivery of local and regional transportation services in a timely and cost-effective manner for the purposes intended in state/federal laws and regulations.

5.1.2 Interviews with the Major Service Support Provider of CTIPS and with the Department of Information Technology at Caltrans

In order to better understand the current status and potential issues of the CTIPS system and areas that require improvements, we carried out an interview with the CTIPS service support provider.

Some of the questions asked include:

- i) What is the current status of ADA compliance? What is the roadmap/procedure to reach ADA compliance? Can the grid system be replaced?
- ii) What kind of security problems are you aware of? What are the causes of the issues? Are there any steps to mitigate those issues? For migrating to Spring, is it Spring MVC or Boot? How flexible would the frontend be accepting the architecture change in the backend? Can we

make all the features as reusable components if all the features are dependent on each other making it difficult for any change?

iii) Are there any comments on the current database (DB) system and any suggestions for the future DB system? What are your suggestions for a new DB system? Would you recommend migrating the database from Oracle?

iv) Could you please share with us your opinions regarding the upgrade or replacement of the current CTIPS?

Currently, Caltrans IT provides routine maintenance for CTIPS. Therefore, we also interviewed Caltrans IT to better understand the current status, potential issues and replacement of CTIPS.

Some of the questions we asked the Caltrans IT department include:

i) The current CTIPS system is not ADA compliant. In order to make the system ADA compliant, what kind of procedure and technical approaches would you recommend others to take? Are there any other policies, procedures, or issues that we should be aware of in making the system ADA compliant or making recommendations on fixing the problems?

ii) There are some concerns regarding security issues for the CTIPS system. In order to make the system more secure, what kind of procedure and technical approaches would you recommend others to take? Are there any other policies, procedures, or issues that we should be aware of in making the system more secure or making recommendations on fixing the problem?

iii) Besides security and ADA issues, are there any other issues with the current CTIPS system such as maintenance, downtime, backup, and hosting environment that we should be aware of? Do you think the current CTIPS service support provider can or cannot fix all these issues, and why?

iv) If Caltrans decides to apply a new system to replace current CTIPS, do you have any recommendations or comments on the new/candidate DB systems that we could explore? Are there any specific requirements for the new DB system that we should be aware of from Caltrans IT perspective?

v) If a new DB system will be applied to replace the current CTIPS system, what kind of procedures would you recommend for us to take to ensure a smooth, safe and efficient transition from Caltrans IT perspectives? Or what kind of issues do you think we should be aware of during the transition time period?

vi) Could you please let us know the roles and responsibilities of Caltrans IT in the current CTIPS system and possibly future replacement?

5.1.3 Surveys and Interviews with other Software Vendors

One of the major purposes for this research is to make improvement recommendations of the current CTIPS system. We wanted to identify key aspects that the current system lacked as compared to the cloud-hosted applications on the market. As part of the research process, we reached out to ten software companies, which were selected based on surveys with other state DOTs, market research, and consultations from Caltrans, to learn more about their services and products that can perform the same or similar functions as CTIPS provides to Caltrans.

For the survey with the software companies, we are interested in some particularly important features of their products and services, including ADA compliance, security, automation of deployment, project management, and new features like AI/ML (Artificial Intelligence/Machine Learning) based services. We are also interested in exploring the possibility of the new system being scalable, robust, and adaptable, and eventually replace the current CTIPS application.

The survey questions in our survey form sent to these software companies include:

- i) Is your product cloud hosting available as Software as a Service (SaaS)? If yes, what are the other SaaS projects you have worked on? Is there a milestone project that we can look up for reference? How long have you been developing SaaS projects?
- ii) How many layers of security do you offer for the cloud environment? After the initial deployment, can the subsequent deployment be automated?
- iii) Is your product available through the California Department of General Services Software Licensing Program?
- iv) Is your product used as a “programming” system (for transportation project funding) by a state Department of Transportation or Metropolitan Planning Organization in the United States? Which states or MPOs? If not, what are the “programing”/portfolio management capabilities of your product (the Federal Highway Administration refers to portfolio prioritization, selection, and authorization as “programming”)?
- v) What are the different infrastructure features offered with the service? Do you offer cutting-edge features like ML or AI to improve the process workflow?
- vi) Describe how your pricing is calculated and include, where appropriate, information and cost drivers on:
 - 1) Availability of Multi-year enterprise-wide master agreements;
 - 2) Existing cost-sharing models with counts;
 - 3) What products or services are one-time costs;

- 4) Ongoing costs (per transaction, per subscription, etc.);
- 5) Onsite scanning and index services;
- 6) Maintenance;
- 7) Volume discounts;
- 8) Other pricing information you deem relevant.

vii) If you develop a new system, will your system be flexible, adaptable and scalable?

viii) Is your system ADA compliant? If not, could you give us a roadmap to achieving ADA compliance?

ix) Could you give us a brief overview of the general project management and implementation procedures? Approximately, how long does it take for the completion and hosting of an application?

x) Could you please share your migration plan from the old system to the new system based on your product? Since the current CTIPS system is a grid system (Grids are the skeleton of design, and they help create order and organize the content of the design), we are wondering whether you have worked with the migration process from an old grid system to your new system before?

For various reasons, we did not receive responses from all the companies we sent the survey forms to, but we have received responses from multiple software companies regarding the services and the applications that they provide or host.

5.2 Risks of the Current Financial Programming Tools, i.e., CTIPS

Based on the interviews with the CTIPS support provider and Caltrans IT, and also responses from related software companies, we have identified the following risks of the current financial programming tools, i.e., CTIPS.

5.2.1 *ADA compliance*

Based on the meetings with the CTIPS support provider and Caltrans IT, the original CTIPS was migrated from an old FoxPro environment to the Struts framework, an open-source framework expanded from the Java Servlet API and applying a Model, View, and Controller (MVC) architecture. There were not any requirements or laws passed to incorporate ADA compliance during that period, however, Caltrans was aware of the ADA compliance requirement when the new applications for CTIPS were being developed. It was then suggested that the online tools be used to test readability, so that a person with a disability could access the application easily.

Achieving ADA compliance on the current application is very tedious and a time-consuming process. As per the conversation with the CTIPS support provider and Caltrans IT, the CTIPS application code has to be rewritten from the start using a different library, since CTIPS uses the grid system for the user interface, and the current application is coded by importing a library for the grids that is fundamentally not ADA compliant. To enable screen readability, the application must be coded again from scratch using a new library which could be a timely and expensive effort. If the user interface is re-coded using a new library, the corresponding backend code also needs to be changed in accordance with the frontend code.

There are over 200 pages, i.e., different screens (web pages), in the CTIPS application, and there are 80,000 issues reported. With the available time and resources, there has been an effort to rewrite the code with a new library, which made 9 grids out of the 150 grids ADA compliant. But the 20,000 remediations in the 9 grids, proposed by the CTIPS support provider but not elaborated on during the interview, were never deployed into production since it is expected that the entire application be ADA compliant, not only 9 grids. However, the procedure for fixing other grids would be different from that for those 9 grids, since each grid has a different level of complexity. In addition, the PDFs generated from the application are also not ADA compliant.

There are some online tools that can be used to assess the compliance of the pages in the application in order to remediate the ADA issue. But there is not one tool that can do the work entirely, and thus multiple tools are required to test all the pages in the application to find issues and resolve them, which would be laborious. Siteimprove is a tool used for testing the accessibility of a web page and currently used by the CTIPS support provider to test ADA compliance. The grid is an important feature for designing responsive web pages that work across all web browsers, and it uses tables and columns to easily create the web page layout. Specific expertise in tools such as Siteimprove and the knowledge of grids are needed to dive deeper into and fix ADA issues.

Changes to the frontend would require equal efforts on the backend code since the data flow from the user interface (UI) to the backend and to the database (DB) happens if the frontend-backend integration is established. If there is a code change in the UI and the backend code is not modified, the application functionality breaks and there would not be a seamless flow of data within the application. For example, it might take a JavaScript expert more than a week's worth of effort to replace one grid, depending on the grid's complexity. In addition, it seems that it is hard to find a way to work with the 1,000 users to make the application ADA compliant. The pages in CTIPS are largely made of tables, and the screen is crammed with small controls and checkboxes. The interviewees claimed that users did not want any changes to the application's functionality which is required for ADA compliance since they were used to the current application.

We asked the CTIPS support provider and the Caltrans IT whether some modules of the application could be made ADA compliant sooner than others. It was found that fixing just a few modules would still require analysis of the root cause which would take intense effort, and hence it would not make much sense or benefit Caltrans or the users to achieve ADA compliance with

only a few modules. Unsnapping the entire application to understand the root cause would also take much effort, while unable to guarantee screen readability.

In summary, based on the interviews with the CTIPS support provider and Caltrans IT team, it has been confirmed that the current application is complex and ADA compliance cannot be incorporated easily. To dive deeper into the problem, they need to start by recording the readability issues in the current application through an online tool. But there is no guarantee on the time and effort required to ultimately achieve full ADA compliance. After great resource investment, the CTIPS applications still seem far away from being fully ADA compliant.

5.2.2 Security Concerns

Based on the meetings with the CTIPS support provider and Caltrans IT, it seems that the CTIPS application itself is secure but the code security cannot be guaranteed. The Struts framework is currently being used as the development framework on the backend, which is known to have some security issues. Caltrans would like the applications to be transferred to a newer version of Spring (a framework, different from Struts, that is used to develop Java applications), which can provide an active development platform and presumably will better handle the security issues. Therefore, migrating to Spring seems to be on the top of the support provider's deliverable list for now.

One of the challenging issues with migration is that the current version of Spring is not compatible with CTIPS's Object-Relational Mapping (ORM), Hibernate version 3, as Spring requires at least version 4. Hence, as part of architecture changes, Hibernate needs to be replaced and upgraded.

The effort required for the migration needs to be done page by page, and there are 200 pages. Since most of the logic need not be modified, two to three pages per day can be migrated and tested for any issues. Through the learning curve, 10 to 20 pages per day can be completed, and the entire codebase can be migrated.

Taking the time to rewrite the code to fix the security issue would be similar to the process of fixing the ADA issue, which is a tedious process. Caltrans IT are not necessarily experts on information security, but they do try to follow the policies and procedures as best as they can. For custom applications they have used a tool called AppScan to look for potential security issues such as the SQL injection vulnerabilities and so on, but they have limited licensing on this tool. It is installed in a Windows box, and they are not sure whether it is successfully maintained since they do not perform an app scan run regularly for all their applications, such as CTIPS.

Spring Boot is built on the top of the conventional Spring framework, which provides all the features of Spring but is easier to use. Since there are a few other applications in Caltrans developed with Spring Boot, it might take some effort to research if Spring Boot is feasible for the CTIPS application. This change in the architecture was included in the previous contract between Caltrans and the CTIPS support provider. CTIPS users are responsible for contributing to the resources that make these changes possible, and they had other changes which were prioritized. Therefore,

the migration to Spring was not given the priority it needed. Though, as per the initial discussion, the application backend would be in Spring MVC, which implements all of the basic features of a core Spring framework and follows the Model-View-Controller (MVC) design pattern, further analysis is required to see if Spring Boot might be a good fit.

The other security concern is the environment in which the application and the database of CTIPS are hosted. As per the meetings with both the support provider and Caltrans IT, the application is currently hosted on a secure server and follows all current security standards. The servers go through a rigorous process to communicate with the external or internal contact. The DMZ (Demilitarized Zone) is closely monitored by the WAN (Wide Area Network) team in the server admin, so issues of vulnerabilities and server patches have been addressed in an orderly/systematic approach from month to month. There are parts of the application that were originally slated for upgrade from Struts to Spring, and it was found that the code security in both Struts and Spring were the same, and hence no changes were made.

