Leveraging Project-Level and Scenario-Level Performance Assessment to Achieve Sustainability Goals of Plan Bay Area

Paper submitted for presentation at the 92nd Transportation Research Board Annual Meeting (2013)

Initial submission on July 31, 2012
Revised submission on November 15, 2012

David Vautin (corresponding author)
Metropolitan Transportation Commission
101 8th Street
Oakland, CA 94607
dvautin@mtc.ca.gov
(510) 817-5709

Lisa Klein
Metropolitan Transportation Commission
101 8th Street
Oakland, CA 94607
lklein@mtc.ca.gov
(510) 817-5832

Sean Co
Metropolitan Transportation Commission
101 8th Street
Oakland, CA 94607
sco@mtc.ca.gov
(510) 817-5748

Krista Jeannotte
Cambridge Systematics, Inc.
555 12th Street, Suite 1600
Oakland, CA 94607
kjeannotte@camsys.com
(510) 873-8700

Doug Sallman
Cambridge Systematics, Inc.
9209 NW Murdock Street
Portland, OR 97229
dsallman@camsys.com
(503) 292-3322

4,865 (text) + 2,000 (figures & tables) = 6,865
Leveraging Project-Level and Scenario-Level Performance Assessment to Achieve Sustainability Goals of Plan Bay Area

David Vautin, Lisa Klein, Sean Co, Krista Jeannotte, and Doug Sallman

ABSTRACT

Senate Bill 375 requires metropolitan planning organizations in California to develop an integrated transportation, land use, and housing plan – known as a Sustainable Communities Strategy. This plan must be targeted to reduce greenhouse gas emissions from cars and light-duty trucks. To meet these requirements, the San Francisco Bay Area Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG) are developing Plan Bay Area, which integrates the Sustainable Communities Strategy with the upcoming cycle of the Regional Transportation Plan.

In order to achieve the plan’s sustainability goals, San Francisco Bay Area regional agencies are relying on a performance-based approach, targeting key issues such as strengthening the region’s economy, promoting equity, and enhancing the environment. This approach focuses on measurable outcomes to help understand how land use strategies and potential transportation investments could advance the region’s goals. Following the adoption of a set of ten quantitative performance targets, transportation projects and scenarios were evaluated based on their level of support for these targets. A benefit-cost assessment was also leveraged to assess the cost-effectiveness of regionally-significant transportation projects and scenarios.

This paper will present Plan Bay Area’s performance assessment methodology and discuss both its abilities and limitations in capturing impacts of infrastructure investments. The assessment approach will be examined both for individual transportation projects and for integrated regional transportation and land use scenarios.
OVERVIEW AND CONTEXT

Plan Bay Area is the San Francisco Bay Area’s first Sustainable Community Strategy, a planning effort initiated by the Sustainable Communities and Climate Protection Act of 2008 (1). This effort includes an update to the federally-mandated Regional Transportation Plan, thus integrating transportation, land use, and housing planning efforts into a single regional plan for the first time. By creating this type of unified plan, issues like climate change and housing availability can be dealt with through overarching policies, such as incentives for new transit-oriented development near high-capacity transit nodes. The Plan, to be finalized and adopted in early 2013, will be updated every four years as required by state and federal law.

Performance assessment was a fundamental component of Plan Bay Area from the very beginning, building upon previous work from MTC’s prior Regional Transportation Plan known as Transportation 2035 (2). Over the past several years, staff have been engaged in performance evaluation to ensure the Plan meets regional objectives. The key elements of this performance assessment process are listed below and described in further detail in this paper:

- **Plan Bay Area Performance Targets**
  - Identification and evaluation: July 2010 to December 2010
  - Adoption by MTC and ABAG: January 2011
- **Scenario Assessment**: March 2011 to December 2011
- **Project Performance Assessment**
  - Methodological development: February 2011 to May 2011
  - Modeling and analysis: June 2011 to November 2011
  - Policy discussions: November 2011 to March 2012
- **Definition of Preferred Scenario**: March 2012 to May 2012

IDENTIFYING PERFORMANCE TARGETS FOR THE PLAN

To help define the sustainability goals of the region, the Metropolitan Transportation Commission and the Association of Bay Area Governments sought to develop a set of performance measures. Staff relied on the following concept of performance measures when seeking to identify suitable metrics:

“Performance measures are broadly defined as quantifiable criteria that can be used to track progress toward specific goals or objectives. Ideal performance measures are easily understood, provide a clear indication of moving toward an established goal, and can be tracked using accessible and available data”. (3)

