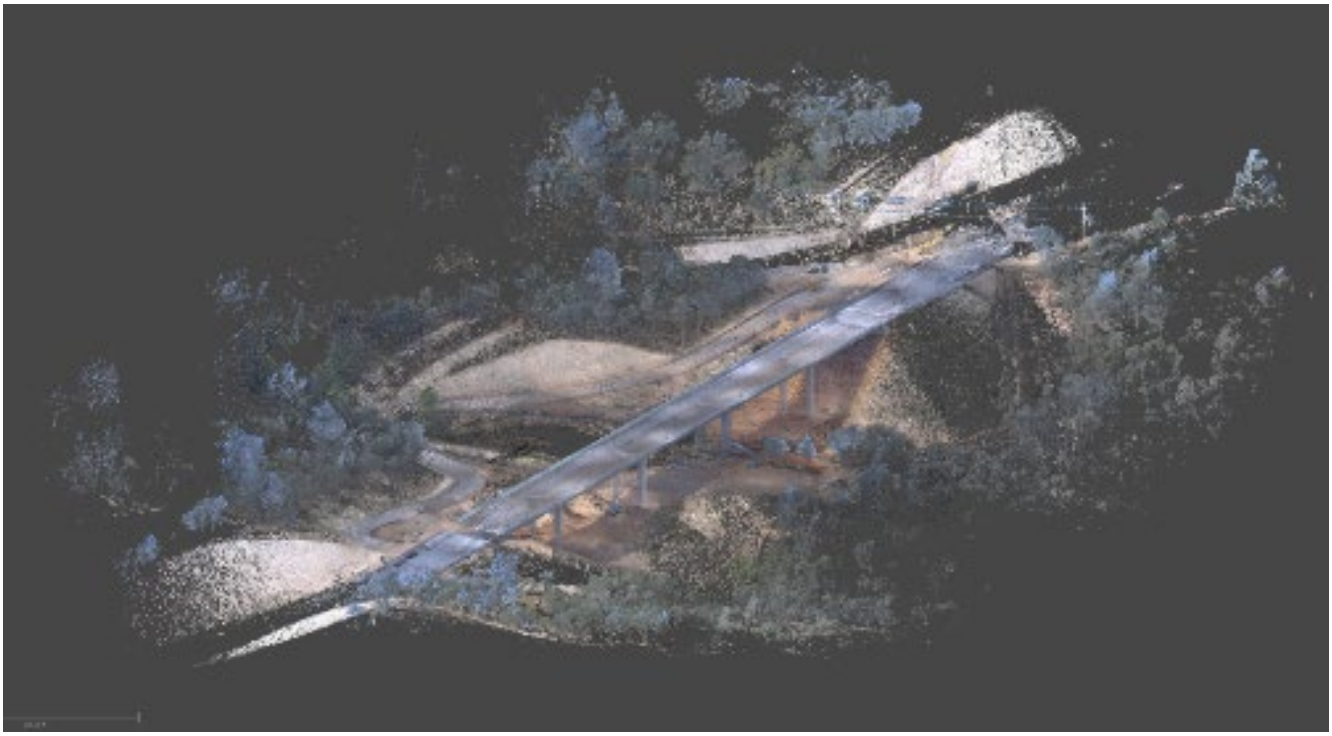
Building Information Modeling for Infrastructure (BIM4I) Initiative Implementation Plan



April 2023

Prepared by
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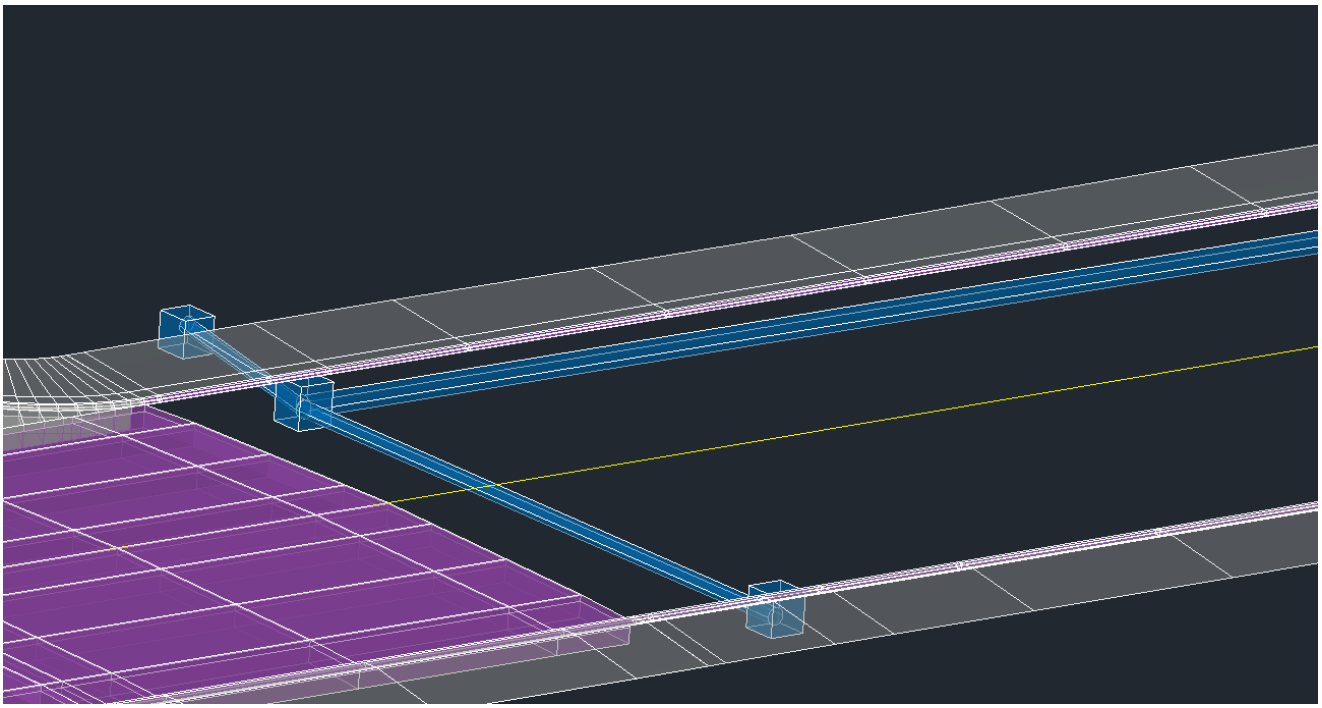


STUDY SUMMARY

STUDY SUMMARY

FINAL

OVERVIEW

A Value Analysis (VA) study, sponsored by the California Department of Transportation (Caltrans) and facilitated by Value Management Strategies, Inc. (VMS), was conducted virtually for the Building Information Modeling for Infrastructure (BIM4I) Project, formerly referred to as Virtual Design and Construction (VDC), between August 2021 and March 2023.

OBJECTIVES

The objectives of this project were to develop an implementation plan with a greater level of understanding of the activities, resources, and training required to fully realize the Department's goal of improving project development and delivery by:

- Using a project information model (PIM) and digital files to convey design intent for construction;
- Establishing the PIM and digital files as the project's legal document in lieu of a two-dimensional (2D) plan set; and
- Capturing digital as-built data during construction of the physical asset to build the Asset Information Model (AIM), the digital asset that will enhance collaboration, support asset management, planning, and future project development.

Please see the BIM for Infrastructure subsection on the following page for a more in-depth description of this framework.

BACKGROUND

Rapid development of information technology is transforming how information is produced, shared, exchanged, and managed throughout a project's life cycle. This transformation is accelerating in Departments of Transportation across the country due to the pressing need for increased efficiency, accountability, and transparency in the methodology of delivering transportation projects.

One of Caltrans' 2020-2024 Strategic Plan goals focuses on strengthening stewardship and efficiency and calls for promoting and implementing innovative and creative solutions. Implementing VDC is listed within the action plan for this goal and strategy. As such, in 2021, the Caltrans Project Delivery Program launched an initiative to implement VDC, more widely known in the industry as BIM4I and/or Advanced Digital Construction (ADC) systems.

The BIM4I committee leveraged numerous external studies and reports to inform this implementation plan. Those include the University of California, Davis's *Strategic Roadmap for Caltrans Implementation of Virtual Design Construction/Civil Integrated Management*, dated February 28, 2020; FHWA's *Advancing BIM for Infrastructure, National Strategic Roadmap,* dated June 2021; and the AASHTO BIM for Bridges and Structures pooled fund study.

PURPOSE & NEED

FHWA summarizes that "at its core, BIM is a collaborative work method for structuring, managing, and using data and information about transportation assets throughout their life cycles.[1]"

Caltrans continues to seek ways to maximize the value of taxpayer dollars and drive the best possible value for its investments by emphasizing efficiency and quality of delivery. Currently, the Department primarily develops and constructs transportation improvement projects by creating 2D plan sheets to represent a given project's design intent to be built in the three-dimensional, real world. Although Caltrans adopted some of the information and communication technology innovations such as Geographic Information Systems (GIS), e-Construction, Light Detection and Ranging (LiDAR), Automated Machine Guidance (AMG), etc., these technologies and tools are not yet fully implemented statewide. Processes and data are locked into siloes without automation and are not interoperable. Advances in engineering and project management software programs enable the transportation industry to utilize the BIM approaches as applied in other civil engineering projects, such as the design and construction of office buildings and industrial facilities. Data and digital design products developed for capital improvement projects used in the BIM4I approach become valuable transportation assets to be maintained by the owner and operator of the State's transportation system.

Implementing BIM4I will require sharing information from various programs in a 3D virtual world. This visual and digital representation of the proposed design, over time, will establish an environment that enables decision makers to have access to higher-quality information on which to base their decisions. Furthermore, at the end of the project, Caltrans will obtain a high-quality digital asset that will provide continuous value for the 75–100-year operational lifetime of the transportation infrastructure by providing key information on the existing asset for maintenance, rehabilitation, and safety improvements. As such, implementing BIM4I now directly supports the Department's strategic goals by increasing efficiency and productivity; improving multi-disciplinary collaboration by sharing and transferring digital data and documents internally and externally; reducing delivery time, design errors, modifications, omissions, and construction conflicts and claims; developing more sustainable infrastructure, and improving worker safety.

BIM FOR INFRASTRUCTURE

Caltrans embraces FHWA's summary of BIM above as "a collaborative work method for sharing, managing, and using data and information." The below narrative outlines this approach applied to infrastructure projects.

I. PLANNING/DESIGN

The BIM4I process begins in the planning and design stages. Roadway Design, Bridge Design, and Subsurface Utility Engineering among other functional units contribute their discipline-specific information models to the overall PIM. The PIM resides in the Common Data Environment (CDE), a collaboration platform where all project stakeholders can access and review it. At regular daily intervals, project stakeholders synchronize their information models with the CDE so the system contains the most up-to-date project design. When Bridge Engineers reference Roadway Design's

[1] Wood, Nathan. "The Dimensions of BIM for Infrastructure." Tech Brief. US Department of Transportation. Accessed 5/29/2022. Page 1. Available at: https://www.fhwa.dot.gov/construction/bim/pdfs/fhwa_hif_20_056.pdf

information model in their bridge model file, the reference information is drawn from the centralized CDE and reflects the most current information/version.

Clash detection (when two elements in a design interfere with one another) and other quality checks take place in the CDE to coordinate conflicts between the systems. Design, Construction, and Maintenance log into the CDE to conduct their model-based constructability and maintenance reviews. Comments are tracked and model owners are notified via the CDE system in a structured model approvals workflow.

CONTRACTING

Once the PIM is complete and ready for bid, it enters the bidding, award, and contract administration process. Contractors have access to a single, integrated model during the contract advertisement period to identify potential issues before bid opening and subsequently reduce potential change orders during construction. Using the model, contractors can more accurately estimate material quantities and costs associated with the advertised contracts, resulting in more competitive bids.

II. CONSTRUCTION

In construction, the process for transforming the virtual asset into the physical one begins. When the PIM is utilized by the Contractor, certain project components, such as precast bridge girders, for example, are further detailed by the fabricators or subcontractors. Caltrans specifies and gathers data to add to the PIM over the course of construction. The Contractor uses the PIM to develop their own construction quantities, track costs, and report schedule progress through 4D and 5D simulations.

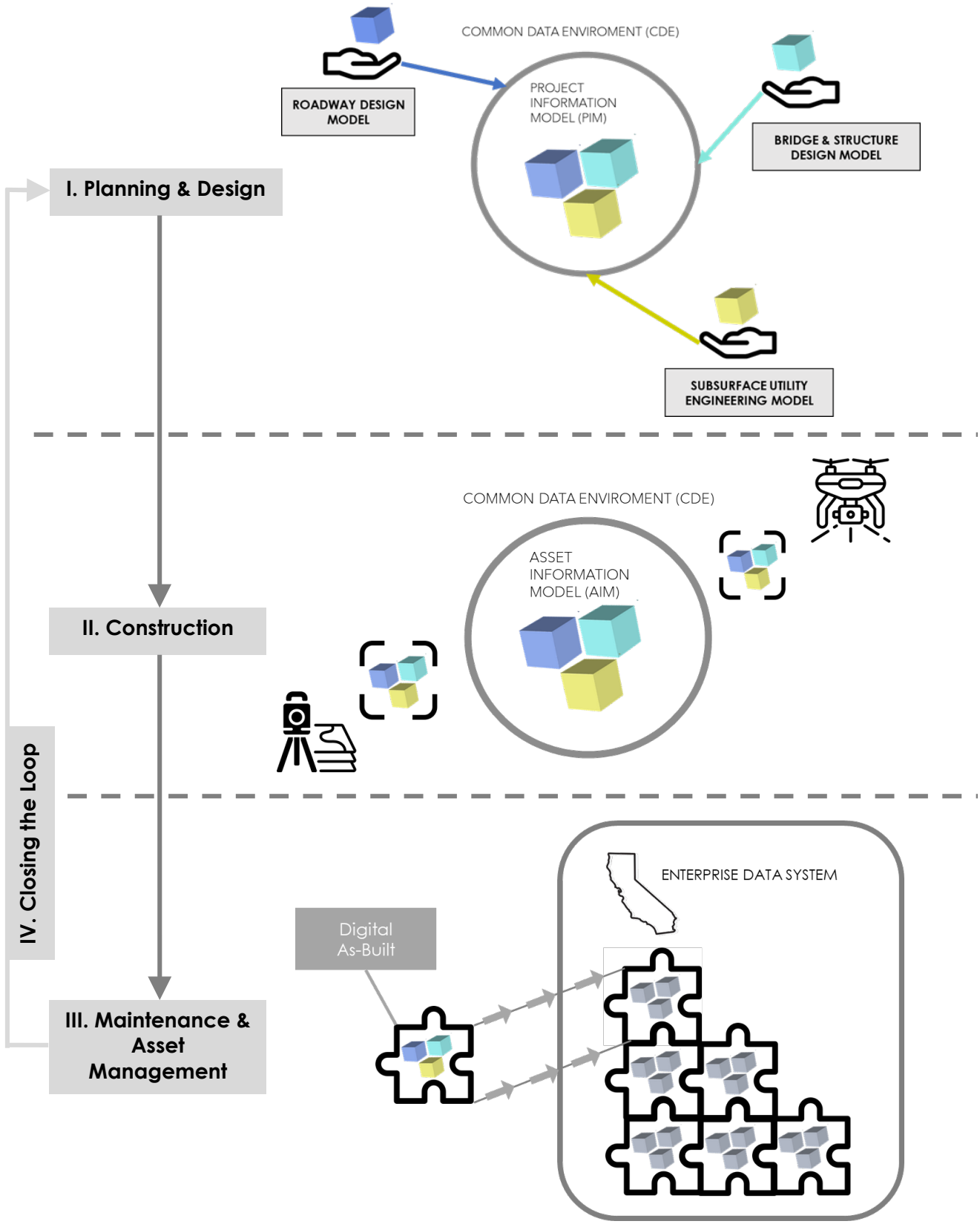
Throughout construction, data is captured in the field using survey data collection devices, laser scans, drones, and 360-degree images. This field data-capture incrementally builds a digital representation of the reality in the field. As components are completed during construction, the digital field data is overlaid on top of the corresponding objects in the PIM. Once these objects in the PIM are validated or adjusted to reflect the as-built condition, they are transitioned to the Asset Information Model (AIM).

III. MAINTENANCE & ASSET MANAGEMENT

At the end of construction, the AIM is completed. The surveyor or construction staff capture the final scans and as-built data. When the AIM is verified and validated against this final data, it becomes the "digital as-built (DAB)." The DAB is placed in a centralized "Enterprise Data System," where this DAB is stored alongside other DABs of the California Highway Network. Ultimately, through a layered GIS map of the entire state of California, Bridge Inspectors, Asset Managers, Maintenance staff, Designers, and decision makers, et. al., can review the total virtual highway network or locate particular assets of interest and access the relevant information via the linked digital as-built models.

IV. CLOSING THE LOOP

When it is time for maintenance, a rehabilitation, safety improvement, other improvement project, or at the end of the asset's useful life, the digital as-built is retrieved from the Enterprise Data System and this model becomes the basis for the next Project Information Model. The BIM4I cycle begins again.



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PILOT PROJECTS

Leveraging pilot projects to test, refine, and codify the systems, tools, processes, procedures, etc. for digital project delivery proposed by the initial BIM4I committee and numerous proposed task forces will be essential to the success of implementing BIM4I at Caltrans. The below list presents what the committee feels present the greatest opportunities for generating lessons learned at this early stage of implementation.

Potential Hybrid Projects

Hybrid projects would generate a 3D model of the finish grade, while meeting PD-06 requirements (alignments, survey Digital Terrain Model (DTM), break lines, etc.), as the legal binding contract document for those files only, instead of For Information Only (FIO). The .pdf plans of the design will be the remaining binding legal documents, just like today. One option would be to use one .pdf for layouts instead of having multiple ones with match lines, thus minimizing delineation and the overall number of sheets. This would work for other plan sets as well, like drainage and striping.

Hybrid pilot projects could also utilize the mandatory use of the AMG specification and include other files and information that Caltrans already creates (such as the .dgn file, cross sections, etc.). Design will have to do more QC/QA on the model to ensure it is complete, however the committee's opinion is doing so will generate even greater learning for both the designers and those conducting the review. These pilots will allow the Department to test and implement the process to sign and seal the 3D finish grade model with Legal, Districts, and HQ OE. They will also provide Construction with a base model for the project's digital as-built.

Similar to the specific project types below, the committee recommends using projects that are just starting Phase 1, or nearing completion of 0 Phase. A safety project (realignment), with at least 5,000 cy of earthwork would also make a great candidate for a hybrid pilot.

ADA Model

ADA curb ramp projects are already designed utilizing Civil 3D software, therefore, these projects are excellent candidates for pilot projects by taking the extra step to make the model available as the legal document. In this case, the entire plan set could be digital with no .pdfs. These would also present ideal pilot projects to test and implement the signing and sealing of 3D models and also provide Construction with a Design model for the digital as-built. The committee recommends focusing on projects just starting Phase 1, or nearing completion of 0 Phase.

Structures/Culvert Model

Structures or culvert-only projects would also be good candidates for early BIM4I pilots. Similar to ADA curb ramp projects, it's recommended to focus on projects just starting Phase 1 or nearing completion of 0 Phase. In addition to eliminating the need for a .pdf, refining the signing and sealing process, and providing a model for the digital as-built, etc., utilities could also be included to better understand their integration.

Broadband Model

Broadband projects should present similar benefits to both ADA and Structures projects listed above.

ONGOING EFFORTS

In addition to numerous pilot projects underway in support of BIM4I implementation, many more pilot projects have been identified. Pilot projects have been or are currently underway to implement the following initiatives (as of July 2022):

- 3D Roadway Model, Finished Grade (provided "For Information Only")
- 3D Visualization – training available
- LiDAR (Aerial, Mobile, UAS)
- AMG – Specification for optional use of AMG
- 3D Utility Database (CUD)
- Utility Conflict Matrix
- Electronic Document Management System (EDMS) – Piloting 4 Workflows in Document Retrieval System (DRS)
    - Draft Project Report
    - Project Report
    - Design Standard Decision Document (DSDD)
    - Advanced Planning Studies - Structures
- E-Construction
    - iPads
    - Document Management System
    - Drones
- Intelligent Compaction
- Ground Penetrating Radar

RECOMMENDATIONS & IMPLEMENTATION ROADMAP

In 2022, the committee identified 17 focus areas requiring exploration as part of the BIM4I VA study. Multi-disciplinary sub-teams were established with members of the main committee designated as leads for each. During the study, it was determined to include IT resources within each of the individual recommendations in lieu of showing them as a separate need. Leveraging an electronic document management system (EDMS) was also included in the original BIM4I recommendations; however, the pre-existing working committee responsible for implementing it was reinitiated and therefore their recommendations, action plan, etc., will be addressed separately outside of this effort. As such, standalone recommendations for these topics are not included herein.

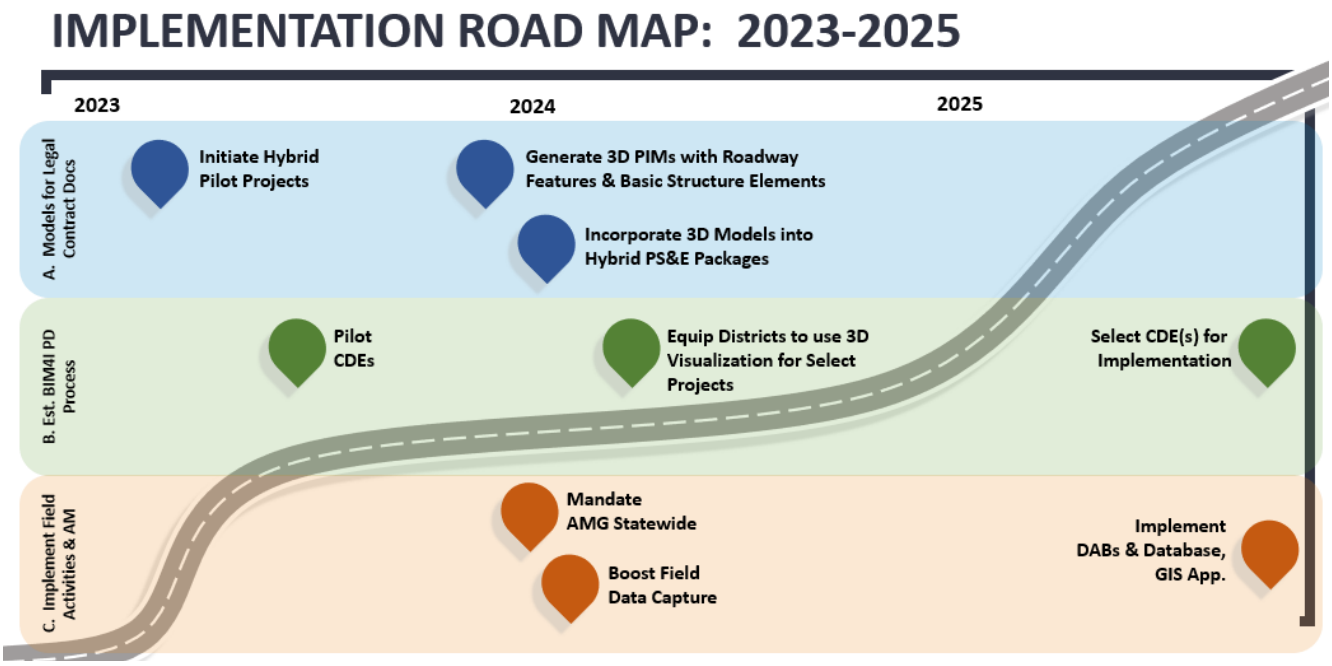
The BIM4I committee's remaining 15 recommendations were organized into three categories [(A) through (C)], which roughly reflect the PIM to AIM to DAB evolution.

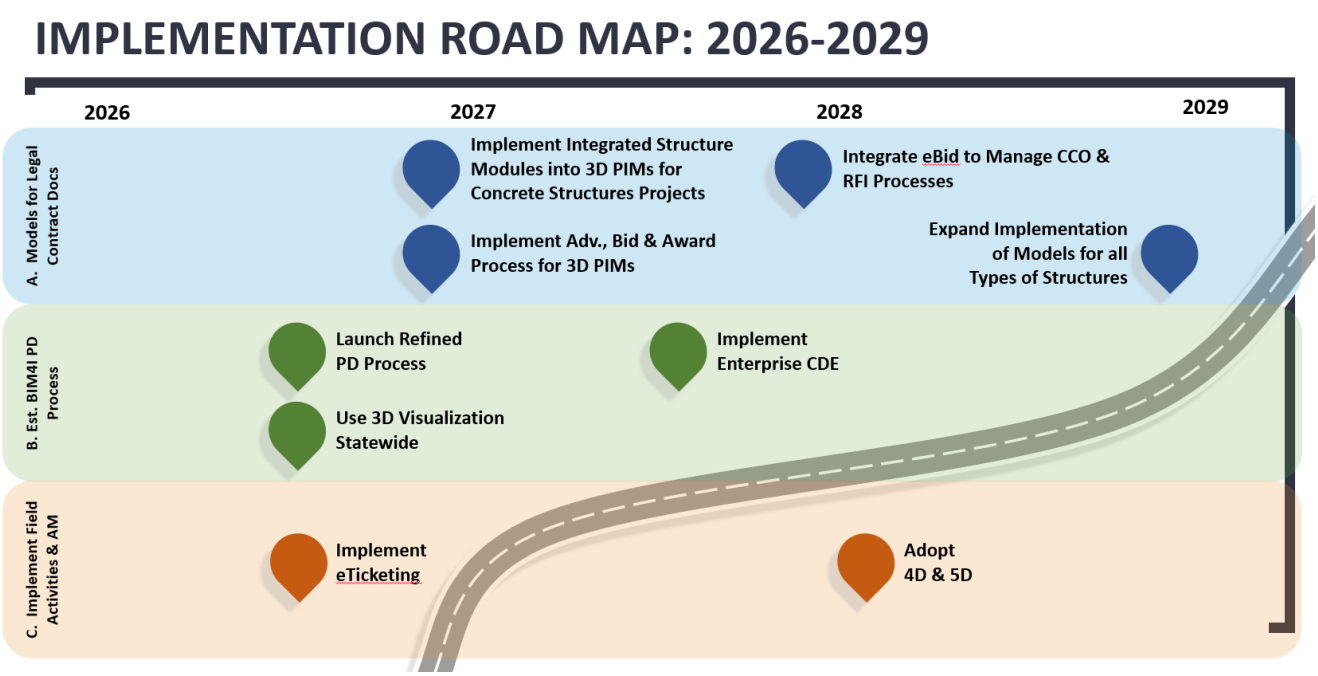
A. Generate BIM4I Models for Legal Contract Documents
B. Establish BIM4I Project Delivery Process
C. Develop & Implement BIM4I Field Activities & Asset Management

The original recommendations are summarized in the next section and are included in full in the Appendix. These were further consolidated and refined to reflect 12 core activities and corresponding milestones which are depicted on the next page.

IMPLEMENTATION ROADMAP MILESTONES

Below is a high-level summary of the anticipated milestones for each of the three categories of the BIM4I implementation initiative's recommendations followed by a more detailed list.





A. Generate BIM4I Models for Legal Contract Documents

1.	Implement 3D Project Information Models (PIM) for Roadway and Structures Projects	
	a. Initiate Hybrid Pilot Projects	Feb 2023
	b. Generate 3-D PIM models that include roadway features and basic structure elements	Dec 2023
	c. Implement providing full 3-D PIM Models that integrate above- and below-surface features and structures	Mid 2026
	d. Establish and implement integrated structure analysis, design, detailing, visualization, and quantities modules into the 3-D PIM model for concrete structures	Dec 2026
	e. Expand implementation of generating comprehensive structure 3D model for all types of structures	Dec 2028
2.	Advertise & Award 3D Models	
	a. Incorporate 3-D models into the hybrid PS&E package for use as a legal contract for Advertise, Bid, and Award	Dec 2023/ Jan 2024
	b. Bidding & Award process of packaging full 3-D PIM models for contracts	Dec 2026
	c. Expand implementation to Integrate eBid into the tool or other bidding software for managing CCO and RFI processes	Dec 2027

B. Establish BIM4I Project Delivery Process

3.	Implement use of a Common Data Environment (CDE) to optimize collaboration among all stakeholders	
	a. Pilot CDEs	June 2023
	b. Select CDEs for implementation	Dec 2025
	c. Implement Enterprise CDE	Mid 2027
4.	Amplify use of 3D models for visualization	
	a. Equip District to use 3D visualization for selected projects	Apr 2024
	b. Use 3D visualization statewide	Mid 2026
5.	Refine overall project development and delivery process to support digital project delivery	
	a. Launch refined PD process	Mid 2026

C. Develop & Implement BIM4I Field Activities & Asset Management

6.	Statewide mandate of Automated Machine Guidance (AMG)	Dec 2023
7.	Digitally capture & integrate high-quality data during surveys & construction activities	Jan 2024
8.	Implement use of e-Ticketing	Mid 2026
9.	Strengthen use of UAS with central data repository, training, streamlined procurement, & fleet management system	Dec 2026
10.	Provide Digital As-Builts (DAB) that accurately capture the final state of both surface and subsurface elements in lieu of red lined pdf as-builts	Dec 2025

11. Utilize GIS applications and workflows to support digital data sharing, interoperability, & visualization throughout the project development process and asset life cycle	Dec 2025
12. Adopt 4D (Scheduling) & 5D (Cost) into the Caltrans' project development & delivery process	Jan 2028

RESOURCE NEEDS SUMMARY

The original BIM4I committee organized actions and associated resource needs into three timeframes: Short-, Mid-, and Long-Term as shown below.

In support of implementation, some of the below resources for Short-Term were requested in a 22/23 and 23/24 Finance Letter (FL) for Capital Outlay Support (COS) functions. Resources originally identified for other non-COS functional areas will be requested via Budget Change Proposals or other avenues. Resource needs for other time frames will be assessed annually. Please see the full distribution of resources among HQ functional areas and districts in Appendix B.

Note: the actions and resources shown in Appendix A represent the committee's original proposed implementation needs. These were identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 FLs and may differ from the actual resources requested and/or received.

A. Generate BIM4I Models for Legal Contract Documents

	Training	Committees	C-PY	D-PY	OE (One Time)	OE (Annual Ongoing)
Short-Term	3.00	2.00	4.00	16.00	$2,192,000	$1,000,000
Mid-Term	3.80	0.00	4.50	0.50	$4,110,000	$0
Long-Term	1.00	0.00	1.00	0.00	$425,000	$0

B. Establish BIM4I Project Delivery Process

	Training	Committees	C-PY	D-PY	OE (One Time)	OE (Annual Ongoing)
Short-Term	1.25	8.00	7.10	2.00	$1,055,0000	$0
Mid-Term	0.00	0.00	22.700	20.00	$5,900,000	$0
Long-Term	34.50	0.00	3.50	0.00	$17,580,000	$0

C. Develop & Implement BIM4I Field Activities & Asset Management

	Training	Committees	C-PY	D-PY	OE (One Time)	OE (Annual Ongoing)
Short-Term	22.00	0.00	40.95	41.50	$1,160,000	$12,400,000
Mid-Term	3.00	0.00	38.75	47.00	$4,150,000	$6,705,000
Long-Term	0.00	0.00	2.50	0.00	$0	$1,310,000
Short-Term	26.25	10.00	52.05	59.50	$4,407,000	$13,400,000
Mid-Term	6.80	0.00	65.95	67.50	$14,160,000	$6,705,000
Long-Term	35.50	0.00	7.00	0.00	$11,050,000	$1,310,000
TOTALS	68.55	10.00	125.00	127.00	$29,617,000	$21,415,000

FOCUS AREA RECOMMENDATION SUMMARIES

As noted above, below are summaries of the BIM4I committee's 15 original recommendations developed August 2021 – July 2022. Please see the Appendix for full documentation for each recommendation.

Note that where the term "3D Model" is mentioned in some of the recommendations, it denotes an information model that consists of a 3-dimensional graphical representation with attributes (sometimes also referred to as metadata, non-graphical information, or model object properties).

A. Generate BIM4I Models for Legal Contract Documents

1. Implement 3D Models for Roadway Projects
2. Implement 3D Models for Structures Projects
3. Enforce Implementation & Use of Caltrans' Utility Database
4. Advertise & Award 3D Models in lieu of 2D Plan Sets

B. Establish BIM4I Project Delivery Process

5. Establish Short- & Long-Term Pilot Project Support
6. Implement Use of a Common Data Environment (CDE) to Optimize Collaboration
7. Amplify Use of 3D Models for Visualization
8. Refine Overall Project Development & Delivery Process to Support Digital Project Delivery

C. Develop & Implement BIM4I Field Activities & Asset Management

9. Digitally Capture & Integrate High-Quality Data During Surveys & Construction Activities
10. Expand Statewide Implementation of Automated Machine Guidance (AMG) and Project Delivery Directive 6 (PD-06) – Sharing of Electronic Files
11. Fully Implement Use of e-Ticketing
12. Strengthen Use of UAS with Central Data Repository, Training, Streamlined Procurement, & Fleet Management System
13. Require Digital As-Builts (DAB) that Accurately Capture the Final State of Both Surface and Subsurface Elements
14. Formally Establish Project Delivery/GIS Data Organization Structure to Support Digital Data Sharing, Interoperability, & Visualization Throughout the Project Development Process and Asset Life Cycle
15. Adopt 4D (Scheduling) & 5D (Cost) into the Caltrans Project Development & Delivery Process

1. IMPLEMENT 3D MODELS FOR ROADWAY PROJECTS

A fundamental element of implementing BIM4I at Caltrans is to improve the existing project development and delivery process, procedures, and quality of the design by conveying design intent via 3D parametric and feature-based model digital files as the legal contract document in lieu of a 2D plan set. The model can then be updated in the Construction Phase to create a 3D DAB that will support Enterprise Asset Management, Planning, and future Project Development.

To start implementing this process, the committee determined that the next step is to start hybrid pilot projects that will provide the digital file deliverables identified in PD-06 as legal contract documents along with a 2D plan set. These digital files would no longer be provided "for information only" but be part of the legal contract. Please refer to the Implementation Activities section for a full list of recommended actions in the short-, mid-, and long-term implementation time frames.

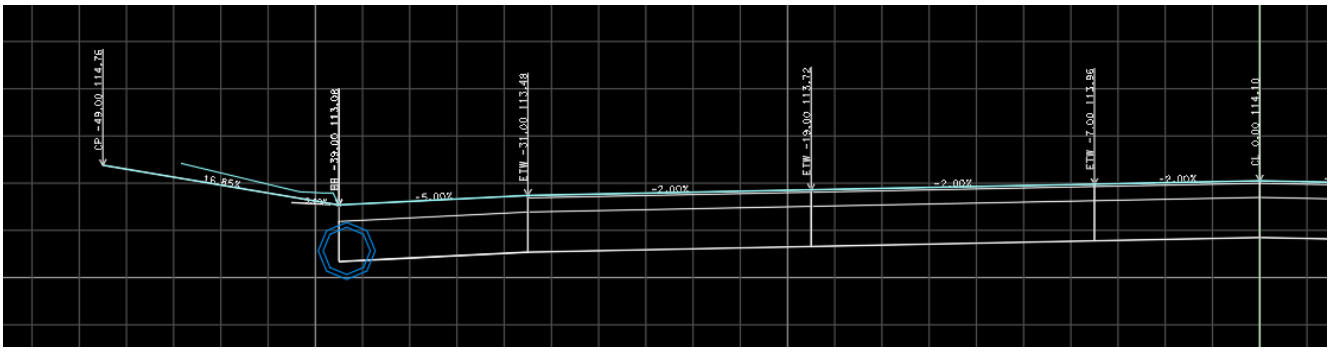
An analysis should also be done to review the current traditional survey deliverable to designers and vice versa. Survey points, lines, curves, and surfaces may no longer be viewed as the optimal deliverables; instead, solids— in lieu of points and lines— might be more applicable for digital delivery. Design information in the model could eliminate the need for cross sections and slope stake notes.

The BIM4I committee determined that three questions should be addressed relative to 3D PIMs: what the model must do, what is the process to create the model, and what the model must contain.

The committee's analysis concluded that the model must allow for multiple layers and levels of information and detail, accurately calculate quantities, summarize quantities for cost estimates, associate GIS metadata, tie items to asset management, connect to existing Caltrans databases, and tie design elements to standard plans, specs, construction details, and AASHTOWare bid items. The model must also allow for robust quality assurance/quality control (QA/QC) procedures, starting with correct state plane coordinates and ensuring standards are being followed. It must also support other BIM uses such as 4D/5D, visualization, asset management, and risk mitigation.

The process to create the model will include using a low Level of Detail (LOD) initially— with the option to update the model with a higher LOD as design progresses— and should be accessible and sharable among platforms as part of the CDE, contain strong administrative rights management to allow for multiple levels of permissions, contain a 3D asset/cell library comprehensive enough to support the necessary level of development, allow for signing and sealing of digital files, and allow for creation of pipe networks from objects.

LOD is a standard that defines how much detail is included in the model for different features such as utilities, structures, drainage systems, etc. Enough data and information should be provided for contractors to bid and build the project. Models must also contain universal standards, and multiple model deliverables should be allowed for more complex projects including construction staging needs. Additionally, models should be able to use open-source file systems— such as Industry Foundation Classes (IFC)— and include a method to add to databases, such as Bridge Inspection Records Information System (BIRIS) or Document Retrieval System (DRS) for future reference.



Using a model in 3D view highlights a conflict where the pipe encroaches into the structural section.

CLICK HERE to review the full recommendation writeup.

2. IMPLEMENT 3D MODELS FOR STRUCTURES PROJECTS

Bridge Design has initiated numerous BIM pilots for bridges and retaining walls. In addition to advancing their pilot project work, the BIM4I committee recommends expanding their efforts to not only deliver bridge and structures projects in 3D, but also embed key properties of the structural components in the model. This information will allow the models to be used for other processes such as estimation, constructability reviews/coordination, and structure maintenance inspections.

Currently Bridge Design is delivering two bridge projects in the LandXML format using the Caltrans' roadway software. In addition, pilot digital models are being developed for bridge projects in construction, as well as early-stage design studies, which include bridge and retaining wall elements. Bridge Design is testing new software and technologies to design and deliver the structure models alongside roadway, utilities, and digital information from other functional units.

To realize this goal, Bridge Design developed a BIM Execution Plan (BEP) template for three common bridge types based on the internationally recognized BIM Standard: ISO 19650. The plan identifies and defines the four high value-added BIM uses that Bridge Design is currently targeting, namely using the structure BIM model for engineering analysis, visualizations for public outreach, quantity take-off for cost and estimates for greenhouse gas emissions, and deriving the 2D structure plans from the 3D models. Bridge Design is also making sure that the classification structure defined in the BEP aligns with the neutral data standard for BIM that is being developed in the AASHTO BIM for Bridges & Structures Pooled Fund project and implemented in infrastructure software tools. With the BEP in place and pilot projects underway, all pieces are falling into place, not only to advertise projects with accessible digital information on highway structures, but also to work together at Caltrans across functions in a more integrated and collaborative way.

As part of the BIM4I project, the committee recommends increasing Bridge Design's existing efforts in the short-, mid-, and long-term phases by supporting BEP template maintenance, purchasing software, refining processes, updating manuals and guidance, developing and delivering training, developing model checking requirements, supporting industry engagement, automating and expanding features for structural analysis and 3D drawing production, and creating and maintaining a BIM object library.

CLICK HERE to review the full recommendation writeup.

3. ENFORCE IMPLEMENTATION & USE OF CALTRANS' UTILITY DATABASE

A 3D utility database (Caltrans' Utility Database (CUD)) exists today that stores utility information that can be referenced in Caltrans' drafting and roadway design software as well as being viewed in a GIS application. However, the database is not used widely or consistently statewide. The committee's recommendation is to focus on implementation and enforcement of the current memo directing districts to ensure underground facilities are identified and stored in the database and included in the 3D model that will be the legal document. Knowing the location of facilities, especially underground, will avoid conflicts and incidents resulting in a safer project.

Based on input from District Utility Engineering Workgroups (UEWs) to assist in enforcing the memo and Chapter 17, Article 9, of the Project Development Procedures Manual, the committee recommends the following:

- Provide additional resources to the UEWs to support CUD, store project data on current and past projects, and build expertise within their units.
- Allocate adequate statewide funds to districts to positively identify and locate existing utilities.
- Prioritize funds and resources for capturing underground utilities so that they are included in the pilot projects.
- Provide additional resources to the DES Geotechnical Office to create another unit to support southern districts to utilize Ground Penetration Radar for identifying underground utilities as the one unit cannot cover all statewide needs.

CLICK HERE to review the full recommendation writeup.

4. ADVERTISE & AWARD 3D MODELS IN LIEU OF 2D PLAN SETS

In conjunction with recommendations above, the committee recommends advertising and awarding PIMs and digital files in lieu of 2D plan sets as the Model as Legal Document (MALD). The process and all parties involved in the process from design through pre-advertising, advertising, pre-bid, and bid would all occur digitally.

It is noted that some 2D plan sheets may still exist for things such as the Title Sheet, layout of Stage Construction and Traffic Handling plans, or for other minor projects that would not typically be designed using BIM software.

Implementation will begin with hybrid pilot projects in the short-term to understand the necessary refinements in real time with the goal of implementing a fully vetted delivery process in the mid-term implementation phase.

CLICK HERE to review the full recommendation writeup.

5. ESTABLISH SHORT- & LONG-TERM PILOT PROJECT SUPPORT

Understanding that the use of pilot projects will be integral to thoroughly understanding how BIM4I should be organized and implemented within the Department, the committee recommends establishing a Pilot Support Task Force in the short-term implementation phase. This group would be

comprised of six to eight subject matter experts (SMEs) from various functions and districts who will establish recommended pilot selection criteria, maintain the BIM Execution Plan (BEP) standard templates to be used on all pilot projects, and develop and deploy BEP training that will assist Districts when identifying pilot projects for implementation of BIM4I efforts and innovations. This will include guidance, training, tools, criteria/requirements, and consideration in selecting and executing those projects. This group will also collect and disseminate lessons learned from relevant pilots in support of finalizing Caltrans' ultimate BIM4I process implementation plan.

In the mid- to long-term phase, the committee recommends establishing a permanent new office or branch in HQ to serve as a hub for communication of lessons learned, continuously maintaining the standard BEP templates, providing support and expertise to pilot teams statewide, and developing and providing guidance and training. Work conducted by the initial task force (as well as the resources allocated to it) would be transitioned to this office/branch roughly when the long-term 'ultimate' process is defined and implemented.

The third recommendation is to create a District Liaison in each district for BIM4I support, managing and monitoring performance matrices, communicating the latest guidance, and implementing new innovations in the districts for pilots and future projects.

CLICK HERE to review the full recommendation writeup.

6. IMPLEMENT USE OF A COMMON DATA ENVIRONMENT (CDE) TO OPTIMIZE COLLABORATION

The BIM4I committee's analysis concluded that the utilization of a CDE is a foundational component of realizing the vision of BIM4I at Caltrans. FHWA's *National Strategic Roadmap for Advancing BIM for Infrastructure* defines a CDE as "a centralized environment that allows for the collection, storage, collaborative editing, review, approval, sharing, and dissemination of digital data models." This focal point of graphical and non-graphical information management, storage, and dissemination of data provides key functionality to realize a PIM and support the BIM4I process. The "single source of truth," or the most up-to-date project design that the project team builds jointly in the CDE, will support cross-functional collaboration and transform the way Caltrans' infrastructure projects are designed, built, and maintained to benefit California taxpayers and stakeholders. The core requirements are described below:

a. Cloud-/server-based engineering data and document management systems/platforms.
b. CDE (automatically generates real-time comment notifications) with intuitive graphical interface.
c. Information models from Design are routed to the designated Checkers/Approvers through preset workflow logic implemented in the CDE. Notifications are sent to remind team members of submittal or review deadlines. The PIM in CDE platforms is available to other teams such as Construction and Asset Management.
d. Organize CT project data sets by providing seamless access to LIVE/CURRENT project data held in its native format without reorganizing data and maintaining data integrity. Data accessibility internally and externally with specific permissions.
e. Support the ISO 19650 Common Data Environment Workflow: all files have structured metadata to identify the model author, checker, approver, state, status, etc.
f. The CDE tracks project development and has a dashboard of intuitive graphs to report project progress based on defined performance metrics.

The committee is currently evaluating CDEs from multiple vendors. Projects are recommended in the short-term implementation phase to determine which software best meets the Department's needs. Once the preferred systems are identified and purchased, workflows will be aligned with ISO standards, and significant training and rollout activities would ensue in the mid-term phase.

CLICK HERE to review the full recommendation writeup.

7. AMPLIFY USE OF 3D MODELS FOR VISUALIZATION

The goal is to utilize the 3D models developed in the BIM4I process for visualizations within projects in all districts. The BIM4I committee recommends establishing a statewide Visualization Task Force comprised of SMEs drawn from the BIM4I Visualization sub-team and other relevant units to guide Districts and Regions in establishing localized expertise, PDT communication coordination, and PIM integration process. This group would be responsible for establishing criteria and scope of work for procuring a statewide service contract for visualization. When required, Districts will be able to write task orders for specific projects (in different phases) to generate visual aids such as 360 Tours, animations, videos, and simulations to benefit the project as specified in the visual communication plan as detailed in the visual communication policy. They would also establish reference material, general guidelines, and a decision matrix to educate PDTs on capabilities and benefits as well as determine the best visualization method(s) for their projects (e.g., 3D modeling will lower the cost of enhanced visualization). Doing so will allow the PDTs to increase the use of visualization in public outreach and stakeholder involvement to promote equity and localized solutions. Finally, the committee recommends establishing Visualization SME positions in Districts, Regions, and/or HQ to support the long-term growth and use of these tools.

