Draft Transportation Analysis Framework:

Induced Travel Analysis

March 2020

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INTRODUCTION

In response to recent state laws, revisions to CEQA regulations, CEQA case law, and in order to achieve better alignment with state objectives on greenhouse gas emissions reduction, preservation of the environment, and betterment of human health, Caltrans has determined that Vehicle Miles Traveled (VMT) is the most appropriate primary measure of transportation impacts for capacity-increasing transportation projects on the State Highway System (SHS). The determination of significance of VMT impact will require a supporting induced travel analysis methodology for capacity-increasing transportation projects on the SHS when Caltrans is lead agency or when Caltrans designates another entity as lead agency. The Governor's Office of Planning and Research (OPR) has prepared a Technical Advisory on Evaluating Transportation Impacts in CEQA (California Governor's Office of Planning and Research, 2018) to assist agencies in VMT analysis for both land use and transportation projects. Caltrans recommends using the VMT analysis approaches recommended in OPR's advisory when evaluating the transportation impacts of projects on the State Highway System (SHS).

PURPOSE OF THE TRANSPORTATION ANALYSIS FRAMEWORK

The purpose of this Transportation Analysis Framework is to assist Caltrans Districts in identifying the best approach for analyzing VMT (induced travel) under CEQA in various settings and for projects on the SHS. It provides Caltrans District engineers and planners additional information and recommendations to enable analysts to successfully and consistently implement the new CEQA guidelines in the analysis of transportation impacts. The guidance supports robust, context-sensitive approaches that may in some cases streamline the project delivery process. This framework may also be useful to others assessing the transportation impacts of transportation projects on the SHS. The Framework is not intended to be used for NEPA analyses or other CEQA analyses (such as air and noise). Those analyses have their own distinct requirements.

CONSIDERING INDUCED TRAVEL UNDER CEQA

CEQA requires assessing and disclosing environmental impacts resulting from a project, i.e. impacts that would not occur but for the project. Therefore, under CEQA, the transportation impact of a roadway capacity project is the overall increase in VMT that is attributable to the project, distinct from any background changes in VMT due to other factors such as population or economic growth. The VMT impact is the difference in VMT with the project and without the project.

With a hypothetical project, Figure 1 illustrates the induced travel effect unfolding over time. The baseline trend, shown in the figure by the line labeled "VMT Without Project", shows VMT on the network growing over time, perhaps the result of population and/or economic growth. As described above, an increase in capacity generally leads to an increase in vehicle travel on the network, as shown by the line labeled "VMT With Project". The VMT attributable to the project, or induced travel is the difference in VMT on the network with the project and without the project, counted in the horizon year.

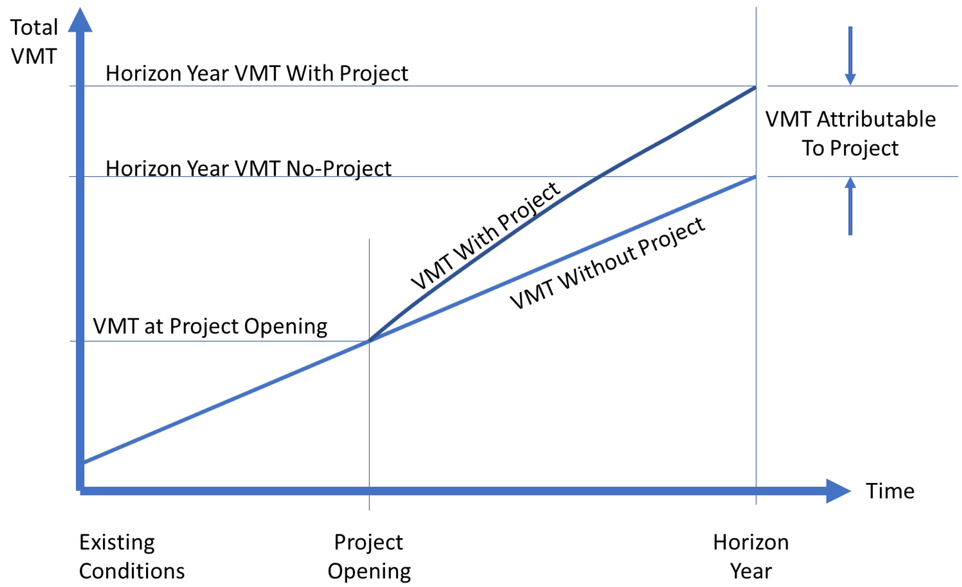

Figure 1: Identification of VMT Attributable to a Transportation Project

METHODS FOR ASSESSING INDUCED VMT

In general, two approaches exist for induced travel assessment. The first is the empirical approach, which applies elasticities from empirical studies that quantify the induced travel effect (the National Center for Sustainable Transportation (NCST) Induced Travel Calculator applies this approach (Susan Handy[1]). The other is the travel demand model-based approach. The general guideline is to use both methods and disclose both induced travel numbers wherever applicable.

The OPR Technical Advisory states that induced travel is generally most accurately assessed by directly applying the "empirical research". OPR also states that the "empirical approach" is also the simplest and most transparent approach for assessing induced travel. For these reasons, the OPR Technical Advisory recommends the empirical approach be used (pp 23-24) where applicable. The NCST has developed a tool to apply this approach, and a project that falls within its scope of application, as stated in the "About" tab of the NCST tool website (https://blinktag.com/induced-travel-calculator/), should employ it for induced VMT assessment. The Department endeavors to use the empirical approach or the NCST induced travel calculator as the primary tool where applicable. For most General Purpose (GP) or High Occupancy Vehicle (HOV) lane addition projects on the SHS, the NCST tool can be applied to assess induced travel.