In addition, policymakers and agency staff agreed that identifying a smaller set of highly meaningful performance measures would increase comprehension of Plan goals and would encourage selection of only the highest-priority goals. Furthermore, it was agreed upon that each performance measure would include a numeric target – a goal for achievement which would allow policymakers to understand how close a particular planning future (known as a scenario) came to meeting those goals. Note that many of these numeric targets were quite ambitious in order to define a future vision for the region.
<table>
<thead>
<tr>
<th>GOAL/OUTCOME</th>
<th>#</th>
<th>TARGET (numeric targets are for year 2035 compared to a year 2005 base)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATUTORY TARGETS</strong></td>
<td>1</td>
<td>Reduce per-capita CO₂ emissions from cars and light-duty trucks by 15%</td>
</tr>
<tr>
<td>CLIMATE PROTECTION</td>
<td></td>
<td>Source: California Air Resources Board, as required by SB 375</td>
</tr>
<tr>
<td>ADEQUATE HOUSING</td>
<td>2</td>
<td>House 100% of the region’s projected 25-year growth by income level (very-low, low, moderate, above-moderate) without displacing current low-income residents</td>
</tr>
<tr>
<td>Source: ABAG adopted methodology, as required by SB 375</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VOLUNTARY TARGETS</strong></td>
<td>3</td>
<td>Reduce premature deaths from exposure to particulate emissions:</td>
</tr>
<tr>
<td>HEALTHY &amp; SAFE COMMUNITIES</td>
<td></td>
<td>- Reduce premature deaths from exposure to fine particulates (PM₂.₅) by 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduce coarse particulate emissions (PM₁₀) by 30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Achieve greater reductions in highly impacted areas</td>
</tr>
<tr>
<td>Source: Adapted from federal and state air quality standards by BAAQMD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Reduce by 50% the number of injuries and fatalities from all collisions (including bike and pedestrian)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Source: Adapted from California State Highway Strategic Safety Plan</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Increase the average daily time walking or biking per person for transportation by 60% (for an average of 15 minutes per person per day)</td>
</tr>
<tr>
<td>Source: Adapted from U.S. Surgeon General’s guidelines</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Direct all non-agricultural development within the urban footprint (existing urban development and urban growth boundaries)</td>
</tr>
<tr>
<td>Source: Adapted from SB 375</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Decrease by 10% the share of low-income and lower-middle income residents’ household income consumed by transportation and housing</td>
</tr>
<tr>
<td>Source: Adapted from Center for Housing Policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Increase gross regional product (GRP) by 90% — an average annual growth rate of approximately 2% (in current dollars)</td>
</tr>
<tr>
<td>Source: Bay Area Business Community</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>- Increase non-auto mode share by 10%</td>
</tr>
<tr>
<td>Source: Adapted from Caltrans Smart Mobility 2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Maintain the transportation system in a state of good repair:</td>
</tr>
<tr>
<td>Source: Regional and state plans</td>
<td></td>
<td>- Increase local road pavement condition index (PCI) to 75 or better</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Decrease distressed lane-miles of state highways to less than 10% of total lane-miles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reduce the share of transit assets past their useful life to 0%</td>
</tr>
</tbody>
</table>
Dozens of potential performance targets were proposed, but many fell short of the criteria listed above. Through a collaborative process with local government staff, policy advocates, and public officials, the list of potential targets was narrowed down and proposed to policymakers for final approval. The Plan Bay Area targets, as shown in Table 1, were adopted by MTC and ABAG in January 2011. The first two targets, relating to greenhouse gas emissions and housing availability, represent statutory performance targets required by the state under SB 375.

Unlike previous Regional Transportation Plans, the majority of the performance targets dealt with issues beyond the scope of traditional transportation planning – with a particular focus on the sustainability goals of the region. Sustainability is typically considered to be the intersection of three “E’s”: the environment, the economy, and social equity. Each of these elements can be located within the list of adopted targets:

- Environmental concerns are reflected in the greenhouse gas reduction target, the particulate matter emissions targets, and the open space preservation target.
- Economic impacts are considered via the gross regional product target, as well as through the transportation system effectiveness targets.
- Equity issues are identified in the low-income household affordability target, as well as the housing production target for all income groups.

Notably – and somewhat controversially – the Plan does not include one of the most traditional transportation performance measures: reduction of vehicle delay. Advocates for more sustainable transportation argued such a target would encourage driving and boost auto-oriented development. Some stakeholders remain disconcerted by this decision to eschew a mobility performance target in Plan Bay Area.

**ANALYZING PERFORMANCE OF ALTERNATIVE SCENARIOS**

Five alternative scenarios were jointly developed by MTC and ABAG, each consisting of a particular land use pattern and a corresponding transportation investment strategy. While scenario definition and development is beyond the scope of this paper, the scenarios exhibited differences in population and employment assumptions, land use patterns, and transportation investment strategies. Transportation projects included in each scenario were roughly assigned to align with the amount and type of growth projected for particular geographic areas. This scenario assessment process, when combined with the subsequent project-level assessment (described later in this paper), formed the cornerstone of development for the Plan Bay Area preferred scenario.

In order to quantitatively compare the alternative scenarios and to determine which scenario best supported the performance targets, each of the aforementioned Plan Bay Area performance targets was analyzed using model-based methodologies. The transportation model was run for base year 2005 to determine the baseline levels of CO₂ emissions, travel time, etc. The model was then run again for each of the five scenarios, reflecting the various population, land use, and transportation assumptions that go into each scenario for year 2035. The model then re-calculates those metrics (CO₂, travel time, etc.) and is able to calculate the percent change between year 2005 and horizon year 2035.

