PERFORMANCE ASSESSMENT REPORT

Plan Bay Area 2040

FINAL SUPPLEMENTAL REPORT

Metropolitan Transportation Commission

Association of Bay Area Governments

JULY 2017

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Plan Bay Area 2040

Plan Bay Area 2040:

Final Performance Assessment Report

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Executive Summary

Performance-based planning is at the core of Plan Bay Area 2040, incorporating performance targets, project-level evaluation, and scenario assessment to better inform policy decisions and the public at large. As part of the performance-based planning process for Plan Bay Area 2040, MTC and ABAG developed a set of regional performance targets to evaluate both planning scenarios and individual transportation projects. Building on the framework established as part of Plan Bay Area, the work for Plan Bay Area 2040 featured an expanded emphasis on equity and sustainability, while at the same time conducting new performance analyses on state of good investments.

Methodology

Thirteen performance targets, based on seven regional goals, were developed collaboratively with state, regional, and local public agencies, as well as stakeholder groups. The adopted targets addressed a broad spectrum of issues including climate change, housing, health and safety, open space, equity, economic vitality, and transportation efficiency. While all of the goals and a handful of targets were carried over from Plan Bay Area, new targets were added on topics such as displacement risk and access to jobs that gained greater emphasis than in prior plans.

Performance assessment was a critical component throughout the development of Plan Bay Area 2040. After establishing the performance targets in late 2015, scenarios combining various land use patterns and transportation investments were quantitatively evaluated to determine how strongly they supported the adopted targets. In order to refine these scenarios and develop the Preferred Scenario, MTC also evaluated individual transportation projects to prioritize high-performers and to reconsider the efficacy of low-performers. This project-level assessment examined major projects' qualitative support for the Plan targets, in addition to quantitatively evaluating major projects' cost-effectiveness via a benefit-cost analysis. Finally, most scenarios were carried over into the EIR analysis as alternatives, alongside a new alternative added as a response to scoping comments. The ultimate scenario target results highlight where the Plan has succeeded in meeting the targets and where it falls short, as well as what alternative approaches or strategies might strengthen the Preferred Scenario or future long-range planning efforts.

Key Findings

Identification of Performance Targets: New issues emerged as priorities in this cycle of performance-based planning. As noted above, new targets were created on emerging issues like displacement risk and middle-wage jobs that had not previously been included in Plan Bay Area. In the end, five targets were carried over from the last Plan, and eight new targets were added to the mix, for a total of thirteen performance targets. Equitable Access and Economic Vitality, which each had one target in Plan Bay Area, were expanded to feature three targets each – an indication of a broader array of interests related to those two goals this cycle.

Scenario Targets Assessment: As with Plan Bay Area, scenarios often fell short of the adopted targets due to the ambitious nature of the targets selected by the Commission and by ABAG. This being said, many, if not all, scenarios made notable progress on issues like open space preservation, greenhouse gas reduction, middle-wage job growth, and congestion reduction on freight corridors. Serious challenges remained across all scenarios, though. Despite which land use pattern or transportation investment strategy was pursued, target results related to affordability and displacement risk consistently pointed in the wrong direction.

Project Performance Assessment: Results of the project-level assessment revealed the high cost-effectiveness and strong support of Plan Bay Area 2040 targets for maintaining public transit and state highways. Fully investing in state of good repair for these modes, when compared with medium-performing local streets & roads maintenance, would generate approximately $7 billion in annual benefit compared to $5 billion in annual benefit for the sum of the remaining 63 non-maintenance investments. Additionally, the assessment reinforced the positive effect of a focused growth land use pattern on performance, particularly for transit projects that would serve densifying PDAs in the South bay. Generally, modernization 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)

The assessment identified 11 high-performing projects, for which staff subsequently prioritized future regional discretionary revenues. The assessment also identified 18 low-performing projects that were further screened before inclusion in Plan Bay Area 2040. Of the low-performing projects, 7 were approved with minor changes, 7 were re-scoped to a lower-cost phase or environmental/planning phases, and 4 were dropped via a compelling case process.

Conclusions

While the Preferred Scenario moves in the right direction on many of the region's important performance targets, the targets analysis revealed that the region's mature development pattern and extensive transportation system lead to challenges in changing the status quo and achieving aggressive adopted goals. Limited policy levers related to key equity and affordability challenges further constrain the ability of MTC and ABAG, in concert with local jurisdictions, to "move the needle" and reverse historical trends. In order to achieve the aspirational goals established in the Plan targets, much more aggressive action from multiple levels of government will be required after the adoption of this Plan.

Purpose of Performance Assessment

Plan Bay Area 2040 relied upon a performance-based planning approach, utilizing quantifiable metrics to evaluate the outcomes of integrated transportation investments and land use policies. By leveraging analytical tools to identify measureable outcomes of policy decisions, we can make more informed decisions and better understand the impacts of Plan Bay Area 2040.

Performance-based transportation planning is not a new approach for the Bay Area – over a period spanning nearly two decades, MTC's long-range transportation plans have been developed using performance measures to evaluate their support for regional goals. Starting with the 2001 Regional Transportation Plan (RTP), transportation investment packages were compared using a set of performance measures. Since then, qualitative and quantitative evaluations have been added to assess the impacts of individual transportation projects proposed for inclusion in RTPs.

This report provides documentation of the three-year-long effort to evaluate and improve the performance of Plan Bay Area 2040. These efforts have helped craft and guide the Plan from a series of vision scenarios to the Final Preferred Scenario, while examining how integrated transportation and land use planning efforts can help the region address long-term environmental, equity, and economic challenges. The remainder of this report is organized into the following chapters, which reflect the various phases of performance assessment during the planning process:

- **Identification of Performance Targets and Methodologies**
- **Scenario & EIR Alternative Performance Targets Analysis**
- **Project Performance Assessment** *(including State of Good Repair Performance)*

Identification of Performance Targets & Methodologies

Performance targets form the foundation of a performance-based planning approach – that is, one must start by defining the region's objectives before assessing the performance of various alternatives. Given that Plan Bay Area 2040 was a limited and focused update to the initial Plan adopted in 2013, the sustainability-focused goals – built on the 3 "E's" framework (equity, environment, economy) – were preserved. These goals – climate protection, adequate housing, healthy and safe communities, open space and agricultural protection, equitable access, economic vitality, and transportation system effectiveness – reflect the wide spectrum of sustainability objectives for this long-range planning effort. While the goals were carried over from Plan Bay Area, the performance measures and associated targets were updated to better reflect the priorities of the region today. These targets then provided a framework that allowed us to better understand how different projects and policies might affect the region's future.

Each target was designed to compare conditions over the life of the Plan – that is, measuring the change between the baseline year (2005 or 2010) and the planning horizon year (2035 or 2040). Importantly, the targets were crafted to focus on desirable regional outcomes that did not prescribe a specific mode or investment type to reach the target. For example, a potential target might focus on health outcome improvements, which can be addressed through a wide variety of investments such as new or improved transit services, changes in land use patterns to encourage walking and biking, increased incentives for adoption of electric vehicles, or reduced speed limits to address fatalities from collisions.

Criteria and Process for Performance Targets

In order to evaluate potential performance targets and to help advise staff on which targets should be recommended to MTC and ABAG for approval, staff assembled a Performance Working Group. Open to the public, Performance Working Group meetings were attended by local and regional government staff (including county congestion management agencies), Policy Advisory Council members, and non-governmental organization representatives (from groups focused on social equity, the environment, and the economy).

To guide the process, MTC staff developed a set of criteria (as shown in Table 1) to make the targets as meaningful as possible in measuring the Plan's success. The criteria utilized in this process primarily focused on ensuring the targets could be forecasted using available analytical tools and could be influenced by the Plan's investments and policies.

#	Criterion
1	**Targets should be able to be forecasted well.** A target must be able to be forecasted reasonably well using MTC's and ABAG's models for transportation and land use, respectively. This means that the target must be something that can be predicted with reasonable accuracy into future conditions, as opposed to an indicator that can only be observed.
2	**Targets should be able to be influenced by regional agencies in cooperation with local agencies.** A target must be able to be affected or influenced by policies or practices of ABAG, MTC, BAAQMD and BCDC, in conjunction with local agencies. For example, MTC and ABAG

	policies can have a significant effect on accessibility of residents to jobs by virtue of their adopted policies on transportation investment and housing requirements.
3	**Targets should be easy to understand.** A target should be a concept to which the general public can readily relate and should be represented in terms that are easy for the general public to understand.
4	**Targets should address multiple areas of interest.** Ideally, a target should address more than one of the three "E's" – economy, environment, and equity. By influencing more than one of these factors, the target will better recognize the interactions between these goals. Additionally, by selecting targets that address multiple areas of interest, we can keep the total number of targets smaller.
5	**Targets should have some existing basis for the long-term numeric goal.** The numeric goal associated with the target should have some basis in research literature or technical analysis performed by MTC or another organization, rather than being an arbitrarily determined value.

Table 1. Technical criteria for selecting performance targets.

Furthermore, staff established criteria for identifying the set of targets, seeking to ensure a reasonable number of distinct and quantifiable metrics. This focused the process on the most important issues for Plan Bay Area 2040 stakeholders. The criteria established for the overall set of targets is shown below in Table 2.

#	Criterion
A	**The total number of targets selected should be relatively small.** Targets should be selected carefully to make technical analysis feasible within the project timeline and to ensure that scenario comparison can be performed without overwhelming decision-makers with redundant quantitative data.
B	**Each of the targets should measure distinct criteria.** Once a set of targets is created, it is necessary to verify that each of the targets in the set is measuring something unique, as having multiple targets with the same goal unnecessarily complicates scenario assessment and comparison.
C	**The set of targets should provide some quantifiable metric for each of the identified goals.** For each of the seven goals identified, the set of performance measures should provide some level of quantification for each to ensure that that particular goal is being met. Multiple goals may be measured with a single target, resulting in a smaller set of targets while still providing a metric for each of the goals.

Table 2. Technical criteria identifying a set of targets.

Over a period of five months, the Performance Working Group discussed potential performance measures affecting a broad range of regional issues, debating which metrics reflected the most important objectives for this planning process. Incorporating this feedback, staff developed a proposal for the Commission and ABAG to review in September 2015. Both agencies approved nine performance targets at that time and asked for further review and refinement of four additional performance targets. The remaining four targets were approved in November 2015 by the Commission and by ABAG.

Adopted Goals and Targets

As discussed above, MTC Resolution 4204, Revised was adopted in fall 2015 and identified seven goals and thirteen performance targets for Plan Bay Area 2040. Accompanying the resolution were approved methodologies to be used in evaluating the performance measures as part of the scenario planning process (discussed later in this section). Like Plan Bay Area, the Plan Bay Area 2040 performance targets went well beyond the traditional mobility targets from past RTPs. The targets focused on broad outcomes – such as public health, displacement risk, and access to opportunity – that could be achieved by a variety of transportation and land use policies. This outcome-oriented approach to performance targets expanded the focus of the planning effort, emphasizing the societal benefits derived from implementing transportation projects or changing land use patterns.

One significant shift in the performance targets for Plan Bay Area 2040 was an increased emphasis on social equity and affordability, reflecting growing regional challenges associated with adverse impacts from the current economic boom. Ultimately, six of the targets had an equity nexus (public health, affordability, affordable housing, displacement risk, middle-wage job creation, and access to jobs) and were used as metrics in the equity analysis process; more information on that effort is available in the Equity Assessment Report.

Goal	#	Target
Climate Protection	**1**	Reduce per-capita CO_2 emissions from cars and light duty trucks by **15%**
Adequate Housing	**2**	House **100%** of the region's projected growth by income level without displacing current low-income residents and with no increase in in-commuters over the Plan baseline year
Healthy & Safe Communities	**3**	Reduce adverse health impacts associated with air quality, road safety, and physical inactivity by **10%**
Open Space & Agricultural Preservation	**4**	Direct **all** non-agricultural development within the urban footprint (existing urban development and UGBs)
Equitable Access	**5**	Decrease the share of lower-income residents' household income consumed by transportation and housing by **10%**
	6	Increase the share of affordable housing in PDAs, TPAs, or high-opportunity areas by **15%**
	7	**Do not increase** the share of low- and moderate-income renter households in PDAs, TPAs, or high-opportunity areas that are at risk of displacement
Economic Vitality	**8**	Increase by **20%** the share of jobs accessible within 30 minutes by auto or within 45 minutes by transit in congested conditions
	9	Increase by **38%** the number of jobs in predominantly middle-wage industries
	10	Reduce per-capita delay on the Regional Freight Network by **20%**

Transportation System Effectiveness	**11**	Increase non-auto mode share by **10%**
	12	Reduce vehicle operating and maintenance costs due to pavement conditions by **100%**
	13	Reduce per-rider transit delay due to aged infrastructure by **100%**

Table 3. Final adopted goals and performance targets for Plan Bay Area 2040.

Baseline and Horizon Years for Target Assessment

Baseline and horizon years for each target were identified in the methodology documentation associated with MTC Resolution 4204. In general, the Plan relies on a baseline year of 2005 and a horizon year of 2040; however, in some cases, specific rationale justified slight alterations to these assumptions due to data availability, consistency with land use forecasts, or state requirements under Senate Bill 375. A summary of the baseline and horizon years by target is shown below.

- Target 1: baseline year of 2005, horizon year of **2035** *[due to SB 375/CARB target]*
- Target 2: baseline year of **2010**, horizon year of 2040 *[due to control total timeframe]*
- Target 3: baseline year of 2005, horizon year of 2040
- Target 4: baseline year of **2010**, horizon year of 2040 *[per MTC Resolution No. 3987]*
- Target 5: baseline year of 2005, horizon year of 2040
- Target 6: baseline year of **2010**, horizon year of 2040 *[due to land use forecast constraint]*
- Target 7: baseline year of **2010**, horizon year of 2040 *[for consistency with land use targets]*
- Target 8: baseline year of 2005, horizon year of 2040
- Target 9: baseline year of **2010**, horizon year of 2040 *[due to control total timeframe]*
- Target 10: baseline year of 2005, horizon year of 2040
- Target 11: baseline year of 2005, horizon year of 2040
- Target 12: baseline year of 2005, horizon year of 2040
- Target 13: baseline year of 2005, horizon year of 2040

Target Descriptions and Methodologies

Performance Target #1: Climate Protection

Reduce per-capita CO_2 emissions from cars and light duty trucks by 15%

Background Information

Under California Senate Bill 375, major metropolitan areas in the state are required to develop a Sustainable Communities Strategy as part of their Regional Transportation Plan. This means that the adopted Plan must achieve per-capita greenhouse gas reduction targets as established by the California Air Resources Board (CARB). CARB established two climate protection targets for the San Francisco Bay Area in 2010, which have been incorporated into both Plan Bay Area and Plan Bay Area 2040:

- Per-capita reduction of greenhouse gas emissions by 7 percent by year 2020
- Per-capita reduction of greenhouse gas emissions by 15 percent by year 2035

This is a statutory target and therefore must be reflected in the set of Plan performance targets. Under Senate Bill 375, the Plan must meet state-identified greenhouse gas reduction targets to comply without the adoption of a separate Alternative Planning Strategy (APS).

Past Experience

This target is fully consistent with Plan Bay Area; no changes have been made to the target as originally adopted in 2011. Before the passage of Senate Bill 375, previous MTC long-range plans, including Transportation 2035, included non-statutory targets to reduce greenhouse gas emissions.

Plan Bay Area exceeded the greenhouse gas emissions target, achieving a 16 percent reduction for year 2035 and an 18 percent reduction in emissions between 2005 and 2040, while at the same time also exceeding its 2020 interim target. The target performance results incorporate both the emissions reduction from transportation, land use and demographics (from Travel Model One and EMFAC), in addition to the emissions reductions associated with the Regional Climate Program (based on off-model assessments).

Evaluation Methodology

The statutory Climate Protection target reflects greenhouse gas emissions reductions, focusing specifically on carbon dioxide emissions per statewide modeling guidance. Travel Model One – the region's activity-based travel demand model – was used to forecast emissions reductions as a result of various scenarios. Travel Model One analyzes daily travel patterns as a result of scenarios' transportation investments and land use patterns, making possible the calculation of vehicle miles traveled (VMT) and speed of travel. The California Air Resources Board's EMFAC air quality model was then used to calculate the pounds of carbon dioxide emissions associated with the forecasted levels of regional travel.

For off-model Climate Initiatives, which may include efforts like regional electric vehicle incentives, greenhouse gas emissions reductions were calculated by estimating the direct greenhouse gas emissions reduction of specific funded programs, rather than forecasting travel impacts in the model. This is appropriate, as many of the programs are not designed to necessarily reduce VMT, but instead reduce emissions through cleaner vehicles and improved driving habits. These greenhouse gas emission reductions were added to the model calculations, resulting in combined greenhouse gas emission reductions from the Plan as a whole. Reductions were normalized based on relevant population forecasts developed by ABAG. Refer to additional information on the forecasting methodology in the Plan Bay Area 2040 Travel Model One Data Summary.

Note that the target relies upon a horizon year of 2035 instead of the standard 2040 horizon year used for other performance targets to ensure consistency with the CARB target.

Performance Target #2: Adequate Housing

House 100% of the region's projected growth by income level without displacing current low-income residents and with no increase in in-commuters over the Plan baseline year

Background Information

Similar to the greenhouse gas reduction target, California Senate Bill 375 requires Plan Bay Area to house all of the region's growth. This is an important regional issue given that long interregional trips – which typically have above-average emission impacts – can be reduced by planning for sufficient housing in the region.

The Adequate Housing target relates to a Regional Housing Control Total per the 2014 settlement agreement signed with the Building Industry Association (BIA), which increases the housing forecast by the housing equivalent to in-commute growth. The forecast of households, jobs, population, and in-commute will remain as established by the approved forecast methodology and best practices.

Past Experience

A similar version of this target was included in Plan Bay Area adopted in 2013, although Plan Bay Area 2040 incorporates language clarifying how the regional housing control total was calculated, as agreed to by MTC, ABAG, and the Building Industry Association as part of a 2014 legal settlement. In 2013, Plan Bay Area housed 100% of the region's projected growth as defined under the adopted language from 2011.

Evaluation Methodology

Evaluation of this performance target utilized the methodology relating to the Regional Forecast agreed to by both agencies. The regional housing control total estimated the total number of units needed to accommodate all of the residents in the region plus the number of housing units that correspond to the in-commute increase. The number of units included a reasonable vacancy level for circulation of units among movers. The figure below diagrams the overall regional forecast process that led to a regional housing control total.

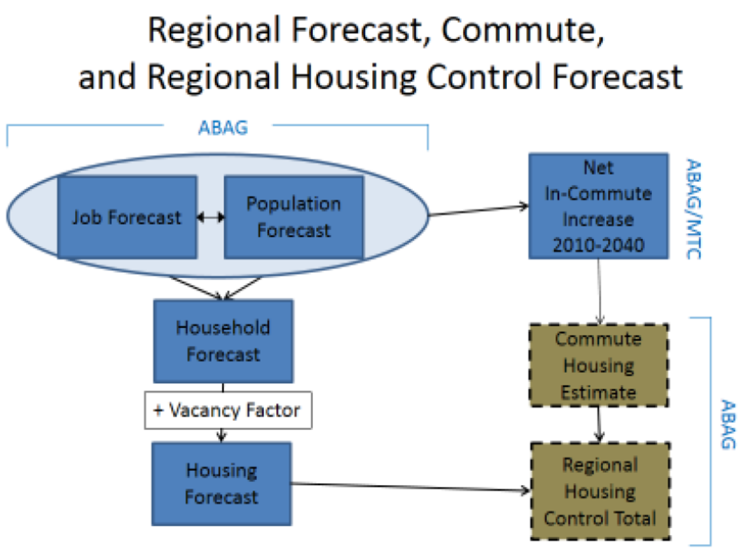


Figure 1. Diagram of regional housing forecast methodology.

Performance Target #3: Healthy and Safe Communities

Reduce adverse health impacts associated with air quality, road safety, and physical inactivity by 10%

Background Information

This target focuses on the issue of public health by evaluating the net impacts of air quality, road safety and physical activity improvements. By creating a unified target that directly measures the net health impact of scenarios, Plan Bay Area 2040 elevated this issue when compared to prior planning cycles. Rather than adopting separate targets for air quality, road safety and physical activity, this proposed target focuses on the combined impact of the transportation and land use policies that move the region towards a common goal of improved health outcomes. Adverse health impacts are measured in disability-adjusted life-years of impact (DALYs) on a per-capita basis.

The numeric target was selected based on an analysis by Neil Maizlish, et al. entitled "Health Cobenefits and Transportation-Related Reductions in Greenhouse Gas Emissions in the San Francisco Bay Area", published in the American Journal of Public Health. In this paper, Maizlish et al. conducted an analysis of the Bay Area to see how an aggressive scenario focused on increased bicycle and pedestrian mode shares might move the needle for public health. When the net impact of such a policy (versus a business-as-usual scenario) is compared to the total disability-adjusted life-year impacts to the region from MTC model runs, the region yielded a reduction of just over five percent. While active transportation is the largest component of health benefits, road safety and air quality focused investments in the Plan can also move the needle. Given that analysis, a slightly more aggressive target of 10 percent reduction was recommended for this performance target.

Past Experience

This is a new target for Plan Bay Area 2040 that incorporates components of multiple Plan Bay Area targets into a single integrated target. It reflects one of the top priorities of the Performance Working Group in terms of advancing public health as a key element of the long-range planning process.

Evaluation Methodology

To calculate the health impacts of a given scenario, staff ran the Integrated Transportation and Health Impact Model (ITHIM), which was calibrated for the Bay Area by the California Department of Public Health. The run requires inputs from Travel Model One, which include travel activity patterns for walking and biking as well as rates related to collisions and air quality. ITHIM then translates those inputs into a detailed suite of health impact measures, including disability-adjusted life-year impacts. The impacts were normalized based upon population to take into account the overall growth expected in the region between 2005 and 2040.

Performance Target #4: Open Space and Agricultural Preservation

Direct all non-agricultural development within the urban footprint (existing urban development and UGBs)

Background Information

This performance target is focused very specifically on the protection of open space and agricultural lands. In order to move towards this goal, the target seeks to limit development to publicly-defined urban areas. SB 375 legislation asks regions to consider the best available data on resource lands. Special resource lands and farmland are specifically defined in SB 375 and include:

- Publicly owned parks and open space;
- Open space and habitat areas protected by natural resource protection plans;
- Species habitat protected by federal or state Endangered Species Acts;
- Lands subject to conservation or agricultural easements by local governments, districts, or non-profits
- Areas designated for open space/agricultural uses adopted in elements of general plans;
- Areas containing biological resources described in CEQA that may be significantly affected by a Sustainable Communities Strategy (SCS) or Alternative Planning Strategy (APS);
- Areas subject to flooding as defined by the National Flood Insurance Program; and
- Lands classified as prime/unique/state-significant farmland or lands classified by a local agency meeting or exceeding statewide standards that are outside of existing city spheres of influence/city limits.

One key difference between this target and the Adequate Housing target is that this measure is not statutory and therefore some scenarios may fall short in achieving the target.

Past Experience

This target is fully consistent with Plan Bay Area, which was the first regional plan in the Bay Area to include such a target related to greenfield protection. Plan Bay Area met the target with 100% of non-agricultural development focused in the urban footprint.

Evaluation Methodology

Using the localized development pattern forecasted by the UrbanSim land use model for each scenario, staff calculated the number of acres of new development, as well as significant redevelopment, across the entire region. Once identified, staff identified each development as occurring within the urban footprint or outside the 2010 urban footprint. The number of acres of development within the urban footprint was divided by the total acres of development across the region to calculate this target.

Note that the target relies upon the 2010 urban footprint instead of the standard year 2005 baseline used for other performance targets, per policy action taken during the adoption of Plan Bay Area targets in 2011.

Performance Target #5: Equitable Access (Affordability)

Decrease the share of lower-income residents' household income consumed by transportation and housing by 10%

Background Information

As an affordability target, decreasing the combined costs of housing and transportation for lower-income residents as a share of their income addresses a key challenge for these residents when they consider where to live and how far to travel to get to work, services and amenities. Often low-income households are not able to afford housing close to where they currently work, or where they may have access to a range of job opportunities and amenities. Being priced out of these high-opportunity areas may result in lower household income (as opportunity costs rise) and higher travel costs.

In the end, a household that can afford to live close to work and use transit or other affordable transportation options, may spend a similar or even lower share of its household income on the combined cost of housing and transportation. Reducing these costs across the region will increase affordability and boost economic opportunities for lower-income residents.

The numeric target was adapted from a 2006 report by the Center for Housing Policy ("A Heavy Load: The Combined Housing and Transportation Burdens of Working Families"). According to that report, Bay Area families with annual incomes under $70,000 spend a combined average of 61% of earnings on housing (39%) and transportation (22%). This share of 61% of earnings is approximately 10% above the national average share spent by lower-income households. Therefore, this target is set to improve transportation and housing affordability to approximately match the national average by 2040.

Past Experience

This target was included in Plan Bay Area, but the methodology for estimating housing costs has been improved as described below. Under Plan Bay Area, the region was forecasted to move in the opposite direction of this target, with housing and transportation costs as a share of income rising by 3% between 2005 and 2040. This reflects the difficulty of increasing affordability in an economically vibrant region, particularly given the forecasted future costs of housing.

Evaluation Methodology

The share of household income consumed by both transportation and housing will be forecasted by combining results from the transportation model (for future transportation costs) and land use model (for future housing costs). Both models are adjusted to identify costs for low-income households. Note that lower-income households are defined as households earning less than $60,000 in year 2000 dollars, roughly reflecting the lower two quartiles of the income spectrum.

For the transportation model, user costs account for the cost of maintaining and owning an automobile, purchasing transit fares and passes, and paying bridge and roadway tolls, etc. These costs are forecasted using Travel Model One using observed travel behavior for low-income and lower-middle-income residents; and assumptions about gas prices, toll fees, and transit fares, etc. For more information on the travel model and details on assumptions, refer to the Plan Bay Area 2040 Travel Model One Data Summary.

Housing costs for lower-income households were estimated using a combination of UrbanSim model output and a national cross-sectional model. Overall size and growth in regional population, regional income and wealth, and housing market leakage beyond the nine counties are all expected to influence housing prices in the long run. Therefore, median market-rate housing costs were estimated using a national cross-sectional model that relates housing prices to changes in population, income, and other region-specific factors. For lower-income households exposed to market-rate housing costs (i.e., the majority of lower-income households), their future costs are estimated by taking current housing costs and increasing those costs linearly at the same percent growth rate as the median home price.

Two other types of lower-income households exist as well; these households are not directly exposed to market-rate housing cost growth. First, deed-restricted housing residents are assumed to continue paying 27 percent of their income on housing, with the number of households falling into this category identified by UrbanSim model output (based on policy inputs to a given scenario). Second, lower-income households living in rent-controlled units are assumed to continue to pay roughly 85 percent of the market-rate housing costs, but households protected by rent control are forecast to continue to decline based on recent rates. Because rent control cannot be explicitly modeled at this time, these assumptions regarding rent control are the same across all scenarios analyzed. For more information on the land use model and details on assumptions, refer to the Plan Bay Area 2040 Land Use Model Data Summary.

Performance Target #6: Equitable Access (Affordable Housing)

Increase the share of affordable housing in PDAs, TPAs, or high-opportunity areas by 15%

Background Information

The provision of affordable housing is one of the Bay Area's most pressing issues. This target addresses the region's need to increase its overall share of housing that is affordable to lower-income households, focusing particularly on communities with strong transit access and communities with high levels of opportunity. The target has a nexus with anti-displacement efforts, as preservation and expansion of affordable housing in these communities helps to mitigate the risk of displacement for lower-income households.