Where the NCST tool is not applicable, a travel demand model-based approach supplemented with off-model post-processing and/or iteration may be called for. For example, when a project and/or project alternative involves more than just GP/HOV lane facilities, or when in a single environmental document, a consistent set of VMT information is needed to enable the evaluation of air quality conformity or noise level analysis together with induced travel analysis, including a travel demand model-based approach may be necessary. Figure 2 provides a selection matrix for choosing the applicable VMT assessment method(s) for various locations and project types.

<table>
<tr><th>Project Location*</th><th>Add Capacity (GP or HOV) Lane to Interstate Freeway</th><th>Add Capacity (GP or HOV) to Other State Routes</th><th>Other Potentially VMT Inducing Projects on a State Route</th><th>Non-VMT Inducing Projects</th></tr>
<tr><td>Urban counties in MSA with Class I facilities**</td><td colspan="2">- Use NCST Induced Travel Calculator for proposed project.
- Use travel demand model (with off-model post processing and/or iteration.
- Report both results.</td><td rowspan="2">Use travel demand model (off-model post processing and/or iteration) for induced VMT analysis of proposed project, alternatives, and mitigations (as appropriate).</td><td rowspan="4">Brief description about why the project is not likely to result in substantial induced travel.</td></tr>
<tr><td>Other Urban Counties***</td><td>Use travel demand model (with off-model post processing and/or iteration) for induced VMT analysis of proposed project, alternatives, and mitigations (as appropriate).</td><td>- Use NCST Induced Travel Calculator for proposed project.
- Use travel demand model (with off-model post processing and/or iteration).
- Report both results.</td></tr>
<tr><td>Rural counties with existing or forecasted congestion at or near project site****</td><td colspan="2">Use travel demand model (off-model post processing and/or iteration) for induced VMT analysis of proposed project, alternatives, and mitigations (as appropriate).</td><td>Use travel demand model (off-model post processing and/or iteration) for induced VMT analysis of proposed project, alternatives, and mitigations (as appropriate).</td></tr>
<tr><td>Rural county with <u>No</u> existing or forecasted congestion at or near project site</td><td colspan="3">Qualitative assessment of likely VMT effects.</td></tr>
</table>

Figure 2: Induced VMT Assessment Method Selection Matrix

*Note that this chart applies only to the forecasting of state highway project induced VMT attributable to the project (induced travel) for CEQA transportation impact analysis. Other methods and tools are necessary to forecast total VMT in the horizon year for other CEQA and NEPA (when applicable) impact analysis purposes. Consult with Caltrans Division of Environmental Analysis (DEA) and Division of Transportation Planning (DOTP) for details.

** According to its technical documentation, the NCST Induced Travel Calculator can be applied to mainline general-purpose lane additions and mainline HOV lane additions on Class 1 facilities (Interstate freeways) and Class 2/3 facilities (Other Freeways, Expressways, and Other Principal Arterial state routes) as defined by FHWA (see Appendix C). Freeway ramps and minor arterials or collector-distributor roads associated with a freeway fall outside the scope of application for the NCST Induced Travel Calculator. The VMT inducing effects for ramp, minor arterial, and collector-distributor road capacity projects should be evaluated as "Other Potentially VMT Inducing Project" in this matrix.

Urban counties located within metropolitan statistical areas (MSA's) with sufficient Class I facilities for application of NCST Induced Travel Calculator tool are: Alameda, Contra Costa, Fresno, Imperial, Kern, Kings, Los Angeles, Marin, Merced, Orange, Placer, Riverside, Sacramento, San Benito, San Bernardino, San Diego, San Francisco, San Joaquin, San Mateo, Santa Cruz, Shasta, Solano, Stanislaus, Sutter, and Yolo.

*** Urban counties where the NCST Induced Travel Calculator is limited to Class 2 and 3 facilities are: Butte, El Dorado, Madera, Monterey, Napa, San Luis Obispo, Santa Barbara, Santa Clara, Sonoma, Tulare, Ventura, Yuba.

**** Rural counties where the NCST Induced Travel Calculator should not be used for forecasting induced VMT are: Alpine, Amador, Calaveras, Colusa, Del Norte, Glenn, Humboldt, Inyo, Lake, Lassen, Mariposa, Mendocino, Modoc, Mono, Nevada, Plumas, Sierra, Siskiyou, Tehama, Trinity, Tuolumne.

PROCESS FOR RECONCILING VMT ASSESSMENT METHODS FOR PROJECTS ON THE STATE HIGHWAY SYSTEM

SB 743 calls for a modernization of transportation impact analysis. With this modernization comes a necessary recognition that the current methods have known limitations with estimating the induced VMT phenomenon. Current practice for estimating project-generated VMT is about to undergo a necessary evolution, and Caltrans will adapt its recommendations to stay in step with the state of the science and the technical practice as methods evolve and improve.

This draft guidance document puts forward two possible methods for assessing induced VMT from state highway projects, and acknowledges that both methods (i.e., the elasticity approach and the travel demand modeling-based approach) have limitations. Ultimately, an impact determination is required, so a single estimate of project-generated VMT will be necessary.

To advance this discussion, Caltrans plans to convene a panel of expert practitioners that specialize in induced VMT estimation. This panel will prepare recommendations on how to select the best method, or reconcile multiple methods, to obtain a defensible, full accounting of induced VMT from different transportation project types. The expert panel’s recommendations will be made available for stakeholder review and incorporated into subsequent versions of Caltrans’ guidance.

In the meantime, projects that are currently undergoing environmental review and analysis should follow the framework in Figure 2 to assess project-generated VMT. This way, projects can continue to move forward with scoping and analysis while additional expertise is collected. Because the NCST tool is free and straightforward to use, reporting the elasticity-based result in combination with a travel demand model-generated result should not increase the cost of the analysis.