Table 2 summarizes the results of the targets assessment for the five alternative scenarios, showing the range between the best- and worst-performing scenarios for each target. While some targets show little-to-no difference between the various scenarios, a general trend does emerge from this analysis. The best-performing scenarios – including Core Concentration – focus growth in the urban core of the Bay Area and support that growth with frequent transit service. Meanwhile, the Outward Growth scenario, which places growth at the edges of the region and relies more heavily on roadway improvements,
## TABLE 2  Targets Performance for Plan Bay Area Scenarios

<table>
<thead>
<tr>
<th>#</th>
<th>TARGET</th>
<th>GOAL*</th>
<th>BEST-PERFORMING SCENARIO**</th>
<th>WORST-PERFORMING SCENARIO**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carbon Dioxide (CO₂) per capita</td>
<td>-15%</td>
<td>-9% Core Concentration</td>
<td>-8% Outward Growth</td>
</tr>
<tr>
<td>2</td>
<td>Adequate Housing</td>
<td>100%</td>
<td>100% Initial Vision</td>
<td>98% Other scenarios</td>
</tr>
<tr>
<td>3a</td>
<td>Fine Particulate Matter (PM₂.₅) (premature deaths due to emissions)</td>
<td>-10%</td>
<td>-32% Core Concentration</td>
<td>-23% Initial Vision</td>
</tr>
<tr>
<td>3b</td>
<td>Coarse Particulate Matter (PM₁₀) (tons of particulate emissions)</td>
<td>-30%</td>
<td>-13% Core Concentration</td>
<td>-6% Initial Vision</td>
</tr>
<tr>
<td>3c</td>
<td>Particulates in Highly-Impacted Areas (CARE Communities) (achieve greater reductions)</td>
<td>Yes</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>4</td>
<td>Collisions (fatalities and injuries)</td>
<td>-50%</td>
<td>+18% Core Concentration</td>
<td>+26% Initial Vision</td>
</tr>
<tr>
<td>5</td>
<td>Active Transport (time spent biking/walking)</td>
<td>+70%</td>
<td>+20% Core Concentration</td>
<td>+10% Outward Growth</td>
</tr>
<tr>
<td>6</td>
<td>Open Space &amp; Agricultural Preservation (development within urban footprint)</td>
<td>100%</td>
<td>98% Initial Vision</td>
<td>90% Outward Growth</td>
</tr>
<tr>
<td>7</td>
<td>Low-Income Housing + Transportation Affordability (for households with income less than $60,000)</td>
<td>-10%</td>
<td>-4% Initial Vision</td>
<td>+9% Outward Growth</td>
</tr>
<tr>
<td>8</td>
<td>Gross Regional Product (GRP)</td>
<td>+90%</td>
<td>+134% Core Concentration</td>
<td>+113% Focused Growth</td>
</tr>
<tr>
<td>9a</td>
<td>Non-Auto Mode Share</td>
<td>26%</td>
<td>20% Core Concentration</td>
<td>18% Outward Growth</td>
</tr>
<tr>
<td>9b</td>
<td>VMT per capita</td>
<td>-10%</td>
<td>-7% Core Concentration</td>
<td>-5% Focused Growth</td>
</tr>
<tr>
<td>10a</td>
<td>Local Road Maintenance (PCI)</td>
<td>+19%</td>
<td>+5% - Same for all scenarios</td>
<td></td>
</tr>
<tr>
<td>10b</td>
<td>Highway Maintenance (distressed lane-miles)</td>
<td>-63%</td>
<td>+30% - Same for all scenarios</td>
<td></td>
</tr>
<tr>
<td>10c</td>
<td>Transit Maintenance (assets past useful life)</td>
<td>-100%</td>
<td>+138% - Same for all scenarios</td>
<td></td>
</tr>
</tbody>
</table>

* = percentage targets were converted from the numeric goals to allow for consistent percentage-based comparisons across all of the targets

** = targets achieved via scenarios marked in green; targets where scenarios fell short marked in yellow; targets where scenarios move in the wrong direction marked in red

*** = not evaluated for alternative scenarios

performs the worst on the performance targets. This suggests that the sustainability goals of Plan Bay Area are best achieved by a concentrated growth strategy linked to supportive public transportation investments.
However, in general, the various planning scenarios analyzed did not achieve the region’s ambitious targets (4). Most importantly, none of the alternative scenarios met the greenhouse gas emissions target, the most essential (and mandatory) element of a Sustainable Communities Strategy. The availability of this targets assessment for a variety of alternative scenarios spurred efforts to identify additional funding specifically targeted at reducing greenhouse gas emissions. When developing the preferred scenario for Plan Bay Area, MTC and ABAG built upon the focused growth pattern of the Core Concentration approach. To meet the ambitious greenhouse gas target, additional regional transportation policies were slated for funding, including smart driving education programs, electric vehicle incentives, and vehicle buy-back initiatives. These cost-effective approaches to achieve this critical target provided an additional 7% reduction in greenhouse gas emissions, leading to a combined 17% reduction in per-capita greenhouse gas emissions by 2035 – thus exceeding the region’s 15% reduction target (5).