CLICK HERE to review the full recommendation writeup.

8. REFINE OVERALL PROJECT DEVELOPMENT & DELIVERY PROCESS TO SUPPORT DIGITAL PROJECT DELIVERY

Development of a revised workflow for digital project delivery that aligns with and supports implementation of all recommendations in this report will be required for successful implementation of BIM4I. Ultimately, as various pilot projects are conducted during the short-term implementation phase, the BIM4I committee recommends creating a cross-divisional task force in the mid-term to modify and finalize this workflow based on lessons learned. This task force would also create training and provide ongoing project development training for the modified processes based on 3D PIM digital delivery. During the short-term and mid-term implementation of BIM4I, the committee will revise the current workflow based on the project needs for pilot projects.

A list of recommended refinements for this revised workflow includes capturing and providing survey data and starting the development of 3D PIMs in the K-phase, developing a statewide Quality Management Plan (QMP) in lieu of delegating to Districts, shifting as much 1-Phase design work to 0-Phase as possible, etc. The full list of modifications can be found in the recommendation documentation in the Appendix. The committee acknowledges that several of these activities are already being done earlier in the development process in some districts. However, efforts to advance the process have largely been sporadic as opportunities arise and are not yet consistent within or among districts. Implementing BIM4I digital delivery statewide presents the Department with an opportunity to create greater consistency, quality, and effectiveness statewide in both workflows and deliverables.

CLICK HERE to review the full recommendation writeup.

9. DIGITALLY CAPTURE & INTEGRATE HIGH-QUALITY DATA DURING SURVEYS & CONSTRUCTION ACTIVITIES

To support the overall BIM4I initiative, the committee recommends enhancing how as-built data is captured and integrated throughout surveys and construction activities. Robust multi-phased training must be developed and delivered for digital construction inspection; additional equipment will be needed for field verification along with high-speed computers and ample cloud storage. In collaboration with the BIM digital as-builts focus group, a guidance manual will need to be developed on capturing timely high-quality as-built locations and metadata throughout the construction phase of projects.

CLICK HERE to review the full recommendation writeup.

10. EXPAND STATEWIDE IMPLEMENTATION OF AUTOMATED MACHINE GUIDANCE (AMG) SPECIFICATION AND PD-06

The recommendation is to focus on further implementation and enforcement of the current policy (PD-06) as directed already. Develop AMG files (3D finished grade models) for every project that meets mandatory requirements and provide at the time of bid. While the policy exists, full implementation of it will require a multifaceted approach to ensure adoption and use are consistent statewide. The recommended steps include:

a. Be on the recommended "X" year replacement cycle of aging equipment. Timeline of replacement TBD and funding necessary for replacement.
b. Further staff development to use tools (training).
c. Develop District AMG Coordinators in every district.
d. Mandatory AMG specifications for all projects that meet requirements (with exceptions for poor Global Navigation Satellite System (GNSS) environments).
e. Caltrans' Spatial Reference Network (CTSRN) modernization and expansion.
f. Expansion of elements provided in 3D design model (develop 3D object code library to supplement feature code library).
g. Expansion of AMG elements to include pavements, structures, and underground elements.
h. Develop constructability review and verification process for AMG files prior to RTL (30%, 60%, and 90% plans review requirement).
i. Project Management enforcement and tracking of AMG projects.
j. Refine file types and standards for each AMG element.

k. Seek support from the legislation to support/fund the codified authority of the California Spatial Reference System: California Spatial Reference Center (CSRC).
l. Develop Change Management Plan with detailed Communication Plan (including statewide roadshow).

CLICK HERE to review the full recommendation writeup.

11. FULLY IMPLEMENT USE OF E-TICKETING

E-ticketing technology, offered by several commercial venders, provides for the transfer of electronic load delivery tickets of bulk materials to mobile devices. The process typically involves the commercial e-ticketing vendor connecting to the loadout system of a material producer to collect critical load information. A web-based interface allows for real-time tracking of deliveries and reporting of electronic load information. Onsite staff will receive the electronic loadout tickets and can electronically accept or reject the load prior to incorporation into the work. This technology improves worker safety, eliminates paper documents, protects against damage or loss of tickets, and improves project management through data collection and analysis.

The Department is currently performing an e-ticketing pilot project with two vendors. This committee has identified the following core requirements for full implementation:

a. Complete pilot projects to determine platform(s) to utilize.
    i. Ensure Caltrans owns the data generated from platforms.
    ii. Determine archival location (EDMS or other data system).
b. Develop guidance and tools for staff to utilize.
c. Develop information link between e-ticketing/DIME and the PIM to show what materials are being proposed by the Contractor for specific construction features as well as tracking exactly what materials were installed and where.
d. Develop baseline needs of delivery ticket information by material. Internal discussion will be needed to identify what material information is important to Caltrans (e.g., mix, batch, batch time, total water content, slump, etc.).
e. Develop automated notifications across systems for triggers of testing protocols, delivery window for time-restricted materials, alterations to materials in route, and proper delivery location.
f. Develop and deliver training for products being utilized.
g. Ensure specification compliance.
h. Track the correct material mix design for the right location.

CLICK HERE to review the full recommendation writeup.

12. STRENGTHEN USE OF UNMANNED AIRCRAFT SYSTEMS (UAS) WITH CENTRAL DATA REPOSITORY, TRAINING, STREAMLINED PROCUREMENT, & FLEET MANAGEMENT SYSTEM

UAS offers a multitude of improvements for BIM4I efforts as it increases safety, accuracy, and efficiency in capturing data and provides accessibility to hard-to-reach areas. UAS tools can be equipped with various types of technology for the different Divisions to utilize in performing their work in a more data-forward process. Recommendations include:

a. Each Division to continue developing their own best practices guidance for staff to utilize UAS technology. Leverage the existing Division working groups to develop resource and operating expense requests to implement UAS across the Department for BIM4I efforts.
b. Create a central repository for UAS data information to share data and capture efficiencies. Develop a cross-divisional group to determine how this process will happen and be utilized.
c. Each District or Division will need to determine who will utilize UAS tools for their business needs. Determine whether a specific office should be established with staff trained as UAS pilots or whether existing staff should be trained to perform the work as necessary. Each District and Division has different needs, so these would need to be established at their level.
d. Provide resource time for staff training to perform these functions. As most divisions and districts do not have many staff trained and equipped to utilize UAS tools, there is a need to determine who would/should be licensed to perform this work and then be provided with the necessary resource time to complete the training required per the UAS Safety Management System.
e. Provide a more streamlined procurement process for UAS equipment, software, and training as well as funding mechanisms for divisions and districts to acquire the tools necessary to perform these efforts.
f. Procure a fleet management system for statewide UAS use in coordination with Division of Aeronautics' ongoing efforts. The fleet management system should handle real-time flight tracking, monitoring, and flight metrics.
g. Leverage and maximize any and all grants related to UAS provided in the Infrastructure Investment and Jobs Act (IIJA).
h. The Survey Office should update the survey request form to include the accuracy and the data sets needed (e.g., imagery, video, topographical, etc.). Surveys would determine the best and most efficient way to collect the requested data. LiDAR data is not needed for all projects. The level of accuracy and level of detail should be the driver for selecting the appropriate data collection tools.

CLICK HERE to review the full recommendation writeup.

13. REQUIRE DIGITAL AS-BUILTS (DAB) THAT ACCURATELY CAPTURE THE FINAL STATE OF BOTH SURFACE AND SUBSURFACE ELEMENTS

The vision is to provide a 3D model digital as-built at the end of construction that accurately captures the final state of the project for both surface and subsurface elements. In doing so, the Department will be able to create a 3D model with 3D feature lines or objects according to the Caltrans Asset Information data dictionary that can be utilized for future uses. Recommendations include:

a. Develop AIM Execution Plan to outline 3D digital as-built's attributes and activities at the end of the construction phase. Determine asset information to be captured and utilized.

b. Develop link of geolocation with GIS (spatial and metadata).
c. Finalize process moving forward of incrementally developing the AIM. The final verified/validated AIM becomes the project's digital as-built.
d. Create and update information in the uniform 3D model object library and feature code library.
e. Conduct pilot project(s) that will tell us more about a variety of different project types (e.g., earthwork, pavement, box culverts, bridges, etc.), help determine milestones regarding when scans or data captures would take place, and inform development of guidance and processes.

CLICK HERE to review the full recommendation writeup.

14. FORMALLY ESTABLISH PROJECT DELIVERY/GIS DATA ORGANIZATION STRUCTURE TO SUPPORT DIGITAL DATA SHARING, INTEROPERABILITY, & VISUALIZATION THROUGHOUT THE PROJECT DEVELOPMENT PROCESS AND ASSET LIFE CYCLE

The BIM4I committee recommends creating a cross-disciplinary GIS committee (potentially a technical working group of the Geospatial Sub Committee or Enterprise Data Stewards Committee) comprised of SMEs (members must understand GIS and data interoperability) to determine the most appropriate project delivery GIS organization structure, establish standards, identify essential data layers and databases, research and adopt industry best practices, determine ideal workflows, and assist with implementation and change management. This short-term solution would be funded through December 2023 with two PYs with the intention of this funding rolling over into a long-term support unit of two full-time employees to support this portion of the BIM4I effort. The task force would continue as long as the team determined it was necessary to complete BIM4I tasks.

The lessons learned by the Task Force and other BIM4I sub-teams during the implementation process will be used to adjust current project delivery workflows to leverage GIS for PIMs and AIMs. This effort would occur during all phases of the project delivery process along with facilitation of the asset life cycle processes on an enterprise level. This effort would provide project delivery team members a common framework to communicate geospatial data, maintain current data, and allow iterative design/data collection procedures without exchanging data files of differing format, version, and content.

Due to the extraordinary nature of this change in the way Caltrans does business along with the lack of GIS staff to perform this work at the district and division level, the committee recommends that specialty staff positions be created to support this effort. The workflows that will be developed from this effort are more than the existing District and Division GIS staff can handle. The task “Project Delivery GIS/Data Organization Structure” should be considered for funding across all districts and at the HQ level. True BIM4I GIS support, for this effort to be fully successful, would consist of a multi-disciplinary unit in each district and HQ. The minimum increase in staffing that would allow this effort to be successful is one specialty GIS support position per district and two at HQ.

CLICK HERE to review the full recommendation writeup.

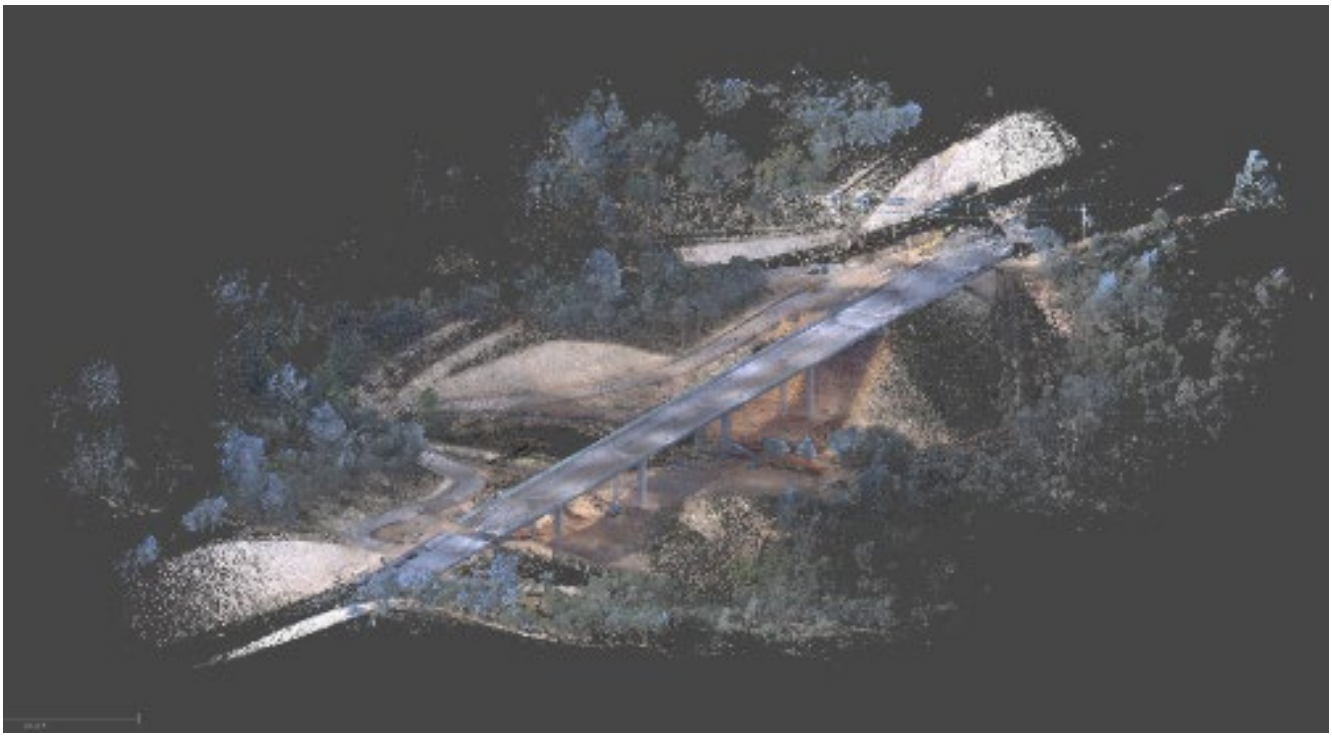
15. ADOPT 4D (SCHEDULING) & 5D (COST) INTO THE CALTRANS PROJECT DEVELOPMENT & DELIVERY PROCESS

This encourages work with internal and external partners, including the highway construction industry, to adopt 4D (scheduling) and 5D (cost estimation) into the standard Caltrans project delivery process. This will require a mindset shift and a change in management to model everything with metadata at the outset (model with attributes). Very close coordination will be required internally across functional areas involved with BIM4I to ensure attributes are structured appropriately as early as the design stage, and all information that needs to be input over the project life cycle is considered.

Like many of the BIM4I committee's recommendations, pilots will be required to fully determine the best way to implement this recommendation. Specific questions these pilots should answer include:

- Does Caltrans accept contractor estimation in the schedule provided to Caltrans?
- How does traffic control/staging fit into the schedule?
- Who updates the model (Contractor, Caltrans, or both) to reflect what has been built?
- How should activities, such as structural backfill that is not modelled, be included?
- How should embodied carbon in materials and carbon emissions from construction equipment be included?

CLICK HERE to review the full recommendation writeup.



APPENDICES

A. Full Recommendation Documentation & Action Plans
B. Task & Resource Request Breakdown
C. Terms & Definitions
D. VA Study Process
E. Project Charter

APPENDIX A: FULL RECOMMENDATION DOCUMENTATION & ACTION PLANS

1. IMPLEMENT 3D MODELS FOR ROADWAY PROJECTS

CLICK HERE for recommendation summary.

Description of Baseline Process:

Current Caltrans process is to provide 2D .pdf plan sets for bidding, award, and construction of our design intent. These files are a byproduct of the 3D files that designers utilize today using 3D design software, Civil 3D and 2D design using MicroStation. These 2D pdf files are then used by Surveys to create staking notes and other data products along with Construction to create redlined as-builts. In some districts/regions, 3D Models are created for earthwork that will be constructed using Automated Machine Guidance (AMG).

Description of Recommended Change/Solution:

Caltrans is embarking to improve the project delivery process by using multidimensional data to better represent the complexities of geospatially referenced transportation system features using clear parametric models of the existing and proposed project features. This will involve improving the existing project delivery processes, procedures, and the quality of design products by conveying design intent via 3D parametric and feature-based digital model files and using them as the legal contract document in lieu of a 2D plan set. The design model can then be updated during Construction to create a 3D digital as-built that will support Enterprise Asset Management, Planning, and future Project Development. The 3D parametric design model will include the 3D geometry plus additional information (metadata). The 3D parametric design models will be known as the 3D Project Information Model (PIM) during the design phase.

To start implementing this process, the committee analyzed three questions: what the model must do, what the process should be to create the model, and what the model must contain. Through this analysis, the team developed a clearer picture of a path toward implementation. The below narrative highlights key aspects of this path. In order to more fully understand the implications of this monumental change, the committee recommends starting with hybrid pilot projects that will provide the digital file deliverables identified in PD-06 as legal contract documents along with a 2D plan set. These digital files would no longer be provided “For Information Only” but would be part of the contract.

An analysis should also be done to review the current requirements for traditional survey deliverables to designers and vice versa. Survey points, lines, cross sections, curves, and surfaces may no longer be viewed as the optimal deliverable; solids (surfaces) in lieu of points, and lines might be more applicable for digital BIM4I delivery. Design information in the model could eliminate the need for slope stake notes.

- What must the 3D PIM do?
    - Layers/levels of information and detail
    - Accurately calculate quantities
    - Summarize quantities for cost estimate

    - Associate GIS metadata
    - Tie items to asset management
    - Connect to existing CT databases
    - Tie design elements to standard plans, specifications, construction details, and bid items which can be used for asset management as well
    - Allow for Quality Assurance and Quality Control (QA/QC): start with correct state plane coordinate projection, 3D datum realization, including vertical and horizontal datum, and epoch to ensure standards are being used and followed
    - Support other Building Information Modeling for Infrastructure (BIM4I) uses: 4D/5D, visualization, asset management, risk mitigation
- What is the process to create the 3D PIM?
    - Level of detail (LOD): recommending 200 to start for short-term projects
    - Have a comprehensive 3D asset/cell library to support Level of Development (LOD)
    - Update model with higher level of detail
    - Accessibility & shareability: need to be multi-platform
    - Administrator rights management, levels of permissions
    - Security – sign and seal model(s)
    - Productivity: creation of pipe networks from objects
    - Make accessible to and usable by others
    - Make part of Common Data Environment (CDE)
- What must the 3D PIM contain?
    - LOD: ex. drainage inlet slopes and end point elevations (LOD 400) vs referring to Std plans (LOD 200)
    - Existing features - utilities (above and below ground), R/W, survey monuments, structures
    - 3D (Triangular Irregular Network (TIN), Mesh & Solid) surfaces for Digital Terrain Model (DTM) Original Ground, Digital Design Model (DDM) Finish Grade, intermediate layers, etc.
    - Automation of commands
    - Link to databases for supporting information and updates
    - All alignments for layout, profiles, log of test borings (LOTBs)
    - Metadata - needs to have attributes to document the utilities type, size, owner, capacity, age
    - Enough data and information for Contractor to bid and build
    - Standard layers, levels, and outputs so products are similar for Contractors to bid; every model should not have its own standards
    - Multiple model deliverables should be allowed for more complex projects
    - Way to process changes and add to online database such as Bridge Inspection Records Information System (BIRIS) or Document Retrieval System (DRS) for future projects
    - Use open data standard such as Industry Foundation Classes (IFC)
    - Handle all structure types
    - Stage Construction information

For additional Project Information Model items, refer to notes at the end of this recommendation.

Implementation will begin with pilot projects.

Anticipated Benefits:

- Improve safety
- Early clash/conflict detection
- Incorporation of more Highway Design Manual safety checks
- Maximize clarity of Design intent and minimize misinterpretation
- Improved multi-disciplinary collaboration
- Decrease construction project cost and time
- Reduce project delivery time
- Increase productivity/efficiency
- Improve quality
- Reduce contract change orders
- No loss of data integrity
- Provide an environment for collaboration and increased data sharing and accessibility
- Eliminate/reduce need to create pdf plan sheets as native digital files can be shared
- Analyze and improve engineering design and alternatives in 3 dimensions
- Support new technology, such as AMG
- Easier to create visualizations, animations, and virtual reality applications
- Recruitment and retention
- Easier to review complex projects
- Use the 3D PIM in lieu of plan sheets for more effective constructability and safety reviews

Implementation Considerations:

There is a concern among staff members that the roadway design software currently used by the department is not ready for full model-based delivery. Civil 3D Design Software currently lacks the following:

- Automation - Design change is an extremely manual process
- Interoperability - Exporting data/model to other software
- Ability to accurately model our Standard Plans or detailed information

- **Financial Implications:**
    - Short-Term
        - Resources Needed (PYs): 3 PY
        - Operating Expenses: $1,312,000 one time
    - Mid-Term
        - Resources Needed (PYs): No additional PY
        - Operating Expenses: $1,100,000 one time
    - Long-Term
        - Resources Needed (PYs): No additional PY
        - Operating Expenses: None

- **Policy Impact:**
    - Create Digital Delivery/Modeling Standards Manual
    - Create new BIM4I QA/QC manual
    - Develop Legal requirements to assign Engineer License Seals to Models (Model as Legal Document)
    - Develop workflows and Expectations (Duty Statements) of Project Development Team Members
    - PDPM updates
    - CADD Manual updates
    - Develop Local Assistance/Permit Model Independent Quality Assurance requirements
    - Update the RE and Survey Engineer File Requirements
    - Update Survey Manual - ensure survey information is included in the model

- **Potential Implementation Challenges:**
    - Shift mindset to modeling everything (including drainage, traffic electrical, etc.) with metadata attached
    - Change in Task Management
    - Training and skill set of Design & Functional Units staff
    - Availability of Design Grade Survey at the "K" & "0" phase
    - Development of BIM4I Guidelines for Level of Development (LOD)
    - Information Exchange between the 3D Project Information Model & Functional units spatial analysis (i.e., Traffic Analysis, Structure Analysis, etc.)
    - Integration between Asset Management Data dictionary and AASHTOWare Preconstruction Quantity Takeoff and Estimate
    - Implementation of the Common Data Environment for PIM & Asset Information Model (AIM)
    - IT Support for changes in the System Architecture for post-pandemic hybrid environment
    - Creation of a 3D cell/block library
    - Sharing of information from different data sources
    - Robust 3D parametric and feature based model exchange and interoperability
    - Referencing the Standard plans and Special Provisions
    - Bandwidth for data sharing
    - Include details from third parties in the model such as Cities, Utility Owners, or Others
    - Models must be backward compatible with previous versions of software
    - Admin rights/levels of permissions
    - Additional time/resources for adding/updating changes to the final model
    - Consultants - expect 3D Project Information model from them
    - Additional RAM for laptops
    - Completeness of 3D Project Information model for support of AMG and digital as-builts
    - Construction sign-off of 3D PIM similar to current acceptance of cross sections at Ready to List (RTL)

- **Performance Measurement:**
    - 3D PIM constructability review
    - Performance metrics captured in PIM for BIM Execution Plan
    - Number of construction claims due to issues with the 3D PIM accuracy
    - Developing Analytics for tracking CCOs & RFIs

- **Implementation Lead (Division):**
    - Division of Design

- **Recommended Involved Parties:**
    - Vendors
    - Contractors
    - Consultants
    - Local Agencies & Metropolitan Planning Organizations (MPOs)
    - Functional Units
    - Railroad Companies
    - Other California State Departments
    - Permit Agencies
    - IT

1. IMPLEMENT 3D MODELS FOR ROADWAY PROJECTS

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1.01	1- Short	1. Org	Initiate and process hybrid pilot projects, make PD-06 deliverables as part of legal contract documents along with 2D plan set *Assumes can be achieved within current resources*	Districts				
1.02	1- Short	1. Org	Have 20 personnel become BIM4I Certified by taking Train the Trainer certification course (assumes 20 staff @ $600/person)	Design			$12,000	
1.03	1- Short	2. Tools	Automate and expand features and capabilities of roadway design software *Assumes can be achieved within current resources*	Design			$500,000	
1.04	1- Short	2. Tools	Create a 3D cell library for design elements, including drainage inlets, signs, barriers, etc.				$800,000	

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1.05	1- Short	3. Policy	Conduct analysis to review the current traditional survey deliverable to designers to support streamlining of the current workflow	Surveys	1.00			
1.06	1- Short	3. Policy	Standardize Level of Development (including Metadata/Attributes requirements)	Design				
1.07	1- Short	3. Policy	Tie design elements to Std plans, Specs, construction details and Bid items which can be used for asset management as well	Design	2.00			
1.08	1- Short	3. Policy	Manage shared data	Design				
1.09	1- Short	3. Policy	Share the 3D PIM with the contractor and establish CCO & RFI communication Protocol	Design/ Construction				
1.10	1- Short	4. Data	Develop constructability platform to circulate and review the 3D model and provide feedback to the designers and other functional groups	Design/CADD				
1.11	1- Short	4. Data	Update current bid items *Assumes can be achieved within current resources*	Design/OE				
1.12	2- Mid	1. Org	Develop Training Manual (by consultant)	Design			$75,000	
1.13	2- Mid	1. Org	Develop Modeling Standards Manual	Design			$150,000	

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1.14	2- Mid	1. Org	Develop training for Consultants, outside partners, city & local government	Design				
1.15	2- Mid	1. Org	Train staff using Service Contract ~10,000 staff (25 per class, $1,950/class)	Design			$770,000	
1.16	2- Mid	1. Org	Deliver training for Contractors with BEP, PIM, & AIM	Design/Con-struction			$5,000	
1.17	2- Mid	3. Policy	Develop new QC/QA manual	Design/OE			$100,000	

2. IMPLEMENT 3D MODELS FOR STRUCTURES PROJECTS

CLICK HERE for recommendation summary.

Description of Baseline Process:

For over 100 years, Caltrans construction contracts have been advertised in the same format: two-dimensional paper plan sheets. Roadway Design began to include three-dimensional (3D) alignments and profiles, digital terrain models, and finished grade models in their project advertisement, but the 3D model was incomplete because it contained no information about the highway infrastructure such as bridges. The Associated General Contractors (AGC) and other partners requested structure models, but Caltrans Bridge Design was not part of digital delivery. Conventional plan sheets remained the only deliverable for project advertisement. As a result of this disconnect between Roadway and Bridge Design, the project delivery teams did not catch some clashes in advance at the interfaces. For example, conflicts between drainage and structure components went undetected and caused expensive change orders in the field. The need to break the traditional silos and deliver projects that are both integrated with Roadway design's 3D models as well as accessible to contractors became very clear to Bridge Design.

Description of Recommended Change/Solution:

Bridge Design is piloting Building Information Modeling (BIM) in their design projects. The committee's recommendation is to not only deliver bridge and structures projects in 3D, but also embed key properties of the structural components in the model. This information will allow the models to be used for other processes such as quantity take-offs, clash detection/coordination with other functions, and structure maintenance inspections.

Currently Bridge Design is delivering two bridge projects in the LandXML format using the Caltrans roadway software. In addition, pilot digital models are being developed for an ongoing construction project and a new design project, which include bridge and retaining wall elements. Bridge Design is testing new software and technologies to design and deliver the structure models alongside roadway, utilities, and digital information from other functional units.

To realize this goal, Bridge Design developed a BIM Execution Plan (BEP) template for three common bridge types based on the internationally recognized BIM Standard: ISO 19650. The plan identifies and defines the four high value-added BIM uses that Bridge Design is currently targeting, namely using the structure BIM model for engineering analysis, visualizations for public outreach, quantity take-off for cost and estimates for greenhouse gas emissions and deriving the 2D structure drawings. Bridge Design is also making sure that the classification structure defined in the BEP aligns with the neutral data standard for BIM that is being developed in the AASHTO BIM for Bridges & Structures Pooled Fund project and implemented in infrastructure software tools. With the BEP in place and pilot projects under way, all pieces are coming into place not only to advertise projects with accessible, digital information on highway structures, but also to work together at Caltrans across functions in a more integrated and collaborative way.

As part of the BIM4I project, the committee recommends amplifying Bridge Design's existing efforts in the short-, mid-, and long-term phases by supporting BEP template maintenance, purchasing software, refining processes, updating manuals and guidance, developing and delivering training, developing model checking requirements, supporting industry engagement, automating and expanding features for structural analysis and 3D drawing production, and creating and maintaining a BIM object library. Please see complete list of recommended implementation activities in the table at the end of this section.

Anticipated Benefits:

- SAFETY FIRST
  Risk assessment is a part of every design decision, and the transparency of a digital model can help inform this process. The model allows the project delivery team to review and understand the design early and assess risks collaboratively. When risks cannot be eliminated, the PIM can be used to alert relevant parties to potential safety issues or form the basis for a contractor's simulation of a challenging construction sequence.

- STEWARDSHIP AND EFFICIENCY
  The BIM models developed during design are validated in the construction process and subsequently stored in a repository for structure maintenance inspections. The advantages of BIM are not only focused on project delivery, but rather extend throughout the project's useful life and inform structure maintenance interventions (the model can be used through the whole life cycle of the project and asset management as a digital twin).

- CULTIVATE EXCELLENCE
  The millennial generation and Gen Z are the digital natives. Unlocking and leveraging the power of BIM in the design, construction, and maintenance of exciting projects will attract young graduates to apply their talents to the transportation fields and build careers in the public sector. These technologies and tools will enable an innovative and performance-driven workforce to find solutions to society's biggest challenges. Moreover, BIM will help to retain employees, so they can stay connected to dispersed teams and projects while teleworking.

- CLIMATE ACTION
  Reducing the environmental impact of transportation projects involves understanding the life cycle energy and net embodied carbon associated with design decision. BIM will enable project engineers to quickly extract quantities from the model for their marginal cost estimates. These quantities will also be linked to existing Carbon Calculators such as the FHWA's Infrastructure Carbon Estimator (ICE). This will allow designers and decision-makers to evaluate alternatives based on carbon estimates alongside costs.

- EQUITY AND LIVABILITY
  The bridge information models can be enhanced with context, lighting, and material textures to support public outreach meetings. The Caltrans project development team can dynamically inform the public and receive feedback more effectively because they are using a visually enhanced form of the engineer's bridge model that they have been working with throughout the project. The models can also support a virtual meeting format very effectively, which may

reach a broader audience than traditional in-person meetings. Moreover, the intuitive visualization model enables non-technical stakeholders to understand the project and engage more meaningfully in discussions with Caltrans. They can identify/raise their interests and concerns early, reducing the potential for delays late in the project delivery process.

Implementation Considerations:

- **Financial Implications:** Please see costs detailed per activity in the timeline below.
    - Short-Term
        - Resources Needed (PYs): 6 PYs
        - Operating Expenses: $480,000 one time, $200,000 annual
    - Mid-Term
        - Resources Needed (PYs): 8 PYs
        - Operating Expenses: $3,010,000 one time
    - Long-Term
        - Resources Needed (PYs): 2 PYs
        - Operating Expenses: $425,000 one time

- **Policy Impact:**
    - Revise the Bridge Design Process & Procedures Manual to include BIM -- in particular, hand-off of model to structure construction and construction support
    - Develop Legal Policy for engineer to seal the model (Model as the Legal Document)
    - Workflows and Expectations (Duty Statements) of Project Engineer/BIM Manager and Project Development Team Members
    - CADD Manual updates
    - Model QA/QC checking requirements and Bridge Analysis Independent Check process needs to be defined in a BIM workflow
    - Update the RE and Survey Engineer File Requirements
    - Survey Manual - ensure survey information is included in the model
    - Policy to be developed for collaborative working on bridge models in CDE with design consultants
    - Guidance/Recommendations will be written for developing and exchanging models with fabricators (precast girders, reinforcement) so we can avoid duplication of effort
    - Guidance/Recommendations for Bridge Design's role/responsibility & process for developing the bridge digital as-built

- **Potential Implementation Challenges:**
    - Bridge Contractors' BIM capabilities will need to mature
    - Slow pace of IT/DPAC procurement
    - Recruiting/Training/Upskilling staff
    - Technology Readiness
    - Specific Analysis requirements for Bridge Design in California
    - Legal issues related to sharing and stamping models

- Software Interoperability
- Completeness of 3D model for support of AMG and digital as-built files

- **Performance Measurement:**
  - Bridge project teams will define their performance metrics in the BIM Execution Plan section 4. Working with the Pilot Resources Sub-Team, Bridge Design will standardize performance metrics so consistent data can be obtained/summarized for insight.
  - AAHSTO T-19 BIM for Bridges & Structures pooled fund will recommend performance metrics of bridge/structures projects using the neutral IFC data format. This will enable projects across the nation to track their performance in a consistent way, which will yield useful results.

- **Implementation Lead (Division):** DES, Bridge Design

- **Recommended Involved Parties:**
  - Internal: Structure Construction, Structure Maintenance & Investigation, Asset Management, Roadway Design, SES, GS, METS
  - External: Contractors, Fabricators, A&E consultants

2. IMPLEMENT 3D MODELS FOR STRUCTURES PROJECTS

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2.01	1- Short	1. Org	Resource staff hours on software training and BIM Execution Plan/Information Management training	Bridge Design	3.00			
2.02	1- Short	1. Org	Develop Training Manual: will include software vendor training document and Caltrans-specific workflows. Develop Caltrans BIM bridge/structure model examples for training and testing.	Bridge Design	0.50		$80,000	
2.03	1- Short	1. Org	Support national engagement: support participation in different working task groups of national funded projects [e.g., TPF-5(372)] Provide presentation materials, write articles to demonstrate BIM efforts and pilot project outcomes, and conduct research on new tools/software in implementing BIM for infrastructure	Bridge Design	2.00		$50,000	

2.04	1- Short	2. Tools	Purchase software for pilot projects	HQ CADD DES Software Managers IT Certifica-tion DPAC HQ IP Legal EAC/IT				$200,000
2.05	1- Short	3. Policy	BIM Execution Plan review, revision, and maintenance, create template model production delivery tables for various bridge types with standardized LOD	Bridge Design Collab-orate with Asset Manage-ment			$350,000	
2.06	1- Short	4. Data	Develop Information Standard for Bridge Modelling/Quality checking based on the IFC standard from TPF-5(372). Updates to Bridge Design Manuals/Detailing Manuals, etc.	Bridge Design	0.50			
2.07	2- Mid	1. Org	Training for Structure Construction and Structure Maintenance & Investigations, including BEP, PIM, using the model for inspections, digital as-builts	Bridge Design	3.00		$100,000	
2.08	2- Mid	1. Org	Training for and outreach/collaboration with Consultants, Regulatory Agencies, City & Local government, if required (Model Viewers, CDE, and basic model breakdown / structure & navigation)	Bridge Design / ACEC OSFP	0.50		$10,000	

2.09	2- Mid	1. Org	Train Bridge Contractors on BEP, PIM, Digital As-builts	Bridge Design/ AGC, Structure Construc-tion			$600,000	
2.10	2- Mid	1. Org	Update Duty Statements to reflect BIM -- Workflows and Expectations (Duty Statements) of Project Engineer/BIM Manager and Project Development Team Members	Bridge Design DHR	0.00	0.50		
2.11	2- Mid	2. Tools	Bridge/Structure Software Customization and Testing: Automate and expand features for structural analysis and 2D drawing production	Bridge Design			$500,000	
2.12	2- Mid	3. Policy	Develop new BIM section in Bridge Design Process and Procedure Manual (2-4 years) Model QA/QC checking requirements and Bridge Analysis Independent Check process needs to be defined in a BIM workflow Connect Bridge Model to AASHTOWare Preconstruction software	Bridge Design Structure OE			$150,000	

2.13	2- Mid	3. Policy	Contractor/Fabricator Industry Engagement through Forums with Caltrans to set up Guidance for model exchange and streamlined workflows between design & construction Setting up procedures for CCO & RFI processes (including Caltrans legal) (5-7 years) Guidance/Recommendations for Bridge Design's role/responsibility & process for developing the bridge digital as-built	Bridge Design/ Structure Construc-tion			$800,000	
2.14	2- Mid	4. Data	Model LOD Guide for Caltrans BIM Bridge/Structure Objects (3-5 years)	Bridge Design			$350,000	
2.15	2- Mid	4. Data	Create a BIM object library for bridge/structure design elements, including deck, superstructure, substructure, retaining walls, etc. (using pilot projects to populate the BIM bridge/structure object library) All bridge/structure library objects will be tied to Std plans, Specs, construction details and Bid items which can be used for asset management as well (3-5 years)	Bridge Design	4.00		$500,000	
2.16	3- Long	1. Org	Continued Training for Bridge Design Staff	Bridge Design	1.00			
2.17	3- Long	2. Tools	Continued Bridge/Structure Software Customization and Testing: Automate and expand features for structural analysis	Bridge Design			$125,000	

2.18	3- Long	3. Policy	Continued Contractor/Fabricator Industry Engagement through Forums with Caltrans to set up Guidance for model exchange and streamlined workflows between design & construction Setting up procedures for CCO & RFI processes (including Caltrans legal) (5-7 years) Guidance/Recommendations for Bridge Design's role/responsibility & process for developing the bridge digital as-built	Bridge Design/ PCI & Fabricatio n Industry, Structure Construc-tion			$200,000	
2.19	3- Long	4. Data	Expand/Update the Caltrans BIM object library for bridge/structure design elements, including deck, superstructure, substructure, retaining walls, etc. All bridge/structure library objects will be tied to Std plans, Specs, construction details and Bid items which can be used for asset management as well	Bridge Design	1.00		$100,000	

3. ENFORCE IMPLEMENTATION & USE OF CALTRANS UTILITY DATABASE

CLICK HERE for recommendation summary.

Description of Baseline Process:

Information regarding existing utilities and or facilities, in particular those underground, are not stored in a common database for future use and asset management.

Description of Recommended Change/Solution:

A 3D utility database (Caltrans Utility Database (CUD)) exists today that stores utility information that can be referenced in our drafting and roadway software and can be viewed in a GIS application. However, the database is not widely or consistently used statewide. The recommendation is to focus on implementation and enforcement of the January 2021 memo from Division of Design mandating the use of the database and directing districts to ensure underground facilities are identified and stored in the database and included in the 3D PIM that will be the legal document. Knowing the location of facilities, especially underground, will help avoid conflicts and incidents, resulting in safer projects.

Based on input from District Utility Engineering Workgroups (UEW), to assist in enforcing the memo and Chapter 17, Article 9, of the Project Development Procedures Manual, the committee recommends the following:

- Provide additional resources to the UEWs to support CUD implementation, store project data on current and past projects, and build expertise within their unit
- Allocate adequate Statewide funds to districts to positively identify/locate existing utilities
- Prioritize funds and resources for capturing underground utilities so that they are included in the BIM4I pilot projects
- Provide additional resources to the DES Geotechnical office to create another unit to support southern districts to utilize Ground Penetration Radar (GPR) for identifying underground utilities as the one current unit cannot cover all statewide needs

Anticipated Benefits:

- Safer projects as knowing where locations of existing underground facilities avoids conflicts and incidents in construction
- Storage of data for underground facilities
- Includes Metadata, including x, y, z values, other properties, and level of accuracy
- Videos available on 3D Utility Database on CADD website
- Ties into MicroStation, Civil 3D, and GIS for displaying in 3D view/3D model
- Some Parametric cells for drainage are available in MicroStation that can be shown in 3D
- 3D elements can be shown/included in a 3D MicroStation .dgn file (ex. drainage could include utilities as well and then share with C3D to include in model)
- Video of CUD and ArcMap interaction
- Training videos on CUD available on CADD website

- Ability to identify potential utility conflicts during the design phase before construction commences
- Data stored in GIS can be pushed to CUD

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 16 PYs
    - Operating Expenses: $1.2 Million
  - Mid-Term
    - Resources Needed (PYs): No additional PYs
    - Operating Expenses: None
  - Long-Term
    - Resources Needed (PYs): No additional PYs
    - Operating Expenses: None

- **Policy Impact:**
  - Traffic - has a standard specification whereby Contractor provides digital files of existing traffic utilities
  - There is already an existing Memo on storing of utility data in CUD
  - Recommend having District surveys set control for Permit projects
  - Identify possible format for files to upload data into database and shared with respective partners/customer:
    - CSV file
    - Dgn or DWG
    - Excel spreadsheet
    - Shapefile
    - IFC
    - Point Clouds from images

- **Potential Implementation Challenges:**
  - Expertise/skill set is lacking in Districts to start utilizing/requiring 3D tools in database
  - In some districts, the Utility Engineering Workgroup (UEW) is responsible for design of utility relocation plans, creating utility plans, coordinating with utility companies, and responsible for overall utility information. Each district UEW has different roles and responsibilities.
  - D1, D2, and D9 do not have a UEW
  - Most UEW groups are still being established
  - When Districts request hours for projects that have utilities, PMs not loading into workplan
  - UEWs not getting compliance from other divisions
  - Civil 3D has difficulty bringing in data from CUD as it can't bring in most of the elements

- Permits – lack of support and data sharing from Permits office
- Need to map all facilities, including the following:
    - Electrical
    - Irrigation
    - Broadband
- Concerted support effort from Caltrans HQ to do the necessary positive location for existing utilities. Currently many Districts do not allocate enough funding to capture 3D dimension of the existing utilities. May need to establish a statewide fund to support districts to positively locate existing utilities.
- The CUD currently does not have the framework to store the geometry of the structure
- No method to account for the accuracy of the data graphically. Showing a potential range of accuracy graphically could be used to identify utilities that need more investigation.
- Geotechnical office - has a staff of 7 so can't assist all district at one time for GPR services
- Districts don't have enough UEW staff to import data and support database
- Allowance of UEW's access to Permit Database to review existing permits as-builts
- Modify the workflow for all Utility/Caltrans Facilities related to as-builts from Permits and Construction to be routed through Surveys to check the control accuracy of the data before it gets transferred to the UEW group to be inputted in the CUD.
- Completeness of 3D Asset Information model for 3D digital as-builts
- Collaboration and participation from Utility Companies

- **Performance Measurement:**
    - CUD is underutilized and not being used to store data
    - Measure database quarterly to see if data is being stored
        - Report data by projects to identify districts or design groups not including collected utility data into the CUD

- **Implementation Lead (Division): Design**

- **Recommended Involved Parties: All Divisions**

3. ENFORCE IMPLEMENTATION & USE OF CALTRANS UTILITY DATABASE

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3.01	1- Short	1. Org	Develop expertise and support for UEWs (1 PY per district or spread accordingly between regions and districts)	Design	0.00	12.00		
3.02	1- Short	1. Org	Create another GPR unit to serve southern districts	DES-Geo Tech office	0.00	4.00		
3.03	1- Short	2. Tools	Create statewide fund to support districts to positively identify existing utilities	R/W				$1,000,000
3.04	1- Short	2. Tools	Develop 3D planimetric cells for utilities	Design			$200,000	

4. ADVERTISE & AWARD 3D MODELS IN LIEU OF 2D PLAN SETS

CLICK HERE for recommendation summary.

Description of Baseline Process:

Currently, the bidding and award process is largely a 2D process. Division of Engineering Services (DES), Program/Project Management, and Office Engineer (PPM&OE) provide support to districts for the assembly, advertisement, bidding, award, and approval process for the Department's construction contracts. The process begins with the verification of the completeness of the Plans, Specifications, and Estimate (PS&E) submittal and is followed by the advertisement, bidding and award, and approval processes. Upon receipt of a complete PS&E submittal, a project is scheduled for advertisement and bid opening. PPM&OE staff prepare the construction contract documents from the Districts PS&E submittal. During advertisement, PPM&OE staff from the Quality Management Program (QMP) provide Independent Quality Assurance (IQA) reviews on a representative number of projects. As part of this process, the QMP team review the advertised construction contract for consistency, errors, and omissions. As part of the advertisement process, if errors or omissions are found within the bid documents, addenda can be issued to address the issue. At the end of the contract advertisement, bids from contractors are opened and the Department moves forward with the contract award and approval process in which licensing, bonding, and other contractual commitments are verified.

For the existing process, the existing contract advertisement requires the use of plans, specifications, and the estimate. Specifically, the plans consist of two-dimensional sheets that depict the proposed work to be constructed. For clarity, each plan sheet is typically prepared at a 1"=50' scale and there are different sets of plans for different items of work. For example, there is often a specific set of drainage plans for drainage work, separate from other roadway work plans. The Notice to Bidders and Special Provisions (NTB&SP) is generated by the Bid Book & Addenda Unit (BBAU) staff using Standard Special Provisions (SSP), Non-Standard Special Provisions (NSSP), Revised Standard Specifications (RSS), and other information provided by the districts.

Description of Recommended Change/Solution:

The proposed change is to advertise and award a Project Information Model (PIM) in lieu of 2D plan sets. The process, and all parties involved in the process, from design through pre-advertising, advertising, pre-bid, and bid will all occur digitally.

It is noted that some 2D plan sheets may still exist for things such as the layout of Stage Construction and Traffic Handling plans or for other minor projects that wouldn't typically be designed using BIM software. Implementation will begin with pilot projects to understand the process in real time.

Anticipated Benefits:

- Efficiency of communication
    - Bidder inquiry responses could be posted within contract model by Construction Inquiry Desk.

    - Addenda changes could be made in the model and HQ DES could hit the "post" button (rather than drafting new plans, sending out new plans attached to an addendum).
- More accurate and complete bids from contractor
- Take-offs more accurate
- Efficiency for bidders
- Higher quality contract product – checks will be known by designers – currently not cross referenced
- Reduced Change Orders (CO) and claims in construction

Implementation Considerations:

- **Financial Implications:**
    - **Resources Needed (PYs):** 0.8 PY in the mid-term phase, to be determined during pilot phase. Pending resolution of the ultimate solution, additional resources are primarily anticipated to be needed for training of staff.

