Supplemental Attachment #1

Plan Bay Area Project Performance Assessment:
Benefit-Cost Assessment Methodology

Revised 2/6/2012

Overview of Benefit-Cost Assessment Methodology

MTC calculated benefit-cost ratios for approximately 90 higher-cost projects with regionally significant impacts based on project definitions and cost estimates provided by projects sponsors. Impacts and costs reflected in the benefit-cost ratio are listed below. The calculation, which is based on best practices for benefit-cost assessment, captures many of the factors reflected in the adopted targets.

Project Impacts	Project Costs
• travel time • emissions • collisions • out-of-pocket user costs (including parking, auto ownership, and auto operating costs) • health costs due to level of physical activity • noise	• Capital cost • Net operating and maintenance cost

The benefit-cost ratio compares annual benefits in year 2035 with annualized cost. For most projects, MTC used the regional travel demand model to estimate project impacts in year 2035. For regional programs such as TLC, Lifeline, and the Regional Bike Network, MTC estimated impacts using sketch planning approaches similar to those used in Transportation 2035. Larger locally sponsored projects that cannot be represented in the regional travel demand model were not subject to the benefit-cost analysis but are still evaluated on an individual basis in the target assessment. **Attachment I** includes a discussion of the criteria MTC staff used to determine which larger projects could be assessed using the regional travel demand model. In general, this group includes projects with cost greater than $50 million (in 2013 dollars) that expand or significantly enhance transit services, freeways, state highways or local roads. The methodologies used to estimate benefits (using the travel demand model) and costs are described in **Attachment II**.

The benefit-cost calculation monetizes project impacts on travel time, emissions, collisions, health costs due to level of physical activity, noise, and out-of-pocket user costs. These benefits are expressed in monetary terms. For example, the monetary value of travel time is tied to the average regional wage rate; similarly, the monetary value of particulate matter emissions reflects the costs associated with the known health impacts. MTC conducted research into current best practices for valuing project impacts; this information was reviewed with the ad hoc Project Performance Technical Advisory Committee prior to embarking on the analysis. The basis for valuing each benefit is described in **Attachment III**.

In reviewing the benefit cost methodology, it is important to recognize the intent is to identify outliers and make broad comparisons. Projects will be grouped in benefit-cost ranges, such as **High** (B/C ratio > 10), **Medium-High** (B/C ratio between 5 and 9), **Medium-Low** (B/C ratio between 1 and 4), and **Low** (B/C ratio < 1).

In an effort to provide a more robust analysis, MTC staff has conducted sensitivity testing of the benefit-cost assumptions. Staff has also performed a confidence assessment to flag projects for which the benefit-cost ratio may have been over- or under-estimated.

Sensitivity testing – We have conducted sensitivity tests to validate the robustness of our results. We principally aimed to understand if certain assumptions fundamentally change the position of projects among the benefit-cost ranges. Sensitivity tests included:

- Testing of travel time valuation
  - Value non-recurring delay reduction at three times the value of travel time
  - Value travel time at significantly lower levels (to reflect after-tax value of time)
- Testing of CO_2 valuation
  - Value CO_2 at significantly higher level (based on recent GHG valuation studies from the U.K.)
- Testing of collision valuations
  - Value collisions using USDOT valuations (which are somewhat higher than the Cal B/C values used in the analysis)
- Testing of noise valuation
  - Value noise levels at a greater level to reflect health impacts
- Testing of transit O&M cost assumptions
  - Reduce transit operating & maintenance costs to reflect potential savings from the Transit Sustainability Project

Confidence rating – We see value in identifying the strengths and shortcomings of the benefit-cost assessment. As discussed in the spring, we have identified our level of confidence with each of the benefit-cost ratios. Three primary criteria were used to develop this rating:

- **Modeling Accuracy**
  - Has MTC's model (known as Travel Model One) been successful at modeling similar types of projects, or does the model have limitations in understanding a particular type of travel behavior?
  - Does the "mode choice" modeling approach under- or over-estimate the number of trips affected by a particular project?
- **Framework Completeness**
  - Does the model capture all of the primary benefits of the project?
  - Are we capturing real-world limitations (e.g. system capacity issues)?
- **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)?

