An Alternative to LOS: A Traffic Impact Analysis Standard Based on Auto Trips Generated

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ABSTRACT
Many states and cities require evaluation of the potential transportation impacts of proposed development and other projects, through environmental impact analysis, congestion management rules, or adequate public facilities requirements. In California, the California Environmental Quality Act (CEQA) requires public agencies to evaluate potential transportation impacts. The City of San Francisco currently uses the Highway Capacity Manual's Level of Service (LOS) intersection delay measure to identify transportation impacts. The San Francisco County Transportation Authority is encouraging the City to replace LOS with a measure based on the number of automobile trips generated by a proposed project. An auto trips generated impact measure would create consistency between the City's implementation tools and its Transit First Policy, which recognizes that short term LOS impacts will occur as improvements to transit, bicycling, and walking are implemented. This paper describes the Authority's effort to define a transportation impact analysis measure based on the volume of auto trips generated by a project. Potential "thresholds of significance" – the points at which the volume of auto trips generated by a proposed project constitutes a significant negative environmental impact – are described. The thresholds under consideration are based on the effects of auto traffic on mobility, quality of travel service, safety, neighborhood conditions, and other factors. The near term objective of the effort is to forward a new measure and threshold for adoption by the City for environmental impacts analysis purposes. In the longer term, the measure could provide a basis for a transportation impact fee.

BACKGROUND

Many states require analysis of potential transportation impacts of new development and other projects, through requirements for environmental impact analysis, congestion management, or adequate public facilities. The California Environmental Quality Act (CEQA) requires California's public agencies to evaluate the potential for significant impacts on the environment, including on transportation, from proposed projects. CEQA also encourages agencies to develop thresholds of significance—the quantitative point at which an environmental effect may be considered significant—to facilitate these determinations. Although CEQA gives jurisdictions discretion to adopt impact measures locally, California agencies and agencies in other states with similar requirements typically measure project effects on transportation using the Highway Capacity Manual's Level of Service (LOS) (1) measure (typically of intersection delay) (2). The City of San Francisco enforces intersection LOS "E" as the threshold of significance for traffic impacts (3).

The San Francisco County Transportation Authority (Authority) is encouraging the City of San Francisco to replace LOS as the measure and threshold for traffic impact with a measure based on the number of automobile trips generated by a proposed project. As reported in Hiatt (2006) (4) and in previous Authority work (5), San Francisco's use of LOS is not an appropriate measure of the environmental impact of proposed projects in an urban area. Specifically, use of LOS for this application is:

- Unpredictable and not transparent for project sponsors;
- Inefficient for the Planning Department, which administers the CEQA locally; and
- Inconsistent with the Transit First policy in San Francisco's City Charter.

Furthermore, use of the LOS measure in this application is inconsistent with the Authority's efforts to measure transportation system performance with multimodal measures (6).

San Francisco's Transit First Policy, Section 16.102 of the City Charter (7), states in part:

1. "The primary objective of the transportation system must be the safe and efficient movement of <u>people</u> *(emphasis added)* and goods;" and
2. "Decisions regarding the use of limited public street and sidewalk space shall encourage the use of public rights of way by pedestrians, bicyclists, and public transit, and shall strive to reduce traffic and improve public health and safety."

With these clauses, the Transit First policy recognizes that short-term auto congestion (i.e., LOS impact) is an expected consequence of implementing the Transit First policy, and recognizes that mode shift will occur gradually as these modal networks are improved.

The City's adopted transportation policies should be implemented in part through tools such as the measure used to determine when a proposed project would have a significant impact on the transportation system. However, the Authority describes the conflict between Transit First and LOS thresholds as the "incumbent mode" problem:

- Because auto is the dominant mode on the network, and
- The City's road network is built-out, and
- Existing rights-of-way (ROW) for transit, bicycles, and pedestrians are limited,
- Auto LOS tends to be maintained at the expense of improvements to transit, bicycle and pedestrian LOS when right-of-way trade-offs are required (5).