    - **Operating Expenses:** To be determined during pilot phase. It is anticipated that staff training will be covered by CADD as part of training all Project Delivery staff for the utilization of the PIM.
        - Training:
            - Initial training for staff
            - Refresher training or training for subsequent software or policy updates
        - Update current software and system – to be determined in pilot process
            - Integration of item quantities from the 3D design software to AASHTO Preconstruction software for estimate

- **Policy Impact:**
    - Revise the following:
        - Procedures for Advertisement and Award process
        - SAM
        - PD-06
        - Standard Specifications
        - QMP procedure
        - Construction Contract Development Guide (CCDG)
    - AASHTOWare manuals and guidance

- **Potential Implementation Challenges:**
    - Notice to Bidders and Special Provisions – ensure consistency
    - Addendum process must be addressed to maintain version control of the PIM
    - Legislation: what is considered a plan? Confirm legislation does not need to change to allow digital files vs hard copies.
    - Must determine the process of addressing bidders' inquiries at the district level, within the model
    - Must determine how to address small businesses and accessibility to software
    - New data needs for storing

- Access to model by externals
- ADA compliance – addenda letter
- Integration – interaction with local agencies and contractors

- **Performance Measurement:**
  - Number of Independent Quality Assurance Reviews performed
  - Percentage of projects requiring addenda
  - Percentage of bidder inquiries per project related to the PIM
  - Number of projects advertised and awarded with the PIM

- **Implementation Lead (Division):**
  - PPM and OE

- **Recommended Involved Parties:**
  - Districts – Design, Maintenance, and OE
  - Structure Design
  - IT
  - Legal
  - Construction

- **Overall Timeline:** To be determined. May be finalized during the piloting stage.

4. ADVERTISE & AWARD 3D MODELS IN LIEU OF 2D PLAN SETS

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
4.01	1- Short	1. Org	Work with Districts to determine candidate 3D Hybrid Design Projects to Pilot through Bidding and Award *Assumes can be achieved within current resources*	Districts, Construction, DES PPM&OE				
4.02	1- Short	2. Tools	Consider interfacing 3D model design files with AASHTOWare Preconstruction System bid item list *(Resources covered under 3D model recommendations)*	Design				
4.03	1- Short	3. Policy	Prior to Advertisement, work with Division of Construction to ensure companies are prepared to bid on pilot project *Assumes can be achieved within current resources*	DES PPM&OE, Construction				
4.04	1- Short	3. Policy	Determine how to present Additive Bidding item & Plans in the Design Files *Assumes can be achieved within current resources*	Design/ Construction				

4.05	1- Short	3. Policy	Solve process of redlining and comments during quality review *Assumes can be achieved within current resources*	Design				
4.06	1- Short	3. Policy	Solve addenda process and version control *Assumes can be achieved within current resources*	Design				
4.07	1- Short	3. Policy	Districts consider including a Key Map (per PPM) in Project Plans using Design File name instead of Plan Sheet Name - this will help DES OE check Submittal & Contractors & RE check Design Files content and convention. May be useful for identification of changes for Addenda processing as well. *Assumes can be achieved within current resources*	Design				
4.08	1- Short	3. Policy	Implement process of packaging pilot projects for Advertisement *Assumes can be achieved within current resources*	DES PPM&OE				
4.09	2- Mid	1. Org	Update the Training on Process for new delivery *Assumes 10% PY for each senior*	DES OE	0.50			

4.10	2- Mid	1. Org	Training on this new process (basics to process specific) 1) Transportation Engineers (Civil, Electrical), Landscape Architects, 2) Assume DES PPM&OE will need discipline-specific training for reviewing and checking 3D models but likely at a similar number of resources as that for roadway designers 3) DES PPM&OE performing project reviews 4) 2-3 classes Software specific *Assumes 24 hrs/person; 23 people*	DES PPM& OE	0.30			
4.11	2- Mid	3. Policy	Review project details and evaluate for unique features requiring process updates *Assumes can be achieved within current resources*	DES PPM& OE				
4.12	2- Mid	3. Policy	Update Best Bid Standard: Guideline and checklist to be developed for completeness of the model from the District and should be used in PPMOE to revalidate the completeness Quality review *Assumes can be achieved within current resources*	DES PPM& OE				
4.13	2- Mid	3. Policy	Update Plan Preparation Manual (PPM) checklist *Assumes can be achieved within current resources*	DES PPM&OE, CADD				
4.14	2- Mid	3. Policy	Update SAM Manual Language *Assumes can be achieved within current resources*	DES PPM&OE, DPAC				

4.15	2- Mid	3. Policy	Update Standard Specification language (Confirm with "legal") - PD-06 - (electronic files), Spec changes: Section 2-1.06 for Design Files naming & convention and SS Section 5-1.02 for Contract Components hierarchy for description of 3D design files *Assumes can be achieved within current resources*	DES PPM&OE, CADD				
4.16	2- Mid	3. Policy	Solve addenda process and version control *Assumes can be achieved within current resources*	Design				
4.17	2- Mid	3. Policy	Implement process of packaging projects for Advertisement *Assumes can be achieved within current resources*	DES PPM& OE				
4.18	3- Long	2. Tools	Integrate e-bid into the tool or other bidding alternative software - perhaps a data group investigate *Assumes can be achieved within current resources*	DES PPM&OE				

5. ESTABLISH SHORT- & LONG-TERM PILOT PROJECT SUPPORT

CLICK HERE for recommendation summary.

Description of Baseline Process:

When identifying pilot projects for implementation of new innovations or process, there is no criteria or requirements identified or documented.

Description of Recommended Change/Solution:

First recommendation is to establish a Pilot Support Committee (PSC) comprised of 6-8 SMEs from various functions and Districts that will establish recommended pilot selection criteria and a Building Information Model Execution Plan (BEP) template, and training that will assist Districts when identifying pilot projects for implementation of BIM4I efforts/innovations. This will include guidance, training, tools, criteria/requirements, and consideration in selecting and executing those projects. Each project must also develop a BEP.

- Short-Term Pilots (1-2 years)
- Mid-Term Pilots (2-5 years total, Planning to Construction)
- Long-Term "Ultimate" BIM4I Process (5+ years, Planning to Construction/AM)

Second recommendation is to transition the PSC in the mid- or long-term into a new office or branch in HQ to serve as a hub for communication of lessons learned, keep and update BEP, support, expertise, and develop and provide guidance and training.

Third recommendation is to create a District Liaison in each District for BIM4I support, managing and monitoring performance matrices, communication of latest guidance, and implementation of new innovations in the Districts for pilots and future projects.

Anticipated Benefits:

- Standardized guidance and templates
- Common considerations to consider
- Criteria consistency
- Eliminate redundant efforts
- Capture and share lessons learned across Districts/centralized governance
- Systematic strategy to adopt and apply innovations
- Share items that can be added to improve Design Process

Implementation Considerations:

- Develop BEP template - include needed attachments, such as Level of Development (LOD). A first draft has been completed.
- BEP template is a live document that will need to be updated periodically as technology changes and feedback from pilot projects will be incorporated to improve the BEP.
- Formal BIM Execution Plan/Information Management Training for Project Engineers
- Cheat sheet for Districts to use to determine which projects would be ideal candidates

- PSC comprised of SMEs from Design, Surveys, CADD, OE, Construction, and Structures Constructions.
- In lieu of a District Liaison, each District will need the following BIM4I office organization chart to effectively manage and monitor the BIM4I performance matrices and provide support to the pilot projects and future projects.
    - Senior Transportation Engineer
        - (Policies, Accountability, Project monitoring & reporting, software support)
            - TE (Range-D)
            - TE (Range-D or C)
- Develop a separate and general guidance which identifies and defines scope of BIM uses, defines maturity level and goals for each BIM use. This is to help District to select what innovations they would like to try and implement.

- **Financial Implications:**
    - Short-Term
        - Resources Needed (PYs): 9 PYs
        - Operating Expenses: $30,000
    - Mid-Term
        - Resources Needed (PYs): 10 PYs
        - Operating Expenses: None
    - Long-Term
        - Resources Needed (PYs): No additional PYs
        - Operating Expenses: None
    - Notes:
        - 19 PYs above assume one pilot at a time. This number will scale with number of pilots running concurrently. PSC PYs to become part of new branch or office in HQ.
        - $30,000 and additional 5% Contingency per pilot project if needed on top of standard contingency.

- **Policy Impact:**
    - Add BEP as a requirement in WBS guide
    - Add requirement in PDPM
    - Update WBS guide with lessons learned

- **Potential Implementation Challenges:**
    - Resources for District staff to participate on PSC
    - Creation of office, branch, or District office, new PYs
    - Procurement (IT)
    - Training on BIM Execution Planning/Information Management/Life Cycle BIM process – connection between design, construction, asset management
    - Change Management/Culture Shift
    - Consistent and committed support from all involved functions

- **Performance Measurement:**
    - Baseline vs. new process evaluation
    - Project teams have listed Performance Metrics in their BIM Execution Plan and defined a continuous improvement process to evaluate the progress toward these goals throughout the project. Performance will be an audit of the BIM Execution plan vs. what the team has accomplished.

- **Implementation Lead (Division):** HQ/District Design, DES

- **Recommended Involved Parties:**
    - District staff: Design, Construction, Surveys, PM, Asset Management, IT
    - HQ staff: DES, Design, Construction, Surveys, Asset Management, IT

Current selected Pilot Projects

North Region

- 01-0J631 Soda Creek Retaining Wall
- 03-0H160 Binney Junction RR Bridge
- 03-3F070 American River Bridge, Deck Replacement
- 03-3H730 Marconi Curve Median Barrier
- 02-0J640 Roundabout

District 4

- 04-2Q770 Roundabout/Signal
- 04-4J820 Replace Tulucay Creek Bridge
- 04-0Q120B Replace Cayuga Park Pedestrian OC

PROPOSED PILOT SELECTION CRITERIA

Short-Term Pilots **(1-2 years total)**	**Mid-Term Pilots** **(2-5 years total, Planning to Construction)**	**Long-Term "Ultimate" VDC Process (5+ years, Planning to Construction/AM)**
Criteria (Hard Requirements) ○ Can be designed and constructed within 1-2 years ○ Project located within area having a good real-time network and cellular coverage – NR, D11, and D6 ▪ Avoid D1 coastal area ○ No ROW takes ○ CE Environmental process (includes no railroad involvement) ○ Minimal utility relocation ○ Project is early in design phase with approved Project Report and Environmental Document ○ Project Engineer and team must have appropriate training (Civil 3D, MicroStation, etc.) ○ Construction staff need adequate training (Civil 3D, MicroStation, etc.) ○ Design team has PS&E level digital terrain model (DTM) available ○ Project teams have appropriate surveying and field data capture hardware and software ○ Risk registers do not contain any schedule risks that are moderate to high (yellow to red)	**Criteria (Hard Requirements)** ○ Can be designed and constructed within 2-5 years ○ Project located within area having a good real-time network and cellular coverage ○ Project is at PA&ED phase with approved PID document ▪ Mandated AMG project ○ ROW – Minimal ROW (temp. construction easements, eminent domain, but avoid railroad involvement) ○ ENV – Minimal special status species mitigation within the corridor, no noise level requirements, no 401 or 404 permits ○ Utilities – Minimal to moderate utility relocations ○ Structures – take advantage of accelerated bridge construction (ABC) ○ Projects include most core functional units ▪ Structures, Hydraulics, Geotech, Traffic, Landscape Arch, Elec, Utility Eng., Water Quality, Highway Ops, and Traffic Safety, etc. ○ Risk registers do not contain any schedule risks that are high (red)	○ Project is at PID Phase *Based on lessons learned from short- and mid-term pilots, develop criteria to determine* *a) which projects will have 3D models vs 2D plan sets or* *b) the level of detail within the electronic document.*

Additional Selection Guidance ○ Regional diversity ○ Project type/scope diversity ○ Team engagement ○ Number of innovations proposed (e.g., digital as-builts, clash detection, quantity take-offs, 3D pipe network, etc.) ○ Past track record for successful implementation of innovations **Notes** ○ Will need a BIM Execution Plan ○ Look at NR quality control matrix and consider using as a template for all pilots **Potential Example Candidates** ○ Medium size CAPM ○ 3R Rehabilitation projects ○ Safety projects ○ District Directors Orders ○ Directors Orders ○ IQA ○ HM Assume 3D model and 2D plan sets are both used to ensure SBEs have time to transition. Look at larger projects first as larger contractors (Kiewit, Granite, Flatiron, etc.) have already adopted VDC.	○ **Possible project delivery methods** ▪ CM/GC ▪ PPP ▪ SB1 ○ **Possible project elements** ▪ Structures ▪ Complete Streets ▪ Sea level rise **Additional Selection Guidance** ○ Past track record for successful implementation of innovations **Notes** ○ Will need a BIM Execution Plan ○ Want to start using EDMS ○ Start adapting integrated project delivery team processes Transition to 3D model only.	

Depending on the project and team, pilots could follow one of two paths: • Option 1: 2D plans govern and the 3D model with sufficient level of detail (LOD) is supplemental • **Preferred Option 2: 3D model governs and 2D plans would be part of digital information attributes within the 3D model (assume title sheet, construction details, quantity tables, etc. will be digital)**		

5. ESTABLISH SHORT- & LONG-TERM PILOT PROJECT SUPPORT

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
5.01	1- Short	1. Org	Create Pilot Support Task Force using existing Sub-Team members comprised of various disciplines	PM	5.00			
5.02	1- Short	1. Org	Provide additional funding for pilot projects (functional units involved, including Design, Construction, and IT) *Assumes 1-2 PY per Pilot Project plus 2 total from HQ functions, including IT* *Assumes a 5-10% Contingency per Pilot*	Districts/ PM	2.00	2.00		
5.03	1- Short	1. Org	Team to provide training on BEP and pilot project education training *Assumes can be achieved under resources identified for the Pilot Support Task Force but will require ~$30,000 for travel*	PM/PSTF	0.00		$30,000	
5.04	1- Short	3. Policy	Develop language to modify manuals *Assumes can be achieved under resources identified for the Pilot Support Task Force*	PSTF				
5.05	1- Short	3. Policy	Create guidance documents (define LOD for various levels) *Assumes can be achieved under resources identified for the Pilot Support Task Force*	PSTF				

5.06	2- Mid	1. Org	Establish a District Liaison for each district or region	Districts	0.00	10.00
5.07	2- Mid	1. Org	Transition task force to permanent HQ office or branch *Assumes no additional resources outside of those requested for the PSTF*	PM		

6. IMPLEMENT USE OF A COMMON DATA ENVIRONMENT (CDE) TO OPTIMIZE COLLABORATION

CLICK HERE for recommendation summary.

Description of Baseline Process:

The baseline collaboration process for project delivery is accomplished through use of the standard Caltrans Uniform File System (UFS) structure, emails, phone communications, video teleconferencing, and by utilizing Civil3D shortcut functionalities that are established by Land Surveys, Design, and Structures functional units. For the past two years, PDTs have also been using a variety of online collaboration tools such as Webex, Microsoft Teams, Filr, and SharePoint to optimize the project delivery process and enhance collaboration during the pandemic. There are many existing paper-based processes in current use for both internal and external collaboration. Currently, Construction's collaboration with the contractor industry is still performed verbally, by email, or through physical correspondence. There is no interaction with information collaborated on nor any data system for retention and processing or work flowing of information. There is no 3D model-based collaboration platform currently in use between delivery teams, for instance between roadway and structure design or between design and construction. Some teams have made limited use of platforms such as ProjectWise, SharePoint, and Procore.

Description of Recommended Change/Solution:

The desired outcome from this sub-team is to create a 'single source of truth' or the most up-to-date project design that the team jointly builds. In this repository, all discipline-specific information models are integrated. Together these model contributions from diverse disciplines including Roadway, Structures, Hydraulics, and Utilities, among others, constitute the Project Information Model (PIM). The PIM can be shared and used by all teams during the project delivery process and forms the basis for the construction contract document. Design teams will continue to use their BIM software applications and will upload their model elements to a shared model space at regular intervals. The software environment in which the PIM is stored, managed, and shared is called the Common Data Environment (CDE). The utilization of a CDE is recommended as a foundational component of the Caltrans Building Information Modeling for Infrastructure (BIM4I) implementation program. FHWA's National Strategic Roadmap for Advancing BIM for Infrastructure defines a CDE as "a centralized environment that allows for the collection, storage, collaborative editing, review, approval, sharing, and dissemination of digital data models." This focal point of graphical and non-graphical information management, storage, and dissemination of data is a key functionality to realize a PIM and support the BIM4I process. The PIM that the project team builds jointly in the CDE will support cross-functional collaboration and transform the way public infrastructure projects in California are designed, built, and maintained. Multiple CDEs from various application developers may be needed to meet the needs for various teams at various points of the project life cycle. The data should be interchangeable between different CDEs to allow for a seamless transition with minimal loss of data quality and integrity. An example of this could be Planning and Design using one CDE application for K, 0, 1 Phase project development, and Surveys and Construction using another CDE application to view and utilize the same data in different ways that meet their needs.

The core requirements are described below:

1. Cloud-/server-based engineering data and document management systems/platforms.
2. Common Data Environment (automatically generates real-time comment notifications) with intuitive graphical interface.
3. Workflows – Information models from Design are routed to the designated Checkers/Approvers through preset logic implemented in the CDE. Notifications are sent to remind team members of submittal or review deadlines. The PIM in CDE platforms is available to other teams such as Construction and Asset Management.
4. Organize Caltrans project data sets by providing seamless access to LIVE/CURRENT project data held in its native format without reorganizing data and while maintaining data integrity. Data accessibility is provided internally and externally with specific permissions.
5. Implement the ISO 19650 CDE Workflow: All files have structured metadata to identify the model author, checker, approver, state, status, etc.
6. Performance Metrics: The CDE tracks project development and has a dashboard which include intuitive graphs and reports to convey project progress.

This collaboration platform's sub-team is currently investigating the use and acquisition of CDE applications from multiple vendors (Bentley, Autodesk, Trimble, AllPlan, and Procore). We recommend testing various CDE applications via pilot projects to determine which CDE applications will best meet the Department's needs. This includes testing different cross compatible CDE applications for different divisions (Design, Construction, DES, etc.) as their needs may require.

A note on coordination with the FHWA national strategic roadmap for advancing BIM4I: The FHWA national strategic roadmap (roadmap) lays out a 10-year plan for incrementally developing and implementing enterprise BIM4I through a three-phase process consisting of short-, medium-, and long-term phases. Each of the phases includes foundational and developmental activities and each phase includes pilot projects; early, extended, and mainstreaming. The enterprise implementation of the CDE(s) corresponds to roadmap deployment activity D4 "Set up BIM tools and technologies (e.g., common data environment, (CDE) system interfaces)" which occurs in the latter part of the medium phase (year 3). However, it is understood that CDE implementation will begin in the early pilot projects to allow for evaluation and practice across delivery teams. Also, while the roadmap describes activities which precede activity D4 (D1, D2, D3) - those are indicated in the roadmap as being performed on the national, rather than state, level and they precede the enterprise CDE implementation, not the pilot CDE implementation.

Anticipated Benefits:

- Shared information models in the CDE will **improve safety** by reducing rework, change orders, claims, and reduced overall contract durations.
- Better risk identification and evaluation will lead to **better risk management**.
- Increased collaboration up front will generate **higher quality** products.
- **Optimize project delivery schedules** and resources to realize process improvements by engaging all stakeholders with the PIM and data in a single platform, a process which can be referred to as Integrated Project Delivery (IPD).
- **Reduced or eliminated loss of data** between phases and functional units.

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 4.35 PY
    - Operating Expenses: $925,000
  - Mid-Term
    - Resources Needed (PYs): 18.10 PY
    - Operating Expenses: $2,500,000
  - Long-Term
    - Resources Needed (PYs): 36.00 PY
    - Operating Expenses: $10,500,000

- **Policy Impacts:**

  The BIM4I implementation will require updating Department policies, procedures, and best practices to comprehensively align the Department's project delivery process with BIM4I. The following draft list of the Caltrans project delivery manuals will need to be updated to utilize Integrated Project Delivery (IPD) workflows.

  (1) CT CADD Manual
    - Standard Methods & Procedures/Best Practices docs for BIM Uses
    - Model File-Naming Convention
    - Guidance – saving/storing a parametric model object in the library
    - Model Checking: Assurance/Validation Procedures

  (2) CT Survey Manual
    - Survey: Feature coding

  (3) CT GIS Standard

  (4) IT Security Process

  (5) Software-Specific Manuals

  (6) Caltrans Construction Manual

  (7) PDPM

  (8) Plans Preparation Manual

- **Potential Implementation Challenges:**
  - Change Management – acceptance and adoption of major, transformative changes to current planning, delivery, maintenance, and asset management processes.
  - Security and IT certification (Fed-Ramp, etc.) polices are under continuous development.
  - The overall project development and delivery process demonstrating how work will be done in the future long-term paradigm using BIM4I is not yet fully defined and will be developed in tandem as lessons from pilots are captured.
  - Staff skill set and training.

- Required resources (PY & $) throughout pilot projects.
- Rigid Caltrans CADD standards and requirement for off the shelf software customization.

- **Performance Measurement:**
  - Section 4.4 of the Project Information Model (PIM) BIM Execution Plan describes the Performance Metrics requirements for the BIM4I pilot projects.
  - Performance metrics such as time savings, cost savings, reduced change orders, etc., will need to be developed as the BIM4I pilot program matures.

- **Implementation Lead & Involved Parties (Division):**
  - For BIM4I pilot projects in various phases (short, medium, long) the implementation leads and involved parties will depend on the needs and goals of the pilots and stakeholders will be involved as appropriate. Divisions of Design and Construction will likely be very involved.
  - As BIM4I is implemented on an enterprise basis, many divisions will be involved, including IT, HQ, Planning, Surveys, Design, Environmental, Right-of-Way, Construction, Maintenance, Asset Management, and others.

6. IMPLEMENT USE OF A COMMON DATA ENVIRONMENT (CDE) TO OPTIMIZE COLLABORATION

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
6.01	1- Short	1. Org	Acquire CDE application training from a vendor for users on early BIM4I pilots, including Design, Construction, Surveys, others *Assume CDE application developer has trainings ready to provide and will provide to BIM4I early pilot teams. No resources needed to develop CDE trainings for BIM4I early pilot teams = 0 PY.*	Collab: Design, DES, Const., Surv.	0.00		$300,000	
6.02	1- Short	1. Org	Provide CDE training to early BIM4I pilot team members, including Design, Construction, Surveys, etc. *Assume CDE application developer will provide CDE training to CT staff. Assume 2 trainings @ 2 Hrs per pilot, 25 ppl per pilot, 25 pilots. 2 trainings X 2 Hrs X 25 ppl x 25 pilots = 1.25 PY (rounded down).*	Collab: Design, DES, Const.	1.25			
6.03	1- Short	2. Tools	Meet with CDE application vendors to learn about application capabilities and use cases. *Assume quarterly meetings with CDE application vendors and HQ, IT, Design, Surveys, DES, Construction for 2 hours. 8 mtgs X 10 ppl X 2 Hrs = 0.1 PY*	Collab: IT, Design, Const.	0.10			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
6.04	1- Short	2. Tools	Develop CDE requirements, specifications *Assume an initial effort has been completed by team members (no further expenses). Assume this will be an ongoing effort to refine CDE requirements as pilots and new technology advance. Assume bi-annual team discussion (IT, Design, Construction, Surveys, HQ) for 4 hours. 4 mtgs X 10 ppl X 4 Hrs = 0.1 PY.*	Collab: IT, Design, Const.	0.10			
6.05	1- Short	2. Tools	Collaborate with IT to get approval to implement cloud-based CDE applications *Assume bi-annual meetings with IT, HQ, Design, Construction, DES for 1 Hr. 4 mtgs X 10 ppl X 1 Hr = 0.05 PY*	Collab: IT, Design, DES, Const.	0.05			
6.06	1- Short	2. Tools	Continue learning from pooled fund members about their CDE use experiences (ongoing) *Assume quarterly meetings. Assume this will be ongoing and will span phases (resources will be estimated by phase). 8 mtgs X 10 ppl X 2 Hrs = 0.1 PY.*	Collab: Design, DES, Const., IT	0.10			
6.07	1- Short	2. Tools	Select, acquire, use, and evaluate various CDE applications on early BIM4I pilot projects in Design & Construction phases *Assume 25 CDE licenses needed per pilot, 25 pilots, $1000 per license. 25 X 25 X $1,000 = $625,000 OE Note: CDE application vendors may provide free licenses for early pilot evaluation. Much uncertainty on this probability at this point. For now, will assume worst case, can adjust going forward.*	Collab: Design, DES, Const.			$625,000	

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
6.08	1- Short	2. Tools	Implement CDE applications with contractors on CMGC early BIM4I pilots *Assume monthly coordination between CMGC & Design, IT, HQ for 2 Hrs. Assume 5 of 25 pilots use CMGC. 5 pilots X 10 ppl X 2 Hrs X 18 mo = 1 PY.*	Collab: Design, DES, Const., IT	1.00			
6.09	1- Short	3. Policy	Identify CDE implementation in BIM execution plans for early BIM4I pilots *Assumptions: Pilot Teams and coordinators identify if CDE use is applicable on BIM4I pilot. 10 ppl X 2 Hrs (per pilot) = 0.01 PY/Pilot. Assume 25 pilots need determination by 12/31/23 = 25X.01 PY = 0.25 PY.*	Design	0.25			
6.10	1- Short	3. Policy	Develop lessons learned from CDE implementation on early BIM4I pilots *Assume lessons learned is discussed quarterly for 0.5 Hr. 8 qtrs X 10 ppl X 25 pilots X 0.5 Hr = 0.5 PY*	Collab: Pilot Project division reps	0.50			
6.11	1- Short	3. Policy	Develop & implement Caltrans-focused CDE workflows based on ISO 19650 standards *Assume this activity is led by HQ BIM4I and adjusted by district pilot teams. Assume this is an ongoing process with recurring updates: a regular topic on BIM4I discussion agendas.* *Assume monthly discussions on this topic.* *Assume 10 ppl X 1 Hr (per pilot) X 25 pilots X 24 mo = round down to 3 PY -> seems excessive - > use 1 PY.*	Collab: Design, DES, Const, IT	1.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
6.12	2- Mid	1. Org	Refine/update CDE training based on lessons learned from the early pilots *Assume bi-annual training update meetings with 12 districts, trainings split by division (Design, Construction, Surveys, PPM, other) plus HQ training, 4 hour meetings* *2 mtgs/yr X 3 yrs X 12 dist X 5 div X 4 Hr = 0.75 PY (rounded)*	Collab: Design, DES, Const.	0.75			
6.13	2- Mid	1. Org	Provide CDE training to BIM4I extended pilot team members *Assume 100 pilots X 25 ppl/pilot X 2 Hrs X annual. 100 pilots X 25 ppl/pilot X 2 Hrs X 3 Yrs = 8 PY. Seems excessive – use 5 PY.*	Collab: Design, DES, Const.	5.0			
6.14	2- Mid	1. Org	Continue learning from pooled fund members about their CDE use experiences *Assume 10 ppl meeting quarterly for 2 hours over phase span (3 yrs). 10 pplX 4 mtgs/yr X 3 yrs X 2 Hrs = 0.1 PY*	Collab: Design, DES, Const.	0.1			
6.15	2- Mid	1. Org	Develop lessons learned from CDE implementation on extended BIM4I pilots *Assume bi-annual meetings, 10 ppl pe r pilot, 3 yrs, 2 hour mtgs. 2 mtgs/yr X 3 Yrs X 100 pilots X 10 ppl/pilot X 2 hrs = 6 PY.*	Collab: Design, DES, Const.	6.0			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
6.16	2- Mid	2. Tools	Acquire additional CDE licenses for additional extended BIM4I pilots in more Districts across the state *Assume 100 new BIM4I pilots in medium phase (01/01/24 - 12/31/26). Assume 25 CDE licenses needed per extended BIM4I pilot. Assume no longer free for evaluation. 100 ext. Pilots X 25 lic X $1,000/lic = $2,500,000.*	Collab: Design, DES, Const.			$2,500,000	
6.17	2- Mid	2. Tools	Implement CDE applications with contractors on CMGC extended BIM4I pilots and potentially other ways *Assume monthly coordination between CMGC & Design, IT, HQ for 2 Hrs. Assume 20 of 100 pilots use CMGC.* *20 pilots X 10 ppl X 2 Hrs X 36 mo = 1 PY = 8 PY. Seems excessive – use 5 PY.*	Collab: Design, DES, Const.	5.0			
6.18	2- Mid	3. Policy	Update pilot guidelines and workflows for CDE implementation based on the lessons learned from the early pilots *Assume quarterly 4 Hr meetings to focus on updating guidelines and workflows across IT, HQ, Design, Construction, Surveys. 12 mtgs X 4 Hrs X 10 ppl = 0.25 PY.*	Collab: Design, DES, Const.	0.25			
6.19	2- Mid	3. Policy	Implement updated Caltrans focused CDE workflows based on ISO 19650 standards *Assume no resources needed – folded into project hours*	Collab: Design, DES, Const.	0.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
6.20	2- Mid	4. Data	Establish enterprise framework for CDE(s) *Note: This is activity D4 in the FHWA roadmap. This is a significant challenge. It encompasses organizing, preparing, training, everything needed to roll out CDE across the Department. This is such a bit task/activity that it is difficult to estimate with any certainty.* *Assume divisions meet quarterly for 4 hours for last 2 years of phase. Includes IT, HQ, DES, Design, Construction, others. 4 mtgs/ye X 2 yrs X 4 Hrs/mtg X 20 ppl = 0.5 PY -> round up to 1 PY.*	Collab: IT Design, DES, Const.	1.0			
6.21	3- Long	1. Org	Develop enterprise CDE training based on lessons learned from pilots *Assume collaboration between consultants and in-house teams. Assume in-house team = 2 ppl, 1 yr, full time = 2 PY. Assume consultant = $500k.*	Collab: ALL	2.0		$500,000	
6.22	3- Long	1. Org	Provide CDE training across Department *Assume 1 trainer per district, plus HQ trainer + 10,000 staff. Assume 3 modules (beginner, intermediate, advanced) @ 2 hrs each – once & done. 10,000 staff X 3 modules X 2 hrs/module = 34 PY.*	Collab: ALL	34.0			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
6.23	3- Long	2. Tools	Acquire CDE licenses for enterprise *Assume 10,000 licenses needed across Department at $1,000 / license. 10,000 licenses X $1,000/lic = $10M. Note, rather than being a distributed activity, this may be more likely a single large purchase at a point in time.*	IT, Divisions			$10,000,000	
6.24	3- Long	2. Tools	Implement enterprise-wide CDE to support BIM4I *Assume this is already covered by ongoing training and normal delivery needs*	IT, Divisions	0			
6.25	3- Long	3. Policy	Establish guidance and workflows for enterprise CDE implementation based on lessons learned from pilots *Work in conjunction with Recommendation #8 Overall Process – resources captured there*	Collab: ALL	0			
6.26	3- Long	3. Policy	Establish & publish enterprise workflows for CDE based on ISO 19650 standards *Work in conjunction with Recommendation #8 Overall Process – resources captured there*	Collab: ALL	0			

7. AMPLIFY USE OF 3D MODELS FOR VISUALIZATION

CLICK HERE for recommendation summary.

Description of Baseline Process:

Visualization is defined as a 3D representation of proposed transportation improvements. Levels of visualization can range from wire frame representation to photorealistic modeling. The goal of visualizations is the visual explanation of project intent to project development teams, community stakeholders, and government agencies. BIM-based visualization can be a powerful tool that can greatly enhance safety, improve project communication, promote transparency, and drive efficiency.

The current process is haphazard, at best, and is not applied on a uniform basis on projects. Limitations in expertise, tools, project funding, and mainly exposure to this technology continue to hamper implementation. The primary challenge has been the lack of a policy for planners, project managers, environmental analysts, and public information officers to follow that describes the value, use strategies, and implementation procedures of visualizations. Visualization expertise does not reside in one functional unit in Caltrans and thus, it is difficult to promote the benefits that this technology can add to project planning and delivery.

Description of Recommended Change/Solution:

The goal is to utilize the 3D models developed in the BIM4I process for visualizations in projects in all Districts. The Visualization Sub-Team recommends the following:

- Create a statewide task force comprised of Subject Matter Experts drawn from the Visualization Sub-Team and other relevant units to guide Districts and regions in establishing localized expertise and develop a visual communication policy. The policy will describe the process for identifying projects that will benefit from visualizations, development of visual communication strategies, development of a visual communication plan, PDT communication coordination, and PIM integration process.
- Procure a statewide service contract for visualization. When required, Districts will be able to write Task Orders for specific projects (in different phases) to generate visual aids such as 360 Tours, animations, videos, and simulations to benefit the project as specified in the visual communication plan as detailed in the visual communication policy.
- Establish communication tool and decision matrix to identify projects that will benefit from visualization (reference material) to educate Project Delivery Teams (PDTs) on capabilities and benefits as well as value added (3D modeling will lower the cost of enhanced visualization).
- Increase the use of visualization in public outreach and stakeholder involvement to promote equity.
- Develop general guidelines for the use of visualization.
- Establish positions in Districts, HQ, or regions for expertise.

Anticipated Benefits:

- Project visualization can help the team to identify safety issues and mitigate/eliminate risks together.
- Clear and intuitive communication of the design intent.

- Improved stakeholder engagement.
- Enhanced community engagement.
- Greater transparency.
- Tighter coordination with regulatory agencies.
- Better alternative comparison.

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 13 PY
    - Operating Expenses: $100,000 one time
  - Mid-Term
    - Resources Needed (PYs): 14.5 PY
    - Operating Expenses: $3.4 million one time
  - Long-Term
    - Resources Needed (PYs): 0.5 PY
    - Operating Expenses: $125,000 one time

- **Policy Impact:** Consider visualization needs during Planning, Environmental, Design, and Construction Phases. Formalize process for using enhanced visualizations for public engagement.

- **Potential Implementation Challenges:**
  - Funding.
  - Slow adoption.
  - Change management. (Educate PMs and management on value of Visualization).
  - Establish the right classification(s) for Visualization group – HR.

- **Performance Measurement:** (Performance Metrics for visualization will be listed in the BIM Execution Plan Section 4).
  - Public hearing comments & Surveys.
  - Resource agency feedback.
  - Stakeholder feedback.
  - Public Information Office (PIO) feedback.

- **Implementation Lead (Division):** Visualization Task Force (Joaquin Pedrin, Austin Bossetti, Stephan Heath, Reece Miller, Environmental, PIO, PM). Identify pilot projects (at least one per District).

- **Recommended Involved Parties:** Planning, Construction, District Landscape Architecture, Bridge Architecture and Aesthetics, District Environmental, HQ Environmental Analysis, Design, District PM, PIO.

- **Overall Timeline:** Implementation to begin within a year and continue to develop over the next several years (5 yrs).

- **Further Considerations**

  In the decision matrix, the team will also consider the amount of input data available for the visualization at different stages: K, 0, 1 and 2-3. In the early stages, there may be no model information to use, and a basic model will be created only for the purpose of visualization. During the design stages, the Project Information Model (PIM) can be integrated with the visualization. The PIM can be enhanced with lighting, materials, and textures for the visualizations.

7. AMPLIFY USE OF 3D MODELS FOR VISUALIZATION

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
7.01	1- Short	1. Org	Establish Visualization Steering/Advisory Committee and determine best location Planning, Environmental Analysis, Landscape Arch., Bridge Arch/Aesthetics, Construction, and Public Information Office *Assumes .40 PY per member (8)*	SME Group from HQ/DES + Districts with expertise	3.0			
7.02	1- Short	1. Org	Develop training and general guidelines/matrix *Assumes can be achieved with Visualization Task Force*	Visualization SME Group				
7.03	1- Short	2. Tools	Procure tools not currently under existing contracts (e.g., Autodesk-Infraworks)	DOD CADD Services			$100,000	
7.04	2- Mid	1. Org	Establish positions dedicated to visualization 1-3 PY per District or Region	Districts		10.0		
7.05	2- Mid	1. Org	Establish positions dedicated to visualization 1-2 PY HQ/DES	HQ/DES	2.0			
7.06	2- Mid	1. Org	Expand upon existing training to create robust training program	Planning & Project Delivery			$300,000	
7.07	2- Mid	2. Tools	Fund A&E Service Contract statewide	Planning & Project Delivery			$3,000,000	

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
7.08	2- Mid	3. Policy	Document Information-delivery specifications for data exchanges between modelling and visualization systems in different project phases (K-Phase, 0 phase, 1-phase, etc.) Document examples and regulatory-agency specific best-practices for types of model visualizations that effectively satisfy regulatory agency needs/questions and support meetings/discussions	Planning, Landscape Arch., Bridge Arch. Environmental Analysis, Planning, Public Information Office	0.5			
7.09	2- Mid	4. Data	Create a visualization library -- materials, objects, textures, infrastructure features (using pilot projects to populate the library)	Planning, Landscape Arch, Bridge Arch. Environmental Analysis, Planning, Public Information Office	2.0		$100,000	
7.10	3- Long	2. Tools	Continue to evaluate visualization tools				$25,000	
7.11	3- Long	3. Policy	Establish guidelines for model preparation for visualization and the exchange requirements for infrastructure in Caltrans manuals Develop department policy for use of models in public outreach meetings and stakeholder engagement discussions/workshops	Planning, Landscape Arch, Bridge Arch. Environmental Analysis, Public Information Office				

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
7.12	3- Long	4. Data	Expand a visualization library -- materials, objects, textures, infrastructure features (using pilot projects to populate the library)	Planning, Landscape Arch, Bridge Arch. Environmental Analysis, Public Information Office	0.5		$100,000	

8. REFINE OVERALL PROJECT DEVELOPMENT & DELIVERY PROCESS TO SUPPORT DIGITAL PROJECT DELIVERY

CLICK HERE for recommendation summary.

Description of Baseline Process:

Currently projects are planned, designed, and constructed based on the existing project development process. The focus of this BIM4I effort is from start of the Planning phase through construction completion and into 3D Digital As-built, Enterprise Asset Management and into the Maintenance and Operation phase. The design engineer, in cooperation with the PDT, collects, organizes, and disperses information to the various disciplines. The project is developed through many iterations as risks are managed. Although it is a team approach, the designer is charged with developing the engineering proposal which is typically printed or shared as printed drawings or limited access to electronic version of the proposal. Inter-discipline communication is done through team meetings, focused meetings, or circulation throughout the process. As the final design stages are approaching, the various functional units engage in contributions to the final design or contract documents. These designs require the designer to verify if the functional units work is compatible with the overall contract plans. Furthermore, the geo-referenced base map or drawings (.dwg) & (.dgn) are converted into the construction plans (.pdf). Often, the geo referencing in the base maps and pertinent information is 'lost' when the project plans are created.

Subsequently, once projects are constructed, the as-builts are developed as a 2D file for future reference. The construction contractor and resident engineer reference the plans as the official record for the project. Any changes during the construction phase are to be documented on the official as-awarded project plans and converted into an as-built plan for project closeout.

Description of Recommended Change/Solution:

The proposal is to have all projects utilize a Project Information Model (PIM) protocol using a Collaboration Platform. This requires development of a revised workflow for digital project delivery. Ultimately, as various pilots are conducted, we recommend creation of a cross-division team to modify and finalize this workflow based on lessons learned. This team would identify modifications to the project development and delivery workflows based on the method of project delivery (e.g., DB) and type of projects (i.e., Maintenance) before implementation of PIM as Legal Document. This team would create training and provide ongoing project development training for the modified processes based on 3D PIM digital delivery.

The BIM for Infrastructure (BIM4I) team developed a list of recommended refinements for this new workflow. These are shown below. Note: several of these activities are being done earlier in the development process currently in some districts. However, efforts to advance the process have largely been sporadic as opportunities arise and are not yet consistent within or among Districts. The team's recommendation is to have these following workflow changes documented and standardized statewide to provide for consistency and efficiency:

- Planning (WBS 150)
    - Provide Design Grade survey data in the K-phase

    - Start 3D PIM in the K-phase
- PM (WBS 100)
    - Unified Statewide QMP
    - Develop and implement better risk strategies based on available metadata in the model
- 0 Phase, PAED (160, 165, & 180)
    - Use of advanced survey technologies such as LiDAR, UAV, RTN, AR
    - Create 3D parametric- and feature-based models of alternatives and construction staging of the project
    - Create 3D visualization model for improved communications with stakeholders
    - Create/enhance 3D structure models based on the preferred alternative using geotechnical data
- Right-of-Way
    - Request utility as-builts from utility companies to include in the 3D PIM. Add metadata in the Caltrans Utility Database (CUD).
    - Use AR technology to show proposed impacts to stakeholders
    - Keep paper documents as needed
- 1 Phase, PS&E (185, 230, 240, 250 & 255, 260, 265)
    - Revise the title from PS&E to MALD or revise the definition of Plans in the Standard Specification similar to NYDOT pilot projects
    - Acquire survey data as early as possible to allow for early 3D model creation. K-phase if possible, or early 0-phase.
    - Shift as much 1-phase design work to 0-phase as possible
    - Use 3D parametric- and feature-based model and visualizations to communicate with stakeholders for project impacts and strategies
    - Modify WSG, WBS, and other guidance to integrate with new BIM4I processes
    - Add process for 3D PIM QC/QA and reviews
    - Eliminate Draft General Plan and Foundation Plan under WBS 240 since it will be part of the 3D Model in WBS 185
    - Revise the task 255.20.05 to review 3D PIM for Contract Standards
    - Discuss with surveys how Survey Engineer File requirements may be impacted or eliminated using 3D PIMs
    - Discuss with Construction how Resident Engineer File requirements may be impacted, or possibly eliminated, by using 3D PIM

Anticipated Benefits:

- Improved design and collaboration for safer roads and construction work conditions
- Improved project quality and efficiency throughout project life cycle
- Improved interdisciplinary work during project delivery between PDT members and teams
- Avoid loss of information in transfer between groups and phases
- Reduce duplicate data collection
- Reduce project's risks and construction change orders
    - Design-related change orders, claims, and delays reduced

- Enhance communication with stakeholders
- Modelling in the K-phase and updating models during 0- & 1-Phases allows the PDT to have better risk strategies

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 0 PYs
    - Operating Expenses: None
  - Mid-Term
    - Resources Needed (PYs): 2.1 PYs
    - Operating Expenses: None
  - Long-Term
    - Resources Needed (PYs): 1.5 PYs
    - Operating Expenses: None
  - Notes
    - Resources required for cross-function team members to modify workflows (see recommended involved parties below).
    - While no $OE has been captured within this recommendation, it will be implemented in conjunction with several others, in particular Recommendations #6 which implements a CDE, and #7 which increases the use of visualizations. As such, any overlapping PYs and resources have been removed.

- **Policy Impact:** Legislative Changes include Business & Professional code section 6735 – 6735.6 Requires engineering seals on plans and as-builts
  - Revised Plan Preparation Manual or a new VDC Manual – allowances for VDC
  - Revised MicroStation, Caltrans Standard Drafting Software Memorandum 9-9 –2014
  - Construction Contract Standards Guide adapted VDC advertising, bidding, and award
  - Revised Project Development Procedures Manual Chapters 10 –14
  - Project Development Workflow Guide
  - Workplan Standards Guide
  - Construction Manual 5.104 D; 5.103D and 5-102 Project Documents

- **Potential Implementation Challenges:**
  - Personnel Training
  - Technology is not static and will change
  - Coordinate with external agencies
  - Required resources (PY & $) throughout pilot project
  - Change Management – acceptance and adoption of major, transformative changes to current process

- **Performance Measurement:**
    - Lower expended versus planned resources
    - Shorter VDC versus traditional project schedules
    - Higher satisfaction ratings by teams, sponsor, and construction contractors
- **Implementation Leads (Divisions):**
    - Design, PPM, DES

- **Recommended Involved Parties:**
    - Design, Construction, Surveys, Environmental, ROW, Maintenance, Asset Management, HQ, DES, IT, Others

8. REFINE OVERALL PROJECT DEVELOPMENT & DELIVERY PROCESS TO SUPPORT DIGITAL PROJECT DELIVERY

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
8.01	1- Short	2. Tools	Verify impact on PRSM, FALCON EDMS, Vision/essop (FY 23/24)					
8.02	2- Mid	1. Org	Capture lessons learned to modify workflow from BIM4I pilot projects	BIM4I SMEs	0.1			
8.03	2- Mid	3. Policy	Develop refined BIM4I workflow with a resourced cross-divisional team *Assumes .15 PY per division (10)*	BIM4I Program HQ, Design, PPM, DES, Construction	1.5			
8.04	2- Mid	3. Policy	Identify manuals that are impacted with BIM4I such as WSG, PDPM, PDWG, CADD Manual, PPM, Construction Manual, etc.	HQ, Design, PPM, DES, Construction	0.5			
8.05	2- Mid	4. Data	Update PRSM and other software identified during short-term study *PYs are a part of an ongoing contract*	HQ – Project Management				
8.07	3- Long	1. Org	Staff training for updated Workflow guidelines *Assumes this will be covered by existing training resources*					

8.08	3- Long	1. Org	Develop training for updated policies and procedures	BIM4I Program HQ, Design, PPM, DES, Construction	0.5
8.09	3- Long	3. Policy	Continue and complete development of new BIM4I workflow with Cross-Divisional Team	BIM4I Program HQ, Design, PPM, DES, Construction	1
8.10	3- Long	4. Data	Update PRSM and other software identified during mid-term study *PYs are a part of an ongoing contract*	HQ – Project Management	

9. DIGITALLY CAPTURE & INTEGRATE HIGH-QUALITY DATA DURING SURVEYS & CONSTRUCTION ACTIVITIES

CLICK HERE for recommendation summary.