Attachment I: Projects Subject to Benefit-Cost Analysis

MTC staff selected projects from among projects submitted in response to the 2011 Call for Projects. Staff selected from projects submitted both as "New Commitments" (i.e. financially constrained) and as "Vision" projects, based on the following guidelines:

1. Committed projects and programs as defined by Commission action in April 2011 (MTC Resolution No. 4006) are not subject to project evaluation (benefit-cost or targets assessment).
2. MTC staff selected approximately 90 uncommitted transit and roadway projects for benefit-cost assessment based on a combination of cost and functional criteria. Projects with total costs greater than $50 million (2013$) were candidates for analysis. In addition, it was necessary that projects' impacts could be captured in the regional travel demand model. Examples include:
   - New/enhanced transit service, including transit priority measures
   - Freeway-to-freeway interchanges
   - Freeway widenings, including HOV lanes & auxiliary lanes, generally more than 5 miles
   - State highway widenings and major arterial connectors/reliever route improvements, generally more than 5 miles

   A few projects that cost less than $50 million were selected if they had area-wide impacts. Examples include the Grand-MacArthur BRT and the Alameda-Oakland BRT.

   In some cases, multiple project phases submitted as individual projects were grouped together for project evaluation. Examples include the SR-4 Bypass widening and SMART's "Phase 2" projects.

3. Due to technology and resource limitations, some transit and roadway improvements costing more than $50 million were not evaluated. These include projects considered to have localized impacts and other projects ill-suited for our analysis tools. Examples include:
   - Arterial or intersection improvements
   - Freeway-to freeway interchanges that do not include mainline widening
   - Local interchanges
   - Transit center improvements & parking expansion
   - Core transit capacity improvements, which do not result in more frequent service, though they may impact carrying capacity
   - Grade separations
   - Freight improvements
4. Regional Programs that are not "committed" under Commission policy are also subject to the benefit-cost assessment: Local Streets and Roads Maintenance & Transit Capital Need programs; New Freedom Program & Lifeline; Climate Initiative Program; Transportation for Livable Communities; Regional Bikeway Network; Freeway Performance Initiative; and emissions reduction programs (Electric Vehicle Solar Installation, Truck and Motorcycle Retirement, Heavy Duty Truck Replacement)

Attachment II: Modeling Approach & Approach to Costs

Modeling Approach to Estimate Benefits

For approximately 80 of the 90 projects, impacts (e.g., changes in travel time, emissions, and out-of-pocket costs) were estimated using the regional travel demand model. Each project was coded as its own "Build" scenario and compared to a "No Build", which included only those projects "committed" as per Commission policy. Both the Build and No Build reflect the land use assumptions in ABAG's Current Regional Plans scenario. MTC's Travel Model One was used for the analysis. The travel model estimates daily impacts by projecting travel conditions during five time periods over a 24-hour day. MTC multiplied the daily impacts by a factor of 300 to estimate annual impacts.

For nine regional programs, MTC staff employed off-model analysis, based on available research, to estimate benefits, using approaches similar to those used in Transportation 2035. These projects include:

- Transportation for Livable Communities
- Lifeline
- Climate Initiatives Program
- Regional Bikeway Network
- Local Streets and Roads Maintenance
- Transit Capital Need
- New Freedom
- Emissions reduction programs (Electric Vehicle Solar Installation, Truck and Motorcycle Retirement, Heavy Duty Truck Replacement)
- Selected elements of the Freeway Performance Initiative (incident management, emergency preparedness and 511 Rideshare)

Cost Approach

All measures are calculated based on annualized benefits in year 2035 and annualized total costs. Both benefits and costs are expressed in 2013 dollars.