EMPIRICAL APPROACH

As stated above, many past studies investigated the induced travel effect, quantifying it in terms of elasticities (the percent increase in VMT resulting from a given percent increase in lane miles). The studies apply various approaches to controlling for confounding factors such as population and economic growth, and for simultaneity bias[1], so they capture only the VMT caused by the roadway capacity expansion (i.e. the induced travel). Using various approaches, they reported the average magnitude of the induced travel effect per lane mile of additional capacity in each county or Metropolitan Statistical Area (MSA). Many of these studies are summarized in the California Air Resources Board’s Policy Brief, *Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions* (Handy

[1] Simultaneity bias can arise from the simultaneous effects of (1) added lane miles inducing VMT and (2) growth in VMT leading to the adding of lane miles. Most recent induced travel studies apply methods to control for it.

and Boarnet, 2014). Note that the results of these studies are generally limited in applicability to roadway expansions on freeways, expressways, and principal arterials (but not on minor arterials, collector or local streets).

To assess induced travel using the empirical approach, simply use the formula for an elasticity, and solve for the final VMT:

$$\frac{\%Change\ in\ VMT}{\%Change\ in\ Lane\ Miles} = Elasticity$$

In its VMT Technical Advisory, OPR provides the algebraic form of this equation that can be used directly, and lists the required inputs:

To estimate VMT impacts from roadway expansion projects:

1. Determine the total lane-miles over an area that fully captures travel behavior changes resulting from the project (generally the region, but for projects affecting interregional travel look at all affected regions).
2. Determine the percent change in total lane miles that will result from the project.
3. Determine the total existing VMT over that same area.
4. Multiply the percent increase in lane miles by the existing VMT, and then multiply that by the elasticity from the induced travel literature:

[% increase in lane miles] x [existing VMT] x [elasticity] = [VMT resulting from the project]

A National Center for Sustainable Transportation tool can be used to apply this method: https://ncst.ucdavis.edu/research/tools

Technical Advisory on Evaluating Transportation Impacts in CEQA, OPR 2018.

While the assessment is straightforward, it is important to apply the appropriate data. Specifically, it is important to choose VMT and lane mile data to match the federal functional facility classifications used in the research from which the elasticity is taken. And, it must be applied to facility types and geographies that match the studies from which the elasticities are taken. NCST's Induced Travel Calculator is designed to automatically address these issues. Advantages of using the tool include that it has assembled all the needed data, it automatically chooses an elasticity appropriate for the location and functional classification of the facility, it automatically pulls the correct VMT and lane-mile information to undertake the calculation, and it is free and publicly available.

The empirical approach has the advantage of being based directly on the best available science; it entails a direct application of empirical studies that quantify induced travel. It also has the advantage over travel demand models that it captures the full induced travel effect, including the effect of the project on land use, which is required for analysis under CEQA. Note that the NCST tool assesses induced travel by applying county- or MSA-level total lane miles and VMT and an elasticity applicable to the facility's functional classification. It may not be sensitive to localized circumstances. The current release of the NCST Tool is based on the 2016 VMT and lane mile data from the Caltrans Highway Performance Monitoring System (HPMS) Program. Effort is underway to make sure the tool is updated using the most current data available.

The NCST tool assesses induced travel for the horizon year. It does not distinguish between GP and HOV lanes, so the tool cannot be used to assess the difference in induced travel between those two project types.

TRAVEL DEMAND MODEL-BASED APPROACH

A travel demand model-based approach may be used to assess induced VMT in conjunction with off-model post-processing and/or iteration. Note that OPR's technical advisory recommends checking results from a travel demand model-based approach using the empirical approach (i.e. the elasticity-based approach) wherever possible (OPR Technical Advisory, p. 34).

Travel demand models assess travel between land uses explicitly, applying mathematical functions to predict travel between locations. They are not, however, able to assess changes in land use that will result from the project, and some are unable to assess increases in trips resulting from the project, each of which can lead to an underestimation of induced vehicle travel if that effect is not addressed off-model. Also, models employing static trip assignment may fail to constrain modeled vehicle flows along links, impeding ability to assess the difference in vehicle travel with and without a capacity-increasing project (Marshall 2018).

As noted by the OPR Technical Advisory (Appendix 2, page 33):

"Proper use of a travel demand model can capture the following components of induced VMT:

- *Trip length (generally increases VMT)*[2]
- *Mode shift (generally shifts from other modes toward automobile use, increasing VMT)*
- *Route changes (can act to increase or decrease VMT)*
- *Newly generated trips (generally increases VMT)*
  - *Note that not all travel demand models have sensitivity to this factor [newly generated trips], so an off-model estimate may be necessary if this effect could be substantial.*

However, estimating long-run induced VMT also requires an estimate of the project's effects on land use…If a lead agency chooses to use a travel demand model, additional analysis would be needed to account for induced land use." An add-on approach, such as use of a land use model (if an accurate one is available) or the input of an expert panel, should be applied to assess the land use change component of the induced travel effect, and that should be fed back into the travel demand model for VMT

[2] The Advisory is here speaking of road capacity projects and not transportation projects in general.

assessment. OPR's technical advisory recommends checking the results using the empirical approach (i.e. the elasticity-based approach) described above (p. 34).

For projects, alternatives, or mitigations for which the NCST Induced Travel Calculator is not applicable, a travel demand model can be used so long as off-model post processing and/or iteration with an add-on approach is applied to cover any known deficiencies (e.g. land use, trip generation).

Where a travel demand model is used, generally the regional travel demand model will be the most appropriate. However, near a model boundary, a regional travel demand model may truncate the VMT assessment, which may result in an underestimate of induced VMT. This truncation can be addressed by adding exterior "halo zones" to the model to extend its geographical reach, or with an off-model estimate of VMT (for example, multiplying gateway volumes provided by the California Statewide Travel Demand Model (CSTDM) with distance to the next major destination or job center, and adding that to the model's assessment).