As of 2010, approximately 15 percent of housing units in these communities have been identified as affordable; the proposed performance target would double this share to approximately 30 percent of housing units, an increase of 15 percentage points. Relying upon ballpark calculations using Plan Bay

Area growth forecasts, this would be the equivalent of locating all affordable housing in PDAs, TPAs or high opportunity areas while still allowing for 80 percent of all market-rate housing to be constructed in these zones as well.

Several definitions are critical for the evaluation of this target:

- Affordable Housing: refers to housing that is affordable to lower income households (moderate income making 80-120% AMI, low income making 50%-80% AMI, very low income making 0-50% AMI) that is either deed-restricted or produced by the market (non-deed-restricted).
- Priority Development Areas (PDAs): refers to locally-designated areas that are planned to accommodate the vast majority of regional housing and job growth.
- Transit Priority Areas (TPAs): refers to an area within a ½-mile of high quality transit (i.e., rail stop or a bus corridor that provides or will provide at least 15-minute frequency service during peak hours by the year 2040).
- High-Opportunity Areas: refers to areas that score highly in a composite score of 18 indicators, developed by the Kirwan Institute of Race and Ethnicity, pertaining to education, economic mobility, and neighborhood and housing quality.

Past Experience

This target was not included in Plan Bay Area and represents an expansion of Equitable Access targets to focus specifically on affordable housing development.

Evaluation Methodology

Baseline and future performance for this target were calculated using UrbanSim, the regional land use model, which will evaluate housing costs to identify affordable units available. UrbanSim incorporates deed restrictions into its analysis and thus reflects both deed-restricted and non-deed-restricted units in its calculations. GIS layers pertaining to PDAs, TPAs, and high-opportunity areas were then merged and overlaid on top of that baseline to determine the existing share of housing affordable to moderate to very low-income households in the Bay Area residing in those respective geographies.

Performance Target #7: Equitable Access (Displacement Risk)

Do not increase the share of low- and moderate-income renter households in PDAs, TPAs, or high-opportunity areas that are at risk of displacement

Background Information

Displacement has consistently been identified as a major concern for low-and-moderate-income households, who are most vulnerable to rising costs in the Bay Area's housing market. As households relocate to more affordable areas within and outside the region, they may lose not only their homes but also their social networks and support systems. The scale of displacement across the Bay Area has triggered major concerns among the region's elected officials who requested that displacement be directly addressed in Plan Bay Area.

The region's strong economy has brought many benefits such as employment growth, innovative technologies, and tax revenues for infrastructure improvements and public services. However, since housing production usually lags job creation, especially in a booming economy, there has been upward pressure on housing costs which is most keenly felt by households with the least resources. The working definition of displacement in this document is: Displacement occurs when a household is forced to move from its place of residence due to conditions beyond its ability to control. These conditions may include unjust-cause eviction, rapid rent increase, or relocation due to repairs or demolition, among others.

While there is currently no precise tool available to predict which and what number of households would be displaced from a given neighborhood, current research allows planners to measure existing and future displacement risk. The methodology used is based on work by the Regional Early Warning System for Displacement (REWS) study by the Center for Community Innovation at UC Berkeley (www.urbandisplacement.org). It is important to note that this approach highlights areas where lower-income households are potentially vulnerable to displacement; however, this study does not "predict" which specific neighborhoods will experience displacement, or how many households will be displaced in the future.

With a numeric target for ensuring displacement risk does not increase between the baseline and horizon years, ABAG and MTC are signaling the importance of this issue at the regional level. At the same time, regional agencies and stakeholders recognize that more specific local strategies will be needed beyond the scope of the Plan. The broader trend of risk is a function of job growth and wage disparities without an equal or greater expansion of adequate affordable housing at all income levels.

The performance target relies upon a consistent geography as target #6 (affordable housing), emphasizing minimization of displacement risk for low- and moderate-income renters who live in PDAs, TPAs (transit priority areas, per Senate Bill 375), or high-opportunity areas (as defined under target #6). This ensures consistency between the region's goals for affordable housing and minimization of displacement risk.

Past Experience

This target is not new to Plan Bay Area 2040, although it represents a more refined version of a displacement risk measure that was based on overburdened renters in the initial Plan Bay Area Equity Analysis. Overburdened renters served as a proxy for vulnerable populations. Using this methodology, the Equity Analysis conducted in 2013 estimated that the Plan increased the risk of displacement by 36% in Communities of Concern and by 8% everywhere else.

Evaluation Methodology

Displacement risk was calculated by measuring the decline of low and moderate-income households in PDAs, TPAs, or high-opportunity areas between the target baseline year and 2040. In order to forecast the risk of displacement in 2040 relative to conditions in the baseline year, the analysis compared the following data points [note that "lower-income" is defined as including both low- and moderate-income households; i.e., quartiles 1 and 2 for household income]:

- Number of lower-income households in the target baseline year in each TAZ; and
- Number of lower-income households in each TAZ in 2040 based on UrbanSim output (land use model)

Due to model limitations which make it impossible to identify household tenure by income level, all lower-income households are included in the target calculation. Only zones designated as PDAs, TPAs, or high-opportunity areas that lost lower-income households are included in the target calculation per the adopted language.

The analysis estimated which zones (i.e., TAZs) gained or lost lower-income households; those zones that lost lower-income households over the time period would be flagged as being "at risk of displacement." The share of lower-income households at risk of displacement would be calculated by dividing the number of lower-income households living in TAZs flagged as PDAs, TPAs, or high-opportunity areas with an increased risk of displacement by the total number of lower-income households living in TAZs flagged as PDAs, TPAs, or high-opportunity areas in 2040.

The relative risk of displacement for each Plan scenario was estimated using this methodology, comparing to trends between year 2000 and year 2010 to establish baseline risk levels. Relative risk is varied between scenarios, since each scenario allocated households across the region based on different growth patterns.

Performance Target #8: Economic Vitality (Access to Jobs)

Increase by 20% the share of jobs accessible within 30 minutes by auto or within 45 minutes by transit in congested conditions

Background Information

Given that economic forecasts for the Plan are consistent across scenarios, the Plan's greatest potential to affect the region's economic vitality can be measured via access to jobs. The general consensus amongst economists is that a higher number of jobs a worker can access within a reasonable commute shed leads to greater prospects for employment and greater potential for economic advancement. This performance measure is designed to capture the ability of workers to get to jobs in congested conditions, reflecting the economic impact of traffic congestion on the region's economy. Rather than a "pure" measure of congestion (such as minutes of delay), which primarily captures the benefit of highway projects and fails to recognizes the underlying economic justification for projects that tackle this regional issue, this performance measure reflects the full suite of policy tools that can be used to improve access to jobs during congested times of day. These include highway expansion, highway operational improvements, transit expansion, transit operational improvements, and land use strategies to bring workers and jobs closer together (i.e., jobs-housing balance).

Congested conditions are defined as the AM peak period, the most common time of day for commuting to work. The 30-minute and 45-minute thresholds for each mode of transport approximately reflect the average regional door-to-door commute time for each mode per Vital Signs data originally tabulated by the U.S. Census Bureau in 2013. The performance target focuses on all residents connecting to all jobs, given that this is a measure of the region's overall economy (rather than a specific industry or economic class). It is not possible to measure jobs-housing fit as ABAG does not forecast jobs by income level, making it impossible to link residents and jobs based on income classification for future years (e.g. year 2040).

The numeric target was developed relative to the baseline conditions in 2005, at which point roughly one in five regional jobs was accessible to the average Bay Area resident within the time and congestion criteria identified above. The numeric target represents an approximate doubling of this level of jobs access by year 2040; this is reflected in the target as an increase in jobs access by 20 percentage points. The target was inspired by research incorporated in the "Access to Destinations" report produced by the University of Minnesota Center for Transportation Studies, which cites a 2012 Transportation Research Board paper on productivity effects from accessibility (Melo et al., 2012). The report identified that doubling jobs access correlates to real average wage growth of 6.5 percent for the average U.S. metro area. This linkage between the target and wage growth highlights how improved access to jobs can result in real-world economic benefits for workers.

Past Experience

This target is new to Plan Bay Area 2040. However, long-range plans developed by MTC in the past have used access to jobs as an economic performance target. The proposed target expands upon this past work by specifically incorporating congestion into the target to highlight the importance of congestion reduction as a regional economic concern. The prior Plan's economic target of gross regional product was removed as a performance target as it will not differ between scenarios, making it a poor yardstick by which to compare scenarios focused on differing transportation investments and land use patterns.

Evaluation Methodology

This performance target relies upon the Travel Model One "skims" for zone-to-zone congested travel times both for single-occupant vehicles and public transit. Using a Python script developed to evaluate accessibility, the "skim" matrices are loaded into the script, which then calculates for each zone which other zones it can reach either within 30 minutes by auto or within 45 minutes by transit. It is assumed that auto users are single-occupant vehicle drivers who decline the use of Express Lanes; the job access target looks specifically at the AM peak period, when the greatest share of the region's residents are commuting to work. By focusing on the AM peak, both auto and transit travel times reflect the impact of congestion on job access. Once the script has calculated which zones are accessible, the number of jobs accessible for the zone is summed and divided by the total jobs in the region. Using the share of jobs accessible for each zone, a regional share is calculated using a weighted average of all 1454 zones based on the number of residents in each zone. The result is a reflection of the average share of jobs accessible to the average number in the Bay Area.

Performance Target #9: Economic Vitality (Jobs/Wages)

Increase by 38% the number of jobs in predominantly middle-wage industries

Background Information

As home to some of the world's most innovative and successful businesses, the Bay Area boasted a gross regional product of $631 billion in 2013, making it one of the world's largest economies. However, the region's economic prosperity is unevenly felt, as 36% of the region's 1.1 million workers earn less than $18 per hour – with the majority of these workers earning even less than $12 per hour. As the Bay Area's cost of living (particularly housing costs) continues to skyrocket, a decent quality of life is becoming increasingly out of reach for hundreds of thousands of workers, particularly those without higher education.

This performance target acknowledges the importance of middle-wage jobs in the Bay Area's economy. The numeric target is based on a goal to preserve the target baseline year share of middle-wage jobs - by growing middle-wage jobs at the same rate as the region's overall growth in total jobs. The exact numeric target was updated in early 2016 to make it fully consistent with the overall job growth rate forecast from the finalized control totals, consistent with adopted direction from the Commission and ABAG Board.

Past Experience

This target is new to Plan Bay Area 2040, as the issue of middle-wage jobs was not specifically addressed in Plan Bay Area.

Evaluation Methodology

The number of jobs in predominantly middle-wage industries was forecast using ABAG's Forecast of Housing, Population and Jobs. This target seeks to achieve proportional growth of jobs in predominantly middle-wage industries to the region's overall growth in jobs; forecasts show overall job growth of 38% between the target baseline year and 2040.

Given that some industries have a higher proportion of middle-wage jobs than others, ABAG used the number of jobs in predominantly middle-wage industries as a proxy for the number of middle-wage jobs. Presently, forecasting limitations do not allow us to project the number of jobs in individual occupations (i.e., how many nurses there will be in 2040); however, ABAG could project the sectoral makeup of jobs within different industries. The share of middle-wage jobs within each industry was identified using baseline data for wage breakdowns by industry; the share of middle-wage jobs in a given industry today was assumed to be the same in 2040 for the purpose of target forecasting.

Notably, this target does not differ between scenarios, typically a requirement for performance targets. All regional forecast totals are held constant throughout the Plan process in order to focus on the Plan's different transportation investments and land use patterns and to assure consistency within the EIR analysis. In this sense, this performance target is more of an aspirational target, rather than a measure that can be compared across scenarios.

Performance Target #10: Economic Vitality (Goods Movement)

Reduce per-capita delay on the Regional Freight Network by 20%

Background Information

This target reflects the importance of goods movement as a component of the region's overall economy. In addition to ensuring access to and from the Port of Oakland – a major economic engine for the Bay Area – goods movement is critical in supporting agricultural and industrial sectors in the region. This proposed target focuses specifically on how trucks – the primary mode for goods movement – are affected by traffic congestion. While truck traffic cannot be forecasted with a high level of precision, this performance target captures the delay on high-volume truck corridors already identified by the Regional Goods Movement Plan.

The numeric target, reflecting a goal of reducing per-capita delay on these corridors by 20 percent, was based on Transportation 2035 (adopted in 2009). That plan was the most recent long-range regional plan to incorporate a delay target, as Plan Bay Area did not have a specific target related to goods movement. While Transportation 2035 focused on delay across the entire network, this performance target is slightly refined to focus in on goods movement corridors under the overarching goal of Economic Vitality.

Past Experience

This target is similar to a performance target used in Transportation 2035; however, no targets related to congestion reduction or goods movement were included in Plan Bay Area. In Transportation 2035, per-capita congestion increased as a result of capacity-constrained infrastructure (combined with robust pre-recession employment forecasts). Plan Bay Area congestion forecasts, included in the Environmental Impact Report (EIR), also showed a significant increase in congestion between baseline year and horizon year conditions.

Evaluation Methodology

In addition to calculating total delay, Travel Model One outputs vehicle hours of delay for specific corridors. To calculate this target, the appropriate corridors were flagged for analysis based on the Regional Freight Network from the Regional Goods Movement Plan; these include segments of the following highway corridors: I-880, I-80, I-580, US-101, I-680, SR-12/SR-37, SR-152 and SR-4. Vehicle hours of delay on this network were calculated for a typical weekday and were based on the differential between forecasted and free-flow speeds. The total vehicle hours of delay accrued on the network identified above were then divided by the regional population to calculate the per-capita delay along these freeway segments. Note that rail freight delay – which is a relatively small component of both overall goods movement and goods movement delay in the Bay Area – was not reflected in the target due to travel model limitations.

Performance Target #11: Transportation System Effectiveness (Mode Share)

Increase non-auto mode share by 10%

Background Information

This target reflects the overall efficiency of the transportation system by capturing the share of trips taken by non-auto modes – public transit, walking and bicycling. By aiming to increase the share of trips taken without a car by 10 percentage points, the target reflects a given scenario's ability to make non-auto modes more convenient and accessible for all. While this target is in many ways a proxy for the benefits associated with sustainable modes of transport, it reflects key policy goals related to modal shift in support of sustainable communities and transport efficiency.

Unlike other performance targets, there was not a strong foundation for this specific target at the time of its identification in Plan Bay Area, as it was a result of target modifications after initial adoption by MTC/ABAG in 2011. The initial target was related to non-auto travel time reduction, which proved problematic given that modal shift tended to increase rather than decrease travel times. However, the performance target does align to a certain extent with the aggressive targets established by the California Department of Transportation (Caltrans) in 2015, which seek to double mode shares for walking and public transit and triple mode share for target. The Plan Bay Area 2040 target would nearly double non-auto mode share, albeit over a more achievable time period (between 2005 and 2040) when compared to Caltrans' goal to increase mode shares between 2010 and 2020.

Past Experience

This target is fully consistent with Plan Bay Area; no changes have been made to the target as originally adopted in 2011. Plan Bay Area fell short on this performance target, achieving only a 4 percentage point increase in non-auto mode share (an increase from 16% non-auto mode share in 2005 to 20% non-auto mode share in 2040). This reflects the difficulty of achieving significant modal shifts in a mature region without more aggressive transportation and land use interventions. While non-auto mode share is particularly strong in the center of the region, a significant share of Bay Area residents live in lower-density communities without time-competitive alternatives to the automobile.

Evaluation Methodology

Non-auto mode share is a direct output of Travel Model One. The region's mode share is based on all trips made by Bay Area residents, rather than a narrow focus on commute trips. To calculate non-auto mode share, all non-auto trips (transit, bicycle and pedestrian) trips were first summed. They were then divided by the total number of regional trips (which includes the aforementioned modes but also adds in single-occupant and multi-occupant vehicle trips), which resulted in the percentage of trips utilizing non-auto modes.

Performance Target #12: Transportation System Effectiveness (State of Good Repair for Roads)

Reduce vehicle operating and maintenance costs due to pavement conditions by 100%

Background Information

This target focuses on the user impacts as a result of road maintenance for the region's freeways, arterials, and local streets. In a reflection of the region's "Fix It First" policy, the performance target seeks to bring all roads to a state of good repair and thus reduce the extra vehicle operating and maintenance costs associated with rough roads to zero. This would result in a 100% decrease in such costs between 2005 and 2040.

The target combines two separate targets from Plan Bay Area into a single target, while still respecting the importance of preserving all streets and continuing MTC's long-standing commitment to infrastructure preservation as a top priority. The target incorporates the monetary impacts to drivers, regardless of the facility type in question. Furthermore, it reflects the miles traveled on each type of road – the greater the traffic volumes, the greater the impact on vehicle operating and maintenance costs.

Past Experience

This target is new to Plan Bay Area 2040, as it was not included as a performance target in Plan Bay Area. However, every long-range transportation plan adopted by MTC over the past decade has included some measure of road and/or freeway state of good repair as a performance target, reflecting the high-priority nature of this transportation issue area. The target works to quantify the impacts of road maintenance funding levels in terms an average citizen can understand – additional vehicle maintenance costs as a result of system condition – regardless of the facility type the driver chooses to use to get from point A to point B.

Evaluation Methodology

This performance target was calculated using MTC's StreetSaver tool, Caltrans pavement forecasts, and Travel Model One. The specific methodology is detailed both in the 2015 Transportation Research Board Annual Meeting Compendium of Papers (Paterson and Vautin, 2015) and in the road state of good repair methodology (found later in this document). The methodology relies upon pavement condition index and international roughness index to calculate increased vehicle operating and maintenance costs as a result of rough roads. In general, roads with a PCI greater than 60 and freeways with IRI less than 95 are considered to be in fair, good, or excellent condition, moving us towards the regional goal of bringing our road infrastructure to a state of good repair. The target was calculated by calculating extra vehicle operating and maintenance costs in Travel Model One for both baseline and horizon year conditions to determine whether cost burdens on drivers increase or decrease over this period. The methodology incorporates all motor vehicles, including trucks; while it does not capture bike or pedestrian impacts, it serves as a useful proxy for potential safety disbenefits on these users due to potholes or other impacts of disrepair.

Performance Target #13: Transportation System Effectiveness (State of Good Repair for Public Transit)

Reduce per-rider transit delay due to aged infrastructure by 100%

Background Information

MTC has consistently prioritized a "Fix It First" policy in regional transportation plans, in which preservation of the existing system takes priority over expansion projects. In the past, transit asset condition has been measured with an index known as PAOUL (percent of transit assets over their useful life) – with a goal of replacing all transit assets on time. For Plan Bay Area 2040, the performance target focuses on the impacts of replacing (or not replacing) transit assets on time, with a goal of replacing delay impacts on riders due to aged assets by 100 percent (e.g., achieve zero delays due to aged buses, trains, tracks, etc. failing and thus affecting transit riders).

The numeric target was selected to align the target with the Plan Bay Area PAOUL target (same goal of replacing assets on time) and to reflect the "Fix It First" policy. Given that objective, it seems appropriate to set this aggressive target to bring the entire transit system to a state of good repair. Note that per-rider transit delay was measured in minutes for Bay Area transit riders.

Past Experience

This target is new to Plan Bay Area 2040, as it was not included as a performance target in Plan Bay Area. However, every long-range transportation plan adopted by MTC over the past decade has included some measure of transit state of good repair as a performance target, reflecting the high-priority nature of this transportation issue area. The target works to quantify the impacts of transit maintenance funding levels in terms an average citizen can understand – minutes of delay impacting their commute (or non-commute) onboard public transit as a result of system condition.

Evaluation Methodology

This performance target was calculated using the Regional Transit Capital Inventory, the Federal Transit Administration's TERM-Lite transit asset prioritization tool, and Travel Model One. This methodology is detailed both in the 2015 Transportation Research Board Annual Meeting Compendium of Papers (Paterson and Vautin, 2015) and in the transit state of good repair methodology (found later in this document). These failure rates are translated into per-boarding and per-mile delay rates that affect passengers. To calculate a regional impact, the delays for each system will be weighted by the number of passengers experiencing such delay to identify the average delay for the typical transit rider in the Bay Area as a whole. Delays from assets still within their useful life were not reflected in the performance target, as the target focuses specifically on "aged infrastructure" – that is, infrastructure past its useful life.

Scenario & EIR Alternative Performance Targets Analysis

The primary purpose of the performance targets is to evaluate scenarios – combinations of different land use growth patterns aligned with complementary transportation investment packages. The performance targets help planners, policymakers, and the public at large to understand the benefits and drawbacks of each, in addition to identifying areas where more effort may be needed in future planning cycles to achieve ambitious targets. The section discusses the scenarios and EIR alternatives that were evaluated the process, the overall key findings of the performance targets analysis, and specific outcomes on a target-by-target basis.

Defining the Scenarios and EIR Alternatives

As part of the scenarios analysis process, four scenarios were developed in early 2016, designed to look at a range of alternative visions for transportation and land use. Ultimately, three of these scenarios were carried over to the Environmental Impact Report (EIR), alongside a Preferred Scenario that pulled the strongest elements from each of the previously evaluated scenarios. In addition, a fifth scenario known as Equity, Environment, and Jobs 2.0 was added to the mix in response to EIR scoping comments. The following sub-sections briefly describe each scenario's key concepts; refer to the Environmental Impact Report and Investment Strategy Report for more detailed descriptions of the scenarios.

Scenarios Evaluated in the Planning Process and as EIR Alternatives

Four scenarios were evaluated during the planning process, including the Preferred which was adopted in November 2016 by MTC and ABAG. The scenarios were evaluated using final year 2040 model runs during the EIR process; these final results are discussed below.

- **No Project:** No new growth strategies would be implemented (upzoning, office caps, CEQA streamlining, etc.), meaning that future growth would likely follow historic trends. Urban growth boundaries would be allowed to expand at historical rates, while only committed transportation projects (e.g., those under construction) would be allowed to proceed.
- **Main Streets:** Select suburban Priority Development Areas would be upzoned to increase residential and commercial development capacity, while urban growth boundaries would be allowed to expand at faster rate. In addition to limited affordable housing requirements on new development, transportation investments would be focused on service frequency increases and highway capacity expansion, as well as increased funding for state of good repair.
- **Big Cities:** To encourage growth the three largest cities, upzoning would be focused in areas with significant transit access. Development caps would be eliminated in urban areas, and urban growth boundaries would not be allowed to expand. Additional inclusionary zoning policies and development fees on high-VMT areas would be applied. Transportation investments would focus on public transit and other alternatives to the car, including core capacity investments, expansion projects linking to the three largest cities, and cordon pricing.
- **Preferred:** The Preferred Scenario, also referred to as the Draft Plan, would upzone Priority Development Areas across the region and keep existing urban growth boundaries in place to focus regional growth. Additionally, it assumes 10 percent of new housing units would be deed-restricts and that a development fee on high-VMT areas would be implemented. Transportation investments would be balanced between modes, emphasizing "Fix It First", modernization of roads and transit systems, and high-performing expansion projects.

Scenarios Only Evaluated in the Planning Process

One scenario was studied in the planning process but did not move forward to the EIR, primarily due to the fact that it was most similar to the Preferred Scenario. As such, performance results for this scenario are not shown below as preliminary (year 2035) target results for this scenario cannot be accurately and consistently compared to the final (year 2040) target results for all other scenarios.

- **Connected Neighborhoods:** Similar to the Preferred Scenario, upzoning, fees, and related policies would be applied to encourage growth in PDAs, especially those well served by transit. Transportation investments would be balanced across roads and public transit, with an emphasis on maintenance, operations, and modernization.

Scenarios Only Evaluated as EIR Alternatives

One scenario was added to the mix based on comments received during the EIR Notice of Preparation (NOP) process – an updated version of the Equity, Environment, and Jobs (EEJ) scenario from the Plan Bay Area EIR. This scenario has the same control total and transportation revenue total as the other scenarios, but focuses more growth in high-opportunity suburban communities and prioritizes transit and non-motorized projects over road expansion.

- **Equity, Environment, and Jobs 2.0:** Upzoning would be implemented in select PDAs but also high-opportunity TPAs as well; job caps and urban growth boundaries today would be preserved through 2040. A significantly higher 20 percent inclusionary requirement for affordable housing would be applied in all cities with PDAs, and development fees on high-VMT areas would be applied to encourage growth in transit-served locations. Transportation investments would focus on improved service frequencies for transit (especially buses) as well as similar transit expansion projects to the Preferred Scenario. A VMT tax of 2 cents per mile would be applied and uncommitted highway expansion projects would not be constructed.

Overall Results for Final Scenarios/EIR Alternatives

- **The Preferred Scenario achieves five performance targets, moves in the right direction on four performance targets, and moves in the wrong direction on the remaining four performance targets.** While notable successes exist relating to climate protection, open space preservation, and goods movement exist, the Preferred fails to slow rising unaffordability, mitigate growing displacement risk, increase access to opportunity, or provide sufficient funding to maintain aging freeways and local streets. The Equity, Environment, and Jobs 2.0 alternative performs slightly better on several targets, such as greenhouse gas emissions reduction and housing + transportation affordability, but results in significantly greater traffic congestion on freight corridors.
- **While all scenarios except the No Project alternative achieve the greenhouse gas target, lower levels of driving in Big Cities and Equity, Environment, and Jobs 2.0 result in stronger performance.** Compared to the more dispersed land use pattern in Main Streets, these two scenarios have higher non-auto mode shares that yield additional greenhouse gas benefits and build upon the foundation of the Climate Initiatives Program (which is included in all scenarios except the No Project scenario). The Preferred Scenario also achieves the targets but performs slightly worse due to its greater investment in capacity-increasing highway projects.
- **The region's ambitious public health target remains stubbornly out of reach across all scenarios.** Much higher levels of walking and bicycling, combined with significant reductions in

traffic collisions, would be needed to improve residents' health outcomes. Transformative shifts, ranging from highly-focused development patterns and generational shifts in public perceptions of biking and walking modes to widespread deployment of automated electric vehicles, would be necessary to reach this goal.

- **Strict urban growth boundaries are effective in focusing growth within the existing urban footprint.** The Preferred Scenario, Big Cities, and Equity, Environment, and Jobs alternatives achieve the Open Space and Agricultural Preservation target due to their inclusion of strict urban growth boundaries, while No Project and Main Streets fare worse on this target.
- **Significant housing affordability challenges exist in all scenarios.** Challenges related to affordability and displacement risk increase in all scenarios, with the No Project alternative resulting in the greatest adverse impacts. Despite various housing and land use strategies included across all the scenarios to make the region more affordable, housing costs continue to rise, reflecting an increasingly expensive Bay Area housing market. Of the scenarios analyzed, the Equity, Environment, and Jobs 2.0 alternative performs slightly better than its peers in this regard, thanks to expanded inclusionary zoning and associated housing subsidies.
- **Freight flows benefit from regional transportation investments and smart land use decisions.** Main Streets, Big Cities, and the Preferred Scenario exceeded the congestion reduction target for freight corridors using different strategies. Main Streets and the Preferred Scenario both relied on an expanded express lane network to reduce congestion on truck corridors, while Big Cities succeeded in improving goods movement by focusing growth in the urban core and encouraging use of non-auto modes through new transportation options. Conversely, the lack of capacity-increasing highway projects, combined with a more suburban land use pattern, results in higher levels of traffic congestion in Equity, Environment, and Jobs 2.0 and No Project.
- **Increasing funding to "Fix It First" leads to much smoother streets and more reliable transit.** Main Streets' funding brings state highway pavement to ideal conditions while improving local streets as well, saving residents a significant amount of money each year. Other scenarios prioritize local streets – where funding has a lower bang-per-buck – but lack sufficient funding to even keep local pavement from declining from today's conditions. Turning to transit, boosted funding levels compared to Plan Bay Area mean that all scenarios make substantial progress, reducing delays from aged infrastructure by roughly 75 percent by 2040.