Description of Baseline Process:

As-built information and locations are primarily captured via markings on paper plans in the field. The 3D location information is "as drawn" with no accuracy standards or ease of corporate accessibility to utilize the information on future projects. Lack of data quality, accuracy, and corporate accessibility results in greatly diminished value for future use.

Description of Recommended Change/Solution:

In collaboration with the BIM digital as-builts focus group, develop a guidance manual on capturing timely, high-quality as-built locations and metadata throughout the construction phase and maintenance phase of projects. This may include capturing elements, such as rebar in structures, underground utilities, or other structures that are only measurable when exposed. The guidance manual will include aspects such as utilizing survey control, types of measurement equipment, applied measuring methods, data processing for point cloud feature extraction, roles of responsible charge, and statewide accuracy requirements. Once the training guidelines are developed, trainers will need to be developed to instruct the future workforce who will be responsible for creating the digital as-built products.

As the training guidelines and trainers are being developed, additional measuring equipment will need to be procured, including but not limited to, terrestrial scanners, mobile terrestrial LiDAR scanners, total station scanners, and SLAM LiDAR scanners. It will be from these LiDAR-based measurement tools that point clouds will be collected from constructed assets. The point clouds will serve as the starting point and foundation of the digital as-built process. Registration and extraction software will need to be provided to produce the final digital as-built data sets.

Lastly, the Caltrans Spatial Reference Network (CTSRN) will require expansion and maintenance across the state to continue to support critical measurement tools and processes. The CTSRN allows for GNSS Rover units to be deployed efficiently and simply in the field. In addition to GNSS rover units utilizing the network, the CTSRN can be used for other RTK-type measurement systems.

Anticipated Benefits:

- More complete 3D digital as-builts and construction data sets by collecting x, y, & z coordinates of the constructed 3D features as they are available and/or exposed.
- Field verification of assets can be captured in near real-time, with fewer people, to quickly and efficiently determine constructed locations relative to design locations.
- Roles, methods, equipment, accuracy, and data processing will be clearly defined and standardized.
- The complete 3D digital as-built dataset/model will be easily archived and available for the life cycle of the constructed assets, including clash detection analysis for future projects.

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 29.75 PYs
    - Operating Expenses: $1,000,000 one time, $4,700,000 annual
  - Mid-Term
    - Resources Needed (PYs): 18 PYs
    - Operating Expenses: None
  - Long-Term
    - Resources Needed (PYs): No additional PYs
    - Operating Expenses: $1,000,000 annual
  - Notes
    - $1m one-time expense and $5.7 million annual ongoing cost based on equipment, methods, and roles identified.
    - The resource needs for sustained administration, operation, and maintenance of the Caltrans Real-Time GPS Reference Network are being pursued through the AMG recommendation.

- **Policy Impact:** Revisions to various manuals will need to be made, outlining the new processes to be followed.

- **Potential Implementation Challenges:** Training staff to perform the needed measurements with various tools, such as stationary scanners and GNSS/GPS equipment if work is not performed by Caltrans surveyors. Ensuring measurement milestones are identified and schedule properly to capture exposed elements when available for measurement.

- **Performance Measurement:** Capture complete, accurate asset 3-D measurements for incorporation into the final digital as-built model(s).

- **Implementation Lead (Division):** Land Surveys

- **Recommended Involved Parties:** Land Surveys, Construction

9. DIGITALLY CAPTURE & INTEGRATE HIGH-QUALITY DATA DURING SURVEYS & CONSTRUCTION ACTIVITIES

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
09.01	1- Short	1. Org	Develop training for digital construction inspection and development of District support trainers. Development of in- person and online training for staff. Developing tools, training, databases, acquiring servers. *Assumes 1 PY each from OLS and DOC with some support from DES SC and 0.5 PY per district and DES for train-the-trainers.*	HQ OLS, HQ DOC, DES SC	2.00	6.50	$1,000,000	
09.02	1- Short	1. Org	Training for Field Staff – 40-80 hours of training on relevant field equipment per staff member is anticipated. This will be a combination of web-based training and hands-on field trainings. *Assumes .04 PY per field staff @ 450 staff per year.*	HQ OLS, HQ DOC, DES SC	2.00	18.00		

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
09.03	1- Short	2. Tools	Procure additional equipment for the use of field verification in 3D-related project data. Estimating purchase of two Mobile Terrestrial Lidar Scanners (MTLS) every year until each District has its own tool. Replacement on a 6-year cycle. These purchases will include the vehicle to hold the scanner, the scanner technology, and the processing/publishing software for the scanner. *Assumes 0.25 PY for Construction to manage their own portfolio.*	HQ OLS / HQ DOC / DES SC	0.25			$2,000,000
09.04	1- Short	2. Tools	Procure additional equipment for the use of field verification in 3D-related project data. Estimating purchase of 50 Terrestrial Lidar Scanners (TLS) for the purpose of building the initial need. In subsequent years this need will grow due to increased use of tools. *Assumes 0.25 PY for Construction to manage their own portfolio.*	HQ OLS / HQ DOC / DES SC	0.25			$2,000,000
09.05	1- Short	2. Tools	Develop secure storage locations for Mobile Terrestrial Lidar Scanner (MTLS) vehicles. We will need to build two of these each year for the next 5 years.	HQ OLS / HQ DOC / DES SC	0.50			$200,000
09.06	1- Short	2. Tools	Procure 50 high-speed computers that will need to be replaced on a 3-year cycle. Cloud storage for MTLS data accounted for in Digital As-builts. *PY is for IT labor.*	HQ OLS / HQ DOC / DES SC / Design	0.50			$500,000

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
09.07	2- Mid	1. Org	Continue Training for Field Staff – 40-80 hours of training on relevant field equipment per staff member is anticipated. This will be a combination of web-based training and hands-on field trainings. *Assumes .04 PY per field staff @ 450 staff per year.*	HQ OLS, HQ DOC, DES SC	2.00	18.00		
09.08	3- Long	2. Tools	Expansion of existing LiDAR technologies. Implementation of emerging remote sensing technologies.	HQ OLS / HQ DOC / DES SC	0.50			$1,000,000

10. EXPAND STATEWIDE IMPLEMENTATION OF AUTOMATED MACHINE GUIDANCE (AMG) AND PROJECT DELIVERY DIRECTIVE 6 (PD-06) – SHARING OF ELECTRONIC FILES

CLICK HERE for recommendation summary.

Description of Baseline Process:

Directive PD-06 is currently in place for Design to create 3D digital surface models (finish grade); however, implementation and enforcement are not consistent. Some projects were never planned in accordance PD-06 and many others create the product at the end of delivery, and products are often incomplete. The 3D surface model is necessary for AMG and many times not planned in the PDT process. North Region is the only location in the state where this process is near 100% effective.

Description of Recommended Change/Solution:

The recommendation is to focus on implementation and enforcement of the current policy (PD-06) as directed already. Develop AMG files (3D models) for every project that meets mandatory requirements and provide them at the time of bid. While the policy exists, full implementation of it will require a multifaceted approach to ensure adoption and use is consistent statewide. The recommended steps include:

- Procurement of necessary tools and "X" year cycle replacement of aging equipment. Timeline of replacement and funding necessary for replacement TBD
- Further staff development to use tools (training)
- Develop District AMG Coordinators in every District (this could be combined with Model QC)
- Mandatory AMG specifications for all projects that meet requirements (with exceptions for poor Global Navigation Satellite System (GNSS) environments)
- Caltrans Spatial Reference Network (CTSRN) modernization and expansion
- Expansion of elements provided in 3D design model (develop 3D object code library to supplement feature code library)
- Expansion of AMG elements to include Pavements, Structures, Underground Elements
- Develop Constructability Review and verification process for AMG files prior to RTL (30%, 60%, and 90% plans review requirement)
- Project Management (PM) enforcement and tracking of AMG projects
- Refine file types and standards for each AMG element
- Seek support from the legislation to support/fund the codified authority of the California Spatial Reference System: California Spatial Reference Center (CSRC)
- Develop Change Management Plan with detailed Communication Plan (including statewide roadshow)
- Seek early adopters and develop rollout plans to provide projects teams, seniors, and managers across all divisions to develop understanding and support of process and goals

Anticipated Benefits:

- Safety
  - Reduced exposure for Construction staff due to increased efficiency of checking grade
  - Reduced exposure to Survey staking due to reduced amount of survey staking removing a conflict between construction equipment and surveying activities
  - Reduced exposure to contractor's grade checker by removing a conflict between construction equipment
  - Increased worker safety as it could reduce the incidence of back pain from bending down to nail in grade check tools
- ~20% or more savings in support costs have been found on the few projects currently utilizing AMG – this will increase with full implementation
- Enable savings to contractor-specific costs during construction by utilizing AMG and will lead to lower contract bids
- More accurate and complete design at the bid milestone
- Capture of all constructed elements on a project for clash detection and control
- Improves construction documents, which provides more detailed information to the construction team
- Increases efficiency when conducting construction measurement tasks
- More complete PIM and AMG deliverables (surfaces) will facilitate improved stakeholder understanding and buy-in on projects
- Enhances identification and resolution of conflicts, issues, design errors, and omissions prior to construction
- Offers intuitive subsurface visualization, thereby reducing utility conflicts and delays
- Optimizes material usage and increased bid quantity accuracy
- Increases productivity during the design and bidding phases by relaying the information in a more efficient manner
- Allows for efficient incorporation of detailed as-built information into the asset management system
- Reduction of errors in construction from manual processes: Misinterpreted staking information, bad calculations, and string lining to check grade, etc.
- GHG emission reduction in construction by reduced rework, project efficiencies, and equipment utilization. Material is placed where it is needed the first time and idle equipment time is reduced not waiting for intermittent survey information.

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 24 PYs
    - Operating Expenses: $3,000,000 annual
  - Mid-Term

        - Resources Needed (PYs): 2.25 PYs
        - Operating Expenses: $1,000,000 annual
    - Long-Term
        - Resources Needed (PYs): No additional PYs
        - Operating Expenses: None
    - Notes
        - $OE for funding purchase of AMG equipment estimated at $2M per year
        - Caltrans Spatial Reference Network (CTSRN) management estimated at $1M per year

- **Policy Impact:**
    - Develop a Deputy Directive or Director's Policy regarding the roles of licensed professionals regarding AMG

- **Potential Implementation Challenges:**
    - Design staff training in 3D model deliverable for complete AMG file – historically, portions have been missing and surfaces not complete
    - One platform only has drafting capabilities – multiple platforms currently in use interfere with implementation/adoption
    - Risk that projects will be allowed to progress without following the AMG guidelines established per PD-06. Lack of accountability in completeness of work.
    - Lack of geodetic control and CTSRN coverage statewide
    - Lack of Mobile Internet availability
    - Lack of qualified field staff for project site calibration, inspection, and verification
    - Inconsistent 3D design competency

- **Performance Measurement:**
    - Contract change orders
    - Bid amounts
    - Project schedule
    - Environmental impacts
    - Project closeout duration
    - Support cost savings
    - Delivery of required PD-06 AMG files for relevant projects

- **Implementation Lead (Division):**
    - AMG Committee

- **Recommended Involved Parties:**
    - Construction
    - Design
    - Office of Land Surveys: HQ & Districts
    - Structures Design and Construction
    - District Design and Construction

10. EXPAND STATEWIDE IMPLEMENTATION OF AUTOMATED MACHINE GUIDANCE (AMG) AND PROJECT DELIVERY DIRECTIVE 6 (PD-06) – SHARING OF ELECTRONIC FILES

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
10.01	1- Short	1. Org	Resource District AMG Coordinators/Support in each District. *One PY per district with some needing 2 based on capacity = 12-16 total.*	Districts, Construction, OLS	0.00	16.00		
10.02	1- Short	1. Org	Develop design-specific training for better understanding of complete AMG file delivery at the time of RTL.	Design w/ support from DOC and OLS	0.50			
10.03	1- Short	1. Org	Update training platform that field staff can use to understand technology used for AMG inspection/verification and keep up with technology changes (FY 22-23 and yearly thereafter). *1 PY for FY 22-23, then 0.25 PY ongoing after.*	HQ DOC, HQ OLS	1.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
10.04	1- Short	1. Org	Develop consistent yearly funding source for Caltrans Spatial Reference Network (CTSRN) expansion, modernization, and maintenance. Developing two CTSRN Administrators (2 PY) for the maintenance of systems and one PY for support of the building of new CTSRN stations. Two PYs focused on OLS for the CTSRN Administrators and one PY to share between OLS and DOC for the building of new stations.	OLS w/ support from DOC, OLS/D6, Realtime Verification and Measurement Subgroup	5.00			$1,500,000
10.05	1- Short	2. Tools	Develop consistent funding source for yearly procurement of new and replacement GNSS equipment for Construction staff to utilize in the field for digital construction inspection and AMG verification work (yearly). *$1.5M per year to account for multiple tiers of equipment purchasing 50 units/year.*	DOC w/ help from OLS	0.25			
10.06	1- Short	2. Tools	Conduct regular Datum adjustments and realizations by California Spatial Reference Center (CSRC) for support of AMG use (FY 22-23). *DPAC contract cost TBD.*	OLS work w/ OLS Geodetic Coordinator	1.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
10.08	2- Mid	1. Org	Conduct AMG for Structures pilot to develop functionality of construction and inspection/verification of structures.	HQ DOC, HQ DES, HQ OLS	1.00			
10.09	2- Mid	1. Org	Conduct AMG 3D Milling and HMA and PCC paving pilots to develop functionality of construction and inspection/verification of paving operations.	HQ DOC, HQ OLS	1.00			
10.10	2- Mid	2. Tools	Develop consistent funding source for yearly procurement of new and replacement GNSS equipment for Structure Construction staff to utilize in the field for digital construction inspection and AMG verification work. *Estimating 100 units needed throughout the state purchased at 20 units per year and a 5-year replacement cycle (yearly). $1M per year.*	Structures Construction w/ help from OLS	0.25			$1,000,000

11. FULLY IMPLEMENT USE OF E-TICKETING

CLICK HERE for recommendation summary.

Description of Baseline Process:

Hand collection of paper load delivery tickets from haul trucks of bulk materials (e.g. all bituminous, Portland cement, and aggregate base materials) delivered to the jobsite and stored in the field offices for archiving purposes. The current practice exposes onsite personnel to safety hazards including walking in close proximity to moving equipment, climbing on the side of trucks to retrieve paper tickets, and exposure to high-speed traffic. Archiving paper tickets requires effort and resources to manually sort, organize, and store for future reference and in many cases are maintained in the field offices and not included with the archive files to be destroyed after the retention period.

Description of Recommended Change/Solution:

E-ticketing technology, offered by several commercial venders, provides for the transfer of electronic load delivery tickets of bulk materials to mobile devices. The process typically involves the commercial e-ticketing vendor connecting to the loadout system of a material producer to collect critical load information. A web-based interface allows for real-time tracking of deliveries and reporting of electronic load information. Onsite staff will receive the electronic loadout tickets and can electronically accept or reject the load prior to incorporation into the work. This technology eliminates paper documents, improves worker safety, protects against damage or loss of tickets, and improves project management through data collection and analysis.

The Department is currently performing an e-ticketing pilot project with two vendors. This committee has identified the following core requirements for full implementation:

1. Complete pilot projects to determine platform/s to utilize.
   a) Ensure Caltrans owns the data generated from platforms.
   b) Determine archival location (EDMS or other data system).
2. Develop guidance and tools for staff to utilize.
3. Develop information link between e-Ticketing/DIME and the PIM to show what materials are being proposed by the contractor for specific construction features as well as tracking exactly what materials were installed and where.
4. Develop baseline needs of delivery ticket information by material. Internal discussion to identify what material information is important to Caltrans (e.g. mix, batch, batch time, total water content, slump, etc.).
5. Develop automated notifications across systems for triggers of testing protocols, delivery window for time restricted materials, alterations to materials in route, and proper delivery location.
6. Develop training for products being utilized.
7. Specification compliance.
8. Track the correct material mix design for the right location.

Anticipated Benefits: There are a variety of uses and benefits to replacing paper tickets with e-tickets. Those benefits include:

- Safety
  - Reduces exposure for inspectors and work crews collecting paper tickets.
- Quality
  - Allows field data entry on the ticket (e.g., temperature, location, etc.).
  - Prevents loss of ticket information during shift change or if inspector is not onsite at the time of delivery.
  - Payment accuracy based on ticket information.
- Efficiency
  - Reduces processing time for quality assurance and payment.
  - Industry benefit to have better data for production rates and processing time for material information.
  - Reduces efforts of people in the field.
- Improved database structure
  - Tracking material source information and quantity for potential legislative reporting mandates.
  - Trend analysis for quarries and materials sources and tracking of problematic assets that can be linked to previous material qualities and deliveries.
  - Centralized data source to aid in investigations into premature failures.
  - Archival improvements for long-term retention of the material information.
- Transparency
  - Ticket information can be retrieved by some parties involved in the project (proprietary materials excluded).

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 1.75 PYs
    - Operating Expenses: $160,000 one time
  - Mid-Term
    - Resources Needed (PYs): 2.5 PYs
    - Operating Expenses: $3,750,000 one time
  - Long-Term
    - Resources Needed (PYs): No additional PYs
    - Operating Expenses: None

- **Policy Impacts:**
  - New specifications
  - Construction Manual Update
  - Construction Procedure Directive
  - METS Manual Updates
  - Concrete Technology Manual Update
  - Bridge Construction Memos (BCMs)

- Design-Build Manual to include e-Ticketing Spec
- Non-Caltrans projects in the state right-of-way (assets that we will own)
- Design-Build Manual to include e-Ticketing Spec

- **Potential Implementation Challenges:**
  - Industry (contractors and material suppliers) buy-in
  - Trucking industry (third-party haulers with multiple contractors)
  - Material suppliers sole source interest platform that may not match with Caltrans selected platform
  - Accessibility for users
  - Integrating with plant/supplier IT systems
  - Remote plants without cellular/internet service
  - Remote projects without cellular/internet service
  - Loss of connectivity

- **Performance Measurement:**
  - To be determined

- **Implementation Lead (Division):**
  - Construction

- **Recommended Involved Parties:**
  - METS
  - Structure Construction
  - IT
  - FHWA
  - Industry organizations (contractors, suppliers, trucking, etc.)
  - DPAC
  - Pavement and Materials Partnering Committee (PMPC)

- **Additional resources needed to support:**
  - Construction
  - METS
  - IT
  - Structure Construction
  - Design

11. FULLY IMPLEMENT USE OF E-TICKETING

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
11.01	1- Short	2. Tools	Pilot of DOTSlip (HaulHub) (ABD) *Assumes $10k for unlimited access*	Construction w/ help: IT, METS, Structures Construction	0.00	0.50	$10,000	
11.02	1- Short	2. Tools	Select platform to utilize following the pilot projects. Includes engagement with industry.	Construction w/ help: METS, Structures Construction	0.25			
11.03	1- Short	2. Tools	Pilot of Connex (Command Alcon) (ABD) (Complete FY 22-23) *Assumes $15,000/project for 10 projects*	Construction w/ help: METS, IT, Structure Construction	0.00	0.50	$150,000	
11.04	1- Short	3. Policy	New Specification, Construction Procedure Directive (CPD), and Construction Manual (CM) Update	Construction w/ help: METS, Structure Construction	0.25			
11.05	1- Short	3. Policy	Develop implementation plan and training for e-Ticketing	Construction w/ help: METS, Structures Construction	0.25			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
11.06	1- Short	4. Data	Develop API of data transfer from e-Ticketing solution to applicable data servers for business functions (DIME, ProDMS, etc.). Include metadata development with data transfer.	Construction w/ help: IT, METS, Structures Construction	0.50			
11.07	2- Mid	1. Org	Implement e-Ticketing solution statewide (training complete, specification, CPD, CM update)	Construction w/ help: IT, METS, Structures Construction	0.25			
11.08	2- Mid	1. Org	Provide training for e-Ticketing solution statewide (Data Management, System Use, internal and external users)	Construction	1.00			
11.09	2- Mid	2. Tools	Procurement of e-Ticketing solution after pilot project identifies the preferred selection *$10,000/yr to $3,750,000/yr*	Construction w/help: IT, Legal, DPAC	0.25		$3,750,000	
11.10	2- Mid	3. Policy	Determine process to link e-Ticketing information with 3D model (digital as-built/AIM/digital twin/4D-5D model)	Construction, METS, Design w/ help: IT, Structure Construction	1.00			

12. STRENGTHEN USE OF UNMANNED AIRCRAFT SYSTEMS (UAS) WITH CENTRAL DATA REPOSITORY, TRAINING, STREAMLINED PROCUREMENT, & FLEET MANAGEMENT SYSTEM

CLICK HERE for recommendation summary.

Description of Baseline Process:

The Division of Aeronautics in conjunction with the UAS Steering Committee has established the Caltrans UAS Program which includes policies and procedures for UAS operations (DD-118, UAS Operations Handbook), the UAS Safety Management System, and the UAS Training Program to ensure safe and consistent Caltrans UAS operations. The UAS Steering Committee has also approved the formation of Working Groups for many Divisions utilizing UAS that will focus on the needs of those Divisions and how these tools are utilized. Across all the Divisions these tools are being used in various ways and not all functions have established best practices to be implemented on a broader scale. Furthermore, not every Division or District is using these tools to their fullest capabilities which may be due to lack of pilots, equipment, best practice manuals/guidance, and support for the high data volume necessary for utilizing this tool and information that could be shared across Division lines. And the data is not centrally stored where others could benefit from previous flights conducted by other divisions that provides data useful across division and functional lines without requesting other flights. Below is a high-level breakdown of the different UAS use cases identified at this time.

Data Collection Methods:

- Photography
- Videography, including real-time data streaming
- Structure-from-Motion Photogrammetry (3D modelling and Orthorectified imagery)
- LiDAR data collection
- Thermal/Multi-spectral Imagery

Applications:

- Environmental studies/Mitigation Site Monitoring
- Surveying: Project cycle, Earth Surface Measurements, Supplemental Survey Data, Orthomosaic Imagery
- Hydrology/Hydraulics
- Construction Inspection/Site Monitoring/Quantities
- Geotechnical Inspection/Studies
- Culvert Inspection and other Maintenance Activities
- Emergency Response (e.g., fire damage, mudslides, rockfall, accident reconstruction)
- Bridge Inspections (scheduled and emergency)
- Structures Planning, Design, and Construction
- Structures Hydraulics
- Public Information/Outreach
- Capturing of photos/videos for visual survey

    - Environmental compliance reviews
    - Construction site monitoring
    - Public outreach
- Project planning
- Emergency response
- Some units (surveys) utilize technology to the full capability to perform measurements and calculations of the earth's surface
    - LiDAR capture
    - Photogrammetry
    - Mapping
    - Point Cloud-Structures
    - Orthophoto
    - Augment existing mapping
- Bridge inspection

Description of Recommended Change/Solution:

UAS offers a multitude of improvements for BIM for Infrastructure (BIM4I) efforts as it increases safety, accuracy, efficiency, and provides the ability to access hard to reach areas and the tool can be equipped with various types of technology for the different Divisions to utilize in performing their work in a more data forward process. Each Division has their own needs that are specific but there are times when Divisions could partner to save resources. Developing a central storage location for all UAS data captured could create efficiencies for the Divisions to share information and utilize other data but there is also the need for each Division to understand if the data available is pertinent to their need. Furthermore, utilization of UAS technology at the "K" & "0" Phase with Planning and Design grade accuracy to develop a more accurate Project Initiation Document (PID), approved Project Report (PR), and Environmental Document (ED) for design alternative analysis, for the 3D Project Information Model (PIM) from PID & PAED phase rolled to the PS&E design phase without loss of data.

Recommendations:

- The first recommendation is for each Division to continue developing their own best practices guidance for staff to utilize UAS technology. Leverage the Division working groups already established to identify the needs from the various Districts and Divisions to develop resource and operating expense requests to implement UAS across the Department for VDC efforts.
- The second recommendation is to create a central repository for UAS data information as there may be the capability to share across Division lines and reduce staff work necessary to capture relevant details and along with that develop a cross divisional group to determine how this process will happen and be utilized. Configuration of which could be per District or statewide. Discussion with IT to determine architectures as necessary.
- The third recommendation is that each District or Division will need to determine who will utilize the tools for the business needs. Will there be a specific office established with staff trained as UAS pilots or will staff be present within the various offices in the Divisions be trained to perform the work as necessary? Each District and Division has a different need so that would need to be established at their level.

- The fourth recommendation is to provide resource time for staff training to perform these functions. As most Divisions and Districts do not have many staff trained and equipped to utilize UAS tools, there is a need to determine who would/should be licensed to perform this work and then provide with the necessary resource time to complete the training required per the UAS Safety Management System. This step is also contingent upon the decisions made in third recommendation.
- The fifth recommendation is to provide a more streamlined procurement process for UAS equipment, software, and training. Funding mechanisms for Divisions and Districts to acquire the tools necessary to perform these efforts are critical. This will entail working with IT to get select equipment necessary added to the IT Standards list, development of a Leveraged Procurement Agreement (LPA) for a licensed vendor, funding to purchase the tools, software, and DARTdrones (or similar) training licenses.
- The sixth recommendation is to procure a fleet management system for statewide UAS use, in coordination with Division of Aeronautics' ongoing efforts. The fleet management system should handle real-time flight tracking, monitoring, and flight metrics.
- The seventh recommendation is to leverage and maximize any and all grants related to UAS provided in the Infrastructure Investment and Jobs Act (IIJA).
- The eighth recommendation is for the Survey office to update the survey request form, which would be updated to include the accuracy and the data sets needed (i.e., imagery, video, topographical, etc.). Surveys would determine the best and most efficient way to collect the data. LiDAR data is not needed for all projects. The level of accuracy and level of detail should be the driver for selecting the appropriate data collection tools.

Anticipated Benefits:

- A safer and more efficient way of capturing project specific details or performing inspections of roadway facilities
- Faster data collection
- Broader focus on applications of these tools beyond how they are used currently
- Centralized location of data collected
- Uniformity in data collection and use
- Career and staff development
- Modernization of the tools and capabilities of the Department
- Opportunity for continued development and expansion of improvements as UAS technology advances

Implementation Considerations:

- **Financial Implications:**
    - Short-term resources needed for the working group to investigate these recommendations further.

        - Resources Needed (PYs): ~27.6 PYs
        - Operating Expenses: $100K
            - Per year for fleet management system SAAS solution.
    - Mid-term resources needed for the implementation of UAS for the various functions and practices that support BIM4I.
        - Resources Needed (PYs): ~19PYs
        - Operating Expenses: ~$5.1M per year
            - See Specific Implementation Activities in this document for further breakdown.
    - Long-term resources needed
        - Resources Needed (PYs): ~2PYs
        - Operating Expenses: No new $OE added in the long-term.

- **Policy Impact:** The implementation of UAS for BIM4I efforts may require various policy and guidance changes to be made and created. Proposed changes to Caltrans UAS policies require coordination with the Caltrans UAS Program in the Division of Aeronautics and may necessitate the approval of the UAS Steering Committee. List of main topics is below:
    - Develop policy establishing roles and responsibilities for who is allowed to perform certain UAS technology data capture tasks based on work classifications and applicable laws governing the work classifications (see AMG recommendations for specific action and resourcing).
    - Creation of Division specific best practice manuals for utilizing UAS devices for business practices and establishing standardized use cases, in coordination with existing Division Working Groups.
    - Develop policy or guidance for storing and sharing of data captured via UAS in central repository for others to utilize for their work benefits. Include workflow processing for how the information is utilized and transferred.
    - Develop guidance and process for cloud processing of the data captured.
    - Develop retention process for data captured using UAS.
    - Develop a privacy policy on what needs to be obscured in images or deleted upon collection.
    - Adjusting WBS activities' (M060, M090, M100 & M160) definition to provide the necessary resources to survey to utilize UAS technology to develop design grade survey at the "K" & "0" phase.

- **Potential Implementation Challenges:**
    - Staff capabilities, skill set and training
    - Funding for the acquisition of tools
    - Available staff to perform these tasks and duties
    - Data storage capabilities for the large file sizes from data captures
    - IT bandwidth to and from storage server
    - Procurement issues
    - IT Standards not keeping up with technology changes
    - Lack of Geoprocessing server or an image server for UAS datasets

- **Performance Measurement:**
    - Development of Division specific best practices manual/guidance
    - Central data storage location acquisition
    - Development of District and Division specific plans for who will provide UAS services for the various business practices
    - Number certified pilots (training)
    - Number of UAS operations
    - Cost savings
    - Procurement of tools for use in the field
    - Working group findings for PYs and Operating Expenses to implement fully

- **Implementation Lead (Division):** Each Division would lead their own concerted effort and coordinate on what can be shared.
    - Construction
    - Design
    - Environmental
    - Surveys
    - Maintenance
    - Engineering Services

- **Recommended Involved Parties:**
    - Office of Performance and Innovation
    - Office of Land Surveys
    - Office of Photogrammetry and Preliminary Investigations
    - Asset Management
    - Structures Maintenance & Investigations
    - Structures Construction
    - Structures Design
    - District Design and Construction
    - IT
    - CTDATA
    - Public Affairs

12. STRENGTHEN USE OF UNMANNED AIRCRAFT SYSTEMS (UAS) WITH CENTRAL DATA REPOSITORY, TRAINING, STREAMLINED PROCUREMENT, & FLEET MANAGEMENT SYSTEM

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
12.01	1- Short	1. Org	Statewide Training - Staff time for training and "train the trainers" time. This goes along task that determines who should be trained by each Division/District. *Assumes 60 hours of training per person @ 500 people statewide*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	20.00			
12.02	1- Short	2. Tools	Fleet Management - Procurement of fleet management software.	Aeronautics w/ support: DOC, DES, DEA, Surveys, Maint., others	0.50			$100,000
12.03	1- Short	3. Policy	Each Division to develop best practices and use cases for UAS for business needs. *Assumes .5 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, IT, and others	4.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
12.04	1- Short	3. Policy	Revise survey request process and form to consider all stakeholders and data collection modes.	Surveys	0.50			
12.05	1- Short	3. Policy	Develop Division-/District-specific plans for who will utilize UAS as a new tool (i.e., specific office providing this service or staff trained in each office/unit that provide service for those functions). *Assumes 0.25 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	2.00			
12.06	1- Short	3. Policy	Fleet Management - Develop process for managing drones through fleet software.	Aeronautics w/ support: DOC, DES, DEA, Surveys, Maint., others	0.50			
12.07	2- Mid	2. Tools	Procure processing software for various purposes. Caltrans use of UAS varies widely by Division. Additional enterprise software is needed to further develop uses. Procurement of software platforms such as Pix4D mapper, Trimble UAS Master, Datubim by Datumate, and others are needed to enable the full benefits of UAS platforms. *Assumes 0.25 PY per Division per year plus ongoing software cost*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	4.00			$100,000

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
12.08	2- Mid	2. Tools	Procurement of UAS Hardware – Processing Servers for LiDAR and Photogrammetry Data. Current practices involve local processing of data, which is both slow and cannot be easily backed up for compliance with data retention policies. A Central, High Bandwidth, High-Capacity Virtual Server processing system for processing point cloud, and LiDAR data is more efficient and will reduce the need for high end desktop computers. Data outputs from this system would be moved to the storage system described in Implementation Activity #2. *Assumes 0.5 PY per Division*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	4.00			$500,000
12.09	2- Mid	2. Tools	Procurement of Drones - Set up LPA system to streamline acquisitions and define funding stream. Set up BCP to fund UAS hardware (estimated $3-4 million per year, further analysis will refine final numbers). *Assumes 0.5 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	4.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
12.10	2- Mid	2. Tools	Procurement of Drones – Leverage LPA and funding streams to purchase equipment. *Assumes ~$3-4M (2K up to 300K per system and total need TBD)*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others				$4,000,000
12.11	2- Mid	4. Data	Procure/develop and implement a central repository for UAS data information. Centralized Server repository system will warehouse all UAS data captured to provide access to other users who may want access to aerial data. Current practices involve storage of large UAS data sets on individual computers. This makes the data vulnerable to loss and is not consistent with retention policies.	IT w/ support from DOC, Surveys, Design, DEA, Maintenance, DES, PAO	3.00			$500,000
12.12	2- Mid	4. Data	Develop a cross-divisional group to determine the process for storing, sharing, and utilizing UAS data captures across phases and divisions. Determine processes, retention times for beneficial information (recommendation 2). *Assumes 0.25 PY per Division per year*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	4.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
12.13	3- Long	3. Policy	File for Grant funds available from Infrastructure Investment and Jobs Act (IIJA). *Assumes 0.25 PY per Division*	DRISI w/ support from other Divisions for specific information	2.00			

13. REQUIRE DIGITAL AS-BUILTS (DAB) THAT ACCURATELY CAPTURE THE FINAL STATE OF BOTH SURFACE AND SUBSURFACE ELEMENTS

CLICK HERE for recommendation summary.

Description of Baseline Process:

Creation of as-bult drawings is currently a paper driven process. The current process is to redline paper documents in the field and then transfer red lines to .dgn files for creation of .pdf/.tiff files for retention. There is inconsistent policy compliance across the districts and across divisions regarding functional units in terms of who processes the as-builts and store them. Some districts retain .dgn CAD files in addition to the .pdf/.tiff image files.

While all project as-built files are stored in document management systems, the roadway as-builts and the structure as-builts are stored in different locations. The structure as-builts are stored in Bridge Inspection Records Information System (BIRIS) and the roadway as-builts are stored in the Document Retrieval System (DRS).

Description of Recommended Change/Solution:

The vision is to provide a 3D model digital as-built at the end of construction that accurately captures the final state of the project for both surface elements as well as all subsurface elements. In doing so, the Department will be able to create a 3D model with 3D feature lines or objects according to Caltrans Asset Information data dictionary that can be utilized for future uses.

Specific recommendations:

1. Further study is necessary to determine improved risk mitigation for future projects as well as worker safety benefits utilizing technology to capture as-built information (it is currently anticipated that worker exposure will be reduced; however, the degree to how much needs to be studied)
2. Develop Asset Information Execution Plan to outline Digital As-Built's attributes and activities at the end of the construction phase
3. Each Department function determines asset information to be captured and utilized
    a. Partner with Structure Maintenance and Investigations (SM&I) for which features needed from 3D digital as-builts
4. Develop link of geolocation with GIS (spatial and metadata)
5. Finalize process moving forward of incrementally developing the Asset Information Model (AIM) by modifying a copy of the Project Information Model (PIM) based on the digital twin that has been captured during the project. The final, verified/validated Asset Information Model becomes the project's digital as-built.
    a. Determine process for changes to be updated in the PIM
    b. Determine process for digital as-builts to be created/captured for projects that were delivered with 2D plan sets
        i. Decide which, when, etc.

6. Creation of manuals/guidance/processes
    a. Document both 2D plan set to 3D digital as-built and revision of 3D model for 3D digital as-built
7. Model is full reality data capture and supplies multiple disciplines in compatible platforms
    a. Consider breaking final model into separate information models that show specified elements that are asset/function specific
8. Creation and updating of information in the uniform 3D model object library and feature code library
    a. Assess compliance in naming conventions based on industry and Federal standards with Caltrans standards for feature naming
9. Develop dashboards for analytics of information captured based on the asset/function needs
10. Include distributed ledger technology (DLT) as part of the solution (this refers to blockchain or version control)
11. Training
12. Pilot Project(s) that will tell us more:
    a. Identify variety of project types that would be beneficial:
        i. Earthwork
        ii. Pavement
        iii. Box culverts
        iv. Bridges (CIP PS Box Girder, Precast, Steel)
        v. Earth retaining systems
        vi. Utilities (Overhead, at-grade and underground)
        vii. Drainage systems (culverts, inlets, etc.)
        viii. Delineation
        ix. Signs and sign structures
        x. Guardrails, barriers, safety features
    b. Determine milestones regarding when scans or data captures would take place
    c. Pilot Project will assist in the development of guidance and process
    d. Employing different software vendors on pilot projects will assist the department to decide on which software vendors to continue
13. Partner with Asset Management and Structure Maintenance to determine which features need to be captured in 3D digital as-builts
14. Determine if all digital as-built files will be housed in one location or if two separate locations will be required to satisfy the needs of structures as-builts and roadway as-builts.
15. Further study is necessary to address the legal issues of signing or stamping the final digital as-built as the legal model/document
    a. Coordination with the 3D model group for model as legal document solution
16. Further development needed for workflow process of scans and mapping and how this will affect the data processing and storage locations
    a. Steps to capture
    b. Data Processing
        i. Determine final deliverable type. DTM, DSM, surface w/line work, 3D objects, etc.
        ii. Develop more AI or ML for automated point cloud extraction
    c. Determine retention process

i. Determine how long to keep digital as-built information. Based on business needs and discussions with Legal.
ii. Document after digital as-built capture who uses the data and how long before storage in permanent cloud location
    1. Hot storage or cold storage
    2. Download/upload to and from cloud solution

d. Determine how we compute in cloud environment or download off cloud to computing device

Anticipated Benefits:

1. Safety
    a. Construction using digital information can lead to safer projects and shorter work zone traffic impacts.
    b. Better information following a project can allow for increased Design safety decisions on the next project.
2. Time Savings
    a. Digital information provided to construction enhances planning and can streamline project delivery.
    b. Digital as-builts including utility locations and other asset information will improve post-construction decisions and shorten future project delivery.
3. Quality.
    a. Digital as-builts can provide enhanced historical data, enabling State DOTs to better maintain the transportation infrastructure and develop future projects.
        i. Verification of final pay quantity
        ii. Identify design errors
        iii. Field data capture technologies will increase the accuracy and completeness of the as-built documentation compared to the conventional redlining of 2D plan sets
4. Efficiency: Readily available information for clash detection ultimately reduces project timelines and cost.
    a. Seamless sharing, transferring, and collaborating of digital data and documents.
    b. Automated document archiving with built-in record retention schedules.
    c. Improve multi-disciplinary collaboration.
    d. Easier to review complex projects.
    e. Field capture tools will also provide updated coordinate information if the construction team detects or encounters an inaccurate utility location during construction. They will use these revised coordinates to update the Caltrans Utility Database.
5. Improve database structure and enhancing efficiency of the use of the data for Asset Management and Maintenance to have an automatically feed database of information.
    a. DAB will be available to Structure Maintenance and Investigations via Augmented Reality (AR) visualization for inspections, asset management, and project engineers with the information they need to develop future projects, further extending the service life of existing transportation assets.
6. Significant opportunity to expand Best Practices throughout the Department by standardization of document management.

7. Inform future decision-making by unlocking valuable information for future projects, maintenance activities, rehabilitation interventions, and asset management.
8. Legibility of as-built information
9. Advance Planning – Provides valuable, relevant, and geospatially located information for the next project on a section of highway where at digital as-built was created. Ultimately develops a full 3D picture of above and below finish surface infrastructure elements that can be used for better decision making in the next projects.

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): ~ 15.5 PYs
      - Spread across numerous divisions and districts
    - Operating Expenses:
      - ~$4.5M/yr for unlimited storage
  - Mid-Term
    - Resources Needed (PYs): ~ 25 PYs
      - Spread across numerous divisions and districts
    - Operating Expenses:
      - ~$200,000/yr to pilot Digital As-Built platform
      - ~$400,000/yr to procure Digital As-Built platform after pilot
  - Long-Term
    - Resources Needed (PYs):
      - No additional PY
    - Operating Expenses:
      - No additional $OE

- **Policy Impact:**
  - Data accessibility and security
  - Develop new policy for legality of digital as-builts
  - Develop communication protocol between the CT Construction Office and Contractor to utilize Common Data Environment to validate Construction Asset Information elements that have been certified by CT in order to be utilize for the 3D Digital As-Built
  - Develop new specifications
  - Construction Procedure Directive
  - Construction Manual Updates
  - Survey Manual Updates
  - Bridge Construction Memos (BCMs)
  - Non-Caltrans projects in the state right-of-way (assets that we will own)

- **Potential Implementation Challenges:**
  - Buy in from Asset Management, Maintenance, Structure Maintenance and Investigations (SM&I)
  - Getting legal acceptance of stamped digital as-builts
  - Sharing of information for legal proceedings
  - Data accessibility and security
  - Not having enough or the appropriate data collection equipment
  - Procurement process and coordination with IT for tools needed
  - IT support for the software and tools needed
  - Standardize Asset Information attributes and metadata for Asset Information Model (AIM) Execution Plan
  - Limitations in Current Commercial Software or Software as a Service (SAAS) solutions

- **Performance Measurement:**
  - TBD

- **Implementation Lead (Division):**
  - Construction and Structure Construction with support
  - Surveys (CALMS workflow)

- **Recommended Involved Parties:**
  - Design (roadway and structures)
  - Construction (roadway and structures)
  - Surveys
  - Maintenance (Asset Management and Structure Maintenance & Investigations (SM&I))
  - Industry
  - Legal
  - Measurements and Verification Subcommittee

13. REQUIRE DIGITAL AS-BUILTS (DAB) THAT ACCURATELY CAPTURE THE FINAL STATE OF BOTH SURFACE AND SUBSURFACE ELEMENTS

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
13.01	1- Short	1. Org	Complete Digital As-Builts Pilots currently underway. (FY 22-23) Projects include: • 03-3F5104 Timbuctoo • 03-1H8604 Chico ITS • 03-0F2804 SR99 CMGC • 07- 323404 Box Culvert • 11- 056374 Siempre Viva	HQ DOC w/ support: District Construction, HQ/District Office of Land Surveys, Structures Construction	1.00			
13.02	1- Short	1. Org	Develop Training for District As-Built Coordinators	HQ DOC w/ support: Structures Construction, HQ OLS, Asset Management	1.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
13.03	1- Short	3. Policy	Start discovery process to develop asset extraction process, feature types, file formats, and manuals for features desired by Asset Management and Maintenance, and Structures Maintenance. *Assumes 0.5 PY per each of the 4 groups: Construction, Land Surveys, Structure Construction, and Structures PI. Assumes additional funding for AM and Mtce is not required.*	HQ DOC, HQ OLS, Structures Construction, HQ Asset Management, Maintenance, Structures PI	2.00			
13.04	1- Short	3. Policy	Determine information that Structure Maintenance will use and add to digital as-built.	Structure Maintenance w/ support of DOC	0.50			
13.05	1- Short	3. Policy	Develop workflow for data capture and storage for processing. • Establish data capture time periods • Functionality for data processing (hot vs. cold storage) • Retention period (hot vs. cold storage) • Estimate of storage per highway mile (40GB/lane-mile is current estimate) • Estimate of copies to be retained	HQ DOC, Structures Construction, HQ OLS	4.00			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
13.06	1- Short	4. Data	Establish working group to determine Digital As-Builts repository and long-term storage solution/s. Based off preliminary estimates, we could expect more than 15 PB of storage for the state may be needed long-term based on 386,000 lane miles @ 40 GB/mile. Storage would increase over time based on completed projects at a rate of ~350 projects per year. Much of this issue is based off the final workflow of 3D model capturing and workflow of retaining models and how many models are needed. There is need for a focused effort of cross-functional groups to determine the workflows and ultimately determine future needs. *Assume 0.5 PYs per year per functional group. Solution costs to be determined, likely significant (millions per year); however, according to a recent cloud storage quote from Autodesk, Project Delivery could be sustained for data storage needs at about $4.5M/year for approximately 6,000 users in the system. This would account for unlimited storage for any cold storage of project delivery data needs (i.e., digital as-built data, 3D model data, point cloud data, large imagery files, UAS data, etc.).*	DOC, IT, DES, OLS, Design, Asset Management, Legal	4.00			$4,500,000

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
	1- Short	4. Data	Determine data storage locations and capacity. • Single location for all data or multiple locations to cover roadway and structures as-builts. • Long-term vs. Short-term storage. • Cloud or server storage. *Assumes 1-2 PYs*	IT w/ support: HQ DOC, Surveys, Structure Construction, Asset Management	2.00			
13.08	1- Short	4. Data	Determine data accessibility, security, and data storage platform for digital as-builts.	IT, Legal, DOC	1.00			
13.09	2- Mid	1. Org	Develop (Additional) Training for District As-Built Coordinators.	DOC w/ Support: Surveys, Structures Construction	0.50			
13.10	2- Mid	1. Org	Establish Digital As-Builts coordinator in every District (12), DES Structure Construction (1), and Office of Land Surveys (1). There is a possibility this need will grow to 20+ PYs depending on Districts' abilities to accomplish the work with one team member. This role may start in Construction but ultimately will support all Project Delivery. *Assumes 12-20+ PYs statewide*	DOC w/ Support: District Construction, Surveys, Structures Construction	2.00	12.00		
13.11	2- Mid	2. Tools	Pilot and acquire Digital As-Builts visualization platform and process (evaluation of ArcGIS, Quadri, Autodesk Build etc.) *Assumes 1+ PY + assistance from Visualization group, $200,000 for software licensing*	HQ DOC w/ support: HQ IT, HQ DES, HQ OLS	1.00		$200,000	

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
13.12	2- Mid	2. Tools	Procurement of solution following pilot projects. *~$400,000/yr for solution*	DOC w/ support: DPAC, IT, Structures	0.50			$400,000
13.13	2- Mid	3. Policy	Development and integration of Asset Information Model feature code library. Develop a unified feature code library that will fit the needs of all stakeholders (Design, Asset Management, Surveys, Construction, Structures Construction). This ensures data standardization. *8 Staff @ .25 PYs Each*	HQ OLS, HQ DOC, HQ DES, HQ Asset Management	2.00			
13.14	2- Mid	3. Policy	Develop digital as-builts policies, procedures, and manuals for implementation. *1-2 PYs*	HQ DOC, HQ OLS with Support	2.00			
13.15	2- Mid	3. Policy	Determine information Asset Management will extract from digital as-built to assist DOC in capturing correct information.	Asset Management w/ support of DOC	0.50			
13.16	2- Mid	3. Policy	Determine information Traffic Operations will extract from digital as-built to assist DOC in capturing correct information.	Traffic Ops w/ support of DOC	0.50			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
13.17	2- Mid	3. Policy	Determine information Planning and Environmental will need captured and retained in the digital as-built to have available for the next project in vicinity.	Transpor-tation Planning and Environmenta l w/ support of DOC	0.50			
13.18	2- Mid	3. Policy	Develop implementation plan and CPD to implement digital as-built process on all projects completing after a certain date.	DOC	0.50			
13.19	2- Mid	3. Policy	Implement digital as-built process on all projects that will complete Construction Contract Acceptance (CCA) after a certain date.	DOC w/ support: Surveys, Structures Construction	3.00			

14. FORMALLY ESTABLISH PROJECT DELIVERY/GIS DATA ORGANIZATION STRUCTURE TO SUPPORT DIGITAL DATA SHARING, INTEROPERABILITY, & VISUALIZATION THROUGHOUT THE PROJECT DEVELOPMENT PROCESS AND ASSET LIFE CYCLE

CLICK HERE for recommendation summary.

