



Technical communications for transportation professionals

Measuring the Benefits of Transportation Research

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A Caltrans Preliminary Investigation



Project background

- ❑ Caltrans sought information about other agencies' practices to measure the benefits of transportation research
- ❑ A Caltrans benefits measurement process is expected to assist with:
 - Prioritizing and selecting project proposals
 - Selecting projects for implementation
 - Demonstrating the impact of Caltrans' research efforts
 - Providing data to support Caltrans' response to Senate Bill 1, the Road Repair and Accountability Act of 2017 (SB-1)

Project background

- ❑ Today's presentation highlights findings from the July 2020 Preliminary Investigation [Measuring the Benefits of Transportation Research: Survey of Practice](#)
- ❑ Survey of AASHTO Research Advisory Committee members
 - Survey responses were received from 26 state and district departments of transportation (DOTs)
 - Twelve respondents reported on agency experiences with measuring research benefits:

Alaska	Kansas	Utah
Arizona	Michigan	Vermont
Florida	Nevada	Washington
Indiana	Texas	Wyoming
- ❑ Literature search
 - Examined publicly available resources describing best practices
 - Identified measurement tools and practices of agencies not responding to the survey

What we'll cover today

- ❑ Selected tools and practices to measure research benefits
 - Brings together key findings from the survey and literature search
 - Highlights mature or promising measurement tools and practices
- ❑ Survey highlights
- ❑ What's next for Caltrans
- ❑ Questions?
 - We'll have time for a brief Q&A after the presentation
 - Submit questions using the Chat box on your screen

Selected tools and practices to measure research benefits

- ❑ Florida DOT's Financial Achievability Model (FAM)
- ❑ Indiana DOT's benefit-cost analysis
- ❑ Minnesota DOT's seven-step benefit quantification process
- ❑ New England Transportation Consortium's five-step benefit quantification process
- ❑ Texas DOT's Value of Research (VoR) template
- ❑ Utah DOT's benefit-cost analysis and grading system

Florida DOT: Financial Achievability Model (FAM)

- ❑ Financial Achievability Model (FAM) is a framework to identify and quantify the benefits of Florida DOT research projects
- ❑ FAM was developed by Florida State University Center for Insurance Research
- ❑ Cost-benefit data is collected using forms completed by project managers:
 - Kickoff survey
 - Midpoint survey
 - Closeout survey
 - Deployment plan
- ❑ SharePoint data repository in development will house these forms and track project-related data and benefits measurement
 - Part of Research Contract Administration project management database

Florida DOT: Financial Achievability Model (FAM)

- ❑ FAM starts with an assessment of benefits at project kickoff
- ❑ Project managers select benefit categories:
 - Materials enhancement
 - Materials savings
 - Time savings
 - Lives saved/injuries prevented
 - Other benefits
- ❑ Data is identified as qualitative or quantitative (if the latter, provide the methodology or data sources to support it)

Part III - Benefits Assessment

Project Benefits (Select all that apply and explain)	Qualitative Benefits	Quantifiable Benefits (units, dollars, etc. if applicable)	Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits
<input type="checkbox"/> Materials Enhancement			
<input type="checkbox"/> Materials Savings			
<input type="checkbox"/> Time Savings			
<input type="checkbox"/> Lives Saved/ Injuries Prevented			
<input type="checkbox"/> Other (Explain)			
<input type="checkbox"/> Other (Explain)			

FDOT Research Center Project Manager Kickoff Page 4

Florida DOT: Financial Achievability Model (FAM)

- ❑ Deployment plan includes section for project managers to identify performance measures
 - Economic benefits
 - Noneconomic benefits
 - Safety enhancement
 - System efficiencies
 - Resource savings
 - Environmental gains
 - Community enrichment
 - Other qualitative benefits

Part IV - Performance Measures
This section of the survey requests project managers to identify performance measures that could be applied to the output and/or outcome of the research. Quantitative measures refer to quantifiable benefits that can be measured. Qualitative measures refer to non-quantifiable benefits, i.e., which are not subject to discrete analysis.