Target-by-Target Discussion of Results

Similar to color scheme used in the table below, **green** dots indicate that the scenario achieved the target, **yellow** dots indicate that the scenario is moving in the right direction (but falling short) on the target, and **red** dots indicate that the scenario is moving in the wrong direction on the target. The Preferred Scenario is consistently marked in **bold** for reference purposes.

Performance Target #1: Climate Protection

- 🟡 No Project: -2%
- 🟡 Main Streets: -14%
- 🟢 Big Cities: -17%
- 🟢 **Preferred: -16%**
- 🟢 Equity, Environment, and Jobs 2.0: -17%

Scenarios with a greater investment in public transit and non-motorized alternatives performed marginally better than Main Streets and ultimately met or exceeded this performance target. No Project lacked the Climate Initiatives Program investment and performed markedly worse than all other scenarios evaluated. Big Cities and Equity, Environment, and Jobs 2.0 performed the best – with a 17 percent per-capita reduction in GHG emissions – thanks to transportation investments that were more effective in reducing vehicle miles traveled.

Performance Target #2: Adequate Housing

- No Project: 100%
- Main Streets: 100%
- Big Cities: 100%
- **Preferred: 100%**
- Equity, Environment, and Jobs 2.0: 100%

All scenarios met this performance target as they all rely on consistent control totals for population and housing growth. Plan Bay Area 2040 control totals incorporate additional growth to plan for no growth in in-commuting from outside the Bay Area.

Performance Target #3: Healthy and Safe Communities

- No Project: -0%
- Main Streets: -1%
- Big Cities: -1%
- **Preferred: -1%**
- Equity, Environment, and Jobs 2.0: -1%

Ultimately, the Healthy and Safe Communities target proved too ambitious to achieve in the absence of more aggressive policies and strategies. As shown above, all of the scenarios except for No Project achieved roughly similar performance results when rounded (1% reduction in adverse health impacts for the typical resident). Looking at results using a single decimal point precision, Equity, Environment, and Jobs 2.0 and Big Cities had a very slight edge (-0.7%) over and Preferred (-0.6%) thanks to their greater investment in healthier transportation modes and reduced vehicle miles traveled (which reduces safety impacts from crashes). Much more aggressive policies would be needed to achieve this visionary target, ranging from slower speed limits and additional fees to discourage driving to extremely robust bicycle/pedestrian infrastructure investments and an even more highly focused land use pattern.

Performance Target #4: Open Space and Agricultural Preservation

- No Project: 84%
- Main Streets: 98%
- Big Cities: 100%
- **Preferred: 100%**
- Equity, Environment, and Jobs 2.0: 100%

Three scenarios achieved the open space preservation target – Big Cities, Preferred, and Equity, Environment, and Jobs 2.0 – thanks to their inclusion of strict urban growth boundaries through year 2040. While the other two scenarios – No Project and Main Streets – still put the vast majority of growth in non-greenfield locations, both convert rural lands outside of existing growth boundaries (including farmlands and open space) to urbanized uses. Main Streets would do so for roughly 1,300 acres and No Project would allow nearly 16,000 acres of greenfield development. Note that all scenarios do include some greenfield development within urban growth boundaries, which is not reflected in this target as it allows for growth within year 2010 boundaries (many of which have been approved by voters).

Performance Target #5: Equitable Access (Affordability)

- No Project: +15%
- Main Streets: +13%

- Big Cities: +13%
- **Preferred: +13%**
- Equity, Environment, and Jobs 2.0: +12%

No scenario evaluated was able to reduce the already-high cost of living in the Bay Area and all move in the wrong direction on this important target. That being said, strategies boosting housing production in transportation-efficient locations generates more naturally-affordable and deed-restricted housing in all scenarios except for No Project. Furthermore, Big Cities, Preferred, and Equity, Environment, and Jobs 2.0 all reduce dependence on automobiles, the most expensive mode for system users – encouraging transit, walking, and bicycling instead through multimodal investments. Combined, these policies reduce the rise of combined housing & transportation costs by several percentage points. Equity, Environment, and Jobs 2.0 does the best in this regard, primarily due to housing strategies like a greater inclusionary requirement for new developments.

Performance Target #6: Equitable Access (Affordable Housing)

- No Project: -0%
- Main Streets: +2%
- Big Cities: +1%
- **Preferred: +3%**
- Equity, Environment, and Jobs 2.0: +3%

Similar to some targets discussed above, the goal of doubling the share of affordable housing in identified locations was remarkably ambitious given limited resources on the housing front. That being said, all scenarios except for No Project made progress towards the target – which means the number of affordable units grew faster than housing growth overall. Main Streets, Big Cities, and Preferred all boosted the number of deed-restricted units in PDAs, TPAs, and HOAs – but Equity, Environment, and Jobs 2.0 resulted in 40,000 additional units more than the runner-up (Main Streets with 119,000 units). However, in terms of naturally-affordable units, Preferred performs the strongest of the scenarios evaluated, with Equity, Environment, and Jobs 2.0 only outperforming No Project. Ultimately, Preferred and Equity, Environment, and Jobs 2.0 tied for strongest performance on this target. Additional affordable housing production policies and subsidies would be required to achieve stronger performance on this target.

Performance Target #7: Equitable Access (Displacement Risk)

- No Project: +18%
- Main Streets: +6%
- Big Cities: +9%
- **Preferred: +5%**
- Equity, Environment, and Jobs 2.0: +5%

Displacement risk was highest in the No Project scenario as it lacked any substantive policies – such as inclusionary zoning – to help mitigate the displacement crisis. Furthermore, it produces more housing at the periphery and less in the region's core, where housing is most needed to alleviate the imbalance between supply and demand. Preferred and Equity, Environment, and Jobs 2.0 performed the best on this target. While neither achieved the goal of mitigating all growth in displacement risk, they performed better than the Big Cities scenario which funneled a greater level of growth into the urban core with a more limited inclusionary zoning policy.

Performance Target #8: Economic Vitality (Access to Jobs)

- No Project: -3%

- Main Streets: -1%
- Big Cities: -1%
- **Preferred: -0%**
- Equity, Environment, and Jobs 2.0: -1%

All scenarios saw some slippage in the share of regional jobs accessible to the typical Bay Area resident between 2005 and 2040, although the Preferred did the best job in this regard. The Preferred Scenario did the best due to its investment in all modes, which mitigated some of the rising congestion expected in a growth scenario while also providing a robust suite of transit options. In addition, it focused growth in existing job centers well-served by transit, rather than distributing jobs across the region. The No Project scenario performed the worst – it was hobbled by its lack of transportation investments, both in terms of highways and transit.

Performance Target #9: Economic Vitality (Jobs/Wages)

- No Project: +43%
- Main Streets: +43%
- Big Cities: +43%
- **Preferred: +43%**
- Equity, Environment, and Jobs 2.0: +43%

As noted in the target methodology section, all of the scenarios saw the same performance for this target, which relies on the regional control totals and associated forecasts. The target results highlight relatively good news on this front – indicating that jobs in middle-wage industries are expected to grow at a rate faster than overall job growth. This bodes well for reversing the trend of declining middle-wage jobs in the Bay Area in recent decades. However, as there is no guarantee that middle-wage industries will continue paying decent wages in the future, ongoing monitoring will be a more important avenue forward.

Performance Target #10: Economic Vitality (Goods Movement)

- No Project: +38%
- Main Streets: -25%
- Big Cities: -33%
- **Preferred: -29%**
- Equity, Environment, and Jobs 2.0: -16%

Of all the performance targets, the results for this one showed the greatest variance across scenarios – perhaps speaking to the greater policy levers at our disposal to tackle traffic congestion and goods movement. While No Project performs the worst due to only committed projects advancing in that scenario, Big Cities outperformed all other scenarios, thanks to its urban-focused land use pattern and investment in alternative modes. These policies reduced auto demand for long-distance freight corridors, smoothing flow for trucks and remaining motorists. Equity, Environment, and Jobs 2.0 struggled on this target, falling short due to increased congestion due to greater suburb-to-suburb commuting and elimination of all highway expansion projects. Preferred Scenario was in the middle of the pack, with slightly better results than Main Streets and slightly worse results than Big Cities, but all of these scenarios met the 20 percent per-capita reduction target.

Performance Target #11: Transportation System Effectiveness (Mode Share)

- No Project: +2%
- Main Streets: +2%
- Big Cities: +4%
- **Preferred: +3%**

- Equity, Environment, and Jobs 2.0: +4%

All scenarios made limited but notable progress in terms of increasing the regional mode share by 10 percentage points by 2040. Big Cities and Equity, Environment, and Jobs 2.0 performed the best with a 4% increase due to their denser land use patterns (which result in greater competitiveness for non-auto modes) and greater investments in bus and rail networks across the Bay Area. Bike and walk mode shares are relatively consistent across all scenarios; increased transit ridership forecasts accounted for the bulk of the non-auto mode share growth.

Performance Target #12: Transportation System Effectiveness (State of Good Repair for Roads)

- No Project: +53%
- Main Streets: -59%
- Big Cities: +8%
- **Preferred: +6%**
- Equity, Environment, and Jobs 2.0: +10%

While the No Project scenario performs the worst due to the lack of regional discretionary dollars being put towards highway and road maintenance, the notable result for this target is the significant improvement in the Main Streets scenario. This was one area where Main Streets far outperformed its peers, and it was primarily driven by a focus on highway maintenance; regional discretionary funds were only allocated towards state highway maintenance in this scenario. While local street maintenance was also funded, it was the heavily-used highway network where funding allowed the region to achieve ideal conditions and make very significant progress towards the target. The other scenarios were relatively similar in terms of impacts on drivers from highway and road maintenance, with the Preferred seeing a slight uptick not evident in draft model runs (due to failure of select ballot measures and updates to reflect year 2040 pavement conditions).

Performance Target #13: Transportation System Effectiveness (State of Good Repair for Public Transit)

- No Project: -57%
- Main Streets: -77%
- Big Cities: -78%
- **Preferred: -75%**
- Equity, Environment, and Jobs 2.0: -76%

Thanks to the strategic priorities set in the MTC's Transit Capital Prioritization (TCP) policy – which prioritize vehicles and other critical infrastructure first – all of the scenarios make significant strides in reducing delay due to vehicle and non-vehicle system breakdowns from aged assets. Marginal differences exist across scenarios due to slight variation in funding levels, as well as the ridership levels of each system. For example, the transportation and land use pattern in Equity, Environment, and Jobs 2.0 results in higher levels of BART ridership (a system where not all SGR funding needs for assets with operational impacts are met), resulting in slightly weaker performance than in Big Cities.

Goal	#	Target	%	No Project	Main Streets	Big Cities	Preferred	EEJ2*
Climate Protection	**1**	Reduce per-capita CO_2 emissions from cars and light duty trucks	-15%	**-2%**	**-14%**	**-17%**	**-16%**	**-17%**
Adequate Housing	**2**	House region's projected growth by income level without displacing current low-income residents and with no increase in in-commuters over the Plan baseline year	100%	**100%**	**100%**	**100%**	**100%**	**100%**
Healthy & Safe Communities	**3**	Reduce adverse health impacts associated with air quality, road safety, and physical inactivity	-10%	**-0%**	**-1%**	**-1%**	**-1%**	**-1%**
Open Space & Agricultural Preservation	**4**	Direct non-agricultural development within the urban footprint (existing urban development and UGBs)	100%	**84%**	**98%**	**100%**	**100%**	**100%**
Equitable Access	**5**	Decrease the share of lower-income residents' household income consumed by transportation and housing	-10%	**+15%**	**+13%**	**+13%**	**+13%**	**+12%**
	6	Increase the share of affordable housing in PDAs, TPAs, or high-opportunity areas	+15%	**-0%**	**+2%**	**+1%**	**+3%**	**+3%**
	7	Do not increase the share of low- and moderate-income renter households in PDAs, TPAs, or high-opportunity areas that are at risk of displacement	+0%	**+18%**	**+6%**	**+9%**	**+5%**	**+5%**
Economic Vitality	**8**	Increase the share of jobs accessible within 30 minutes by auto or within 45 minutes by transit in congested conditions	+20%	**-3%**	**-1%**	**-1%**	**-0%**	**-1%**
	9	Increase the number of jobs in predominantly middle-wage industries	+38%	**+43%**	**+43%**	**+43%**	**+43%**	**+43%**
	10	Reduce per-capita delay on the Regional Freight Network	-20%	**+38%**	**-25%**	**-33%**	**-29%**	**-16%**
Transportation System Effectiveness	**11**	Increase non-auto mode share	+10%	**+2%**	**+2%**	**+4%**	**+3%**	**+4%**
	12	Reduce vehicle operating and maintenance costs due to pavement conditions	-100%	**+53%**	**-59%**	**+8%**	**+6%**	**+10%**
	13	Reduce per-rider transit delay due to aged infrastructure	-100%	**-57%**	**-77%**	**-78%**	**-75%**	**-76%**

Table 4. Final scenario/EIR alternative analysis for Plan Bay Area 2040 performance targets.

** = Targets shown in **green** were achieved. Targets shown in **orange** fell short but moved in the right direction. Targets shown in **red** are moving in the wrong direction. Underlined text indicates which alternative performed the best for a given target. Note that EEJ2 is the acronym for the Equity, Environment, and Jobs 2.0 alternative.*

Project Performance Assessment

One of the primary methods for prioritizing long-term regional investments when crafting the Preferred Scenario was an evaluation of the largest, capacity-increasing projects that transportation agencies submitted during the Call for Projects in 2015. These projects were assessed individually to determine their support of the Plan's performance targets and to determine their cost-effectiveness. This assessment goes beyond the scenario-level analysis, which evaluated packages of projects tied to different land use strategies. The project performance assessment evaluated individual major investments in more detail than in the scenario analysis and informed creation of the Preferred Scenario. Because the transportation plan is fiscally constrained, not all projects evaluated could ultimately be included. Conducting project performance assessment was critical to help MTC and county staff determine which projects to prioritize.

Approach to Project Performance Assessment

The performance assessment was designed to identify high-performing investments among the variety of potential investments to prioritize for regional funding and to flag low-performing investments that might merit further review through a follow-on process. For medium-project projects, congestion Management Agencies (CMAs) ultimately prioritized those investments on a county-by-county basis, subject to fiscal constraint.

Projects were evaluated using two primary distinct assessments – one quantitative and one qualitative – that were used to define performance. Methodologies for both assessments were similar to the methodologies developed in Plan Bay Area, with several notable improvements and changes.

The targets assessment illustrated which projects would help the region reach the Plan's ambitious targets. Projects received a score for each target and the combined targets score provided a basis for determine which projects were most supportive (or least supportive) of the Plan's targets. The second assessment was a benefit-cost assessment that provided a basis for determining which projects yielded the highest regional benefit and, when divided by annual cost, which would generate benefits beyond the annual costs.

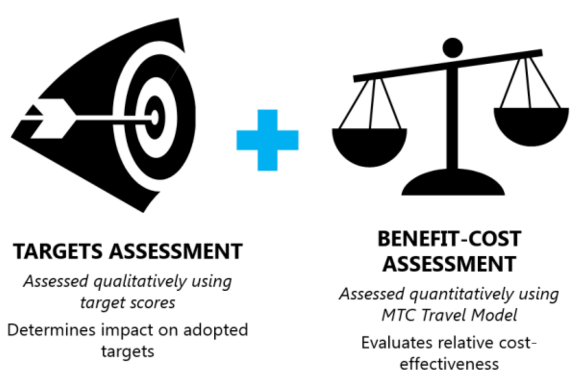


Figure 2. Project performance components.

Of the projects submitted for consideration in the long-range Plan, Projects that were fully committed, meaning having either a full funding plan or designated as committed by the MTC Commission, were not evaluated individually. Committed projects and programs, as defined by MTC Resolution No. 4182, were either fully funded by local/committed sources or had a certified environmental document by September 2015. Resolution 4182 also stated that committed programs such as Clipper and 511 were not subject to evaluation. These projects automatically were included in Plan Bay Area 2040.

Of the remaining, non-committed projects, MTC staff evaluated projects that met the following criteria:

1. The project impacts could be captured in the regional travel demand model (i.e., able to be modeled and either capacity-increasing or improving state of good repair). The following are examples of projects in this category:

   - Transit expansion projects (e.g., BART to Silicon Valley Phase 2)
   - Transit modernization projects (e.g., AC Transit Frequency Improvements)
   - Transit state of good repair investments (e.g., Muni Metro Maintenance)
   - Road expansion projects (e.g., SR-152 Widening)
   - Road modernization projects (e.g., Columbus Day Initiative)
   - Road state of good repair investments (e.g., Local Streets & Roads Maintenance)

2. The total project costs were at least $100 million (as measured in 2017 dollars), taking into account both capital and O&M costs through year 2040.

Using these criteria, staff evaluated 63 projects and 6 state of good repair investments. Unlike the modernization and expansion projects, state of good repair, or maintenance, investments were not submitted by transportation agencies through the Call for Projects process. Instead, MTC developed different state of good repair scenarios based on funding levels from the various modal Needs Assessments to evaluate against the traditional expansion projects under consideration for the Plan. One of the key questions in developing the Plan was how much future funding to direct toward operations and maintenance compared to modernizing and expanding the existing transportation system. Understanding the cost-effectiveness of different investment levels and across modes helped inform this decision.

State of good repair investments were grouped into four modes – highways, local streets, rail transit, and bus transit. Costs and resulting asset conditions were forecast for three different scenarios – ideal conditions, preservation of existing asset condition, and a no funding scenario. For maintenance of local streets and roads, costs and pavement condition were also determined if only local funding was available. Benefits were then evaluated in the context of moving from one condition to the next. Table 5 presents the six state of good repair packages evaluated in this assessment. The assessment determined the cost-effectiveness of different investment levels in maintenance and across different modes.

Table 5. State of good repair investments in project-level performance assessment.

State of Good Repair Investment	Description	
Highway Pavement Maintenance	1	Preserve **existing** highway pavement conditions vs. **no future funding** for highway pavement

State of Good Repair Investment		Description
	2	**Ideal** highway pavement condition vs. preserve **existing** highway pavement conditions
Local Streets and Roads Maintenance	1	Preserve **existing** local streets and roads pavement conditions vs. **no future funding** for local streets and roads maintenance
	2	Preserve **existing** local streets and roads pavement conditions vs. **only local future funding** for local streets and roads maintenance
Public Transit Maintenance	1	Preserve **existing** rail asset condition (vehicles, fixed-guideway, etc) vs. **no future funding** for rail maintenance
	2	Preserve **existing** bus asset condition (primarily vehicles) vs. **no future funding** for bus maintenance

Targets Assessment

The first half of the project assessment was the qualitative targets assessment. As with the original Plan Bay Area, staff qualitatively evaluated the project's support for each of the targets on a 5-point scale, ranging from 1 to -1, in increments of 0.5. A project received a "+1" for a particular target if it strongly supported the target and a "-1" if it had a strong adverse impact on the target. The final target score is a sum across targets with the maximum possible score of a +13 and the lowest possible score of a -13. Ultimately though, target scores ranged from -1.5 to 9.5, with no project having adverse impacts across the board and no project advancing every target to the maximum extent.

Table 6 summarizes the criteria used to assess projects in this qualitative assessment; more detailed information, along with example projects evaluated as part of the targets assessment, can be found in Appendix A.

Table 6. Targets assessment methodology.

#	Target	General Methodology
1	Reduce per-capita CO_2 emissions from cars and light duty trucks by 15%	**Positive Score:** Likely to reduce VMT **Negative Score:** Likely to increase VMT
2	House 100% of the region's projected growth by income level without displacing current low-income residents and with no increase in in-commuters over the Plan baseline year	**Positive Score:** Serves jurisdictions that approved high shares of RHNA for majority of income levels and planned to grow in Plan Bay Area **Negative Score:** Serves jurisdictions that approved low shares of RHNA across income categories and did not plan to grow in Plan Bay Area

#	Target	General Methodology
3	Reduce adverse health impacts associated with air quality, road safety, and physical inactivity by 10%	**Positive Score:** Likely to cause moderate to large shift to non-auto modes **Negative Score:** Likely to moderately to significantly increase auto mode share or auto trips *Bonus 0.5 point if the project improves safety*
4	Direct all non-agricultural development within the urban footprint (existing urban development and urban growth boundaries)	**Positive Score:** Promotes infill development within urban growth boundaries or increases access to agricultural land **Negative Score:** Requires construction through open space or agricultural land or worsens access to agricultural land
5	Decrease by 10% the share of lower-income residents' household income consumed by transportation and housing	**Positive Score:** Transit project that improves service for an operator with significant low-income ridership or that serves a large share of the region's low-income riders **Negative Score:** Reduces transportation choices for low- and middle-income residents or increases transportation costs
6	Increase the share of affordable housing in PDAs, TPAs, or high-opportunity areas by 15%	**Positive Score:** Serves jurisdictions that permitted high share of affordable housing in the last two cycles of RHNA **Negative Score:** Serves jurisdictions that permitted low share of affordable housing in the last two cycles of RHNA
7	Reduce the share of low- and moderate-income renter households in PDAs, TPAs, or high-opportunity areas that are at an increased risk of displacement to 0%	**Positive Score**: No project is anticipated to reduce the risk of displacement **Negative Score:** Serves jurisdictions that plan to growth significantly in the most recently adopted long-range plan (Plan Bay Area) and are currently undergoing displacement
8	Increase the share of jobs accessible within 30 minutes by auto or within 45 minutes by transit by 20% in congested conditions	**Positive Score**: Decreases travel time during commute hours and serves a regional or sub-regional job center **Negative Score:** Increases travel time
9	Increase by 38% the number of jobs in predominantly middle-wage industries)	**Positive Score**: Directly adds short-term and long-term jobs to the region (construction and operations) **Negative Score:** Reduces the number of transportation-related jobs required
10	Reduce per-capita delay on the Regional Freight Network by 20%	**Positive Score**: Reduces congestion or improves reliability on freight corridors **Negative Score:** Increases travel time or decreases reliability on freight corridors
11	Increase non-auto mode share by 10%	**Positive Score:** Likely to cause moderate to large shift to non-auto modes **Negative Score:** Likely to moderately to significantly increase auto mode share or auto trips
12	Reduce vehicle operating and maintenance costs due to pavement conditions by 100%	**Positive Score:** Improves roadway surface condition **Negative Score:** No project would be anticipated to generate an adverse impact by worsening pavement quality.
13	Reduce per-rider transit delay due to aged infrastructure by 100%	**Positive Score:** Improves transit asset condition **Negative Score:** No project would be anticipated to generate an adverse impact by worsening transit asset condition.

Several of the targets for Plan Bay Area 2040 have a housing focus. To evaluate individual transportation projects against housing targets, staff first determined a service area for each transportation project. Service areas varied by the scale of the transportation project. For example, the service area for the express lane network was the full nine-county Bay Area, whereas the service area for a BRT project is only the jurisdictions through which the project passes. Housing performance was then calculated for each jurisdiction, relying either on the last two RHNA cycles for a sense of past performance or the most recently adopted land use plan at the time of the assessment for a sense of future performance.

Benefit-Cost Assessment

The second half of the project assessment was a benefit-cost assessment. The assessment quantified as many benefits as technically feasible, relying heavily on the methodology developed in the benefit-cost assessment from the original Plan Bay Area. Benefits included changes in accessibility (travel time and cost), reliability, emissions, physical activity, and noise. All benefits were monetized with the benefit valuations found in Appendix B.

Modeling Approach to Estimate Benefits

For all projects and state of good repair investments, a project's benefit was estimated using the regional travel demand model, Travel Model One. Each project was coded as its own "Build" scenario and compared to a "No Build" scenario. Both the Build and No Build used the same land use assumptions in the most recently adopted land use projection at the time of the assessment, Plan Bay Area (2013), for the horizon year, 2040. MTC ran the full travel model through three iterations to estimate project benefits. MTC developed a tool known as COBRA to difference the build and no build metrics and monetize the metrics appropriately. The script is open source and available here: https://github.com/MetropolitanTransportationCommission/travel-model-one/tree/master/utilities/PBA40/metrics

Modeling Update

Due to modeling constraints in Plan Bay Area (2013), only half of the model was run for each project. As a consequence, some of the more long-term decisions in the model, like where to live or whether to purchase of a vehicle, were held constant between the build and no build runs. For Plan Bay Area 2040, staff ran the full travel model through three iterations to estimate project benefits. For example, a project with significant transit benefits might allow residents to own one fewer car. The cost savings associated with owning fewer cars is a benefit for the transit projects in the benefit-cost assessment. With this modeling, no benefit categories required post-model adjustments.

User Benefits

Typically, the primary benefits of transportation projects are for the user in the form of travel time and cost savings. The assessment for Plan Bay Area (2013) estimated user benefits of a project by calculating travel time savings and cost savings by mode and monetizing the change. This method was inconsistent with the behavior assumptions in the travel model and required post-model adjustments. For example, a project that encourages shifting from driving to transit would have a negative impact in the previous methodology, because transit is typically slower.

The assessment for Plan Bay Area 2040 applied a methodology developed by the Federal Transit Administration to estimate user benefits. The methodology monetizes the accessibility benefits of projects, which are estimated through the change in the "composite utility" of all travel models after a project is constructed. In the Travel Model, composite utility is estimated through the logsum term. By measuring the change in utility (or satisfaction) of travel models, the logsum term is also a measure of consumer surplus, or the economic value of a transportation project. With this method, everyone should be better off with a project that improves access, with the degree varying by the level of impact of a project. Projects that remove access (e.g. consolidate stations or remove travel lanes) might have overall negative impacts if there are not enough compensating benefits.

Mechanically, user benefits are estimated with the destination-choice logsum, which is the generalized cost of all modes weighted by the attractiveness of each destination. Generalized cost is the sum of the monetary and non-monetary costs of a journey. Since all modes are reflected in the logsum term and not just the traveler's chosen mode, a project may benefit a traveler even if they do not choose to use a particular mode because they value having more choices. The units of the logsum metric are in minutes so this metric is converted to economic value by multiplying by an assumed value of time.

Approach to Estimate Project Costs

To complete the assessment, a project's monetized annual benefits in year 2040 were divided by a project's annualized total cost using 2017 dollars throughout. Annualized total cost was calculated by taking capital costs and dividing by the expected life of the capital investment (as shown in Table 3) and then adding one year of net operating and maintenance costs in 2040. For roadway projects, MTC staff estimated annual operations and maintenance costs using average per-mile road maintenance costs. For transit projects, the operating costs reflect potential revenues from fares, approximated with each operator's farebox recovery ratio[1]. For tolling projects, staff assumed the tolls would cover the operations and maintenance costs.

Evaluation of Modernization and Expansion Investments

The majority of projects in the assessment were either modernization or expansion projects. Modernization projects involve upgrading existing assets with infrastructure that provides more service or more capacity. Expansion projects involve physically extending a rail line or adding lanes to a roadway. To forecast the benefits of these two types of projects, staff worked with project sponsors on understanding the new service patterns for transit or capacity increases for road projects. Since these projects may not be well defined at the time they are seeking inclusion in the long-range plan, project sponsors submitted information on one project alternative knowing that project definitions may evolve over time. After working with sponsors, MTC translated the project definitions into inputs for Travel Model One. For transit projects, this information included routing, frequencies by time of day, locations of bus stops or rail stations, fares, and availability of parking at stations. For roadway projects, this information included number of lanes, facility type, speed limit, and extents of the project.

Evaluation of State of Good Repair Investments

In addition to more traditional transportation projects, staff evaluated six state of good repair investment scenarios. This evaluation was one of the significant differences between the assessments in

[1] Based on the operators' FY13 farebox recovery ratio (most recent fully-audited data point at the time of this assessment) – from the Statistical Summary of Transit Operators.