Description of Baseline Process:

Existing data providers create digital data and digital data visualization for many functional areas of Caltrans already. This digital data is available for consumption at will by Caltrans staff and in some instances, the public. Digital data contributors to the BIM4I effort include a wide variety of classifications and participate as appropriate throughout the project life cycle. This team will explore ways to take advantage of data sharing, interoperability, and visualization as the BIM4I effort matures.

Key to this effort will be the utilization of GIS and its functionalities. Currently, GIS data providers are randomly located throughout Caltrans organization and usually represent 1 or 2 staff who support a District or Division. These staff typically focus on a specific task or supporting a specific type of work. As a result, GIS digital data that is provided tends be designed to meet a very specific portion of the asset life cycle rather than a more strategic approach to data, accessibility, interoperability, and reusability.

Existing GIS units tend to have been created by managers that recognize the value of including GIS processes to enhance workflows and to encourage efficiency. GIS units tend to be in Planning, Design, Surveys, or Environmental Planning. These business areas have existing workflows that can be leveraged. In District 4 and 12, GIS staff directly support critical data sharing such as the right-of-way ownership information. Division Environmental Analysis (DEA) directly supports many portions of the Environmental Planning process. In the North Region, the GIS unit supports data sharing throughout the entire Capital Outlay Support (COS) processes. Areas of GIS excellence exist within Caltrans; however, there is opportunity to capture many additional advantages from GIS.

Description of Recommended Change/Solution:

The BIM4I committee recommends creating a cross-disciplinary GIS committee (potentially a technical working group of the Geospatial Sub Committee or Enterprise Data Stewards Committee) comprised of SMEs (members must understand GIS and data interoperability) to determine the most appropriate project delivery GIS organization structure, establish standards, identify essential data layers and databases, research and adopt industry best practices, determine ideal workflows, and assist with implementation and change management.

This short-term solution would be funded until FY 23 with 2 PYs with the intention of this funding rolling over into a long-term support unit of 2 full-time employees to support this portion of the BIM4I effort. The task force would continue as long as the team determined it was necessary to complete BIM4I tasks.

BIM4I is a cultural shift that Caltrans is embracing, and part of this shift is recognizing that Data is an

Asset. For Caltrans to leverage this asset to its fullest extent we must support data driven processes within our Project Development workflows. These workflows require employees to support and maintain them ensuring that this valuable data can support all of Caltrans's many programs to their fullest extent. To address this issue and for the BIM4I vision of the project data rolling over into the asset life cycle, Caltrans will need to create one technical expert position per District who will conduct training and provide support to Project Development Teams (PDT) within the District. This will require 12 PYs initially, which will roll into the workplan over time. We anticipate that as these support hours are incorporated into each District's work plans, the programmed hours will equate to support units in each District.

This task force would be responsible for evaluation of the following list of tasks to determine the feasibility of implementing them into the BIM4I project delivery process and asset life cycle. Tasks under the Critical Tasks heading must be implemented to be successful.

- <u>Critical Tasks</u>
- Establish Standards
    - CAD to GIS feature and symbology crosswalk
    - Spatial Accuracy of essential layers
    - Data Standards
        - Data Dictionary
        - Metadata
        - Naming
    - Web Applications and Visualizations
        - Crosswalk with other visualization platforms
        - Web Scene for 3D Applications
- Identification of essential data layers and databases
    - Interoperability (Crosswalks) to add them into VDC project development process
- Industry Best Practices
- Involvement on other VDC Implementation Teams
- Project Delivery GIS/Data Organization Structure
    - Critical Functions
    - Classifications
    - Central unit or decentralized staff imbedded in production units to perform work
- Digital Property Management System (Parcel Fabric) - establish a single source of digital real property geospatial information repository for the sharing of State right of way and ownership.
- Workflows
    - K Phase (PID)
        - Essential data layers and database interoperability
    - 0 Phase (PA&ED)
        - Public Meetings Visualizations
        - Essential data layers and database interoperability
    - 1 Phase (PS&E)
        - Data model information sharing standards
        - Essential data layers and database interoperability

    - 2 Phase (Right-of-Way)
        - Parcel Fabric
    - 3 Phase (Construction)
        - Essential layers updated from digital as-builts
        - Sharing standards with asset management and maintenance
        - Database interoperability
- Change Management
- Tasks discovered during implementation
- Tasks
    - Workflows
        - Data interoperability (Crosswalks)
        - Maintenance
            - Essential data layers and database interoperability
        - Operations
            - Essential data layers and database interoperability
        - Planning
            - Essential data layers and database interoperability
    - Establish Standards
        - Branding
        - Database size and scope
        - Findable data
        - Accessible data
    - Develop web applications that would enhance the BIM4I project delivery process
    - Common Storage Environment
    - Ensure combability with systems currently under development
        - Transportation Asset Management System (TAMS)
        - Parcel Fabric
        - Others
    - Caltrans Best Practices and Lessons Learned

Using lessons learned by the Task Force and other BIM4I sub teams during the implementation process, adjust current project delivery workflow to leverage GIS for the project information model and asset information model. This effort would occur during all phases of the project delivery process along with facilitation of the asset life cycle processes on an enterprise level.

This Task Force will identify existing digital data processes and leverage and scale them to meet enterprise level needs as best as they are able.

Due to the extraordinary nature of this change in the way Caltrans does business along with the lack of GIS staff to perform this work at the District and Division level, it is also recommended that specialty staff positions be created to support this effort. The workflows that will be developed from this effort are more than the existing District and Division GIS staff can handle. The task “Project Delivery GIS/Data Organization Structure” should be considered for funding across all Districts and at the HQ level. The minimum increase in staffing that would allow this effort to be successful is one specialty GIS support position per District and two at HQ. The Task Force would recommend correct classifications and organization locations. Minimum of 14 PYs to support this VDC implementation

effort. These PYs would eventually roll over in to the workplan and be supported by ongoing capital projects.

As workplans are programmed moving forward, the true BIM4I support level will be realized. This support is anticipated to be somewhere around 4 to 8 PYs per District and a HQ support of 2 to 10 depending on how centralized/decentralized the support organization structure becomes.

Anticipated Benefits:

- Quality Data available through the whole asset life cycle and beyond
- Reduced rework due to improved data availability and reliability
- Common visualization standards across platforms for PIM & AIM
- Data driven decision-making through availability of shared data
- Utilize single and/or federated 3D Model through GIS Geodatabases and IFC Interoperability
- Utilization of Common Data Environment through K,0,1,2,3,4 and Maintenance and Operation
- Project-specific Web Applications for internal and external outreach including social and environmental justice and equity
- Individuals or groups can retrieve the accurate spatial limits of State ownership on demand
- Make the limits of property rights maintained by Caltrans available for inclusion in model

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 1.5 PY
    - Operating Expenses: None
  - Mid-Term
    - Resources Needed (PYs): 14 PY
    - Operating Expenses: $300,000
  - Long-Term
    - Resources Needed (PYs): No new PY
    - Operating Expenses: None

- **Policy Impact:** Anticipate changes to current Project Delivery policy/standards, and CADD standards to accommodate cross platform utilization. Adhere to and follow Caltrans Open Data Policy for all public facing efforts. Implement Enterprise Data Governance per Deputy Directive 120.

- **Potential Implementation Challenges:**
  - Extensive change management outreach required
  - Lack of GIS staff dedicated to this effort
  - This is secondary duty for Task Force

- **Potential Technology Implementation Challenges:**
    - Ensure Enterprise GIS Technology can handle the additional use loads
    - Develop Data Dictionary Schema for Project Information Model (PIM) Geodatabases
    - Develop Data Dictionary Schema for Asset Information Model (AIM) Geodatabases

- **Performance Measurement:**
    - Cost savings
    - Reduce PA&ED Phase since Design and Environmental utilizing the same 3D PIM
    - More Accurate Planning grade model through PID & PR phase which will rollover to PS&E phase (efficiency)

- **Implementation Lead (Division):** Planning & Modal Programs (Chad Baker and Aaron Ott) for the GIS and data governance portion; all other data contributing Divisions for data under their stewardship

- **Recommended Involved Parties:** Department data creators, users, and partners

- **Overall Timeline:** Timeline dependent on work of other teams. Involvement with other teams discussing data creation tool selection and follow up for interoperability and visualization efforts, start of which will begin where other teams' work ends.

14. FORMALLY ESTABLISH PROJECT DELIVERY/GIS DATA ORGANIZATION STRUCTURE TO SUPPORT DIGITAL DATA SHARING, INTEROPERABILITY, & VISUALIZATION THROUGHOUT THE PROJECT DEVELOPMENT PROCESS AND ASSET LIFE CYCLE

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
14.01	1- Short	1. Org	Establish cross-functional GIS Task Force, including Design, Construction, Surveys, Environmental, Right-of-Way, Maintenance, Asset Management, Planning, Traffic Ops, Engineering Services, Information Technology Some participation needed immediately and some after pilot project completion).Team should consist of a combination of HQ and District SMEs who understand GIS and have a general understanding of the Project Delivery process. *Assumes 0.15 PY per division – per year (10) = 1.5 PYs per year for a Total of 7.5 PYs*	Aaron Ott for Chad Baker	1.50			
14.02	1- Short	2. Tools	Establish Common Storage Environment *Assumes resources are provided by the Task Force*	Task Force				

14.03	1- Short	3. Policy	Establish Standards - CAD to GIS feature and symbology crosswalk - Spatial Accuracy of essential layers - Data Standards o Data Dictionary o Metadata o Naming - Web Applications and Visualizations o Interoperability (Crosswalk) with other visualization platforms Web Scene for 3D Applications (Immediate to 1 year) *Assumes resources are provided by the Task Force*	Task Force
14.04	1- Short	3. Policy	Establish Standards - Branding - Database size and scope - Findable data - Accessible data (immediate to 3 years) *Assumes resources are provided by the Task Force*	Task Force
14.05	1- Short	3. Policy	Identify Industry Best Practices (immediate to 5 years) *Assumes resources are provided by the Task Force*	Task Force

14.06	1- Short	3. Policy	Identify Workflows - Data interoperability (Crosswalks) - Maintenance o Essential data layers and database interoperability - Operations o Essential data layers and database interoperability - Planning o Essential data layers and database interoperability 1-3 years *Assumes resources are provided by the Task Force*	Task Force		
14.07	1- Short	4. Data	Identification of essential data layers and databases Interoperability (Crosswalks) to add them into VDC project development process *(Immediate to 1 year)*	Task Force		
14.08	2- Mid	1. Org	Project Delivery GIS/Data Organization Structure Critical Functions - Classifications - Central unit or decentralized staff imbedded in production units to perform work *(Immediate for determination of structure* *1 to 3 years for implementation of approved structure)*	Task Force	2.00	12.00
14.09	2- Mid	2. Tools	Develop web applications that would enhance the BIM41 project delivery process *(1 year to 5 years)*	Task Force		
14.10	2- Mid	2. Tools	Ensure combability with systems currently under development Transportation Asset Management System (TAMS) - Others *(1 year to 5 years)*	Task Force		

14.11	2- Mid	3. Policy	Identify Caltrans Best Practices and Lessons Learned	Task Force
14.12	2- Mid	3. Policy	Workflows - K Phase (PID) o Essential data layers and database interoperability - 0 Phase (PA&ED) o Public Meetings Visualizations o Essential data layers and database interoperability - 1 Phase (PS&E) o Data model information sharing standards o Essential data layers and database interoperability - 2 Phase (Right-of-Way) o Parcel Fabric - 3 Phase (Construction) o Essential layers updated from digital as-builts o Sharing standards with asset management and maintenance o Database interoperability *(1 year to 5 years)*	Task Force
14.13	2- Mid	3. Policy	Change Management *(Immediate to 5 years)*	Task Force
14.14	2- Mid	3. Policy	Tasks discovered during implementation *(Immediate to 5 years)*	Task Force

15. ADOPT 4D (SCHEDULING) & 5D (COST) INTO THE CALTRANS PROJECT DEVELOPMENT & DELIVERY PROCESS

CLICK HERE for recommendation summary.

Description of Baseline Process:

Currently the contractor submits their proposed construction schedule in Primavera P6 after the contract is awarded and there is a bid item related to the schedule. Basic construction staging is provided to the contractors at the time of bid in the project plans.

Anytime traffic is rerouted, or the traveled way is modified into a different path to accommodate work zones, Caltrans prepares 2D construction staging plans. Current construction staging work is not always 3D modeled and not made available to the contractor.

Contracts using Time Related Overhead (TRO) have a progress schedule requirement. The level of detail is based on the duration and complexity of the project. More complex projects use P6 scheduling software for the analysis of the baseline. Lump Sum bid items are used for Progress Schedules.

Schedule: Three levels of critical path method schedules are defined in Section 8-1.02, "Schedule," of the Standard Specifications. The level is determined by the number of working days and the total bid amount. Resident Engineers (REs) make every effort to obtain a reasonable baseline schedule at the beginning of the contract and record in a daily report any communication regarding the schedule. REs notify the contractor in advance if a progress payment will be withheld for failure to submit a satisfactory schedule.

In general, schedules should: • Separate contract items into activities to show controlling activities as well as non-controlling activities. • Be used by the RE and the contractor to monitor and evaluate progress, determine controlling activities of work, and analyze time consequences from changes or work delays. • Be consistent with all contract time requirements. • Display internal milestones and other time constraints, such as placing traffic on detours or new pavement, and beginning new phases of the work in staged construction. The contractor is required to submit a revised schedule monthly to evaluate alterations to the critical path or an adjustment to the completion date. For Levels 1 and 2, the revised schedule may be used instead of a time impact analysis. Also refer to the Project Delivery Training Catalog on Caltrans' Project Delivery training web page.

Progress payments are processed on the 20th of each month for ongoing contracts. Payments for items are not directly tied to schedule, but the contract time elapsed is reported as part of the payments and the percent of work completed as a dollar value can be developed based on payments made to bid items. Individual bid items have specific payment clauses that vary depending on the item.

Some contractors produce basic 3D models (e.g., Sketch Up) out of 2D contract plans for construction planning.

4D: Schedule (Project Phasing): Caltrans has no current process for integrating 4D into any 3D products.

5D: Cost/Estimating (Real-time conceptual modeling and cost planning): monitoring work process: Caltrans has no current process for integrating 5D into any 3D products. The engineer estimate is based on the current cost data using BEES or AASHTOWARE. The BEES System collects cost data. Bid information comes from contractor, input to software (AASHTOWARE) as part of the bidding process before construction starts.

Description of Recommended Change/Solution:

Work with Highway Construction industry to adopt 4D (scheduling) and 5D (cost estimation) into the standard Caltrans project delivery process.

- This will require a mindset shift to model everything with metadata at outset (model with attributes). Must coordinate closely with 3D Model for Roadway sub-team – attributes must be structured from the design stage – consider information that needs to be input over the project life cycle. Like many of the BIM4I committee's recommendations, pilots will be required to fully determine the best way to implement this recommendation. Specific questions these pilots should answer include:
    - Does Caltrans accept contractor estimation in the schedule provided to Caltrans?
    - How does Traffic control 5D fit in the schedule?
    - Who is responsible for updating the 4D/5D models? How to include backfill and portions that are not drawn in 3D?
    - Work with environmental group to capture embodied carbon in materials and carbon emissions from construction equipment.

Anticipated Benefits:

- Improved site planning and scheduling optimization leading to safer projects
- 5D model can be used for record retention which replaces paper retention
- Improved coordination between owner's field engineers and contractors
- Enhanced information sharing related to timeline expectations to avoid costly delays
- Real-time cost visualization in 3D with nonfiction on changes in costs
- Simplified cost analysis and budgetary analysis with predicted and actual expenditures over the course of time
- Minimization of budgetary offshoot due to regular cost reporting and budgeting
- Remove individual redundant steps in process
- Project Information Model can be used as an inspection tool – automated process – information autofill a payment system, replace manual calculation steps
- Beyond construction: understanding what it takes to implement specific types of projects. Metadata tied to unit costs for entire project available as future data source.
    - Future engineering resource data collection
- Increased accuracy improves analyzing claims later – won't rely on contractor's estimates
    - Forensic analysis

Implementation Considerations:

- **Financial Implications:**
  - Short-Term
    - Resources Needed (PYs): 3.7 PYs
    - Operating Expenses: $100,000 annually
  - Mid-Term
    - Resources Needed (PYs): 6.0 PYs
    - Operating Expenses: $105,000 annually
  - Long-Term
    - Resources Needed (PYs): No additional PYs
    - Operating Expenses: $310,000 annually

- **Policy Impact:**
  - New specifications for 4D and 5D implementation will be required
  - New bid item will be required
  - Revise Process and procedure manuals to include 4D & 5D
  - Deputy directives

- **Potential Implementation Challenges:**
  - Ownership of design model (transfer from design to contractor)
  - Contractors' and Caltrans' understanding and readiness of 4D/5D
  - File format interoperability
  - Equity of Contractors' access to projects – smaller orgs may not have software to manage these projects
  - Define Roles and Responsibilities as EOR (Engineer of Records) for 4D/5D

- **Performance Measurement:**
  - Precision of bid
  - CCO counts
  - Meeting duration and frequency
  - Surveying stakeholders (owner, contractor, subcontractor, regulatory agency, etc.)

- **Implementation Lead (Division):**
  - HQ Construction
  - DES Structures Construction
  - (Design may be involved – further investigation in model capabilities)

- **Recommended Involved Parties:**
  - Design (roadway, structure, OE, consultants, etc.)
  - Construction (Caltrans, consultants)
  - Contractors and sub-contractors
  - HQ OE
  - HQ CADD support
  - Software Vendors

- **Contractors and Consultants Overall Timeline:**
    - Proof of concept in short-term pilots (0-2 years)
    - 4D reach maturity level after a few pilots (~ 2years)
    - 5D reach maturity level after multiple projects (5-7 years)
    - Specification completed and reviewed with input from contractors (3-5 years)

15. ADOPT 4D (SCHEDULING) & 5D (COST) INTO THE CALTRANS PROJECT DEVELOPMENT & DELIVERY PROCESS

The following table presents the committee's original implementation actions associated with the above recommendation. Note, these were originally identified in Summer 2022 prior to development and submittal of the 22/23 and 23/24 Finance Letters and may differ from the actual resources requested.

Specific Implementation Activities:

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
15.01	1- Short	1. Org	Industry Working Group to: Combined with other sub-teams to meet with Construction industry (include IT) *Assumes 0.15 PY per member (8) = 1.2 PYs*	HQ Construction and Structures Construction	1.20			
15.02	1- Short	2. Tools	Software (licensing and maintenance) e.g., Navisworks, Synchro, or other Increased support for CADD to manage all the software – centralize *Assumes 1-2 PY, considers 40 licenses -- 12 districts x 3 licenses to cover district construction and structure construction = 36 licenses, 4 licenses for HQ construction*	IT IT Legal DPAC CADD Construction	2.00			$100,000
15.03	1- Short	3. Policy	Prepare new Spec for 4D/5D (potentially new section) *(1 year)*	Construction	0.50			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
15.04	2- Mid	1. Org	Continue collaboration with Industry Working Group. Combined with other sub-teams to meet with Construction industry (include IT). *Assumes resources identified in the short-term cover this*	HQ Construction and Structures Construction				
15.05	2- Mid	2. Tools	Maintain Software *Considers increase based on inflation. This inflation impact is to be determined in the mid-term timeframe.*	Construction, IT				$105,000
15.06	2- Mid	3. Policy	Pilot project with 3D project: multiple staff across multiple divisions *Assumes 4-5 PY include this in the pilot resource sub-team resources*		0.00	5.00		
15.07	2- Mid	3. Policy	Have requirements for how final pay items are handled in the estimation model (5D). *Policy to be wrapped up in mid-term*	Construction/ OE	0.50			
15.08	2- Mid	3. Policy	Specification update a. Spec: Bid Item: Ensure Contractor software is IFC (Industry Foundation Class) compliant *Policy to be wrapped up in mid-term*		0.50			

Action ID	Timeframe (S, M, L)	Component Org, Tools, Policy, Data	Action/Deliverable	Resp. Party	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
15.09	3- Long	1. Org	Software Training (4D/5D only – reoccurring annually) • Construction group • DES • OE • Structure Design • Structure Construction Further investigation: • Who will be trained? All staff? REs? *1-2 years – will taper off over time* *PY (Needs further investigation – assuming 3-4 in HQ, 1-1.5 per district).* *Use Civil 3D as model for resources.* *Also: service contract*	Vendors Construction/ Structures Construction				$200,000
15.10	3- Long	2. Tools	For all procured software, there should be allocated funds for renewal and maintenance of the software. *Considers increase based on inflation. This inflation impact is to be determined in the long-term timeframe.*					$110,000

APPENDIX B: RESOURCE NEEDS BREAKDOWN

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	1. 3D Models Roadway	1.01	1- Short	1. Org	Initiate and process hybrid pilot projects, make PD-06 deliverables as part of legal contract documents along with 2D plan set. *Assumes can be achieved within current resources*	Districts														0.00			
1 - Models	1. 3D Models Roadway	1.02	1- Short	1. Org	Have 20 personnel become BIM4I Certified by taking Train the Trainer certification course (18 staff @ $416.67/person = $7,500 using Division(s) OE $)	Design	0.00		0.00	0.00										0.00		$12,000	
1 - Models	1. 3D Models Roadway	1.03	1- Short	2. Tools	Automate and expand features and capabilities of roadway design software *Assumes can be achieved within current resources*	Design	0.00													0.00		$500,000	
1 - Models	1. 3D Models Roadway	1.04	1- Short	2. Tools	Create a 3D cell library for design elements, including drainage inlets, signs, barriers, etc.		0.00													0.00		$800,000	
1 - Models	1. 3D Models Roadway	1.05	1- Short	3. Policy	Conduct analysis to review the current traditional survey deliverable to designers to support streamlining of the current workflow	Surveys		1.00												1.00			
1 - Models	1. 3D Models Roadway	1.07	1- Short	3. Policy	Tie design elements to Std plans, Specs, construction details and Bid items which can be used for asset management as well	Design	2.00													2.00			
1 - Models	1. 3D Models Roadway	1.06	1- Short	3. Policy	Standardize Level of Development (including Metadata/Attributes requirements)	Design														0.00			
1 - Models	1. 3D Models Roadway	1.08	1- Short	3. Policy	Manage shared data	Design														0.00			
1 - Models	1. 3D Models Roadway	1.09	1- Short	3. Policy	Share the 3D PIM with the contractor and establish CCO & RFI communication Protocol	Design/Construction														0.00			
1 - Models	1. 3D Models Roadway	1.10	1- Short	4. Data	Develop constructability platform to circulate and review the 3D model and provide feedback to the designers and other functional groups	Design/CADD														0.00			
1 - Models	1. 3D Models Roadway	1.11	1- Short	4. Data	Update current bid items *Assumes can be achieved within current resources*	Design/OE														0.00			
1 - Models	1. 3D Models Roadway	1.12	2- Mid	1. Org	Develop Training Manual (by consultant)	Design														0.00		$75,000	
1 - Models	1. 3D Models Roadway	1.13	2- Mid	1. Org	Develop Modeling Standards Manual	Design														0.00		$150,000	
1 - Models	1. 3D Models Roadway	1.15	2- Mid	1. Org	Train staff using Service Contract ~10,000 staff (25 per class, $1,950/class)	Design														0.00		$770,000	
1 - Models	1. 3D Models Roadway	1.14	2- Mid	1. Org	Develop training for Consultants, outside partners, city & local government	Design														0.00			
1 - Models	1. 3D Models Roadway	1.16	2- Mid	1. Org	Deliver training for Contractors with BEP, PIM, & AIM	Design/Construction														0.00		$5,000	
1 - Models	1. 3D Models Roadway	1.17	2- Mid	3. Policy	Develop new QC/QA manual	Design/OE														0.00		$100,000	

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	2. 3D Models Structures	2.01	1- Short	1. Org	Resource staff hours on software training and BIM Execution Plan / Information Management training	Bridge Design												3.00		0.00			
1 - Models	2. 3D Models Structures	2.02	1- Short	1. Org	Develop Training Manual: Will include software vendor training document and Caltrans-specific workflows. Develop Caltrans BIM bridge/structure model examples for training and testing	Bridge Design				0.50										0.50		$80,000	
1 - Models	2. 3D Models Structures	2.03	1- Short	1. Org	Support national engagement: support participation in different working task groups of national funded projects [e.g. TPF-5(372)] Provide presentation materials, write articles to demonstrate BIM efforts and pilot project outcomes, and conduct research on new tools/software in implementing BIM for infrastructure	Bridge Design													2.00	0.00		$50,000	
1 - Models	2. 3D Models Structures	2.04	1- Short	2. Tools	Purchase software for pilot projects	HQ CADD DES Software Managers IT Certification DPAC HQ IP Legal EAC/IT														0.00		$200,000	
1 - Models	2. 3D Models Structures	2.05	1- Short	3. Policy	BIM Execution Plan review, revision and maintenance, create template model production delivery tables for various bridge types with standardized LOD	Bridge Design *Collaborate with Asset Management*														0.00		$350,000	
1 - Models	2. 3D Models Structures	2.06	1- Short	4. Data	Develop Information Standard for Bridge Modelling / Quality checking based on the IFC standard from TPF-5(372). Updates to Bridge Design Manuals / Detailing Manuals, etc…	Bridge Design				0.50										0.50			
1 - Models	2. 3D Models Structures	2.07	2- Mid	1. Org	Training for Structure Construction and Structure Maintenance & Investigations, including BEP, PIM, using the model for inspections, digital as-builts	Bridge Design												3.00		0.00		$100,000	
1 - Models	2. 3D Models Structures	2.08	2- Mid	1. Org	Training for and outreach / collaboration with Consultants, Regulatory Agencies, City & Local government, if required (Model Viewers, CDE, and basic model breakdown / structure & navigation)	Bridge Design / ACEC OSFP												0.50		0.00		$10,000	

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	2. 3D Models Structures	2.09	2- Mid	1. Org	Train Bridge Contractors on BEP, PIM, Digital As-builts	Bridge Design/ AGC, Structure Construction														0.00		$600,000	
1 - Models	2. 3D Models Structures	2.10	2- Mid	1. Org	Update Duty Statements to reflect BIM -- Workflows and Expectations (Duty Statements) of Project Engineer / BIM Manager and Project Development Team Members	Bridge Design DHR														0.00	0.50		
1 - Models	2. 3D Models Structures	2.11	2- Mid	2. Tools	Bridge/Structure Software Customization and Testing: Automate and expand features for structural analysis and 2D drawing production	Bridge Design														0.00		$500,000	
1 - Models	2. 3D Models Structures	2.12	2- Mid	3. Policy	Develop new BIM section in Bridge Design Process and Procedure Manual (2-4 years) Model QA/QC checking requirements and Bridge Analysis Independent Check process needs to be defined in a BIM workflow Connect Bridge Model to AASHTOWare Preconstruction software	Bridge Design Structure OE														0.00		$150,000	
1 - Models	2. 3D Models Structures	2.13	2- Mid	3. Policy	Contractor / Fabricator Industry Engagement through Forums with Caltrans to set-up Guidance for model exchange and streamlined workflows between design & construction Setting up procedures for CCO & RFI processes (including Caltrans legal) (5-7 years) Guidance / Recommendations for Bridge Design's role/responsibility & process for developing the bridge digital as-built	Bridge Design/Structure Construction														0.00		$800,000	
1 - Models	2. 3D Models Structures	2.14	2- Mid	4. Data	Model LOD Guide for Caltrans BIM Bridge/Structure Objects (3-5 years)	Bridge Design														0.00		$350,000	

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	2. 3D Models Structures	2.15	2- Mid	4. Data	Create a BIM object library for bridge/structure design elements, including deck, superstructure, substructure, retaining walls, etc. (using pilot projects to populate the BIM bridge/structure object library) All bridge/structure library objects will be tied to Std plans, Specs, construction details and Bid items which can be used for asset management as well (3-5 years)	Bridge Design				4.00										4.00		$500,000	
1 - Models	2. 3D Models Structures	2.16	3- Long	1. Org	Continued Training for Bridge Design Staff												1.00			0.00			
1 - Models	2. 3D Models Structures	2.17	3- Long	2. Tools	Continued Bridge/Structure Software Customization and Testing: Automate and expand features for structural analysis	Bridge Design														0.00		$125,000	
1 - Models	2. 3D Models Structures	2.18	3- Long	3. Policy	Continued Contractor / Fabricator Industry Engagement through Forums with Caltrans to set-up Guidance for model exchange and streamlined workflows between design & construction Setting up procedures for CCO & RFI processes (including Caltrans legal) (5-7 years) Guidance / Recommendations for Bridge Design's role/responsibility & process for developing the bridge digital as-built	Bridge Design/ PCI & Fabrication Industry, Structure Construction														0.00		$200,000	
1 - Models	2. 3D Models Structures	2.19	3- Long	4. Data	Expand / Update the Caltrans BIM object library for bridge/structure design elements, including deck, superstructure, substructure, retaining walls, etc. All bridge/structure library objects will be tied to Std plans, Specs, construction details and Bid items which can be used for asset management as well	Bridge Design				1.00										1.00		$100,000	
1 - Models	3. 3D SUE	3.01	1- Short	1. Org	Develop expertise and support for UEW's (1 PY per district or spread accordingly between regions and districts)	Design														0.00	12.00		
1 - Models	3. 3D SUE	3.02	1- Short	1. Org	Create another GPR unit to serve southern districts	DES-Geo Tech office														0.00	4.00		

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	3. 3D SUE	3.03	1- Short	2. Tools	Create state-wide fund to support districts to positively identify existing utilities	R/W														0.00			$1,000,000
1 - Models	3. 3D SUE	3.04	1- Short	2. Tools	Develop 3D planimetric cells for utilities	Design	0.00													0.00		$200,000	
1 - Models	4. Bidding and Award	4.01	1- Short	1. Org	Work with Districts to determine candidate 3D Hybrid Design Projects to Pilot through Bidding and Award *Assumes can be achieved within current resources*	Districts, Construction, DES PPM&OE														0.00			
1 - Models	4. Bidding and Award	4.02	1- Short	2. Tools	Consider interfacing 3D model design files with AASHTOWare Preconstruction System bid item list *(Resources covered under 3D model recommendations)*	Design														0.00			
1 - Models	4. Bidding and Award	4.03	1- Short	3. Policy	Prior to Advertisement, work with Division of Construction to ensure companies are prepared to bid on pilot project *Assumes can be achieved within current resources*	PPM& OE, Construction														0.00			
1 - Models	4. Bidding and Award	4.04	1- Short	3. Policy	Determine how to present Additive Bidding item & Plans in the Design Files *Assumes can be achieved within current resources*	esign/Construction														0.00			
1 - Models	4. Bidding and Award	4.05	1- Short	3. Policy	Solve process of redlining and comments during quality review *Assumes can be achieved within current resources*	Design														0.00			
1 - Models	4. Bidding and Award	4.06	1- Short	3. Policy	Solve addenda process and version control *Assumes can be achieved within current resources*	Design														0.00			
1 - Models	4. Bidding and Award	4.07	1- Short	3. Policy	Districts consider including a Key Map (per PPM) in Project Plans using Design File name instead of Plan Sheet Name - this will help DES OE check Submittal & Contractors & RE check Design Files content and convention. May be useful for identification of changes for Addenda processing as well. *Assumes can be achieved within current resources*	Design														0.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	4. Bidding and Award	4.08	1- Short	3. Policy	Implement process of packaging pilot projects for Advertisement *Assumes can be achieved within current resources*	DES PPM&OE														0.00			
1 - Models	4. Bidding and	4.09	2- Mid	1. Org	Update the Training on Process for new delivery	DES OE				0.50										0.50			
1 - Models	4. Bidding and Award	4.10	2- Mid	1. Org	Training on this new process (basics to process specific) 1) Transportation Engineers (Civil, Electrical), Landscape Architects, 2) Assume DES PPM&OE will need discipline-specific training for reviewing and checking 3D models but likely at a similar number of resources as that for roadway designers 3) DES PPM&OE performing project reviews 4) 2-3 classes Software specific *Assumes 24 hrs/person; 23 people*	DES PPM& OE												0.30		0.00			
					Assumes can be achieved within current resources																		
					Assumes can be achieved within current resources																		
1 - Models	4. Bidding and Award	4.12	2- Mid	3. Policy	Update Best Bid Standard: Guideline and checklist to be developed for completeness of the model from the district and should be used in PPMOE to revalidate the completeness Quality review *Assumes can be achieved within current resources*	DES PPM& OE														0.00			
					Assumes can be achieved within current resources																		
1 - Models	4. Bidding and Award	4.14	2- Mid	3. Policy	Update SAM Manual Language *Assumes can be achieved within current resources*	ES PPM& OE, DPAC														0.00			
					with “legal”) - PD-06 – (electronic files), Spec *Assumes can be achieved within current resources*																		

BIM4I INITIATIVE FINAL IMPLEMENTATION

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	4. Bidding and Award	4.16	2- Mid	3. Policy	Solve addenda process and version control *Assumes can be achieved within current resources*	Design														0.00			
1 - Models	4. Bidding and Award	4.17	2- Mid	3. Policy	Implement process of packaging projects for Advertisement *Assumes can be achieved within current resources*	DES PPM& OE														0.00			
1 - Models	4. Bidding and Award	4.18	3- Long	2. Tools	Integrate ebid into the tool or other bidding alternative software - Perhaps a data group investigate *Assumes can be achieved within current resources*	DES PPM& OE														0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	5. Pilot Resources	5.01	1- Short	1. Org	Create Pilot Support Task Force using existing Sub Team members comprised of various disciplines	PM													5	0.00			
2 - Project Delivery	5. Pilot Resources	5.02	1- Short	1. Org	Provide additional funding for pilot projects (functional units involved, including Design, Construction, and IT) *Assumes 1-2 PY per Pilot Project plus 2 total from HQ functions, including IT* *Assumes a 5-10% Contingency per Pilot*	Districts/PM	0.25	0.25	0.5	0.5				0.5						2.00	2.00		
2 - Project Delivery	5. Pilot Resources	5.03	1- Short	1. Org	Team to provide training on BEP and pilot project education training *Assumes can be achieved under resources identified for the Pilot Support Task Force but will require ~$30,000 for travel*	PM/PSTF	0	0	0	0										0.00		$30,000	
2 - Project Delivery	5. Pilot Resources	5.04	1- Short	3. Policy	Develop language to modify manuals *Assumes can be achieved under resources identified for the Pilot Support Task Force*	PSTF														0.00			
2 - Project Delivery	5. Pilot Resources	5.05	1- Short	3. Policy	Create guidance documents (define LOD for various levels) *Assumes can be achieved under resources identified for the Pilot Support Task Force*	PSTF														0.00			
2 - Project Delivery	5. Pilot Resources	5.06	2- Mid	1. Org	Establish a District Liaison for each district or region	Districts														0.00	10.00		
2 - Project Delivery	5. Pilot Resources	5.07	2- Mid	1. Org	Transition task force to permanent HQ office or branch *Assumes no additional resources outside of those requested for the PSTF*	PM														0.00			
2 - Project Delivery	6. Collab Platform	6.01	1- Short	1. Org	CP.S.OW.01: Acquire CDE application training from a vendor for users on early BIM4I pilots, including Design, Construction, Surveys, others. *Assume CDE application developer has trainings ready to provide, and will provide to BIM4I early pilot teams.* *No resources needed to develop CDE trainings for BIM4I early pilot teams = 0 PY*	Collab: Design, DES, Const.,Surv	0													0.00		$300,000	
2 - Project Delivery	6. Collab Platform	6.02	1- Short	1. Org	CP.S.DS.01: Provide CDE training to early BIM4I pilot team members, including Design, Construction, Surveys, others. *Assume CDE application developer will provide CDE training to CT staff. Assume 2 trainings @ 2 Hrs per pilot, 25 ppl per pilot, 25 pilots. 2 trainings X 2 Hrs X 25 ppl x 25 pilots = 1.25 PY (rounded down)*	Collab: Design, DES, Const.													1.25	0.00			
2 - Project Delivery	6. Collab Platform	6.03	1- Short	2. Tools	CP.S.TT.02: Meet with CDE application vendors to learn about application capabilities and use cases. *Assume quarterly meetings with CDE application vendors and HQ, IT, Design, Surveys, DES, Construction for 2 hours* *8 mtgs X 10 ppl X 2 Hrs = 0.1 PY*	Collab: IT, Design, Const.			0.025	0.025				0.05						0.10			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	6. Collab Platform	6.04	1- Short	2. Tools	CP.S.TT.01: Develop CDE requirements, specifications. *Assume an initial effort has been completed by team members (no further expenses). Assume this will be an ongoing effort to refine CDE requirements as pilots and new technology advance. Assume bi-annual team discussion (IT, Design, Construction, Surveys, HQ) for 4 hours. 4 mtgs X 10 ppl X 4 Hrs = 0.1 PY*	Collab: IT, Design, Const.			0.025	0.025				0.05							0.10			
2 - Project Delivery	6. Collab Platform	6.05	1- Short	2. Tools	CP.S.TT.03: Collaborate with IT to get approval to implement cloud based CDE applications. *Assume bi-annual meetings with IT, HQ, Design, Construction, DES for 1 Hr. 4 mtgs X 10 ppl X 1 Hr = 0.05 PY*	Collab: IT, Design, DES, Const.								0.05							0.05			
2 - Project Delivery	6. Collab Platform	6.06	1- Short	2. Tools	CP.S.TT.05: Continue learning from pooled fund members about their CDE use experiences. (ongoing). *Assume quarterly meetings. Assume this will be ongoing and will span phases (resources will be estimated by phase).* *8 mtgs X 10 ppl X 2 Hrs = 0.1 PY*	Collab: Design, DES, Const., IT	0.015		0.015	0.02				0.05							0.10			
2 - Project Delivery	6. Collab Platform	6.07	1- Short	2. Tools	CP.S.TT.04: Select, acquire, use, and evaluate various CDE applications on early BIM4I pilot projects in Design & Construction phases. *Assume 25 CDE licenses needed per pilot, 25 pilots, $1000 per license. 25 X 25 X $1,000 = $625,000 OE* *Note: CDE application vendors may provide free licenses for early pilot evaluation. Much uncertainty on this probability at this point. For now, will assume worst case, can adjust going forward.*	Collab: Design, DES, Const.															0.00		$625,000	
2 - Project Delivery	6. Collab Platform	6.08	1- Short	2. Tools	CP.S.TT.06: Implement CDE applications with contractors on CMGC early BIM4I pilots. *Assume monthly coordination between CMGC & Design, IT, HQ for 2 Hrs. Assume 5 of 25 pilots use CMGC* *5 pilots X 10 ppl X 2 Hrs X 18 mo = 1 PY*	Collab: Design, DES, Const., IT			0.25	0.25				0.5							1.00			
2 - Project Delivery	6. Collab Platform	6.09	1- Short	3. Policy	CP.S.PP.01: Identify CDE implementation in BIM execution plans for early BIM4I pilots. *Assumptions: Pilot Teams and coordinators identify if CDE use is applicable on BIM4I pilot. 10 ppl X 2 Hrs (per pilot) = 0.01 PY/Pilot. Assume 25 pilots need determination by 12/31/23 = 25X.01 PY = 0.25 PY*	Design	0.1			0.15											0.25			
2 - Project Delivery	6. Collab Platform	6.10	1- Short	3. Policy	CP.S.PP.03: Develop lessons learned from CDE implementation on early BIM4I pilots. *Assume lessons learned is discussed quarterly for 0.5 Hr* *8 qtrs X 10 ppl X 25 pilots X 0.5 Hr = 0.5 PY*	Collab: Pilot Project division reps	0.2		0.15	0.15											0.50			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party		ROW & Land Surveys							Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	6. Collab Platform	6.11	1- Short	3. Policy	CP.S.PP.02: Develop & implement Caltrans focused CDE workflows based on ISO 19650 standards. *Assume this activity is led by HQ BIM4I and adjusted by district pilot teams. Assume this is an ongoing process with recurring updates: a regular topic on BIM4I discussion agendas.* *Assume monthly discussions on this topic.* *Assume 10 ppl X 1 Hr (per pilot) X 25 pilots X 24 mo = round down to 3 PY -> seems excessive - > use 1 PY*	Collab: Design, DES, Const, IT	0.15	0.2	0.2	0.2			0.25							1.00			
2 - Project Delivery	6. Collab Platform	6.12	2- Mid	1. Org	CP.M.OW.01: Refine/update CDE training based on lessons learned from the early pilots. *Assume bi-annual training update meetings with 12 districts, trainings split by division (Design, Construction, Surveys, PPM, other) plus HQ training, 4 hour meetings* *2 mtgs/yr X 3 yrs X 12 dist X 5 div X 4 Hr = 0.75 PY (rounded)*	Collab: Design, DES, Const.	0.2		0.25	0.2			0.1							0.75			
2 - Project Delivery	6. Collab Platform	6.13	2- Mid	1. Org	CP.M.OW.02: Provide CDE training to BIM4I extended pilot team members. *Assume 100 pilots X 25 ppl/pilot X 2 Hrs X annual. 100 pilots X 25 ppl/pilot X 2 Hrs X 3 Yrs = 8 PY. Seems excessive – use 5 PY*	Collab: Design, DES, Const.	1	1	1	1			1							5.00			
2 - Project Delivery	6. Collab Platform	6.14	2- Mid	1. Org	CP.M.OW.03: Continue learning from pooled fund members about their CDE use experiences. *Assume 10 ppl meeting quarterly for 2 hours over phase span (3 yrs).* *10 pplX 4 mtgs/yr X 3 yrs X 2 Hrs = 0.1 PY*	Collab: Design, DES, Const.	0.03		0.03	0.04										0.10			
2 - Project Delivery	6. Collab Platform	6.15	2- Mid	1. Org	CP.M.OW.04: Develop lessons learned from CDE implementation on extended BIM4I pilots. *Assume bi-annual meetings, 10 ppl pe r pilot, 3 yrs, 2 hour mtgs. 2 mtgs/yr X 3 Yrs X 100 pilots X 10 ppl/pilot X 2 hrs = 6 PY*	Collab: Design, DES, Const.	1.5	1.5	1.5	1.5										6.00			
2 - Project Delivery	6. Collab Platform	6.16	2- Mid	2. Tools	CP.M.TT.01: Acquire additional CDE licenses for additional extended BIM4I pilots in more districts across the state. *Assume 100 new BIM4I pilots in medium phase (01/01/24 - 12/31/26). Assume 25 CDE licenses needed per extended BIM4I pilot. Assume no longer free for evaluation.* *100 ext. Pilots X 25 lic X $1,000/lic = $2,500,000*	Collab: Design, DES, Const.														0.00		$2,500,000	
2 - Project Delivery	6. Collab Platform	6.17	2- Mid	2. Tools	CP.M.TT.02: Implement CDE applications with contractors on CMGC extended BIM4I pilots and potentially other ways. *Assume monthly coordination between CMGC & Design, IT, HQ for 2 Hrs. Assume 20 of 100 pilots use CMGC.* *20 pilots X 10 ppl X 2 Hrs X 36 mo = 1 PY = 8 PY. Seems excessive – use 5 PY*	Collab: Design, DES, Const.	1.25	1	1.25	1.25			0.25							5.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	6. Collab Platform	6.18	2- Mid	3. Policy	CP.M.PP.01: Update pilot guidelines and workflows for CDE implementation based on the lessons learned from the early pilots. *Assume quarterly 4 Hr meetings to focus on updating guidelines and workflows across IT, HQ, Design, Construction, Surveys. 12 mtgs X 4 Hrs X 10 ppl = 0.25 PY*	Collab: Design, DES, Const.	0.05		0.1	0.1										0.25			
2 - Project Delivery	6. Collab Platform	6.19	2- Mid	3. Policy	CP.M.PP.02: Implement updated Caltrans focused CDE workflows based on ISO 19650 standards. *Assume no resources needed – folded into project hours* *0 PY*	Collab: Design, DES, Const.														0.00			
2 - Project Delivery	6. Collab Platform	6.20	2- Mid	4. Data	CP.M.DS.01: Establish enterprise framework for CDE(s). *Note: This is activity D4 in the FHWA roadmap. This is a significant challenge. It encompasses organizing, preparing, training, everything needed to roll-out CDE across the Department. This is such a bit task/activity that it is difficult to estimate with any certainty.* *Assume divisions meet quarterly for 4 hours for last 2 years of phase. Includes IT, HQ, DES, Design, Construction, others* *4 mtgs/ye X 2 yrs X 4 Hrs/mtg X 20 ppl = 0.5 PY -> round up to 1 PY*	Collab: IT Design, DES, Const.	0.15	0.2	0.2	0.2				0.25						1.00			
2 - Project Delivery	6. Collab Platform	6.21	3- Long	1. Org	CP.L.OW.01: Develop enterprise CDE training based on lessons learned from pilots. *Assume collaboration between consultants and in-house teams.* *Assume in-house team = 2 ppl, 1 yr, full time = 2 PY* *Assume consultant = $500k*	Collab: ALL	0.5	0.5	0.5	0.5										2.00		$500,000	
2 - Project Delivery	6. Collab Platform	6.22	3- Long	1. Org	CP.L.OW.02: Provide CDE training across Department. *Assume 1 trainer per district, plus HQ trainer + 10,000 staff. Assume 3 modules (beginner, intermediate, advanced) @ 2 hrs each – once & done. 10,000 staff X 3 modules X 2 hrs/module = 34 PY*	Collab: ALL											34			0.00			
2 - Project Delivery	6. Collab Platform	6.23	3- Long	2. Tools	CP.L.TT.01: Acquire CDE licenses for enterprise. *Assume 10,000 licenses needed across Department at $1,000 / license. 10,000 licenses X $1,000/lic = $10M* *Note, rather than being a distributed activity, this may be more likely a single large purchase at a point in time.*	IT, Divisions														0.00		$10,000,000	
2 - Project Delivery	6. Collab Platform	6.24	3- Long	2. Tools	CP.L.TT.02: Implement enterprise wide CDE to support BIM4I. *Assume this is already covered by ongoing training and normal delivery needs.*	IT, Divisions														0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	6. Collab Platform	6.25	3- Long	3. Policy	CP.L.PP.01: Establish guidance and workflows for enterprise CDE implementation based on lessons learned from pilots. *Work in conjunction with Recommendation #8 Overall Process*	Collab: ALL														0.00			
2 - Project Delivery	6. Collab Platform	6.26	3- Long	3. Policy	CP.L.PP.02: Establish & publish enterprise workflows for CDE based on ISO 19650 standards. *Work in conjunction with Recommendation #8 Overall Process*	Collab: ALL														0.00			
2 - Project Delivery	7. 3D Models Vis.	7.01	1- Short	1. Org	Establish Visualization Steering/Advisory Committee and determine best location Planning, Environmental Analysis, Landscape Arch., Bridge Arch / Aesthetics, Construction, and Public Information Office *Assumes .40 PY per member (8)*	SME Group from HQ/DES + Districts with expertise													3	0.00			
2 - Project Delivery	7. 3D Models Vis.	7.02	1- Short	1. Org	Develop training and general guidelines/matrix *Assumes can be achieved with Visualization Task Force*	Visualization SME Group														0.00			
2 - Project Delivery	7. 3D Models Vis.	7.03	1- Short	2. Tools	Procure tools not currently under existing contracts (e.g. Autodesk-Infraworks)	DOD CADD Services														0.00		$100,000	
2 - Project Delivery	7. 3D Models Vis.	7.04	2- Mid	1. Org	Establish positions dedicated to visualization 1-3 PY per District or Region	Districts														0.00	10.0		
2 - Project Delivery	7. 3D Models Vis.	7.05	1- Short	1. Org	Establish positions dedicated to visualization 1-2 PY HQ/DES	HQ/DES	2			0										2.00			
2 - Project Delivery	7. 3D Models Vis.	7.06	2- Mid	1. Org	Expand upon existing training to create robust training program	Planning & Project Delivery														0.00		$300,000	
2 - Project Delivery	7. 3D Models Vis.	7.07	2- Mid	2. Tools	Fund A&E / Service Contract statewide	Planning & Project Delivery														0.00		$3,000,000	
2 - Project Delivery	7. 3D Models Vis.	7.08	2- Mid	3. Policy	Document an Information-delivery specifications for data exchanges between modelling and visualization systems in different project phases (K-Phase, 0 phase, 1-phase, etc..) Document examples and regulatory-agency specific best-practices for types of model visualizations that effectively satisfy regulatory agency needs / questions and support meetings / discussions	Planning, Landscape Arch,, Bridge Arch. Environmental Analysis, Planning, Public Information Office	0.25			0.25										0.50			
2 - Project Delivery	7. 3D Models Vis.	7.09	2- Mid	4. Data	Create a visualization library -- materials, objects, textures, infrastructure features (using pilot projects to populate the library)	Planning, Landscape Arch,, Bridge Arch. Environmental Analysis, Planning, Public Information Office	1.25			0.5				0.25						2.00		$100,000	
2 - Project Delivery	7. 3D Models Vis.	7.10	3- Long	2. Tools	Continue to Evaluate visualization tools															0.00		$25,000	