**LINKING SCENARIO AND PROJECT PERFORMANCE ASSESSMENT**

In order to identify a preferred package of transportation improvements for inclusion in a preferred scenario, MTC staff initiated a rigorous project-level performance assessment. This goes beyond the scenario-level analysis typical for Regional Transportation Plans, looking at the much more detailed level of individual projects (as shown in Figure 1). For all non-committed projects in the Bay Area – in other words, projects that were not yet fully funded and had not yet achieved environmental clearance – two assessments were performed to determine their usefulness and efficiency in achieving the Plan’s objectives.

![Diagram](https://example.com/diagram.png)

**FIGURE 1** Plan Bay Area framework for performance assessment.

First, each transportation project, approximately 180 in all, was qualitatively evaluated based on its level of support for the adopted targets. This process sought to answer a fundamental question: does each project being considered for inclusion in the Plan help us reach our goals? Depending on a project’s level of support (or adverse impacts), it could receive an “overall targets score” ranging from +10 (strongly supporting all targets) to -10 (strongly adversely impacting all targets). This project-level targets assessment allowed staff to develop a preferred scenario that prioritized projects that support the Plan’s...
identified targets; furthermore, it acts as a crucial link between the scenario-level and targets-level analyses.

Second, all major capacity-increasing transportation projects (with total costs exceeding $50 million and/or with regional impacts) were evaluated using a quantitative, model-based methodology to determine each project’s benefit-cost ratio. This process went beyond the adopted performance targets to consider as many quantifiable benefits as possible, seeking to determine which projects are most cost-effective in providing benefits to users and society. Given that benefit-cost ratios were developed for 90 major projects, the assessment focused on categorizing projects’ benefit-cost performance by tier – low, medium-low, medium-high, and high – in order to focus primarily on outliers (the highest- and lowest-performers).

The results of this project-level assessment were used for two primary purposes:

- High-performing projects – those that performed well on both the targets assessment and the benefit-cost assessment – were prioritized for funding in the Plan Bay Area preferred scenario.
- Low-performing projects – those that exhibited poor performance on either the targets assessment or the benefit-cost assessment – were subjected to additional scrutiny. Project sponsors were asked to present a compelling case to MTC and ABAG policymakers if they still sought their inclusion in the Plan. Final decisions on the fate of these low-performing projects were made by policymakers after thoughtfully reviewing the various compelling cases.

ANALYZING PROJECT PERFORMANCE: TARGETS ASSESSMENT

As mentioned earlier, the targets assessment sought to score projects based on their support of the adopted targets via a numeric targets score ranging from +10 to -10. Each target was equally weighted when calculating this score, using the following performance ratings for each target:

- Strong Support (+1.0)
- Moderate Support (+0.5)
- Minimal Impact (0)
- Moderate Adverse Impact (-0.5)
- Strong Adverse Impact (-1.0)

Unlike the scenario-level targets assessment or the project-level benefit-cost assessment, projects were assessed qualitatively relative to each target. This contrasts with the model-based approach pursued for the other elements of the Plan Bay Area performance assessment. This approach permitted MTC/ABAG to capture the merits of projects which could not be easily quantified or considered through model-based methodologies. Furthermore, it allowed for the performance assessment to be performed on a wider range of projects than could be subjected to benefit-cost assessment. Smaller-scale projects, or projects lacking capacity increases, could not be accurately analyzed using the travel model and therefore were not subject to the benefit-cost assessment component of project evaluation – but these project could still be evaluated within the targets assessment framework.

For reference purposes, the qualitative criteria for each of the ten performance targets are listed below:

1. **Climate Protection (CO₂ Reduction):** A project supports this target if it can result in reduced vehicle miles traveled (VMT), if it provides an alternative to driving, or if it advances clean fuel vehicles. VMT-increasing projects are assumed to have adverse impacts on this target.

2. **Adequate Housing:** A project’s level of support for this target is dependent on past housing production within the jurisdiction, as well as planned housing growth. Target support is also dependent on the level of affordable housing produced and planned for the jurisdiction.
3. **Healthy and Safe Communities (Particulate Matter):** A project supports this target if it can result in reduced vehicle miles traveled (VMT) or if it provides an alternative to driving. VMT-increasing projects are assumed to have adverse impacts on this target.

4. **Healthy and Safe Communities (Collisions):** A project supports this target if it can result in reduced vehicle miles traveled (VMT) or if it provides an explicit safety benefit (e.g., constructs a protected roadway median).

5. **Healthy and Safe Communities (Active Transportation):** A project supports this target if it provides infrastructure for bicycles or pedestrians. Projects that increase the number of auto trips are assumed to have adverse impacts on this target.

6. **Open Space and Agricultural Preservation:** A project supports this target if it does not consume open space or farmland or if it improves access to agricultural lands. Projects that consume open space or farmland are assumed to have adverse impacts on this target.

7. **Equitable Access (Low-Income Households’ Affordability for Transportation and Housing):** A project supports this target if it provides a lower-cost alternative to the auto ownership. Note that transit agencies with higher numbers of low-income riders received higher scores.

8. **Economic Vitality (GRP):** A project supports this target if it relieves congested corridors, improves access to employment centers, or improves access to airports/seaports.