San Francisco's next generation of multi-modal transportation improvements will require a system management approach, including re-allocating rights-of-way from mixed flow traffic to pedestrian, bicycle, and transit uses. Since improvements to one mode often come at the expense of other modes - especially in a built-out environment—the City's current LOS standard places priority on minimizing a project's contribution to auto congestion, often at the expense of transit, bicycle, and pedestrian conditions. The policy is also a barrier to "Transit First" projects such as Bus Rapid Transit or bicycle lanes, which may degrade LOS. The City's CEQA implementation tools should reflect the city's recognition that LOS impacts are expected those improvements are implemented.

Transportation planners increasingly recognize this conflict, and many researchers and agencies are testing alternatives (4). Agencies in Florida, Maryland, and Washington State are among those that have implemented or are testing alternative approaches to transportation impact measurement. The tools under development include multimodal level of service measures and lower LOS standards in urban settings where infill and transit are encouraged.

Fortunately, as stated above, the laws governing California's impact analysis do not explicitly require use of LOS to measure transportation impacts. CEQA grants agencies authority to define impact standards consistent with local policy. To marry local policy with implementation, the Authority has proposed that the City's LOS measure of transportation impact be replaced with a measure based on the automobile trips generated by a project. The benefits of defining environmental impact as the auto trips generated by a project include:

- Consistency with City policy, by recognizing that adding additional car trips to SF streets is environmentally undesirable;
- Easing of Planning Department development reviews of development and transportation projects, by applying well-developed methods already in existence; and
- Increased appropriateness, by capturing a broader range of negative effects on transportation than the narrow LOS measure.

This paper documents the Authority's effort, in progress, to develop a measure of auto trips generated for environmental impact analysis purposes. Much of this work includes the effort to identify a technically rigorous significance threshold – the point at which the auto trips generated by a project would have a significant negative effect on the environment. To withstand possible legal challenges, the environmental significance threshold for auto trips generated must be strongly link automobile trips generated by development to the environmental effects of those trips.

THRESHOLDS OF SIGNIFICANCE - BEST PRACTICES AND EVALUATION CRITERIA

The California Governor's Office of Planning and Research (OPR) provides specific advice to public agencies for developing significance thresholds. To the extent possible, thresholds should be: quantitative and objective; based on specific and enforceable standards and regulations; consistent with, though not necessarily the same as, those of regulatory and other agencies; simple to interpret and implement; and supportive of local policies. Based on this guidance, a number of evaluation criteria guide our development of an LOS alternative.

Supported by Substantial Evidence

As required by CEQA, thresholds must be supported by "substantial evidence"— enough facts, data and other credible information that supports the threshold as the point at which an impact acquires significance (9). The guidelines define "substantial evidence:"

> [E]nough relevant information and reasonable inferences from this information that a fair argument can be made to support a conclusion, even though other conclusions might also be reached. Whether a fair argument can be made that the project may have a significant effect on the environment is to be determined by examining the whole record before the lead agency. Argument, speculation, unsubstantiated opinion or narrative, evidence which is clearly erroneous or inaccurate, or evidence of social or economic impacts which do not contribute to or are not caused by physical impacts on the environment does not constitute substantial evidence.
>
> And,
>
> Substantial evidence shall include facts, reasonable assumptions predicated upon facts, and expert opinion supported by facts.

The evidence supporting the threshold should be empirical (i.e., based on observations or experiments) and if possible, specific to San Francisco.

Consistent with Local Plans and Policies

Consistency with the Transit First policy as described in the previous section is one objective. Another policy consistency priority is to better match the city's transportation impact measure with its goals to reduce auto collisions. Auto trips are positively related to collisions; therefore, decreasing auto trips is consistent with local policy. The ATG definition should internalize this and other links between auto trips and negative effects as documented in local policies including the General Plan, the Countywide Transportation Plan, and the Congestion Management Plan.

For instance, the Countywide Transportation Plan specifically supports "…neighborhood livability, particularly through promotion of pedestrian activity to support neighborhood commercial activity." (10) Another stated goal calls for multimodal safety:

> …safety and security for all people sharing the streets, including pedestrians and cyclists, by reducing conflicts, accidents, and seismic vulnerability through improved facility design, education and enforcement.

Based on this, an auto trips generated threshold should incorporate the relationship between auto trips and neighborhood livability, and between auto trips and safety for all travelers (10).

Finally, the measure should be consistent with the Authority's Congestion Management Plan (6), which measures transportation performance using multimodal measures such as transit ravel times and ratio of transit to auto travel time.