5.2.3 Database (DB) and User Experiences

As per the support provider and Caltrans IT, the current Oracle database (DB) is one of the more expensive ones on the market, and it is a good relational database. But the CTIPS database shows two sub-degree weaknesses: it shows signs of aging with respect to design over many years more than any other databases, and the table structure, relationships, and normalizations used in the DB are not what Caltrans IT or CTIPS support provider would prefer. It is also noted that some of the big challenges working in the current CTIPS system are the complexity and lack of business reference inside the code. Since it was an auto-conversion from FoxPro to Oracle, it is hard to understand and modify the code from a business standpoint. Also, extensive use of stored procedures makes debugging and maintenance of the code challenging.

If the application needs to be replaced to fix the existing ADA and security issues, the database (DB) can be either left as it is or can be changed. Based on the meetings with the CTIPS support provider and Caltrans IT, it is recommended that a different relational database is worth considering to replace the current DB. This DB has many stored procedures, which would need to be modified or written for the new database if a CTIPS is to be replaced. It will take a lot of effort to migrate the data from the current DB to a new DB system. For example, the conversion from the previous database FoxPro to the current Oracle DB took 2.5 years. But if there were some substantial cost savings, it would be a worthwhile effort to replace the current DB with a new one.

Based on our interviews, it is claimed that CTIPS users are comfortable with the current applications, especially for generating needed reports. There is some concern that, if there is any needed change the features of the DB due to some special requirements, the change will affect all users and will not be easily accepted even though the change would be for the better. It is claimed that CTIPS users are satisfied with the current application and do not want any major changes.

5.3 Opportunities for Improvement of the Financial Programming Tools, i.e., CTIPS

From the survey responses we received from the different software companies, we better understand the services and products provided by these companies and have insight into the IT solutions available on the market. Considering the relevance of those services to the CTIPS requirement, we can identify the opportunities for improving the financial programming tools, i.e., CTIPS, currently used by Caltrans. Most of these opportunities exist in the features of the products or software systems that can be used to replace the current CTIPS system. These features are spread over a few areas, such as cloud hosting environment, ADA compliance, security improvement, system scalability and flexibility, vendors' experience, licensing and purchasing, pricing, AI/ML capabilities, data migration, and project management.

5.3.1 *Cloud Hosting*

Based on our surveys, almost all the companies successfully provide the hosting environment and services for the state DOTs for the same or similar products as the CTIPS currently used by Caltrans. Some companies claim that they have been developing SaaS projects for about three decades, and some of them have completed the migration project to replace the old programming system, similar to CTIPS, with their product hosted in the SaaS hosting environment for a few DOTs. For example, some companies claim that their SaaS products for the management of STIP have already been applied by other state DOTs. But the policy from the California Department of Technology (CDT) needs to be followed for any SaaS projects or products to be used by Caltrans.

In the SaaS hosting environment, product updates and deployments are automated without requiring client input, since it is a cloud-hosted solution that can be completely managed from front to backend by the vendor.

Nowadays, many companies have migrated their products and services to the SaaS hosting environment, and it has been demonstrated that it is a secure hosting environment and can offer a variety of services. Some companies offer their own cloud environment, while others can host the application on the client's server if the customer wishes. In addition, some software perpetually hosted on the company's cloud, which can be used as a SaaS installation, can also be available as a perpetual on-premise installation and can be provided on a subscription basis if needed.

5.3.2 *ADA compliance*

Most of the companies on the market have now started to develop applications that are ADA compliant, based on new regulations and policies. The applications are developed based on some modern technologies, such as those in the REACT framework, a framework to create user interface (UI) in web applications and has compatible libraries to achieve ADA compliance.

Some companies offer web-based solutions, which are compatible with different web browsers, such as Google Chrome™. Those web browsers have the necessary components or add-ins for accessibility and offer different options for ADA compliance and requirements based on the needs of the users. These companies are also planning to increase add-on components for their customers in the future releases of their products if the web browser built-in components are not enough for ADA compliance or their customers' specific needs.

Regarding the roadmap to achieve ADA compliance in the new system, based on the responses from the surveyed companies, it is concluded that the roadmap differs from customer to customer and depends on the environment and the application built.

5.3.3 Security Improvements

During the meetings with the CTIPS support provider and the Caltrans IT, we were informed that the CTIPS application itself was secure but code security cannot be guaranteed. Currently CTIPS applications are developed with the Struts framework, which is known to have some security issues, while a new system, such as the one based on Spring framework, could provide a system with higher security. There are companies on the market that offer products with enterprise-grade security, which must meet the high security standards from some of the largest agencies in the country. Some of them perform the annual SOC (System and Organization Controls) 2 audits to make their products SOC 2 certified.

Some companies offer five layers of security, while others could offer even more layers in order to provide a more secure SaaS environment. For example, some companies provide nine security layers, such as: infrastructure security, application security, network security, data security, identity access management, data center security, perimeter security, human security, policies procedures and awareness. There could be additional costs associated with more security layers. The fully deployable cloud-based solutions are believed to be more secure and reliable than the on-prem or any other custom solutions, which are also believed to be cost effective for the customers.

Most of these companies provide backup servers and monitor them 24/7 to ensure their uptime and frequent data backup, which happens every 10 minutes. Some companies offer containerization of their entire infrastructure (containerized applications are gaining popularity and are preferred by many clients) and maintain multiple layers of security. Since they provide a more secure, reliable, scalable, and configurable solution, they can perform a quick implementation of the off-the-shelf system.

5.3.4 System Scalability and Flexibility

Generally, the development, upgrade, and implementation of the software product are offered at a fast pace today. Most of the software products are designed to be flexible, adaptable, and scalable, without additional coding from the client. The system's infrastructure and product design are built to accommodate the growing capacity, needs, and functionalities of all clients, and the latest and

greatest technologies are continually evaluated and incorporated into the infrastructure to ensure scalability for decades to come. If the software companies already have an off-the-shelf system, it is likely that they will continue to invest in and release free product and technical upgrades for all clients in the future.

One of the important aspects of scalability for the programming system, such as CTIPS, is the flexibility to incorporate any technological innovations introduced in the market in order to enhance the performance of the system at any time in any environment. The great news and opportunity are that most software companies on the market can offer products that are easily integrable within different components of the application, and they are flexible with many different levels of product configurations and customizations available. Since each client, such as state DOTs, has different environments for hardware, databases, and software, their products are designed to effectively integrate into multiple environments.

When the product is built in a cloud environment with the latest and upgraded infrastructure and technologies, the system will be more adaptable to new changes. Product updates and deployments are automated without requiring client input, and the vendors can completely manage from front-to-backend. Sometimes it is necessary to add new product features, such as bulk project carryover or performance measures, or to update technologies in the background to enhance user experience and product performance, such as adding security and CDN (Content Delivery Network) services, and all of these changes can be deployed on the vendor's side with the applications automatically updated without requiring any client touch. For example, when a deployment is made for frontend UI changes, the backend also needs to be deployed with the changes supporting the integration with the frontend changes to ensure seamless data transfer from the DB to the backend and to the screen, viewable by users.

5.3.5 Licensing and Purchasing

Currently, the California Department of General Services (DGS) Software Licensing Program (SLP) makes it easier for the California state government to purchase software services or products from vendors participating in this program. While all the software companies have the license for purchasing the software and consulting service directly from them, a few are not aware of this program. Now, more companies have begun exploring such standardized state purchase programs. More detailed information about SLP can be found on the website: <https://www.dgs.ca.gov/PD/About/Page-Content/PD-Branch-Intro-Accordion-List/Acquisitions/Software-Licensing-Program>.

In the past, there were some challenges with states requiring vendors to sell through resellers on these contracts, which some software companies do not want to do because they choose to own the entire implementation and product service, rather than outsourcing it, in order to ensure the highest level of quality for customer experience. But they are open to learning more about the potential advantages of joining the California Department of General Services Software Licensing

Program (SLP). More detailed information can be found on the DGS website: <https://www.dgs.ca.gov/>.

5.3.6 Vendors' Experience in "Programming" Systems

There are several companies on the market that offer cutting-edge solutions to the "programming" systems for many state DOTs, similar to CTIPS as used by Caltrans. For example, one company claims that they have a major transportation customer using their software in a programming capacity; the funding received by this customer for their capital projects comes from multiple sources, including federal agencies, state funding sources, third party and other sources, and toll revenue, and the assets under management by this customer can include train, port, airport, roads, highways, bridges, tolls, and bus systems.

These companies claim that they start by understanding and analyzing the requirements of their customers; evolve their products to specifically reflect planners' needs for the FTIP, FSTIP and other transportation programs, including ongoing changes in regulations at different levels of governments and their impact on programming; and they also consider the interactions between different plans and other programs like long range plans, bike and pedestrian plans, capital plans, call for specific programs, etc. It is also claimed that they understand the nature of stakeholder participants and workflows in the development of transportation programs across multiple agencies, as well as the nuances of how workflows need to differ from state-to-state and agency-to-agency, while meeting a uniform federal requirements framework.

Some companies claim that even though some products, such as those related to STIP management, are not currently used as a "programming" system, their functions and capabilities can be easily added into the current project programming solution by these software companies.

Some of the companies claim that they are aware of CTIPS' programming structure, have used applications similar to CTIPS in the past, and still currently do for their clients in large states, similar to California. But they would need to better understand Caltrans' specific requirements to determine the best approach for detailed solutions, such as placement of pictures, texts, and charts in specific locations and on specific pages.

It should be noted that the identities of the companies are not provided in this report, and the authors do not intend to endorse any product from any company.

5.3.7 Data Analytical Capabilities

Data analytics is an important capability needed for the programming systems to be used by state DOTs. More automation and advanced data analytical functions are needed to expand and enhance the use of the programming system in the future. Some of the "programming" products in the market can provide some automation functions for data input and analysis, such as automated

notifications on change-of-project status, automated notifications on changes in status of plan amendments, automated data error checking, automated tracked changes, and data validation.

More advanced capabilities, such as AI/ML (Artificial Intelligence / Machine Learning), are fairly new to be incorporated into a state DOT's programming application, but there are companies that can offer good data analytics features for programming applications now. For example, some companies use AWS (Amazon Web Service) virtual machines in a virtual private cloud as the hosted infrastructure, and therefore can have access to all AWS's infrastructure features and utilities, which can be applied per the request of the customers. Some software companies are offering an AI/ML central group that can be utilized for various data analysis and forecasting tasks. For example, they plan to apply these ML-based techniques in calculating a future cost based on predictive models created from clients' own historical datasets for some specific projects.

It is worth noting that, if the application is developed in a scalable manner that can accommodate new features, then the AI/ML functions can be easily added and implemented in the future.

5.3.8 Pricing

If Caltrans decides to procure a new system to replace the current CTIPS system, then price is an important factor in selecting the new system. Based on the responses from the software companies, it seems that different companies have different pricing policies for their products and services. For example, the pricing could be based on the customer's needs for the set of product features, the number of projects in the latest cycle of the FTIP/FSTIP/transportation program, and the number of MPO agencies requiring access.

Usually, the companies offer one-time license prices where the cost for each of their products is based on enterprise licensing. That is, one license is required per customer, per product, for unlimited users, and both server and user access licenses are a one-time cost. Normally, there is a one-time, initial implementation to configure, customize, and launch the product. The price for implementation is determined based on consultation between the software companies and the customers, and all implementation costs are one time.

After product launch, a product subscription fee or annual maintenance fee will recur as long as the client continues to access the software. Annual maintenance support normally includes access to software upgrades and technical support, but does not include professional services or consulting to plan, design, configure, test, and train. The companies can offer pricing through a multi-year master agreement, with maintenance for each product renewed annually for the life of product use.

If SaaS licenses are purchased, the software cost is annual, and the fees for annual software maintenance support are usually included in the annual SaaS subscription fees under a SaaS subscription purchase.

Most companies have a fixed price for each of their products, regardless of number of users, i.e., they offer a flat price and do not charge more for more users. But some companies do offer discounts for purchases of multiple products and also for agencies managing over 1,000 projects. The volume discounts might also depend on the type of license purchased, number of users required, and, if SaaS, number of years of commitment.