In some cases, a regional travel demand model may not be available. In those cases, a qualitative assessment may be appropriate.

No sensitivity to trip generation (some travel demand models). If the trip generation sub-model is not sensitive to travel time and cost, then the analyst will need to provide for a manual intervention in the trip generation stage of the model to adjust the trip generation rates in the model for off-line computed induced travel effects of the project, its alternatives, and potential mitigation measures.

The analyst can employ activity based travel model parameters borrowed from a similar region to manually estimate off-model the effects of the project, its alternatives, and potential mitigation measures on trip generation with and without the project for the desired forecast years (with the land use linkage described above activated) and noting the predicted percentage change in trip generation by purpose predicted by the activity based travel demand model parameters. These percentages, which will vary by project alternative, may then be applied to the output of the trip generation stage of the trip-based model.

No sensitivity to land use (all travel demand models). Any travel demand model used to assess induced travel must be paired, or iterated, with an approach for predicting changes in land use caused by the project.

OPR's VMT Technical Advisory (*Appendix 2, Induced Travel Mechanisms, Research, and Additional Assessment Approaches*, p. 34) lists options for incorporating land use effects in a travel model-based assessment:

"*Options for estimating and incorporating the VMT effects that are caused by the subsequent land use changes include:*

1. *Employ an expert panel. An expert panel could assess changes to land use development that would likely result from the project. This assessment could then be analyzed by the travel demand model*

to assess effects on vehicle travel. Induced vehicle travel assessed via this approach should be verified using elasticities found in the academic literature.

2. *Adjust model results to align with the empirical research. If the travel demand model analysis is performed without incorporating projected land use changes resulting from the project, the assessed vehicle travel should be adjusted upward to account for those land use changes. The assessed VMT after adjustment should fall within the range found in the academic literature.*
3. *Employ a land use model, running it iteratively with a travel demand model. A land use model can be used to estimate the land use effects of a roadway capacity increase, and the traffic patterns that result from the land use change can then be fed back into the travel demand model. The land use model and travel demand model can be iterated to produce an accurate result."*

Model forecast year doesn't match project horizon year. If the model forecast years do not match the needed project analysis assessment years, then the analyst may:

- Run the model for the project analysis forecast year with and without the project with new interpolated or extrapolated socio-economic and network data inputs to the model.
- Run the model with and without the proposed project for the model's original forecast years and manually extrapolate or interpolate the results to the desired project analysis years.

Lack of coverage. The analyst should ensure assessment of VMT impacts is not truncated geographically. Also, the analyst should ensure a model assesses VMT for an appropriate day of the week or season of the year.

Geographical Coverage: Using a select link analysis, the analyst should check whether links that run up to the model's edge show increased volumes as a result of the project. If they do, that indicates VMT increases likely continue outside the model's boundary. Where that is the case, one of three approaches can be used to capture that VMT. First, "halo zones" can be added to capture the additional VMT within the model. Second, a reasonable assumption can be made about length of the missing portion of the trip (e.g. use the distance to next major jobs or population center, if trips are likely headed there), and that distance can be multiplied by the volume. Third, a model with greater coverage, such as the CSTDM, can be used.

Temporal Coverage: The analyst should examine the peaking of traffic flows in the area served by the project to determine the needed temporal coverage of the model (weekday peak hours, peak periods, daily, weekends and holidays, recreational seasons, full year), and then check to ensure the model assesses those time periods.

The VMT attributable to a project is the difference between the project and no-project network-wide VMT for the same forecast year.

Additional model checks for trip-based models

Many trip-based model operators provide for the feedback of congested travel times and costs to the trip distribution stage. This feedback is not often equilibrated, so the analyst should check that origin-destination travel times at the end of traffic assignment are similar to those input into the trip distribution stage. The comparison should be on a cell by cell basis of the travel time skim matrix used to distribute trips. The analyst should use their judgement as to how close the two sets of times must be on a cell-by-cell basis and overall (such as average trip time across all the cells of each matrix).

Many trip-based model operators provide for the feedback of congested travel times and costs to the mode choice stage. This feedback is not often equilibrated, so the analyst should check that origin-destination travel times by mode at the end of traffic assignment are similar to those input into the mode choice stage. The comparison should be on a cell by cell basis of the modal travel time skim matrices used to split trips between modes of travel. The analyst should use their judgement as to how close the two sets of times for each mode must be on a cell-by-cell basis and overall (such as average trip time across all the cells of each mode’s travel time matrix).

Trip-based models employing equilibrium traffic assignment automatically incorporate route choice induced travel effects. Analysts should review the model documentation for models employing alternate traffic congestion sensitive traffic assignment methods to assess the sufficiency of the method for the analyst’s needs.

Trip-based models employing all-or-nothing assignment, assigning all trips to the shortest path do not capture the demand inducing effects of a project on route choice. If congestion is likely with or without the project, then the analyst should consider adding a congestion sensitive traffic assignment method to the model.