Plan Bay Area and Plan Bay Area 2040. The original Plan Bay Area (2013) evaluated different types of maintenance investments using a sketch-level methodology that monetized different benefits than what were included in the benefit-cost evaluation for the other projects. Since adoption of the last Plan, staff developed methodologies for evaluating the benefits of local streets and roads and transit state-of-good repair using the same metrics as for expansion projects. Brief descriptions of the new methodologies are listed below:

> Local Streets and Roads – The methodology involves the connection between pavement condition and vehicle operating costs. Staff forecasts pavement conditions for cities and counties based on funding levels and facility prioritizations using MTC's asset-management software, StreetSaver. A separate model translates pavement condition into vehicle maintenance and fuel consumption costs by type of vehicle, based on the findings in NCHRP Report 720.[2] These costs are incorporated into the vehicle operating cost in the travel demand model, which effectively makes trips more expensive if drivers are traveling on roadways in poor condition. This affects auto mode choice and travel costs.
>
> Transit – The methodology involves the connection between asset age and travel times associated with aging infrastructure. Staff forecasts transit asset conditions for transit operators using FTA's TERM-Lite software. A separate model estimates in-vehicle and out-of-vehicle transit delay as a function of failure frequencies based on TCRP Report 157.[3] Delay varies by transit operator and mode. For example, the impact of a Caltrain failure often leaves a rider with fewer options than if the breakdown occurred on a Muni bus with available parallel routes, but a Muni breakdown might affect a larger number of customers in the travel model. Delay is then input into travel demand model, which effectively increases the travel time on transit modes in poor condition. This affects transit mode choice and travel times.

Appendix C includes more detailed methodologies for the state of good repair assessments.

[2] National Cooperative Highway Research Program (NCHRP) Report 720: Estimating the Effects of Pavement Condition on Vehicle Operating Costs

[3] Transit Cooperative Research Program (TCRP) Report 157: State of Good Repair – Prioritizing the Rehabilitation and Replacement of Existing Capital Assets and Evaluating the Implications for Transit

Table 7. Lifecycle cost assumptions.

Capital Component	Expected Useful Life (in years)
Local bus	14
Express bus	18
Bus rapid transit (BRT) system	20
Rail infrastructure (majority of ROW in tunnel)	80
Rail infrastructure (all other)	30
Ferry	25
Technology/operations	20
Roadway	20
Roadway (majority tunnel)	80

Key Findings of Project Performance

This section highlights several of the key findings from the project performance assessment. Tables with the final results are in Appendix D.

1. **Maintaining regional transit infrastructure ranks as the top priority, given its high level of cost-effectiveness and strong support of adopted targets.**

When considering the projects with the largest total benefits, maintaining the region's highways, local streets and roads and rail assets generated significantly higher benefits than the benefits from all uncommitted expansion and modernization projects combined. Fully investing in state of good repair of all modes would generate approximately $7 billion in annual benefit compared to $5 billion in annual benefit for the non-maintenance investments. The largest maintenance benefit – at roughly $3 billion in annual benefit – would come from improving highway pavement condition. The primary benefit from these investments are reductions in vehicle operating costs that would arise from driving on smoother pavement. Maintaining rail assets would generate $1.4 billion in annual benefit, primarily from reducing maintenance-related delays across the system. Conversely, if the region did not invest in maintaining rail assets, travelers would take between 270,000 and 320,000 fewer transit trips, leading to increasing congestion or just less travel overall. Benefit-cost ratios for these three maintenance investments vary from 11 for highways to 4 for local streets and roads. The annual benefits for rail maintenance are seven times the annual cost.

2. **The two largest benefits for transportation projects were either increases in access or increases in health benefits.**

The most commonly understood benefits for transportation projects are decreases in travel time and travel cost. This evaluation combined these two metrics into a single measure of access[4], which evaluated the ease of reaching destinations after a project is constructed. When monetized by half of the regional wage, access benefits typically comprised at least 40% of a project's benefits. Projects that connected a large number of people to dense activity centers had the largest access benefits. Examples

[4] The estimate of access is primarily a function of destination-choice logsums of the travel model, an estimate of freeway reliability, and an estimate of truck travel time and cost.

include Highway Pavement Maintenance, which would decrease travel costs for the majority of Bay Area residents who continue to drive in the future, and increases in regional transit access, which would connect many people to dense jobs throughout the region (e.g. increasing service on BART and extending Caltrain to downtown San Francisco).

For smaller scale projects that would yield predominantly neighborhood-level benefits, the primary benefit came from health and lower vehicle ownership rates. This assessment evaluated health benefits of both the morbidity and mortality effects of an active lifestyle, with the research supporting the claim that walking and biking leads to longer lifespans (and thus fewer deaths overall). The World Health Organization developed a methodology for this association that staff applied for the first time in this assessment[5]. By valuing a life at $10.8 million and estimating how many lives would be saved from people becoming more active, projects like light rail extensions and bus rapid transit projects in Priority Development Areas would generate significant health benefits. Interestingly, these projects were also more likely to lead to lower vehicle ownership rates than the large-scale transit projects, which would still require driving to stations and for the rest of trips on a given work day.

3. **Land use matters – projects that support Plan Bay Area growth patterns showed strong performance.**

Because the performance assessment informs the ultimate Plan's transportation investments, it uses the most recently adopted land use pattern available at the time of analysis, which is typically from the previous Plan. The project assessment for this Plan used the adopted, focused growth pattern from Plan Bay Area and is thus the first performance assessment of a Sustainable Communities Strategy. Table 9 presents benefit-cost ratios and ranks of several transit projects that were only moderately cost-effective in Plan Bay Area that were among the most cost-effective projects in Plan Bay Area 2040. Several of these transit projects in the South Bay would increase transit service within San Jose and Sunnyvale's planned focused growth corridors, leading to significant benefits from active transportation and reductions in vehicle ownership.

Table 8. Benefit-cost ratios and ranks across two Plans for select projects.

Project	Plan Bay Area		Plan Bay Area 2040	
	B/C[1]	B/C – Rank[2]	B/C[1]	B/C – Rank[2]
BART to Silicon Valley	**5**	23	**8**	6
VTA El Camino BRT	**2**	36	**7**	9
Geary BRT	**2**	44	**6**	10
Capitol Light Rail Extension	**0.5**	68	**6**	11
Vasona Light Rail Extension	**0.0**	77	**3**	30

1. **In both Plans, the highest B/C was "infinite." In Plan Bay Area, the second highest B/C was 59 and in Plan Bay Area 2040, the second highest B/C was 17.**
2. **In Plan Bay Area, benefit-cost assessment included 78 projects. In Plan Bay Area 2040, benefit-cost assessment included 69 projects.**

[5] Source: World Health Organization's Health Economic Assessment Tool, available online: http://www.heatwalkingcycling.org/

Modal and Geographical Performance Differences

Modernization 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 Columbus Day Initiative[6] performed better than freeway widening projects; this is due to the cost-effectiveness of efficiency projects in comparison to capital-intensive construction and the location of investments. Modernization projects in the core of the region, where most congestion is projected to occur in the future, were among the most cost-effective. Additionally, value pricing projects, including a proposal to implement congestion pricing in San Francisco's central business district and on Treasure Island, were shown to be highly cost-effective and particularly supportive of the Plan's targets, given their ability to reduce congestion and fund transit service and bicycle and pedestrian improvements with net revenues.

Transit modernization projects also performed very well, demonstrating a high level of cost-effectiveness and strong support for the targets, particularly when servicing high-growth Priority Development Areas of East Bay and South Bay. Projects such as bus rapid transit systems in San Francisco, Oakland, and San Jose (Geary BRT, Stevens Creek BRT, and San Pablo BRT) emphasized high-demand corridors where dedicated lanes and bus signal priority achieve substantial benefits at a relatively low cost. Additionally, modernization of the BART system would increase service along several of the most congested corridors in the region – leading to significant access benefit with the additional service.

Combining Cost-Effectiveness and Targets Results

For both Plan Bay Area and this update, a project's performance is a function of both cost-effectiveness and support for targets. The best performing projects would score high across both metrics. Figures 3 through 5 present a series of bubble charts that illustrate a project's performance on cost-effectiveness (vertical axis) and target score (horizontal axis). The size of the bubble represents the magnitude of benefits. Among the highest performing projects, regional transit maintenance scored the highest on targets and medium-high on cost effectiveness. Extending BART to San Jose and constructing BRT along Geary Boulevard were also projects with high targets score and medium-high benefit-cost ratios.

High and Low Performers

To apply the results of the performance assessment, staff defined performance thresholds that placed projects in three buckets – high, medium, and low. Staff subsequently prioritized regional funding like New Starts/Small Starts/Core Capacity funding and STP/CMAQ on the highest performing projects. For projects in the low-performing category, sponsors were required to submit a compelling case, detailing reasons these projects should still be considered as candidates for Plan Bay Area 2040.

Performance Thresholds

At their May 2016 meeting, the MTC Planning Committee approved thresholds that created 11 high-performing projects, 40 medium-performing projects, and 18 low-performing projects. As shown in the thresholds below, high-performing projects could have either a high benefit-cost ratio and a medium

[6] The Draft Plan now refers to Columbus Day Initiative as Bay Area Forward.

targets score or a high targets score and a medium benefit-cost ratio. Low-performing projects could have either a negative targets score or a benefit-cost ratio less than 1.

- High-performer Thresholds:
    - Benefit-Cost Ratio $\geq$ 7 and Targets Score $\geq$ 3 **OR**
    - Targets Score $\geq$ 7 and Benefit-Cost Ratio $\geq$ 3
- Low-performer Thresholds:
    - Benefit-Cost Ratio $<$ 1 **OR**
    - Targets Score $<$ 0
- Medium-performer Thresholds: *all other projects*

Staff used the results of the performance thresholds to give priority to high-performing projects in the investment strategy of Plan Bay Area 2040 and work with sponsors to determine if medium and low performing projects should be included within the fiscal constraint of the Plan.

Figure 3. Overall results by project type.

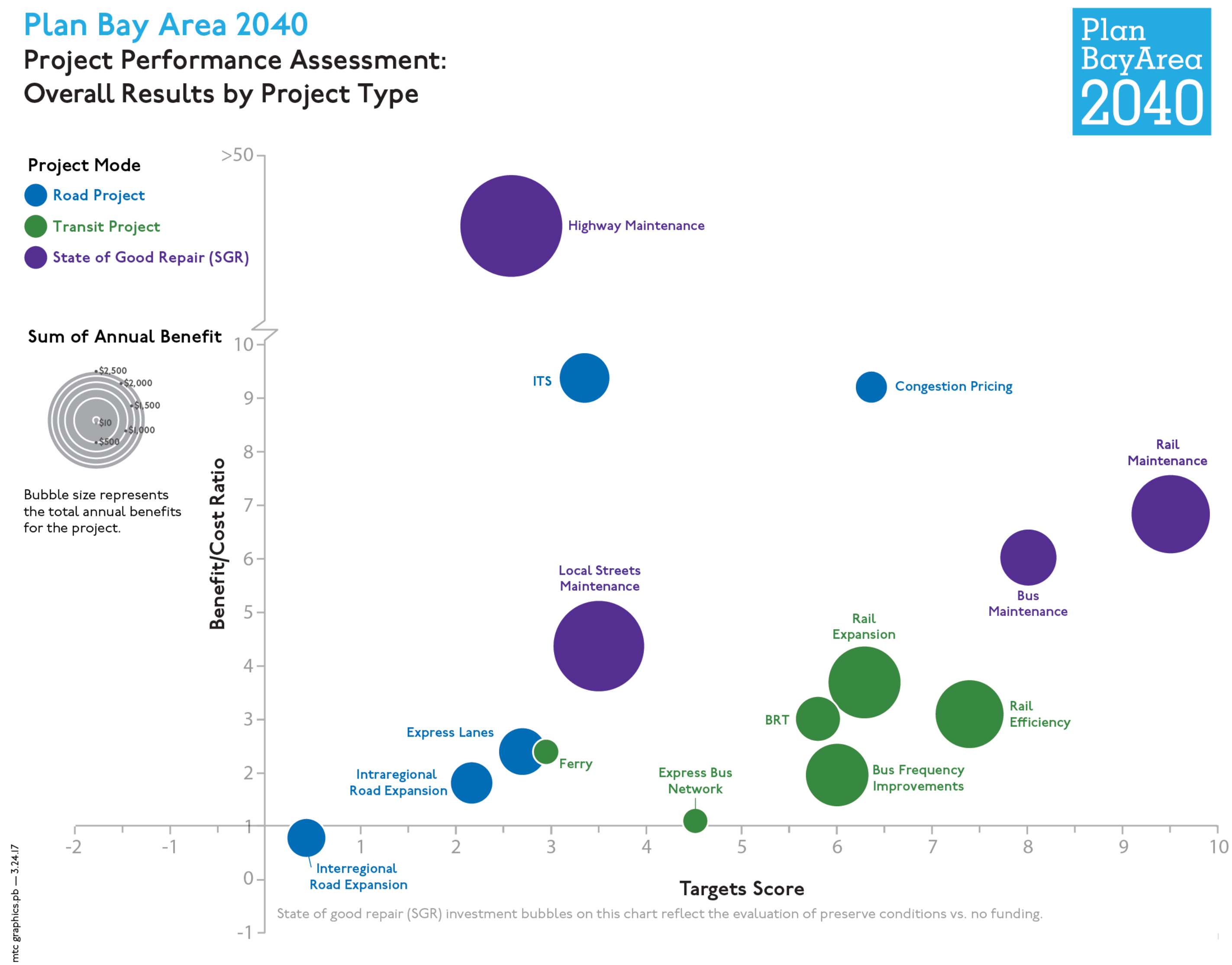


Figure 4. Results for road projects.

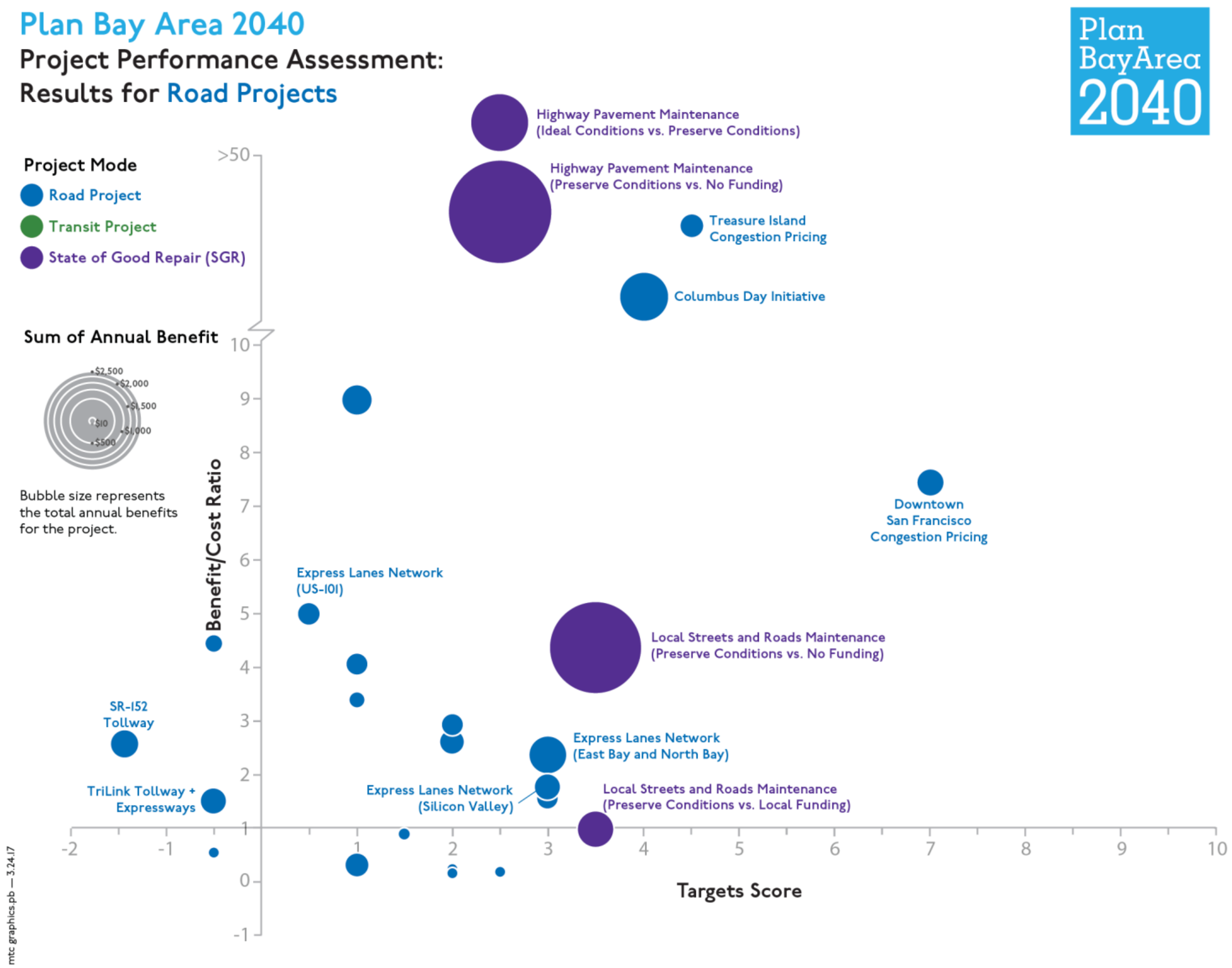
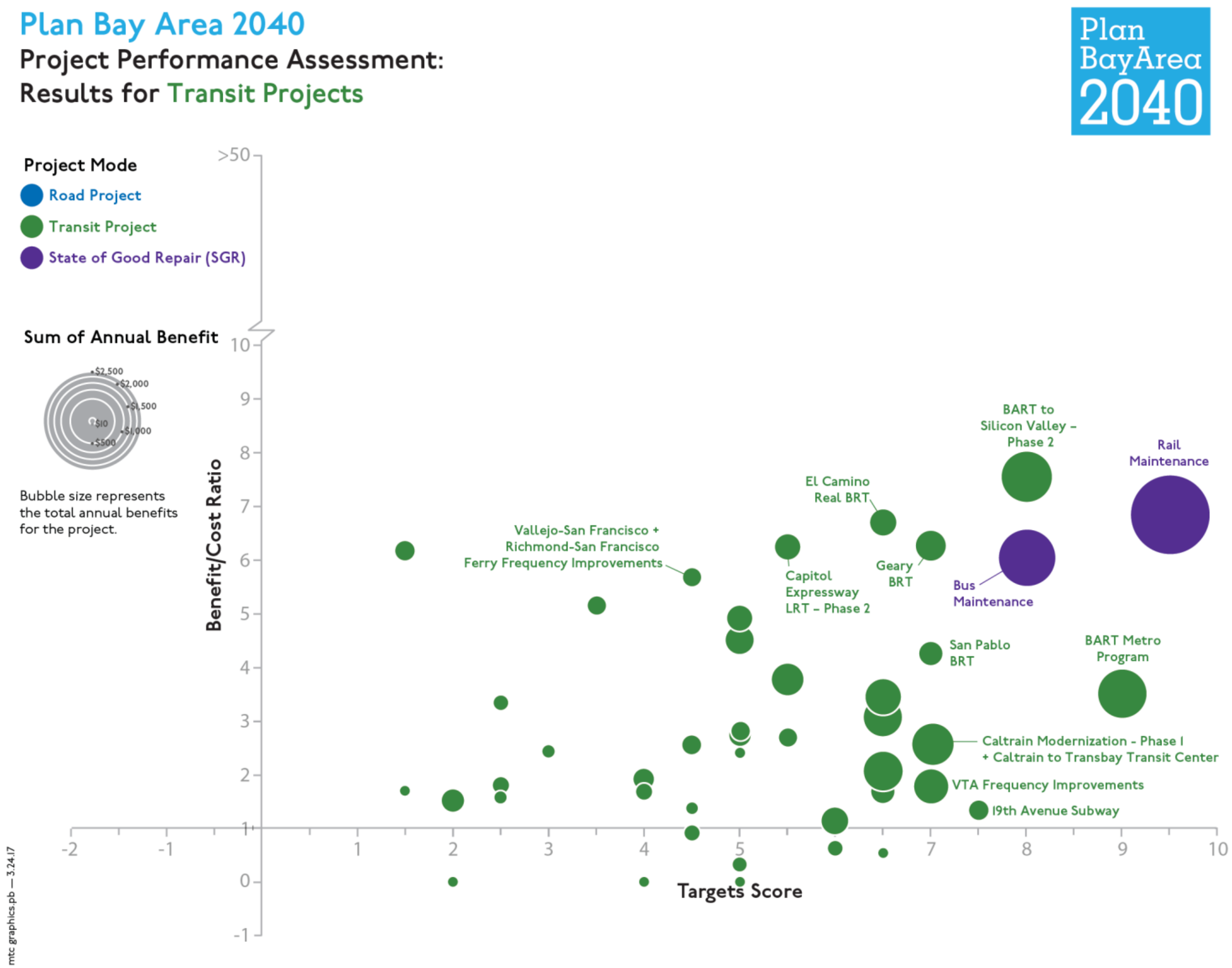


Figure 5. Results for transit projects.



High-Performers

The performance threshold created two categories of high-performing projects – those with strong cost effectiveness and those with strong support for the Plan's targets. Projects with the highest cost-effectiveness and medium support for the targets included the Treasure Island Congestion Pricing Project, Columbus Day Initiative, BART to Silicon Valley (Phase 2), Downtown San Francisco Congestion pricing, Public Transit Maintenance – Rail Operators, and El Camino BRT.

Projects with the highest targets score and medium cost-effectiveness included Geary BRT, San Pablo BRT, Public Transit Maintenance – Bus Operators, BART Metro Program, and Caltrain Modernization + Downtown Extension.

Staff used these results to prioritize future regional discretionary revenues for the 11 high-performing projects. All of the high-performing transit projects reflect the region's latest FTA Section 5309 New Starts/Small Starts/Core Capacity priorities. Columbus Day Initiative and San Francisco's two congestion pricing projects have been prioritized for future regional discretionary funding. Staff have also prioritized almost 30% of regional discretionary funding (approximately $22 billion) to make significant progress on funding transit maintenance needs. For more information on transportation funding priorities in the Plan, see the Investment Strategy Supplemental Report.

Low-Performers

The performance thresholds also created two categories of low-performing projects – those that were not cost-effective and those that affected the region's ability to meet the Plan's targets. Of the latter case, only three projects received negative targets score. These included two major extensions of roadway into open space and one road facility upgrade in an area with poor land use performance. The fifteen remaining projects had benefit cost ratios less than 1.0. These included two express bus projects, tunneling Highway 17 through Santa Cruz Mountain, constructing a bike path on the west span of the Bay Bridge, extending SMART to Cloverdale, running ferry service to Redwood City, and constructing a contraflow bus lane on the Bay Bridge.

Because cost-effectiveness and targets score are not the only two considerations for inclusion in the Plan, staff set up a process for upgrading low-performing to medium-performing status based on more nuanced information. Similar to the original Plan Bay Area process, MTC approved a set of criteria under which a compelling case could be made. These criteria reflect either a short-coming in the benefit-cost methodology or an over-riding consideration related to federal policy initiatives. Table 10 displays the specific criteria and Table 11 presents the list of low-performing projects and outcomes for each project.

Table 9. Compelling case criteria.

CATEGORY 1: Benefits Not Captured by the Travel Model	CATEGORY 2: Federal Requirements
A. **Serves an interregional or recreational corridor** B. **Provides significant goods movement benefits** C. **Project benefits accrue from reductions in weaving, transit vehicle crowding or other travel behaviors not well represented in the travel model** D. **Enhances system performance based on complementary new funded investments**	A. Cost-effective means of reducing CO2, PM, or ozone precursor emission (on cost per ton basis) B. Improves transportation mobility/reduces air toxics and PM emissions in communities of concern

Rather than go through the compelling case process, sponsors for ten of the eighteen low-performing projects decided to drop the project or convert them to a project type that was exempt from the evaluation. Two projects were converted to environmental studies, two projects were reduced in scope and funded completely with a local sales tax, and six projects were ultimately dropped.

Two additional projects provided updated cost or scope data that sufficiently demonstrated they could achieve a benefit-cost ratio greater than one, thus allowing staff to designate them as medium-performing projects.

For the remaining seven projects that did submit a compelling case, staff recommended approving four projects, most of which fell under criterion 2A (improving air quality in a cost-effective manner) or criterion 2B (improving mobility or air quality in Communities of Concern). The 80/680/12 interchange project provided several model-based reasons for justifying the project and staff approved their arguments under 1A, 1B, and 1C. The remaining three projects – totaling $1.2 billion – did not successfully receive approval of their cases based on evaluation against the six adopted criteria. These three projects were either down-scoped to environmental funding or scaled back.

All in all, the compelling case process removed billions of dollars of low-performing projects from Plan Bay Area 2040 and boosted the cost-effectiveness of the overall Plan. A summary of all low-performing projects and their outcomes is shown below.

Table 10. Low-performing projects.

Project Title	Low-Performing Reason	Outcome
Downtown San Jose Subway (Japantown to Convention Center)	Low B/C	Dropped
SR-17 Tollway + Santa Cruz LRT (Los Gatos to Santa Cruz)	Low B/C	Dropped
Bay Bridge West Span Bike Path	Low B/C	Rescoped to environmental
VTA Express Bus Frequency Improvements	Low B/C	Dropped
Express Bus Bay Bridge Contraflow Lane	Low B/C	Rescoped to environmental
TriLink Tollway + Expressways (Brentwood to Tracy/Altamont Pass)	Low Targets Score	Rescoped to only include Airport Connector arterial segment near Byron for a cost less than $100 million
Lawrence Freeway	Low B/C	Rescoped to Tier 1 elements only and funded with local sales tax
Antioch-Martinez-Hercules-San Francisco Ferry	Low B/C	Costs updated to reflect smaller-scale privately-operated ferries, bringing B/C above 1
I-680 Express Bus Frequency Improvements	Low B/C	Costs updated to reflect standard hourly rate for express bus service, bringing B/C above 1
SR-4 Widening (Antioch to Discovery Bay)	Low B/C	Dropped
I-80/I-680/SR-12 Interchange Improvements	Low B/C	Compelling case 1A, 1B, and 1C approved
SR-262 Connector (I-680 to I-880)	Low Targets Score	Compelling case 2A approved

Project Title	Low-Performing Reason	Outcome
East-West Connector (Fremont to Union City)	Low B/C	Compelling case 2B approved
Southeast Waterfront Transportation Improvements	Low B/C	Compelling case 2B approved
Geneva-Harney BRT (Phase 1)	Low B/C	Compelling case 2B approved
San Francisco-Redwood City + Oakland-Redwood City Ferry	Low B/C	Compelling case considered but ultimately included as environmental
SR-152 Tollway (Gilroy to Los Banos)	Low Targets Score	Compelling case considered but ultimately included as environmental
SMART – Phase 3 (Santa Rosa Airport to Cloverdale)	Low B/C	Compelling case considered but ultimately included as an extension to Cloverdale and environmental funding for the remaining segment

Supplemental Assessments

In addition to the targets assessment and benefit-cost assessment for all major projects, three supplemental assessments were conducted. The three supplemental assessments included:

Confidence assessment – this analysis identified the primary shortcomings of the quantitative assessment approach, including limitations in travel model specificity or calibration, completeness of benefit estimation, and the horizon-year approach.

Sensitivity testing – this analysis documented the impact of benefit valuations on the estimate of cost-effectiveness by varying key components of the B/C calculation and evaluating the effects on project ranking.

Equity considerations – this analysis calculated an equity targets score and overlaid projects on the region's Communities of Concern.