9. **Transportation System Effectiveness (Non-Auto Mode Share/VMT):** A project supports this target if it improves transit, pedestrian, or bicycle infrastructure. Projects that increase use of single-occupancy automobiles are assumed to have adverse impacts.

10. **Transportation System Effectiveness (Maintenance):** A project supports this target if it specifically improves roadway conditions or replaces transit assets.

Due to the sustainability focus of the Plan Bay Area performance targets, transit projects tended to fare significantly better on the targets assessment, with scores typically ranging from +5 to +9. Road projects tended to score more poorly, especially road expansion (widening) projects. Those type of highway expansion projects generally received negative target scores, indicating adverse impacts towards many of the Plan Bay Area targets. This caused most highway expansion projects to be flagged as low-performers.

**ANALYZING PROJECT PERFORMANCE: BENEFIT-COST ASSESSMENT**

The benefit-cost assessment expanded the performance assessment scope beyond the adopted targets. Fundamentally, this assessment sought to identify projects that were cost-effective based on the application of state-of-the-practice economic theory. The results of this assessment were intended to ensure that projects included in the Plan were not only sustainable, but also a wise allocation of scarce public dollars. Because of the time-consuming nature of this model-based assessment, the assessment examined the 90 largest capacity-increasing and regionally-impactful transportation projects across the San Francisco Bay Area.

MTC’s activity-based Travel Model One (6) was used to analyze these projects—which created a level playing field across all of the analyzed projects. This approach allowed for fair comparison of B/C ratios between individual projects, as each project’s benefits were calculated using an identical methodology. To determine the impacts of a particular project, a no-build model run was conducted to determine the baseline conditions (e.g., total regional travel time, tons of airborne emissions, fatality collisions, etc.). After changing the baseline conditions to represent project-related improvements—e.g., travel lanes were added, or a rail line was extended—the model was then run again to analyze with-project conditions. Every model run was performed for the geographical scope of the entire Bay Area, meaning that no-build and with-project conditions captured the travel impacts of a given project for simulated travelers across the region. The impacts to each travel metric were calculated by comparing the
no-build and with-project model runs. Given the large number of model runs, a 50% sample was utilized for each run – meaning that the travel behavior of half of all Bay Area households was analyzed to determine each project’s impacts.

Since the activity-based model forecasts the travel behavior of millions of simulated Bay Area residents, its run time is significant – so a new modeling approach had to be developed to analyze the sheer number of projects subject to the assessment. This approach, known as “mode choice” modeling, only re-ran the later stages of the model – mode choice and tour assignment – rather than generating new tours. It was assumed that, given the incremental nature of each transportation improvement, the tour generation on a per-project basis would be relatively small. That said, the “mode choice” modeling approach did capture other responses to new travel choices, such as changes in departure time, routing, and mode choice caused by project implementation.

Combining this “mode choice” modeling approach with the 50% sampling approach mentioned earlier, a single project’s model run time was able to be reduced from 24 hours to 8 hours. This allowed for reasonable model-based forecasts of project impacts, while ensuring the project performance assessment could be completed in time to inform the development of the Plan’s preferred scenario.

Numerous benefits were quantified based on model output metrics, including benefits for individuals (such as time and cost reductions) and for society as a whole (such as improved air quality and reduced CO₂ emissions). However, since the methodology was based on the output of the transportation model, it was not possible to go beyond its scope and capture land use impacts and their monetized benefits (e.g. from new development or property value increases). Those types of land use benefits are highly challenging to quantify for benefit-cost analysis, given the necessity to differentiate between intraregional transfers and interregional net benefits.

While MTC developed estimates of benefits, project costs were provided by project sponsors. MTC worked with an independent consultant to review project cost estimates and ensure cost estimates provided by sponsors were reasonable.

Table 3 lists the project benefits and costs that were quantified and monetized in the project-level benefit-cost assessment. Table 4 documents the various valuations that were assigned to each benefit based off of an extensive review of best practices in benefit-cost assessment.

### Table 3   Benefits & Costs Quantified

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>BENEFACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time reduction:</td>
<td></td>
</tr>
<tr>
<td>• Auto/Truck: free-flow travel time, recurring delay, non-recurring delay</td>
<td></td>
</tr>
<tr>
<td>• Transit: in-vehicle travel time, out-of-vehicle travel time</td>
<td></td>
</tr>
<tr>
<td>Travel cost savings:</td>
<td></td>
</tr>
<tr>
<td>• Auto operating costs</td>
<td></td>
</tr>
<tr>
<td>• Auto ownership costs</td>
<td></td>
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<tr>
<td>• Parking costs</td>
<td></td>
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<tr>
<td>Emissions reduction:</td>
<td></td>
</tr>
<tr>
<td>• CO₂</td>
<td></td>
</tr>
<tr>
<td>• PM₂.₅</td>
<td></td>
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<tr>
<td>• ROG</td>
<td></td>
</tr>
<tr>
<td>• NOₓ</td>
<td></td>
</tr>
<tr>
<td>Collision reduction:</td>
<td></td>
</tr>
<tr>
<td>• Fatalities</td>
<td></td>
</tr>
<tr>
<td>• Injuries</td>
<td></td>
</tr>
<tr>
<td>• Property damage</td>
<td></td>
</tr>
<tr>
<td>Health cost savings due to active transportation</td>
<td></td>
</tr>
<tr>
<td>Noise reduction</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROJECT COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital costs</td>
</tr>
<tr>
<td>Net operating and maintenance costs</td>
</tr>
</tbody>
</table>
### TABLE 4 Benefit Valuations and Sources