PROJECTS SCREENING

The OPR Technical Advisory (California Governor's Office of Planning and Research, 2018) lists (starting on page 20 of that document) many categories of highway projects “that would not likely lead to a substantial or measurable increase in vehicle travel, and therefore generally should not require an induced travel analysis”. The list includes:

- *“Rehabilitation, maintenance, replacement, safety, and repair projects designed to improve the condition of existing transportation assets (e.g., highways; roadways; bridges; culverts; Transportation Management System field elements such as cameras, message signs, detection, or signals; tunnels; transit systems; and assets that serve bicycle and pedestrian facilities) and that do not add additional motor vehicle capacity.*
- *Roadside safety devices or hardware installation such as median barriers and guardrails.*
- *Roadway shoulder enhancements to provide “breakdown space,” dedicated space for use only by transit vehicles, to provide bicycle access, or to otherwise improve safety, but which will not be used as automobile vehicle travel lanes.*
- *Addition of an auxiliary lane of less than one mile in length designed to improve roadway safety.*
- *Installation, removal, or reconfiguration of traffic lanes that are not for through traffic, such as left, right, and U-turn pockets, two-way left turn lanes, or emergency breakdown lanes that are not utilized as through lanes.*

- *Addition of roadway capacity on local or collector streets provided the project also substantially improves conditions for pedestrians, cyclists, and, if applicable, transit.*
- *Conversion of existing general-purpose lanes (including ramps) to managed lanes or transit lanes, or changing lane management in a manner that would not substantially increase vehicle travel.*
- *Addition of a new lane that is permanently restricted to use only by transit vehicles.*
- *Reduction in number of through lanes.*
- *Grade separation to separate vehicles from rail, transit, pedestrians or bicycles, or to replace a lane in order to separate preferential vehicles (e.g., HOV, HOT, or trucks) from general vehicles.*
- *Installation, removal, or reconfiguration of traffic control devices, including Transit Signal Priority (TSP) features.*
- *Installation of traffic metering systems, detection systems, cameras, changeable message signs and other electronics designed to optimize vehicle, bicycle, or pedestrian flow.*
- *Timing of signals to optimize vehicle, bicycle, or pedestrian flow.*
- *Installation of roundabouts or traffic circles.*
- *Installation or reconfiguration of traffic calming devices.*
- *Adoption of or increase in tolls.*
- *Addition of tolled lanes, where tolls are sufficient to mitigate VMT increase.*
- *Initiation of new transit service.*
- *Conversion of streets from one-way to two-way operation with no net increase in number of traffic lanes.*
- *Removal or relocation of off-street or on-street parking spaces.*
- *Adoption or modification of on-street parking or loading restrictions (including meters, time limits, accessible spaces, and preferential/reserved parking permit programs).*
- *Addition of traffic wayfinding signage.*
- *Rehabilitation and maintenance projects that do not add motor vehicle capacity.*
- *Addition of new or enhanced bike or pedestrian facilities on existing streets/highways or within existing public rights-of-way.*
- *Addition of Class I bike paths, trails, multi-use paths, or other off-road facilities that serve nonmotorized travel.*
- *Installation of publicly available alternative fuel/charging infrastructure.*
- *Addition of passing lanes, truck climbing lanes, or truck brake-check lanes in rural areas that do not increase overall vehicle capacity along the corridor."*

APPENDIX A. BACKGROUND: INDUCED TRAVEL

When capacity is increased on a congested roadway, vehicle travel times dip, making vehicle travel quicker and easier, which in turn leads to more vehicle travel. This additional vehicle travel induced by the added roadway capacity is called “induced travel”. The chart below, from Milam et al., (2017), illustrates how the effect unfolds over time:

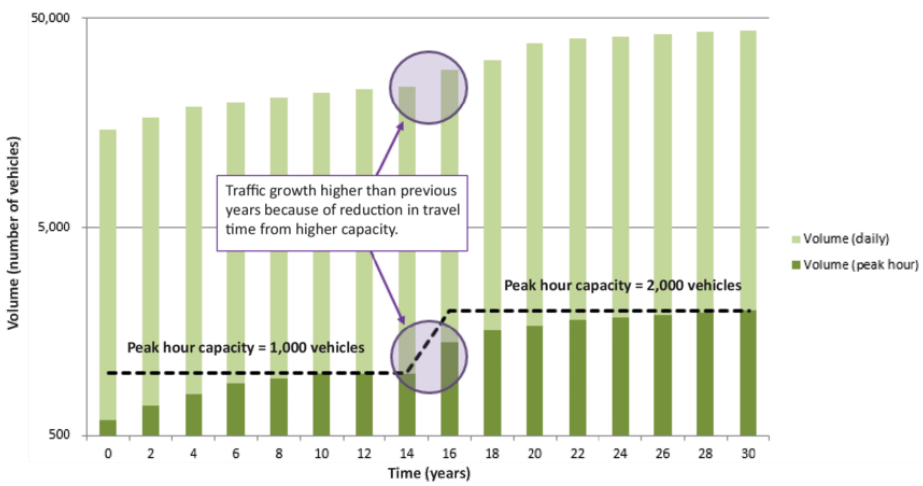

Figure A-1 Example of Induced Travel: Influence of Capacity Expansion on Vehicle Traffic Growth

Adding capacity to an existing roadway generally causes traffic congestion to dip, reducing the “time-cost” of travel. That reduction leads to more vehicle travel, as shown in the following figure from Milam et al., (2017). Much like any public utility (e.g. electricity or water), more is used when the impedance or cost is reduced.

Adding a new road where there wasn’t one before has a similar effect. It opens new and more distant areas to development. This increases vehicle travel regardless of the volume to capacity ratio after the new link is opened.