Confidence Assessment

The confidence assessment described potential limitations of the benefit-cost assessment. Disclosure of these limitations informed the project prioritization process for Plan Bay Area 2040 and is included in Appendix D. Staff qualitatively assessed confidence in the benefit-cost ratios based on the following criteria:

Travel Model Output

- Does the travel model have limitations in understanding a particular type of travel behavior (e.g. merging and weaving at interchanges)?
- Does the travel model lack an understanding of smaller-scale project travel changes relative to the region (e.g. single infill station, expressway improvements)?

Framework Completeness

- Does the travel model output capture all of the primary benefits of the project (e.g. the value of relieving transit crowding or primarily recreational or tourism benefits)?

Timeframe Inclusiveness

- Is the project an “early winner” (i.e. can be implemented quickly and provides key benefits in the short term)?
- Is the project a “late bloomer” (i.e. benefits will not be realized until the final years of the planning horizon)

Sensitivity Testing

Sensitivity testing was used to understand how benefit valuations and project cost assumptions affected the cost-effectiveness estimates across projects. The sensitivity test included three types of tests: one on a project’s costs, one on the valuation of travel time, and one on the valuation of life. The test on cost increased a project’s annual cost depending on project type, acknowledging that capital-intensive rail projects have historically experienced significant cost increases over several years of planning. The second test on the valuation of travel time reduced this valuation by 50% to assess which projects would have higher “social benefits” (e.g. safety and health) relative to user benefits. The third test on the valuation of life reduced this valuation by 50%. After these three tests, staff evaluated the new benefit/cost ratios and rankings for the projects.

Changing the valuation on travel time had a significant effect on the project rankings. Many of the projects with a high share of travel time benefits and that already were at the border of cost-effectiveness fell below the benefit-cost ratio threshold of 1. Examples include the Express Lane Network, US-101 Marin Sonoma Narrows Phase 2, TriLink Tollway, Golden Gate Transit Frequency Improvements and Muni Service Frequency Improvements. Additionally, benefit-cost ratios for Rail Maintenance and the Columbus Day Initiative decreased enough to drop their rankings by at least 4 projects. With this lower valuation, the resulting benefit-cost distribution would be more uniform, implying that the final performance outcomes (e.g. high, medium, low) might have relied more heavily on the targets score.

Increasing annual costs based on project type had the largest effect on rail projects. This is the type of project that has historically experienced the highest amount of cost increase of the period of project development. This sensitivity test mostly moved rail projects out of the top 10 and moved maintenance projects higher on the list. Changing the valuation of life did not generate significant changes in project ranking nor did any project’s B/C ratio fall from above 1 to below 1.

Appendix F includes detailed results for the sensitivity test.

Project-Level Equity Considerations

The third supplemental assessment evaluated a project’s ability to support the equity issue areas of Plan Bay Area 2040 and the degree to which they would serve a Community of Concern (CoC). This equity assessment first isolated each project’s scores on the six equity related targets for Plan Bay Area 2040 – healthy and safe communities, housing and transportation costs, affordable housing, displacement risk, access to jobs, and middle-wage jobs creation. Next, the assessment considered how each project would increase access for the region’s Communities of Concern. Projects that would not increase access for these populations did not receive a score in the equity assessment. Projects that would increase access were ranked according to their score on the subset of targets that have an equity nexus.

Every project with a high benefit-cost ratio and a strong support rating for regional targets would improve access to at least one Community of Concern in the Bay Area. The notable result reflects the strong equity nexus in the adopted performance targets, with six of the thirteen targets having a clear nexus with social equity. While the highest possible equity targets score possible was six, the three highest-performers only received a score of four. This is in part due to the many “Moderate Adverse” scores on the displacement target. The same inner urban areas that have the potential to increase access for a number of Communities of Concern, are also the areas with some of the highest risks for displacement.

Additionally, 19 projects would not increase access for a Community of Concern. These include ferry projects without an access point in a Community of Concern and light rail projects in the South Bay with stations outside Community of Concerns.

Appendix G includes more detailed methodology and results.

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Appendix A: Targets Criteria

This section describes the methodology used to assign targets scores during the project-level assessment. The methodology includes example projects that received a range of target ratings, as well as common reasons for rating projects in a given way. This qualitative assessment is designed to complement the purely quantitative evaluation of cost-effectiveness.

As a reminder, the score for a particular target ranges from -1 to +1 and can be one of five categories: strong support, moderate support, minimal support (0), moderate adverse impact, and strong adverse impact. The final targets score is the straight sum of the 13 individual scores.

Target 1: Reduce per-capita CO_2 emissions from cars and light-duty trucks by 15%.

Projects supported the target if they were likely to reduce VMT; provide an alternative to driving alone; or advance clean fuel vehicles. Projects that were likely to lead to an increase VMT are assumed to have an adverse impact on the target.

Guidelines for Applying Criteria

Transit, bicycle and pedestrian projects were expected to reduce VMT and were rated as supportive of the target. Larger projects, those likely to serve a large number of trips or serve longer trips, were rated as strongly supportive. Smaller projects, those likely to serve fewer trips or shorter trips, were rated as moderately supportive.

Projects that increased roadway capacity or were expected to increase VMT were generally rated as having a strong adverse impact on the target. Operational roadway projects, such as highway interchange projects, were not expected to increase VMT significantly since they did not add capacity and were generally rated as having minimal impact. Roadway projects that include transit, bicycle and pedestrian elements were given minimal or moderate support to recognize the impacts of these multi- modal elements.

Examples

Projects with the potential to reduce long car trips by attracting long-distance riders received strong support for this target. Example projects include BART Metro Program and Caltrain Electrification.

Projects that would expand a roadway, reducing congestion and making driving attractive received moderate to strong adverse impact scores. Example projects include SR-4 Auxiliary Lanes, TriLink, and SR-152 Alignment.

Target 2: House 100% of the region’s projected growth by income level without displacing current low-income residents and with no increase in in-commuters over the Plan baseline year.

The assessment of a project’s impact on housing was dependent upon two criteria: potential for housing growth in the jurisdictions affected and those jurisdictions’ past track record on producing housing at multiple income levels. The strongest support was for projects that were located in jurisdictions that had above average production for at least three income categories and a high amount of housing planned in the future (at least 20%). Staff designed the performance thresholds such that regional performance would receive a “moderate support” rating.

Guidelines for Applying Criteria

To determine a project's potential support for adequate housing, a project's service area was first determined. Service areas varied by project type, location, and travel demand. An expansive, regional project would cover more jurisdictions whereas a project on smaller facilities would likely only serve one jurisdiction. As an example, the service area for BART to San Jose spans multiple jurisdictions in Santa Clara and Alameda counties whereas the service area for Geary BRT is San Francisco.

For each service area, staff evaluated RHNA performance across the previous two RHNA cycles – 1999-2006 and 2007-2014. RHNA performance is based on the share of housing units permitted for the four income categories (very low income, low income, moderate income, and above moderate income). A project in a service area where most of the jurisdictions permitted above average shares of RHNA category would receive stronger ratings for this target. For each service area, staff also evaluated anticipated growth in Plan Bay Area 2013. A project in a service area where jurisdictions planned to increase housing stock by at least 10% received moderate to strong support for this target.

The data tables used to score this target are included at the end of this Appendix.

Examples

Projects in eastern Contra Costa County and eastern San Clara County received strong support, because jurisdictions like Antioch, Brentwood, San Jose, Milpitas, and Sunnyvale have historically permitted housing across the income spectrum and accepted significant housing in Plan Bay Area 2013. Example projects include the SR-4 Operational Improvements, Capitol Expressway Light Rail Extension, and VTA Bus Service Increases.

Projects in San Mateo County and western Santa Clara County received minimal or moderate adverse results despite serving areas that plan to grow significantly in Plan Bay Area 2013. If a jurisdiction historically has only permitted housing for above-moderate incomes, the project serving that jurisdiction received a minimal score. Example projects include US-101 Express Lanes, Caltrain Electrification, and Stevens Creek BRT.

Target 3: Reduce adverse health impacts associated with air quality, road safety, and physical inactivity by 10%

Projects supported the target if it was likely to cause large shifts to non-auto modes. A shift to non-auto modes leads to more active lifestyles, reduces the amount of emissions associated with driving, and could reduce the number of auto collisions by virtue of few people in vehicles. If a project is primarily a road safety project, staff increased the target score by half a point.

Guidelines for Applying Criteria

Projects generally received the same rating for this target as they did for CO_2 reduction (target 1)

Examples

BRT projects that received moderate support in Target 1 received strong support in this target due to their ability to not only improve air quality but significantly increase non-auto mode share. The benefit- cost results support this claim as the BRT projects were more likely to create mortality benefits and reduce vehicle ownership than regional rail extensions. Example BRT projects include Geary BRT, San Pablo BRT, and Stevens Creek BRT. Significant road expansion projects like TriLink and SR-152 received a moderate adverse score for this target due to their substantial safety components. These two projects received strong adverse scores for Target 1.

Target 4: Direct all non-agricultural development within the urban footprint (existing urban development and urban growth boundaries)

Projects that do not consume open space or agricultural lands support the target. Projects that improve access to agricultural lands support the target because they maintain economic viability of those lands; this is consistent with requirements in SB 375. Plan Bay Area must show how farmland is preserved from urban development and issues like access for farm to market are considered. Projects that directly consume open space or agricultural land have an adverse impact.

Guidelines for Applying Criteria

Projects that helped to promote infill development are given a supportive rating for this target, as developing or redeveloping existing urban areas reduced the demand for sprawling developments at the fringe of the region.

Support for the target was also given for improved access to agricultural lands. Highway projects that connected agricultural lands to urban areas were supportive of the target since these projects could foster improved goods movement by trucks to their destination. A project would receive an adverse score if it would require new right-of-way in previously undeveloped open space or agricultural land.

Examples

Staff evaluated transit projects that significantly increase access within Priority Development Areas while also not consuming open space as being strongly supportive of this target. Example projects include the BART Metro Program, BART to San Jose, Caltrain Electrification and Regional Transit State of Good Repair.

Staff evaluated road extension projects as having strong adverse impacts on achieving this target. Example projects include TriLink and SR-152 Alignment.

Target 5: Decrease by 10% the share of lower-income residents' household income consumed by transportation and housing

Projects supported the target if they included transit enhancements that provided a lower-cost transportation alternative to driving. The degree of support varied based on the operator's current low-income ridership. Road project with a significant low cost option such as HOV lanes, transit, bicycle, or pedestrian component AND that serves a Community of Concern could also receive a moderate support for this target.

Guidelines for Applying Criteria

Staff considered transit projects to be provide a lower-cost alternative to auto ownership and thus supported this target. The degree of support was based on the percentage of the region's total low- income riders and the proportion of low income riders served by the operator. The percentages of low- income riders were based on an MTC or Operator Survey conducted between 2013 and 2016. These data are included at the end of this Appendix.

Transit operators' projects received a strong support rating if low-income riders constitute over 40% of system ridership or if the operator serves more than 10% of the region's low-income transit riders. Transit operators' projects received a moderate support rating if the projects serves more than 0.5% of the region's low-income transit riders; transit projects for operators with less than this threshold received a minimal impact rating.

Examples

The projects that most strongly supported this target were VTA and AC Transit projects, two operators whose share of low-income riders is over 40%. Example projects include San Pablo BRT and El Camino BRT. Muni and BART projects also strongly support this target for serving more than 10% of the region's low-income riders. Example projects include Geneva BRT and BART Metro Program.

Although Treasure Island Value Pricing and Downtown San Francisco Cordon Pricing includes significant increases to transit service, these two projects remove a free drive alone option and thus were rated as having a minimal impact on this target. No projects received a moderate or adverse impact.

Target 6: Increase the share of affordable housing in PDAs, TPAs, or high-opportunity areas by 15%

Staff considered projects to be supportive of this target if they serve jurisdictions that permitted high shares of affordable units in the last two RHNA cycles (1999-2014), irrespective of transportation mode.

Guidelines for Applying Criteria

To determine a project's potential support for affordable housing, a project's service area was first determined. The service area is the same as the service area for Target 2. Staff then evaluated the share of affordable units each jurisdiction permitted relative to their RHNA target. Affordable units are based on very low, low, and moderate income levels. Project's that serve areas with jurisdictions that approved more than 50% of their affordable housing target received strong support for this target. Staff created the RHNA thresholds such that region-wide performance was moderately supportive of the target.

Examples

Most of the cities in Contra Costa County and many cities in Sonoma County permitted high shares of affordable housing over the last decade. Projects serving these areas that received strong support for this target include San Pablo BRT, Sonoma County Bus Service Increases, and the SMART extension to Cloverdale.

Projects that received moderate adverse scores for this target served low growth communities of San Mateo County and communities that have permitted significant housing but at higher income levels like Dublin and Fremont. Example projects in this category include Caltrain Electrification, US 101 Express Lanes, Irvington BART Station, and I-580 Integrated Corridor Management.

Target 7: Reduce the share of low- and moderate-income renter households in PDAs, TPAs, or high-opportunity areas that are at an increased risk of displacement to 0%

Admittedly, the criteria for this target was the most difficult to develop and implement. Staff determined that no transportation project would reduce the risk of displacement. These criteria assume that any increase in access would increase the attractiveness of a neighborhood, potentially leading to displacement of existing residents. The target score is a function of project location – whether a project serves a high growth area and the level of existing displacement risk for low-income and moderate- income households. If a project is completely outside of Priority Development Areas, the project would have a minimal impact on this target.

Guidelines for Applying Criteria

To determine a project's potential support for displacement risk, a project's service area was first determined. The service area is the same as the service area for Target 2 and Target 6. Staff then evaluated whether the service area had high growth jurisdictions, planned to grow more than 20%, or was in an area with high displacement risk. An area is currently undergoing displacement if it exhibits displacement typologies 2-4 for both lower income and moderate to high income tracts per the Regional Early Warning System definitions (REWS). For a map of displacement trends, see: http://www.urbandisplacement.org/map# Because the REWS typologies are for census tracts, staff assumed that if more than 75% of a jurisdiction's tracts are undergoing displacement then the jurisdiction is underdoing displacement.

Examples

Based on planned growth in Plan Bay Area 2013 and existing displacement trends, all San Francisco projects received a strong adverse impact score for this target. The two central bay ferry projects also received strong adverse impact for the displacement conditions in Oakland and Alameda.

Projects that received a minimal impact include projects in Contra Costa County like the 680/SR-4 Interchange and ferry expansion to Hercules, Martinez and Antioch. Additionally, projects in Solano and Marin counties, which are either low growth areas or are not experiencing displacement issues, would only minimally impact this target.

Target 8: Increase the share of jobs accessible within 30 minutes by auto or within 45 minutes by transit by 20**%** in congested conditions

Supportive projects were those that significantly decrease travel times and connected many workers to the region's job centers. Rating was dependent on project location and degree of travel time improvement.

Guidelines for Applying Criteria

Projects serving the regional job centers of San Francisco, Silicon Valley, and Oakland and that significantly increased access to these job centers by virtue of major transit extensions or frequency increases strongly supported this target. Projects with moderate travel time savings like an interchange that are also relatively far from a sub-regional job center received minimal scores. If a project increased travel time, it would adversely impact the target.

Examples

Major transit extensions to existing and future job centers strongly supported this target. Example projects include BART to San Jose and the extension of Caltrain to downtown San Francisco. Service increases throughout San Francisco also strongly support this target.

Interchange and highway projects far from subregional job centers minimally supported this target. Example projects include the SR-152 alignment and SR-4 widening in Brentwood. Maintenance investments in highways and local streets and roads would have a minimal effect on travel times and received minimal scores for this target.

Target 9: Increase by 38% the number of jobs in predominantly middle-wage industries)

Supportive projects were those that through construction and an increase in service would add both short term and long term jobs to the regional economy. If a project reduces the number of transportation-related jobs, like automating an existing bus route, would adversely impact this target. Transportation-related jobs are typically middle-wage and supportive of the target.

Guidelines for Applying Criteria

All projects received moderate or strong support for this target as all projects either require constructing new infrastructure or operating new service. For example, increased maintenance funding would require additional long-term workers and a highway operational project would require short term construction workers. Transit and ITS projects that require both short term construction workers and long term operators strongly support this target.

Examples

Constructing and operating express lanes and integrated corridors received strong support for this target. Additionally, constructing and operating rail extensions also received strong support.

Examples of moderate support include service frequency increases and auxiliary lane projects.

Target 10: Reduce per-capita delay on the Regional Freight Network by 20%

Supportive projects were those that reduce congestion on the highest delay highway segments for truck activity. Projects would receive negative scores if they actually increased travel time on the regional freight network.

Guidelines for Applying Criteria

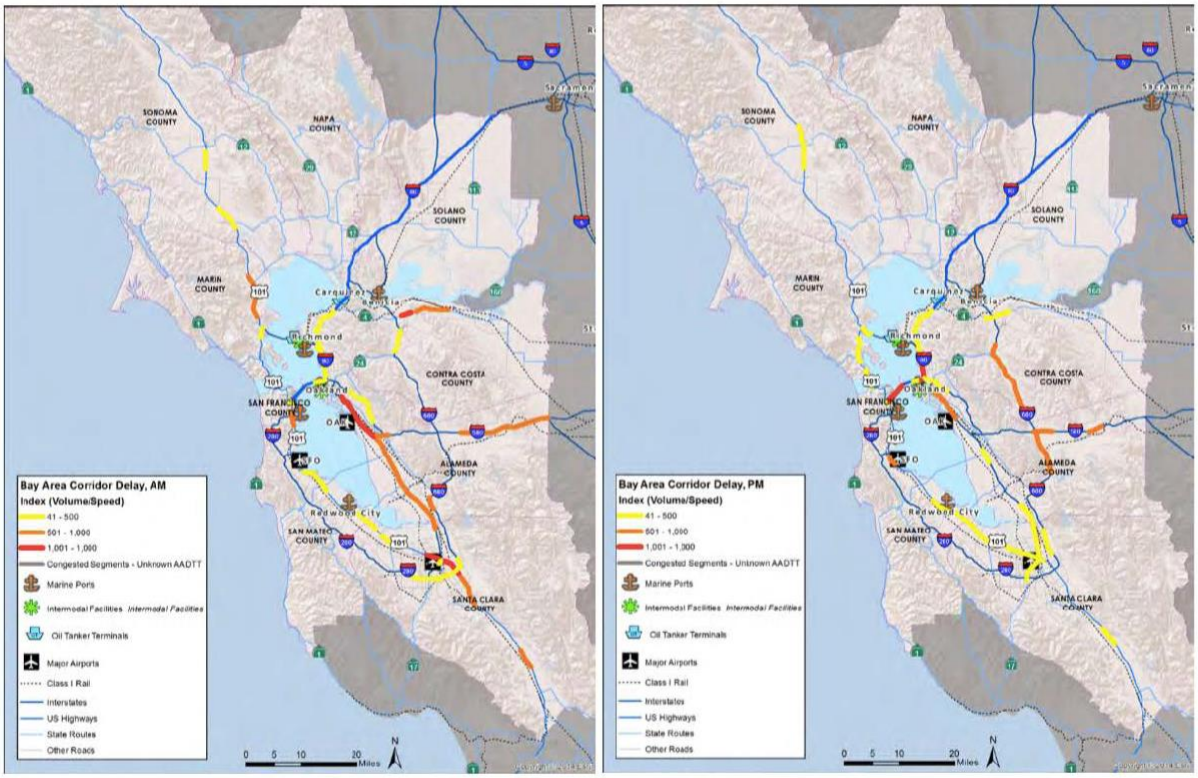
The MTC Regional Goods Movement Plan evaluated corridor delay and truck volumes. Projects that reduce congestion on segments with a medium or high corridor delay index would receive the highest score for this target. The corridor delay index is truck volume divided by speed so segments with high truck volumes and medium speed would receive the same index value as corridors with low truck volumes but significant congestion. The map is on the following page. Projects on the rest of the freight network or that would increase freight reliability would receive moderate scores and projects that do not affect the freight network would receive a minimal score.

Examples

The projects that received the strongest support were highway improvement projects on I-880 in Alameda County, US-101 in San Mateo, Marin, and Santa Clara counties, I-580 in Alameda County I-680 in Contra Costa and Alameda counties, and along the Bay Bridge. Example projects include US-101 Express Lanes, VTA Express Lane network, and the Columbus Day Initiative. Major transit projects that could remove driving trips from high-delay segments also received strong support. These projects include Regional Transit State of Good Repair and BART Metro Program.

No projects received negative scores for this target. Projects that minimally affected the goods movement network received a minimal score. These projects were mostly transit projects and included the Irvington

BART Station, Geary BRT, and El Camino BRT.



Source: Congested Segments from INRIX 2013; Truck Volumes data from Caltrans Truck Counts, 2012; Analysis by Cambridge Systematics, Inc.

Target 11: Increase non-auto mode share by 10%

Criteria for this target are similar to those for the CO_2 and PM targets. Projects that provide alternatives to the single occupant vehicle such as public transit or bicycling/walking are generally supportive of the target. Projects that would potentially increase the use of single occupancy vehicles received the lowest score.

Guidelines for Applying Criteria

Scoring for this target was very similar to the guidelines under Target 1. Transit projects were supportive of this target if they provided frequency or operational improvements that would make transit service more convenient and attractive. Highway projects could receive a moderate score if they were a managed lane project that would significantly benefit transit service along the corridor.

Examples

Projects with the strongest support were similar to the projects that received strong support in Target 1 but also included neighborhood bus projects that would increase walking and biking to transit. Example projects include AC Transit's San Pablo Avenue BRT and VTA's El Camino BRT.

Projects with the lowest score for this target were highway extension projects like TriLink and SR-152 Alignment due to their increase in auto accessibility without significant provisions for non-auto improvements.

Target 12: Reduce vehicle operating and maintenance costs due to pavement conditions by 100%

Projects that funded street resurfacing, either exclusively or part of an operational project, received moderate to strong support. Staff determined that no project would have an adverse impact to pavement condition by worsening pavement quality.

Guidelines for Applying Criteria

State of good repair investments in state highways and local streets and roads received the highest score for this target. Highway projects that either repaved existing pavement or replaced and existing facility received a moderate support.

Examples

Only two projects - Local Streets and Roads State of Good Repair and State Highways State of Good Repair - received strong support.

Projects like the 680/SR4 Interchange and TriLink received moderate support because they would replace and upgrade existing highway facilities.

Target 13: Reduce per-rider transit delay due to aged infrastructure by 100%

Projects that funded transit vehicle or asset replacement, either exclusively or part of an expansion project, received moderate to strong support. Staff determined that no project would have an adverse impact on transit asset condition by worsening asset quality.

Guidelines for Applying Criteria

State of good repair investments in transit systems received the highest score for this target. Transit service expansion projects that replaced existing vehicles received a moderate support score.

Examples

Regional Bus Maintenance and Regional Rail Maintenance were the only two projects that received a strong support for this target.

Caltrain Electrification and BART Metro Program received moderate support because these projects would replace and upgrade existing fleet and power systems. Caltrain Electrification would replace most of Caltrain’s diesel vehicles with electric vehicles. BART Metro Program would replace and upgrade BART traction power system to support higher frequencies.

Target 2 Performance: Share of RHNA Allocation by Income Level for Bay Area Cities and Anticipated Growth in Plan Bay Area
Source: 1999-2014 RHNA and Plan Bay Area, 2013

Jurisdiction	County	1999-2014 RHNA Performance - Share of RHNA Allocation Permitted					Plan Bay Area Growth 2015-2040	Target 2 Performance
		Very Low	Low	Moderate	Above Moderate	# of Income Categories Above 40%		
Alameda	Alameda	41%	6%	12%	34%	1	16%	Moderate Adverse
Albany	Alameda	4%	21%	178%	47%	2	15%	Moderate Support
Berkeley	Alameda	47%	60%	14%	115%	3	17%	Moderate Support
Dublin	Alameda	24%	28%	21%	177%	1	45%	Minimal
Emeryville	Alameda	64%	25%	47%	244%	3	71%	Strong Support
Fremont	Alameda	23%	13%	22%	94%	1	21%	Minimal
Hayward	Alameda	26%	3%	63%	138%	2	23%	Moderate Support
Livermore	Alameda	14%	27%	41%	97%	2	27%	Moderate Support
Newark	Alameda	0%	0%	0%	37%	0	23%	Minimal
Oakland	Alameda	46%	35%	3%	91%	2	28%	Moderate Support
Piedmont	Alameda	84%	14%	71%	63%	3	2%	Minimal
Pleasanton	Alameda	10%	37%	18%	70%	1	22%	Minimal
San Leandro	Alameda	54%	227%	34%	124%	3	20%	Strong Support
Union City	Alameda	39%	18%	10%	153%	1	13%	Moderate Adverse
Unincorporated Alameda	Alameda	19%	40%	11%	78%	1	9%	Strong Adverse
Antioch	Contra Costa	31%	50%	179%	123%	3	14%	Moderate Support
Brentwood	Contra Costa	35%	32%	163%	331%	2	11%	Moderate Support
Clayton	Contra Costa	64%	26%	15%	54%	2	4%	Minimal
Concord	Contra Costa	16%	16%	8%	106%	1	38%	Minimal
Danville	Contra Costa	26%	64%	51%	101%	3	8%	Minimal
El Cerrito	Contra Costa	109%	52%	25%	135%	3	11%	Moderate Support
Hercules	Contra Costa	39%	50%	35%	330%	2	43%	Moderate Support
Lafayette	Contra Costa	43%	11%	7%	182%	2	13%	Moderate Support
Martinez	Contra Costa	9%	0%	1%	54%	1	8%	Strong Adverse
Moraga	Contra Costa	20%	0%	0%	41%	1	12%	Moderate Adverse

Target 2 Performance: Share of RHNA Allocation by Income Level for Bay Area Cities and Anticipated Growth in Plan Bay Area
Source: 1999-2014 RHNA and Plan Bay Area, 2013

Jurisdiction	County	1999-2014 RHNA Performance - Share of RHNA Allocation Permitted					Plan Bay Area Growth 2015-2040	Target 2 Performance
		Very Low	Low	Moderate	Above Moderate	# of Income Categories Above 40%		
Oakley	Contra Costa	96%	198%	226%	246%	4	41%	Strong Support
Orinda	Contra Costa	71%	30%	22%	169%	2	10%	Minimal
Pinole	Contra Costa	27%	8%	74%	41%	2	14%	Moderate Support
Pittsburg	Contra Costa	38%	98%	148%	173%	3	31%	Strong Support
Pleasant Hill	Contra Costa	36%	38%	83%	95%	2	8%	Minimal
Richmond	Contra Costa	32%	204%	32%	61%	2	24%	Moderate Support
San Pablo	Contra Costa	127%	66%	28%	110%	3	19%	Moderate Support
San Ramon	Contra Costa	20%	61%	84%	234%	3	17%	Moderate Support
Walnut Creek	Contra Costa	33%	21%	24%	148%	1	21%	Minimal
Unincorporated Contra Costa	Contra Costa	24%	19%	19%	184%	1	8%	Strong Adverse
Belvedere	Marin	33%	100%	67%	180%	3	2%	Minimal
Corte Madera	Marin	66%	55%	4%	147%	3	6%	Minimal
Fairfax	Marin	0%	0%	13%	33%	0	6%	Strong Adverse
Larkspur	Marin	22%	19%	8%	44%	1	6%	Strong Adverse
Mill Valley	Marin	81%	104%	52%	49%	4	6%	Minimal
Novato	Marin	49%	131%	64%	104%	4	5%	Minimal
Ross	Marin	9%	38%	30%	121%	1	6%	Strong Adverse
San Anselmo	Marin	21%	47%	2%	70%	2	5%	Minimal
San Rafael	Marin	8%	27%	46%	52%	2	13%	Moderate Support
Sausalito	Marin	37%	36%	4%	44%	1	6%	Strong Adverse
Tiburon	Marin	6%	17%	0%	122%	1	6%	Strong Adverse
Unincorporated Marin	Marin	43%	99%	61%	148%	4	4%	Minimal
American Canyon	Napa	29%	20%	11%	256%	1	28%	Minimal
Calistoga	Napa	28%	57%	3%	65%	2	2%	Minimal
Napa	Napa	23%	47%	60%	81%	3	11%	Moderate Support
St. Helena	Napa	20%	44%	62%	107%	3	2%	Minimal