5.3.9 Migration Plan

If Caltrans decides to procure a new system to replace the current CTIPS system, then a migration plan is another important factor to be considered in selecting the new system. From the responses we received from the software companies, they will develop a specific migration plan based on the current environment for each customer. The major steps in a migration plan can include: understanding and planning; designing, building, and testing; executing; and validating.

Their migration plans are usually customized based on the clients' application setup in the old environment. They will analyze the current hosting environment and the application in the old setup, and then devise a plan to migrate to the new cloud hosting. Most of the software companies prefer doing a cleanup to remove all the unnecessary data before they start migration. They will confirm and review the data with the clients to sort out what data is to be migrated to the new system and what others are to be flagged for cleanup. They will communicate with their clients, regarding the current business process, review and test platform configurations, and offer suggestions to improve the data on the new platform, then they finalize on a sandbox environment for migration before implementing the deployment to the production environment.

Most companies are familiar with Oracle and Oracle-based data migrations as well as SQL Server migrations. Some companies use a grid system from Google Material Design, and they have worked extensively with different grid systems in UI/UX frameworks both from their own product and from working with clients' old systems. Some companies have not worked with a grid system migration, but have addressed migrations from many platforms ranging from mainframe-based applications and databases to Microsoft Access and spreadsheets.

During the migration and implementation period, clients typically can continue using their current system as is. After the new system is completed and implemented, the clients can even continue using the old system in parallel for a short time period if needed.

5.3.10 Project Management

If Caltrans decides to procure a new system to replace the current CTIPS system, then a detailed, sophisticated, and robust project management plan must be prepared. Most vendors have an extensive and specific team to carry out all project implementation and have thoroughly researched the best practices that are to be followed when defining the steps and implementing them.

The software companies will generally discuss the scope of the project with the customer first. They would understand the customer's vision for the new system and help them understand the advantages and disadvantages of each process. They would chart a project agenda based on the customer's requirements and draft a statement of work with the client to clarify and understand their product needs for which product modules are applicable, the level of configuration, and any customizations that may be needed. Once the statement of work is ready, the software company will design the contract, sign it, and lead the project implementation: to import the data, configure the product, and perform testing. They will have periodic meetings with the client in the process.

The project implementation can include such major steps as definition, implementation, data migration, stabilization, certification, deployment, and maintenance. During the stabilization stage, the quality assurance team performs rigorous integration and regression testing to ensure software completeness before releasing it to the customer. During certification, the pre-defined tests are performed with the customer to verify all functionalities as documented correctly.

Generally, the vendors will take care of everything that needs to be done from the clients' end to import the data, configure the product, and perform testing. What they need from clients is to provide their data in a timely manner, answer any questions the vendors may have during data validation and review and product configuration and customization, and then perform a final review of imported data and platform testing before launch. A training session usually will be provided after the launch of the new system.

Some companies have a live product demo to show how the product works, and a smaller component of their product is in the automated public website companion module, which can be checked freely at any time.

Some software companies have implemented and launched their products in as quickly as 3 to 6 months, while a more complex implementation can take 12 months or more. Implementation timing will vary depending on various factors, such as which and the number of product modules requested, the quantity and complexity of modifications to the out-of-the-box ("OOTB") standard product, the number and complexity of integration sources and interface points, and the availability of data provision from client.

5.4 Recommendations for Improving the Financial Programming Tools, i.e., CTIPS

Based on the interviews with Caltrans IT and the CTIPS support provider, and the survey responses from the other software companies, we made a few recommendations for improving the financial programming tools, i.e., CTIPS.

The short-term goal for Caltrans is to fix the readability issue by re-coding the application using an advanced and enhanced framework for both the frontend and backend, while assuring security of the code and the overall system. Since the current application is built on an old Struts

framework, which requires certain propriety and conventions for the implementation of the software, even just to make the application partially ADA compliant, it is necessary to unsnap the entire application to identify the root of the problem. Based on our interviews, this process would be difficult and time consuming, and there is no guarantee that ADA compliance will be fully met. Based on our understanding and analysis of the original design and framework of the CTIPS system, it seems that there is not much benefit from trying to fix the current application in order to achieve full ADA compliance.

Regarding security improvements, some short-term measures can be applied. For example, a multi-factor authentication process can be implemented if it is deemed necessary based on Caltrans security policies. As for the Struts framework, the development platform for CTIPS, it has some fundamental security issues, and the security issues for the application cannot be fixed without changing the current platform.

Therefore, we think that the current CTIPS application should be replaced with a new system. It should be put through the software development cycle of planning, design, implementation, and testing phases in order to develop a new system that is more secure, flexible, scalable, adaptable, and sustainable in the future. For example, the new application could be hosted in a secure SaaS environment, which allows for automatic application upgrades and changes without involving the customer in the future.

We recommend a new system replace the current applications of CTIPS from various perspectives, such as hosting environment, vendor selection, ADA compliance, security improvement, scalability and flexibility, database and user access, ML/AI and data analytics features, procurement platform, product license and price, migration plan, and project management.

5.4.1 Hosting Environment

We recommend that the current CTIPS be replaced with a new system hosted in a SaaS or any cloud-based environment, which can be vendor-hosted or hosted by any third party. There should be no need for Caltrans to buy an additional server or other software. The application should be automatically upgraded and updated in the future. The SaaS offering should be configured jointly by the vendor and Caltrans, which should give an advantage to Caltrans to either scale up or down the application depending on performance.

The benefits of SaaS include reduced time spent on installation and configuration, mitigation or elimination of the issues for software deployment, and savings of cost for maintenance. The SaaS application deployment requires little or no software installation on the client side, so there is little or no risk of configuration. The overall distribution cost will be low as the client will not need to purchase complex software packages. All clients of the vendor will receive any new upgrade or enhancement for the SaaS environment, and therefore any additional or new cost will be shared by the clients in the SaaS environment, which can achieve significant economies of scale. Since the SaaS provider usually owns its hosting environment, maintenance and other operation costs

will be split among all the customers that use those solutions. Whenever an application is hosted in SaaS, it exists in a cloud scalable environment that allows integrations with other SaaS offerings.

It is also worthwhile to note that, while the SaaS hosting environment is preferred to standard or traditional hosting ones, currently the budget needed for the SaaS environment is usually higher than that for the traditional environment.

5.4.2 Vendor Selection

Since the SaaS hosting and its implementation is fairly new to the market, the more experienced product vendor and service provider would be better suited to perform hosting the CTIPS system. The particular experiences and expertise of the companies in replacing CTIPS with a new system mainly depend on the number of years they have successfully been providing the hosting environment and services for the state DOTs for the same or similar purposes.

Based on the responses from the software companies, some developed related software products for some state DOTs in the past. Some companies have even provided competitive solutions and developed programming systems for a few DOTs, which is similar to California's CTIPS system.

Therefore, we recommend that Caltrans consider several options for a new system with the products already available in the market and identify a few companies as candidate vendors suitable for developing the new system for CTIPS.

5.4.3 ADA Compliance

Full ADA compliance is the most pressing issue that needs to be fixed as soon as possible. Since the current application is coded using a library for the grids that is not ADA compliant, achieving ADA compliance in the application is difficult. In order to make CTIPS ADA compliant in the current system, the application must be coded again from scratch using a new library which be a timely and costly effort. Also, fixing the issues for some of the grids cannot guarantee the ADA compliance for the overall system.

For the new system to be hosted in the cloud environment, the application could easily be made ADA compliant, since ADA compliance could be addressed from the start when a new system is going to be applied to replace the current CTIPS.

Therefore, instead of fixing the issues partially in the current system, we recommend that the application for the new system be applied in the future, which should be coded from the beginning using advanced frameworks such as REACT, Angular, or Vue JS for the frontend and a more advanced framework for the backend, since the current Struts framework has already been proven not to be secure enough and any changes on the frontend will also require changes on the backend.

5.4.4 Security Improvements

Since the Struts framework currently applied in CTIPS is known to have some security issues, we recommend that the system be moved to a newer version of Spring, which can better handle the issues and provide an active development platform. For example, Spring Boot has been gaining popularity among many companies who have used the framework to build their software.

Based on the responses from the software companies, a wide variety of security environment setups can be offered based on their clients' needs and requirements. It has also been proven that the more layers of security in the system, the less chance of an attack. Therefore, we recommend that the new system be coded using a more secure, advanced, and reliable framework for both the frontend and backend, and also support the migration from Struts to the new system. The new application should have as many layers of security as possible within the allowable budget.

In addition, currently, the security check and test for any attack in the CTIPS system is rarely performed. More security tests need to be done periodically and the results need to be recorded for the new system in the future.

5.4.5 Scalability and Flexibility

We recommend that a new scalable system, on a good and reliable infrastructure, should be designed and built for CTIPS, in order to accommodate the growing capacity, needs, and functionalities of all CTIPS users. A scalable system will reduce the cost of upgrades, as the improvements and enhancements can be incorporated very easily into the application.

The software company should have an off-the-shelf system where the product and technical upgrades can be completed free of cost for the clients, and the vendor should provide a highly configurable solution without customization to accommodate a wide range of clients' requirements, processes, and preferences. When there is any new and major feature upgrade required in the new system, it is the vendor who should design and develop the change. For instance, if it is determined that the CTIPS system will continue with the current database, then the application integration should be hassle-free, since the application and the database might be hosted in different environments.

On the other hand, the new system should also be flexibly developed and designed so that Caltrans can make some minor changes in the applications whenever needed in the future, without constantly involving the vendor.

The system should be designed to behave according to the number of users logged in for the particular session: scaling up the resources and functionalities when the users load is high, and reducing the system resources when the users load is lower. This will optimize the overall efficiency of the system and achieve cost-savings, which is one of the benefits of having a scalable application.

The scalable application will not only manage different loads of traffic accordingly, but can also increase the user experience, since it does not require vendor's assistance with application deployment and upgrade. Hence, the application scalability should be implemented from the start.

Depending on the requirements and scale of the implementation, the application server can be scaled both vertically (adding resource to the application server) and/or horizontally (adding additional application servers in parallel), and the database server can be scaled both vertically (adding resources to the database server) and/or horizontally (clustering database servers via the database vendor's native functionality). The software should be designed with the ability to integrate with nearly any type of third-party system.

We also recommend that periodic testing is performed to observe the extent of the scalability of the application and investigate at which point (break point) the application might lose its characteristics to scale, which would help the team backtrack the problem and find solutions.

5.4.6 Database and User Access

By replacing the current CTIPS applications, the existing Oracle database can also be replaced with a good relational database with possibly a better price and more useful and advanced features. The code security can also be improved by using more secure frameworks in both the frontend and backend of the new system.

It is recognized that different vendors offer different packages of IT solutions, such as SQL, NoSQL, .NET, cloud-based SaaS, etc. Currently, Caltrans IT department is moving away from an Oracle-based platform to a Microsoft SQL-based one, while some systems in Caltrans might continue to use the Oracle database.

Within the application itself, a robust set of user access rights and rules should be clearly specified to define what data the users from different agencies and roles can see and what actions they can perform, so that the system can maintain automated safeguards to ensure data integrity and security.

5.4.7 ML/AI and Data Analytics Features

ML/AI and other data analytical capabilities are beneficial and needed to expand and enhance the use of the programming system in the future. Such capabilities include forecasting and estimating some needed metrics, identifying possible alerts and problems in the early stages, providing quantitative support tools for other related decisions, and analysis for programming purposes.

The feature of adding ML/AI and other data analytics to the CTIPS system will also help intelligently manage data and avoid any unnecessary accumulation of data in the system. We therefore recommend that Caltrans request that the software vendor incorporate some data analytics features, including ML/AI, into the new CTIPS system.

5.4.8 Procurement Platform

The Software Licensing Program (SLP) is administered by the California Department of General Services, Procurement Division which helps simplify the procurement process for the companies that sell the software products to the state government of California. Therefore, it is recommended that Caltrans first conduct a search for companies offering services under the SLP (<https://www.dgs.ca.gov/PD/About/Page-Content/PD-Branch-Intro-Accordion-List/Acquisitions/Software-Licensing-Program>) and investigate whether a new system to replace the current CTIPS can be purchased through SLP.