Induced travel occurs via five mechanisms:

- Route changes (may increase or decrease overall VMT)
- Mode shift (increases overall VMT)
- Longer trips (increases overall VMT)
- More trips (increases overall VMT)
- More disperse development (increases overall VMT)

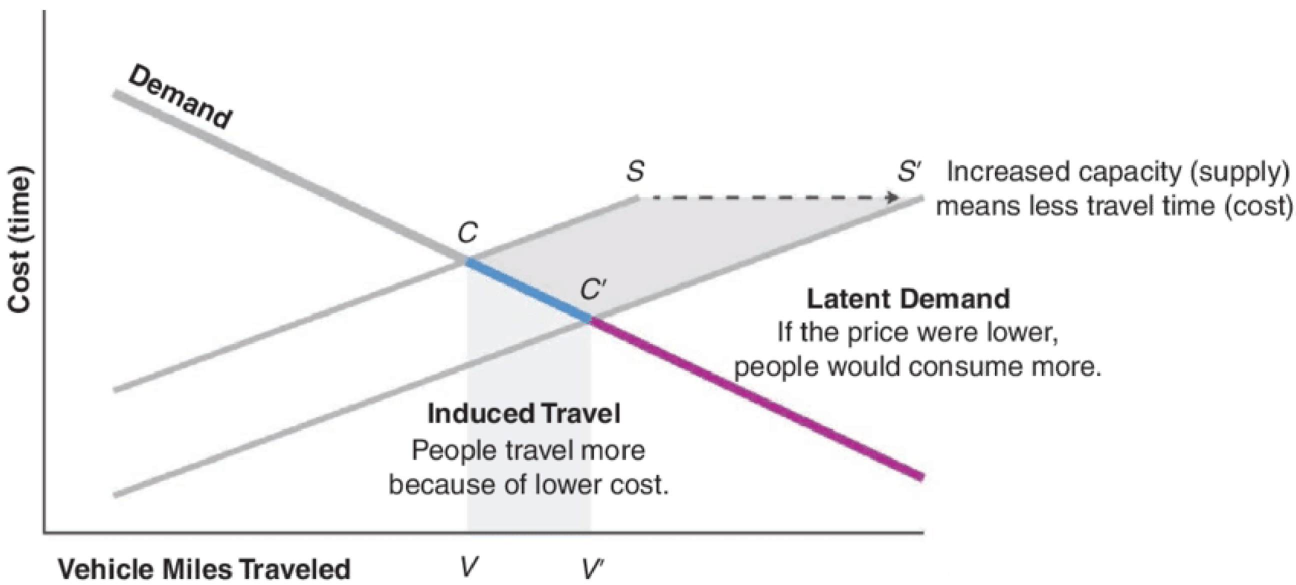

Figure A-2 Supply and Demand Relationships for Induced Travel (C=initial cost; C'=new cost; S=initial supply/capacity; S'=new supply/capacity; V=initial VMT; V'=new VMT)

APPENDIX B. A CASE STUDY

There will be one comprehensive case study covering the entire gamut of the CEQA document development process, using both TAF and Transportation Analysis under CEQA (TAC). To be added!

APPENDIX C. THE NCST INDUCED TRAVEL CALCULATOR

The UC Davis National Center for Sustainable Transportation (NCST) Induced Travel Calculator is designed to enable the estimation of *"the VMT induced annually as a result of adding general-purpose or high-occupancy-vehicle (HOV) lane miles to roadways managed by the California Department of Transportation (Caltrans) in one of California's urbanized counties (counties within a Metropolitan Statistical Area (MSA))."*

The NCST calculator predicts only those changes in regional annual VMT that are due to capacity improvements. In order to isolate those effects, it purposefully excludes changes in VMT due to land use changes, population, employment, income, tolls, price of gasoline, or other travel cost changes.

The calculator applies only to Caltrans-managed facilities with Federal Highway Administration (FHWA) functional classifications of 1, 2 or 3, which respectively corresponds to interstate highways (Class 1), other freeways and expressways (Class 2), and other principal arterials (Class 3).

The tool and additional documentation on the tool are available at: https://blinktag.com/induced-travel-calculator/index.html . The "About" tab at the website provides the technical documentation.

CONCEPTS

Handy and Boarnet (Handy & Boarnet, Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions Policy Brief, 2014) define "induced travel" as an "increase in vehicle miles traveled (VMT) attributable to increases in capacity."

According to Handy and Boarnet, "*Increased highway capacity can lead to increased VMT in the short run in several ways: if people shift from other modes to driving, if drivers make longer trips (by choosing longer routes and/or more distant destinations), or if drivers make more frequent trips. Longer-term effects may also occur if households and businesses move to more distant locations or if development patterns become more dispersed in response to the capacity increase. Capacity expansion can lead to increases in commercial traffic as well as passenger travel.*"

"*The induced-travel impact of capacity expansion is generally measured with respect to the change in VMT that results from an increase in lane miles, determined by the length of a road segment and its number of lanes (e.g. a two mile segment of a four-lane highway equates to eight lane miles). Effect sizes are usually presented as the ratio (elasticity) of the percent change in VMT associated with a one percent change in lane miles."*

According to a survey of the literature by Handy and Boarnet, *"Elasticity estimates of the short-run effect of increased highway capacity range from 0.3 to 0.6. Estimates of the long-run effect of increased highway capacity are considerably higher, mostly falling into the range from 0.6 to just over 1.0."*

RESEARCH BASIS

Handy and Boarnet (Handy & Boarnet, Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions Technical Background Document, 2014) provides some of the technical background for six of the studies they included in their policy brief. Key characteristics shared by many of the research studies upon which the elasticity estimates are based are:

- They measure changes in regional, county, or statewide VMT and lane-miles of road in most cases only on freeways. Some focused on state owned highways. One used samples from the US DOT Highway Statistics database for all road types in that database.
- Data on changes in capacity and traffic volumes for non-freeways, minor roads and arterials was not available to the researchers in most cases so they could not account for diversion effects, where traffic shifts to and from minor roads and arterials in the region to the freeways. The background documentation for the UC Davis NCST Induced Travel Calculator states that Duranton estimated this unmeasured diversion effect to be between zero and 10% (which would have no effect or reduce the reported elasticity).
- The long-term time frames considered varied from 14 years to 22 years.
- They fitted log-linear regression models with lane-miles as one of various explanatory factors for observed changes in regional or county VMT.
- They all included changes in population as one of the explanatory factors but varied in what additional variables impacting VMT were included. Some included income, some employment density, some fuel cost. The additional explanatory factors usually lowered the elasticity with respect to lane-miles.
- They used different approaches to control for demand driven capacity construction, called simultaneity bias.
- Three of the studies used only California data. Three used data from around the United States.