Target 2 Performance: Share of RHNA Allocation by Income Level for Bay Area Cities and Anticipated Growth in Plan Bay Area
Source: 1999-2014 RHNA and Plan Bay Area, 2013

Jurisdiction	County	1999-2014 RHNA Performance - Share of RHNA Allocation Permitted					Plan Bay Area Growth 2015-2040	Target 2 Performance
		Very Low	Low	Moderate	Above Moderate	# of Income Categories Above 40%		
Yountville	Napa	54%	80%	86%	93%	4	2%	Minimal
Unincorporated Napa	Napa	7%	13%	23%	41%	1	7%	Strong Adverse
Atherton	San Mateo	44%	0%	0%	-2%	1	9%	Strong Adverse
Belmont	San Mateo	16%	21%	9%	105%	1	9%	Strong Adverse
Brisbane	San Mateo	4%	1%	7%	69%	1	12%	Moderate Adverse
Foster City	San Mateo	50%	30%	19%	113%	2	7%	Minimal
Half Moon Bay	San Mateo	0%	122%	0%	79%	2	6%	Minimal
Hillsborough	San Mateo	245%	132%	87%	147%	4	7%	Minimal
Colma	San Mateo	0%	384%	0%	30%	1	46%	Minimal
Daly City	San Mateo	16%	22%	7%	71%	1	12%	Moderate Adverse
Burlingame	San Mateo	0%	0%	29%	24%	0	25%	Minimal
Portola Valley	San Mateo	40%	18%	7%	54%	2	7%	Minimal
East Palo Alto	San Mateo	12%	62%	19%	89%	2	9%	Minimal
Menlo Park	San Mateo	16%	4%	8%	45%	1	14%	Moderate Adverse
Woodside	San Mateo	47%	50%	31%	410%	3	5%	Minimal
Millbrae	San Mateo	1%	3%	10%	211%	1	30%	Minimal
Mountain View	Santa Clara	28%	5%	9%	142%	1	24%	Minimal
Palo Alto	Santa Clara	39%	21%	27%	165%	1	22%	Minimal
Unincorporated San Mateo	San Mateo	16%	18%	0%	167%	1	19%	Moderate Adverse
Redwood City	San Mateo	12%	28%	11%	149%	1	25%	Minimal
San Bruno	San Mateo	52%	244%	94%	127%	4	24%	Strong Support
San Carlos	San Mateo	1%	4%	7%	76%	1	13%	Moderate Adverse
San Francisco	San Francisco	69%	34%	15%	127%	2	23%	Moderate Support
Pacifica	San Mateo	3%	10%	19%	78%	1	4%	Strong Adverse
San Jose	Santa Clara	47%	64%	7%	117%	3	34%	Strong Support
San Mateo	San Mateo	25%	19%	12%	103%	1	22%	Minimal

Target 2 Performance: Share of RHNA Allocation by Income Level for Bay Area Cities and Anticipated Growth in Plan Bay Area
Source: 1999-2014 RHNA and Plan Bay Area, 2013

Jurisdiction	County	1999-2014 RHNA Performance - Share of RHNA Allocation Permitted					Plan Bay Area Growth 2015-2040	Target 2 Performance
		Very Low	Low	Moderate	Above Moderate	# of Income Categories Above 40%		
Santa Clara	Santa Clara	27%	39%	31%	174%	1	26%	Minimal
Campbell	Santa Clara	15%	158%	44%	95%	3	15%	Moderate Support
Cupertino	Santa Clara	10%	10%	15%	103%	1	16%	Moderate Adverse
Gilroy	Santa Clara	18%	72%	38%	127%	2	16%	Moderate Support
Los Altos	Santa Clara	35%	44%	10%	674%	2	9%	Minimal
Los Altos Hills	Santa Clara	138%	67%	27%	411%	3	5%	Minimal
Los Gatos	Santa Clara	7%	84%	10%	178%	2	6%	Minimal
Milpitas	Santa Clara	62%	37%	46%	278%	3	49%	Strong Support
Monte Sereno	Santa Clara	78%	136%	75%	130%	4	6%	Minimal
Morgan Hill	Santa Clara	46%	83%	41%	163%	4	25%	Strong Support
So. San Francisco	San Mateo	35%	20%	17%	92%	1	26%	Minimal
Sunnyvale	Santa Clara	38%	117%	102%	106%	3	29%	Strong Support
Saratoga	Santa Clara	36%	13%	61%	126%	2	5%	Minimal
Unincorporated Santa Clara	Santa Clara	66%	158%	36%	167%	3	9%	Minimal
Benicia	Solano	25%	89%	83%	125%	3	11%	Moderate Support
Dixon	Solano	25%	1%	3%	115%	1	8%	Strong Adverse
Fairfield	Solano	3%	17%	40%	218%	2	26%	Moderate Support
Rio Vista	Solano	6%	66%	78%	187%	3	10%	Moderate Support
Suisun City	Solano	35%	63%	16%	164%	2	13%	Moderate Support
Vacaville	Solano	6%	77%	121%	89%	3	12%	Moderate Support
Vallejo	Solano	25%	26%	0%	97%	1	6%	Strong Adverse
Unincorporated Solano	Solano	0%	23%	0%	33%	0	18%	Strong Adverse
Cloverdale	Sonoma	64%	54%	85%	204%	4	21%	Strong Support
Cotati	Sonoma	41%	42%	30%	107%	3	15%	Moderate Support
Healdsburg	Sonoma	74%	107%	17%	105%	3	4%	Minimal
Petaluma	Sonoma	53%	53%	57%	132%	4	11%	Moderate Support

Target 2 Performance: Share of RHNA Allocation by Income Level for Bay Area Cities and Anticipated Growth in Plan Bay Area
Source: 1999-2014 RHNA and Plan Bay Area, 2013

Jurisdiction	**County**	**1999-2014 RHNA Performance - Share of RHNA Allocation Permitted**					**Plan Bay Area Growth 2015-2040**	**Target 2 Performance**
		Very Low	**Low**	**Moderate**	**Above Moderate**	**# of Income Categories Above 40%**		
Rohnert Park	Sonoma	41%	93%	63%	101%	4	19%	Moderate Support
Santa Rosa	Sonoma	30%	93%	86%	90%	3	21%	Strong Support
Sebastopol	Sonoma	41%	106%	36%	64%	3	11%	Moderate Support
Sonoma	Sonoma	69%	69%	37%	161%	3	6%	Minimal
Windsor	Sonoma	34%	57%	9%	142%	2	17%	Moderate Support
Unincorporated Sonoma	Sonoma	42%	36%	30%	85%	2	8%	Minimal

Target 5 Performance: Low Income Transit Ridership for Bay Area Operators
Source: MTC or Operator Survey, 2013-2016

Transit Operator	Share of Low Income Riders	Share of Regional Low Income Riders	Target 5 Performance
AC Transit	46%	15%	Strong Support
ACE	2%	0.0%	Minimal
BART**	21%	15%	Strong Support
Caltrain	9%	0.8%	Moderate Support
County Connection	31%	0.6%	Moderate Support
FAST**	33%	0.2%	Minimal
Golden Gate Transit (total)	15%	0.8%	Moderate Support
LAVTA	37%	0.3%	Minimal
Muni**	34%	46%	Strong Support
Napa Vine	38%	0.2%	Minimal
Petaluma	45%	0.1%	Strong Support
SamTrans	35%	3%	Minimal
Santa Rosa CityBus	52%	0.9%	Strong Support
SF Bay Ferry	4%	0.0%	Minimal
SolTrans	23%	0.4%	Minimal
Sonoma County	50%	0.4%	Strong Support
Tri-Delta	33%	0.6%	Moderate Support
Union City	36%	0.1%	Minimal
VTA**	55%	15%	Strong Support
WestCat**	32%	0.3%	Minimal
WETA	4%	0%	Minimal

**based on weekday ridership

Results are for weekday and weekend, except where noted.

Target 6 Performance: Share of RHNA Permitted for Very Low, Low, and Moderate Income Levels for Bay Area Cities
Source: 1999-2014 RHNA

Jurisdiction	County	1999-2014 Very Low + Low + Moderate RHNA Performance			Target 6 Performance
		RHNA Allocation	Permits Issued	Share Permitted	
Alameda	Alameda	2522	541	21%	Moderate Adverse
Albany	Alameda	333	251	75%	Strong Support
Berkeley	Alameda	2115	783	37%	Moderate Support
Dublin	Alameda	5174	1227	24%	Moderate Adverse
Emeryville	Alameda	1078	511	47%	Moderate Support
Fremont	Alameda	6640	1335	20%	Moderate Adverse
Hayward	Alameda	3623	1270	35%	Moderate Support
Livermore	Alameda	5141	1436	28%	Minimal
Newark	Alameda	1235	0	0%	Strong Adverse
Oakland	Alameda	12306	3144	26%	Minimal
Piedmont	Alameda	54	33	61%	Strong Support
Pleasanton	Alameda	4947	969	20%	Strong Adverse
San Leandro	Alameda	1426	1242	87%	Strong Support
Unincorporated Alameda	Alameda	5223	1070	20%	Moderate Adverse
Union City	Alameda	2418	550	23%	Moderate Adverse
Antioch	Contra Costa	3822	3623	95%	Strong Support
Brentwood	Contra Costa	3972	3205	81%	Strong Support
Clayton	Contra Costa	289	103	36%	Moderate Support
Concord	Contra Costa	2895	372	13%	Strong Adverse
Danville	Contra Costa	916	412	45%	Moderate Support
El Cerrito	Contra Costa	340	217	64%	Strong Support
Hercules	Contra Costa	648	257	40%	Moderate Support
Lafayette	Contra Costa	359	80	22%	Moderate Adverse
Martinez	Contra Costa	1334	52	4%	Strong Adverse
Moraga	Contra Costa	266	21	8%	Strong Adverse
Oakley	Contra Costa	1082	1819	168%	Strong Support
Orinda	Contra Costa	265	114	43%	Moderate Support
Pinole	Contra Costa	337	133	39%	Moderate Support

Target 6 Performance: Share of RHNA Permitted for Very Low, Low, and Moderate Income Levels for Bay Area Cities
Source: 1999-2014 RHNA

Jurisdiction	County	1999-2014 Very Low + Low + Moderate RHNA Performance			Target 6 Performance
		RHNA Allocation	Permits Issued	Share Permitted	
Pittsburg	Contra Costa	2367	2299	97%	Strong Support
Pleasant Hill	Contra Costa	754	408	54%	Strong Support
Richmond	Contra Costa	2639	1894	72%	Strong Support
San Pablo	Contra Costa	459	336	73%	Strong Support
San Ramon	Contra Costa	4584	2460	54%	Strong Support
Unincorporated Contra Costa	Contra Costa	5244	1097	21%	Moderate Adverse
Walnut Creek	Contra Costa	2034	548	27%	Minimal
Belvedere	Marin	17	11	65%	Strong Support
Corte Madera	Marin	244	98	40%	Moderate Support
Fairfax	Marin	92	5	5%	Strong Adverse
Larkspur	Marin	390	60	15%	Strong Adverse
Mill Valley	Marin	313	234	75%	Strong Support
Novato	Marin	2119	1523	72%	Strong Support
Ross	Marin	29	7	24%	Moderate Adverse
San Anselmo	Marin	150	28	19%	Strong Adverse
San Rafael	Marin	1971	558	28%	Minimal
Sausalito	Marin	212	50	24%	Moderate Adverse
Tiburon	Marin	156	10	6%	Strong Adverse
Unincorporated Marin	Marin	718	460	64%	Strong Support
American Canyon	Napa	1192	227	19%	Strong Adverse
Calistoga	Napa	162	43	27%	Minimal
Napa	Napa	3204	1386	43%	Moderate Support
St. Helena	Napa	163	68	42%	Moderate Support
Unincorporated Napa	Napa	1570	229	15%	Strong Adverse
Yountville	Napa	103	75	73%	Strong Support
San Francisco	San Francisco	31887	12600	40%	Moderate Support
Atherton	San Mateo	108	18	17%	Strong Adverse
Belmont	San Mateo	400	58	15%	Strong Adverse

Target 6 Performance: Share of RHNA Permitted for Very Low, Low, and Moderate Income Levels for Bay Area Cities
Source: 1999-2014 RHNA

Jurisdiction	County	1999-2014 Very Low + Low + Moderate RHNA Performance			Target 6 Performance
		RHNA Allocation	Permits Issued	Share Permitted	
Brisbane	San Mateo	496	22	4%	Strong Adverse
Burlingame	San Mateo	703	81	12%	Strong Adverse
Colma	San Mateo	85	73	86%	Strong Support
Daly City	San Mateo	1519	203	13%	Strong Adverse
East Palo Alto	San Mateo	1224	305	25%	Moderate Adverse
Foster City	San Mateo	600	192	32%	Moderate Support
Half Moon Bay	San Mateo	393	106	27%	Minimal
Hillsborough	San Mateo	81	128	158%	Strong Support
Menlo Park	San Mateo	1100	112	10%	Strong Adverse
Millbrae	San Mateo	453	23	5%	Strong Adverse
Pacifica	San Mateo	522	60	11%	Strong Adverse
Portola Valley	San Mateo	74	17	23%	Moderate Adverse
Redwood City	San Mateo	2534	384	15%	Strong Adverse
San Bruno	San Mateo	791	921	116%	Strong Support
San Carlos	San Mateo	537	22	4%	Strong Adverse
San Mateo	San Mateo	3175	584	18%	Strong Adverse
So. San Francisco	San Mateo	1724	421	24%	Moderate Adverse
Unincorporated San Mateo	San Mateo	1733	163	9%	Strong Adverse
Woodside	San Mateo	41	17	41%	Moderate Support
Campbell	Santa Clara	935	534	57%	Strong Support
Cupertino	Santa Clara	2067	254	12%	Strong Adverse
Gilroy	Santa Clara	3077	1105	36%	Moderate Support
Los Altos	Santa Clara	357	99	28%	Minimal
Los Altos Hills	Santa Clara	98	77	79%	Strong Support
Los Gatos	Santa Clara	580	150	26%	Minimal
Milpitas	Santa Clara	3746	1874	50%	Strong Support
Monte Sereno	Santa Clara	61	55	90%	Strong Support
Morgan Hill	Santa Clara	2110	1110	53%	Strong Support

Target 6 Performance: Share of RHNA Permitted for Very Low, Low, and Moderate Income Levels for Bay Area Cities
Source: 1999-2014 RHNA

Jurisdiction	County	1999-2014 Very Low + Low + Moderate RHNA Performance			Target 6 Performance
		RHNA Allocation	Permits Issued	Share Permitted	
Mountain View	Santa Clara	3467	520	15%	Strong Adverse
Palo Alto	Santa Clara	2598	771	30%	Minimal
San Jose	Santa Clara	34058	12033	35%	Moderate Support
Santa Clara	Santa Clara	6879	2144	31%	Moderate Support
Saratoga	Santa Clara	454	187	41%	Moderate Support
Sunnyvale	Santa Clara	4729	3824	81%	Strong Support
Unincorporated Santa Clara	Santa Clara	1811	1255	69%	Strong Support
Benicia	Solano	563	350	62%	Strong Support
Dixon	Solano	1302	138	11%	Strong Adverse
Fairfield	Solano	4416	913	21%	Moderate Adverse
Rio Vista	Solano	1485	701	47%	Moderate Support
Suisun City	Solano	946	330	35%	Moderate Support
Unincorporated Solano	Solano	1694	92	5%	Strong Adverse
Vacaville	Solano	4398	2987	68%	Strong Support
Vallejo	Solano	3634	586	16%	Strong Adverse
Cloverdale	Sonoma	487	343	70%	Strong Support
Cotati	Sonoma	490	180	37%	Moderate Support
Healdsburg	Sonoma	535	310	58%	Strong Support
Petaluma	Sonoma	1886	1029	55%	Strong Support
Rohnert Park	Sonoma	2143	1331	62%	Strong Support
Santa Rosa	Sonoma	8267	5533	67%	Strong Support
Sebastopol	Sonoma	257	141	55%	Strong Support
Sonoma	Sonoma	621	346	56%	Strong Support
Unincorporated Sonoma	Sonoma	4790	1723	36%	Moderate Support
Windsor	Sonoma	1686	481	29%	Minimal

Target 7 Performance: Share of Census Tracts with Displacement Risk for Bay Area Cities and Anticipated Growth in Plan Bay Area (2013)
Source: Urban Displacement Project, 2015; Plan Bay Area, 2013

Jurisdiction	County	Share of Tracts with Displacement Risk**	Plan Bay Area Growth	Target 7 Performance
Alameda	Alameda	81%	16%	Moderate Adverse
Albany	Alameda	100%	15%	Moderate Adverse
Berkeley	Alameda	73%	17%	Minimal
Dublin	Alameda	50%	45%	Moderate Adverse
Emeryville	Alameda	75%	71%	Moderate Adverse
Fremont	Alameda	23%	21%	Moderate Adverse
Hayward	Alameda	28%	23%	Moderate Adverse
Livermore	Alameda	28%	27%	Moderate Adverse
Newark	Alameda	0%	23%	Moderate Adverse
Oakland	Alameda	84%	28%	Strong Adverse
Piedmont	Alameda	50%	2%	Minimal
Pleasanton	Alameda	14%	22%	Moderate Adverse
San Leandro	Alameda	56%	20%	Moderate Adverse
Unincorporated Alameda	Alameda	50%	9%	Minimal
Union City	Alameda	20%	13%	Minimal
Antioch	Contra Costa	16%	14%	Minimal
Brentwood	Contra Costa	14%	11%	Minimal
Clayton	Contra Costa	0%	4%	Minimal
Concord	Contra Costa	30%	38%	Moderate Adverse
Danville	Contra Costa	0%	8%	Minimal
El Cerrito	Contra Costa	80%	11%	Moderate Adverse
Hercules	Contra Costa	17%	43%	Moderate Adverse
Lafayette	Contra Costa	40%	13%	Minimal
Martinez	Contra Costa	67%	8%	Minimal
Moraga	Contra Costa	50%	12%	Minimal
Oakley	Contra Costa	0%	41%	Moderate Adverse
Orinda	Contra Costa	0%	10%	Minimal

Target 7 Performance: Share of Census Tracts with Displacement Risk for Bay Area Cities and Anticipated Growth in Plan Bay Area (2013)
Source: Urban Displacement Project, 2015; Plan Bay Area, 2013

Jurisdiction	County	Share of Tracts with Displacement Risk**	Plan Bay Area Growth	Target 7 Performance
Pinole	Contra Costa	33%	14%	Minimal
Pittsburg	Contra Costa	38%	31%	Moderate Adverse
Pleasant Hill	Contra Costa	33%	8%	Minimal
Richmond	Contra Costa	65%	24%	Moderate Adverse
San Pablo	Contra Costa	17%	19%	Minimal
San Ramon	Contra Costa	0%	17%	Minimal
Unincorporated Contra Costa	Contra Costa	37%	8%	Minimal
Walnut Creek	Contra Costa	60%	21%	Moderate Adverse
Belvedere	Marin	0%	2%	Minimal
Corte Madera	Marin	50%	6%	Minimal
Fairfax	Marin	100%	6%	Moderate Adverse
Larkspur	Marin	50%	6%	Minimal
Mill Valley	Marin	33%	6%	Minimal
Novato	Marin	30%	5%	Minimal
Ross	Marin	0%	6%	Minimal
San Anselmo	Marin	67%	5%	Minimal
San Rafael	Marin	27%	13%	Minimal
Sausalito	Marin	0%	6%	Minimal
Tiburon	Marin	0%	6%	Minimal
Unincorporated Marin	Marin	19%	4%	Minimal
American Canyon	Napa	0%	28%	Moderate Adverse
Calistoga	Napa	100%	2%	Moderate Adverse
Napa	Napa	45%	11%	Minimal
St. Helena	Napa	50%	2%	Minimal
Unincorporated Napa	Napa	33%	7%	Minimal
Yountville	Napa	100%	2%	Moderate Adverse
San Francisco	San Francisco	88%	23%	Strong Adverse

Target 7 Performance: Share of Census Tracts with Displacement Risk for Bay Area Cities and Anticipated Growth in Plan Bay Area (2013)
Source: Urban Displacement Project, 2015; Plan Bay Area, 2013

Jurisdiction	**County**	**Share of Tracts with Displacement Risk****	**Plan Bay Area Growth**	**Target 7 Performance**
Atherton	San Mateo	0%	9%	Minimal
Belmont	San Mateo	60%	9%	Minimal
Brisbane	San Mateo	100%	12%	Moderate Adverse
Burlingame	San Mateo	100%	25%	Strong Adverse
Colma	San Mateo	100%	46%	Strong Adverse
Daly City	San Mateo	61%	12%	Minimal
East Palo Alto	San Mateo	50%	9%	Minimal
Foster City	San Mateo	0%	7%	Minimal
Half Moon Bay	San Mateo	0%	6%	Minimal
Hillsborough	San Mateo	100%	7%	Moderate Adverse
Menlo Park	San Mateo	75%	14%	Minimal
Millbrae	San Mateo	67%	30%	Moderate Adverse
Pacifica	San Mateo	38%	4%	Minimal
Portola Valley	San Mateo	0%	7%	Minimal
Redwood City	San Mateo	53%	25%	Moderate Adverse
San Bruno	San Mateo	44%	24%	Moderate Adverse
San Carlos	San Mateo	44%	13%	Minimal
San Mateo	San Mateo	58%	22%	Moderate Adverse
So. San Francisco	San Mateo	100%	26%	Strong Adverse
Unincorporated San Mateo	San Mateo	50%	19%	Minimal
Woodside	San Mateo	0%	5%	Minimal
Campbell	Santa Clara	29%	15%	Minimal
Cupertino	Santa Clara	17%	16%	Minimal
Gilroy	Santa Clara	25%	16%	Minimal
Los Altos	Santa Clara	43%	9%	Minimal
Los Altos Hills	Santa Clara	50%	5%	Minimal
Los Gatos	Santa Clara	56%	6%	Minimal
Milpitas	Santa Clara	13%	49%	Moderate Adverse

Target 7 Performance: Share of Census Tracts with Displacement Risk for Bay Area Cities and Anticipated Growth in Plan Bay Area (2013)
Source: Urban Displacement Project, 2015; Plan Bay Area, 2013

Jurisdiction	County	Share of Tracts with Displacement Risk**	Plan Bay Area Growth	Target 7 Performance
Monte Sereno	Santa Clara	0%	6%	Minimal
Morgan Hill	Santa Clara	44%	25%	Moderate Adverse
Mountain View	Santa Clara	58%	24%	Moderate Adverse
Palo Alto	Santa Clara	67%	22%	Moderate Adverse
San Jose	Santa Clara	32%	34%	Moderate Adverse
Santa Clara	Santa Clara	39%	26%	Moderate Adverse
Saratoga	Santa Clara	17%	5%	Minimal
Sunnyvale	Santa Clara	63%	29%	Moderate Adverse
Unincorporated Santa Clara	Santa Clara	29%	9%	Minimal
Benicia	Solano	14%	11%	Minimal
Dixon	Solano	67%	8%	Minimal
Fairfield	Solano	19%	26%	Moderate Adverse
Rio Vista	Solano	100%	10%	Moderate Adverse
Suisun City	Solano	0%	13%	Minimal
Unincorporated Solano	Solano	0%	18%	Minimal
Vacaville	Solano	45%	12%	Minimal
Vallejo	Solano	29%	6%	Minimal
Cloverdale	Sonoma	0%	21%	Moderate Adverse
Cotati	Sonoma	50%	15%	Minimal
Healdsburg	Sonoma	100%	4%	Moderate Adverse
Petaluma	Sonoma	38%	11%	Minimal
Rohnert Park	Sonoma	11%	19%	Minimal
Santa Rosa	Sonoma	44%	21%	Moderate Adverse
Sebastopol	Sonoma	100%	11%	Moderate Adverse
Sonoma	Sonoma	67%	6%	Minimal
Unincorporated Sonoma	Sonoma	24%	8%	Minimal
Windsor	Sonoma	33%	17%	Minimal

**based on the following typologies: At risk of gentrification or displacement, undergoing displacement, and advanced gentrification for lower income and moderate to high income tracts

Appendix B: Benefit Valuations

	Benefit	Valuation ($2017)	What does this valuation represent?
Travel Time and Reliability	In-Vehicle Travel Time per Person Hour of Travel	$12.66	In-vehicle travel time for auto and transit users is set at 50% of the median regional wage rate ($25.32).[7] The valuation represents the discomfort to travelers of enduring transportation-related delay and the loss in regional productivity for on-the-clock travelers and commuters.
	Transit Out-of-Vehicle Travel Time per Person Hour of Travel	$27.85	This value is equal to 2.2 times the valuation of in-vehicle travel time.[8] 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.
	Freight/Truck In-Vehicle Travel Time per Vehicle Hour of Travel	$33.69	The valuation is the total hourly compensation paid to truck drivers. This valuation represents the labor cost of transporting goods on the roadway network,[9] multiplied by a total compensation factor to estimate the total compensation cost.[10]
	Auto Travel Time Reliability per Person Hour of Non-recurring Delay	$12.66	The value is set equal to the value of in-vehicle travel time for autos. The valuation represents the additional traveler frustration of experiencing non-expected incident related travel delays.
	Freight/Truck Travel Time Reliability per Vehicle Hour of Non-recurring Delay	$33.69	The value is set equal to the value of in-vehicle travel time for trucks. The valuation represents the additional loss of regional productivity due to experiencing non-expected incident related travel delays.
Safety	Fatality Collisions (per fatality)	$10.8 million	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.[11]
	Injury Collisions (per injury)	$124,000	The valuation includes the internal costs to an individual (and their family) resulting from the injury, as well as the external societal costs.[12]
	Property Damage Only Collision (per incident)	$4,590	The valuation includes the internal costs to a property damage collision victim (and their family) resulting from the time required to deal with the

[7] Valuation source: Plan Bay Area 2013, guidance from USDOT and Caltrans. Median wage is for the San Francisco-Oakland-Fremont MSA ($23.72), from the Bureau of Labor Statistics 2014 Metropolitan Area Occupational Employment and Wage and uprated to 2017 using a 2.2% expansion rate.

[8] Valuation source: FHWA Surface Transportation Economic Analysis Model (STEAM).

[9] Source: FHWA Highway Economic Requirements System. The wage value used is the weighted average of the mean wage rates for light and heavy truck drivers in the San Francisco-Oakland-Fremont MSA ($20.61), adjusted with a 2.2% escalation rate between 2014 and 2017.

[10] The total compensation factor is the national average total compensation divided by the national average wages, from the Bureau of Labor Statistics 2014 Employer Costs of Employee Compensation survey.

[11] Source: NHTSA May 2015 revision to The Economic and Societal Impact of Motor Vehicle Crashes

[12] See note 11.