Can economic benefits be determined if the results of this research are successfully implemented?
 Yes No

Are there non-economic quantifiable benefits that could be assessed if the research results are successfully implemented?
 Yes No

Will successful implementation of the research result in a safety enhancement?
 Yes No

Will successful implementation of the research result in system efficiencies?
 Yes No

Will successful implementation of the research result in resource savings?
 Yes No

Will successful implementation of the research result in environmental gains?
 Yes No

Will successful implementation of the research result in community enrichment?
 Yes No

Are there any other qualitative benefits that could be measured?
 Yes No

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Florida DOT: Financial Achievability Model (FAM)

❑ Closing thoughts

- FAM application is in its early stages
- FAM developers noted that successfully implementing the framework will “require the establishment of a clear process for data collection that starts at the research kickoff presentation”
- Survey respondent expects FAM implementation will help the agency “perfect benefits [measurement] upfront,” though its application will vary from project to project

❑ Learn more

[Financial Achievability of the Florida Department of Transportation Research Projects: Putting the Financial Analysis Framework Into Action](#), February 2018

Indiana DOT: Benefit-cost analysis

- ❑ Benefit-cost analysis was conducted by agency consultant in 2016, 2017 and 2018
- ❑ Consultant selects projects for the analysis based on:
 - Whether costs and benefits can be quantified on outcomes that impact agency operations
 - Implementation costs
 - Expected impact time period

Indiana DOT: Benefit-cost analysis

- ❑ 2018 return on investment (ROI) analysis included examination of **agency savings and costs**, **road user cost savings** and **safety cost savings**
 - Road user and safety cost savings are the primary goals
 - Savings accrued primarily for the benefit of the customer (road user) may not result in agency cost savings
 - Separate benefit-cost ratio is calculated for agency savings
 - Safety and road user savings are often related and combined in a single category
- ❑ Before application of the 2016 benefit-cost analysis, agency used a modified internal rate of return (MIRR) to assess research benefits
 - MIRR spreadsheet developed by Indiana DOT's Central Office calculated the value of ROI in research and development

Indiana DOT: Benefit-cost analysis

❑ Closing thoughts

- Some projects are difficult to measure quantitatively even when data is available
- Research projects that are proof of concept complicate benefits calculation
- Projects resulting in a specification change may take time to generate benefits; anticipated benefits may need to be calculated

❑ Learn more

[INDOT Research Program Benefit Cost Analysis—Return on Investment for Projects Completed in FY 2018](#), December 2019

Minnesota DOT: Seven-step benefit quantification process

- ❑ July 2017 research effort produced a guidance document and user tool for quantifying benefits of research recommendations
- ❑ Excel workbook is used to execute a seven-step benefit quantification process and generate benefit-cost ratio
 - Performs calculations with user input values and serves as a repository for data, assumptions and sources
 - Calculates potential benefit realized by implementation and estimates a benefit-cost ratio
- ❑ Researchers applied this process to a limited number of previously completed Minnesota DOT research projects

Minnesota DOT: Seven-step benefit quantification process

□ *Step 1: Determine benefit category.*

- Construction saving (materials, labor/time, equipment)
- Decrease engineering/administrative costs (planning/design costs, paperwork)
- Decrease life cycle costs
- Environmental aspects (pollution, hazardous waste reductions, recycling)
- Increase life cycle
- Operation and maintenance saving (materials, labor/time, equipment)
- Safety (reduction of crash frequency and/or severity)
- User benefits (time/dollars)
- Risk management (tort liability, environmental fines)

□ *Step 2: Build the benefit estimation tool.*

- User selects applicable templates based on benefit categories identified in Step 1 and assembles them into a single workbook

Minnesota DOT: Seven-step benefit quantification process

- ❑ *Step 3: Collect input data.*
 - Necessary data to estimate potential benefits ideally is included in the research report
 - Data missing from the research report is gathered by meeting with agency staff and university researchers or from outside sources (local agency engineers and industry representatives)
- ❑ *Step 4: Document implementation of recommendations.*
 - User includes potential locations for implementation
 - Data from existing condition before implementation should be representative of current practices
- ❑ *Step 5: Populate the benefit estimation tool.*
 - User enters all the required input data into the appropriate color-coded cells

Minnesota DOT: Seven-step benefit quantification process

❑ *Step 6: Determine benefit.*

- User determines the benefit by referring to the value presented in the Net Present Value column of the template spreadsheet
- User can document the applicable benefit category and corresponding Net Present Value along with the total benefit on one of the benefit calculation tabs in the quantification spreadsheet

❑ *Step 7: Compare benefit to cost.*

- Workbook automatically performs benefit-to-cost calculation after user enters all necessary data and information in the Benefit-Cost Ratio Estimation section