Annualized total costs are capital costs divided by the expected life of the capital investment (as shown in the table below) plus one year of net operating and maintenance costs in 2035. The total project cost, as opposed to the discretionary funding request, was used as the basis for the benefit-cost calculation. Project sponsors provided capital cost estimates. Where annual operating and maintenance cost estimates were provided, they were used. Where sponsors did not provide estimates (all cases were roadway projects), MTC staff estimated them using average per-mile road maintenance costs.

Project Lifecycle Assumptions by Project Type	Expected Useful Life of Improvement (in years)
Local Bus (1)	**14**
Over-the-Road Bus (1)	**18**
BRT Systems (2)	**20**
Rail Project – if majority of costs are new tunnels and/or stations (3)	**80**

Project Lifecycle Assumptions by Project Type	Expected Useful Life of Improvement (in years)
Rail Project – all others (4)	**30**
Ferry Project – if majority of costs are for ferry boats (1)	**30**
Ferry Project – if majority of costs are for ferry terminals (1)	**50**
Technology/Operations Components (5)	**20**
Roadway (6)	**20**

Sources:

(1) Reflects MTC's Transit Capital Priorities Process and Criteria (MTC Resolution No. 3908).

(2) Reflects that BRT system costs typically reflect considerable roadway improvements.

(3) Reflects FTA New Starts Guidelines, which estimates a useful life of 125 years for tunnels and underground stations and 50 to 70 years for other stations. An average of 80 years was used to reflect that a portion of costs are for vehicles, track and systems, which typically have a useful life of 20 to 30 years.

(4) Reflects MTC's Transit Capital Priorities Process and Criteria (MTC Resolution No. 3908), which assumes a 25-year replacement cycle for light rail vehicles, heavy rail vehicles and locomotives, in conjunction with FTA's New Starts Guidelines, which suggest a 20 to 35 year lifecycle for guideway and track.

(5) Caltrans Transportation System Management Inventory (December 2003) gives lifecycles for various TOS field elements ranging from 10 to 35 years. Video cameras (10 years), communications hubs (10 years) and HAR elements (15 years); fiber optics (35 years), CMS (25 years) and metering equipment (25 years) are at the high end. 20 year is used as a middle-of-the-road number.

(6) Reflects guidance in Caltrans' Life-Cycle Cost Analysis Procedures Manual (November 2007), which suggests pavement may have a useful life of 10, 20 or 40 years depending on the type of pavement and project. 20 year was assumed as a mid-point.

Attachment III: Benefit Valuation

Benefit	Plan Bay Area Valuation ($2013)	What does this valuation include?
In-Vehicle Travel Time (Auto and Transit) per Person Hour of Travel	**$16.03**	This valuation is set equal to one-half of the mean regional wage rate ($32.06). The valuation represents the discomfort to travelers of enduring transportation-related delay and the loss in regional productivity for on-the-clock travelers & commuters. *Sources: Caltrans Cal B-C Model; Bureau of Labor Statistics National Compensation Survey, 2011*
Out-of-Vehicle Travel Time (Transit) per Person Hour of Travel	**$35.27**	This valuation is set equal to 2.2 times the valuation of in-vehicle transit time. The valuation represents the additional discomfort to travelers of experiencing uncertainty of transit arrival time, exposure to inclement weather conditions, and exposure to safety risks. *Source: FHWA Surface Transportation Economic Analysis Model (STEAM)*
In-vehicle Travel Time (Freight/ Trucks) per Vehicle Hour of Travel	**$26.24**	The valuation is set equal to the average wage rate for a Bay Area employee in the Transportation – Truck Driver (average of heavy and light) occupation sector ($23.83/hour), plus the average hourly carrying value of cargo ($2.41/hour). *Sources: FHWA Highway Economic Requirements System; Bureau of Labor Statistics National Compensation Survey, 2011*
Travel Time Reliability per Person Hour (Auto) or per Vehicle Hour (Truck) of Non-recurring Delay	**$16.03 [Auto]** **$26.24 [Truck]**	The valuation represents the additional traveler frustration and loss of regional productivity of experiencing non-expected incident related travel delays. The value is set equal to the value of in-vehicle travel time for autos and trucks. *Source: SHRP2 L05 Project – "Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes"*
Fatality Collisions *(valuation per fatality)*	**$4,590,000**	The valuation includes the internal costs to a fatality collision victim (and their family) resulting from the loss of life, as well as the external societal costs. The valuation represents: • Loss of life for the victims • Medical costs incurred in attempts to revive victims • Loss of enjoyment of family member to other members of the family • Loss of productivity to the family unit (e.g. loss of earnings) • Loss of productivity to society • Loss of societal investment in the victim (e.g. educational costs) *Sources: Caltrans Cal-BC Model, 2010; National Safety Council, 2010*
Injury Collisions *(valuation per injury)*	**$64,000**	The valuation includes the internal costs to an individual (and their family) resulting from the injury, as well as the external societal costs. The valuation represents: • Pain and inconvenience for the individuals • Pain and inconvenience for the other family members • Medical costs for injury treatment • Loss of productivity to the family unit (e.g. loss of earnings) • Loss of productivity to society *Sources: Caltrans Cal-BC Model, 2010; National Safety Council, 2010*