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Plan Bay Area Valuation ($2013)</th>
<th>What does this valuation include?</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Vehicle Travel Time (Auto and Transit) per Person Hour of Travel</td>
<td>$16.03</td>
<td>This valuation is set equal to one-half of the mean regional wage rate ($32.06). The valuation represents the discomfort to travelers of enduring transportation-related delay and the loss in regional productivity for on-the-clock travelers &amp; commuters. Sources: Caltrans Cal B-C Model; Bureau of Labor Statistics National Compensation Survey, 2011</td>
</tr>
<tr>
<td>Out-of-Vehicle Travel Time (Transit) per Person Hour of Travel</td>
<td>$35.27</td>
<td>This valuation is set equal to 2.2 times the valuation of in-vehicle transit time. The valuation represents the additional discomfort to travelers of experiencing uncertainty of transit arrival time, exposure to inclement weather conditions, and exposure to safety risks. Source: FHWA Surface Transportation Economic Analysis Model (STEAM)</td>
</tr>
<tr>
<td>In-vehicle Travel Time (Freight/Trucks) per Vehicle Hour of Travel</td>
<td>$26.24</td>
<td>The valuation is set equal to the average wage rate for a Bay Area employee in the Transportation – Truck Driver (average of heavy and light) occupation sector ($23.83/hour), plus the average hourly carrying value of cargo ($2.41/hour). Sources: FHWA Highway Economic Requirements System; Bureau of Labor Statistics National Compensation Survey, 2011</td>
</tr>
</tbody>
</table>
| Travel Time Reliability per Person Hour (Auto) or per Vehicle Hour (Truck) of Non-recurring Delay | $16.03 [Auto]  
$26.24 [Truck] | The valuation represents the additional traveler frustration and loss of regional productivity of experiencing non-expected incident related travel delays. The value is set equal to the value of in-vehicle travel time for autos and trucks. Source: SHRP2 L05 Project – "Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes" |
| Fatality Collisions (valuation per fatality)                             | $4,590,000                       | The valuation includes the internal costs to a fatality collision victim (and their family) resulting from the loss of life, as well as the external societal costs. The valuation represents:  
  • Loss of life for the victims  
  • Medical costs incurred in attempts to revive victims  
  • Loss of enjoyment of family member to other members of the family  
  • Loss of productivity to the family unit (e.g. loss of earnings)  
  • Loss of productivity to society  
  • Loss of societal investment in the victim (e.g. educational costs)  
Sources: Caltrans Cal-BC Model, 2010; National Safety Council, 2010 |
| Injury Collisions (valuation per injury)                                  | $64,000                          | The valuation includes the internal costs to an individual (and their family) resulting from the injury, as well as the external societal costs. The valuation represents:  
  • Pain and inconvenience for the individuals  
  • Pain and inconvenience for the other family members  
  • Medical costs for injury treatment  
  • Loss of productivity to the family unit (e.g. loss of earnings)  
  • Loss of productivity to society  
Sources: Caltrans Cal-BC Model, 2010; National Safety Council, 2010 |
<table>
<thead>
<tr>
<th>Benefit</th>
<th>Plan Bay Area Valuation ($2013)</th>
<th>What does this valuation include?</th>
<th>Source:</th>
</tr>
</thead>
</table>
| Property Damage Only (PDO) Collisions        | $2,455                           | The valuation includes the internal costs to a property damage collision victim (and their family) resulting from the time required to deal with the collision, as well as the external societal costs from this loss of time. The valuation represents:  
  - Inconvenience to the individual and to other members of the family  
  - Loss of productivity to the family unit  
  - Loss of productivity to society                                                                                                                      | Caltrans Cal-BC Model, 2010                                                                  |
| CO\textsubscript{2} per Metric Ton           | $55.35                           | This valuation represents the full global social cost of an incremental unit (metric ton) of CO\textsubscript{2} emissions from the time of production to the damage it imposes over the whole of its time in the atmosphere.                                                                 | BAAQMD Clean Air Plan, 2010 (uprated to year 2035 using a 2% annual adjustment)               |
| Particulate Matter per Ton                   | $490,300 [diesel PM\textsubscript{2.5}]  
$487,200 [direct PM\textsubscript{2.5}] | These valuations represent the negative health effects of increased emissions including:  
  - Loss of productive time (work & school)  
  - Direct medical costs from avoiding or responding to adverse health effects (illness or death).  
  - Pain, inconvenience, and anxiety that results from adverse effects (illness or death), or efforts to avoid or treat these effects  
  - Loss of enjoyment and leisure time  
  - Adverse effects on others resulting from their own adverse health effects                                                                 | BAAQMD Clean Air Plan, 2010                                                                  |
| NOx per Ton                                  | $7,800                           |                                                                                                                                                                                                                                |                                                                                               |
| ROG per Ton                                  | $5,700 [acetaldehyde]  
$12,800 [benzene]  
$32,200 [1,3-butadiene]  
$6,400 [formaldehyde]  
$5,100 [all other ROG] | This valuation represents the variable costs (per mile) of operating a vehicle. This valuation includes fuel, maintenance, depreciation (mileage), and tires.                                                                 | Caltrans Cal-BC Model, 2010                                                                  |
| SO\textsubscript{2} per Ton                  | $40,500                          |                                                                                                                                                                                                                                |                                                                                               |
| Vehicle Operating Costs per Vehicle Mile Traveled (VMT) | $0.2688 [Auto]  
$0.3950 [Truck] | This valuation represents the value of property value decreases and societal cost of noise abatement.                                                                                                                                     | FHWA Federal Cost Allocation Report                                                           |
| Noise per Vehicle Mile Traveled              | $0.0012 [Auto]  
$0.0150 [Truck] | This valuation represents the savings achieved by influencing an insufficiently active adult to engage in moderate physical activity five or more days per week for at least 30 minutes. It reflects annual Bay Area health care cost savings of $326 (2006 dollars), as well as productivity savings of $717 (2006 dollars).  
  Source: California Center for Public Health Advocacy/ Chenoweth & Associates 2006, “The Economic Costs of Overweight, Obesity, and Physical Inactivity Among California Adults”  
  Source: MTC Bay Area auto ownership analysis, 2011                                                                 |                                                                                               |
| Costs of Physical Inactivity                 | $1,220                           |                                                                                                                                                                                                                                |                                                                                               |
| Auto Ownership Costs per Vehicle (change in the number of autos) | $6,290                           | This valuation represents the annual ownership costs of vehicles, beyond the per mile operating costs. This valuation includes purchase/lease cost, maintenance, and finance charges.                                                                 | MTC Bay Area auto ownership analysis, 2011                                                  |
In order to calculate the benefit-cost ratio (7), benefits and costs were annualized to reflect the project impacts in horizon year 2035. Benefits were based on year 2035 travel model output for a typical weekday, and therefore had to be multiplied by an annualization factor to determine the annual benefits. Capital costs were annualized based on the expected useful life of the corresponding transportation asset type, and then combined with their net annual operating and maintenance cost.