Minnesota DOT: Seven-step benefit quantification process

- ❑ Learn more

[Development of a Process for Quantifying the Benefits of Research](#), July 2017

[User Guide: Process for Quantifying the Benefits of Research](#), July 2017

[MnDOT Research Program Strategic Plan 2017-2022](#), March 2017

New England Transportation Consortium (NETC): Five-step benefit quantification process

- ❑ January 2019 research effort describes a five-step process to quantify research benefits
 - Researchers tasked with developing a tool to “help the NETC in evaluating and financially justifying its research projects”
- ❑ Excel-based tool performing the benefit calculation was adapted from Minnesota DOT’s seven-step, Excel-based benefit estimation tool
- ❑ Five-step process and tool applied to two NETC projects to demonstrate the tool and inform efforts to refine it

New England Transportation Consortium (NETC): Five-step benefit quantification process

- *Step 1: Determine applicable benefit categories (deconstruction phase).*
 - NETC tool can apply one category or separate subcategories or line items
 - Tool uses Minnesota DOT categories with minor changes:
 - Engineering and administrative costs
 - Construction and installation costs
 - Operation and maintenance costs
 - Road user costs (time, fuel, wear and tear, user costs)
 - Environmental costs
 - Life cycle costs
 - Safety costs
 - Risk management costs
 - Other costs

New England Transportation Consortium (NETC): Five-step benefit quantification process

- ❑ *Step 2: Collect input data (analysis phase).*
 - All calculations require two types of data:
 - Input value for quantifiable changes in labor hours, prices, quantities from before and after implementing the research results
 - Anticipated level of deployment or frequency of activity
- ❑ *Step 3: Populate the benefit estimation tool (analysis phase).*
 - Users enter input data into color-coded Excel templates, modifying the templates as needed
- ❑ *Step 4: Calculate the benefits and the benefit-cost ratio (rebuilding phase).*
 - Excel workbook automates this process with built-in formulas that link individual categories and subcategories, and perform the calculations

New England Transportation Consortium (NETC): Five-step benefit quantification process

- *Step 5: Evaluate the results (evaluation phase).*
 - Key outputs of the Excel calculations:
 - Total monetary benefit in current dollars
 - Benefit-cost ratio
 - Benefit-cost ratio less than 1.0 indicates the research cost is greater than the potential monetary benefits
 - Benefit-cost ratio greater than 1.0 indicates the potential benefits outweigh the research costs

New England Transportation Consortium (NETC): Five-step benefit quantification process

❑ Closing thoughts

- Vermont NETC member noted that “benefits quantification is really, really hard. We’re just trying to get started.”
- Connecticut NETC member commented that “using a quantitative measure is risky (it is biased toward outcomes that are implementable in the short term)” and highlighted the “noninsignificant proportion of initiatives that don’t produce a readily and neatly quantifiable benefit”
- Rhode Island NETC member noted that there is “no easy way” to determine direct benefits using a benefit-cost ratio for most projects in terms of dollars saved or deaths and injuries reduced; determining indirect benefits can be even more challenging

❑ Learn more

[Quick Response: Quantification of Research Results](#), January 2019

Texas DOT: Value of Research (VoR) template

- ❑ Value of Research (VoR) template is an Excel workbook used by the agency's principal investigators in collaboration with project panels
- ❑ The third of three worksheets provides data and graphics that illustrate the project's economic value in:
 - Total savings
 - Net present value
 - Payback period (in years)
 - Cost-benefit ratio

Texas DOT: Value of Research (VoR) template

- ❑ Panel members identify relevant benefit areas to focus on during the research
- ❑ Researcher is responsible for gathering and processing data with input from various sources, including articles, engineers and agency staff
 - Requests for assistance with data are directed to the project manager
- ❑ Five or more variable amounts may be entered in the template for each economic benefit area

Texas DOT: Value of Research (VoR) template

- User selects from among benefit areas that are qualitative, economic or both, and impact Texas DOT, the state or both:
 - Level of knowledge
 - Management and policy
 - Quality of life
 - Customer satisfaction
 - Environmental sustainability
 - System reliability
 - Increased service life
 - Improved productivity and work efficiency
 - Expedited project delivery
 - Reduced administrative costs
 - Traffic and congestion reduction
 - Reduced user cost
 - Reduced construction, operations and maintenance cost
 - Materials and pavements
 - Infrastructure condition
 - Freight movement and economic vitality
 - Intelligent transportation systems
 - Engineering design improvement