	Benefit	Valuation ($2017)	What does this valuation represent?
			collision, as well as the external societal costs from this loss of time. [13]
GHG Emissions	CO_2 per Metric Ton	$100	This valuation represents the full global social cost of an incremental unit (metric ton) of CO_2 emission from the time of production to the damage it imposes over the whole of its time in the atmosphere.[14]
Air Quality	Diesel $PM_{2.5}$ per Ton	$665,400	These valuations represent the negative health effects of increased emissions including[15] loss of productivity, direct medical costs, pain and anxiety that result from adverse effects, loss of enjoyment time, and adverse effects on others due to health impacts.
	Direct $PM_{2.5}$ per Ton	$658,800	
	NO_x per Ton	$6,000	
	Acetaldehyde per Ton	$5,100	
	Benzene per Ton	$15,200	
	1,3-Butadiene per Ton	$42,600	
	Formaldehyde per Ton	$5,900	
	All Other ROG per Ton	$4,300	
	SO_2 per Ton	$22,200	
Operating, Parking and Ownership Costs	Auto Operating Costs per Auto Mile Traveled	$0.3072	This valuation represents the variable costs (per mile) of operating a vehicle, including fuel, maintenance, depreciation (mileage), and tires. Fuel costs and efficiencies reflect 2040 forecasts.[16]
	Truck Operating Costs per Truck Mile Traveled	$0.8795	
	Parking Costs per Auto Trip	Model Output	This valuation is consistent with parking cost estimation in Travel Model One.
	Auto Ownership Costs per Vehicle (change in the number of autos)	$3,920	This valuation represents the annual ownership costs of vehicles, beyond the per mile operating costs. This valuation includes purchase/lease costs, maintenance, and finance charges.[17]
Health	Costs of Physical Inactivity: Morbidity and Productivity, per Active Adult	$1,341	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).[18]

[13] See note 11

[14] Source: Interagency Working Group on Social Cost of Carbon and using the 2040 cost at a 2.5% discount rate, adjusted to 2017 dollars.

[15] Source: BAAQGM Multi-Pollution Evaluation Method (MPEM

[16] Source: 2014 California High Speed Rail Benefit-Cost Analysis.

[17] Source: 2011-2012 Consumer Expenditure Survey (Bureau of Labor Statistics, 2014).

[18] Source: "The Economic Costs of Overweight, Obesity, and Physical Inactivity Among California Adults", California Center for Public Health Advocacy/Chenweth and Associates, 2006,

	Benefit	Valuation ($2017)	What does this valuation represent?
	Costs of Physical Inactivity: Mortality, per Life Saved	$10.8 million	The value of life estimation from the fatality benefit is used again to determine the value of reducing life-threatening disease by becoming more active.[19]
Noise	Noise per Auto Mile Traveled	$0.0013	This valuation represents the property value decreases and societal cost of noise abatement.[20]
	Noise per Truck Mile Traveled	$0.0170	

[19] Source: World Health Organization's Health Economic Assessment Tool, available online: http://www.heatwalkingcycling.org/

[20] Source: May 2000 addendum to the FHWA federal Cost Allocation report.

Appendix C: State of Good Repair Performance Assessment – Objectives and Methodology

Assessment Objectives

In order to integrate state of good repair and to allow it to be assessed on a level playing field with other investments, MTC staff developed and implemented new methodologies for evaluating roads and public transit maintenance. By quantifying the effects of asset condition on system users, these investments were analyzed for their cost-effectiveness and their support of regional performance targets, just like a traditional expansion project, using the regional travel demand model. The ultimate objective was to have “apples to apples” performance results, meaning that the scores could be easily compared between project performance and state of good repair performance to inform key policy decisions.

By evaluating state of good repair investments in the same manner as expansion and efficiency projects, staff sought to provide additional information for policymakers to address the following questions:

- How does system maintenance perform relative to expansion and efficiency investments – both in terms of cost-effectiveness and targets support?
- Within the realm of state of good repair, what differences exist between modes and operators when it comes to cost-effectiveness and targets support?
- Are certain state of good repair investments high-performing, and if so, should they be eligible for regional discretionary dollars?
- Are certain state of good repair investments low-performing, and if so, is there a compelling case for funding these investments regardless of this status?

Approach

As the state of good repair performance assessment is designed to complement both the existing project performance and needs assessments, it builds off of the existing frameworks used in prior Plans. Like the project performance assessment, state of good repair performance was evaluated based on two primary scores:

- **Benefit-cost ratio**. By exploring how asset conditions (forecasted by StreetSaver and TERM- Lite) affect system operations, Travel Model One simulates how system users respond to improved or degraded infrastructure. These benefits are monetized and compared to the costs of SGR investments as part of a benefit-cost assessment. For more information on the benefit-cost tool, COBRA, see this website: https://github.com/MetropolitanTransportationCommission/travel-model-one/tree/master/utilities/PBA40/metrics
- **Targets score.** State of good repair investments can also be evaluated qualitatively against performance targets in the same manner as expansion projects. This is consistent with the approach taken in Plan Bay Area, albeit with the new Plan Bay Area 2040 targets.
- **Other supplemental data.** Several supplemental assessments being conducted for the project performance assessment will also be made available for state of good repair, including an examination of equity impacts, a confidence assessment of benefit-cost results, and sensitivity testing of the final results.

Given the thousands of assets that need to be replaced over the course of the Plan cycle, it was not possible to conduct a performance assessment of each asset individually. Instead, MTC assessed performance at a modal and system level, looking at the impacts of different funding levels on operations and ultimately system users. For pavement maintenance on local streets and state highways, benefit-cost ratios and targets scores were produced for the following scenarios:

- For local streets and roads: Preservation of existing conditions vs. system degradation
- For local streets and roads: Preservation of existing conditions vs. local funding only
- For state highways: Preservation of existing conditions vs. system degradation
- For state highways: Achievement of ideal conditions vs. preservation of existing conditions

Benefit-Cost Methodology for Local Streets and Roads and State Highways

In the case of local streets & roads and state highways, it is important to note that the methodology focuses specifically on the benefits and costs for pavement preservation and does not address non-pavement assets. This is due to the fact that sufficient literature exists on the user benefits associated with pavement preservation, while benefits of non-pavement assets may be more difficult to quantify. That said, preserving pavements in the San Francisco Bay Area costs billions of dollars over the Plan lifecycle, playing a primary role in local streets and state highway needs over the coming decades. For the sake of simplicity, the term "road maintenance" in this document refers specifically to the pavement on the roads in question.

While the methodology has been finalized for this iteration of the Plan, future efforts could enhance and expand on this work to provide even more refined results. Further discussion of research opportunities in this area will be included in a document slated for release later this year.

Step 1: Forecast year 2040 pavement conditions by city and facility type using StreetSaver.

1. Before analyzing a given scenario for road state of good repair, it is necessary to identify the following characteristics:
    a. Geographic scope[21]
    b. Facility type(s)[22]
    c. Funding prioritization strategy[23]
    d. Horizon year for analysis[24]
2. A state of good repair scenario compares conditions and impacts to users and society for two different funding levels. Before running StreetSaver, it is necessary to identify:
    a. Baseline funding level for pavement preservation[25] or baseline PCI target
    b. "With-project"[26] funding level for pavement preservation or "with-project" PCI target

[21] For the purposes of this work, analysis was performed on the regional level. However, it would be possible to use this methodology to analyze benefits on a county or city level as well.
[22] For the purposes of this work, analysis was performed for the entire local streets and roads system and for the entire state highway system. However, it would be possible to use this methodology to study arterials in isolation, for example.
[23] Weighting factors for arterials, collectors, and residential streets in StreetSaver
[24] For the purposes of this work, the Plan has a horizon year of 2040.
[25] Regional funding for pavement preservation directed towards the geography and facilities in question
[26] Higher level of funding being analyzed in comparison to baseline

3. StreetSaver also requires an inventory or dataset of street conditions in the baseline year as a foundation for forecasting pavement conditions in a future year:
    a. For local streets and roads: this data is readily available for all jurisdictions in the San Francisco Bay Area via StreetSaver itself.[27]
    b. For state highways: Caltrans develops an inventory of pavement conditions every few years that can be converted into StreetSaver using the IRI[28]-to-PCI conversion formula discussed later this in document[29].
4. Run MTC's StreetSaver asset management model[30] to forecast pavement conditions in the horizon year for both the baseline and "with project" funding levels using the parameters identified above. If a PCI target seek forms the basis of this scenario instead of funding levels, run StreetSaver in that mode instead. (Note that this approach is consistent with the needs assessment process for Plan Bay Area 2040.)
    a. For each local streets and roads scenario, request that StreetSaver output pavement conditions by jurisdiction, facility type, and PCI bin in terms of lane-mileage.[31]
        i. Jurisdictions: 101 cities, 8 counties
        ii. Facility types: arterials, collectors, residential/local streets, other
        iii. PCI bins[32]: 25 or less, 26 to 30, 31 to 35, 36 to 40, 41 to 45, 46 to 50, 51 to 60, 61 or greater
    b. For each state highway scenario, request that StreetSaver output pavement conditions for three bins commonly used by Caltrans: good (IRI of 1 to 94), fair (IRI of 95 to 170), and poor (IRI greater than 170).[33] Unlike local streets, the state highway system was analyzed on the regional, rather than jurisdictional, level due to the coarseness of the Caltrans data.

Step 2: Convert pavement conditions into operational impacts for roadway users.

Note to readers: *In benefit-cost analysis, it is important to clearly delineate benefits to users and to society and costs to the system operator without double-counting any metrics in the process. For a more detailed explanation of the inclusion or exclusion of certain benefits, and an overarching literature*

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[27] This analysis relied on the inventories as of late 2015, the most recent available at the time the analysis began.

[28] IRI stands for the International Roughness Index, an alternative measure of pavement conditions.

[29] This analysis relied on the latest iteration of that Caltrans dataset produced in late 2013.

[30] StreetSaver leverages inventories of local streets and state highways with pavement condition index (PCI) data for each segment. Note that PCI ranges from 0 to 100; higher index scores mean that roads are in better condition. StreetSaver operates using the principles of life-cycle cost assessment described above to maximize the cost effectiveness of pavement investments, factoring in the higher costs of repair as a result of deferred maintenance and mimicking the decision choices of pavement management professionals across the region. Funding level and prioritization inputs to StreetSaver affect its decisions about which pavements should get specific treatments, as it seeks to maximize pavement condition over time given resource constraints. In addition to being able to run StreetSaver with a given funding level, it can be run to seek to achieve a PCI and report back the funding level required.

[31] As there is not a one-for-one relationship between street segments in StreetSaver and Travel Model One, it is necessary to do some level of aggregation for local streets and state highways. Future upgrades to both tools will make it possible to link them directly on every street segment.

[32] As defined by MTC's StreetSaver team to provide more refined information between PCI of 25 and PCI of 60.

[33] These bins were designed to maximize consistency with Caltrans' historical reporting of pavement condition by district. As such, conditions and impacts for the state highway network are not geographically specific in the way local streets and roads are.

review, please refer to Paterson and Vautin (2015) in the TRB 94th Annual Meeting Compendium of Papers.[34]

1. Summarize cost outputs from the StreetSaver files for use in Step 4 below. Note that road maintenance costs to system operators – the basis for the cost side of the benefit-cost ratio – are relatively straightforward thanks to StreetSaver; they represent the difference between the two funding levels for the scenario in question, as the region's transportation agencies will be expending these dollars.[35]
2. In order to calculate benefits, it is necessary to focus on the impacts to system users and to society. Timely maintenance is known to reduce treatment costs over time, yielding greater marginal benefits by reducing deferred maintenance.[36] Travel Model One is used to forecast these benefits based on the operational impacts expected on roads across the network[37]. In the case of road maintenance, there are two primary direct[38]operational impacts demonstrated and quantified in literature[39]: **vehicle maintenance and repair costs** (for automobiles, trucks and buses) and **vehicle fuel costs** (for automobiles, trucks and buses).[40] Benefits derived from these operational impacts are calculated in Step 3 below and include time, cost, emissions, health, and safety impacts (among others)[41].
    a. Load the local streets and/or state highway StreetSaver output tables into the Operational Impact Calculator (OIC)[42]. OIC automatically calculates the share of lane-mileage in each jurisdiction and facility type combination that falls into each PCI bin.
    b. Given that StreetSaver outputs lane-mileage by jurisdiction, by facility type, and by PCI bin, and that Travel Model One requires vehicle operator costs by jurisdiction and by facility type, OIC makes the conversion to connect the two models, starting with a PCI to IRI conversion using a formula developed by Park, Thomas, and Lee.[43] While StreetSaver does not include data on segment IRI due to the unreliability of IRI data collection on lower-speed facilities, it is possible to estimate IRI based on observed PCI as shown

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[34] See URL: http://trid.trb.org/view.aspx?id=1336990
[35] Funding levels can be either inputs or outputs of StreetSaver in Step 1B.
[36] While a lower level of pavement preservation funding may reduce the cost side of the B/C ratio, it will also worsen pavement conditions and thus reduce the benefit side of the ratio as well – capturing the adverse impacts of deferred maintenance (as the remaining dollars will stretched even thinner).
[37] Travel Model One, and the overall assessment framework, is focused on long-term benefits and disbenefits and does not incorporate the positive and negative impacts associated with construction activities.
[38] Expansion project example: faster travel time from a bus frequency boost; state of good repair project example: educed fuel costs from pavement preservation funding
[39] Refer to the TRB paper cited above for additional discussion on this particular topic.
[40] Several other smaller-scale benefits may exist but lack a quantifiable link between pavement condition and operational impacts. Both are related to non-motorized users – bicycle maintenance costs may increase as pavement condition worsens, and non-motorized users may be particularly susceptible to safety hazards as pavement conditions worsens. Additional research efforts could address these limitations and quantify these expected links. Other often-cited operational impacts are weak at best – air quality and travel time impacts from pavement condition are likely small or negligible, especially when compared to indirect effects from induced demand.
[41] More information on this can be found in the upcoming Plan Bay Area 2040 Performance Assessment Report, as well as the materials provided to the Performance Working Group.
[42] Spreadsheet tool developed by MTC to link StreetSaver and Travel Model One using national research as described below.
[43] Park, K., N. Thomas, and K. Lee. *Applicability of the International Roughness Index as a Predictor of Asphalt Pavement Condition*, 2007. Published in the *Journal of Transportation Engineering*.

below.[44] This calculation is not necessary for highway data, as it was converted to IRI under Step 1.

$$PCI = 100(IRI)^{-0.436}$$

c. Next, maintenance cost adjustment factors and fuel cost adjustment factors are calculated by OIC using NHCRP Report 720 formulas. For each PCI bin, the IRI upper bound is used to calculate the maximum percent increase in maintenance and fuel costs for each vehicle type (auto, small truck, heavy truck, and bus[45]) compared to ideal conditions. Given that speed limit data is unavailable for every road in the region, and many roads have congested speeds lower than their posted limits, local roads were assumed to have an average speed of 35 mph while state highways were assumed to have an average speed of 55 mph.[46]
d. Finally, for each jurisdiction, facility type, and vehicle type, OIC calculates weighted average adjustment factors were calculated based on the share of roads in each PCI bin. OIC's final output is a series of maintenance cost adjustment factors and fuel cost adjustment factors which can be applied across all roads of a given facility type in a given jurisdiction, specific to each vehicle type discussed above.

Step 3: Run Travel Model One using operational impacts to explore benefits & disbenefits.

1. Convert the output matrices from the two operational impact spreadsheets into a Cube-readable format.[47]
    a. For local streets and roads: update Matrix A, which reflects each jurisdiction's adjustment factors in a machine-readable line with its Travel Model One "cityname" field. Unincorporated areas are flagged with a -1 variable, triggering the model to apply the unincorporated county adjustment factors instead. The matrix can then be handed off to the modeling team.
    b. For state highways: update scalar B, which reflects the adjustment factors applied across the entire state highway network. These inputs are then translated into script text that can be handed off to the modeling team.

2. Run Travel Model One twice: once with baseline conditions and once with "with project" conditions to evaluate how travelers respond to changing asset conditions. While additional information on the model can be found in Travel Model One documentation[48], a rough and high-level summary of how the model applies the adjustment factors and associated costs for maintenance & fuel can be found below:
    a. The adjustment factor matrices are multiplied by the ideal maintenance costs and ideal fuel costs per mile; these values are then summed to create a vehicle operating cost for each jurisdiction, facility type, and vehicle type combination.

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[44] Note that IRI in the formula above is output in meters per kilometer; IRI data from StreetSaver is output in inches per mile and then converted accordingly.
[45] Vehicle types from NHCRP 720 were correlated with MTC vehicle types as follows: auto = medium car, small truck = light truck, heavy truck = articulated truck, bus = heavy bus.
[46] To better reflect operating impacts on highly degraded streets, maintenance cost adjustment factors were capped between 2.0 and 3.0 (depending on vehicle class) and fuel cost adjustment factors were capped between 1.05 and 1.13 (depending on vehicle class).
[47] Cube is the travel model software used by Travel Model One for network coding.
[48] For more information: http://mtcgis.mtc.ca.gov/foswiki/Main/UsersGuide

b. Every link on the network is assigned specific attributes; one set of these attributes is the operating cost per mile for each vehicle type traversing the network. The operating cost attributes in the matrix above are assigned to the geography or jurisdiction in question. For example, all of the arterials in city X would be assigned four attributes, one for each vehicle type on the network.
c. The model then begins to simulate how travelers respond to the various vehicle operating costs on the links they decide to traverse, generating impacts to those travelers but also influencing their decisions. This approach is similar to what is done for expansion projects, insofar that new conditions are loaded on the network and benefits/disbenefits are a result of the input conditions.
d. Metrics calculated by Travel Model One are produced for the two runs, including the inputs to the COBRA benefit-cost script.

Step 4: Calculate benefit-cost ratio using Travel Model One outputs and funding levels from StreetSaver.

1. First, calculate the costs by subtracting the 24-year baseline StreetSaver treatment costs[49] from the "with-project" treatment costs. In order to compare to the annualized benefit, divide by 24 to calculate the expenditures in a single year.
2. Second, calculate the benefits by running the COBRA benefit-cost script using the Travel Model One output CSV files. The benefits associated with the scenario are calculated by COBRA using standard benefit monetizations[50] applied to all projects evaluated for Plan Bay Area 2040, which compares the "with-project" and baseline conditions.
3. Finally, COBRA outputs the benefit-cost ratio by dividing the annualized benefits by the annualized costs. The result is a B/C ratio that reflects the benefits to users and society from increasing maintenance funding as defined in the scenario.

Benefit-Cost Methodology for Transit

This section provides additional detail on the Plan Bay Area 2040 methodology used for the state of good repair benefit-cost assessments of public transit. In short, the methodology is designed to link the TERM-Lite asset management model[51] used for the needs assessment purposes to Travel Model One (the regional travel demand model used for performance assessment purposes). The end result is an "apples to apples" benefit-cost ratio that allows for the comparison of expansion and maintenance across modes based on impacts to system users and society at large.

In the case of public transit, it is important to note that the methodology focuses on operational impacts of asset condition – i.e., slow zones, stoppages, etc. – and how those impacts benefit or disbenefit existing and potential riders. Because safety is priority #1, it is assumed that operators would stop or delay service rather than risking harm to passengers. These sorts of time impacts – either from asset failures or from shutdowns or slowdowns associated with safety – have been quantified via significant research on the national and regional levels. However, improved asset condition may also affect the perception of a given mode – i.e., cleaner seats on new buses or brighter platforms at new/refreshed

[49] Adjusted to year 2017 dollars using a 2.2% inflation rate.
[50] Benefit categories include: travel time, non-transfer user cost, public health, air pollutants, greenhouse gas emissions, noise, etc.
[51] For more information on TERM-Lite, refer to the Federal Transit Administration's website: http://www.fta.dot.gov/13248_13251.html.

rail stations. Due to a lack of data on these types of aesthetic or non-operational impacts, the transit state of good repair analysis focuses primarily on assets with direct operational impacts, while recognizing that there may be smaller secondary benefits that cannot be easily quantified or monetized. Future efforts could enhance and expand on this work to provide even more refined results.

Step 1: Forecast year 2040 transit asset ages for a given operator(s) using TERM-Lite.

1. Before analyzing a given scenario for transit state of good repair, it is necessary to identify the following characteristics:
    a. Agency + mode combination(s) subject to analysis[52]
    b. Asset categories subject to analysis[53]
    c. Funding prioritization strategy[54]
    d. Horizon year for analysis[55]

2. A state of good repair scenario compares conditions and impacts to users and society for two different funding levels. Before running TERM-Lite, it is necessary to identify:
    a. Baseline funding level for transit asset preservation[56] or baseline PAOUL[57] target[58]
    b. “With-project”[59] funding level for transit asset preservation or “with-project” PAOUL target

3. TERM-Lite also requires an inventory or dataset of transit assets in the baseline year as a foundation for forecasting pavement conditions in a future year, generally collected every four years by MTC[60].

4. Run the TERM-Lite asset management model to forecast asset ages in the horizon year[61] for both the baseline and “with project” funding levels using the parameters identified above. If a PAOUL target seek (such as preserve current PAOUL or zero PAOUL) forms the basis of this scenario instead of funding levels, run TERM-Lite in that mode instead. (Note that this approach is generally consistent with the needs assessment process for Plan Bay Area 2040.)

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[52] For the purposes of this work, analysis was performed for each of the region’s seven major operators by bus and rail (when applicable) as well as the remaining small operators as a group. No national or regional methodology is currently available for ferries, meaning that ferries were not analyzed in this analysis; future work could involve regression analysis to identify coefficients for a ferry mode.
[53] For the purposes of this work, analysis was performed for the system as a whole, rather than calculating a benefit-cost ratio specifically for vehicle replacement (for example). However, the methodology could be used for that type of task in the future.
[54] For the purposes of this work, funding was prioritized using the same approach as the needs assessment – 90% based on the TCP score and 10% based on condition.
[55] For the purposes of this work, the Plan has a horizon year of 2040.
[56] Regional funding for transit asset preservation directed towards the operator and system in question
[57] PAOUL stands for the percent of transit assets past their useful lives – i.e., share of aged assets.
[58] When run in target mode that seeks to reduce the backlog, TERM-Lite needs to know the year by which the target needs to be achieved (and preserved thereafter). For this analysis, a year 10 assumption for target achievement is provided as an input in line with the Needs Assessment work.
[59] Higher level of funding being analyzed in comparison to baseline
[60] Refer to the Plan Bay Area 2040 Needs Assessment work for more information on this process.
[61] To minimize noise from asset replacement in the horizon year dataset, a five-year average age (with the horizon year as its midpoint) for each asset is output by TERM-Lite.

5. For each public transit scenario, request the following TERM-Lite output values for every asset in the relevant inventory:
    - Basic Information
        - TRS ID – transit operator ID code
        - Transit System – name of system
        - Asset Type Code – five-digit code identifying category & element across operator
        - Category, Sub-Category, Element, Sub-Element – associated text data for validation purposes
        - Operational Flag – binary variable identifying the asset has operational impacts[62]
    - Age Data
        - Useful Life
        - Date Built
        - Age – five-year average age in horizon year[63]
    - Quantity and Valuation Data
        - Quantity[64]
        - Units[65]
        - Valuation – value of the asset(s) in question
        - Investment Costs by Year – stream of rehabilitation and replacement costs by year for a given asset(s)

Step 2: Convert asset ages into failure rates and associated delays from vehicle and non-vehicle assets.

Note to readers: *In benefit-cost analysis, it is important to clearly delineate benefits to users and to society and costs to the system operator without double-counting any metrics in the process. For a more detailed explanation of the inclusion or exclusion of certain benefits, and an overarching literature review, please refer to Paterson and Vautin (2015) in the TRB 94th Annual Meeting Compendium of Papers[66] and the Journal of Public Transportation.[67]*

1. Begin this part of the process as a new iteration of the Operational Impact Calculator (OIC) for public transit state of good repair.[68] OIC takes the TERM-Lite customized outputs as input and calculates the delays for each transit system, which can be then input into Travel Model One for simulation.

[62] As defined by later formulas and data tables developed from TCRP Report 157.
[63] Five-year average age is used to minimize "lumpiness" from asset replacement cycles, especially in small operators; those operators are more likely to replace all of their vehicles at once, rather than on a rolling basis. This improves the accuracy of the future year forecast, especially given the horizon year approach. The five-year average is calculated using 2040 as the midpoint.
[64] Technically relies on AdjustedQNTY variable from TERM-Lite.
[65] For example, feet or miles of track – this variable is essential for later conversions to standardize across systems.
[66] See URL: http://docs.trb.org/prp/15-1207.pdf.
[67] See URL: http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1445&context=jpt.
[68] Spreadsheet tool developed by MTC to link TERM-Lite and Travel Model One using the formulas and methodologies highlighted below.

2. Gather key data inputs from the FTA National Transit Database[69] required for use of Transit Cooperative Research Program (TCRP) Report 157[70] by operator and by mode to establish baseline year conditions:
    a. Annual revenue vehicle miles
    b. Number of revenue vehicles[71]
    c. Major and minor vehicle failures per year
    d. Fuel consumption and fuel type[72]

3. Gather key data inputs from past Travel Model One (TMO) forecasts[73] by operator and by mode to establish baseline year and forecast year system-level conditions:
    a. Typical weekday passenger-miles
    b. Typical weekday revenue vehicle miles
    c. Typical weekday boardings
    d. Weighted-average[74] weekday headway[75]
    e. Weighted-average route length
    f. Fuel prices[76]

4. Calculate a series of key calibration values based on the NTD and TMO data above:
    a. Boardings per mile[77]
    b. Average vehicle loading[78]
    c. Average mileage on an individual vehicle[79]
    d. Average number of lines using a given segment of track or guideway[80]

5. Gather data from regional transit operators how they would respond to failures of different types of non-vehicle assets (due to the lack of failure formulas in national literature and the system-specific differences that exist across the United States). Key variables include whether the typical failure of a given asset[81]:

[69] NTD data is available online at: http://www.ntdprogram.gov/ntdprogram/.
[70] See URL: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_157.pdf.
[71] Used primarily to calculate consistent NTD rates below; RTCI asset inventory is primary source for this data when calculating impacts.
[72] Fuel consumption, type, and price data is used later in the analysis; however, for the sake of brevity, the data collection process is shown here instead.
[73] For the purposes of this analysis, model runs from the adopted Plan Bay Area (2013) were used to establish consistent historical and forecast data by operator.
[74] Weighted average is used to account for the fact that some lines on a given system are used more heavily than others; the weighted average headway reflects the user experience (passenger-mileage as weighting factor) while the weighted average route length reflects the bus or rail operator experience (vehicle-mileage as weighting factor).
[75] For rail operators with complex stopping patterns (such as Caltrain), slight adjustments were made to headways to better correspond to the user experience.
[76] In addition to Travel Model One data for gasoline prices, CNG and diesel prices were calculated using data from the Department of Energy.
[77] Calculated as typical weekday boardings divided by typical weekday revenue vehicle-miles.
[78] Calculated as typical weekday passenger-miles divided by typical weekday.
[79] Calculated as annual revenue vehicle miles divided by the number of revenue vehicles.
[80] Only for fixed-guideway systems.
[81] A data table of the merged and standardized failure operational impacts across operators is available by request.

a. Affects one or both directions of service?[82]
b. Causes a slow zone or a stoppage?[83]
c. Generates how many minutes of delay for the average rider?[84]
d. Requires how many hours for repair under regular conditions?[85]

Also, gather information about the availability of work crews to fix non-vehicle failures (i.e., the number of non-vehicle failures that can be fixed per day given current staffing) and the average amount of time required to clear tracks of a stalled train (for rail systems only)[86].

