DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

# Cross-Asset Multi-Objective Optimization Approach for Caltrans SHOPP Project Programming

Development, validation, and demonstration of a performance-based cross-asset optimization methodology to support infrastructure programming and budgeting.

Executive

JULY 2021

**Project Title:**
Cross-Asset Multi-Objective Optimization Approach for Caltrans SHOPP Project Programming

**Task Number:** 3631

**Completion Date:** July 27, 2021

**Task Manager:**
Lee Hicks
Senior Transportation Engineer
lee.hicks@dot.ca.gov

## WHAT WAS THE NEED?

As part of its business strategy to enhance transportation asset management (TAM), Caltrans needs to develop cross-asset optimization decision models to support the prioritization and optimal programming of projects across all highway system assets. These models should support effective allocation of limited funds among competing projects to meet a range of performance and financial constraints, and achieve organizational objectives and performance targets.

## WHAT WAS OUR GOAL?

The objective of this project was to develop and demonstrate a cross-asset optimization methodology to help Caltrans optimize project selection and budget allocations, maximize the value of investment, and optimally achieve performance objectives by directing investments where most needed.

## WHAT DID WE DO?

A novel cross-asset optimization methodology was developed and demonstrated through the application to State Highway System (SHS) bridges and pavements. Based on robust multi-objective optimization algorithm, the methodology integrated asset-level, system-level, and program-level analyses in a single framework to support efficient workflows between inter-dependent decision processes.

The proposed methodology integrated Caltrans' existing project-level Multi-objective Decision Analysis (MODA) model into a holistic framework for trade-off analyses and optimal development and management of programs and budgets across the entire transportation asset portfolio. The methodology defined several techniques for selecting optimal treatment types and timing, performance and risk modeling, analyzing what-if scenarios, performing capital versus maintenance investment trade-off analysis, optimizing budget distribution among different asset classes, and performing bundling analysis.

Implementation of the methodology was supported using a software tool, called Asset OptimizerTM. Asset OptimizerTM is a cloud-based AI-powered geo-enabled cross-asset optimization and decision analytics platform that implements various components of the proposed methodology. The software implements a comprehensive data model that embodies key data elements and relationships needed to model and analyze assets data, needs, lifecycle performance, and programming and budgeting decisions.

## WHAT WAS THE OUTCOME?

A robust cross-asset performance-based optimization methodology has been developed to support TAM programming and budgeting decisions and processes. The methodology has been validated by developing programs for Caltrans State Highway System (SHS) bridges and pavements inventory. The methodology was also demonstrated to be applicable to other transportation asset classes.

Analyzing assets at the portfolio level provided the opportunity to find investment and work efficiencies through bundling of treatments and coordination of program development, management, and project delivery processes across different asset classes. Bringing a broader perspective to the portfolio planning process over longer planning horizons help maximize the value of infrastructure investments.

Future research can include actual implementation of the methodology and associated software tool to support lifecycle planning, programming, and budgeting decisions at a sample of districts, and demonstrate the process of project portfolio nomination, advancement, and management throughout the program development and delivery workflow.

## WHAT IS THE BENEFIT?

The cross-asset optimization methodology and associated software tool can potentially support programming and budgeting decisions at Caltrans and other DOTs in a number of ways, such as:

- Efficient development and management of programs and budgets across the entire transportation asset portfolio.
- Identification of optimal budget allocation and balanced investment strategies to meet performance objectives and ensure long-term sustainability of assets.
- Quantify trade-offs between funding levels and performance measures for different asset classes and groups, across the entire asset portfolio.
- Implementation of common performance management, lifecycle models, trade-off analyses, and programming decision models across different districts, thus promoting consistency and transparency in project evaluations, and establishing a quantitative, data-driven, and repeatable process.