The resulting benefit-cost ratios allow us to better understand the cost-effectiveness of investing in various transportation projects in the Bay Area. Most projects were shown to be at least somewhat cost-effective (as indicated by a benefit-cost ratio greater than 1), while a subset of projects (with benefit-cost ratios less than 1) were identified as low-performers due to their poor performance on this cost-effectiveness metric.

**PROJECT ASSESSMENT – KEY FINDINGS**

By combining the targets assessment and benefit-cost assessment, the project assessment allowed MTC staff to inform policymakers about the merits and limitations of projects (8). While the targets assessment tended to favor non-roadway projects such as transit frequency improvements or expansions to the bicycle network, the benefit-cost assessment complemented the targets assessment by considering overall project cost-effectiveness and capturing additional quantifiable benefits such as congestion reduction.

The results of the project-level performance assessment are summarized in Figures 2, 3, and 4. Each “bubble chart” shows the benefit-cost ratio (on the vertical axis) and the targets score (on the horizontal axis), while the bubble size corresponds to the magnitude of benefits. High-performers can be identified in the upper-right corners of each “bubble chart”. Several important themes emerged from the project performance assessment as a whole, highlighting key differences between efficiency and expansion projects, as well as between projects in the urban core versus projects in the outer Bay Area.

First, efficiency projects (which focus on improving existing transportation assets) typically performed better on both components of the project assessment than expansion projects (which emphasize widening highways or extending fixed transit guideways to new service areas). Implementation of ITS technologies – such as ramp metering and signal coordination – through programs like MTC’s Freeway Performance Initiative performed better than freeway widening projects; this is due to the cost-effectiveness of efficiency projects in comparison to capital-intensive construction. Congestion pricing projects, including a proposal to implement cordon pricing in San Francisco’s central business district, were shown to be even more highly cost-effective, given their ability to reduce congestion and fund additional transit service with net revenues. In addition to their cost-effectiveness, road efficiency and congestion pricing projects achieved many of the Plan Bay Area targets. In comparison, the Express Lane Network projects, which include some widening elements, showed adverse impacts to some of the Plan Bay Area targets by increasing capacity for automobiles through construction of new highway lane-mileage.

Transit efficiency projects also performed very well, demonstrating a high level of cost-effectiveness and strong support for the targets. Projects such as bus rapid transit systems in San Francisco and Oakland emphasized high-demand corridors where dedicated lanes and bus signal priority achieve substantial benefits at a relatively low cost. In fact, the highest-performing project in the entire assessment – the BART Metro Program – was entirely focused on efficiency. This project, emphasizing improvements to the urban core of the heavy-rail BART system, would construct new turnbacks and implement express train service to provide more frequent and faster service along existing routes. In this era of constrained resources, both transit and road efficiency projects appear to meet regional goals and provide the best “bang per buck”.