Comprehensive
Based on case law and guidelines, impact measures should capture the broadest possible range of potential negative effects that a project could have on the transportation system, such as on mobility, accessibility, impacts to other modes, on neighborhood livability, and to health and safety.

Quantitative rather than qualitative, whenever possible
Quantitative thresholds are simpler to interpret and implement, are more objective and transparent, and encourage more-consistent application.

Easy to Calculate
The auto trips generated measure should not be more difficult to apply than the existing LOS measure, and should not increase the burden of CEQA analysis on local officials or project sponsors.

Non-Duplicative
The measure should not duplicate other established impact criteria.

CONCEPTUAL DEFINITION OF THE AUTO TRIPS GENERATED IMPACT MEASURE: APPROACH

This section identifies the conceptual links between auto trips generated by a project and effects on the transportation environment. Added auto trips have an array of negative effects on transportation; each effect is an approach to defining the auto trips generated measure and to identifying the significance threshold. Added auto trips have direct effects on the performance of the transportation system from the perspective of 1) the system user (traveler) of any mode; and 2) the system operator, the entity responsible for maintaining the entire transportation system, improving its performance, ensuring equitable service, and ensuring efficient operation. Auto trips also have external effects on the environment beyond the transportation system, including on air and water quality, noise levels, neighborhood livability, and greenhouse gas levels.

User Perspective
A number of researchers have developed models to measure the quality of transportation by transit, walking, and bicycling (4). These modal transportation LOS measures are sensitive to the effects of added vehicle trips on LOS for all modes, and auto volumes are negatively explanatory related to the LOS of any given mode of transportations. Bicycle LOS (11) and Pedestrian LOS (12) equations use auto volumes as an explanatory variable with a negative explanatory relationship. The Florida Transit Capacity & Quality of Service Manual (TCQSM) incorporates the negative impact of automobile traffic on bus lanes (13). The coefficient on auto volumes is negative; as auto volumes increase, transit, pedestrian and bicycle LOS decreases. The National Cooperative Highway Research Program (NCHRP) is currently funding research to a model of multimodal LOS, which would measure the performance of available surface transportation modes using a common denominator; this project is in progress, and results are not available at this time.

Although, theoretically, the threshold of significance for an auto trips generated measure could be derived from the model LOS models already developed, the coefficients on these models are not San Francisco specific.

System Performance Perspective
Mobility at the system level is often measured by average travel times or delays by mode. At low volume levels, added auto trips on a link do not meaningfully degrade speeds or raise travel times; thus, additional trips increase person throughput and mobility more than they degrade performance. However, as volumes approach the capacity of a link, each additional auto trip disproportionately adds delay for all users, including transit vehicles, thereby disproportionately affecting performance and mobility. (Changes in auto speeds affect transit speeds operating on the same link, thus both auto and transit system effects are encompassed).

This relationship is described by the well-known “BPR Equation” from the Bureau of Public Roads, shown in Equation (1). This equation has an exponential form which reflects this relationship of progressively worse performance as road volume increases.

$$t = t_0 \times \left(1.0 + \alpha \times \left[\frac{V}{C}\right]^{\beta}\right) \qquad (1)$$

Where,

t = average travel time for a vehicle on the link
t_0 = free flow travel time on link
V =*link volume or demand*
C = *link capacity*
α, β = *locally derived parameters, based on observed data*

The BPR curve models the effect of increasing volumes of traffic on mobility. The San Francisco Travel Demand Forecasting Model, SF-CHAMP, incorporates recently re-validated parameters α and β for five roadway types (facilities with different capacities) (14). SF-CHAMP estimates transit speeds as a function of auto speeds, so this approach quantifies multimodal impacts on mobility and person-throughput on San Francisco streets.

Safety

As auto volumes increase, collisions (especially with pedestrians) increase, providing another approach to a threshold for an auto trips generated impact measure (15). A one percent reduction in vehicle-miles traveled (VMT) reduces collisions by one percent (16); additionally, variation in U.S. highway fatalities correlates with variation in U.S. highway VMT (17). While much of the research on the relationships between vehicle usage and collisions is at the national or state level, some recent studies have documented these relationships with greater geographic specificity. LaScalla et al. (2000) found that traffic volumes are positively correlated with pedestrian / auto collisions in San Francisco neighborhoods (although the methodology of this study has been criticized) (18). Litman (2001) found a strong positive correlation between VMT and collisions in the Vancouver, B.C. region (19).