CALTRANS/FHWA HPMS FUNCTIONAL CLASSIFICATION SYSTEM

The Caltrans/FHWA functional classification system used in the UC Davis NCST Induced Travel Calculator is defined in an FHWA memorandum (https://www.fhwa.dot.gov/policy/ohpi/hpms/fchguidance.cfm):

Functional Class 1 = Interstate
Functional Class 2 = Other Freeways and Expressways
Functional Class 3 = Other Principal Arterial
Functional Class 4 = Minor Arterial
Functional Class 5 = Major Collector
Functional Class 6 = Minor Collector
Functional Class 7 = Local

Note that according to the technical documentation for the NCST Induced Travel Calculator, functional classes 1, 2, and 3 are within the scope of the NCST tool provided that they are state highways.

The FHWA memorandum states in Section 5, Ramps and Other Non-Mainline Highways*: "Note that at this time, there is no change to the status of ramps with respect to public road mileage or lane mileage or vehicle-miles traveled for apportionment purposes; they are not considered mainline and are not included in those public road mileage inventories."*

Regarding other non-mainline roadways, the memorandum states: *"At their option, States may collect data and assign functional classifications to other kinds of non-mainline roadways. These may include other collector-distributor roads, other turning movement facilities not associated with a grade-separated interchange, and other auxiliary roadways. In general, such roadways within the interchanges should be assigned the same functional classification as the highest facility served. However, since many configurations exist, States may assign the functional classification as they deem appropriate. While data for other non-mainline roadways is not required for HPMS, States have the option of reporting it beginning with the 2009 HPMS data reported in 2010."*

SCOPE OF NCST INDUCED TRAVEL CALCULATOR

The technical documentation for the NCST Induced Travel Calculator defines the scope of application for the tool (see https://blinktag.com/induced-travel-calculator/about.html *accessed October 31, 2019):*

- *"The calculator is limited to use for capacity expansions. It cannot be used to estimate VMT effects of capacity reductions or lane type conversions.*
- *The calculator is limited to use for additions of general-purpose and high occupancy vehicle lanes.*
    - *It should not be used for additions of toll lanes or high occupancy-toll (HOT) lanes.*
    - *Hundreds of both general-purpose and HOV lane mile additions were included in the two studies used to derive the elasticities for the calculator* (Duranton & Turner, 2011)*;* (Cervero & Hansen, 2002)*;* (Long & Curry, 2000)*. By contrast few toll and high-occupancy toll (HOT) lanes were added to Caltrans-managed roadways before the end of the data collection periods for the two studies. The studies' estimated elasticities therefore might not reflect – and this calculator should not be used to estimate the induced travel impacts of toll and HOT lanes.*
- *The calculator is limited to use for lane additions to Caltrans-managed roadways with FHWA functional classifications of 1, 2 or 3. See Caltrans' California highway system map with functional class delineations.*
- *The calculator is limited to use in California's 37 urbanized counties (counties within MSAs). The calculator cannot be used to assess the VMT effects of roadway expansions in California counties outside of MSAs, or in any geography outside California.*
- *Please also be aware that there are 10 MSAs in which there are no interstate highways. In addition, sufficient data are not available on baseline VMT for interstate lane miles in the Napa MSA to calculate induced VMT from interstate capacity expansions there.*
- *The calculator produces long-run estimates of induced VMT, the additional annual VMT that could be expected 5 to 10 years after facility installation.*
- *All estimates account for the possibility that some of increased VMT on the expanded facility is traffic diverted from other types of roads in the network. In general, the studies show that*

"capacity expansion leads to a net increase in VMT, not simply a shifting of VMT from one road to another" (Handy & Boarnet, Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions Policy Brief, 2014)

- *The calculator currently uses 2016 lane mileage and VMT data. The data will be updated periodically as new data become available.*
- *Knowledge of local conditions can help contextualize the calculator's estimates."*

Table C-1 lists the California counties where according to the technical documentation on the NCST Induced Travel Calculator website the NCST tool can be applied. There are eleven counties which have insufficient interstate freeway mileage or interstate VMT data for the NCST tool's elasticities to be applied to interstate freeways (Class 1) within the county. In these eleven counties the tool can be used only for Class 2 and 3 state highway lane additions. There are 21 rural counties where the tool cannot be used for any state highway project, according to its technical documentation.