Many software companies are unaware of this program or have not participated in it, but they could request a placement on the SLP. Based on our survey, most companies are interested in knowing details about this SLP. There is a great opportunity to publicize more to make more software companies aware of this SLP and offer them more resources so they know more about the program, which could make the procurement of their expertise, service, or products easier. For example, based on the surveys from MPOs and other states, we can identify the companies who can provide similar tools, products, or services that can be used to develop a new CTIPS system, and then encourage these companies to join the SLP for easier procurement in the future.

Lastly, while we should encourage potential vendors to sell their products and services through the SLP, which should be more beneficial and easier for Caltrans, a competitive bidding process could be required to complete the procurement process if not through SLP.

5.4.9 Product License and Price

Caltrans should take advantage of any possible discounts for the price associated with the features of the product and service. While some companies might offer a standard license with the cost irrespective of the number of users for the application, some other companies offer a base price for the usage for a particular number of users and then increase the amount depending on the number of users. Based on the number of potential users requiring the access to the application, Caltrans should be prepared to choose a best and most efficient plan that would benefit all the users.

If the current Oracle database is replaced by a different and new database, then the cost should also be taken into consideration for the overall system. Based on the response from the software companies, any good relational database in the market would be a good fit for the new system, but the vendors of the applications should be consulted on which one should ultimately be selected.

It is recommended that the total cost should be considered in selecting the vendor for the new CTIPS system. This might include license cost, implementation cost, annual maintenance cost, consultation and training cost, costs associated with the number of users, cost for future upgrading, cost associated with the database, and various discounts associated with the features of the systems and the number of users.

5.4.10 Migration Plan

Software companies generally customize the migration process for each of their clients. They generally take the client's old data and import them into their system using the company's tools that can automatically process the configuration of the product.

We recommend that the vendor research the current CTIPS setup first, and then provide different options on how the data configurations can be carried out. Caltrans needs to work with the vendor to help them understand the business process, and the functions and capabilities of the CTIPS system before the data migration plan is developed. During the implementation, Caltrans should request access to the server to periodically test the new environment and provide feedback to the vendor so that the issues can be fixed before go-live (deployment to the production environment).

During the migration period, Caltrans should be able to continue using the current CTIPS systems as usual. When the new system is completed, Caltrans should be allowed to use both the old and new systems for a short time period. It is also recommended that all the old data are backed up in a storage server for at least 10 years before they are completely deleted.

5.4.11 Project Management

Caltrans should set up an advisory committee to oversee the implementation of the whole project, which can include staff from various divisions such as financial programming, IT, procurement, etc. Caltrans should help the selected vendor understand the business process, requirements, and needs of the new CTIPS systems first. Then a scope of work or scope of project should be clearly designed and defined jointly by the vendor and Caltrans, which should include such details as the level of configuration and level of customization of the system. The detailed timeline, deliverables, and meeting schedules should also be listed.

Since the vendor will fundamentally take control of all the components and steps during the project replacement process, we recommend that, before the project starts, Caltrans request a road-map and plan from the vendor on all the detailed project management information including how the end product will look and all the necessary changes that will be made, and then periodically meet and review the progress and possible adjustments during the implementation process. A backup and contingency plan should also be prepared jointly by the vendor and Caltrans.

After performing the final testing and launch of the new system, the vendor should provide a training session to help Caltrans staff and users understand the new system for their routine tasks.

6. Summary & Conclusions

The goal of this project was to evaluate the current financial programming processes and tools, i.e., CTIPS, and explore various new solutions and options which will maintain the current functionality of CTIPS, meet legislative guidelines for ADA compliance, ensure security of the system against attacks, and also have sufficient scalability and capabilities for integration with other systems that share CTIPS data and enhancement in the future. To achieve this goal, we completed the following tasks: identified the risks associated with the current financial programming processes and tools, i.e., CTIPS; identified opportunities for improvements to the financial programming processes and tools, i.e., CTIPS; compared the processes in California with currently recognized best practices as well as with the processes and tools used in the other 49 states in the U.S.; and made recommendations for the improvement of the financial programming processes and tools, i.e., CTIPS.

In Section 2, we provided an overview of the current Caltrans financial programming processes and tools and analyzed and assessed existing financial programming business processes. This is based on the review of current and historical documents, interviews, and surveys of the customers of the Division of Financial Programming. This helped us understand the current issues and problems of the financial programming process, and the customers' expectations and desire from the financial programming process.

In Section 3, we researched the national market for programming systems as used by the DOTs of the fifty U.S. states and the District of Columbia. The survey covered a variety of questions and areas, such as whether there is a dominant commercially available system, security practices, programmatic usage, financial interfaces, other interfaces, and input methods. We concluded that there are no dominant commercial systems in the market for DOT STIP programming, although six of the seventeen DOTs that do utilize commercial systems use one product. We found that a clear majority of DOTs use their own in-house systems, and most DOT STIP programming systems appear to have room for improvement in their financial interfaces.

In Section 4, we recommend mid-level business-based requirements for a future CTIPS replacement system and associated processes. Our recommendations spread across a variety of areas, such as automation and workflow; batch upload; Caltrans IT strategy; compliance and audits; custom reports and information for RTPAs, MPOs, and Caltrans units; data storage, dates, and milestones; data validation and integrity; federal processes and systems; Geographic Information System interface; hand entry of data; interfaces with Caltrans systems; interfaces with RTPA and MPO systems; notifications and alerts; replacement of existing systems; security; splits and combines/project identification; statewide reports and reports to the CTC; training, coordination, and information sharing; and use of funds.

In Section 5, we identified the risks associated with the tools used by the current financial programming processes, i.e., CTIPS, identified the opportunities for improvements to CTIPS,

and then made recommendations to improve CTIPS. Our recommendations cover 11 different areas, such as hosting environment, vendor selection, ADA compliance, security improvements, scalability and flexibility, database and user access, ML/AI and data analytics features, procurement platform, product license and price, migration plan, and project management.

It is expected that our research results will help Caltrans better capture the current data needs and future analytics requirements and enhancements, and develop a comprehensive plan for the next steps involved, so that Caltrans can utilize resources more efficiently, make the reporting process more effective, and improve the department's transparency in communicating about the cost, scope, and benefits of current and planned projects. Our research project will also help Caltrans make an informed decision about modernizing and upgrading an essential programming database, and get a comprehensive picture of the unbiased options that can help structure the existing functions and potential upgrades to the California Transportation Improvement Program System.

Appendix A. Text of the Online Questionnaire

The following is the text of the online questionnaire submitted to DOTs (see Chapter 3):

The California Department of Transportation (Caltrans) has hired a research team from San José State University to make recommendations for the improvement of the processes and tools that it uses to commit funds to transportation projects. The research team is made up of Dr. Wenbin Wei and Dr. Nigel Blampied.

We would like to know what systems other states use in assigning funds to transportation projects. To this end, we request you to complete the questionnaire below by June 30, 2021.

The questionnaire should take less than 7 minutes to complete.

Your participation in this study is completely voluntary. You can refuse to participate in the entire study or any part of the study without any negative effect on your relationship with Caltrans or San José State University. You also have the right to skip any question you do not wish to answer. Your completion of the questionnaire indicates your willingness to participate. There is no compensation for participation.

We ask for the following information about you: name, e-mail, telephone number, and government agency employer. Your name, e-mail, and telephone number will not be included in any reports, except that your participation and your agency will be acknowledged unless you or your agency prefer not to be acknowledged. We expect that our report will include an appendix listing the responses from each state. In some cases, we might find that you have provided exceptional information, and may wish to refer to your agency in association with that information. Such a reference, however, will not be made without consulting you or your agency.

If you have any questions about this research, please contact Dr. Blampied at nigel.blampied@sjsu.edu.

Q1. Your name (optional)

A text box was provided for the response

Q2. What agency do you represent?

A text box was provided for the response

Q3. So that we may follow up with you if needed, please provide your email address.

A text box was provided for the response

Q4. What is the name of the electronic system that you use to commit funds to transportation projects?

A text box was provided for the response

Q5. Is this a commercially available system?

☐ *Yes*

☐ *No*

Q6. If it has a commercial name that is different from the name that you use, what is the commercial name?

A text box was provided for the response

Q7. Is the system public-facing (visible to the public) or secured behind a firewall (visible only to agency staff)?

☐ *public-facing*

☐ *behind a firewall*

☐ *Other (we may follow-up with you to get information)*

Q8. Has the system been determined to be ADA compliant?

☐ *Yes*

☐ *No*

☐ *Other (we may follow-up with you to get information)*

Q9. For sign-on, does the system use a two-step process or other advanced security beyond a simple password?

☐ *Yes*

☐ *No*

Q10. If it requires advanced security, what is required (please check all that apply):

☐ *Code sent to email or phone?*

☐ *Security token (e.g., USB stick)?*

- ☐ *Challenge question(s)?*
- ☐ *Biometrics (iris, fingerprint, etc.)?*
- ☐ *Third party authenticator (Google Authenticator, AUTH, Microsoft Authenticator, Duo, etc.)?*
- ☐ *Other (we may follow-up with you to get information)?*

Q11. Which project phases is the system used to manage (please check all that apply):

- ☐ *Preliminary Engineering?*
- ☐ *Construction Engineering?*
- ☐ *Right-of-Way staff work (appraisal, acquisition, etc.)?*
- ☐ *Right-of-Way capital?*
- ☐ *Construction capital?*
- ☐ *Other (we may follow-up with you to get information)?*

Q12. Does the system reconcile the authorized funding with actual expenditures to show the balance of funds remaining?

- ☐ *Yes*
- ☐ *No*
- ☐ *Other (we may follow-up with you to get information)*

Q13. Does the system interface with the agency's accounting system for purposes of expenditure authorization?

- ☐ *Yes*
- ☐ *No*
- ☐ *Other (we may follow-up with you to get information)*

Q14. Does the system have a method for tracking situations where a single environmental document provides environmental clearance for multiple sets of plans, specifications, and estimates?

- ☐ *Yes*

- ☐ *No*
- ☐ *Other (we may follow-up with you to get information)*

Q15. Does the system generate data or forms for federal authorization?

- ☐ *Yes*
- ☐ *No*
- ☐ *Other (we may follow-up with you to get information)*

Q16. Does the system interface with (please check all that apply):

- ☐ *Geographic information systems?*
- ☐ *The agency's construction management system?*
- ☐ *The agency's right-of-way management system?*
- ☐ *The agency's environmental permitting system?*
- ☐ *The agency's annual budgeting system?*
- ☐ *The agency's project management system?*

Q17. Do you (please check all that apply):

- ☐ *Allow hand-entry of individual project data by your agency's staff*
- ☐ *Allow batch upload of data for multiple projects by your agency's staff*
- ☐ *Allow hand-entry of individual project data by MPOs*
- ☐ *Allow batch entry of data for multiple projects by MPOs*
- ☐ *Other (we may follow-up with you to get information)*

Q18. Does the system track each project's expected contribution to the state's performance targets under MAP-21?

- ☐ *Yes*
- ☐ *No*
- ☐ *Other (we may follow-up with you to get information)*

Q19. Are there other features of the system that you consider to be relevant or anything you would like to add that might assist in this study?

A text box was provided for the response

Q20. May we contact you if we need additional information? (we will need your email address above)

☐ *Yes*

☐ *No*

Q21. Would you like to receive a copy of our report? (we will need your email address above).

☐ *Yes*

☐ *No*

Thank you for taking the time to complete this questionnaire. Please click on the arrow to finish.

Appendix B. Recommendations and Requirements as they Appear in the Sources

As noted in the report, the present study is the fifth study of financial programming that Caltrans has conducted since 2000. Previous studies were conducted in 2000, 2004, 2012, and 2013. Some issues have persisted throughout this time, with problems identified in 2000 continuing to be raised in 2021–2022.

Between them, these studies proposed 278 possible requirements or recommendations, which are listed in the table below. They are grouped under the 19 recommendations in Section 4.3 of this report, plus a grouping of prior recommendations that are excluded from the recommendations made in this report.