The San Francisco Department of Public Health has developed a model of San Francisco pedestrian collisions, currently in peer review, which provides a quantitative link between traffic volumes and pedestrian collisions in San Francisco (20). Traffic volumes in a census tract are an explanatory variable positively related to pedestrian injury collisions in San Francisco census tracts. The authors found that auto volumes have a statistically significant effect on the rate of pedestrian injury collisions. The coefficient on this variable quantifies the relationship between auto volumes and pedestrian collisions.

Air Quality, Water Quality and Noise Levels

Each new auto trip added to San Francisco streets has direct air quality, water quality, and noise impacts, relationships which could be used to identify an auto trips generated threshold. Numerous empirical studies have established the causal links between automobile use and these environmental impact areas. Ultimately, however, project impacts on water, noise and air quality are commonly analyzed independently (including under CEQA), so basing an auto trips generated threshold on this data would duplicate existing impact areas and “double count” impacts, and is not proposed.

Neighborhood Livability

Conceptually and from residents’ perspectives, additional auto trips on San Francisco streets reduce neighborhood livability. One approach to quantifying the impact of ATG on neighborhood livability is through real estate hedonic models. The effect of auto volumes on neighborhood quality can be measured by the way the market values real estate adjacent to traffic. Bagby (1980) and Hughes & Sirmans (1992) studied this effect and found that traffic volume changes of a few hundred vpd reduced adjacent residential property values between five and 25 percent (27).

Appleyard (1981) provides an alternative approach through oft-cited findings on the effects of auto traffic on residents’ perceptions and neighborhood activity in San Francisco neighborhoods (28). Appleyard studied the impacts of traffic volumes on resident perceptions and behavior. Perceived effects of traffic on safety, emissions, noise & vibrations, aesthetics, maintenance costs, privacy, parking availability, street and home life, and crime were included. The research found that changes in traffic volumes change residents’ levels of satisfaction with their neighborhood environment, and cause adaptive behavioral changes, indicating demonstrable impacts of auto volumes on these environmental and social factors. In particular, danger, noise, vibration, emissions, inconvenience, and intrusions on activities and the home increase with auto volumes, while appearance, maintenance, sense of home, sense of responsibility for one's neighborhood, and street activities decrease as auto volumes increase.

Appleyard's work was used as the basis for the Traffic Impact on the Residential Environment (TIRE) index, which is used as a CEQA measure/threshold system in the City of Palo Alto, a companion measure to traditional automobile LOS.

Carbon Emissions

Carbon dioxide emissions are not currently an impact requiring study under CEQA. This is changing, and policymakers are working to determine the best way to treat carbon impacts in environmental review. Changes to the global climate resulting from human activities are now considered by a vast majority of the scientific community to pose a significant threat to the environment (29). The US Supreme Court has ruled that the US EPA must consider carbon dioxide as a pollutant that should be regulated. The State of California adopted a climate action plan by Executive Order S-3-05 on June 1, 2005, and with the California Global Warming Solutions Act of 2006, adopted greenhouse gas emission-reduction targets (of year 2000 levels by 2010, 1990 levels by 2020; and 80 percent below 1990 levels by 2050).

In 2004, the San Francisco Public Utilities Commission and the Department of the Environment adopted a Climate Action Plan (CAP) designed to reduce greenhouse gas emissions produced by the City (30). The CAP reports that transportation creates 50% of carbon dioxide (CO_2) emissions in San Francisco, and sets a goal of reducing 963,000 tons of CO_2 emissions from the transportation sector by 2012. Priority is given to programs and policies that reduce motor vehicle trips, and increase the mode share of cycling, walking, public transit use, and ridesharing (31).

The CAP targets, which represent absolute reductions in vehicle use, could imply that any additional auto trips generated in San Francisco are a significant negative environmental effect.

POTENTIAL THRESHOLD(S) OF SIGNIFICANCE

The scales above provide strong conceptual and quantitative basis for defining the impacts that auto trips have on San Francisco's transportation environment, though some provide a better resource than others for the quantitative basis for identifying the point at which additional auto trips impose a significant impact. This evaluation is summarized in Table 1.