Benefit	Plan Bay Area Valuation ($2013)	What does this valuation include?
Property Damage Only (PDO) Collisions ***(valuation per incident)***	**$2,455**	The valuation includes the internal costs to a property damage collision victim (and their family) resulting from the time required to deal with the collision, as well as the external societal costs from this loss of time. The valuation represents: • Inconvenience to the individual and to other members of the family • Loss of productivity to the family unit • Loss of productivity to society *Source: Caltrans Cal-BC Model, 2010*
CO_2 per Metric Ton	**$55.35**	This valuation represents the full global social cost of an incremental unit (metric ton) of CO_2 emissions from the time of production to the damage it imposes over the whole of its time in the atmosphere. *Source: BAAQMD Clean Air Plan, 2010 (uprated to year 2035 using a 2% annual adjustment)*
Particulate Matter per Ton	**$490,300 [diesel $PM_{2.5}$]** **$487,200 [direct $PM_{2.5}$]**	These valuations represent the negative health effects of increased emissions including: • Loss of productive time (work & school) • Direct medical costs from avoiding or responding to adverse health effects (illness or death). • Pain, inconvenience, and anxiety that results from adverse effects (illness or death), or efforts to avoid or treat these effects • Loss of enjoyment and leisure time • Adverse effects on others resulting from their own adverse health effects *Source: BAAQMD Clean Air Plan, 2010*
NOx per Ton	**$7,800**	
ROG per Ton	**$5,700 [acetaldehyde]** **$12,800 [benzene]** **$32,200 [1,3-butadiene]** **$6,400 [formaldehyde]** **$5,100 [all other ROG]**	
SO_2 per Ton	**$40,500**	
Vehicle Operating Costs per Vehicle Mile Traveled (VMT)	**$0.2518 [Auto]** **$0.3700 [Truck]**	This valuation represents the variable costs (per mile) of operating a vehicle. This valuation includes fuel, maintenance, depreciation (mileage), and tires. *Source: Caltrans Cal-BC Model, 2010*
Noise per Vehicle Mile Traveled	**$0.0012 [Auto]** **$0.0150 [Truck]**	This valuation represents the value of property value decreases and societal cost of noise abatement. *Source: FHWA Federal Cost Allocation Report*
Costs of Physical Inactivity	**$1,220**	This valuation represents the savings achieved by influencing an insufficiently active adult to engage in moderate physical activity five or more days per week for at least 30 minutes. It reflects annual Bay Area health care cost savings of $326 (2006 dollars), as well as productivity savings of $717 (2006 dollars). *Source: California Center for Public Health Advocacy/ Chenoweth & Associates 2006, "The Economic Costs of Overweight, Obesity, and Physical Inactivity Among California Adults"*
Auto Ownership Costs per Vehicle (change in the number of autos)	**$6,290**	This valuation represents the annual ownership costs of vehicles, beyond the per mile operating costs. This valuation includes purchase/lease cost, maintenance, and finance charges. *Source: MTC Bay Area auto ownership analysis, 2011*