Texas DOT: Value of Research (VoR) template

- ❑ VoR is determined for all projects
- ❑ Initial VoR is included in the project agreement as first deliverable
- ❑ Completed VoR is provided with a Tech Memo that describes calculations, economic variables and qualitative values
- ❑ Final report includes examination of the completed VoR, which is considered part of the final deliverable
- ❑ Agency developed a university handbook that describes the VoR template and provides guidance on how it should be used

Texas DOT: Value of Research (VoR) template

❑ Closing thoughts

- Texas DOT respondent described use of VoR Excel-based measurement tool as “progressive”
- Measuring is not “a plug-and-play of factors” entered in a formula

❑ Learn more

[Value of Research Template](#), undated

[University Handbook](#), March 2019 (see Chapter 6 for guidance on completing the VoR)

Utah DOT: Benefit-cost analysis

- ❑ Benefit-cost studies are completed by consultant every four years
 - Use of consultant helps to establish neutrality
 - Third four-year measurement cycle underway in summer 2020
 - Research studies completed from 2009 to 2012 had an estimated benefit-cost ratio of 14
- ❑ Programwide assessment that measures the benefits of all major research projects and initiatives is completed during that time period
- ❑ Agency documentation includes:
 - Specific benefit-cost calculations
 - Principal benefits calculation is $\text{Benefits} = \text{Number} \times \text{Value} \times \text{Percentage}$
 - Standard values for use in calculations
 - Technical Advisory Committee investment
 - Average cost per crash based on severity

Utah DOT: Benefit-cost analysis

- ❑ Agency's Research and Innovation Division procedure manual describes the objectives for the benefit-cost analysis:
 - Estimate the benefits of major research projects and compare them with the costs to conduct the studies
 - Determine which types of projects produce the highest benefit-cost ratios and which projects are more often unsuccessful or marginal
 - Make recommendations concerning the research program and the types of projects undertaken in the future
- ❑ [Preliminary Investigation Attachment D](#) describes the data-gathering process and includes sample forms and calculation examples
 - Revision of this July 2016 publication is underway

Utah DOT: Grading system

- ❑ A grading system provides an alternate method to monitor project and program effectiveness
- ❑ Surveys ask research project champions to assign a grade of A through E to the research project
- ❑ Grades range from major impact to major tasks not completed

Grade	Definition
A	Major impact: New or revised specifications, policy, methods, etc.
B	Significant impact: Improved operations, procedures or policies.
C	Contributed to state of the practice or institutional knowledge.
D	Unclear or contradicting findings: More study needed.
E	Major tasks not completed: Objectives not met.

Utah DOT: Benefit-cost analysis

❑ Closing thoughts

- Respondent noted that a more ideal model is to move toward real-time collection (immediately after a project concludes)
 - Drawback with this approach is some completed research does not pay dividends until well after a project concludes
- A “built-in delay fuse” can help to protect against false negative values
- Gathering data can be challenging
 - Time and energy are required to generate interest in identifying and gathering retrospective documentation

❑ Learn more

[Research and Innovation Division: Manual of Instruction](#), May 2018

[Investing in Utah Transportation Research](#), July 2016

Other tools and practices

- ❑ Kansas DOT benefit-cost analysis
 - Traditional benefit-cost analysis and multiobjective analysis
 - [Guidelines for Estimating the Triennial Benefits of Kansas Transportation Research and New Developments \(K-TRAN\) Research Projects](#), July 2004

- ❑ North Carolina DOT benefit-cost methodology and predictive model
 - Examines quantitative and qualitative benefits
 - Performance prediction model predicts the probability of success in terms of highly successful, successful and moderately successful
 - [Capturing and Communicating the Value of NCDOT Research](#), February 2018

Survey highlights: What we'll cover

- ❑ Measurement and data inputs
- ❑ Data sources
- ❑ Gathering data
- ❑ Measuring anticipated benefits
- ❑ Measurement methods
- ❑ Successes and challenges
- ❑ Agencies not measuring benefits