TABLE 1 Evaluation Summary

Evaluation Criterion	Supported by Substantial (Local) Evidence	Consistent with Plans	Non Duplicative	Overall
Mobility	HIGH	HIGH	HIGH	HIGH
Quality of Service	MED-LOW	HIGH	HIGH	MED
Safety	HIGH	HIGH	HIGH	HIGH
Neighborhood Livability	HIGH	HIGH	HIGH	HIGH
Water, Noise, Air Quality	MED-LOW	HIGH	LOW	MED
Carbon Emissions	HIGH	HIGH	LOW	LOW

This section identifies the potential thresholds of significance for each, and discusses methodological considerations.

Thresholds of Other Cities

At least two other California cities already use an impact measure based on the auto trips generated by a project for CEQA analysis purposes, although in all of the known cases, the volume of trips generated by a project is measured *in addition to* auto LOS, and not as a replacement (32). Nevertheless, the ATG thresholds set by other California cities can be considered for San Francisco.

Palo Alto, California

The City of Palo Alto applies a CEQA impact threshold for project-related increases in auto volumes on residential streets.

A project in Palo Alto would have a significant negative effect if it would increase vehicles per day (vpd) by 25 percent or more on a residential local, collector or arterial street. An increase of up to 150 vpd is acceptable regardless of the percentage increase or street type; and no increase is allowed on a local street beyond a total volume of 2500 vpd.

Palo Alto's threshold is based on local officials' experiences using the TIRE Index. The 25 percent traffic volume increase threshold for traffic increases corresponds to a 0.1 increase in the TIRE Index. According to the research behind the index, the 0.1 figure is the point at which changes in traffic volumes become noticeable (this threshold will be discussed further in the subsequent Neighborhood Livability section). The baseline value of 150 vpd was identified by local officials as within normal daily volume fluctuations. The ceiling of 2500 vpd was also identified by local officials as the maximum acceptable traffic volume on a local residential street.

San Jose, California

The City of San Jose limits traffic volume increases on "protected" intersections to 1% of existing volumes. "Protected" intersections are those located (i) within the downtown core area, as defined by the general plan; and, (ii) along transit-oriented development corridors, transit station areas, planned communities and neighborhood business districts, all as identified in the general plan.

For standard (non-protected) intersections, conventional intersection LOS thresholds apply and any impacts to LOS must be mitigated. Protected intersections, on the other hand, are subject to different requirements, because, according to the City,

> "To continue to expand local intersections in order to increase their vehicular capacity may, under certain circumstances, result in a deterioration of the local environmental conditions near those intersections, and an erosion of the City's ability to both encourage infill in designated Special Strategy Areas, and to support a variety of multi-modal transportation systems."

The City of San Jose has identified "protected" intersections in built-up areas which cannot be modified to operate at LOS standards and accommodate additional traffic that may be generated by transit improvements or private development. Proposed projects causing a significant LOS impact at a protected intersection are required to implement improvements to other parts of the City's transportation system and areas in the vicinity of the project site. Even for protected intersections, though, the 1% increase limit on auto volumes is enforced as the CEQA impact threshold.

It is important to note that the City does not consider such improvements to be mitigation measures for the purposes of CEQA, since they would not reduce or avoid the significance of the impact to intersection LOS. However, the sponsor of a project whose only significant impact was to the LOS of a protected intersection would not be required to prepare an Environmental impact report for the project. Instead, the environmental review for the project would be able to "tier" off the EIR that was certified by the City when it created its list of protected intersections. (That EIR acknowledged that traffic at protected intersections will eventually exceed the City's LOS standard. In certifying the EIR, the San Jose City council adopted a statement of overriding consideration for LOS impacts to those intersections.) If the project sponsor chooses not to implement the other transportation improvements or not to downsize the project sufficiently, the project would be found to have a significant unavoidable impact under CEQA.