BIM4I INITIATIVE FINAL IMPLEMENTATION

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	7. 3D Models Vis.	7.11	3- Long	3. Policy	Establish guidelines for model preparation for visualization and the exchange requirements for infrastructure in Caltrans manuals Develop department policy for use of models in public outreach meetings and stakeholder engagement discussions / workshops	Planning, Landscape Arch,, Bridge Arch. Environmental Analysis, Public Information Office														0.00			
2 - Project Delivery	7. 3D Models Vis.	7.12	3- Long	4. Data	Expand a visualization library -- materials, objects, textures, infrastructure features (using pilot projects to populate the library)	Planning, Landscape Arch, Bridge Arch. Environmental Analysis, Public Information Office	0.25			0.25										0.50		$100,000	
2 - Project Delivery	8. Master Process	8.01	1- Short	2. Tools	Verify impact on PRSM, FALCON EDMS, Vision/essop (FY 23/24)															0.00			
2 - Project Delivery	8. Master Process	8.02	2- Mid	1. Org	Capture lessons learned to modify workflow from BIM4I pilot projects	BIM4I SMEs	0.1													0.10			
2 - Project Delivery	8. Master Process	8.03	2- Mid	3. Policy	Develop refined BIM4I workflow with a resourced cross-divisional team *Assumes .15 PY per division (10)*	BIM4I Program HQ, Design, PPM, DES, Construction	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2						1.50			
2 - Project Delivery	8. Master Process	8.04	2- Mid	3. Policy	Identify manuals that are impacted with BIM4I such as WSG, PDPM, PDWG, CADD Manual, PPM, Construction Manual, etc.	HQ, Design, PPM, DES, Construction		0.1	0.1	0.1	0.1	0.1								0.50			
2 - Project Delivery	8. Master Process	8.05	2- Mid	4. Data	Update PRSM and other software identified during short-term study *PYs are apart of an ongoing contract*	HQ – Project Management														0.00			
2 - Project Delivery	8. Master Process	8.07	3- Long	1. Org	Staff training for updated Workflow guidelines *Assumes this will be covered by existing training resources*															0.00			
2 - Project Delivery	8. Master Process	8.08	3- Long	1. Org	Develop training for updated policies and procedures	BIM4I Program HQ, Design, PPM, DES, Construction												0.5		0.00			
2 - Project Delivery	8. Master Process	8.09	3- Long	3. Policy	Continue and complete development of new BIM4I workflow with Cross Division Team	BIM4I Program HQ, Design, PPM, DES, Construction	0.15	0.15	0.15	0.15	0.15	0.15	0.1							1.00			
2 - Project Delivery	8. Master Process	8.10	3- Long	4. Data	Update PRSM and other software identified during mid-term study *PYs are apart of an ongoing contract*	HQ – Project Management														0.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	09. Verify & Measure	09.01	1- Short	1. Org	Develop training for digital construction inspection and development of District support trainers. Development of in- person and online training for staff. Developing tools, training, databases, acquiring servers. *Assumes 1 PY each from OLS and DOC with some support from DES SC and 0.5 PY per district and DES for train-the-trainers.*	HQ OLS, HQ DOC, DES SC		0.9	0.9	0.2										2.00	6.50	$1,000,000	
3 - Field	09. Verify & Measure	09.02	1- Short	1. Org	Training for Field Staff – 40-80 hours of training on relevant field equipment per staff member is anticipated. This will be a combination of web-based training and hands on field trainings *Assumes .04 PY per field staff @ 450 staff per year*	HQ OLS, HQ DOC, DES SC												2		0.00	18.00		
3 - Field	09. Verify & Measure	09.03	1- Short	2. Tools	Procure additional equipment for the use of field verification in 3D related project data. Estimating purchase of two Mobile Terrestrial Lidar Scanners (MTLS) every year until each District has it's own tool. Replacement on a 6 year cycle. These purchases will include the vehicle to hold the scanner, the scanner technology, and the processing/publishing software for the scanner. *Assumes 0.25 PY for Construction to manage their own portfolio*	HQ OLS / HQ DOC / DES SC			0.25											0.25			$2,000,000
3 - Field	09. Verify & Measure	09.04	1- Short	2. Tools	Procure additional equipment for the use of field verification in 3D related project data. Estimating purchase of 50 Terrestrial Lidar Scanners (STLS) for the purpose of building the initial need. In subsequent years this need will grow due to increased use of tools. *Assumes 0.25 PY for Construction to manage their own portfolio*	HQ OLS / HQ DOC / DES SC			0.25											0.25			$2,000,000
3 - Field	09. Verify & Measure	09.05	1- Short	2. Tools	Develop secure storage locations for Mobile Terrestrial Lidar Scanner (MTLS) vehicles. We will need to build two of these each year for the next 5 years.	HQ OLS / HQ DOC / DES SC		0.2	0.2	0.1										0.50			$200,000
3 - Field	09. Verify & Measure	09.06	1- Short	2. Tools	Procure 50 highspeed computers that will need to be replaced on a 3 year cycle. Cloud storage for MTLS data accounted for in Digital As-builts. *PY is for IT labor.*	HQ OLS / HQ DOC / DES SC / Design	0							0.5						0.50			$500,000
3 - Field	09. Verify & Measure	09.07	2- Mid	1. Org	Continue Training for Field Staff – 40-80 hours of training on relevant field equipment per staff member is anticipated. This will be a combination of web-based training and hands on field trainings *Assumes .04 PY per field staff @ 450 staff per year*	HQ OLS, HQ DOC, DES SC												2		0.00	18.00		

Category	Sub Team	Action ID	Timeframe (S, M, L)	Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	09. Verify & Measure	09.08	3- Long	2. Tools	Expansion of existing LiDAR technologies. Implementation of emerging remote sensing technologies.	HQ OLS / HQ DOC / DES SC			0.5											0.50			$1,000,000
3 - Field	10. AMG	10.01	1- Short	1. Org	Resource District AMG Coordinators/Support in each District. *One PY per district with some needing 2 based on capacity = 12-16 total.*	Districts, Construction, OLS														0.00	16.00		
3 - Field	10. AMG	10.02	1- Short	1. Org	Develop Design specific training for better understanding of complete AMG file delivery at the time of RTL.	Design w/ support from DOC and OLS	0.15	0.15	0.2											0.50			
3 - Field	10. AMG	10.03	1- Short	1. Org	Update training platform that field staff can use to understand technology used for AMG inspection/verification and keep up with technology changes (FY 22-23 and yearly thereafter) *1 PY for FY 22-23, then 0.25 PY ongoing after*	HQ DOC, HQ OLS			1											1.00			
3 - Field	10. AMG	10.04	1- Short	1. Org		OLS w/ support from DOC, OLS/D6, Realtime Verification and Measurement Subgroup	5													5.00			$1,500,000
3 - Field	10. AMG	10.05	1- Short	2. Tools	Develop consistent funding source for yearly procurement of new and replacement GNSS equipment for Construction staff to utilize in the field for digital construction inspection and AMG verification work (Yearly) *$1.5M per year to account for multiple tiers of equipment purchasing 50 units/year*	DOC w/ help from OLS			0.25											0.25			$1,500,000
3 - Field	10. AMG	10.06	1- Short	2. Tools	Conduct regular Datum adjustments and realizations by California Spatial Reference Center (CSRC) for support of AMG use (FY 22-23). *DPAC contract cost TBD*	OLS work w/ OLS Geodetic Coordinator DPAC contract, cost TBD	1													1.00			
3 - Field	10. AMG	10.07	1- Short	3. Policy	Develop a Deputy Directive or Director's Policy that identifies the roles and responsibilities as it relates to licensed engineers and licensed surveys use of digital terrain files for data capture and verification (relates to all forms of use of 3D model for AMG, UAS, digital as-builts).	DOC and OLS	0.125	0.125												0.25			
3 - Field	10. AMG	10.08	2- Mid	1. Org	Conduct AMG for Structures pilot to develop functionality of construction and inspection/verification of structures.	HQ DOC, HQ DES, HQ OLS	0.33	0.34	0.33											1.00			
3 - Field																							

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	10. AMG	10.10	2- Mid	2. Tools	Develop consistent funding source for yearly procurement of new and replacement GNSS equipment for Structure Construction staff to utilize in the field for digital construction inspection and AMG verification work. *Estimating 100 units needed throughout the state purchased at 20 units per year and a 5 year replacement cycle (Yearly)* *$1M per year*	Structures Construction w/ help from OLS				0.25										0.25			$1,000,000
3 - Field	11. eTicketing	11.01	1- Short	2. Tools	Pilot of DOTSlip (HaulHub) (ABD) *Assumes $10k for unlimited access*	Construction w/ help: IT, METS, Structures Construction														0.00	0.50	$10,000	
3 - Field	11. eTicketing	11.02	1- Short	2. Tools	Select platform to utilize following the pilot projects. Includes engagement with industry. (	Construction w/ help: METS, Structures Construction			0.25											0.25			
3 - Field	11. eTicketing	11.03	1- Short	2. Tools	Pilot of Connex (Command Alcon) (ABD) (Complete FY 22-23) *($15,000/project for 10 projects)*	Construction w/ help: METS, IT, Structure Construction														0.00	0.50	$150,000	
3 - Field	11. eTicketing	11.04	1- Short	3. Policy	New Specification, Construction Procedure Directive (CPD) and Construction Manual (CM) Update	Construction w/ help: METS, Structure Construction			0.25											0.25			
3 - Field	11. eTicketing	11.05	1- Short	3. Policy	Develop implementation plan and training for e-Ticketing	Construction w/ help: METS, Structures Construction			0.25											0.25			
3 - Field	11. eTicketing	11.06	1- Short	4. Data	Develop API of data transfer from e-Ticketing solution to applicable data servers for business functions (DIME, ProDMS, etc.). Include metadata development w/ data transfer.	Construction w/ help: IT, METS, Structures Construction			0.3					0.2						0.50			
3 - Field	11. eTicketing	11.07	2- Mid	1. Org	Implement e-Ticketing solution statewide (training complete, specification, CPD, CM update)	Construction w/ help: IT, METS, Structures Construction			0.2					0.05						0.25			
3 - Field	11. eTicketing	11.08	2- Mid	1. Org	Provide training for e-Ticketing solution statewide (Data Management, System Use, internal and external users)	Construction												1		0.00			
3 - Field	11. eTicketing	11.09	2- Mid	2. Tools	Procurement of e-Ticketing solution after pilot project identifies the preferred selection *$10,000/yr to $3,750,000/yr*	Construction w/help: IT, Legal, DPAC			0.25											0.25		$3,750,000	
3 - Field	11. eTicketing	11.10	2- Mid	3. Policy	Determine process to link e-Ticketing information with 3D model (digital as-built/AIM/digital twin/4D-5D model)	Construction, METS, Design w/ help: IT, Structure Construction			0.6	0.2				0.2						1.00			
3 - Field	12. UAS	12.01	1- Short	1. Org	Statewide Training - Staff time for training and “train the trainers” time. This goes along task that determines who should be trained by each Division/District. *Assumes 60 hours of training per person @ 500 people statewide*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others												20		0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	12. UAS	12.02	1- Short	2. Tools	Fleet Management - Procurement of fleet management software.	Aeronautics w/ support: DOC, DES, DEA, Surveys, Maint., others									0.5					0.50			$100,000
3 - Field	12. UAS	12.03	1- Short	3. Policy	Each Division to develop best practices and use cases for UAS for business needs. *Assumes .5 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, IT, and others		0.5	0.5	0.5		0.5	0.5	0.25	0.25	0.5	0.5			4.00			
3 - Field	12. UAS	12.04	1- Short	3. Policy	Revise survey request process and form to consider all stakeholders and data collection modes.	Surveys		0.5												0.50			
3 - Field	12. UAS	12.05	1- Short	3. Policy	Develop Division/District specific plans for who will utilize UAS as a new tool (i.e. specific office providing this service or staff trained in each office/unit that provide service for those functions). *Assumes 0.25 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others		0.25	0.25	0.25		0.25	0.25		0.25	0.25	0.25			2.00			
3 - Field	12. UAS	12.06	1- Short	3. Policy	Fleet Management - Develop process for managing drones through fleet software.	Aeronautics w/ support: DOC, DES, DEA, Surveys, Maint., others									0.5					0.50			
3 - Field	12. UAS	12.07	2- Mid	2. Tools	Procure processing software for various purposes. Caltrans use of UAS varies widely by Division. Additional enterprise software is needed to further develop uses. Procurement of software platforms such as Pix4D mapper, Trimble UAS Master, Datubim by Datumate, and others are needed to enable the full benefits of UAS platforms. *Assumes 0.25 PY per Division per year plus ongoing software cost*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others		0.6	0.6	0.6		0.6	0.3	0.3		0.5	0.5			4.00			$100,000
3 - Field	12. UAS	12.08	2- Mid	2. Tools	Procurement of UAS Hardware – Processing Servers for LIDAR and Photogrammetry Data. Current practices involve local processing of data, which is both slow, and cannot be easily backed up for compliance with data retention policies. A Central, High Bandwidth, High-Capacity Virtual Server processing system for processing point cloud, and lidar data is more efficient and will reduce the need for high end desktop computers. Data outputs from this system would be moved to the storage system described in Implementation Activity #2. *Assumes 0.5 PY per Division*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others		0.6	0.6	0.6		0.6	0.3	0.3		0.5	0.5			4.00			$500,000

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	12. UAS	12.09	2- Mid	2. Tools	Procurement of Drones - Set up LPA system to streamline acquisitions and define funding stream. Set up BCP to fund UAS hardware (estimated $3-4 million per year, further analysis will refine final numbers). *Assumes 0.5 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	0.5	0.5	0.5	0.5		0.5	0.5			0.5	0.5			4.00			
3 - Field	12. UAS	12.10	2- Mid	2. Tools	Procurement of Drones – Leverage LPA and funding streams to purchase equipment. *Assumes ~$3-4M (2K up to 300K per system and total need TBD)*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others														0.00			$4,000,000
3 - Field	12. UAS	12.11	2- Mid	4. Data	Procure/develop and implement a central repository for UAS data information. Centralized Server repository system will warehouse all UAS data captured to provide access to other users who may want access to aerial data. Current practices involve storage of large UAS datasets on individual computers. This makes the data vulnerable to loss and is not consistent with retention policies.	IT w/ support from DOC, Surveys, Design, DEA, Maintenance, DES, PAO	0.25	0.25	0.25	0.25			1	1						3.00			$500,000
3 - Field	12. UAS	12.12	2- Mid	4. Data	Develop a cross divisional group to determine the process for storing, sharing, and utilizing UAS data captures across phases and divisions. Determine processes, retention times for beneficial information (recommendation 2) *Assumes 0.25 PY per Division per year*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	0.25	0.5	0.5	0.5		0.5	0.25	0.25	0.25	0.5	0.5			4.00			
3 - Field	12. UAS	12.13	3- Long	3. Policy	File for Grant funds available from Infrastructure Investment and Jobs Act (IIJA). *Assumes 0.25 PY per Division*	DRISI w/ support from other Divisions for specific information	0.25	0.5	0.5	0.5		0.25								2.00			
3 - Field	13. Digital As-Builts	13.01	1- Short	1. Org	Complete Digital As-Builts Pilots currently underway. (FY 22-23) Projects include: •03-3F5104 Timbuctoo •03-1H8604 Chico ITS •03-0F2804 SR99 CMGC •07- 323404 Box Culvert •11- 056374 Siempre Viva	HQ DOC w/ support: District Construction, HQ/District Office of Land Surveys, Structures Construction		0.2	0.6	0.2										1.00			
3 - Field	13. Digital As-Builts	13.02	1- Short	1. Org	Develop Training for District As-Built Coordinators	HQ DOC w/ support: Structures Construction, HQ OLS, Asset Management,		0.2	0.5	0.2			0.1							1.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	13. Digital As-Builts	13.03	1- Short	3. Policy	Start discovery process to develop asset extraction process, feature types, file formats, and manuals for features desired by Asset Management and Maintenance, and Structures Maintenance. *Assumes 0.5 PY per each of the 4 groups: Construction, Land Surveys, Structure Construction, and Structures PI. Assumes additional funding for AM and Mtce is not required.*	HQ DOC, HQ OLS, Structures Construction, HQ Asset Management, Maintenance, Structures PI		0.5	0.5	0.5			0.5								2.00			
3 - Field	13. Digital As-Builts	13.04	1- Short	3. Policy	Determine information that Structure Maintenance will use and add to digital as-built.	Structure Maintenance w/ support of DOC			0.2	0.3										0.50			
3 - Field	13. Digital As-Builts	13.05	1- Short	3. Policy	Develop workflow for data capture and storage for processing. •Establish data capture time periods •Functionality for data processing (hot vs. cold storage) •Retention period (hot vs. cold storage) •Estimate of storage per highway mile (40GB/lane-mile is current estimate) •Estimate of copies to be retained	HQ DOC, Structures Construction, HQ OLS	1	1	1	1										4.00			
3 - Field	13. Digital As-Builts	13.06	1- Short	4. Data	Establish working group to determine Digital As-Builts repository and long-term storage solution/s. Based off preliminary estimates we could expect more than 15 PB of storage for the state may be needed long term based on 386,000 lane miles @ 40 GB/mile. Storage would increase over time based on completed projects at a rate of ~350 projects per year. Much of this issue is based off the final workflow of 3D model capturing and workflow of retaining models and how many models are needed. There is need for a focused effort of cross functional groups to determine the workflows and ultimately determine future needs. *Assume 0.5 PYs per year per functional group* *Solution costs to be determined, likely significant (Millions per year), however according to a recent cloud storage quote from Autodesk, Project Delivery could be sustained for data storage needs at about $4.5M/year for approximately 6,000 users in the system. This would account for unlimited storage for any cold storage of project delivery data needs (i.e. digital as-built data, 3D model data, point cloud data, large imagery files, UAS data, etc.)*	DOC, IT, DES, OLS, Design, Asset Management, Legal	0.5	1	1	0.5			0.5	0.5						4.00			$4,500,000
3 - Field	13. Digital As-Builts	13.07	1- Short	4. Data	Determine data storage locations and capacity. •Single location for all data or multiple locations to cover roadway and structures as-builts. •Long-term vs. Short term storage. •Cloud or server storage. *Assumes 1-2 Pys*	IT w/ support: HQ DOC, Surveys, Structure Construction, Asset Management	0.25	0.25	0.25	0.25			0.5	0.5						2.00			
3 - Field	13. Digital As-Builts	13.08	1- Short	4. Data	Determine data accessibility, security, and data storage platform for digital as-builts.	IT, Legal, DOC	0.25		0.25					0.5						1.00			
3 - Field	13. Digital As-Builts	13.09	2- Mid	1. Org	Develop (Additional) Training for District As-Built Coordinators.	DOC w/ Support: Surveys, Structures Construction		0.1	0.3	0.1										0.50			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	13. Digital As-Builts	13.10	2- Mid	1. Org	Establish Digital As-Builts coordinator in every District (12), DES Structure Construction (1), and Office of Land Surveys (1). There is a possibility this need will grow to 20+ PYs depending on Districts' abilities to accomplish the work with one team member. This role may start in Construction but ultimately will support all Project Delivery. *Assumes 12-20+ PYs statewide*	DOC w/ Support: District Construction, Surveys, Structures Construction		0.5	1	0.5											2.00	12.00		
3 - Field	13. Digital As-Builts	13.11	2- Mid	2. Tools	Pilot and acquire Digital As-Builts visualization platform and process (evaluation of ArcGIS, Quadri, Autodesk Build etc.) *Assumes 1+ PY + assistance from Visualization group, $200,000 for software licensing*	HQ DOC w/ support: HQ IT, HQ DES, HQ OLS		0.1	0.8	0.1										1.00		$200,000	
3 - Field	13. Digital As-Builts	13.12	2- Mid	2. Tools	Procurement of solution following pilot projects. *~$400,000/yr for solution*	DOC w/ support: DPAC, IT, Structures			0.5											0.50			$400,000
3 - Field	13. Digital As-Builts	13.13	2- Mid	3. Policy	Development and integration of Asset Information Model feature code library. Develop a unified feature code library that will fit the needs of all stakeholders (Design, Asset Management, Surveys, Construction, Structures Construction). This ensures data standardization. *8 Staff @ .25 PYs Each*	HQ OLS, HQ DOC, HQ DES, HQ Asset Management		0.5	0.5	0.5			0.5							2.00			
3 - Field	13. Digital As-Builts	13.14	2- Mid	3. Policy	Develop digital as-builts policies, procedures, and manuals for implementation *1-2 PYs*	HQ DOC, HQ OLS with Support	0.5	0.5	0.5	0.5										2.00			
3 - Field	13. Digital As-Builts	13.15	2- Mid	3. Policy	Determine information Asset Management will extract from digital as-built to assist DOC in capturing correct information.	Asset Management w/ support of DOC			0.1				0.4							0.50			
3 - Field	13. Digital As-Builts	13.16	2- Mid	3. Policy	Determine information Traffic Operations will extract from digital as-built to assist DOC in capturing correct information.	Traffic Ops w/ support of DOC			0.1							0.4				0.50			
3 - Field	13. Digital As-Builts	13.17	2- Mid	3. Policy	Determine information Planning and Environmental will need captured and retained in the digital as-built to have available for the next project in vicinity.	Transportation Planning and Environmental w/ support of DOC			0.1			0.4								0.50			
3 - Field	13. Digital As-Builts	13.18	2- Mid	3. Policy	Develop implementation plan and CPD to implement digital as-built process on all projects completing after a certain date	DOC			0.5											0.50			
3 - Field	13. Digital As-Builts	13.19	2- Mid	3. Policy	Implement digital as-built process on all projects that will complete Construction Contract Acceptance (CCA) after a certain date	DOC w/ support: Surveys, Structures Construction	0.5	0.5	1	0.5			0.5							3.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	14. GIS	14.01	1- Short	1. Org	Establish cross-functional GIS Task Force, including Design, Construction, Surveys, Environmental, Right of Way, Maintenance, Asset Management, Planning, Traffic Ops, Engineering Services, Information Technology Some participation needed immediately and some after pilot project completion).Team should consist of a combination of HQ and District SME's who understand GIS and have a general understanding of the Project Delivery process. *Assumes 0.15 PY per division – per year (10) = 1.5 PY's per year for a Total of 7.5 PY's*	Aaron Ott for Chad Baker		0.15	0.15	0.15		0.15	0.3	0.15	0.15	0.15	0.15			1.50			
3 - Field	14. GIS	14.02	1- Short	2. Tools	Establish Common Storage Environment *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field	14. GIS	14.03	1- Short	3. Policy	Establish Standards -CAD to GIS feature and symbology crosswalk -Spatial Accuracy of essential layers -Data Standards oData Dictionary oMetadata oNaming -Web Applications and Visualizations oInteroperability (Crosswalk) with other visualization platforms Web Scene for 3D Applications(Immediate to 1 year) *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field	14. GIS	14.04	1- Short	3. Policy	Establish Standards -Branding -Database size and scope -Findable data -Accessible data (immediate to 3 years) *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field	14. GIS	14.05	1- Short	3. Policy	Identify Industry Best Practices (immediate to 5 years) *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field	14. GIS	14.06	1- Short	3. Policy	Identify Workflows -Data interoperability (Crosswalks) -Maintenance oEssential data layers and database interoperability -Operations oEssential data layers and database interoperability -Planning oEssential data layers and database interoperability 1-3 years *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field	14. GIS	14.07	1- Short	4. Data	Identification of essential data layers and databases Interoperability (Crosswalks) to add them into VDC project development process *(Immediate to 1 year)*	Task Force														0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	14. GIS	14.08	2- Mid	1. Org	Project Delivery GIS/Data Organization Structure Critical Functions -Classifications -Central unit or decentralized staff imbedded in production units to perform work *(Immediate for determination of structure* *1 to 3 years for implementation of approved structure)*	Task Force		0.25	0.25	0.25		0.25	1							2.00	12.00		
3 - Field	14. GIS	14.09	2- Mid	2. Tools	Develop web applications that would enhance the BIM41 project delivery process *(1 year to 5 years)*	Task Force														0.00			
3 - Field	14. GIS	14.10	2- Mid	2. Tools	Ensure combability with systems currently under development Transportation Asset Management System (TAMS) -Others *(1 year to 5 years)*	Task Force														0.00			
3 - Field	14. GIS	14.11	2- Mid	3. Policy	Identify Caltrans Best Practices and Lessons Learned	Task Force														0.00			
3 - Field	14. GIS	14.12	2- Mid	3. Policy	Workflows -K Phase (PID) oEssential data layers and database interoperability -0 Phase (PA&ED) oPublic Meetings Visualizations oEssential data layers and database interoperability -1 Phase (PS&E) oData model information sharing standards oEssential data layers and database interoperability -2 Phase (Right of Way) oParcel Fabric -3 Phase (Construction) oEssential layers updated from digital as-builts oSharing standards with asset management and maintenance oDatabase interoperability *(1 year to 5 years)*	Task Force														0.00		$200,000	$100,000
3 - Field	14. GIS	14.13	2- Mid	3. Policy	Change Management *(Immediate to 5 years)*	Task Force														0.00			
3 - Field	14. GIS	14.14	2- Mid	3. Policy	Tasks discovered during implementation *(Immediate to 5 years)*	Task Force														0.00			
3 - Field	15. 4D-5D Models	15.01	1- Short	1. Org	Industry Working Group to: Combined with other sub teams to Meet with Construction industry (include IT) *(1 year)* *.15 PY per member (8) = 1.2 PY's*	HQ Construction and Structures Construction			0.5	0.5				0.2						1.20			
3 - Field	15. 4D-5D Models	15.02	1- Short	2. Tools	Software (licensing and maintenance) e.g. Navisworks, Synchro, or other Increased support for CADD to manage all the software – centralize *1-2 PY, Considers 40 licenses -- 12 districts x 3 licenses to cover district construction and structure construction = 36 licenses* *4 licenses for HQ construction*	IT IT Legal DPAC CADD Construction	1.25		0.25	0.25				0.25						2.00			$100,000
3 - Field	15. 4D-5D Models	15.03	1- Short	3. Policy	Prepare new Spec for 4D/5D (potentially new section) *(1 year)*	Construction			0.5											0.50			
3 - Field	15. 4D-5D Models	15.04	2- Mid	1. Org	Continue collaboration with Industry Working Group Combined with other sub teams to Meet with Construction industry (include IT) *Covered in Short term*	HQ Construction and Structures Construction														0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	15. 4D-5D Models	15.05	2- Mid	2. Tools	Maintain Software *Considers increase based on inflation. This inflation impact is to be determined in the midterm timeframe*	Construction, IT														0.00			$105,000
3 - Field	15. 4D-5D Models	15.06	2- Mid	3. Policy	Pilot project with 3D project: multiple staff across multiple divisions *Assumes 4-5 PY include this in the pilot resource sub-team resources*															0.00	5.00		
3 - Field	15. 4D-5D Models	15.07	2- Mid	3. Policy	Have requirements for how final pay items are handled in the estimation model (5D). *Policy to be wrapped up in mid-term*	Construction/ OE			0.3	0.2										0.50			
3 - Field	15. 4D-5D Models	15.08	2- Mid	3. Policy	Specification update a.Spec: Bid Item: Ensure Contractor software is IFC (Industry Foundation Class) compliant *Policy to be wrapped up in mid-term*				0.5											0.50			
3 - Field	15. 4D-5D Models	15.09	3- Long	1. Org	Software Training (4D/5D only – reoccurring annually) •Construction group •DES •OE •Structure Design •Structure Construction Further investigation: •Who will be trained? All staff? RE's? *1-2 years – will taper off over time* *PY (Needs further investigation – assuming 3-4 in HQ, 1-1.5 per district) Use Civil 3D as model for resources* *Also: service contract*	Vendors Construction / Structures Construction														0.00			$200,000
3 - Field	15. 4D-5D Models	15.10	3- Long	2. Tools	For all procured software, there should be allocated funds for renewal and maintenance of the software. *Considers increase based on inflation. This inflation impact is to be determined in the long-term timeframe*															0.00			$110,000

APPENDIX C: TERMS AND DEFINITIONS

Terms used in this BIM Execution Plan adhere to the ISO 19650 suite of BIM Standards. The definitions of terms can be found on the ISO's online browsing platform at the link:

https://www.iso.org/obp

List of Acronyms

Acronym	Term
AGC	Associated General Contractors
AIM	Asset Information Model
AMG	Automated Machine Guidance
AR	Augmented Reality
BCM	Bridge Construction Memos
BEP	BIM Execution Plan
BIM	Building Information Modelling
BIM4I	BIM For Infrastructure
BIRIS	Bridge Inspection Records Information System
C3D	Autodesk Civil 3D Software
CADD	Computer Aided Design and Drafting
CCO	Contract Change Order
CDE	Common Data Environment
CFD	Contract for Delivery
CMGC	Construction Manager General Contractor
COS	Capital Outlay Support
CSRC	California Spatial Reference Center
CSV	Comma Separated Values
CTSRN	Caltrans Spatial Reference Network
CUD	Caltrans Utility Database
DDM	Digital Design Model
DDXX	Deputy Directive #XX
DAB	Digital As-Built
DEA	Division of Environmental Analysis
DES	Division of Engineering Services
DIME	Data Interchange for Materials Engineering
DLT	Distributed Ledger Technology
DRS	Document Retrieval System
DTM	Digital Terrain Model
EDMS	Electronic Document Management System
EOR	Engineer of Record

Acronym	Term
GDO	Geospatial Data Officer
GIS	Geographic Information Systems
GNSS	Global navigation satellite system
GPR	Ground Penetrating Radar
HDM	Highway Design Manual
HQ	Caltrans Headquarter Office
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
IQA	Independent Quality Assurance
ISO	International Standards Organization
IT	Information Technology
LIDAR	Light Detection and Ranging
LOD	Level of Development
LOTB	Log Of Test Boring
MIDP	Master Information Delivery Plan
MPDT	Model Production Delivery Table
MPO	Metropolitan Planning Organizations
NTB&SP	Notice to Bidders and Special Provisions
PA&ED	Planning Approval & Environmental Document
PDPM	Project Development Procedure Manual
PDT	Project Delivery Team
PE	Project Engineer
PID	Project Initiation Document
PIG	Preliminary Investigations Group
PIM	Project Information Model
PIO	Public Information Office
PIP	Project Implementation Plan
PPM&OE	Program/Project Management and Office Engineer
PS&E	Plans, Specifications, & Estimate
RAM	Random Access Memory
RFI	Request for Information
RE	Resident Engineer
REF	Resident Engineer File
ROW	Right-of-Way
RTL	Ready To List
QA/QC	Quality Assurance/Quality Control
QMP	Quality Management Program
SEF	Survey Engineer File
SME	Subject Matter Expert
SUE	Subsurface Utility Engineering
TAMS	Transportation Asset Management System

Acronym	Term
TIDP	Task Information Delivery Plan
TIN	Triangular Irregular Network
UAS	Unmanned Aerial System
UEW	Utility Engineering Workgroup
UFS	Caltrans Uniform Filing System
VDC	Virtual Design & Construction

APPENDIX D: VALUE ANALYSIS (VA) STUDY PROCESS

The Caltrans VA process involves 16 activities needed to accomplish a VA study, organized in three parts: Pre-study, VA Study, and Report.

The following provides an overview of the Caltrans approach to VA for capital projects, processes, policies, or other organizational focuses. The Caltrans VA Study Activity Chart at the end of this narrative identifies the steps in each activity, which are detailed as follows. Depending on the focus of the VA Study, tools and techniques from each step are selected and utilized to achieve the desired product. Therefore, while the Value Methodology is always used, each project may not require each activity described below.

PRE-STUDY

Meaningful and measurable results are directly related to the pre-study work performed. Depending on the type of study, all or part of the following information needs to be determined during the pre-study phase:

- Clear definition of the current situation and study objectives
- Identification of study team members
- Identification of project partners and interested parties
- Definition of how partners are impacted by the project
- Identification of key issues and concerns
- Identification of project's performance requirements and attributes
- Status of project cost estimate, if applicable
- Project data gathered to be distributed to VA team

In preparation for the VA study, the team leader confers with the Steering Committee, Project Manager, and/or other project leadership representatives to outline the VA process, initiate data gathering, refine project scope and objectives, structure the scope and team members and technical specialists, and finalize study plans. Specific deliverables are provided as needed.

VA STUDY

The VA Job Plan guides the VA team in their search to enhance value in the project or process. Caltrans follows a seven-phase VA Job Plan:

1. Information Phase
2. Function Analysis Phase
3. Creativity Phase
4. Evaluation Phase

5. Development Phase
6. Presentation Phase
7. Implementation Phase

Information Phase

At the beginning of a capital project VA study, the design team presents a more detailed review of the design and the various systems. This includes an overview of the project and its various requirements, which further enhances the VA team's knowledge and understanding of the project. The project team also responds to questions posed by the VA team. The project's performance requirements and attributes are discussed, and the performance of the baseline concept is evaluated. The kickoff point of a Process study may differ somewhat depending on the process, procedure, or other organizational element being analyzed. This could include survey or interview data gathering, workshop-based process mapping, or other means of understanding the current state of the study's focus.

Function Analysis Phase

Key to the VA process is the function analysis techniques used during the Function Analysis Phase. Analyzing the functional requirements of a project is essential to assuring an owner that the project has been designed to meet the stated criteria and its need and purpose. The analysis of these functions in terms cost, performance, time, and risk is a primary element in a VA study and is used to develop alternatives or recommendations for change. This procedure is beneficial to the VA team, as it forces the participants to think in terms of functions and their relative value in meeting the project's need and purpose. This facilitates a deeper understanding of the project or process being reviewed.

Creativity Phase

The Creativity Phase involves identifying and listing creative solutions to address functional needs. During this phase, the VA team participates in brainstorming or other ideation sessions to identify as many means as possible to provide the necessary project functions. The judgment of the ideas is not permitted in order to generate a broad range of ideas.

Evaluation Phase

The purpose of the Evaluation Phase is to systematically assess the potential impacts of ideas generated during the Creativity Phase relative to their potential for value improvement. Each idea is evaluated in terms of its potential impact to performance, cost, time, and risk. Once each idea is fully evaluated, it is given a rating based on an agreed upon scale. For this project, ideas were thoroughly discussed and organized into several categories: items to be developed, dismissed, or determined that they were already being done. Note: Due to the magnitude and breadth of the BIM for Infrastructure scope, this report contains only those ideas and recommendations for focus areas that were identified for development and recommended for implementation.

Development Phase

During the Development Phase, the highly rated ideas are expanded and developed into VA alternatives or recommendations (note these terms are used interchangeably herein). The development process considers the impact to performance, cost, time, and risk of the alternative concepts relative to the baseline concept. This analysis is prepared as appropriate for each alternative or recommendation, and the information may include a performance assessment, initial cost and life cycle cost comparisons, schedule analysis, and an assessment of risk. Each recommendation herein describes the baseline concept, proposed changes, anticipated benefits, implementation considerations including resource implications, potential challenges, and the organization's functional groups that would be involved and/or impacted. Calculations are also prepared for each recommendation as appropriate.

Presentation Phase

The VA study concludes with a preliminary presentation of the VA team's assessment of the project and VA alternatives. The presentation provides an opportunity for the owner, project team, and stakeholders to preview the alternatives and develop an understanding of the rationale behind them.

Implementation Phase

After the stakeholders have had an opportunity to review the alternatives identified by the VA team, the team leader conducts an implementation meeting to discuss the alternatives and resolve appropriate action for each VA alternative. If necessary, any other VA report edits requested by the representatives are also made by the VA team leader and a final report is issued.

This implementation meeting helps to ensure that savings or process improvements are not lost due to lack of communication, and that those VA alternatives that are accepted are properly integrated into the project design.

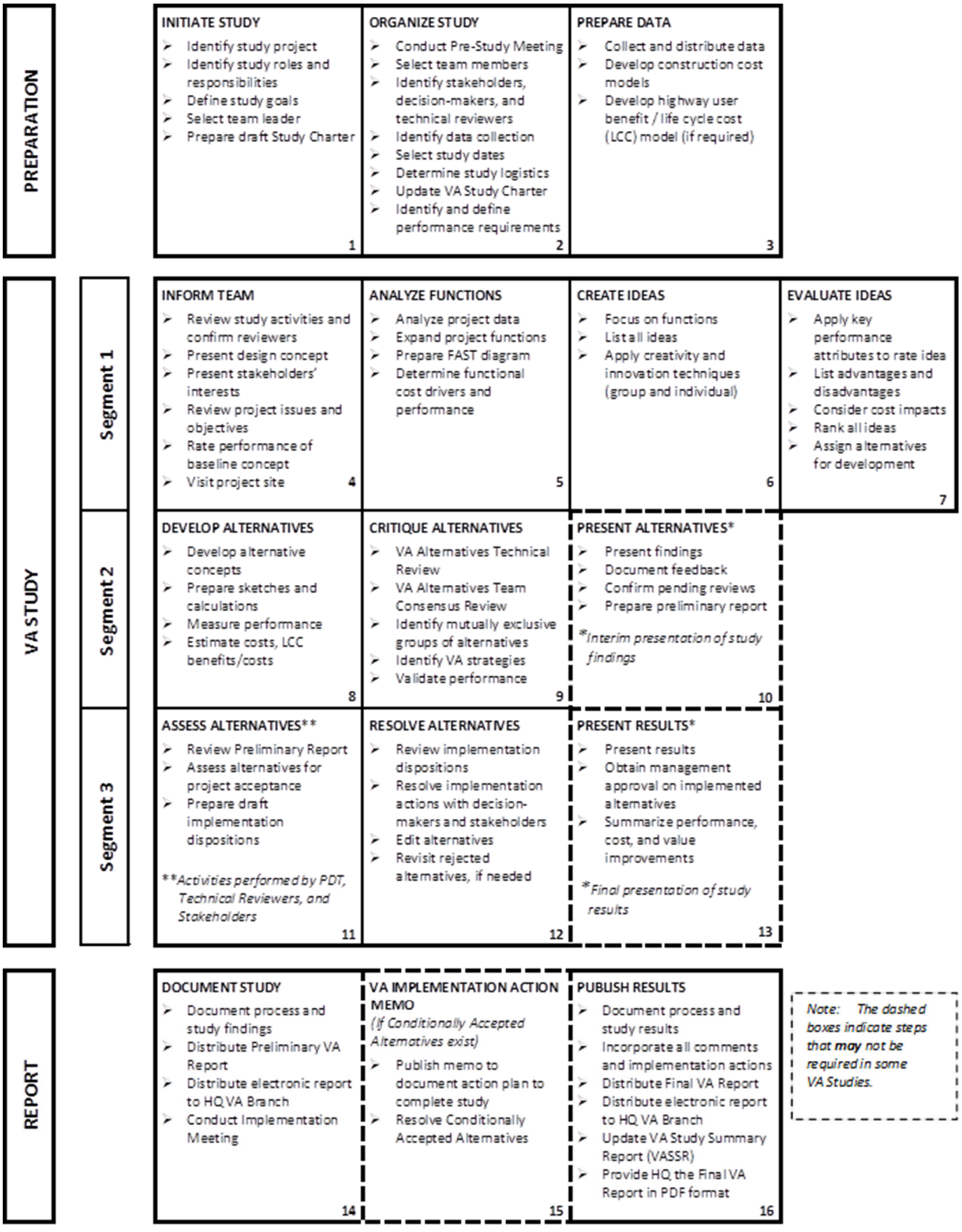
VA REPORT

Preliminary Report: Following the completion of the VA study, the team leader compiles the information developed during the VA study into the *Preliminary Value Analysis Study Report*. This report, documenting viable alternatives, is provided to the customer within the timeframe requested.