Survey highlights: Measurement and data inputs

- ❑ Respondents most likely to measure the benefits of selected completed research projects
 - Least likely to conduct a programwide assessment
- ❑ Two agencies conduct periodic comprehensive analyses:
 - *Arizona DOT*. Major investigation every five to seven years to identify the impact on the agency of the implementation of research recommendations and the factors influencing implementation.
 - *Utah DOT*. Comprehensive benefit-cost analysis every four years; interested in moving toward real-time data collection.
- ❑ Data inputs most frequently cited by respondents:
 - Implementation costs and material costs (10 state DOTs)
 - Material quantities and project costs (nine state DOTs)

Survey highlights: Data sources

- ❑ ***Project proposals and preliminary deliverables.*** Kansas, Texas and Vermont take action early in the research process to allow for measuring benefits as a project unfolds.
- ❑ ***Final reports.*** More than three-quarters of respondents use the final report—the most common final deliverable for a research project—to track or document project benefits.
 - Research programs in six states—Alaska, Indiana, Michigan, Nevada, Texas and Vermont—expect principal investigators to deliver final reports that include benefits data or calculations.
- ❑ ***Standard values.*** Only the Utah DOT respondent indicated that standard values have been established for use in benefits calculations.
- ❑ ***Other data sources.*** Respondents gather insurance and safety-related data; use the results of interviews, surveys and findings from national research and pooled fund studies; and use data from other state DOTs.

Survey highlights: Gathering data

- ❑ In almost all cases, the individual or group gathering the data is responsible for completing the benefits measurement process
- ❑ Respondents are more likely to task a consultant or principal investigator with gathering and processing data than employ a collaborative effort spearheaded by agency staff
- ❑ Timing of data collection is a significant challenge
 - Retrospective data may not be collected on a granular level
 - Study horizons are much shorter than the longer-term duration needed to follow up on benefits accrued
 - Respondents also cited inadequate data collection

Survey highlights: Measuring anticipated benefits

- ❑ *Alaska*. Research needs statement includes section addressing potential benefits.
 - Scoring criteria for project selection includes points for a benefit-cost assessment that is “liberally considered” by the agency
- ❑ *Nevada*. Anticipated benefits are estimated using historical data and assumptions about the effects of new methods and processes.
- ❑ Other respondents said analysis at this stage was either premature or not yet fully implemented
 - Arizona DOT doesn’t support the calculation of anticipated benefits given the lack of necessary data
 - Texas DOT verifies anticipated benefits through later implementation; at that time, a standard for calculating benefits would be required for similar implementation projects

Survey highlights: Measurement methods

- ❑ Respondents are most likely to use a **benefit-cost** ratio
- ❑ Several agencies apply more than one measurement method
- ❑ Arizona DOT has a custom measurement tool in development that is expected to be largely qualitative
- ❑ Tools and practices cited previously provide more details

Survey highlights: Successes and challenges

❑ Successes

- No consensus on what constitutes success when measuring research benefits
 - Collaborative process (Kansas)
 - Encouraging advocacy for data collection and analysis (Florida)
 - High-value projects likely to yield demonstrable benefits (Michigan, Nevada and Utah)

❑ Challenges

- Complexity of measurement and lack of resources
- Other challenges:
 - Lack of an agencywide standard for performance metrics
 - Limited data to quantify benefits and long-term costs
 - Unclear or unrealistic expectations
 - Difficulty of benefits quantification; some agencies just getting started or hoping to begin

Survey highlights: Agencies not measuring benefits

- ❑ All but two of the 14 agencies reported on some aspect of benefits measurement or interest in doing more
- ❑ Pending research in Mississippi and Ohio is expected to help those state DOTs quantify research benefits
- ❑ Other agency efforts:
 - Small-scale assessments of implementation and project benefits for selected projects (Kentucky)
 - Proposal to add benefits measurement as a requirement in future university support contract (District of Columbia)
 - Plans to develop processes and forms for implementation and performance measures that will inform benefits measurement practices (Montana)

What's next for Caltrans

- ❑ After today's presentation and further discussion
 - The Caltrans team developing new benefits measurement practices will recommend tools and methodologies that can be applied or adapted for Caltrans' use
 - The team's recommendations may be added to this presentation as a final slide or series of slides

Questions?

- ❑ Let's continue the discussion with your questions
- ❑ Submit your questions using the Chat box on your screen
- ❑ We'll take as many questions as we can during the hour
- ❑ Any questions we can't address today we'll address in a group email to attendees

Thank you!

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