Mobility, safety, and neighborhood livability-based thresholds

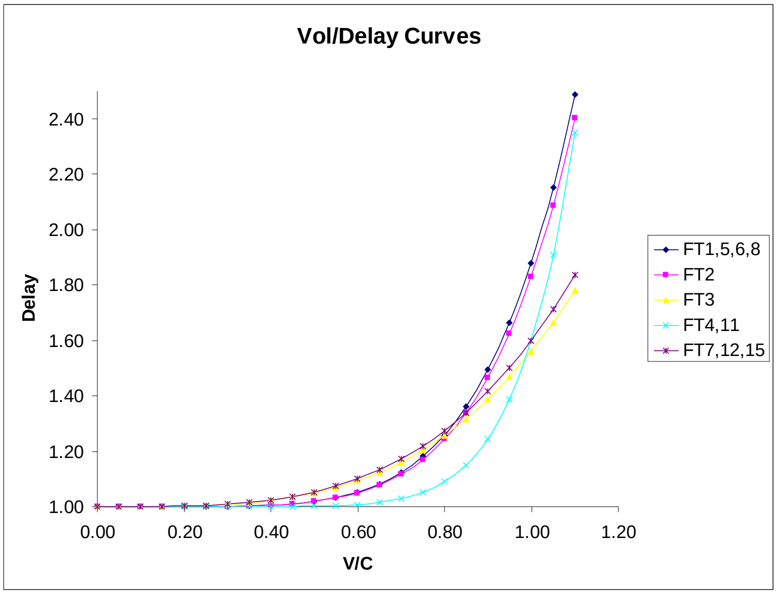
This section describes the specific significance thresholds derived for the safety, mobility, and neighborhood liability effects of auto trips described above.

Mobility

The BPR network assignment curves validated for San Francisco's countywide travel demand forecasting model, SF-CHAMP, provide an auto volume threshold level for mobility. The threshold is proposed as the auto volume level at which an additional car trip adds disproportionately more to delay than to person throughput. Figure 1 below shows the plots of San Francisco's BPR equations (delay, rather than travel time, is shown as the dependent variable on the y axis). A slightly distinct relationship between added auto trips and travel time changes is estimated for each of five facility types.

The exponential shape of the curves implies a natural threshold of significant effect - at the point where an additional car adds disproportionately more to delay than it adds to person-throughput. The threshold of significance – that is, the point at which added auto trips begin to significantly affect mobility by auto and by transit – can be identified by the point at which the slope of a line tangent to the curve is 45 degrees. At this point, one unit increase in auto volumes causes more than one unit increase in delay for autos and for transit vehicles. The value on the x axis, the volume to capacity (V/C) ratio, at that point is defined as the threshold for a link of that facility type. Since capacity (C) is constant for each facility type, this V/C can be directly translated to a threshold volume (V) above which significant mobility impacts occur.

FIGURE 1 Delay as a function of volume/capacity, as calibrated for San Francisco.