Recommendations Regarding Automation and Workflow

2000 Feasibility Study Report

Eliminate redundant input.

Provide the capability to move project level data seamlessly through the various programming documents.

2004 Business Process Review

Capture standardized data at its source.

Expedite review cycle by using workflow and electronic signature approvals.

Upon approval of a STIP or SHOPP amendment, automatically create FTIP amendments and electronically route the requests to MPOs.

2012 Business Case

Apply an on-line iterative review for data that is processed through the system in order to complete the applications processes for the fund program types

Automate the 150-plus program and/or project forms that partners are currently submitting to Caltrans for project transactions

Automate the Program “Application” processes and “Call for Project” processes including input from required stakeholders

Automate the Project Amendment process and automatically reflect approved changes in Programming data system modules

Capture allocation results, including delegated project allocations, CTC outcomes

Capture Data entry on all activities performed on the following projects transactions: Initial allocation data, Adjustment data, Authorizations data, Obligations data, Apportionment data, Expenditures data

Electronic approval signatures on processes executed within the system, where legally allowed

For SHOPP projects, electronically process the approval of the Project Change Request (PCR)/amendment request document for STIP projects

Log user transactions for agreed upon business needs so that transactions are traceable to original user

Module will support iterative review process that allows agreed upon users to refine scope, schedule, cost, and priority of projects

Official CTC actions can be transmitted via the new system to all impacted stakeholders

Process time extension requests (Example SB45) electronically and automatically reflect approved changes in Programming data modules

Provide an integrated process for processing federal and State requests

Provide an online iterative review process for E-76s

Provide on-line business requirements “Checklist Pop-up” for each type of project transaction so that users have quick access to the requirements in order to submit the transaction successfully

Support an iterative process to refine and finalize Statewide Programming lists, by Program type, District, Region, and Agency

Support the development and management of the Interregional Transportation Improvement Program (ITIP) List

System designed to conduct iterative review of data including the ability to electronically approve or reject transactions at agreed upon authorization points at the Program and/or project levels

System designed to conduct project “close-out” process by developing tools to automate the review and close checklist

System to provide the ability to generate approval letters signaling any negotiated conditions approved by the Federal Programming Chief and Program Manager(s) in Caltrans Ability to develop, edit, and generate rural non-MPO Project Listing based on information on all adopted STIP and approved SHOPP projects

This web-based tool to use standard document templates for all project transactions and processes statewide. New project requests submitted through this web-based tool will also contain verification functionality to ensure that the request has funding and is “programmed” for an approved action by the requesting agency.

2013 Feasibility Study Report

Upon implementation of the new system, new templates for project transactions will be standardized for use by all external Caltrans partners.

Upon implementation of the proposed solution, the new system will automate project transactions which includes the conversion of approximately 219 forms and processes, greatly reducing the amount of paper used.

Upon implementation of the proposed solution, this new system will maximize communication, dataflow, and partnership with external stakeholders by creating a single IT tool for direct access to required data for Caltrans, its partners, and Control Agencies (FHWA, FTA, CTC, etc.).

Upon implementation, the new system will replace manual subvention fund management processes with more automated processes in electronic format.

Upon implementation, the system will improve tracking for project fund allocations by creating a single data source for federal, state, and local funds allocation (including split funds), thereby reducing reports development time for Program Managers by 45%.

2021–2022 Study

The new system should provide the workflow to generate request forms that permit Districts, RTPAs and MPOs to draft changes in the database that can then be approved by Caltrans headquarters and CTC personnel as appropriate.

Recommendations Regarding Batch Uploads

2012 Business Case

Develop a “batch” import process with existing MPO IT systems that already electronically process FTIP information to Caltrans.

Develop a web-based tool so that external partners can submit project documents and transactions for the following processes: New transportation projects; Existing project change transactions related to Scope, Cost, and Schedule; Fund allocation transactions and award; supplemental fund transactions; splitting or combining existing projects; Agreements processing; Milestone data based on agreed business rules.

Module to allow RTPAs to electronically develop and or submit Programming Lists with nomination data, candidate data, and/or project data.

2021–2022 Study

The new system should allow batch upload of data for multiple projects by designated Caltrans district employees for projects within their jurisdiction.

The new system should allow batch upload of data for multiple projects by designated Caltrans employees.

The new system should allow batch upload of data for multiple projects by designated MPO and RTPA employees for projects within their jurisdiction.

Recommendations Regarding Caltrans Information Technology (IT) Strategy

2013 Feasibility Study Report

Upon implementation, establish the IT infrastructure and technical foundation for future business improvement.

Recommendations Regarding Compliance and Audits

2000 Feasibility Study Report

Provide the capability for a project and document level audit trail.

2012 Business Case

Allow users to check fund accounts to ensure funds are available; when funds are not available, do not allow authorization request to continue

Automatically calculate and ensure that obligation funds do not exceed available federal funds

2013 Feasibility Study Report

Upon implementation, Caltrans will comply with control agency regulations (Ex. AB 1012, Moving Ahead for Progress in the 21st Century (MAP-21)) to integrate and manage Caltrans data more efficiently, which is the final identified phase in the IFMS plan for Caltrans.

Upon implementation, the new system will increase project monitoring capabilities designed to increase project delivery compliance with federal and state regulations.

Upon implementation, the new system will increase the capability for stakeholders to ensure accountability for federal and state funds for Caltrans and local projects.

Recommendations Regarding Custom Reports for RTPAs, MPOs, and Caltrans Units

2000 Feasibility Study Report

Generate proposed and adopted transportation programming documents with project listings for multiple programs such as State Transportation Improvement Program (STIP), Federal Transportation Improvement Program (FTIP), Highway Bridge Rehabilitation Program, and Railroad At-Grade Crossing Program with opportunity for documentation of votes, awards, and amendments.

Make milestone data available to meet needs of internal and external customers.

Provide information that is timely and integrated with the other components of project management, i.e., project baselines and current plans, time sheet, budgeting (funding), expenditure, and region/district portfolio management.

Provide project information to project stakeholders.

Provide the ability to automatically create standard reports based upon pre-determined conditions.

Provide the ability to generate standard and ad hoc reports for functional and project managers at various levels of detail. The reports are to include fixed format and user definable formats.

2012 Business Case

Create “Canned Reports” based off of existing reporting needs of all stakeholders

Information will be available to stakeholders based on agreed upon business needs

Provide “real-time” ad hoc reports for business decisions of essential stakeholders including the following parameters: District, Program Type, Agency, Regional, and State

2021–2022 Study

Caltrans Financial Programming should provide program Supplements.

Caltrans Financial Programming should provide project lists identifying funding sources to program in the FTIP, for example, new Active Transportation Program projects awarded, or new apportionment distributions issued.

The new system should include updated forms, program/programming changes and information

The new system should provide funding and programming details on programmed projects.

The new system should provide a complete funding picture of programmed projects. At this time, federal, local, and other non-State funds committed on programmed projects are not always included in their CTIPS database. For these funds to be included, someone has to make the request, which does not always happen. For this reason, some projects do not have a complete funding picture.

The new system should provide a single source for backup lists for local grouped projects such as HBP, HSIP, etc. and provide for batch-entry or transfer of data for the FTIP. (This responds to a note from a local agency: "I have to manually enter into CTIPS and manually enter a financial spreadsheet and submit to Caltrans. Way too much hand-entry. Caltrans controls the apportionments and, in many cases, the projects which are selected for grant funding such as HBP and HSIP. They enter and control their SHOPP projects, control the STIP...etc., manual entry into the FTIP does not make sense.")

CTIPS should be expanded or updated to enter Performance Reporting requirements such as PM1, 2, or 3. Also, if you are a non-attainment area and receive and program CMAQ projects, you should be able to click a box and a new tab appear in order to enter emissions reductions requirements. This would GREATLY facilitate the annual reporting requirements to FHWA. Makes sense instead of 18 separate regions reporting.

The new system should provide additional project and phase details for the annual CMAQ-specific obligation/de-obligation reports including the project sponsor, the phase of work, and the total cost of the project/phase being obligated/de-obligated.

The new system should provide an annual or semi-annual list that highlights the list of investments going to the NHS.

The new system should provide annual obligation transactions including: All federal programs, CMAQ-specific transactions, and CMAQ-specific transfers to FTA.

The new system should provide annual programs of projects for Caltrans and CTC managed programs including: 5310, 5311f, Statewide ATP, HBP, HSIP, Railway-Highway Crossings (Section 130), Recreational Trails Program, SHOPP, and the Tribal Transportation Program.

The new system should provide drafts of action items for the CTC agenda prior to finalization so errors can be caught and corrected. It should also provide confirmation of what action was taken by CTC.

The new system should provide Fund Code and Program ID assignments for new programs and cycles of programming.

The new system should provide grouped listings (from other databases, such as HBP, HSIP, SHOPP) that are transferred automatically into CTIPS. It should also provide reports that satisfy reporting requirements such as Performance Measures and emissions reporting requirements for CMAQ, as examples.

The new system should provide lists of potential projects for ITIP consideration and PPRs for those projects.

The new system should provide PPNO and federal project numbers as soon as they are created for various programs. Including but not limited to: SCCP, TCEP, LPP-F, LPP-C, ATP, STIP.

The new system should provide project information for the FTIP including backup lists, and amendment update requests as well as apportionment levels and RTIP PPRs.

The new system should routinely publish list of toll credit balances. Further the list should include a summary of what regions are generating the toll credits and what regions are using the toll credits.

Recommendations Regarding Data Input, Storage, Dates, and Milestones

2000 Feasibility Study Report

Provide the ability to maintain a department wide project inventory containing information at each key point in a project including transportation improvement needs, a region/district's candidate projects, and projects that are approved by the California Transportation Commission (CTC).

2012 Business Case

Ability to archive project history including scanned attachments and uploaded files into the system

Ability to develop, edit, and generate non-STIP/SHOPP projects that are programmed in non-MPO areas.

Develop status "Dashboard" on the online tool for partners to view status of identified, essential, and agreed upon data elements

Maintain Vote Box data for CTC transactions:

Module data entry managed by required stakeholders based on agreed upon business rules

Store ITIP data including “Scratchpad,” historical, and future cycle data

System management and maintenance of data for 10-year biennial SHOPP Plan

System management and maintenance of data for 4-year biennial SHOPP Plan

System will capture Fund Program specific eligibility criteria and milestones based on user data entry

System will contain and manage project information (including milestone data) with “real-time” access by users

Vote box lists and attachments will be stored in database based upon agreed business rules

2013 Feasibility Study Report

Upon implementation, external partners will be able to directly input information electronically to Caltrans (Reports, electronic signature, project invoices, applications, and attachments, etc.) where feasible.

Upon implementation of the proposed solution, the system will provide functionality for internal and external stakeholders to capture project notes and other miscellaneous data in one database.

2021–2022 Study

If a future consideration of funding resolution was approved, the new system should show the date of approval

The new system should show the Env Cert date, RW Cert date, type of RW Cert, and funding request from the BEES

The new system should provide fillable PDF files that accommodate different programs, including PPM.

The new system should track each project’s expected contribution to the state’s performance targets under MAP-21.

Time extensions and supplemental votes and Greater than 120s need to be captured in the SHOPP side of CTIPS. They are captured on the STIP side, but not on the SHOPP side.

Recommendations Regarding Data Validation and Integrity

2012 Business Case

Implement agreed upon system validation and security rules to ensure consistent state-wide data management for impacted stakeholders

System will contain validation rules on submitted transactions based on agreed upon business rules

2013 Feasibility Study Report

Upon implementation, the solution will define and isolate project data to a single data source/system in order to promote data ownership and enforce referential integrity.