## IMAGES

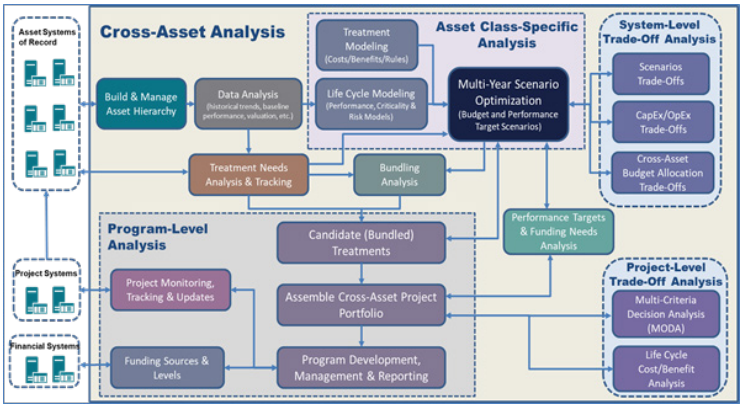


Image 1: Schematic of the main processes and information flow in the proposed methodology

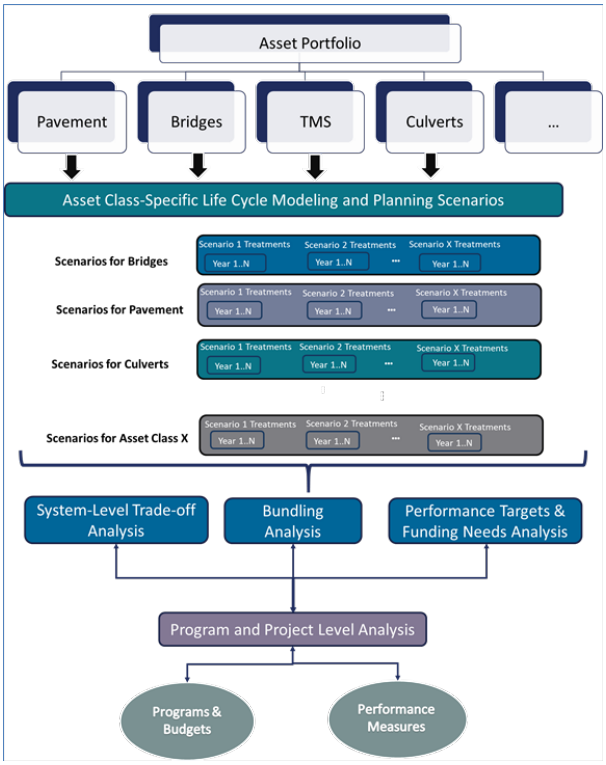


Image 2: Portfolio-Level Programming and Budgeting

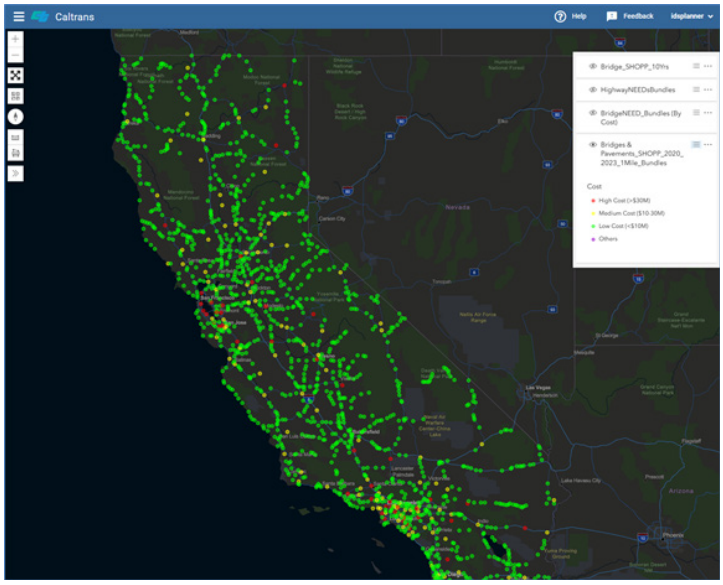


Image 3: Example of cross-asset treatment bundles for bridge and pavement treatments recommended by the SHOPP 10-year planning scenario