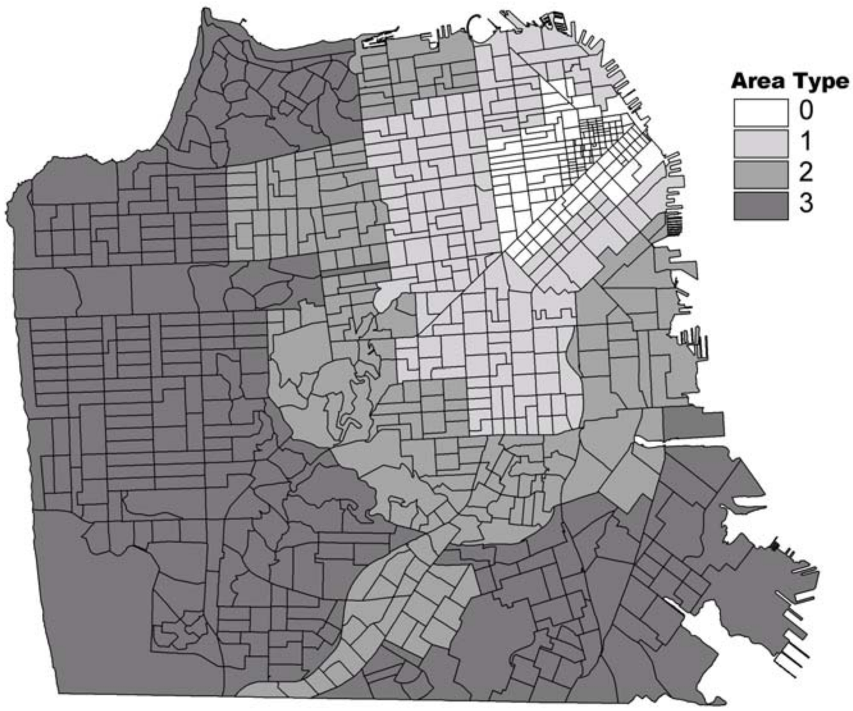


The threshold points are intuitive, ranging from a V/C ratio of 0.58 to 0.74. Table 2 below provides the link volume level associated with the slope=1 for each facility type as described above. The volume threshold point can further be stratified by "area type," an additional SF-CHAMP variable that accounts for unique land use and intensity characteristics. Area Type 0 (Downtown) represents the most intensive, highest-density land uses in San Francisco, while Area Type 3 (urban) roughly represents moderate density residential and neighborhood commercial uses. Figure 2 provides a map of San Francisco's area types as used for travel time and delay estimation.

TABLE 2 Volume Per Lane at Slope 1.0

		Area Type			
Facility Type	**V/C Ratio**	Downtown (0)	Urban Core (1)	Urban Business (2)	Urban (3)
Freeway	0.714	1320	1320	1356	1356
Ramps	0.665	864	864	930	930
Rural Arterial	0.688	894	894	997	997
Major Artl.	0.587	499	529	558	558
Minor Artl.	0.587	411	411	470	470
Collector	0.744	409	446	484	521
Local	0.744	223	223	223	260

FIGURE 2 San Francisco area types for travel time and delay estimation.



One drawback to this threshold is the link-level unit of geographic analysis. A link-based threshold is not an appropriate geographic unit of analysis for many projects that will generate auto trips on multiple links or which encompass an area including several links. A methodology which converts the link-based unit to an area unit, such as TAZ or Census tract, is desirable.

Safety/Collisions
The San Francisco Department of Public Health's model of pedestrian collisions in San Francisco census tracts provides the data source for a safety-based trips generated threshold. However, identifying the threshold is not straightforward; the data do not imply an obvious threshold as they do for the mobility relationship. The relationship is summarized in Equation (2):

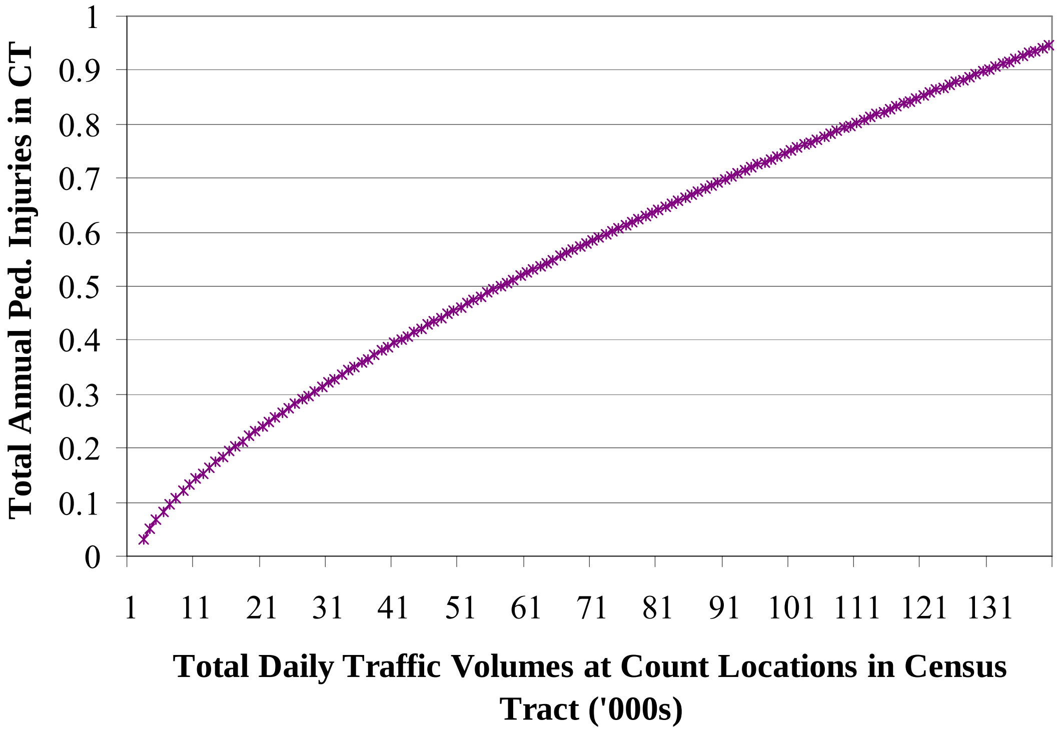
$$E(PI)=\exp(b_0 + \Sigma b_i X_i) * X_v^{bv} \quad (2)$$