6. Start by calculating failure rates in order to forecast the frequency for which SGR-related events take place on an average weekday in the forecast year:

a. TCRP Report 157 developed an exponential curve that calculates future vehicle failure rates of a given vehicle based on the vehicle's lifetime mileage, its "year zero" failure rate[87], and a mode-specific constant:

$$\mathrm{RM(LM)} = \mathrm{k_{r2}} \mathrm{e}^{\mathrm{k_{r1}} * \mathrm{LM}}$$

where:
RM = road calls or failures per vehicle mile
LM = lifetime mileage[88]
k_{r1} = a constant reflecting the sensitivity of road calls or failures to lifetime mileage[89]
k_{r2} = a system-specific constant set to match year zero road calls or failures

b. For each system, calibrate the "year zero" failure rate constant using current failure rate data (both major and minor vehicle failures) per vehicle revenue mile in the formula above. Once the k_{r2} values are calibrated, it is then possible to forecast failures (i.e., road calls) per mile for the forecast year for each operational vehicle in the inventory.

c. TCRP Report 157 developed a Weibull distribution curve that calculates future non-vehicle failure probability in a given year based on the asset age and asset type-specific shape and scale parameters:

$$\mathrm{PF} = 1 - \frac{\mathrm{e}^{-\left(\frac{t+1}{\lambda}\right)^{k}}}{\mathrm{e}^{-\left(\frac{t}{\lambda}\right)^{k}}}$$

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82 Based upon information submitted by transit operators.
83 Based upon information submitted by transit operators; majority opinion used to standardize across region.
84 Informed by ranges submitted by transit operators but generally scaled upwards by MTC.
85 Informed by ranges submitted by transit operators but generally scaled upwards by MTC. This information is used later to scale up delay impacts in catastrophic scenarios when work crews would be overwhelmed by system failures.
86 Based on operator input, geographic system scope (i.e., distance to rail yard), etc., we assumed 15 minutes for Muni, 20 minutes for VTA, 30 minutes for BART and Caltrain, and 60 minutes for ACE and SMART for the purposes of this analysis.
87 "Year zero" failure rate would be the failure rate of the asset when first purchased (i.e., brand-new).
88 Estimated based on FTA NTD year 2013 data multiplied by asset age.
89 Constant k_{r1} was estimated in TCRP Report 157 to be 7.0×10^{-7} for heavy rail, 1.0×10^{-6} for light rail, and 1.98×10^{-6} for buses.

where:
PF = probability of asset failure in the forecast year[90]
t = asset age in the forecast year
k = asset-specific shape parameter[91]
λ = asset-specific scale parameter[92]

d. Using the formula above, for each non-vehicle asset in the inventory, calculate its probability of failure in the forecast year. Adjust all linear unit assets to track-mile or mile to align with TCRP Report 157 units, as well as operational impact assumptions discussed later on.

7. Now that the failure rates of each asset have been calculated, it is necessary to estimate the impacts of each failure in terms of minutes of delay for input to Travel Model One[93]. For both vehicles and non-vehicles, there are two primary direct operational impacts for a customer: **per-mile delays** (when on board a transit vehicle) and **per-boarding delays** (when waiting for a transit vehicle to arrive). For more information on formula derivations, refer to Paterson and Vautin (2015).

   a. Starting with vehicle per-mile delays, calculate the passenger delays both on-board the vehicle and for other vehicles trapped behind the stalled vehicle[94]:

$$\mathrm{DWBT} = \mathrm{AWT} * \left(\frac{\mathrm{PM}}{\mathrm{VM}}\right)$$

$$\mathrm{AWT} = \frac{\sum_{\mathrm{i-NT}} \left(\frac{\mathrm{TC}}{\mathrm{H}}\right) - \mathrm{i}}{\mathrm{NT}} * \mathrm{H}$$

$$\mathrm{NT} = \mathrm{RoundDown}\left(\frac{\mathrm{TC}}{\mathrm{H}}\right)$$

where:
DWBT = delay from waiting behind stalled trains
AWT = average wait time in headways for trains stuck behind stalled train
PM = passenger miles
VM = revenue vehicle miles
i = each additional train
TC = average time it takes to clear tracks
H = headway
NT = the number of trains that are delayed due to a stalled train ahead

[90] Assumes the asset is functioning in the year prior to the forecast year.
[91] Identified for each asset type in TCRP Report 157 – Table E-1, pages 118 to 121.
[92] Identified for each asset type in TCRP Report 157 – Table E-1, pages 118 to 121.
[93] Travel Model One, and the overall assessment framework, is focused on long-term benefits and disbenefits and does not incorporate the positive and negative impacts associated with construction activities.
[94] Wait times are capped at 60 minutes. It is assumed that after that point, a passenger will give up on that operator and switch to another transit mode, use their personal automobile, join a carpool, use a bus bridge, or otherwise defer their trip.

$$\text{IVED(V)} = \text{RM} * \left(\text{DWBT} + \left(\text{EH} * \left(\frac{\text{PM}}{\text{VM}}\right)\right)\right)$$

where:
IVED(V) = in-vehicle expected delay from vehicle failures (onboard + upstream)
RM = road calls per mile from equation 3
EH = effective headway (incorporating crowding factor)[95]
PM = passenger miles
VM = revenue vehicle miles

b. Next, calculate the vehicle per-boarding delays, which are based on passengers waiting for the failed vehicle(s).

$$\text{PWV} = \left(\frac{\text{PT}}{\text{VM}}\right) * \text{MR}$$

where:
PWV = passengers waiting for the failed vehicle
PT = passenger trips
VM = revenue vehicle miles
MR = recovery miles (miles before another bus takes over the route)[96]

$$\text{OVED(V)} = \frac{(\text{EH} * \text{PWV}) * (\text{MR} * \text{VM})}{\text{PT}}$$

where:
OVED(V) = out-of-vehicle expected delay from vehicle failures
EH = effective headway (incorporating crowding factor)
MR = recovery miles
VM = revenue vehicle miles
PWV = passengers waiting for the failed vehicle
PT = passenger trips

c. Calculate the average non-vehicle per-mile delays using the following formulas to incorporate both slow zone delays from non-vehicle assets and stoppage delays from non-vehicle assets, making sure to convert from annual to daily failures in the process:

$$\text{SZD} = \text{PF} * \left(\frac{\text{NT} * \text{MD}}{\text{VM} * 300}\right)$$

$$\text{NT} = \text{RoundDown}\left(\frac{(\text{TR}) - \left(\frac{1}{2}\text{H}\right)}{\text{H}}\right) * \text{LA}$$

[95] The crowding factor incorporates the reality that, when a vehicle breaks down, not all passengers will fit on board the next vehicle. Instead, the effective headway represents the average or typical number of headways a passenger would have to be wait (1.0 in normal conditions, 1.5 in crowded conditions, 2.0 in crush load conditions). Crowding factors are identified on a system level based on current and future daily ridership.
[96] Assumed to be half the length of the average route (i.e., on average case, bus breaks down halfway between its origin and destination). However, in catastrophic scenarios, recovery time – as well as recovery miles – increases due to the lack of availability of additional buses.

where:
SZD = expected delay arising from slow zones
PF = probability of failure in 2040
NT = number of trains affected by failure
MD = minutes of delay to the train caused by slow zone
VM = revenue vehicle miles
TR = time until repair or replacement of the failed asset in minutes[97]
H = headways
LA = average number of lines affected by failure

$$\mathrm{STD} = \mathrm{PF} * \left(\frac{\mathrm{NT} * \left(\frac{\mathrm{TR}}{2}\right)}{\mathrm{VM} * 300} \right)$$

where:
STD = expected delay from being on a stopped train due to a non-vehicle failure ahead
PF = probability of failure in 2040
NT = number of trains affected by failure
TR = time until repair or replacement of the failed asset in minutes[98]
VM = revenue vehicle miles

$$\mathrm{IVED(NV)} = \mathrm{SZD} + \mathrm{STD}$$

where:
IVED(NV) = in-vehicle expected delay from non-vehicle asset failures
SZD = expected delay arising from slow zones
STD = expected delay from being on a stopped train due to a non-vehicle failure ahead

d. Finally, calculate the non-vehicle per-boarding delays, which are primarily the result of system stoppages[99], making sure to convert from annual to daily failures in the process.

$$\mathrm{OVED(NV)} = \mathrm{PF} \frac{\mathrm{WT} * \mathrm{WN}}{\mathrm{WB} * 300}$$
$$\mathrm{WT} = \mathrm{TR} - (\frac{1}{2}\mathrm{H})$$
$$\mathrm{WN} = \mathrm{BM} * \left(\frac{1}{2}\mathrm{ARL}\right) * \min(\mathrm{NT}, \mathrm{DT})$$
$$\mathrm{DT} = \mathrm{LA}\left(\frac{\mathrm{MOD}}{\mathrm{H}}\right)$$

where:
OVED(NV) = out-of-vehicle expected delay from non-vehicle asset failures

[97] Minutes needed to repair the asset are adjusted upwards in catastrophic scenarios to reflect that the maintenance crews would be overwhelmed, assuming that additional staff would be called in or that workers would be exhausted due to overtime.
[98] We cap the expected wait until for the stoppage to be resolved at TR/2 = 60 minutes, assuming that the operator would not leave passengers captive on-board for more than that amount of time. Instead, they would likely transition to a bus bridge or other alternative operating pattern.
[99] Impacts to headways from slow zones can generally be overcome by adding a small number of new train runs to preserve frequencies at a slightly slower origin-to-terminus speed.

WT = additional out-of-vehicle wait time when a vehicle is stopped by a non-vehicle asset failure[100]
WN = number of passengers waiting to board a vehicle stopped by a non-vehicle asset failure
TR = minutes until asset repair or replacement[101]
WB = average weekday boardings
BM = average boardings per mile
ARL = average route length
DT = number of trains passing through affected area in one day
NT = number of trains affected by failure
MOD = minutes of operation daily[102]
H = headways
LA = average number of lines affected by failure

e. Calculate the average per-mile delay by aggregating and averaging the vehicle and non-vehicle failure impacts across all rows of the inventory. Repeat for the average per-boarding impacts. Note that these values reflect the experience of average rider on the given system in the horizon year on a per-mile and per-boarding basis (i.e., they are time-based "friction factors" due to breakdowns which riders build into their daily schedule).

8. Summarize cost outputs from the TERM-Lite export files for use in Step 4 below; sum the replacement conditions for all assets flagged as having operational impacts between year 1 and the horizon year (24-year costs). Note that transit asset replacement costs for operators – the primary input on the cost side of the benefit-cost ratio – are relatively straightforward thanks to TERM-Lite; they represent the difference between the two funding levels for the scenario in question, as the region's transportation agencies will be expending these dollars.[103]

Step 3: Run Travel Model One using operational impacts to explore benefits & disbenefits.

1. Convert the Results tab of the OIC spreadsheet into a Cube-readable format by extracting the data in the combined per-mile delay and combined per-boarding delay columns.[104] When an individual operator is run, values will be null or zero for all other operators.
2. Paste the operational impact values into two BLOCK files, using the relevant Travel Model One mode codes to identify the rows to modify.
    a. When evaluating all operators in the region, start with blank BLOCK files for both per-mile and per-boarding delays.

[100] Wait times are capped at 60 minutes. It is assumed that after that point, a passenger will give up on that operator and switch to another transit mode, use their personal automobile, join a carpool, use a bus bridge, or otherwise defer their trip.
[101] Refer to the earlier comment about catastrophic failure scenarios.
[102] For example, 1080 minutes for a 6 AM to 12 AM service schedule.
[103] Funding levels can be either inputs or outputs of TERM-Lite in Step 1.
[104] Cube is the travel model software used by Travel Model One for network coding.

    b. When evaluating one or more operators in isolation, use the year 2040 baseline delay BLOCK files[105] and swap out the per-mile and per-boarding for the operator(s) in question, leaving all other systems with status quo delays.
3. Run Travel Model One twice: once with baseline conditions and once with "with project" conditions to evaluate how travelers respond to changing asset conditions. While additional information on the model can be found in Travel Model One documentation[106], a rough and high-level summary of how the model applies the delay factors can be found below:
    a. For each line on each system, the per-mile travel time impacts are applied to the point-to-point travel times between stops (to simulate greater in-vehicle time), while the per-boarding travel time impacts are applied to the headways (to simulate greater out-of-vehicle time).
    b. The model then begins to simulate how travelers respond to the various levels of typical delay on the systems they decide to use in a given day, generating impacts to those travelers but also influencing their decisions. This will affect their access to destinations, as well as their travel behavior, generating secondary effects like emissions, collisions, etc. This approach is similar to what is done for expansion projects, insofar that new conditions are loaded on the network and benefits/disbenefits are a result of the input conditions.
    c. Metrics calculated by Travel Model One are produced for the two runs, including the inputs to the COBRA benefit-cost script. These metrics are leveraged in Step 4.4 below to calculate benefits, reflecting the forecasted behavioral impacts (both direct and indirect effects on riders and the region as a whole).

Step 4: Calculate benefit-cost ratio using Travel Model One outputs and funding levels from TERM-Lite.

1. First, calculate the costs[107] by subtracting the 24-year baseline TERM-Lite asset replacement costs[108] from the "with-project" asset replacement costs. In order to compare to the annualized benefit, divide by 24 to calculate the expenditures in a single year.
2. Second, adjust the gross cost differential by incorporating vehicle energy and maintenance cost impacts using the energy cost and maintenance cost models identified in TCRP Report 157. The formulas below rely upon exponential curves to calculate energy and maintenance costs based on a given vehicle's lifetime mileage, its "year zero" failure rate[109], and a mode-specific constant:

$$\mathrm{CME(LM)} = \mathrm{k_{e2}} \mathrm{e}^{\mathrm{k_{e1}} * \mathrm{LM}}$$

    where:
    CME = energy costs per mile
    LM = lifetime mileage[110]
    k_{e1} = a constant reflecting the sensitivity of energy consumption to lifetime mileage[111]

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[105] Based on the 2015 inventory and 2040 operating conditions (i.e., assuming that asset conditions for all other operators are about the same as today).
[106] For more information: http://mtcgis.mtc.ca.gov/foswiki/Main/UsersGuide
[107] It is generally appropriate to focus on the costs of operational impact assets for consistency with road SGR methodology, which does not include sidewalks, etc.
[108] Adjusted to year 2017 dollars using a 2.2% inflation rate.
[109] "Year zero" failure rate would be the failure rate of the asset when first purchased (i.e., brand-new).
[110] Estimated based on FTA NTD year 2013 data multiplied by asset age.
[111] Constant k_{e1} was estimated in TCRP Report 157 to be 6.27×10^{-7} for buses and 4.0×10^{-7} for rail vehicles.

k_{e2} = a system-specific constant set to match year zero energy costs[112]

$$\mathrm{CMM(LM)} = \mathrm{k_{m2}} \mathrm{e}^{\mathrm{k_{m1}} * \mathrm{LM}}$$

where:
CME = maintenance costs per mile
LM = lifetime mileage[113]
k_{m1} = a constant reflecting the sensitivity of maintenance costs to lifetime mileage[114]
k_{m2} = a system-specific constant set to match year zero maintenance costs[115]

3. Third, calculate the benefits by running the COBRA benefit-cost script using the Travel Model One output CSV files. The benefits associated with the scenario are calculated by COBRA using standard benefit monetizations[116] applied to all projects evaluated for Plan Bay Area 2040, which compares the "with-project" and baseline conditions.
4. Finally, COBRA outputs the benefit-cost ratio by dividing the annualized benefits by the annualized costs, incorporating a system-wide farebox recovery ratio to roughly account for fare revenue impacts associated with higher or lower ridership in a given run[117]. The result is a B/C ratio that reflects the benefits to users and society from increasing system preservation funding as defined in the scenario.

[112] k_{e2} values by operator are calibrated using a similar process as described in Step 2 under vehicle failure rates – NTD data on the primary fuel type of an operator, and its total consumption of said fuel per mile, allows us to back calculate the rough year zero energy costs by system.
[113] Estimated based on FTA NTD year 2013 data multiplied by asset age.
[114] Constant k_{m1} was estimated in TCRP Report 157 to be 1.26×10^{-6} for bus, 5.0×10^{-7} for light rail, and 4.0×10^{-7} for heavy rail.
[115] k_{m2} values by operator are calibrated using a similar process as described in Step 2 under vehicle failure rates.
[116] Benefit categories include: person time + cost (i.e., access to destinations), truck time + cost, collisions (i.e., fatalities, injuries, property damage), air quality (i.e., greenhouse gas emissions, fine particulate emissions, criteria pollutant emissions), physical activity (i.e., mortality and morbidity), auto ownership costs, and noise.
[117] This approach is consistent with expansion and operational improvement projects.

Appendix E – Confidence Assessment

ID	Project Name	CONFIDENCE ASSESSMENT CRITERIA *if marked in yellow, see comments to the right* Travel Model Accuracy	Framework Completeness	Timeframe Inclusiveness	Comments
101	**Express Lane Network (US-101 San Mateo/San Francisco)**	→			The travel model has difficulty representing the benefits of an operational strategy that relies on real-time price changes throughout the morning and evening commute periods.
102	**US-101 HOV Lanes (San Francisco + San Mateo Counties)**				-
103	**El Camino Real Rapid Bus (Daly City to Palo Alto)**			→	The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
104	**Geneva-Harney BRT + Corridor Improvements**			→	The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
202	**East-West Connector (Fremont to Union City)**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
203	**Irvington BART Infill Station**	→		→	Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model. Infill stations can be implemented quickly for near-term benefits.
206	**AC Transit Service Frequency Improvements**			→	Bus frequency projects can be implemented quickly for near-term benefits.
207	**San Pablo BRT (San Pablo to Oakland)**				-
209	**SR-84 Widening + I-680/SR-84 Interchange Improvements (Livermore to I-680)**				-
210	**I-580 ITS Improvements**				-

ID	Project Name	CONFIDENCE ASSESSMENT CRITERIA *if marked in yellow, see comments to the right* Travel Model Accuracy	Framework Completeness	Timeframe Inclusiveness	Comments
211	**SR-262 Connector (I-680 to I-880)**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
301	**Geary BRT**		→		B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. This project can be implemented quickly to achieve benefits in the near-term.
302	**Treasure Island Congestion Pricing (Toll + Transit Improvements)**				-
304	**Southeast Waterfront Transportation Improvements (Hunters Point Transit Center + New Express Bus Services)**			→	The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
306	**Downtown San Francisco Congestion Pricing (Toll + Transit Improvements)**				-
307	**Caltrain Modernization - Phase 1 (Electrification + Service Frequency Increase) + Caltrain to Transbay Transit Center**		→		Framework does not capture the benefits to residents outside of the Bay Area who would now have improved access to San Francisco. B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. The air quality benefits of converting diesel vehicles to electric vehicles is not included in this assessment.
311	**Muni Forward Program**		→	→	B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. This project can be implemented quickly to achieve benefits in the near-term.

ID	Project Name	CONFIDENCE ASSESSMENT CRITERIA *if marked in yellow, see comments to the right* Travel Model Accuracy	Framework Completeness	Timeframe Inclusiveness	Comments
312	**19th Avenue Subway (West Portal to Parkmerced)**	→	→		B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. The modeling assumes that the land use is the same with and without the project, potentially under-estimating the change in transit benefits between the baseline and the build scenarios.
313	**Muni Service Frequency Improvements**		→	→	B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. This project can be implemented quickly to achieve benefits in the near-term.
331	**Better Market Street**		→	→	B/C framework does not estimate benefits of streetscape elements of the project (including safety and economic development). This project can be implemented quickly to achieve benefits in the near-term.
401	**TriLink Tollway + Expressways (Brentwood to Tracy/Altamont Pass)**	→			Because the land uses outside of the 9-county Bay Area are not explicitly represented, the model does not fully understand the likely impact of projects located near the boundaries of the planning region. The modeling assumes that land use is the same with and without the project, potentially over-estimating the travel time savings of this project.
402	**eBART – Phase 2 (Antioch to Brentwood)**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
403	**I-680 Express Bus Frequency Improvements**			→	Bus frequency projects can be implemented quickly for near-term benefits.
404	**SR-4 Widening (Antioch to Discovery Bay)**				-

ID	Project Name	CONFIDENCE ASSESSMENT CRITERIA *if marked in yellow, see comments to the right* Travel Model Accuracy	Framework Completeness	Timeframe Inclusiveness	Comments
409	**I-680/SR-4 Interchange Improvements + HOV Direct Connector**	→		→	The model does not explicitly represent weaving (thus ignoring the benefits of longer weaving sections), acceleration or deceleration behavior, or queue spillback. The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
410	**Antioch-Martinez-Hercules-San Francisco Ferry**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
411	**SR-4 Auxiliary Lanes - Phases 1 + 2 (Concord to Pittsburg)**	→			The model does not explicitly represent weaving (thus ignoring the benefits of longer weaving sections), acceleration or deceleration behavior, or queue spillback.
501	**BART to Silicon Valley – Phase 2 (Berryessa to Santa Clara)**			→	The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
502	**Express Lane Network (Silicon Valley)**	→		→	The travel model has difficulty representing the benefits of an operational strategy that relies on real-time price changes throughout the morning and evening commute periods. Some portions of the project may be implemented early and accrue benefits over a long period in the Plan, the Network likely will not be complete until near the end of the Plan period.
503	**SR-152 Tollway(Gilroy to Los Banos)**	→			The model poorly estimates freight travel behavior so may be underestimating the freight benefits of this project, both in terms of the number of truck trips and the impacts of steep grades on trucks. The modeling assumes that land use is the same with and without the project, potentially over-estimating the travel time savings of this project.
504	**Stevens Creek LRT**				-
505	**Capitol Expressway LRT – Phase 2 (Alum Rock to Eastridge)**				-

ID	Project Name	CONFIDENCE ASSESSMENT CRITERIA *if marked in yellow, see comments to the right* Travel Model Accuracy	Framework Completeness	Timeframe Inclusiveness	Comments
506	**El Camino Real BRT (Palo Alto to San Jose)**				-
507	**Vasona LRT – Phase 2 (Winchester to Vasona Junction)**				-
508	**SR-17 Tollway + Santa Cruz LRT (Los Gatos to Santa Cruz)**	→	→	→	The model does not estimate inter-regional transit trips so may be underestimating the transit benefits for this project. B/C methodology includes a broad treatment of safety benefits so may underestimate projects with the primary purpose of safety improvement. The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
510	**Downtown San Jose Subway (Japantown to Convention Center)**			→	The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
513	**North Bayshore LRT (NASA/Bayshore to Google)**			→	The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
515	**Tasman West LRT Realignment (Fair Oaks to Mountain View)**			→	The project is likely to be complete toward the end of the Plan, reducing the total benefits potentially accrued during the Plan period.
516	**VTA Express Bus Frequency Improvements**			→	Bus frequency projects can be implemented quickly for near-term benefits.
517	**Stevens Creek BRT**				-
518	**ACE Alviso Double-Tracking**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
519	**Lawrence Freeway**				-
522	**VTA Service Frequency Improvements (10-Minute Frequencies)**			→	Bus frequency projects can be implemented quickly for near-term benefits.
523	**VTA Service Frequency Improvements (15-Minute Frequencies)**			→	Bus frequency projects can be implemented quickly for near-term benefits.

		CONFIDENCE ASSESSMENT CRITERIA *if marked in yellow, see comments to the right*			
ID	**Project Name**	**Travel Model Accuracy**	**Framework Completeness**	**Timeframe Inclusiveness**	**Comments**
601	**I-80/I-680/SR-12 Interchange Improvements**	→			The model does not explicitly represent weaving (thus ignoring the benefits of longer weaving sections), acceleration or deceleration behavior, or queue spillback. Freight benefits are also not explicitly included.
604	**Solano County Express Bus Network**			→	Bus frequency projects can be implemented quickly for near-term benefits.
605	**Jepson Parkway (Fairfield to Vacaville)**				-
801	**Golden Gate Transit Frequency Improvements**			→	Bus frequency projects can be implemented quickly for near-term benefits.
901	**US-101 Marin-Sonoma Narrows HOV Lanes – Phase 2**				-
903	**Sonoma County Service Frequency Improvements**			→	Bus frequency projects can be implemented quickly for near-term benefits.
905	**SMART – Phase 3 (Santa Rosa Airport to Cloverdale)**		→		Analysis is performed for a typical weekday, but many of the project's benefits will be accrued on weekends due to recreational use and tourism.
1001	**BART Metro Program (Service Frequency Increase + Bay Fair Operational Improvements + SFO Airport Express Train)**		→		B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions.
1101	**Caltrain Modernization - Phase 1 (Electrification + Service Frequency Increase)**		→		B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. The air quality benefits of converting diesel vehicles to electric vehicles is not included in this assessment.
1102	**Caltrain Modernization - Phase 1 + Phase 2 (Electrification + Service Frequency Increase + Capacity Expansion)**		→		B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. The air quality benefits of converting diesel vehicles to electric vehicles is not included in this assessment.

ID	Project Name	CONFIDENCE ASSESSMENT CRITERIA *if marked in yellow, see comments to the right* Travel Model Accuracy	Framework Completeness	Timeframe Inclusiveness	Comments
1201	**San Francisco-Redwood City + Oakland-Redwood City Ferry**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
1202	**Oakland-Alameda-San Francisco Ferry Frequency Improvements**	→		→	Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model. Ferry frequency improvements can be implemented quickly for near-term benefits.
1203	**Vallejo-San Francisco + Richmond-San Francisco Ferry Frequency Improvements**	→		→	Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model. Ferry frequency improvements can be implemented quickly for near-term benefits.
1204	**Berkeley-San Francisco Ferry**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
1206	**Alameda Point-San Francisco Ferry**	→			Due to the project's smaller size, the travel model may not accurately estimate its benefits relative to the regional scale of the model.
1301	**Columbus Day Initiative**	→			The model is likely overestimating the benefits of arterial signal coordination in dense, urban environments. The model is likely underestimating the safety benefits of advanced queue-warning and connected vehicles.
1302	**Express Lane Network (East and North Bay)**	→		→	The travel model has difficulty representing the benefits of an operational strategy that relies on real-time price changes throughout the morning and evening commute periods. Some portions of the project may be implemented early and accrue benefits over a long period in the Plan, the Network likely will not be complete until near the end of the Plan period.
1304	**Bay Bridge West Span Bike Path**		→		Analysis is performed for a typical weekday, but many of the project's benefits will be accrued on weekends due to recreational use and tourism.

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1403	**Local Streets and Roads Maintenance(Preserve Conditions vs. No Funding)**		→	→	While time and cost benefits are captured in the B-C framework, potential safety benefits (particularly for non-motorized users) are not included. Because the analysis was conducted for year 2040, benefits are overestimated compared to interim years; however, benefits may continue to accrue past the Plan horizon year as well.
1413	**Local Streets and Roads Maintenance (Preserve Conditions vs. Local Funding)**		→	→	While time and cost benefits are captured in the B-C framework, potential safety benefits (particularly for non-motorized users) are not included. Because the analysis was conducted for year 2040, benefits are overestimated compared to interim years; however, benefits may continue to accrue past the Plan horizon year as well.
1502	**Highway Pavement Maintenance (Preserve Conditions vs. No Funding)**			→	Because the analysis was conducted for year 2040, benefits are overestimated compared to interim years; however, benefits may continue to accrue past the Plan horizon year as well.
1503	**Highway Pavement Maintenance (Ideal Conditions vs. Preserve Conditions)**			→	Because the analysis was conducted for year 2040, benefits are overestimated compared to interim years; however, benefits may continue to accrue past the Plan horizon year as well.
1650	**Public Transit Maintenance - Bus Operators (Preserve Conditions vs. No Funding)**		→	→	B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. Similar to crowding, the model does not reflect the increased comfort or perceived modernity of a new transit vehicle, for example. Because the analysis was conducted for year 2040, benefits are overestimated compared to interim years; however, benefits may continue to accrue past the Plan horizon year as well.

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1651	**Public Transit Maintenance - Rail Operators (Preserve Conditions vs. No Funding)**		→	→	B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions. Similar to crowding, the model does not reflect the increased comfort or perceived modernity of a new transit vehicle, for example. Because the analysis was conducted for year 2040, benefits are overestimated compared to interim years; however, benefits may continue to accrue past the Plan horizon year as well.
205_15	**Express Bus Bay Bridge Contraflow Lane**		→		B/C framework doesn't consider the value of relieving crowded transit vehicles and may be underestimating benefits of projects in areas with crowded conditions.