Recommendations Regarding Federal Processes and Systems

2012 Business Case

Ability to insert a reviewers' comments and provide capability to route E-76 along with comments back to lower review levels for rework

Allow FMIS response data to be disseminated to accounting systems

Allow MPOs to record their boards approval, via electronic signature, and automatically route the FTIP to Caltrans for review and approval

Develop tool for on-line data submittal of E-76 from the local partners to Caltrans

Electronic transfer in "real time" to update FHWA with project E-76 information (via FMIS system)

Electronically process and automate the FHWA FMN-76 (E-76)

Implement validation parameters on E-76 process to error check prior to submission to Caltrans

Interactive access to Federal Resources data (FADS v.2.0) to verify current funding status and availability prior to E-76 transaction approvals

Obligation Authority funds automatically updated based on FHWA approvals for E-76 transactions

Online "real-time" editing of E-76 to ensure accuracy and completeness of data

Verify current funding status and availability prior to E-76 transaction approvals

2013 Feasibility Study Report

Upon implementation of the proposed solution, reconcile multiple Caltrans and external project systems to CTC, FHWA, and federal Fiscal Management Information System (FMIS) data/reporting.

2021–2022 Study

The new system should generate data and forms for federal authorization.

The new System should inform Caltrans Local Assistance on any programs that are receiving FSTIP amendments, and on any particular FSTIP amendment.

The new system should provide Caltrans Local Assistance with FSTIP amendments that are applicable to the projects that they provide oversight for.

The new system should provide requests for approvals of both FTIPs, FSTIP, and associated amendments.

Recommendations Regarding Geographic Information Systems

2021–2022 Study

The new system should include location data for each programmed project that permits each project's location to be identified in the Caltrans-approved geographic information systems.

Recommendations Regarding Hand Entry of Data

2021–2022 Study

The new system should allow hand-entry of individual project data by designated Caltrans district employees for projects within their jurisdiction only.

The new system should allow hand-entry of individual project data by designated Caltrans employees.

The new system should allow hand-entry of individual project data by designated MPO and RTPA employees for projects within their jurisdiction only.

Recommendations Regarding Interfaces with Caltrans Systems

2000 Feasibility Study Report

Integrate financial data as appropriate from the Transportation Accounting and Management System (TRAMS) and Local Programs Accounting and Management System (LPAMS).

2012 Business Case

Agenda and Book Items using existing system data from Funding and Programming modules based on agreed upon business rules

Automate the fund advertisement process to all applicable stakeholders for Categorical Federal and State Programs

Automatically populate as many data fields as possible based on demographic, boilerplate, template, and existing stakeholder data

Automatically update all impacted system modules with CTC transactions and data updates

Interface with external systems as applicable in order to transmit necessary funding data for projects (AMS Advantage, FADS, FMIS, etc.)

Provide for the FMIS response to be electronically processed and sent back to Caltrans with real-time transmittal capability to stakeholders

System designed to interface with essential external and internal systems related to project programming, implementation, and budgeting.

2013 Feasibility Study Report

Upon implementation, the completed system will provide a seamless, updated interface for existing legacy systems and other infrastructure components maintained by Caltrans and external stakeholders.

Upon implementation, the new system will update existing applications and interfaces to strengthen data integrity.

Upon implementation of the proposed solution, the new system will eliminate the duplication of data currently contained within multiple Caltrans systems (CTIPS, FADS, LP2000, ODIS, E-FIS, etc.) through integration.

2021–2022 Study

The new system should interface with the planning Multimodal Operational Transportation Equity Report (MONSTER) List which is currently an Excel spreadsheet but will soon be in Smartsheets.

Recommendations Regarding Interfaces with RTPA and MPO Systems

2000 Feasibility Study Report

Provide the capability for on-line database access by regional and federal agencies.

Provide the capability of electronically moving operational data between Caltrans and the regional and local agencies.

2012 Business Case

Create new system module that allows external partners to submit application/candidate data on-line via the internet

For those RTPAs that use their own internal systems for project nomination development: Data storage of approved “Programming Lists” including archive and new cycles

For those RTPAs that use their own internal systems for project nomination development: Develop data interfaces or import processes so that “Programming Lists,” and project nomination data populates the new system module with relevant project information from FASS system

Recommendations Regarding Notifications and Alerts

2012 Business Case

Alert on Amendment submittals

Alert on changes to APL including project details and milestones

Alert on CTC actions

Alert on Document Review/Approval

Automatic alerts and notifications to impacted stakeholders on CTC transactions

Develop project level auto notifications for agreement processing at review and approval stages, auto-notifications will be sent to impacted stakeholders

Implement an “Alert” system for users so that required transactions can be submitted timely

Implement automatic alerts to impacted stakeholders on CTC transactions

Project closeout automatic notification to all impacted stakeholders

Route FMIS response via auto alerts to impacted stakeholders in “real time”

2013 Feasibility Study Report

Upon implementation, the new system shall automate the ability to alert internal and external stakeholders on upcoming project specific deadlines, report on performance measures, and monitor control agency transactions.

2021–2022 Study

If there are any lapsing funds that need to be obligated Caltrans Financial Programming should send a list out to MPO's along with information on new processes to upload FTIP documents into the new system and updates to any new federal requirements in the FTIP that need to be met.

If there was a Future Consideration of Funding Resolution (FCoF), the new system should show the number and date.

The new system should inform Caltrans Budgets if a SHOPP project support phases 0, 1, 2, 3 is to be rescinded, to permit Caltrans Budgets to de-allocate the budget from their financial database, AMS Advantage (BQ94).

The new system should provide annual apportionment amounts (and estimates) for federal programs including: RSTBG (STP), CMAQ, HIP, and CRRSAA.

The new system should provide approval emails for FTIP Updates and Amendments.

The new system should provide notifications for any programming actions to be taken by RTPAs, MPOs, and Caltrans districts.

The new system should show how much time needed past 6 or 72 months for timely use of funds.

The new system should show the type of environmental document and resolution numbers

Recommendations Regarding Replacement of Existing Systems

2000 Feasibility Study Report

Convert the Caltrans Transportation Improvement Program System (CTIPS) using corporate standards.

Convert the Federal Aid Data System (FADS) using corporate standards to an Oracle based federal aid processing system, which meets changes required by Federal Highway Administration (FHWA), for combined authorization and agreement processing, electronic signature processing and electronic data sharing.

Edit the existing data during the conversion process.

2004 Business Process Review

Build CTIPS II to support the documented functional, technical and detailed requirements.

2012 Business Case

Existing system data will be used to auto populate required data fields so that the requester is not subject to entering the same data multiple times in the system.

Transactions for change requests related to existing data; the user to have access to existing information to be highlighted side-by-side with the updated information, so that the user can inspect the old and new data for the necessary changes.

2021–2022 Study

The new system should incorporate the features of the current CTIPS and VIPER systems, and should replace both of these systems.

The new system should replace the functions of CTIPS, FADS, and CalSmart.

The new system should replace the functions of the CMAQ database and the transportation performance management database.

Recommendations Regarding Security

2012 Business Case

Ad hoc reporting for all system data based on user level needs and security level access with clear areas of responsibility and access for user groups

Module will standardize application templates with security and validation parameters based on agreed upon business rules

User needs and security access will be agreed upon by stakeholders

2021–2022 Study

For sign-on, the system should use a two-step process or other advanced security currently considered Cal Smart to be "state of the art," and it should be adaptable to address changing requirements (i.e., it must be as adaptable as

other leading systems currently on the market, as determined or approved by the Department of Technology and specified by the Department of General Services).

The new system should meet current State software requirements, such as ADA, and should be adaptable to address changing requirements (i.e., it should use current “state-of-the-art” technology and be as adaptable as other leading systems currently on the market, as determined or approved by the Department of Technology and specified by the Department of General Services).

Recommendations Regarding Splits and Combines/Project Identification

2000 Feasibility Study Report

Provide a single point of entry for all project information. This includes the processing of programmed project splits and combines.

Provide the ability to adjust programming and funding across splits and combines.

Provide the ability to track across project splits and combines.

Provide the capability to program an unlimited number of fund sources per project.

2012 Business Case

Allow users to manage and monitor multiple contracts per project and multiple contracts per fund type

System designed to add or subtract multiple funding sources per project.

System project tracking by multiple project key data identifiers that are agreed upon by business rules

Track project splits and combines based on business rules

Utilize and cross-reference various project identifiers used by all partners and organization systems related to specific project to unify project data.

2021–2022 Study

For each program-element-component-task combination (PECT) in the Caltrans accounting system, the Division Chief for Financial Programming should determine whether projects, by phase, using that PECT, require CTC-approved programming. If this requirement exists, it should be noted in the definition of the PECT in the Caltrans Coding Manual. If only some projects, by phase, using a particular PECT require CTC-approved programming, the Division Chief for Financial Programming should establish criteria for when CTC-approved

programming is required, and those criteria should be noted in the definition of the PECT in the Caltrans Coding Manual.

For programs in the Caltrans accounting system that require CTC-approved programming, the new system should include workflow with the Caltrans accounting system so that each new project phase established in the accounting system identifies which specific CTC-approved project phase correlates with the new project phase in the accounting system, including a split between the CTC-approved project phases if more than one CTC-approved project phase correlates with a single project phase in the accounting system.

Program codes used in the new system should be only those listed and defined in the Caltrans Coding Manual. The Division Chief for Financial Programming should have the authority to define new program codes and have them added to the Caltrans Coding Manual.

The new system should assign a unique “programmed project” identifier to each project that receives CTC-approved programmed amounts. This identifier should not be the same as the project code in the Caltrans accounting system because (a) one CTC-approved programmed amount can be split between more than one project in the Caltrans accounting system, and (b) one project in the Caltrans accounting system can combine amounts from more than one CTC-approved programmed project.

The new system should record CTC-approved programmed amounts for these phases within each project: (1) Environmental Studies and Permits, (2) Plans Specifications and Estimates, (3) Right of Way Administration (a.k.a. Right of Way Support), (4) Construction Engineering (a.k.a. Construction Support), (5) Right of Way Capital, (6) Construction Capital (7) any other phases that the Legislature, CTC, or Department of Finance choose to require.

Recommendations Regarding Statewide Reports and Reports to the CTC

2012 Business Case

Allow for automated identification of projects for draft CTC

Allow for automated review of Vote boxes and Vote lists by impacted stakeholders

Allow for automated routing of CTC Agenda including Book items with attachments for review

Automate the approval process for gathering CTC Book items data and attachments

Calculate the ITIP formula including project splits (i.e., North, South, Urbanized, etc.)

Create summary information for CTC agenda and book items electronically based on agreed upon business rules

CTC Selection Process including Book Item review and approval

Generate a Program Fund Lists (STIP, FSTIP, FTIP, SHOPP) List with “real time” data along with entire list of amendments

Maintain an “application status” screen that is viewable by impacted stakeholders with real-time milestone tracking

Process official CTC transactions electronically and transmit to the CTC

Program Fund Lists (STIP, FSTIP, FTIP, SHOPP) automatically updated and maintained by existing data in system

Program Fund Lists (STIP, FSTIP, FTIP, SHOPP) data entered in system by external and internal stakeholders

Programming Lists development (RTIP, ITIP, RCL, and Approved Program Lists (APL)):

Provide the ability to generate Program Fund Lists (STIP, FSTIP, FTIP, SHOPP) documentation directly from the ITIP and RTIP data in the system

“Real-time” CTC summary reports created for stakeholders

Recommendations Regarding Training, Coordination, and Information Sharing

2004 Business Process Review

Team with key stakeholders (Districts, Programs, RTPA, and MPOs) in the CTIPS system design effort.

2021–2022 Study

Caltrans Financial Programming should coordinate CFPG, and biennial FSTIP update workshops

Caltrans Financial Programming should provide guidance for programming new fund types.

Caltrans Financial Programming should provide information from the CFPG meetings, procedures for FTIP amendments, program funding allocation estimates and final amounts, reminders for obligating program awards or new CTC voted projects etc.

Caltrans Financial Programming should provide pertinent information such as schedules, “nuts and bolts” of programming, and any updates to assist us with FTIP Adoption submittals, FTIP Amendment, and Administrative Modification submittals.

Caltrans Financial Programming should provide programming information and requests, updates on transportation/air quality through CFPG meetings, recommendations of approval of FTIP formal amendments, training workshops on FTIP development every two years, RSTP/CMAQ and HIP apportionments, responses to inquiries, etc.