TRB 2013 Annual Meeting Paper revised from original submittal.
Second, projects serving the urban core performed significantly better than projects in less-populated outer regions of the Bay Area. This was particularly evident with transit projects; less-dense locations often lead to reduced accessibility to transit stops and therefore lower levels of ridership. This was exemplified by projects in the North Bay counties of Marin and Sonoma, where transit frequency improvements and commuter rail extensions all showed benefit-cost ratios less than one. In comparison, some of the region’s highest-performing transit projects were along the densest corridors in the region – San Francisco’s Market Street and Van Ness Avenue and Oakland’s MacArthur Boulevard and International Boulevard.

The region’s two proposed heavy-rail BART extensions also were indicative of this trend. BART to San Jose/Santa Clara (Phase 2), going through downtown San Jose and the heart of Silicon Valley received a very strong targets score, while also achieving a benefit-cost ratio of five. Conversely, various alternatives for BART to Livermore, which serves a more suburban city at the edge of the Bay Area, received somewhat supportive targets scores, but only achieved a benefit-cost ratio of one at best.

Roadway expansion projects, which primarily were focused on the outer Bay Area and did not serve the urban core, performed moderately well on the benefit-cost assessment but received the lowest target scores (demonstrating adverse impacts on many of the region’s targets). For example, the New SR-152 Alignment or the proposed SR-239 Brentwood-to-Tracy Expressway significantly increase auto capacity and may lead to a more dispersed land use pattern, concerns that were highlighted in the poor target assessment performance.

In order to take action on the key results of the Plan Bay Area project performance assessment, low-performing projects – those that failed to achieve a benefit-cost ratio less than 1 or those that showed adverse impacts on the targets assessment – were required to present a compelling case to the boards of MTC and ABAG. Policymakers applied appropriate discretion to issues beyond the performance assessment to determine which low-performing projects should be approved or rejected for inclusion in the Plan.

**CONCLUSIONS**

The project assessment methodology used for Plan Bay Area was a significant improvement in comparison to the previous RTP, as staff performed a much more advanced benefit-cost assessment and evaluated targets support for every major uncommitted project on an individual level. Additionally, this project-level evaluation for an RTP process went a step beyond scenario-level analysis typically performed for long-range regional planning – providing a level of detailed analysis an order of magnitude greater than possible at the scenario level.

Some of the key strengths of the Plan Bay Area project assessment are listed below:

- Every uncommitted, capacity-increasing project was evaluated individually, as opposed to scenario-level analysis where projects are bundled together. This assessment allowed MTC staff to identify high- and low-performing projects across the region.
- The modeling approach allowed for flexibility in travel behaviors, while accounting for secondary effects of particular projects (such as congestion reduction on parallel routes). The “mode choice” modeling approach was able to capture modal shifts, while still running in a fraction of the time of the full travel model.
- The targets assessment was able to connect the scenario-level performance measures to the project level; this assessment captured qualitative concerns beyond the scope of the analytically-driven and model-based benefit-cost assessment.

At the same time, we gained a better understanding of our own modeling and analysis limitations through this process:
Land use impacts of projects could not be feasibly considered in the benefit-cost analysis. Although Plan Bay Area relied on MTC’s recently updated Travel Model One with its significantly improved tour-based framework, at the time it did not interact with the region’s UrbanSim land use model, currently under development. Modeling staff will be merging these two models in the next few years, allowing for iteration between these two elements. This will allow transportation projects to have a direct cause-and-effect relationship with the land use pattern – e.g. if a new transit station is built, development might be intensified around that location, if local land use policies permit.

The benefit-cost assessment does not consider accrued benefits over every year of the Plan; it focuses on a single horizon year. This is simply due to the complexity of estimating benefits for more than one year, since each model run can only produce data for a single year. Even though the Plan Bay Area analysis included a confidence assessment to flag this issue of importance, a lifecycle benefit-cost approach would better capture the true benefits of easily-implementable projects that achieve benefits sooner rather than later.

The targets assessment was based on qualitative criteria, rather than quantitative model output. In many cases, qualitative criteria make it very difficult to consider the project’s magnitude of benefits – for example, a 1-station rail extension and a 10-station rail extension could receive the same level of targets support, even though the larger project might have significantly greater benefits in achieving the regional Plan Bay Area targets.

The project-level assessment process took at least 50% longer than originally anticipated, simply due to the large number of projects under consideration. The sheer quantity of model output, combined with the large number of benefits to be calculated, made this process challenging and time-consuming.

Further development of modeling and analysis tools over the coming years has the potential to both strengthen and expedite project assessment processes for future planning efforts. As processes are streamlined, this type of regional project-level analysis will continue to increase in utility.

The advancements in performance assessment throughout the Plan Bay Area process represent an important step in developing well-defined technical data to inform key policy decisions. Thanks to these rigorous scenario- and project-level analyses, policymakers were able to better craft a preferred scenario for Plan Bay Area.
FIGURE 2  Bubble chart of project performance for all road projects.
FIGURE 3 Bubble chart of project performance for all transit projects.
FIGURE 4  Bubble chart of project performance categorized by project type.
REFERENCES