Final Report: Once all VA alternatives have been either accepted or rejected, the team leader updates the *Preliminary Value Analysis Study Report* to show the final results of the study in a *Final Value Analysis Study Report*.

The following Caltrans VA Study Activity Chart describes each activity.

CALTRANS VA STUDY ACTIVITY CHART



APPENDIX E: PROJECT CHARTER

Virtual Design and Construction Initiative (BIM- Infrastructure) Committee and Team Charter

Background	Rapid development of information technologies is transforming how information is produced, shared, exchanged, and managed throughout a project's life cycle. This transformation is accelerating in DOTs across the country due to the pressing need for efficient ways of delivering transportation projects and an enhanced need for collaboration internally and externally. Caltrans rolled out a new Strategic Plan and one of the strategic goals is focused on Stewardship and Efficiency. The Caltrans Project Delivery Program has launched an initiative to Implement Virtual Design and Construction (VDC), more widely known in the industry as Building Information Modeling (BIM) – Infrastructure and/or Advanced Digital Construction (ADC) systems. Caltrans primarily develops and constructs transportation improvement projects by creating two-dimensional plan sheets to represent the design of the project that is built in the three-dimensional real world (3D). Even though Caltrans Surveying and Mapping has been providing 3D data for approximately 20 years, recent advances in engineering and project management software make it possible for the transportation industry to utilize the VDC approach used in other civil engineering sectors and employ VDC in the design and construction of roadways, bridges, and other transportation infrastructure. Data and products developed for capital improvement projects, used in the VDC approach, become transportation assets to be maintained by the owner and operator of the State's transportation system. VDC will share information from various programs and stakeholders in a 3D virtual world. This visual and digital representation of the design, as it is proposed to be built, over time, will establish an environment that enables decision makers to have better information available on which to base their decisions and develop projects that can be designed and constructed safer, in less time, for less money, and with higher quality. Benefits of a fully functional VDC implementation include: • Improve safety (ex. AMG) • Reduce design errors, modifications, and construction conflicts • Reduce printing and paper use to support the Department's Sustainability Program • Expand Best Practices throughout the Department by standardization of document management. • Automate document workflow and notifications

	• Digitize approval processes and electronic signatures • Share, transfer, and collaborate digital data and documents internally and externally • Automate document archiving with built-in record retention schedules • Attract and retain a diverse innovative workforce • Lower bids by providing enhanced project information • Improve multi-disciplinary collaboration • Enhance review of complex projects • Detect construction, utility, and other conflicts (Clash Detection) • Increase efficiency and productivity • Improve Asset Management • Improve Subsurface Utility Engineering • Reduce Construction claims • Lower Capital Outlay Support Costs • Reduce project development risk • Improve decision making through better information
Purpose	Stewardship and Efficiency. Implement Virtual Design and Construction techniques and products into Caltrans' transportation project workflow that results in project development efficiencies, enhanced collaboration, reduced delivery risk, and improves asset management information. The VDC approach develops a cyclical process of continuous improvement and state of the practice knowledge base that will generate a more seamless process for designing, constructing, and maintaining roadway infrastructure.
Desired Goals	• Implement model-based project delivery workflow to achieve digital delivery of project plans, specifications, estimates, construction, construction administration and as-builts into a 360-degree living model concept. • Go paperless from inception to completion and deliver a 3D Model as the Legal Construction Contract Document for appropriate projects in 1-3 years, utilizing phased implementation.
Expected Deliverables	Develop and deploy an implementation plan that includes the following components:

	• An integrated workflow model including all aspects of 3D modeling for all appropriate groups within the department showing inputs and outputs from project inception to asset management
	• Timelines and resource needs for phasing in VDC implementation in the COS program
	• Prioritize the techniques that should be implemented or piloted first based on existing equipment and software already in use by the department (i.e. Civil 3D, MicroStation, LiDAR)
	• Identify additional VDC hardware, software, and IT infrastructure needs, gaps, and deployment challenges
	• Expand the use of on-going VDC efforts (i.e. AMG, LiDAR, 3D modeling, visualization, Subsurface Utility Engineering, e-Construction, Asset Management, Electronic Document Management System, Intelligent Compaction)
	• Enhance Constructability Reviews
	• Identify Pilot Projects to implement elements of VDC
	  ○ Generate a 3D Building Information Model (BIM) for bridge and structures components
	  ○ Create an integrated multi-disciplinary 3D model for highway project
	  ▪ Roadway
	  ▪ Utilities, structures, drainage, and more as applicable
	  ○ Integrate the bridge & structures BIM with highway 3D models
	  ○ Evaluate existing software and databases and align with new industry standards for VDC
	  ○ 3D construction inspection methods
	  ○ Digital As-builts
	• Procure additional and replacement data collection platforms/equipment
	  ○ Aging Mobile Terrestrial LiDAR scanning system SS equipment and drones

Sponsors	Donna Berry, Chief Engineer (Acting) Amarjeet Benipal, Director, District 3 George Akiyama, Chief Information Officer
Champions	Tim Greutert, Chief, Division of Construction (Acting) Janice Benton, Chief, Division of Design

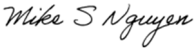
	Tom Ostrom, Chief, Division of Engineering Services (DES) Kimberly Erickson, Chief, Division of Right-of-Way and Land Surveys (RWLS) Karl Dreher, Chief Deputy, North Region Jeff Wiley, Chief, Division of Project Management (Acting) Ramon Hopkins, Chief, Division of Environmental Analysis (Acting) Mike Nguyen, Chief, Infrastructure Management Division
Steering Group	Paul Chung, Division of Design (Lead) Raymond Tritt, Division of Construction Gudmund Setberg, DES Scott Martin, RWLS Helena Lenka Culik-Caro, District 4 Jamal Elsaleh, District 8 Carlos Portillo, North Region Sang Hoong, IT
External Stakeholder Group	Construction Industry FHWA Software Vendors/BIM Industry A&E Consultant Other State DOT's VDC experts
Committee Members	Jesus Mora Chair, VDC Program Manager Devin Porr, Division of Construction Cathy Kurtz, Division of Design, CADD John Lammers, DES, Structures Construction Elias Kurani, DES, Bridge Design Mina Pezeshpour, DES, Bridge Design Doug Nguyen, DES, Office Engineer Scott Williams, Division of Environmental Analysis Rich Williams, Division of Project Management JC Hamilton, Information Technology Chad Baker, Geospatial Data Officer Said Ismail, Division of Traffic Operations Camille Abou-Fadel, Division of Maintenance Ron Tollison, North Region, Design Austin Bossetti, District 4 Dave Olander, District 11 Surveys William Pilkington, North Region, Surveys Issam Abumuhor, District 7 Construction

Subcommittee Subject Matter Experts (SMEs)	Construction: Aaron Chamberlin and Robert Nagy Design: Christopher Fugitt Structure Construction: Elpidio Perez Structure Design: Lynn Hiel Office Engineer: Aaron Daniels Environmental Analysis: As Needed Project Management: Anthony Perry Land Surveys: Chris Thornton and Mark Counts Information Technology Legal: Jeffrey Knox District SME's Asset Management
Frequency of Meetings	Sponsors: • Quarterly Champions & Steering Group: • Monthly Committee: • As needed, minimum Monthly Technical SMEs & Sub-Committees: • As Needed
Roles & Responsibilities	**Champions:** • Provide leadership • Define scope • Provide oversight and direction to team activities • Provide final timely reviews, feedback and approvals on team activities and deliverables • Participate in briefings and decision meetings • Review and approve recommendations • Champion the recommended changes • Provide necessary resources to accomplish objectives and deliverables • Resolve issues **Steering Group:** • Ensure scope and objectives are adequately stated and sized • Provide guidance and direction to the Committee • Communicate corporate issues and priorities • Provide final review of deliverables

	• Participate in briefings and decision meetings • Validate Committee recommendations • Resolve issues **Committee Chair:** • Facilitates committee meetings (arranges agenda, logistics, venue, produces minutes and action items) • Develop a delivery workplan and track and report team progress timely to the Steering Group and Champions • Serves as point of contact for statewide exchange of information to the team • Liaison between the committee and others • Attempts to resolve issues and elevates as necessary • Work with the Committee to clearly define assumptions and risks for a successful outcome and collaborate with the Steering Group on these items • Work with the Steering Group and Champions to ensure members are actively engaged and participate **Committee:** • Identify business requirements (i.e., workflows, notifications, version control, approval process, electronic signatures, automatic document archiving, etc.) • Review and evaluate vendor VDC products • Develop, support, and oversee VDC test pilots in Districts and Headquarters • Seek outside support and input from external entities • Track progress, results, and evaluations of each Project Delivery test pilot for analysis • Report of findings and recommendations on system that best meets Caltrans VDC needs to deploy VDC • Assist in the management of organizational change • Devote the necessary time and thought to fully participate in team activities (i.e. Meetings, implementation plan, training or work sessions, preparation, and presentation of findings) • Fairly and equitably represent the interests and operation of all functions to ensure the best possible decision making • Track and investigate other DOT efforts • Collaborate with External Stakeholder Group

	Technical SME Subcommittee: • Define/refine roles and responsibilities of task-related work • Collect and analyze data • Investigate various issues, functions and/or processes • Conduct related research as needed • Identify risks and alternatives to mitigate them • Make presentations of findings and/or results • Generate and develop recommendations for change • Integrate feedback on deliverables from Sponsors, Champions, Steering Group, and Committee members • Advocate proposed recommendations • Promote and support VDC activities • Assist in District and/or Headquarters training
Reporting Structure	• Technical/External/District Subcommittees will report to the Committee through updates, recommendations, and support materials • Committee will brief Steering Group and Champions regularly on the progress
Decision Process	• VDC Technical Subcommittees, External Advisory Subcommittees, and District Subcommittees present advice and recommendation to Committee • Committee reviews, decides by majority vote if consensus cannot be reached, and makes recommendations under the guidance from the Steering Group • Champions review and make decisions on recommendations and informs the Sponsors for concurrence.
Amendment	• As needed, recommended by the Steering Group and approved by the Champions and Sponsors
Target Completion Date	A workplan that includes sub team target completion dates should be developed for each sub team and consolidated into an over all plan.

This charter is hereby adopted on March 14, 2022.

Champion Signature	Name
	Janice Benton, Chief, Division of Design
	Tim Greutert, Chief, Division of Construction (Acting)
	Tom Ostrom, Chief, Division of Engineering Services
	Kimberly Erickson, Chief, Division of Right-of-Way and Land Surveys
	Jeff Wiley, Chief, Division of Project Management (Acting)
	Karl Dreher, Chief Deputy, North Region
	Ramon Hopkins, Chief, Division of Environmental Analysis (Acting)
	Mike Nguyen, Chief, Infrastructure Management Division

Sponsor Signature

	Donna Berry, Chief Engineer (Acting)
	Amarjeet Benipal, Director, District 3
	George Akiyama, Chief Information Officer

APPENDIX B: RESOURCE NEEDS BREAKDOWN

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	1. 3D Models Roadway	1.01	1- Short	1. Org	Initiate and process hybrid pilot projects, make PD-06 deliverables as part of legal contract documents along with 2D plan set. *Assumes can be achieved within current resources*	Districts														0.00			
1 - Models	1. 3D Models Roadway	1.02	1- Short	1. Org	Have 20 personnel become BIM4I Certified by taking Train the Trainer certification course (18 staff @ $416.67/person = $7,500 using Division(s) OE $)	Design	0.00		0.00	0.00										0.00		$12,000	
1 - Models	1. 3D Models Roadway	1.03	1- Short	2. Tools	Automate and expand features and capabilities of roadway design software *Assumes can be achieved within current resources*	Design	0.00													0.00		$500,000	
1 - Models	1. 3D Models Roadway	1.04	1- Short	2. Tools	Create a 3D cell library for design elements, including drainage inlets, signs, barriers, etc.		0.00													0.00		$800,000	
1 - Models	1. 3D Models Roadway	1.05	1- Short	3. Policy	Conduct analysis to review the current traditional survey deliverable to designers to support streamlining of the current workflow	Surveys		1.00												1.00			
1 - Models	1. 3D Models Roadway	1.07	1- Short	3. Policy	Tie design elements to Std plans, Specs, construction details and Bid items which can be used for asset management as well	Design	2.00													2.00			
1 - Models	1. 3D Models Roadway	1.06	1- Short	3. Policy	Standardize Level of Development (including Metadata/Attributes requirements)	Design														0.00			
1 - Models	1. 3D Models Roadway	1.08	1- Short	3. Policy	Manage shared data	Design														0.00			
1 - Models	1. 3D Models Roadway	1.09	1- Short	3. Policy	Share the 3D PIM with the contractor and establish CCO & RFI communication Protocol	Design/Construction														0.00			
1 - Models	1. 3D Models Roadway	1.10	1- Short	4. Data	Develop constructability platform to circulate and review the 3D model and provide feedback to the designers and other functional groups	Design/CADD														0.00			
1 - Models	1. 3D Models Roadway	1.11	1- Short	4. Data	Update current bid items *Assumes can be achieved within current resources*	Design/OE														0.00			
1 - Models	1. 3D Models Roadway	1.12	2- Mid	1. Org	Develop Training Manual (by consultant)	Design														0.00		$75,000	
1 - Models	1. 3D Models Roadway	1.13	2- Mid	1. Org	Develop Modeling Standards Manual	Design														0.00		$150,000	
1 - Models	1. 3D Models Roadway	1.15	2- Mid	1. Org	Train staff using Service Contract ~10,000 staff (25 per class, $1,950/class)	Design														0.00		$770,000	
1 - Models	1. 3D Models Roadway	1.14	2- Mid	1. Org	Develop training for Consultants, outside partners, city & local government	Design														0.00			
1 - Models	1. 3D Models Roadway	1.16	2- Mid	1. Org	Deliver training for Contractors with BEP, PIM, & AIM	Design/Construction														0.00		$5,000	
1 - Models	1. 3D Models Roadway	1.17	2- Mid	3. Policy	Develop new QC/QA manual	Design/OE														0.00		$100,000	

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	2. 3D Models Structures	2.01	1- Short	1. Org	Resource staff hours on software training and BIM Execution Plan / Information Management training	Bridge Design												3.00		0.00			
1 - Models	2. 3D Models Structures	2.02	1- Short	1. Org	Develop Training Manual: Will include software vendor training document and Caltrans-specific workflows. Develop Caltrans BIM bridge/structure model examples for training and testing	Bridge Design				0.50										0.50		$80,000	
1 - Models	2. 3D Models Structures	2.03	1- Short	1. Org	Support national engagement: support participation in different working task groups of national funded projects [e.g. TPF-5(372)] Provide presentation materials, write articles to demonstrate BIM efforts and pilot project outcomes, and conduct research on new tools/software in implementing BIM for infrastructure	Bridge Design													2.00	0.00		$50,000	
1 - Models	2. 3D Models Structures	2.04	1- Short	2. Tools	Purchase software for pilot projects	HQ CADD DES Software Managers IT Certification DPAC HQ IP Legal EAC/IT														0.00		$200,000	
1 - Models	2. 3D Models Structures	2.05	1- Short	3. Policy	BIM Execution Plan review, revision and maintenance, create template model production delivery tables for various bridge types with standardized LOD	Bridge Design *Collaborate with Asset Management*														0.00		$350,000	
1 - Models	2. 3D Models Structures	2.06	1- Short	4. Data	Develop Information Standard for Bridge Modelling / Quality checking based on the IFC standard from TPF-5(372). Updates to Bridge Design Manuals / Detailing Manuals, etc…	Bridge Design		0.50												0.50			
1 - Models	2. 3D Models Structures	2.07	2- Mid	1. Org	Training for Structure Construction and Structure Maintenance & Investigations, including BEP, PIM, using the model for inspections, digital as-builts	Bridge Design												3.00		0.00		$100,000	
1 - Models	2. 3D Models Structures	2.08	2- Mid	1. Org	Training for and outreach / collaboration with Consultants, Regulatory Agencies, City & Local government, if required (Model Viewers, CDE, and basic model breakdown / structure & navigation)	Bridge Design / ACEC OSFP												0.50		0.00		$10,000	

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	2. 3D Models Structures	2.09	2- Mid	1. Org	Train Bridge Contractors on BEP, PIM, Digital As-builts	Bridge Design/ AGC, Structure Construction														0.00		$600,000	
1 - Models	2. 3D Models Structures	2.10	2- Mid	1. Org	Update Duty Statements to reflect BIM -- Workflows and Expectations (Duty Statements) of Project Engineer / BIM Manager and Project Development Team Members	Bridge Design DHR														0.00	0.50		
1 - Models	2. 3D Models Structures	2.11	2- Mid	2. Tools	Bridge/Structure Software Customization and Testing: Automate and expand features for structural analysis and 2D drawing production	Bridge Design														0.00		$500,000	
1 - Models	2. 3D Models Structures	2.12	2- Mid	3. Policy	Develop new BIM section in Bridge Design Process and Procedure Manual (2-4 years) Model QA/QC checking requirements and Bridge Analysis Independent Check process needs to be defined in a BIM workflow Connect Bridge Model to AASHTOWare Preconstruction software	Bridge Design Structure OE														0.00		$150,000	
1 - Models	2. 3D Models Structures	2.13	2- Mid	3. Policy	Contractor / Fabricator Industry Engagement through Forums with Caltrans to set-up Guidance for model exchange and streamlined workflows between design & construction Setting up procedures for CCO & RFI processes (including Caltrans legal) (5-7 years) Guidance / Recommendations for Bridge Design's role/responsibility & process for developing the bridge digital as-built	Bridge Design/Structure Construction														0.00		$800,000	
1 - Models	2. 3D Models Structures	2.14	2- Mid	4. Data	Model LOD Guide for Caltrans BIM Bridge/Structure Objects (3-5 years)	Bridge Design														0.00		$350,000	

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	2. 3D Models Structures	2.15	2- Mid	4. Data	Create a BIM object library for bridge/structure design elements, including deck, superstructure, substructure, retaining walls, etc. (using pilot projects to populate the BIM bridge/structure object library) All bridge/structure library objects will be tied to Std plans, Specs, construction details and Bid items which can be used for asset management as well (3-5 years)	Bridge Design				4.00										4.00		$500,000	
1 - Models	2. 3D Models Structures	2.16	3- Long	1. Org	Continued Training for Bridge Design Staff	Bridge Design												1.00		0.00			
1 - Models	2. 3D Models Structures	2.17	3- Long	2. Tools	Continued Bridge/Structure Software Customization and Testing: Automate and expand features for structural analysis	Bridge Design														0.00		$125,000	
1 - Models	2. 3D Models Structures	2.18	3- Long	3. Policy	Continued Contractor / Fabricator Industry Engagement through Forums with Caltrans to set-up Guidance for model exchange and streamlined workflows between design & construction Setting up procedures for CCO & RFI processes (including Caltrans legal) (5-7 years) Guidance / Recommendations for Bridge Design's role/responsibility & process for developing the bridge digital as-built	Bridge Design/ PCI & Fabrication Industry, Structure Construction														0.00		$200,000	
1 - Models	2. 3D Models Structures	2.19	3- Long	4. Data	Expand / Update the Caltrans BIM object library for bridge/structure design elements, including deck, superstructure, substructure, retaining walls, etc. All bridge/structure library objects will be tied to Std plans, Specs, construction details and Bid items which can be used for asset management as well	Bridge Design				1.00										1.00		$100,000	
1 - Models	3. 3D SUE	3.01	1- Short	1. Org	Develop expertise and support for UEW's (1 PY per district or spread accordingly between regions and districts)	Design														0.00	12.00		
1 - Models	3. 3D SUE	3.02	1- Short	1. Org	Create another GPR unit to serve southern districts	DES-Geo Tech office														0.00	4.00		

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	3. 3D SUE	3.03	1- Short	2. Tools	Create state-wide fund to support districts to positively identify existing utilities	R/W														0.00			$1,000,000
1 - Models	3. 3D SUE	3.04	1- Short	2. Tools	Develop 3D planimetric cells for utilities	Design	0.00													0.00		$200,000	
1 - Models	4. Bidding and Award	4.01	1- Short	1. Org	Work with Districts to determine candidate 3D Hybrid Design Projects to Pilot through Bidding and Award *Assumes can be achieved within current resources*	Districts, Construction, DES PPM&OE														0.00			
1 - Models	4. Bidding and Award	4.02	1- Short	2. Tools	Consider interfacing 3D model design files with AASHTOWare Preconstruction System bid item list *(Resources covered under 3D model recommendations)*	Design														0.00			
1 - Models	4. Bidding and Award	4.03	1- Short	3. Policy	Prior to Advertisement, work with Division of Construction to ensure companies are prepared to bid on pilot project *Assumes can be achieved within current resources*	PPM& OE, Construction														0.00			
1 - Models	4. Bidding and Award	4.04	1- Short	3. Policy	Determine how to present Additive Bidding item & Plans in the Design Files *Assumes can be achieved within current resources*	esign/Construction														0.00			
1 - Models	4. Bidding and Award	4.05	1- Short	3. Policy	Solve process of redlining and comments during quality review *Assumes can be achieved within current resources*	Design														0.00			
1 - Models	4. Bidding and Award	4.06	1- Short	3. Policy	Solve addenda process and version control *Assumes can be achieved within current resources*	Design														0.00			
1 - Models	4. Bidding and Award	4.07	1- Short	3. Policy	Districts consider including a Key Map (per PPM) in Project Plans using Design File name instead of Plan Sheet Name - this will help DES OE check Submittal & Contractors & RE check Design Files content and convention. May be useful for identification of changes for Addenda processing as well. *Assumes can be achieved within current resources*	Design														0.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	4. Bidding and Award	4.08	1- Short	3. Policy	Implement process of packaging pilot projects for Advertisement *Assumes can be achieved within current resources*	DES PPM&OE														0.00			
1 - Models	4. Bidding and Award	4.09	2- Mid	1. Org	Update the Training on Process for new delivery *Assumes 10% PY for each senior*	DES OE				0.50										0.50			
1 - Models	4. Bidding and Award	4.10	2- Mid	1. Org	Training on this new process (basics to process specific) 1) Transportation Engineers (Civil, Electrical), Landscape Architects, 2) Assume DES PPM&OE will need discipline-specific training for reviewing and checking 3D models but likely at a similar number of resources as that for roadway designers 3) DES PPM&OE performing project reviews 4) 2-3 classes Software specific *Assumes 24 hrs/person; 23 people*	DES PPM& OE												0.30		0.00			
1 - Models	4. Bidding and Award	4.11	2- Mid	3. Policy	Review project details and evaluate for unique features requiring process updates *Assumes can be achieved within current resources*	DES PPM& OE														0.00			
1 - Models	4. Bidding and Award	4.12	2- Mid	3. Policy	Update Best Bid Standard: Guideline and checklist to be developed for completeness of the model from the district and should be used in PPMOE to revalidate the completeness Quality review *Assumes can be achieved within current resources*	DES PPM& OE														0.00			
1 - Models	4. Bidding and Award	4.13	2- Mid	3. Policy	Update Plan Preparation Manual (PPM) checklist *Assumes can be achieved within current resources*	ES PPM& OE, CADD														0.00			
1 - Models	4. Bidding and Award	4.14	2- Mid	3. Policy	Update SAM Manual Language *Assumes can be achieved within current resources*	ES PPM& OE, DPAC														0.00			
1 - Models	4. Bidding and Award	4.15	2- Mid	3. Policy	Update Standard Specification language (Confirm with “legal”) - PD-06 – (electronic files), Spec changes: Section 2-1.06 for Design Files naming & convention and SS Section 5-1.02 for Contract Components hierarchy for description of 3D design files *Assumes can be achieved within current resources*	ES PPM& OE, CADD														0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Envionmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committees	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
1 - Models	4. Bidding and Award	4.16	2- Mid	3. Policy	Solve addenda process and version control *Assumes can be achieved within current resources*	Design														0.00			
1 - Models	4. Bidding and Award	4.17	2- Mid	3. Policy	Implement process of packaging projects for Advertisement *Assumes can be achieved within current resources*	DES PPM& OE														0.00			
1 - Models	4. Bidding and Award	4.18	3- Long	2. Tools	Integrate ebid into the tool or other bidding alternative software - Perhaps a data group investigate *Assumes can be achieved within current resources*	DES PPM& OE														0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	5. Pilot Resources	5.01	1- Short	1. Org	Create Pilot Support Task Force using existing Sub Team members comprised of various disciplines	PM													5	0.00			
2 - Project Delivery	5. Pilot Resources	5.02	1- Short	1. Org	Provide additional funding for pilot projects (functional units involved, including Design, Construction, and IT) *Assumes 1-2 PY per Pilot Project plus 2 total from HQ functions, including IT* *Assumes a 5-10% Contingency per Pilot*	Districts/PM	0.25	0.25	0.5	0.5				0.5						2.00	2.00		
2 - Project Delivery	5. Pilot Resources	5.03	1- Short	1. Org	Team to provide training on BEP and pilot project education training *Assumes can be achieved under resources identified for the Pilot Support Task Force but will require ~$30,000 for travel*	PM/PSTF	0	0	0	0										0.00		$30,000	
2 - Project Delivery	5. Pilot Resources	5.04	1- Short	3. Policy	Develop language to modify manuals *Assumes can be achieved under resources identified for the Pilot Support Task Force*	PSTF														0.00			
2 - Project Delivery	5. Pilot Resources	5.05	1- Short	3. Policy	Create guidance documents (define LOD for various levels) *Assumes can be achieved under resources identified for the Pilot Support Task Force*	PSTF														0.00			
2 - Project Delivery	5. Pilot Resources	5.06	2- Mid	1. Org	Establish a District Liaison for each district or region	Districts														0.00	10.00		
2 - Project Delivery	5. Pilot Resources	5.07	2- Mid	1. Org	Transition task force to permanent HQ office or branch *Assumes no additional resources outside of those requested for the PSTF*	PM														0.00			
2 - Project Delivery	6. Collab Platform	6.01	1- Short	1. Org	CP.S.OW.01: Acquire CDE application training from a vendor for users on early BIM4I pilots, including Design, Construction, Surveys, others. *Assume CDE application developer has trainings ready to provide, and will provide to BIM4I early pilot teams.* *No resources needed to develop CDE trainings for BIM4I early pilot teams = 0 PY*	Collab: Design, DES, Const.,Surv	0													0.00		$300,000	
2 - Project Delivery	6. Collab Platform	6.02	1- Short	1. Org	CP.S.DS.01: Provide CDE training to early BIM4I pilot team members, including Design, Construction, Surveys, others. *Assume CDE application developer will provide CDE training to CT staff. Assume 2 trainings @ 2 Hrs per pilot, 25 ppl per pilot, 25 pilots. 2 trainings X 2 Hrs X 25 ppl x 25 pilots = 1.25 PY (rounded down)*	Collab: Design, DES, Const.													1.25	0.00			
2 - Project Delivery	6. Collab Platform	6.03	1- Short	2. Tools	CP.S.TT.02: Meet with CDE application vendors to learn about application capabilities and use cases. *Assume quarterly meetings with CDE application vendors and HQ, IT, Design, Surveys, DES, Construction for 2 hours* *8 mtgs X 10 ppl X 2 Hrs = 0.1 PY*	Collab: IT, Design, Const.			0.025	0.025				0.05						0.10			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	6. Collab Platform	6.04	1- Short	2. Tools	CP.S.TT.01: Develop CDE requirements, specifications. *Assume an initial effort has been completed by team members (no further expenses). Assume this will be an ongoing effort to refine CDE requirements as pilots and new technology advance. Assume bi-annual team discussion (IT, Design, Construction, Surveys, HQ) for 4 hours. 4 mtgs X 10 ppl X 4 Hrs = 0.1 PY*	Collab: IT, Design, Const.			0.025	0.025				0.05							0.10			
2 - Project Delivery	6. Collab Platform	6.05	1- Short	2. Tools	CP.S.TT.03: Collaborate with IT to get approval to implement cloud based CDE applications. *Assume bi-annual meetings with IT, HQ, Design, Construction, DES for 1 Hr. 4 mtgs X 10 ppl X 1 Hr = 0.05 PY*	Collab: IT, Design, DES, Const.								0.05							0.05			
2 - Project Delivery	6. Collab Platform	6.06	1- Short	2. Tools	CP.S.TT.05: Continue learning from pooled fund members about their CDE use experiences. (ongoing). *Assume quarterly meetings. Assume this will be ongoing and will span phases (resources will be estimated by phase).* *8 mtgs X 10 ppl X 2 Hrs = 0.1 PY*	Collab: Design, DES, Const., IT	0.015		0.015	0.02				0.05							0.10			
2 - Project Delivery	6. Collab Platform	6.07	1- Short	2. Tools	CP.S.TT.04: Select, acquire, use, and evaluate various CDE applications on early BIM4I pilot projects in Design & Construction phases. *Assume 25 CDE licenses needed per pilot, 25 pilots, $1000 per license.* *25 X 25 X $1,000 = $625,000 OE* *Note: CDE application vendors may provide free licenses for early pilot evaluation. Much uncertainty on this probability at this point. For now, will assume worst case, can adjust going forward.*	Collab: Design, DES, Const.															0.00		$625,000	
2 - Project Delivery	6. Collab Platform	6.08	1- Short	2. Tools	CP.S.TT.06: Implement CDE applications with contractors on CMGC early BIM4I pilots. *Assume monthly coordination between CMGC & Design, IT, HQ for 2 Hrs. Assume 5 of 25 pilots use CMGC* *5 pilots X 10 ppl X 2 Hrs X 18 mo = 1 PY*	Collab: Design, DES, Const., IT			0.25	0.25				0.5							1.00			
2 - Project Delivery	6. Collab Platform	6.09	1- Short	3. Policy	CP.S.PP.01: Identify CDE implementation in BIM execution plans for early BIM4I pilots. *Assumptions: Pilot Teams and coordinators identify if CDE use is applicable on BIM4I pilot. 10 ppl X 2 Hrs (per pilot) = 0.01 PY/Pilot. Assume 25 pilots need determination by 12/31/23 = 25X.01 PY = 0.25 PY*	Design	0.1			0.15											0.25			
2 - Project Delivery	6. Collab Platform	6.10	1- Short	3. Policy	CP.S.PP.03: Develop lessons learned from CDE implementation on early BIM4I pilots. *Assume lessons learned is discussed quarterly for 0.5 Hr* *8 qtrs X 10 ppl X 25 pilots X 0.5 Hr = 0.5 PY*	Collab: Pilot Project division reps	0.2		0.15	0.15											0.50			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	6. Collab Platform	6.11	1- Short	3. Policy	CP.S.PP.02: Develop & implement Caltrans focused CDE workflows based on ISO 19650 standards. *Assume this activity is led by HQ BIM4I and adjusted by district pilot teams. Assume this is an ongoing process with recurring updates: a regular topic on BIM4I discussion agendas.* *Assume monthly discussions on this topic.* *Assume 10 ppl X 1 Hr (per pilot) X 25 pilots X 24 mo = round down to 3 PY -> seems excessive - > use 1 PY*	Collab: Design, DES, Const, IT	0.15	0.2	0.2	0.2				0.25							1.00			
2 - Project Delivery	6. Collab Platform	6.12	2- Mid	1. Org	CP.M.OW.01: Refine/update CDE training based on lessons learned from the early pilots. *Assume bi-annual training update meetings with 12 districts, trainings split by division (Design, Construction, Surveys, PPM, other) plus HQ training, 4 hour meetings* *2 mtgs/yr X 3 yrs X 12 dist X 5 div X 4 Hr = 0.75 PY (rounded)*	Collab: Design, DES, Const.	0.2		0.25	0.2				0.1							0.75			
2 - Project Delivery	6. Collab Platform	6.13	2- Mid	1. Org	CP.M.OW.02: Provide CDE training to BIM4I extended pilot team members. *Assume 100 pilots X 25 ppl/pilot X 2 Hrs X annual. 100 pilots X 25 ppl/pilot X 2 Hrs X 3 Yrs = 8 PY. Seems excessive – use 5 PY*	Collab: Design, DES, Const.	1	1	1	1			1								5.00			
2 - Project Delivery	6. Collab Platform	6.14	2- Mid	1. Org	CP.M.OW.03: Continue learning from pooled fund members about their CDE use experiences. *Assume 10 ppl meeting quarterly for 2 hours over phase span (3 yrs).* *10 pplX 4 mtgs/yr X 3 yrs X 2 Hrs = 0.1 PY*	Collab: Design, DES, Const.	0.03		0.03	0.04											0.10			
2 - Project Delivery	6. Collab Platform	6.15	2- Mid	1. Org	CP.M.OW.04: Develop lessons learned from CDE implementation on extended BIM4I pilots. *Assume bi-annual meetings, 10 ppl pe r pilot, 3 yrs, 2 hour mtgs. 2 mtgs/yr X 3 Yrs X 100 pilots X 10 ppl/pilot X 2 hrs = 6 PY*	Collab: Design, DES, Const.	1.5	1.5	1.5	1.5											6.00			
2 - Project Delivery	6. Collab Platform	6.16	2- Mid	2. Tools	CP.M.TT.01: Acquire additional CDE licenses for additional extended BIM4I pilots in more districts across the state. *Assume 100 new BIM4I pilots in medium phase (01/01/24 - 12/31/26). Assume 25 CDE licenses needed per extended BIM4I pilot. Assume no longer free for evaluation.* *100 ext. Pilots X 25 lic X $1,000/lic = $2,500,000*	Collab: Design, DES, Const.															0.00		$2,500,000	
2 - Project Delivery	6. Collab Platform	6.17	2- Mid	2. Tools	CP.M.TT.02: Implement CDE applications with contractors on CMGC extended BIM4I pilots and potentially other ways. *Assume monthly coordination between CMGC & Design, IT, HQ for 2 Hrs. Assume 20 of 100 pilots use CMGC.* *20 pilots X 10 ppl X 2 Hrs X 36 mo = 1 PY = 8 PY. Seems excessive – use 5 PY*	Collab: Design, DES, Const.	1.25	1	1.25	1.25				0.25							5.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	6. Collab Platform	6.18	2- Mid	3. Policy	CP.M.PP.01: Update pilot guidelines and workflows for CDE implementation based on the lessons learned from the early pilots. *Assume quarterly 4 Hr meetings to focus on updating guidelines and workflows across IT, HQ, Design, Construction, Surveys. 12 mtgs X 4 Hrs X 10 ppl = 0.25 PY*	Collab: Design, DES, Const.	0.05		0.1	0.1										0.25			
2 - Project Delivery	6. Collab Platform	6.19	2- Mid	3. Policy	CP.M.PP.02: Implement updated Caltrans focused CDE workflows based on ISO 19650 standards. *Assume no resources needed – folded into project hours* *0 PY*	Collab: Design, DES, Const.														0.00			
2 - Project Delivery	6. Collab Platform	6.20	2- Mid	4. Data	CP.M.DS.01: Establish enterprise framework for CDE(s). *Note: This is activity D4 in the FHWA roadmap. This is a significant challenge. It encompasses organizing, preparing, training, everything needed to roll-out CDE across the Department. This is such a bit task/activity that it is difficult to estimate with any certainty.* *Assume divisions meet quarterly for 4 hours for last 2 years of phase. Includes IT, HQ, DES, Design, Construction, others* *4 mtgs/ye X 2 yrs X 4 Hrs/mtg X 20 ppl = 0.5 PY -> round up to 1 PY*	Collab: IT Design, DES, Const.	0.15	0.2	0.2	0.2				0.25						1.00			
2 - Project Delivery	6. Collab Platform	6.21	3- Long	1. Org	CP.L.OW.01: Develop enterprise CDE training based on lessons learned from pilots. *Assume collaboration between consultants and in-house teams.* *Assume in-house team = 2 ppl, 1 yr, full time = 2 PY* *Assume consultant = $500k*	Collab: ALL	0.5	0.5	0.5	0.5										2.00		$500,000	
2 - Project Delivery	6. Collab Platform	6.22	3- Long	1. Org	CP.L.OW.02: Provide CDE training across Department. *Assume 1 trainer per district, plus HQ trainer + 10,000 staff. Assume 3 modules (beginner, intermediate, advanced) @ 2 hrs each – once & done. 10,000 staff X 3 modules X 2 hrs/module = 34 PY*	Collab: ALL											34			0.00			
2 - Project Delivery	6. Collab Platform	6.23	3- Long	2. Tools	CP.L.TT.01: Acquire CDE licenses for enterprise. *Assume 10,000 licenses needed across Department at $1,000 / license. 10,000 licenses X $1,000/lic = $10M* *Note, rather than being a distributed activity, this may be more likely a single large purchase at a point in time.*	IT, Divisions														0.00		$10,000,000	
2 - Project Delivery	6. Collab Platform	6.24	3- Long	2. Tools	CP.L.TT.02: Implement enterprise wide CDE to support BIM4I. *Assume this is already covered by ongoing training and normal delivery needs.*	IT, Divisions														0.00			

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2 - Project Delivery	6. Collab Platform	6.25	3- Long	3. Policy	CP.L.PP.01: Establish guidance and workflows for enterprise CDE implementation based on lessons learned from pilots. *Work in conjunction with Recommendation #8 Overall Process*	Collab: ALL														0.00			
2 - Project Delivery	6. Collab Platform	6.26	3- Long	3. Policy	CP.L.PP.02: Establish & publish enterprise workflows for CDE based on ISO 19650 standards. *Work in conjunction with Recommendation #8 Overall Process*	Collab: ALL														0.00			
2 - Project Delivery	7. 3D Models Vis.	7.01	1- Short	1. Org	Establish Visualization Steering/Advisory Committee and determine best location Planning, Environmental Analysis, Landscape Arch., Bridge Arch / Aesthetics, Construction, and Public Information Office *Assumes .40 PY per member (8)*	SME Group from HQ/DES + Districts with expertise													3	0.00			
2 - Project Delivery	7. 3D Models Vis.	7.02	1- Short	1. Org	Develop training and general guidelines/matrix *Assumes can be achieved with Visualization Task Force*	Visualization SME Group														0.00			
2 - Project Delivery	7. 3D Models Vis.	7.03	1- Short	2. Tools	Procure tools not currently under existing contracts (e.g. Autodesk-Infraworks)	DOD CADD Services														0.00		$100,000	
2 - Project Delivery	7. 3D Models Vis.	7.04	2- Mid	1. Org	Establish positions dedicated to visualization 1-3 PY per District or Region	Districts														0.00	10.0		
2 - Project Delivery	7. 3D Models Vis.	7.05	1- Short	1. Org	Establish positions dedicated to visualization 1-2 PY HQ/DES	HQ/DES	2			0										2.00			
2 - Project Delivery	7. 3D Models Vis.	7.06	2- Mid	1. Org	Expand upon existing training to create robust training program	Planning & Project Delivery														0.00		$300,000	
2 - Project Delivery	7. 3D Models Vis.	7.07	2- Mid	2. Tools	Fund A&E / Service Contract statewide	Planning & Project Delivery														0.00		$3,000,000	
2 - Project Delivery	7. 3D Models Vis.	7.08	2- Mid	3. Policy	Document an Information-delivery specifications for data exchanges between modelling and visualization systems in different project phases (K-Phase, 0 phase, 1-phase, etc..) Document examples and regulatory-agency specific best-practices for types of model visualizations that effectively satisfy regulatory agency needs / questions and support meetings / discussions	Planning, Landscape Arch,, Bridge Arch. Environmental Analysis, Planning, Public Information Office	0.25			0.25										0.50			
2 - Project Delivery	7. 3D Models Vis.	7.09	2- Mid	4. Data	Create a visualization library -- materials, objects, textures, infrastructure features (using pilot projects to populate the library)	Planning, Landscape Arch,, Bridge Arch. Environmental Analysis, Planning, Public Information Office	1.25			0.5						0.25				2.00		$100,000	
2 - Project Delivery	7. 3D Models Vis.	7.10	3- Long	2. Tools	Continue to Evaluate visualization tools															0.00		$25,000	

BIM4I INITIATIVE FINAL IMPLEMENTATION

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
2 - Project Delivery	7. 3D Models Vis.	7.11	3- Long	3. Policy	Establish guidelines for model preparation for visualization and the exchange requirements for infrastructure in Caltrans manuals Develop department policy for use of models in public outreach meetings and stakeholder engagement discussions / workshops	Planning, Landscape Arch,, Bridge Arch. Environmental Analysis, Public Information Office														0.00			
2 - Project Delivery	7. 3D Models Vis.	7.12	3- Long	4. Data	Expand a visualization library -- materials, objects, textures, infrastructure features (using pilot projects to populate the library)	Planning, Landscape Arch, Bridge Arch. Environmental Analysis, Public Information Office	0.25			0.25										0.50		$100,000	
2 - Project Delivery	8. Master Process	8.01	1- Short	2. Tools	Verify impact on PRSM, FALCON EDMS, Vision/essop (FY 23/24)															0.00			
2 - Project Delivery	8. Master Process	8.02	2- Mid	1. Org	Capture lessons learned to modify workflow from BIM4I pilot projects	BIM4I SMEs	0.1													0.10			
2 - Project Delivery	8. Master Process	8.03	2- Mid	3. Policy	Develop refined BIM4I workflow with a resourced cross-divisional team *Assumes .15 PY per division (10)*	BIM4I Program HQ, Design, PPM, DES, Construction	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2						1.50			
2 - Project Delivery	8. Master Process	8.04	2- Mid	3. Policy	Identify manuals that are impacted with BIM4I such as WSG, PDPM, PDWG, CADD Manual, PPM, Construction Manual, etc.	HQ, Design, PPM, DES, Construction		0.1	0.1	0.1	0.1	0.1								0.50			
2 - Project Delivery	8. Master Process	8.05	2- Mid	4. Data	Update PRSM and other software identified during short-term study *PYs are apart of an ongoing contract*	HQ – Project Management														0.00			
2 - Project Delivery	8. Master Process	8.07	3- Long	1. Org	Staff training for updated Workflow guidelines *Assumes this will be covered by existing training resources*															0.00			
2 - Project Delivery	8. Master Process	8.08	3- Long	1. Org	Develop training for updated policies and procedures	BIM4I Program HQ, Design, PPM, DES, Construction													0.5	0.00			
2 - Project Delivery	8. Master Process	8.09	3- Long	3. Policy	Continue and complete development of new BIM4I workflow with Cross Division Team	BIM4I Program HQ, Design, PPM, DES, Construction	0.15	0.15	0.15	0.15	0.15	0.15	0.1							1.00			
2 - Project Delivery	8. Master Process	8.10	3- Long	4. Data	Update PRSM and other software identified during mid-term study *PYs are apart of an ongoing contract*	HQ – Project Management														0.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	09. Verify & Measure	09.01	1- Short	1. Org	Develop training for digital construction inspection and development of District support trainers. Development of in- person and online training for staff. Developing tools, training, databases, acquiring servers. *Assumes 1 PY each from OLS and DOC with some support from DES SC and 0.5 PY per district and DES for train-the-trainers.*	HQ OLS, HQ DOC, DES SC		0.9	0.9	0.2										2.00	6.50	$1,000,000	
3 - Field	09. Verify & Measure	09.02	1- Short	1. Org	Training for Field Staff – 40-80 hours of training on relevant field equipment per staff member is anticipated. This will be a combination of web-based training and hands on field trainings *Assumes .04 PY per field staff @ 450 staff per year*	HQ OLS, HQ DOC, DES SC												2		0.00	18.00		
3 - Field	09. Verify & Measure	09.03	1- Short	2. Tools	Procure additional equipment for the use of field verification in 3D related project data. Estimating purchase of two Mobile Terrestrial Lidar Scanners (MTLS) every year until each District has it's own tool. Replacement on a 6 year cycle. These purchases will include the vehicle to hold the scanner, the scanner technology, and the processing/publishing software for the scanner. *Assumes 0.25 PY for Construction to manage their own portfolio*	HQ OLS / HQ DOC / DES SC			0.25											0.25			$2,000,000
3 - Field	09. Verify & Measure	09.04	1- Short	2. Tools	Procure additional equipment for the use of field verification in 3D related project data. Estimating purchase of 50 Terrestrial Lidar Scanners (STLS) for the purpose of building the initial need. In subsequent years this need will grow due to increased use of tools. *Assumes 0.25 PY for Construction to manage their own portfolio*	HQ OLS / HQ DOC / DES SC			0.25											0.25			$2,000,000
3 - Field	09. Verify & Measure	09.05	1- Short	2. Tools	Develop secure storage locations for Mobile Terrestrial Lidar Scanner (MTLS) vehicles. We will need to build two of these each year for the next 5 years.	HQ OLS / HQ DOC / DES SC		0.2	0.2	0.1										0.50			$200,000
3 - Field	09. Verify & Measure	09.06	1- Short	2. Tools	Procure 50 highspeed computers that will need to be replaced on a 3 year cycle. Cloud storage for MTLS data accounted for in Digital As-builts. *PY is for IT labor.*	HQ OLS / HQ DOC / DES SC / Design	0							0.5						0.50			$500,000
3 - Field	09. Verify & Measure	09.07	2- Mid	1. Org	Continue Training for Field Staff – 40-80 hours of training on relevant field equipment per staff member is anticipated. This will be a combination of web-based training and hands on field trainings *Assumes .04 PY per field staff @ 450 staff per year*	HQ OLS, HQ DOC, DES SC												2		0.00	18.00		