Caltrans Financial Programming should provide reviews and approvals of TIP amendments and adoptions,

Caltrans Financial Programming should provide State program listings (HBP, HSIP, SHOPP).

Caltrans Financial Programming should provide training, orientation or FAQ for new programming staff.

Caltrans Financial Programming should provide updates on performance measures as subcommittees make progress.

Caltrans Financial Programming should provide updates to programming guidelines/procedures, and interpretation/advice on federal regulations.

Financial Programming should provide meeting notices for the CFPG meetings.

Perhaps the STIP process (like the Fund Estimate), FTA formula grants for urbanized areas less than 200K, local TDA apportionments, etc. should be funneled through the Division of Financial Programming. It is worth discussing the pros and cons of such a strategy.

The Caltrans financial programming website should have more documents on it. Although Caltrans is constrained by the ADA requirements, the net result is that there are no useful documents or information on the website.

The Division of Financial Programming should provide RTPAs, MPOs, and Caltrans districts with a master calendar, which includes information about Federal programs like CARES, federal transportation bills etc., and where these are on the calendar.

The new system should provide MPOs and RTPAS with project data for grouped listings of projects, apportionment levels, PPRs for inclusion in the Federal TIP.

The new system should continue to provide support on the ITSP development and the preparation of the ITIP Scoring Criteria forms. Also, information on the funding status of projects being considered for ITIP and those partially funded through ITIP.

The new system should include training materials and instructions with examples, as well as a dummy instance of the database for use in training.

The new system should provide an annual or semi-annual summary report of state only funds balances from around the state, specifically for programs funded with both state and federal funds like the ATP.

The new system should provide Formula funds appropriations and forecasts.

The new system should provide fund estimates for CTC-managed programs including: STIP and ATP.

The new system should provide instructions for how to complete the correct forms for programming.

The new system, or Division of Financial Programming, should provide RTPAs and MPOs with information about funding awards and updated project lists for Caltrans funded projects (for amendment purposes), communication of needs to be passed along to CFPG members from third parties (i.e., FHWA, FTA), updates on programming requirements, meeting and workshop invites.

Recommendations regarding Use of Funds

2012 Business Case

Track and report funding performance and other agreed upon measures related to overall process

2013 Feasibility Study Report

Upon implementation of the new system, Caltrans will implement better data management processes that will optimize the use of funds, addressing the deficiencies outlined in AB 1012.

2021–2022 Study

The new system should compare the CTC-approved programmed amounts with the actual and planned expenditures by project and phase from the Caltrans project management system and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual and planned expenditures. (This may be accomplished by requiring that the project management system use only project identifiers from the accounting system—see the requirements for reconciliation with the accounting system).

The new system should compare the CTC-approved programmed amounts with the actual expenditures by project and phase from the Caltrans accounting system and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual expenditures.

The new system should compare the CTC-approved programmed amounts with the actual expenditures by project and phase from the Caltrans construction management system and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual expenditures. (This may be accomplished by

requiring that the construction management system use only project identifiers from the accounting system—see the requirements for reconciliation with the accounting system).

The new system should compare the CTC-approved programmed amounts with the actual expenditures by project and phase from the Caltrans right of way management system and show the difference, positive or negative, between the CTC-approved programmed amounts and the actual expenditures. (This may be accomplished by requiring that the right of way management system use only project identifiers from the accounting system—see the requirements for reconciliation with the accounting system).

The new system should provide Caltrans Budgets with programming information related to allocations.

The new system should relate each programmed project to the Caltrans environmental permitting system and show which permits are required for each programmed project. (This may be accomplished by requiring that the environmental permitting system use only project identifiers from the accounting system—see the requirements for reconciliation with the accounting system).

The new system should show the allocation for PSE/RW support, the programmed amount, and the funding request amount

Prior Recommendations and Requirements Excluded from the Recommendations in This Report

2000 Feasibility Study Report

Provide the ability to maintain the Operational Plan.

Provide the identification of rehabilitation projects from the transportation project planning, operations and maintenance systems.

2004 Business Process Review

Certify selected RTPAs to create and submit allocation and amendment requests.

Develop a strategy to improve compliance with programming process deadlines and quality of content received from Districts, MPOs and RTPAs: Programming Publish schedule information on the Caltrans website.

Develop a strategy to improve compliance with programming process deadlines and quality of content received from Districts, MPOs and RTPAs: Programming should commit to reviewing requests by specified dates if “completed” requests are submitted by deadline.

Educate stakeholders on programming policies and procedures: Create an Internet bulletin board

Educate stakeholders on programming policies and procedures: Develop a “how-to” procedures guide.

Educate stakeholders on programming policies and procedures: Establish single points of contact in Districts.

Educate stakeholders on programming policies and procedures: Hold video/phone conferences with Districts.

Educate stakeholders on programming policies and procedures: Hold workshops with District, RTPA, and MPO personnel

Re-deploy Programming staff to higher value activities.

Reorganize amendment coordination staff under the STIP Chief.

Review and reassign responsibilities for preparing allocation requests for presentation to the CTC.

Use District SHOPP 10-Years plans to support the development of the SHOPP.

2012 Business Case

Ability for iterative review/revisions of Vote List/Book Items between Caltrans Divisions

Ability to create CTC vote box item

Ability to electronically transfer BGE94 data to AMS Advantage

Ability to update based on CTC actions for Vote List/Book Item outcomes

Alert impacted users on projects that are in danger of de-obligation or loss of programmed funds

All reports will contain “real time” data including any necessary data gathered from interfaced systems

Allow headquarters users to make revision to funding estimates and identify project applications in process

Allow users to electronically request, in system, to de-obligate funds for cancelled projects or projects that expended less than was programmed.

Automate the initiation, delivery, review and approval of the following transaction agreements: Master Agreements; Finance Letters; Program Supplement Agreements (Including Covenants); FTA Transfer Letters; Invoicing and Final Invoicing for project

Based on agreed upon business rules for strict user access as funds are used, track milestone and performance data for remaining budget authority, apportionments, obligation authority, allocation balances, and program, regional, and local agency levels, for projects

Create “Ledger” account based on fund allocations by state and local splits as well as sub categories (programs, projects, combined projects, etc.)

Create and send Vote List/Book Item to OCTCL (Div. Trans.Prog.)

Data from Budgets, Externals, and Programming modules need to be accessed at the project level so that detailed reports can be generated for performance tracking

Develop auto notifications based on Fund Program type, in order to inform stakeholders of milestones, performance needs, or call for project initiations

Develop report on programmed fund amounts for projects that were advanced or extended to a future year

Distribute compiled DRAFT Vote List to multiple Divisions within Caltrans

Distribute FINAL Vote List to multiple Divisions within Caltrans

Electronic funds tracking and reporting with “real-time” data from AMS Advantage system

Electronically process new estimates for subvention budget authority in “real time” with data required from identified integrated sources

Enhance data sharing with FHWA to include “real-time” data usage of: Annual Budget Information; Process funds adjustments for federal dollars based on new or changing federal mandate; Fund adjustment data by project; Fund adjustment data by fund program; Discretionary fund tracking; Project fund splits and combines (federal, state, and local funds)

Forecasting reports must include the following: Identify the number of projects, including project phases; Identify the number of programmed projects, by phase, for the upcoming fiscal year in the STIP, FTIP, and Approved Program Lists; Identify the number or programmed projects by program type; Identify the number of projects that are either split or combined; Identify programmed projects that are advanced or extended to a future year; Identify projects that have surpassed their expenditure time limits and have been reprogrammed; identify critical project performance measures and milestones agreed upon by business rules; Identify projects that were cancelled; Identify projects that expended less than was programmed; Ability to run reports on this data and export the data to required tools

Identify programmed amounts in the STIP, FSTIP, FTIP, and Approved Program Lists and allow users to compare programmed amounts to level of Obligation Authority

Identify projects and fund types that are approaching their expenditure time limits (Federal and State funds)

Implement a “ledger” system based on individual project, that reconciles federal and state funds using data from: FMIS system; AMS Advantage system; FADS system

Implement electronic funds monitoring and management tools

Implement “real time” reporting and notification tools that identify subvention fund status as well as the status of budget action requests.

Import official AMS Advantage data, FMIS data, and other required data in order to reconcile year-end expenditures against budget authority including detail data.

Iterative review and approve funds requests

Provide year-to-year performance status reports on funds encumbered to expenditures

“Real-Time” Identified Performance Reports for funding life cycle including: Historical Spending Patterns; Expected funding to be programmed for budget year; Future estimates on funding for Federal; Future estimates on CTC Allocations; Fund balance reporting on cancelled projects; Fund balance reporting on project splits/combines; Fund balance reporting on project cost savings; Fund balance reporting on Program reserves; “Real time” reporting on Obligation Authority changes at the project level.

Re-align the Division of Transportation Programming data to sync with Local Assistance, and Budgets with regards to data modeling centered on project and not on fund type.

“Scratchpad” functionality so that District users can draft initial ITIP lists with project nomination and planning data.

Support the ability to move funds between different fund programs including: Transfers; Exchanges; Advanced Construction

Support the process of identifying State and Federal funding availability by the following identifiers: Funding Source; Program type; State RTPA; MPO; County; City; Other Regional Entities as identified and required; Caltrans Region Caltrans District

System designed to develop reports to assist in the calculation of expected workload for subvention projects statewide.

System to electronically process Fed/State split

System to receive electronic Funds Request from Capital/Local Programs

System validation of funds requests data submitted electronically by users

The system will generate a report on projects with no finance activity for a specific period of time (by project, program, region, local agency, etc.)

2013 Feasibility Study Report

Upon implementation, project programming processes will be updated by implementing a new data structure from “funds centric” to “project centric” for state administered and locally administered projects. This will allow Caltrans to more easily track funding and budgets on individual projects.

Bibliography

- American Association of State Highway and Transportation Officials. *State of the Practice in Preconstruction Engineering Management*. Unpublished survey. Washington: AASHTO, 2003.
- California Department of Transportation. “Appendix 3 – Division of Programming (CTIFS).” *Caltrans Integration Study Business Process Review*. June 1, 2004. Sacramento, CA: Caltrans.
- California Department of Transportation. “Asset Management Performance Report.” Accessed May 19, 2022. <https://dot.ca.gov/programs/asset-management/guidelines-phase-1-plan>.
- California Department of Transportation. *California Transportation Infrastructure Funding System (CTIFS)*. Project Number 2660-505. Feasibility Study Report. June, 2013. Sacramento, CA: Caltrans.
- California Department of Transportation. “Chapter 4, Programming,” in the *Project Development Procedures Manual*. Accessed May 20, 2022. <https://dot.ca.gov/-/media/dot-media/programs/design/documents/pdpm-chapter4-a11y.pdf>.
- California Department of Transportation. “Clean California Beautification Projects.” Accessed May 19, 2022. <https://cleancalifornia.dot.ca.gov/projects>.
- California Department of Transportation. *Divisions of Local Assistance, Budgets & Transportation Programming Business Case Document: Analysis of Transition into the CTIFS Solution*. October 23, 2012. Sacramento, CA: Caltrans.
- California Department of Transportation. “Financial Programming.” Accessed May 19, 2022. <https://dot.ca.gov/programs/financial-programming>.
- California Department of Transportation. “Major Projects.” Accessed May 19, 2022. <https://dot.ca.gov/programs/project-management/major-projects>.
- California Department of Transportation. *Project Cost and Schedule Management Feasibility Study Report*. January 24, 2000. Sacramento, CA: Caltrans.
- California Department of Transportation. *Project Delivery Quarterly Report Process*. Caltrans Lean 6-Sigma project. February 8, 2021. Sacramento, CA: Caltrans.
- California Department of Transportation. “Project Management.” Accessed May 19, 2022, <https://dot.ca.gov/programs/project-management>.