Table C-1: California Counties Where NCST Induced Travel Calculator Can be Used

County	OK to Use?	County	OK to Use?
1. Alameda	Classes 1, 2, and 3	**30. Orange**	Classes 1, 2, and 3
2. Alpine	No	**31. Placer**	Classes 1, 2, and 3
3. Amador	No	**32. Plumas**	No
4. Butte	Classes 2, 3	**33. Riverside**	Classes 1, 2, and 3
5. Calaveras	No	**34. Sacramento**	Classes 1, 2, and 3
6. Colusa	No	**35. San Benito**	Classes 1, 2, and 3
7. Contra Costa	Classes 1, 2, and 3	**36. San Bernardino**	Classes 1, 2, and 3
8. Del Norte	No	**37. San Diego**	Classes 1, 2, and 3
9. El Dorado	Classes 1, 2, and 3	**38. San Francisco**	Classes 1, 2, and 3
10. Fresno	Classes 1, 2, and 3	**39. San Joaquin**	Classes 1, 2, and 3
11. Glenn	No	**40. San Luis Obispo**	Classes 2, 3
12. Humboldt	No	**41. San Mateo**	Classes 1, 2, and 3
13. Imperial	Classes 1, 2, and 3	**42. Santa Barbara**	Classes 2, 3
14. Inyo	No	**43. Santa Clara**	Classes 2, 3
15. Kern	Classes 1, 2, and 3	**44. Santa Cruz**	Classes 1, 2, and 3
16. Kings	Classes 1, 2, and 3	**45. Shasta**	Classes 1, 2, and 3
17. Lake	No	**46. Sierra**	No
18. Lassen	No	**47. Siskiyou**	No
19. Los Angeles	Classes 1, 2, and 3	**48. Solano**	Classes 1, 2, and 3
20. Madera	Classes 2, 3	**49. Sonoma**	Classes 2, 3
21. Marin	Classes 1, 2, and 3	**50. Stanislaus**	Classes 1, 2, and 3
22. Mariposa	No	**51. Sutter**	Classes 1, 2, and 3
23. Mendocino	No	**52. Tehama**	No
24. Merced	Classes 1, 2, and 3	**53. Trinity**	No
25. Modoc	No	**54. Tulare**	Classes 2, 3
26. Mono	No	**55. Tuolumne**	No
27. Monterey	Classes 2, 3	**56. Ventura**	Classes 2, 3
28. Napa	Classes 2, 3	**57. Yolo**	Classes 1, 2, and 3
29. Nevada	No	**58. Yuba**	Classes 2, 3

Source: See text and links embedded in https://blinktag.com/induced-travel-calculator/about.html

APPENDIX D. GLOSSARY

Capacity	The Sixth Edition of the Highway Capacity Manual defines capacity as: The maximum sustainable hourly flow rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, environmental, traffic, and control conditions.
CEQA	California Environmental Quality Act
EIR	Environmental Impact Report (state)
EIS	Environmental Impact Statement (federal)
Elasticity	The percentage change of something divided by the percentage change in something else. In transportation forecasting, we can apply studies that provide the percent change in regional VMT divided by the percent change in regional lane-miles of state highways as elasticity.
FHWA	Federal Highway Administration
HCM	Highway Capacity Manual
Induced Travel (VMT)	Induced travel or the VMT attributable to a transportation capacity increase is the increased amount of vehicle travel on the transportation network that is caused by the highway capacity increase. Over the short run, travel behavior changes including longer trips, more trips, mode shift, and route shift all tend to occur as a result of a highway capacity increase. Over the long run, these effects intensify (e.g. as people shift job or residential location to benefit from the infrastructure), and also land use development may become more dispersed, adding additional vehicle travel; for these reasons, long run induced travel is generally greater than short run induced travel. Additionally, other factors, such as population growth, economic growth, and changes in the price of vehicle travel may also add to the amount of vehicle travel on the transportation network; however, these additions in vehicle travel are not part of induced travel and are not attributable to the project.

Latent Demand	Latent demand is the travel that would occur on the transportation network if travel times (or costs) were reduced. Much like any public utility (e.g. electricity or water), consumers will use more of it when its cost or impedance of use is reduced or made free. Note that unless the current price of travel is zero (instantaneous travel at will at no cost), there is always latent demand.
NEPA	National Environmental Protection Act
Network	The connectivity of a transportation system. Changes in connectivity may change travel time and cost. Travel demand models will usually represent network connectivity within modes and across modes through a set of links connecting nodes.
OPR	Governor's Office of Planning and Research
Travel Demand Model	A travel demand model is any relatively complex computerized set of procedures for predicting future trip making as a function of land use, demographics, travel costs, the road system, and the transit system. These models often cover an entire metropolitan area or the entire state, but may also focus on a single city or county.
Transit	Transit generally includes all forms of shared common carrier passenger ground transportation in moderate to high capacity vehicles ranging from dial-a-ride vans to buses, trolleys, light rail, commuter rail, and intercity rail transportation. Less common modes of travel, such as employer provided buses, charter buses, taxis, and transportation network company (TNC) services, have historically not been modeled as explicit transit modes in MPO travel demand models.
Trip-Based Model	Trip-based travel models use the individual person trip as the fundamental unit of analysis. Trip-based models are often referred to as "4-step" models because they split the trip making decision process into 4 discrete steps: trip generation by time of day, destination choice, mode choice, and route choice (traffic assignment).

Trucks	Trucks are a subtype of the heavy vehicles category which includes trucks, intercity buses, and recreational vehicles. This Framework follows the Highway Capacity Manual definition of what constitutes a heavy vehicle: "A vehicle with more than four wheels touching the pavement during normal operation." This is consistent with the Caltrans Traffic Census definition of a truck: "The two-axle (truck) class includes 1-1/2-ton trucks with dual rear tires and excludes pickups and vans with only four tires."
Vehicle Miles Traveled (VMT)	The number of miles traveled by motor vehicles on roadways in a given area over a given time period. VMT may be subdivided for reporting and analysis purposes into single occupant passenger vehicles (SOVs), high occupancy vehicles (HOV's), buses, trains, light duty trucks, and heavy-duty trucks. For example, an air quality analysis may require daily VMT by vehicle class and average speed or vehicle operating mode (idle, acceleration, cruise, deceleration, etc.). For a CEQA compliant transportation impact analysis, automobile VMT (cars and light trucks) may be evaluated.
VMT Attributable to a Project	In the context of a CEQA analysis, the OPR Technical Advisory suggests that the VMT attributable to a transportation project, or induced travel, is the difference in VMT between the with project and without project alternatives. The OPR Technical Advisory also suggests that heavy duty trucks might be excluded from the VMT attributable to a project.

APPENDIX E. REFERENCES

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