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	09. Verify & Measure	09.08	3- Long	2. Tools	Expansion of existing LiDAR technologies. Implementation of emerging remote sensing technologies.	HQ OLS / HQ DOC / DES SC			0.5											0.50			$1,000,000
3 - Field	10. AMG	10.01	1- Short	1. Org	Resource District AMG Coordinators/Support in each District. *One PY per district with some needing 2 based on capacity = 12-16 total.*	Districts, Construction, OLS														0.00	16.00		
3 - Field	10. AMG	10.02	1- Short	1. Org	Develop Design specific training for better understanding of complete AMG file delivery at the time of RTL.	Design w/ support from DOC and OLS	0.15	0.15	0.2											0.50			
3 - Field	10. AMG	10.03	1- Short	1. Org	Update training platform that field staff can use to understand technology used for AMG inspection/verification and keep up with technology changes (FY 22-23 and yearly thereafter) *1 PY for FY 22-23, then 0.25 PY ongoing after*	HQ DOC, HQ OLS			1											1.00			
3 - Field	10. AMG	10.04	1- Short	1. Org	Develop consistent yearly funding source for Caltrans Spatial Reference Network (CTSRN) expansion, modernization, and maintenance. Developing two CTSRN Administrators (2 PY) for the maintenance of systems and one PY for support of the building of new CTSRN stations. Two PY's focused at OLS for the CTSRN Administrators and one PY to share between OLS and DOC for the building of new stations.	OLS w/ support from DOC, OLS/D6, Realtime Verification and Measurement Subgroup	5													5.00			$1,500,000
3 - Field	10. AMG	10.05	1- Short	2. Tools	Develop consistent funding source for yearly procurement of new and replacement GNSS equipment for Construction staff to utilize in the field for digital construction inspection and AMG verification work (Yearly) *$1.5M per year to account for multiple tiers of equipment purchasing 50 units/year*	DOC w/ help from OLS			0.25											0.25			$1,500,000
3 - Field	10. AMG	10.06	1- Short	2. Tools	Conduct regular Datum adjustments and realizations by California Spatial Reference Center (CSRC) for support of AMG use (FY 22-23). *DPAC contract cost TBD*	OLS work w/ OLS Geodetic Coordinator DPAC contract, cost TBD	1													1.00			
3 - Field	10. AMG	10.07	1- Short	3. Policy	Develop a Deputy Directive or Director's Policy that identifies the roles and responsibilities as it relates to licensed engineers and licensed surveys use of digital terrain files for data capture and verification (relates to all forms of use of 3D model for AMG, UAS, digital as-builts).	DOC and OLS	0.125	0.125												0.25			
3 - Field	10. AMG	10.08	2- Mid	1. Org	Conduct AMG for Structures pilot to develop functionality of construction and inspection/verification of structures.	HQ DOC, HQ DES, HQ OLS	0.33	0.34	0.33											1.00			
3 - Field	10. AMG	10.09	2- Mid	1. Org	Conduct AMG 3D Milling and HMA and PCC paving pilots to develop functionality of construction and inspection/verification of paving operations.	HQ DOC, HQ OLS	0.5	0.5												1.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	10. AMG	10.10	2- Mid	2. Tools	Develop consistent funding source for yearly procurement of new and replacement GNSS equipment for Structure Construction staff to utilize in the field for digital construction inspection and AMG verification work. *Estimating 100 units needed throughout the state purchased at 20 units per year and a 5 year replacement cycle (Yearly)* *$1M per year*	Structures Construction w/ help from OLS				0.25										0.25			$1,000,000
3 - Field	11. eTicketing	11.01	1- Short	2. Tools	Pilot of DOTSlip (HaulHub) (ABD) *Assumes $10k for unlimited access*	Construction w/ help: IT, METS, Structures Construction														0.00	0.50	$10,000	
3 - Field	11. eTicketing	11.02	1- Short	2. Tools	Select platform to utilize following the pilot projects. Includes engagement with industry. (	Construction w/ help: METS, Structures Construction			0.25											0.25			
3 - Field	11. eTicketing	11.03	1- Short	2. Tools	Pilot of Connex (Command Alcon) (ABD) (Complete FY 22-23) *($15,000/project for 10 projects)*	Construction w/ help: METS, IT, Structure Construction														0.00	0.50	$150,000	
3 - Field	11. eTicketing	11.04	1- Short	3. Policy	New Specification, Construction Procedure Directive (CPD) and Construction Manual (CM) Update	Construction w/ help: METS, Structure Construction			0.25											0.25			
3 - Field	11. eTicketing	11.05	1- Short	3. Policy	Develop implementation plan and training for e-Ticketing	Construction w/ help: METS, Structures Construction			0.25											0.25			
3 - Field	11. eTicketing	11.06	1- Short	4. Data	Develop API of data transfer from e-Ticketing solution to applicable data servers for business functions (DIME, ProDMS, etc.). Include metadata development w/ data transfer.	Construction w/ help: IT, METS, Structures Construction			0.3				0.2							0.50			
3 - Field	11. eTicketing	11.07	2- Mid	1. Org	Implement e-Ticketing solution statewide (training complete, specification, CPD, CM update)	Construction w/ help: IT, METS, Structures Construction			0.2				0.05							0.25			
3 - Field	11. eTicketing	11.08	2- Mid	1. Org	Provide training for e-Ticketing solution statewide (Data Management, System Use, internal and external users)	Construction												1		0.00			
3 - Field	11. eTicketing	11.09	2- Mid	2. Tools	Procurement of e-Ticketing solution after pilot project identifies the preferred selection *$10,000/yr to $3,750,000/yr*	Construction w/help: IT, Legal, DPAC			0.25											0.25		$3,750,000	
3 - Field	11. eTicketing	11.10	2- Mid	3. Policy	Determine process to link e-Ticketing information with 3D model (digital as-built/AIM/digital twin/4D-5D model)	Construction, METS, Design w/ help: IT, Structure Construction			0.6	0.2			0.2							1.00			
3 - Field	12. UAS	12.01	1- Short	1. Org	Statewide Training - Staff time for training and “train the trainers” time. This goes along task that determines who should be trained by each Division/District. *Assumes 60 hours of training per person @ 500 people statewide*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others												20		0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	12. UAS	12.02	1- Short	2. Tools	Fleet Management - Procurement of fleet management software.	Aeronautics w/ support: DOC, DES, DEA, Surveys, Maint., others									0.5					0.50			$100,000
3 - Field	12. UAS	12.03	1- Short	3. Policy	Each Division to develop best practices and use cases for UAS for business needs. *Assumes .5 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, IT, and others		0.5	0.5	0.5		0.5	0.5	0.25	0.25	0.5	0.5			4.00			
3 - Field	12. UAS	12.04	1- Short	3. Policy	Revise survey request process and form to consider all stakeholders and data collection modes.	Surveys		0.5												0.50			
3 - Field	12. UAS	12.05	1- Short	3. Policy	Develop Division/District specific plans for who will utilize UAS as a new tool (i.e. specific office providing this service or staff trained in each office/unit that provide service for those functions). *Assumes 0.25 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others		0.25	0.25	0.25		0.25	0.25		0.25	0.25	0.25			2.00			
3 - Field	12. UAS	12.06	1- Short	3. Policy	Fleet Management - Develop process for managing drones through fleet software.	Aeronautics w/ support: DOC, DES, DEA, Surveys, Maint., others									0.5					0.50			
3 - Field	12. UAS	12.07	2- Mid	2. Tools	Procure processing software for various purposes. Caltrans use of UAS varies widely by Division. Additional enterprise software is needed to further develop uses. Procurement of software platforms such as Pix4D mapper, Trimble UAS Master, Datubim by Datumate, and others are needed to enable the full benefits of UAS platforms. *Assumes 0.25 PY per Division per year plus ongoing software cost*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others		0.6	0.6	0.6		0.6	0.3	0.3		0.5	0.5			4.00			$100,000
3 - Field	12. UAS	12.08	2- Mid	2. Tools	Procurement of UAS Hardware – Processing Servers for LIDAR and Photogrammetry Data. Current practices involve local processing of data, which is both slow, and cannot be easily backed up for compliance with data retention policies. A Central, High Bandwidth, High-Capacity Virtual Server processing system for processing point cloud, and lidar data is more efficient and will reduce the need for high end desktop computers. Data outputs from this system would be moved to the storage system described in Implementation Activity #2. *Assumes 0.5 PY per Division*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others		0.6	0.6	0.6		0.6	0.3	0.3		0.5	0.5			4.00			$500,000

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	12. UAS	12.09	2- Mid	2. Tools	Procurement of Drones - Set up LPA system to streamline acquisitions and define funding stream. Set up BCP to fund UAS hardware (estimated $3-4 million per year, further analysis will refine final numbers). *Assumes 0.5 PY per Division*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	0.5	0.5	0.5	0.5		0.5	0.5			0.5	0.5			4.00			
3 - Field	12. UAS	12.10	2- Mid	2. Tools	Procurement of Drones – Leverage LPA and funding streams to purchase equipment. *Assumes ~$3-4M (2K up to 300K per system and total need TBD)*	Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others														0.00			$4,000,000
3 - Field	12. UAS	12.11	2- Mid	4. Data	Procure/develop and implement a central repository for UAS data information. Centralized Server repository system will warehouse all UAS data captured to provide access to other users who may want access to aerial data. Current practices involve storage of large UAS datasets on individual computers. This makes the data vulnerable to loss and is not consistent with retention policies.	IT w/ support from DOC, Surveys, Design, DEA, Maintenance, DES, PAO	0.25	0.25	0.25	0.25			1	1						3.00			$500,000
3 - Field	12. UAS	12.12	2- Mid	4. Data	Develop a cross divisional group to determine the process for storing, sharing, and utilizing UAS data captures across phases and divisions. Determine processes, retention times for beneficial information (recommendation 2) *Assumes 0.25 PY per Division per year*	IT, Construction, Design, Environmental, Surveys, Maintenance, Engineering Services, and others	0.25	0.5	0.5	0.5		0.5	0.25	0.25	0.25	0.5	0.5			4.00			
3 - Field	12. UAS	12.13	3- Long	3. Policy	File for Grant funds available from Infrastructure Investment and Jobs Act (IIJA). *Assumes 0.25 PY per Division*	DRISI w/ support from other Divisions for specific information	0.25	0.5	0.5	0.5		0.25								2.00			
3 - Field	13. Digital As-Builts	13.01	1- Short	1. Org	Complete Digital As-Builts Pilots currently underway. (FY 22-23) Projects include: •03-3F5104 Timbuctoo •03-1H8604 Chico ITS •03-0F2804 SR99 CMGC •07- 323404 Box Culvert •11- 056374 Siempre Viva	HQ DOC w/ support: District Construction, HQ/District Office of Land Surveys, Structures Construction		0.2	0.6	0.2										1.00			
3 - Field	13. Digital As-Builts	13.02	1- Short	1. Org	Develop Training for District As-Built Coordinators	HQ DOC w/ support: Structures Construction, HQ OLS, Asset Management,		0.2	0.5	0.2			0.1							1.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	13. Digital As-Builts	13.03	1- Short	3. Policy	Start discovery process to develop asset extraction process, feature types, file formats, and manuals for features desired by Asset Management and Maintenance, and Structures Maintenance. *Assumes 0.5 PY per each of the 4 groups: Construction, Land Surveys, Structure Construction, and Structures PI. Assumes additional funding for AM and Mtce is not required.*	HQ DOC, HQ OLS, Structures Construction, HQ Asset Management, Maintenance, Structures PI		0.5	0.5	0.5			0.5								2.00			
3 - Field	13. Digital As-Builts	13.04	1- Short	3. Policy	Determine information that Structure Maintenance will use and add to digital as-built.	Structure Maintenance w/ support of DOC			0.2	0.3										0.50			
3 - Field	13. Digital As-Builts	13.05	1- Short	3. Policy	Develop workflow for data capture and storage for processing. •Establish data capture time periods •Functionality for data processing (hot vs. cold storage) •Retention period (hot vs. cold storage) •Estimate of storage per highway mile (40GB/lane-mile is current estimate) •Estimate of copies to be retained	HQ DOC, Structures Construction, HQ OLS	1	1	1	1										4.00			
3 - Field	13. Digital As-Builts	13.06	1- Short	4. Data	Establish working group to determine Digital As-Builts repository and long-term storage solution/s. Based off preliminary estimates we could expect more than 15 PB of storage for the state may be needed long term based on 386,000 lane miles @ 40 GB/mile. Storage would increase over time based on completed projects at a rate of ~350 projects per year. Much of this issue is based off the final workflow of 3D model capturing and workflow of retaining models and how many models are needed. There is need for a focused effort of cross functional groups to determine the workflows and ultimately determine future needs. *Assume 0.5 PYs per year per functional group* *Solution costs to be determined, likely significant (Millions per year), however according to a recent cloud storage quote from Autodesk, Project Delivery could be sustained for data storage needs at about $4.5M/year for approximately 6,000 users in the system. This would account for unlimited storage for any cold storage of project delivery data needs (i.e. digital as-built data, 3D model data, point cloud data, large imagery files, UAS data, etc.)*	DOC, IT, DES, OLS, Design, Asset Management, Legal	0.5	1	1	0.5			0.5	0.5							4.00			$4,500,000
3 - Field	13. Digital As-Builts	13.07	1- Short	4. Data	Determine data storage locations and capacity. •Single location for all data or multiple locations to cover roadway and structures as-builts. •Long-term vs. Short term storage. •Cloud or server storage. *Assumes 1-2 Pys*	IT w/ support: HQ DOC, Surveys, Structure Construction, Asset Management	0.25	0.25	0.25	0.25			0.5	0.5						2.00			
3 - Field	13. Digital As-Builts	13.08	1- Short	4. Data	Determine data accessibility, security, and data storage platform for digital as-builts.	IT, Legal, DOC	0.25		0.25					0.5						1.00			
3 - Field	13. Digital As-Builts	13.09	2- Mid	1. Org	Develop (Additional) Training for District As-Built Coordinators.	DOC w/ Support: Surveys, Structures Construction		0.1	0.3	0.1										0.50			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	13. Digital As-Builts	13.10	2- Mid	1. Org	Establish Digital As-Builts coordinator in every District (12), DES Structure Construction (1), and Office of Land Surveys (1). There is a possibility this need will grow to 20+ PYs depending on Districts' abilities to accomplish the work with one team member. This role may start in Construction but ultimately will support all Project Delivery. *Assumes 12-20+ PYs statewide*	DOC w/ Support: District Construction, Surveys, Structures Construction		0.5	1	0.5											2.00	12.00		
3 - Field	13. Digital As-Builts	13.11	2- Mid	2. Tools	Pilot and acquire Digital As-Builts visualization platform and process (evaluation of ArcGIS, Quadri, Autodesk Build etc.) *Assumes 1+ PY + assistance from Visualization group, $200,000 for software licensing*	HQ DOC w/ support: HQ IT, HQ DES, HQ OLS		0.1	0.8	0.1										1.00		$200,000	
3 - Field	13. Digital As-Builts	13.12	2- Mid	2. Tools	Procurement of solution following pilot projects. *~$400,000/yr for solution*	DOC w/ support: DPAC, IT, Structures			0.5											0.50			$400,000
3 - Field	13. Digital As-Builts	13.13	2- Mid	3. Policy	Development and integration of Asset Information Model feature code library. Develop a unified feature code library that will fit the needs of all stakeholders (Design, Asset Management, Surveys, Construction, Structures Construction). This ensures data standardization. *8 Staff @ .25 PYs Each*	HQ OLS, HQ DOC, HQ DES, HQ Asset Management		0.5	0.5	0.5			0.5							2.00			
3 - Field	13. Digital As-Builts	13.14	2- Mid	3. Policy	Develop digital as-builts policies, procedures, and manuals for implementation *1-2 PYs*	HQ DOC, HQ OLS with Support	0.5	0.5	0.5	0.5										2.00			
3 - Field	13. Digital As-Builts	13.15	2- Mid	3. Policy	Determine information Asset Management will extract from digital as-built to assist DOC in capturing correct information.	Asset Management w/ support of DOC			0.1				0.4							0.50			
3 - Field	13. Digital As-Builts	13.16	2- Mid	3. Policy	Determine information Traffic Operations will extract from digital as-built to assist DOC in capturing correct information.	Traffic Ops w/ support of DOC			0.1							0.4				0.50			
3 - Field	13. Digital As-Builts	13.17	2- Mid	3. Policy	Determine information Planning and Environmental will need captured and retained in the digital as-built to have available for the next project in vicinity.	Transportation Planning and Environmental w/ support of DOC			0.1			0.4								0.50			
3 - Field	13. Digital As-Builts	13.18	2- Mid	3. Policy	Develop implementation plan and CPD to implement digital as-built process on all projects completing after a certain date	DOC			0.5											0.50			
3 - Field	13. Digital As-Builts	13.19	2- Mid	3. Policy	Implement digital as-built process on all projects that will complete Construction Contract Acceptance (CCA) after a certain date	DOC w/ support: Surveys, Structures Construction	0.5	0.5	1	0.5			0.5							3.00			

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	14. GIS	14.01	1- Short	1. Org	Establish cross-functional GIS Task Force, including Design, Construction, Surveys, Environmental, Right of Way, Maintenance, Asset Management, Planning, Traffic Ops, Engineering Services, Information Technology Some participation needed immediately and some after pilot project completion).Team should consist of a combination of HQ and District SME's who understand GIS and have a general understanding of the Project Delivery process. *Assumes 0.15 PY per division – per year (10) = 1.5 PY's per year for a Total of 7.5 PY's*	Aaron Ott for Chad Baker		0.15	0.15	0.15		0.15	0.3	0.15	0.15	0.15	0.15			1.50			
3 - Field	14. GIS	14.02	1- Short	2. Tools	Establish Common Storage Environment *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field	14. GIS	14.04	1- Short	3. Policy	Establish Standards - - - - Establish Standards -Branding -Database size and scope -Findable data -Accessible data (immediate to 3 years) *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field																							
3 - Field	14. GIS	14.06	1- Short	3. Policy	Identify Workflows -Data interoperability (Crosswalks) -Maintenance oEssential data layers and database interoperability -Operations oEssential data layers and database interoperability -Planning oEssential data layers and database interoperability 1-3 years *Assumes resources are provided by the Task Force*	Task Force														0.00			
3 - Field					Identification of essential data layers and databases																		

BIM4I INITIATIVE FINAL IMPLEMENTATION PLAN

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	14. GIS	14.08	2- Mid	1. Org	Project Delivery GIS/Data Organization Structure Critical Functions -Classifications -Central unit or decentralized staff imbedded in production units to perform work *(Immediate for determination of structure* *1 to 3 years for implementation of approved structure)*	Task Force		0.25	0.25	0.25		0.25	1							2.00	12.00		
3 - Field	14. GIS	14.09	2- Mid	2. Tools	Develop web applications that would enhance the BIM41 project delivery process *(1 year to 5 years)*	Task Force														0.00			
3 - Field	14. GIS	14.10	2- Mid	2. Tools	Ensure combability with systems currently under development Transportation Asset Management System (TAMS) -Others *(1 year to 5 years)*	Task Force														0.00			
3 - Field	14. GIS	14.11	2- Mid	3. Policy	Identify Caltrans Best Practices and Lessons Learned	Task Force														0.00			
3 - Field	14. GIS	14.12	2- Mid	3. Policy	Workflows -K Phase (PID) oEssential data layers and database interoperability -0 Phase (PA&ED) oPublic Meetings Visualizations oEssential data layers and database interoperability -1 Phase (PS&E) oData model information sharing standards oEssential data layers and database interoperability -2 Phase (Right of Way) oParcel Fabric -3 Phase (Construction) oEssential layers updated from digital as-builts oSharing standards with asset management and maintenance oDatabase interoperability *(1 year to 5 years)*	Task Force														0.00		$200,000	$100,000
3 - Field	14. GIS	14.13	2- Mid	3. Policy	Change Management *(Immediate to 5 years)*	Task Force														0.00			
3 - Field	14. GIS	14.14	2- Mid	3. Policy	Tasks discovered during implementation *(Immediate to 5 years)*	Task Force														0.00			
3 - Field	15. 4D-5D Models	15.01	1- Short	1. Org	Industry Working Group to: Combined with other sub teams to Meet with Construction industry (include IT) *(1 year)* *.15 PY per member (8) = 1.2 PY's*	HQ Construction and Structures Construction			0.5	0.5				0.2						1.20			
3 - Field	15. 4D-5D Models	15.02	1- Short	2. Tools	Software (licensing and maintenance) e.g. Navisworks, Synchro, or other Increased support for CADD to manage all the software – centralize *1-2 PY, Considers 40 licenses -- 12 districts x 3 licenses to cover district construction and structure construction = 36 licenses* *4 licenses for HQ construction*	IT IT Legal DPAC CADD Construction	1.25		0.25	0.25				0.25						2.00			$100,000
3 - Field	15. 4D-5D Models	15.03	1- Short	3. Policy	Prepare new Spec for 4D/5D (potentially new section) *(1 year)*	Construction			0.5											0.50			
3 - Field	15. 4D-5D Models	15.04	2- Mid	1. Org	Continue collaboration with Industry Working Group Combined with other sub teams to Meet with Construction industry (include IT) *Covered in Short term*	HQ Construction and Structures Construction														0.00			

Category	Sub Team	Action ID	Timeframe (S, M, L)	Component Org, Tools,Policy, Data	Action/Deliverable	Resp. Party	Design	ROW & Land Surveys	Construction	DES	PM	Enviornmental	GIS	IT	Planning	Traffic Ops	Maintenance	Training	Committee	Corp. PY Per Year	Dist. Support PY Per Year	$OE One Time	$OE 2 Annual Ongoing
3 - Field	15. 4D-5D Models	15.05	2- Mid	2. Tools	Maintain Software *Considers increase based on inflation. This inflation impact is to be determined in the midterm timeframe*	Construction, IT														0.00			$105,000
3 - Field	15. 4D-5D Models	15.06	2- Mid	3. Policy	Pilot project with 3D project: multiple staff across multiple divisions *Assumes 4-5 PY include this in the pilot resource sub-team resources*															0.00	5.00		
3 - Field	15. 4D-5D Models	15.07	2- Mid	3. Policy	Have requirements for how final pay items are handled in the estimation model (5D). *Policy to be wrapped up in mid-term*	Construction/ OE			0.3	0.2										0.50			
3 - Field	15. 4D-5D Models	15.08	2- Mid	3. Policy	Specification update a.Spec: Bid Item: Ensure Contractor software is IFC (Industry Foundation Class) compliant *Policy to be wrapped up in mid-term*				0.5											0.50			
3 - Field	15. 4D-5D Models	15.09	3- Long	1. Org	Software Training (4D/5D only – reoccurring annually) •Construction group •DES •OE •Structure Design •Structure Construction Further investigation: •Who will be trained? All staff? RE's? *1-2 years – will taper off over time* *PY (Needs further investigation – assuming 3-4 in HQ, 1-1.5 per district) Use Civil 3D as model for resources* *Also: service contract*	Vendors Construction / Structures Construction														0.00			$200,000
3 - Field	15. 4D-5D Models	15.10	3- Long	2. Tools	For all procured software, there should be allocated funds for renewal and maintenance of the software. *Considers increase based on inflation. This inflation impact is to be determined in the long-term timeframe*															0.00			$110,000

APPENDIX C: TERMS AND DEFINITIONS

Terms used in this BIM Execution Plan adhere to the ISO 19650 suite of BIM Standards. The definitions of terms can be found on the ISO's online browsing platform at the link:

https://www.iso.org/obp

List of Acronyms

Acronym	Term
AGC	Associated General Contractors
AIM	Asset Information Model
AMG	Automated Machine Guidance
AR	Augmented Reality
BCM	Bridge Construction Memos
BEP	BIM Execution Plan
BIM	Building Information Modelling
BIM4I	BIM For Infrastructure
BIRIS	Bridge Inspection Records Information System
C3D	Autodesk Civil 3D Software
CADD	Computer Aided Design and Drafting
CCO	Contract Change Order
CDE	Common Data Environment
CFD	Contract for Delivery
CMGC	Construction Manager General Contractor
COS	Capital Outlay Support
CSRC	California Spatial Reference Center
CSV	Comma Separated Values
CTSRN	Caltrans Spatial Reference Network
CUD	Caltrans Utility Database
DDM	Digital Design Model
DDXX	Deputy Directive #XX
DAB	Digital As-Built
DEA	Division of Environmental Analysis
DES	Division of Engineering Services
DIME	Data Interchange for Materials Engineering
DLT	Distributed Ledger Technology
DRS	Document Retrieval System
DTM	Digital Terrain Model
EDMS	Electronic Document Management System
EOR	Engineer of Record

Acronym	Term
GDO	Geospatial Data Officer
GIS	Geographic Information Systems
GNSS	Global navigation satellite system
GPR	Ground Penetrating Radar
HDM	Highway Design Manual
HQ	Caltrans Headquarter Office
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
IQA	Independent Quality Assurance
ISO	International Standards Organization
IT	Information Technology
LIDAR	Light Detection and Ranging
LOD	Level of Development
LOTB	Log Of Test Boring
MIDP	Master Information Delivery Plan
MPDT	Model Production Delivery Table
MPO	Metropolitan Planning Organizations
NTB&SP	Notice to Bidders and Special Provisions
PA&ED	Planning Approval & Environmental Document
PDPM	Project Development Procedure Manual
PDT	Project Delivery Team
PE	Project Engineer
PID	Project Initiation Document
PIG	Preliminary Investigations Group
PIM	Project Information Model
PIO	Public Information Office
PIP	Project Implementation Plan
PPM&OE	Program/Project Management and Office Engineer
PS&E	Plans, Specifications, & Estimate
RAM	Random Access Memory
RFI	Request for Information
RE	Resident Engineer
REF	Resident Engineer File
ROW	Right-of-Way
RTL	Ready To List
QA/QC	Quality Assurance/Quality Control
QMP	Quality Management Program
SEF	Survey Engineer File
SME	Subject Matter Expert
SUE	Subsurface Utility Engineering
TAMS	Transportation Asset Management System

Acronym	Term
TIDP	Task Information Delivery Plan
TIN	Triangular Irregular Network
UAS	Unmanned Aerial System
UEW	Utility Engineering Workgroup
UFS	Caltrans Uniform Filing System
VDC	Virtual Design & Construction

APPENDIX D: VALUE ANALYSIS (VA) STUDY PROCESS

The Caltrans VA process involves 16 activities needed to accomplish a VA study, organized in three parts: Pre-study, VA Study, and Report.

The following provides an overview of the Caltrans approach to VA for capital projects, processes, policies, or other organizational focuses. The Caltrans VA Study Activity Chart at the end of this narrative identifies the steps in each activity, which are detailed as follows. Depending on the focus of the VA Study, tools and techniques from each step are selected and utilized to achieve the desired product. Therefore, while the Value Methodology is always used, each project may not require each activity described below.

PRE-STUDY

Meaningful and measurable results are directly related to the pre-study work performed. Depending on the type of study, all or part of the following information needs to be determined during the pre-study phase:

- Clear definition of the current situation and study objectives
- Identification of study team members
- Identification of project partners and interested parties
- Definition of how partners are impacted by the project
- Identification of key issues and concerns
- Identification of project's performance requirements and attributes
- Status of project cost estimate, if applicable
- Project data gathered to be distributed to VA team

In preparation for the VA study, the team leader confers with the Steering Committee, Project Manager, and/or other project leadership representatives to outline the VA process, initiate data gathering, refine project scope and objectives, structure the scope and team members and technical specialists, and finalize study plans. Specific deliverables are provided as needed.

VA STUDY

The VA Job Plan guides the VA team in their search to enhance value in the project or process. Caltrans follows a seven-phase VA Job Plan:

1. Information Phase
2. Function Analysis Phase
3. Creativity Phase
4. Evaluation Phase

5. Development Phase
6. Presentation Phase
7. Implementation Phase

Information Phase

At the beginning of a capital project VA study, the design team presents a more detailed review of the design and the various systems. This includes an overview of the project and its various requirements, which further enhances the VA team's knowledge and understanding of the project. The project team also responds to questions posed by the VA team. The project's performance requirements and attributes are discussed, and the performance of the baseline concept is evaluated. The kickoff point of a Process study may differ somewhat depending on the process, procedure, or other organizational element being analyzed. This could include survey or interview data gathering, workshop-based process mapping, or other means of understanding the current state of the study's focus.

Function Analysis Phase

Key to the VA process is the function analysis techniques used during the Function Analysis Phase. Analyzing the functional requirements of a project is essential to assuring an owner that the project has been designed to meet the stated criteria and its need and purpose. The analysis of these functions in terms cost, performance, time, and risk is a primary element in a VA study and is used to develop alternatives or recommendations for change. This procedure is beneficial to the VA team, as it forces the participants to think in terms of functions and their relative value in meeting the project's need and purpose. This facilitates a deeper understanding of the project or process being reviewed.

Creativity Phase

The Creativity Phase involves identifying and listing creative solutions to address functional needs. During this phase, the VA team participates in brainstorming or other ideation sessions to identify as many means as possible to provide the necessary project functions. The judgment of the ideas is not permitted in order to generate a broad range of ideas.

Evaluation Phase

The purpose of the Evaluation Phase is to systematically assess the potential impacts of ideas generated during the Creativity Phase relative to their potential for value improvement. Each idea is evaluated in terms of its potential impact to performance, cost, time, and risk. Once each idea is fully evaluated, it is given a rating based on an agreed upon scale. For this project, ideas were thoroughly discussed and organized into several categories: items to be developed, dismissed, or determined that they were already being done. Note: Due to the magnitude and breadth of the BIM for Infrastructure scope, this report contains only those ideas and recommendations for focus areas that were identified for development and recommended for implementation.

Development Phase

During the Development Phase, the highly rated ideas are expanded and developed into VA alternatives or recommendations (note these terms are used interchangeably herein). The development process considers the impact to performance, cost, time, and risk of the alternative concepts relative to the baseline concept. This analysis is prepared as appropriate for each alternative or recommendation, and the information may include a performance assessment, initial cost and life cycle cost comparisons, schedule analysis, and an assessment of risk. Each recommendation herein describes the baseline concept, proposed changes, anticipated benefits, implementation considerations including resource implications, potential challenges, and the organization's functional groups that would be involved and/or impacted. Calculations are also prepared for each recommendation as appropriate.

Presentation Phase

The VA study concludes with a preliminary presentation of the VA team's assessment of the project and VA alternatives. The presentation provides an opportunity for the owner, project team, and stakeholders to preview the alternatives and develop an understanding of the rationale behind them.

Implementation Phase

After the stakeholders have had an opportunity to review the alternatives identified by the VA team, the team leader conducts an implementation meeting to discuss the alternatives and resolve appropriate action for each VA alternative. If necessary, any other VA report edits requested by the representatives are also made by the VA team leader and a final report is issued.

This implementation meeting helps to ensure that savings or process improvements are not lost due to lack of communication, and that those VA alternatives that are accepted are properly integrated into the project design.

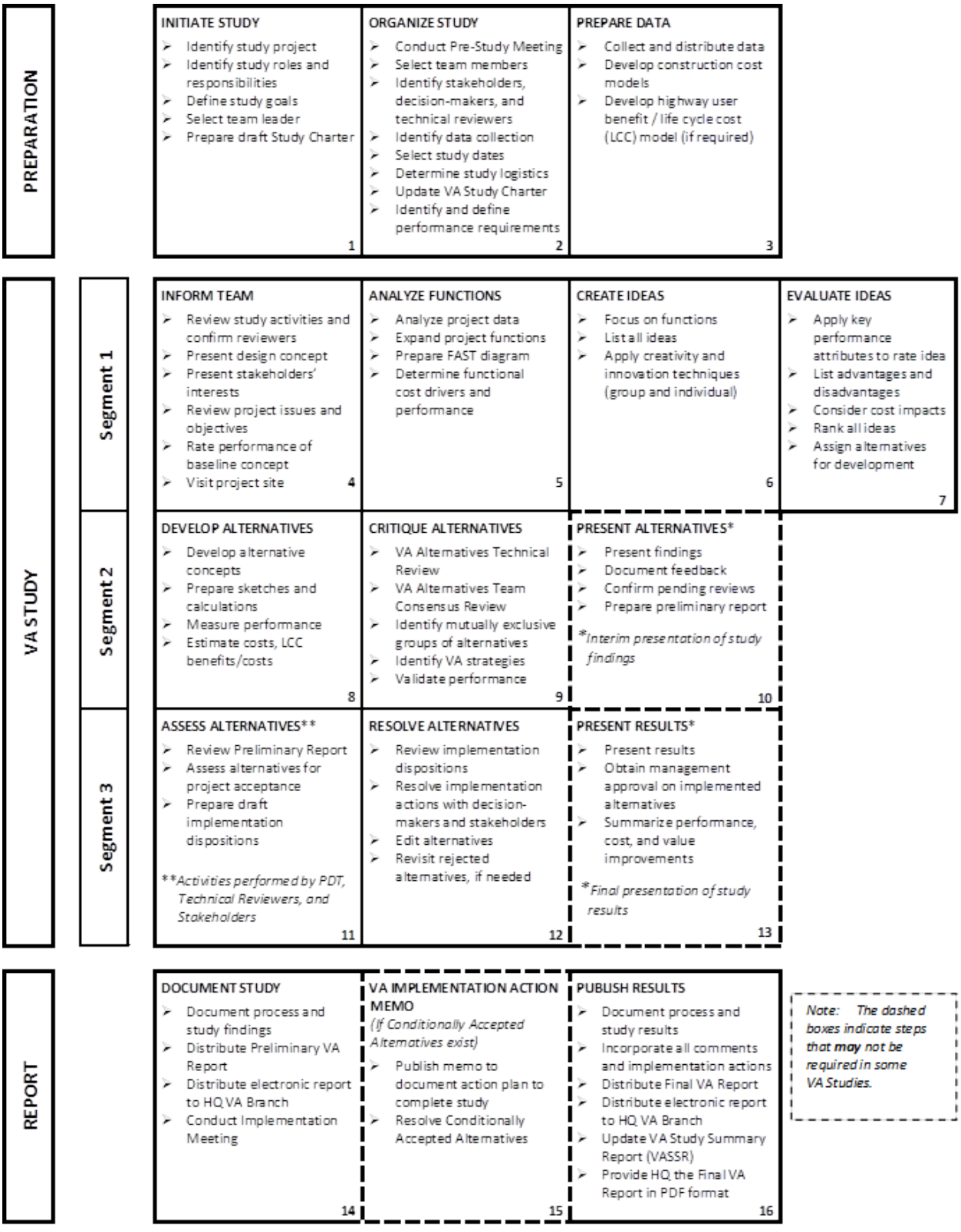
VA REPORT

Preliminary Report: Following the completion of the VA study, the team leader compiles the information developed during the VA study into the *Preliminary Value Analysis Study Report*. This report, documenting viable alternatives, is provided to the customer within the timeframe requested.

Final Report: Once all VA alternatives have been either accepted or rejected, the team leader updates the *Preliminary Value Analysis Study Report* to show the final results of the study in a *Final Value Analysis Study Report*.

The following Caltrans VA Study Activity Chart describes each activity.

CALTRANS VA STUDY ACTIVITY CHART



APPENDIX E: PROJECT CHARTER

Virtual Design and Construction Initiative (BIM- Infrastructure) Committee and Team Charter

Background	Rapid development of information technologies is transforming how information is produced, shared, exchanged, and managed throughout a project's life cycle. This transformation is accelerating in DOTs across the country due to the pressing need for efficient ways of delivering transportation projects and an enhanced need for collaboration internally and externally. Caltrans rolled out a new Strategic Plan and one of the strategic goals is focused on Stewardship and Efficiency. The Caltrans Project Delivery Program has launched an initiative to Implement Virtual Design and Construction (VDC), more widely known in the industry as Building Information Modeling (BIM) – Infrastructure and/or Advanced Digital Construction (ADC) systems. Caltrans primarily develops and constructs transportation improvement projects by creating two-dimensional plan sheets to represent the design of the project that is built in the three-dimensional real world (3D). Even though Caltrans Surveying and Mapping has been providing 3D data for approximately 20 years, recent advances in engineering and project management software make it possible for the transportation industry to utilize the VDC approach used in other civil engineering sectors and employ VDC in the design and construction of roadways, bridges, and other transportation infrastructure. Data and products developed for capital improvement projects, used in the VDC approach, become transportation assets to be maintained by the owner and operator of the State's transportation system. VDC will share information from various programs and stakeholders in a 3D virtual world. This visual and digital representation of the design, as it is proposed to be built, over time, will establish an environment that enables decision makers to have better information available on which to base their decisions and develop projects that can be designed and constructed safer, in less time, for less money, and with higher quality. Benefits of a fully functional VDC implementation include: • Improve safety (ex. AMG) • Reduce design errors, modifications, and construction conflicts • Reduce printing and paper use to support the Department's Sustainability Program • Expand Best Practices throughout the Department by standardization of document management. • Automate document workflow and notifications

	• Digitize approval processes and electronic signatures • Share, transfer, and collaborate digital data and documents internally and externally • Automate document archiving with built-in record retention schedules • Attract and retain a diverse innovative workforce • Lower bids by providing enhanced project information • Improve multi-disciplinary collaboration • Enhance review of complex projects • Detect construction, utility, and other conflicts (Clash Detection) • Increase efficiency and productivity • Improve Asset Management • Improve Subsurface Utility Engineering • Reduce Construction claims • Lower Capital Outlay Support Costs • Reduce project development risk • Improve decision making through better information
Purpose	Stewardship and Efficiency. Implement Virtual Design and Construction techniques and products into Caltrans' transportation project workflow that results in project development efficiencies, enhanced collaboration, reduced delivery risk, and improves asset management information. The VDC approach develops a cyclical process of continuous improvement and state of the practice knowledge base that will generate a more seamless process for designing, constructing, and maintaining roadway infrastructure.
Desired Goals	• Implement model-based project delivery workflow to achieve digital delivery of project plans, specifications, estimates, construction, construction administration and as-builts into a 360-degree living model concept. • Go paperless from inception to completion and deliver a 3D Model as the Legal Construction Contract Document for appropriate projects in 1-3 years, utilizing phased implementation.
Expected Deliverables	Develop and deploy an implementation plan that includes the following components:

	• An integrated workflow model including all aspects of 3D modeling for all appropriate groups within the department showing inputs and outputs from project inception to asset management
	• Timelines and resource needs for phasing in VDC implementation in the COS program
	• Prioritize the techniques that should be implemented or piloted first based on existing equipment and software already in use by the department (i.e. Civil 3D, MicroStation, LiDAR)
	• Identify additional VDC hardware, software, and IT infrastructure needs, gaps, and deployment challenges
	• Expand the use of on-going VDC efforts (i.e. AMG, LiDAR, 3D modeling, visualization, Subsurface Utility Engineering, e-Construction, Asset Management, Electronic Document Management System, Intelligent Compaction)
	• Enhance Constructability Reviews
	• Identify Pilot Projects to implement elements of VDC
	  ○ Generate a 3D Building Information Model (BIM) for bridge and structures components
	  ○ Create an integrated multi-disciplinary 3D model for highway project
	  ▪ Roadway
	  ▪ Utilities, structures, drainage, and more as applicable
	  ○ Integrate the bridge & structures BIM with highway 3D models
	  ○ Evaluate existing software and databases and align with new industry standards for VDC
	  ○ 3D construction inspection methods
	  ○ Digital As-builts
	• Procure additional and replacement data collection platforms/equipment
	  ○ Aging Mobile Terrestrial LiDAR scanning system SS equipment and drones

Sponsors	Donna Berry, Chief Engineer (Acting) Amarjeet Benipal, Director, District 3 George Akiyama, Chief Information Officer
Champions	Tim Greutert, Chief, Division of Construction (Acting) Janice Benton, Chief, Division of Design

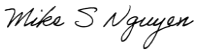
	Tom Ostrom, Chief, Division of Engineering Services (DES) Kimberly Erickson, Chief, Division of Right-of-Way and Land Surveys (RWLS) Karl Dreher, Chief Deputy, North Region Jeff Wiley, Chief, Division of Project Management (Acting) Ramon Hopkins, Chief, Division of Environmental Analysis (Acting) Mike Nguyen, Chief, Infrastructure Management Division
Steering Group	Paul Chung, Division of Design (Lead) Raymond Tritt, Division of Construction Gudmund Setberg, DES Scott Martin, RWLS Helena Lenka Culik-Caro, District 4 Jamal Elsaleh, District 8 Carlos Portillo, North Region Sang Hoong, IT
External Stakeholder Group	Construction Industry FHWA Software Vendors/BIM Industry A&E Consultant Other State DOT's VDC experts
Committee Members	Jesus Mora Chair, VDC Program Manager Devin Porr, Division of Construction Cathy Kurtz, Division of Design, CADD John Lammers, DES, Structures Construction Elias Kurani, DES, Bridge Design Mina Pezeshpour, DES, Bridge Design Doug Nguyen, DES, Office Engineer Scott Williams, Division of Environmental Analysis Rich Williams, Division of Project Management JC Hamilton, Information Technology Chad Baker, Geospatial Data Officer Said Ismail, Division of Traffic Operations Camille Abou-Fadel, Division of Maintenance Ron Tollison, North Region, Design Austin Bossetti, District 4 Dave Olander, District 11 Surveys William Pilkington, North Region, Surveys Issam Abumuhor, District 7 Construction

Subcommittee Subject Matter Experts (SMEs)	Construction: Aaron Chamberlin and Robert Nagy Design: Christopher Fugitt Structure Construction: Elpidio Perez Structure Design: Lynn Hiel Office Engineer: Aaron Daniels Environmental Analysis: As Needed Project Management: Anthony Perry Land Surveys: Chris Thornton and Mark Counts Information Technology Legal: Jeffrey Knox District SME's Asset Management
Frequency of Meetings	Sponsors: • Quarterly Champions & Steering Group: • Monthly Committee: • As needed, minimum Monthly Technical SMEs & Sub-Committees: • As Needed
Roles & Responsibilities	**Champions:** • Provide leadership • Define scope • Provide oversight and direction to team activities • Provide final timely reviews, feedback and approvals on team activities and deliverables • Participate in briefings and decision meetings • Review and approve recommendations • Champion the recommended changes • Provide necessary resources to accomplish objectives and deliverables • Resolve issues **Steering Group:** • Ensure scope and objectives are adequately stated and sized • Provide guidance and direction to the Committee • Communicate corporate issues and priorities • Provide final review of deliverables

	• Participate in briefings and decision meetings • Validate Committee recommendations • Resolve issues **Committee Chair:** • Facilitates committee meetings (arranges agenda, logistics, venue, produces minutes and action items) • Develop a delivery workplan and track and report team progress timely to the Steering Group and Champions • Serves as point of contact for statewide exchange of information to the team • Liaison between the committee and others • Attempts to resolve issues and elevates as necessary • Work with the Committee to clearly define assumptions and risks for a successful outcome and collaborate with the Steering Group on these items • Work with the Steering Group and Champions to ensure members are actively engaged and participate **Committee:** • Identify business requirements (i.e., workflows, notifications, version control, approval process, electronic signatures, automatic document archiving, etc.) • Review and evaluate vendor VDC products • Develop, support, and oversee VDC test pilots in Districts and Headquarters • Seek outside support and input from external entities • Track progress, results, and evaluations of each Project Delivery test pilot for analysis • Report of findings and recommendations on system that best meets Caltrans VDC needs to deploy VDC • Assist in the management of organizational change • Devote the necessary time and thought to fully participate in team activities (i.e. Meetings, implementation plan, training or work sessions, preparation, and presentation of findings) • Fairly and equitably represent the interests and operation of all functions to ensure the best possible decision making • Track and investigate other DOT efforts • Collaborate with External Stakeholder Group

	Technical SME Subcommittee: • Define/refine roles and responsibilities of task-related work • Collect and analyze data • Investigate various issues, functions and/or processes • Conduct related research as needed • Identify risks and alternatives to mitigate them • Make presentations of findings and/or results • Generate and develop recommendations for change • Integrate feedback on deliverables from Sponsors, Champions, Steering Group, and Committee members • Advocate proposed recommendations • Promote and support VDC activities • Assist in District and/or Headquarters training
Reporting Structure	• Technical/External/District Subcommittees will report to the Committee through updates, recommendations, and support materials • Committee will brief Steering Group and Champions regularly on the progress
Decision Process	• VDC Technical Subcommittees, External Advisory Subcommittees, and District Subcommittees present advice and recommendation to Committee • Committee reviews, decides by majority vote if consensus cannot be reached, and makes recommendations under the guidance from the Steering Group • Champions review and make decisions on recommendations and informs the Sponsors for concurrence.
Amendment	• As needed, recommended by the Steering Group and approved by the Champions and Sponsors
Target Completion Date	A workplan that includes sub team target completion dates should be developed for each sub team and consolidated into an over all plan.

This charter is hereby adopted on March 14, 2022.

Champion Signature	Name
	Janice Benton, Chief, Division of Design
	Tim Greutert, Chief, Division of Construction (Acting)
	Tom Ostrom, Chief, Division of Engineering Services
	Kimberly Erickson, Chief, Division of Right-of-Way and Land Surveys
	Jeff Wiley, Chief, Division of Project Management (Acting)
	Karl Dreher, Chief Deputy, North Region
	Ramon Hopkins, Chief, Division of Environmental Analysis (Acting)
	Mike Nguyen, Chief, Infrastructure Management Division

Sponsor Signature

	Donna Berry, Chief Engineer (Acting)
	Amarjeet Benipal, Director, District 3
	George Akiyama, Chief Information Officer