- California Department of Transportation. “State Highway Operation and Protection Program (SHOPP) and Minor Program.” Accessed May 19, 2022, <https://dot.ca.gov/programs/financial-programming/state-highway-operation-protection-program-shopp-minor-program-shopp>.
- California Department of Transportation. *2020 State Transportation Improvement Fund Estimate adopted by California Transportation Commission*. Sacramento, CA: Caltrans, 2019.
- Cline, C.F. *Transportation Engineering Project Management: Survey of Practice Prepared for the Utah Department of Transportation Research Division*. Madison: CTC & Associates, LLC., 2017.
- Dye Management Group. *Best Practices in Project Management*, Final Report 511. Phoenix: Arizona Department of Transportation, 2003.
- Federal Highway Administration. *NEPA Implementation: The Development of Logical Project Termini*. Washington: FHWA, November 5, 1993. https://www.environment.fhwa.dot.gov/legislation/nepa/guidance_project_termini.aspx.
- Forsyth, R. and J. Hagwood. *One Hundred Years of Progress: A Photographic Essay on the Development of the California Transportation System*. Sacramento, CA: California Transportation Foundation, 1996.
- International Organization for Standardization. *Project, Programme and Portfolio management—Guidance on portfolio management*. ISO 21504:2015. Geneva: ISO, 2015.
- International Organization for Standardization. *Project, Programme and Portfolio Management—Guidance on Portfolio Management*. ISO 21504:2022. Geneva: ISO, 2022.
- International Organization for Standardization. *Project, Programme and Portfolio management—Vocabulary*. ISO/TR 21506:2018. Geneva: ISO, 2018.
- McCoy, K., A. Ingles, and W. Lyons. *STIP State of the Practice Review: Development and Use of Statewide Transportation Improvement Programs*. Washington: Federal Highway Administration, 2016.
- Minnesota Department of Transportation. *STIP and TIP Amendment Procedures: A Review of State and MPO Practices*. St. Paul: MNDOT, 2013.
- Montana Department of Transportation. *Survey of Capital PPM in DOTs*. Helena: MTDOT, 2013.
- Neumann, L. A. NCHRP Synthesis 243: *Methods for Capital Programming and Project Selection*. Washington: Transportation Research Board, 1997.

Project Management Institute. *A Guide to the Project Management Body of Knowledge*. Second Edition. ANSI/PMI 99-001-2000. New Town Square, PA: PMI, 2000.

Project Management Institute. *The Standard for Portfolio Management*. Fourth Edition. ANSI/PMI 08-003-2017. New Town Square, PA: PMI, 2017.

Project Management Institute. *The Standard for Portfolio Management*. ANSI/PMI 08-003-2006. New Town Square, PA: PMI, 2006.

State of California. *The Traffic Congestion Relief and Spending Limitation Act Of 1990*. Proposition 111 of 1990. Sacramento, CA: Secretary of State.

State of California. *The Seismic Retrofit Bond Fund of 1996*. Proposition 192 of 1996. Sacramento, CA: Secretary of State.

State of California. *Public Works Projects. Use of Private Contractors for Engineering and Architectural Services*. Proposition 35 of 2000. Sacramento, CA: Secretary of State.

State of California. *Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006*. Proposition 1B of 2006. Sacramento, CA: Secretary of State.

State of California. *Safe, Reliable High-Speed Passenger Train Bond Act for the 21st Century*. Proposition 1A of 2008. Sacramento, CA: Secretary of State.

State of California. Statutes of 1971: Chapter 1400 (SB 325). Sacramento, CA: Secretary of State.

State of California. Statutes of 1977: *Alquist-Ingalls Act*, Chapter 1106 (AB 432). Sacramento, CA: Secretary of State.

State of California. Statutes of 1984: Chapter 446 (SB 2117). Sacramento, CA: Secretary of State.

State of California. Statutes of 1989: *Kopp-Katz-Baker Transportation Blueprint for the Twenty-First Century*. Chapter 105 (SB 300). Sacramento, CA: Secretary of State.

State of California. Statutes of 1989: *Kopp-Katz-Baker Transportation Blueprint for the Twenty-First Century*. Chapter 106 (AB 471). Sacramento, CA: Secretary of State.

State of California. Statutes of 1989: *Kopp-Katz-Baker Transportation Blueprint for the Twenty-First Century*. Chapter 107 (AB 680). Sacramento, CA: Secretary of State.

State of California. Statutes of 1989: *Kopp-Katz-Baker Transportation Blueprint for the Twenty-First Century*. Chapter 108 (AB 973). Sacramento, CA: Secretary of State.

State of California. Statutes of 1989: *Kopp-Katz-Baker Transportation Blueprint for the Twenty-First Century*. Chapter 109 (AB 2218). Sacramento, CA: Secretary of State.

State of California. Statutes of 1995: Chapter 310 (SB 146). Sacramento, CA: Secretary of State.

State of California. Statutes of 1997: Chapter 328 (SB 226). Sacramento, CA: Secretary of State.

State of California. Statutes of 1997: Chapter 622 (SB 45). Sacramento, CA: Secretary of State.

State of California. Statutes of 1999: Chapter 783 (AB 1012). Sacramento, CA: Secretary of State.

State of California. Statutes of 2000: Chapter 91 (AB 2928). Sacramento, CA: Secretary of State.

State of California. Statutes of 2006: Chapter 25 (SB 1266). Sacramento, CA: Secretary of State.

State of California. Statutes of 2008: Chapter 267 (AB 3034). Sacramento, CA: Secretary of State.

State of California. Statutes of 2012: Chapter 272 (SB 1102). Sacramento, CA: Secretary of State.

State of California. Statutes of 2013: Chapter 359 (SB 99). Sacramento, CA: Secretary of State.

State of California. Statutes of 2015: Chapter 917 (SB 486). Sacramento, CA: Secretary of State.

State of California. Statutes of 2017: Chapter 5 (SB 1). Sacramento, CA: Secretary of State.

State of California. Statutes of 2021: *Budget Act of 2021*, Chapter 21 (AB 128). Sacramento, CA: Secretary of State.

State of California. *State Administrative Manual*, Section 6806, accessed on May 21, 2022 <https://www.dgs.ca.gov/Resources/SAM/TOC/6000/6806>).

Taylor, R. and M. Billings. *RTC Universal Transportation Project Identifier (UTPI)*: Final Project Report. June 28, 2001. Sacramento CA: Renée Taylor Consulting.

Tommelein, I. D., and N. Blampied, *Review of the Project Resourcing and Schedule Management (PRSM) System used by Caltrans*. Berkeley: University of California Institute of Transportation Studies, 2018.

Transportation Research Board. *NCHRP Synthesis 48: Priority Programming and Project Selection*. Washington: TRB, 1997.

United States Congress. *Rural Post Roads Act*. Public Law 64–156. 1916.

United States Congress. *Americans with Disabilities Act*. Public Law 101-336, 104 Statutes 327, enacted July 26, 1990, codified at 42 United States Code Chapter 126 (sections 12101 to 12213).

United States Congress. *Intermodal Surface Transportation Efficiency Act*. Public Law 102-240. 1991.

United States Congress. Public Law 103-272. 1994.

United States Congress. *Transportation Equity Act for the 21st Century*. Public Law 105-178. 1998.

United States Congress. *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users*. Public Law 109-59. 2005.

United States Congress. *Moving Ahead for Progress in the 21st Century Act, Public Law 112-141*. 2012.

United States Congress. *Fixing America's Surface Transportation Act*. Public Law 114-94. 2015.

United States Congress. *Infrastructure Investment and Jobs Act*. Public Law 117-58. 2021.

About the Authors

Wenbin Wei, PhD

Dr. Wei is a Professor in the Department of Aviation and Technology at the College of Engineering at San José State University. He is also an Affiliated Professor in the Department of Industrial and System Engineering as well as Director of the Human Automation Integration Lab (HAIL) in the College of Engineering at San José State University. Before joining the faculty at San Jose State University, Dr. Wei was a research analyst in the Department of Operation Research and Decision Support at American Airlines. He has a Ph.D. from the University of California, Berkeley in transportation engineering and management. Dr. Wei's research interests include: transportation planning; traffic control and management, multimodal transportation systems, rail and high-speed rail transportation, airport and airline management, unmanned aerial vehicle (UAV), Advanced Air Mobility (AAM), logistics, and supply chain management. Dr. Wei has obtained more than \$2 million of research grants from agencies such as FAA, NASA, and California Department of Transportation and has published more than 40 research papers in peer-reviewed journals or conference proceedings.

Nigel Blampied, PhD

Dr. Blampied's research and teaching focus on project management in public transportation agencies. He teaches in the Master of Science in Transportation Management program at San José State University, and is a Research Associate at the Mineta Transportation Institute. Nigel retired from Caltrans in 2011 to pursue a Ph.D. at the University of California, Berkeley. He was a CTIPS user from its earliest stages as a FoxPro database, and he is familiar with the Caltrans project management and accounting systems, having designed the project management system and helped to design portions of the accounting system. Dr. Blampied also has extensive experience in writing national and international project management standards. He has represented the United States on the international committees on project, programme, and portfolio management standards, ISO PC236 and TC258, since their inception in 2007, and he was one of the three principal editors of the 2022 revision of the International Standard for Portfolio Management.

Raajmaathangi Sreevijay

Raajmaathangi currently is a graduate student in the Master of Science in Software Engineering program at San José State University. She earned a Bachelor of Technology, Information and Communication Technology from SASTRA University, Thanjavur, India. She is currently providing research assistance to the Mineta Transportation Institute through the SJSU Research Foundation. She has worked in the software development area for more than six years and is interested in gaining more experience creating applications from the development phase to the deployment phase involving best software processes and practices.

Hon. Norman Y. Mineta

MTI BOARD OF TRUSTEES

Founder, Honorable Norman Mineta***
Secretary (ret.),
US Department of Transportation

**Chair,
Will Kempton**
Retired Transportation Executive

**Vice Chair,
Jeff Morales**
Managing Principal
InfraStrategies, LLC

**Executive Director,
Karen Philbrick, PhD***
Mineta Transportation Institute
San José State University

Winsome Bowen
VP, Corporate Development
Brightline

David Castagnetti
Partner
Dentons Global Advisors

Maria Cino
Vice President
America & U.S. Government
Relations Hewlett-Packard Enterprise

Grace Crunican**
Owner
Crunican LLC

Donna DeMartino
Retired Transportation Executive

John Flaherty
Senior Fellow
Silicon Valley American
Leadership Form

Stephen J. Gardner*
President & CEO
Amtrak

Rose Guilbault
Board Member
San Mateo County
Transit District (SamTrans)

Kyle Christina Holland
Senior Director,
Special Projects, TAP Technologies,
Los Angeles County Metropolitan
Transportation Authority (LA Metro)

Ian Jefferies*
President & CEO
Association of American Railroads

Diane Woodend Jones
Principal & Chair of Board
Lea + Elliott, Inc.

Therese McMillan
Executive Director
Metropolitan Transportation
Commission (MTC)

Abbas Mohaddes
CEO
Econolite Group Inc.

Stephen Morrissey
Vice President – Regulatory and
Policy
United Airlines

Toks Omishakin*
Secretary
California State Transportation
Agency (CALSTA)

Marco Pagani, PhD*
Interim Dean
Lucas College and
Graduate School of Business
San José State University

April Rai
President & CEO
Conference of Minority
Transportation Officials (COMTO)

Greg Regan*
President
Transportation Trades Department,
AFL-CIO

Paul Skoutelas*
President & CEO
American Public Transportation
Association (APTA)

Kimberly Slaughter
CEO
Sysra USA

Tony Tavares*
Director
California Department of
Transportation (Caltrans)

Jim Tymon*
Executive Director
American Association of
State Highway and Transportation
Officials (AASHTO)

* = Ex-Officio
** = Past Chair, Board of Trustees
*** = Deceased

Directors

Karen Philbrick, PhD
Executive Director

Hilary Nixon, PhD
Deputy Executive Director

Asha Weinstein Agrawal, PhD
Education Director
National Transportation Finance
Center Director

Brian Michael Jenkins
National Transportation Security
Center Director