Where,

E(PI) = predicted pedestrian injury collisions per census tract
b_0 = intercept
b_v = model coefficient for 1-unit change in traffic volume variable
X_v = census tract aggregate traffic volume
b_i = model coefficient for 1-unit change in predictor variable i
X_i = census tract aggregate data, predictor variable i

The relationship between pedestrian collisions and auto volumes is nonlinear relationship, as shown graphically in Figure 3, but while the total number of pedestrian injuries increases as traffic volumes increase, the rate of increase in pedestrian injuries declines. (The y axis focuses on the lowest values of the variable, and does not include the entire range of values for collisions). This shape is counterintuitive; rate of pedestrian collisions could logically be expected to increase with auto volumes. The likely explanation for this result is that because the model does not adjust for pedestrian exposure/volumes, the curve reflects the actual existing condition of lower pedestrian volumes in areas of San Francisco with high auto volumes.

FIGURE 3 Pedestrian injury collisions in San Francisco census tracts as a function of traffic volumes.



Because the data itself does not imply a threshold, alternate approaches to designating an auto trips threshold based on safety were sought. Two approaches are under consideration: first, an auto trips threshold associated with a nationally-adopted collision rate objective; and second, an auto trips threshold associated with the average observed collision rates in all U.S. or California urban areas.

The Department of Health and Human Services Office of Disease Prevention and Health Promotion provides a threshold basis with its Healthy People 2010 national target of 19 collisions per year per 100,000 population (33). Healthy People 2010 is a nationwide set of disease prevention and health promotion objectives and measures.

However, San Francisco's existing collision rate is 104 collisions per year per100,000 population, over five times the Healthy People objective. San Francisco's fatal injury rate is almost twice the national objective of 1 death/year/100,000 people. The Healthy People 2010 objective could be adjusted to account for higher rates of walking (and therefore pedestrian exposure) in San Francisco, suggesting 32 collisions/year/100,000 population as the basis for the threshold. Nearly all San Francisco census tracts still exceed this rate in the existing condition.

An alternative to using the Healthy People target is to set the auto trips threshold at the level associated with the current San Francisco average pedestrian injury collision rate of 104 collisions per year per100,000 population. A less lenient option is to use the auto trips level associated with the existing collision rate for U.S. urban areas (68 collisions per year per 100,000 population) or with the existing collision rate for California's largest cities, calculated from the Statewide Integrated Traffic Records System database (SWITRS), or 65 pedestrian injury collisions per year per 100,000 population.

For any of these collision levels, the Department of Public Health model can be used to identify the average vehicle volume per census tract associated with that level of pedestrian injury collisions. The result is an auto trips generated threshold of volumes *per census tract,* or *per 100,000 population*. The area-based geographic unit of analysis provides an appropriate study area for analyzing project impacts.

However, even with this conversion, the threshold level of auto volumes per census tract could be exceeded in the existing condition. In such cases, any project that generates one or more auto trips would trigger a significant impact. The situation of deficient existing conditions is discussed further in a later section.

Neighborhood livability

The TIRE index provides an auto trips generated threshold for negative effects on neighborhood livability. The following Figure 4 shows the TIRE index, which provides, for each level of existing roadway volumes, the increase in auto trips generated that constitute a significant negative effect (an 0.1 change in TIRE) on neighborhood liability.

FIGURE 4 Traffic Intrusion on Residential Environments (TIRE) Index.

Existing Volume Range (Vehicles per Day)	TIRE Index	Minimum Daily Traffic Volume Increase to Produce 0.1 Change in the TIRE Index	Minimum Daily Traffic Volume Increase to Produce 0.2 Change in the TIRE Index
29–35	1.5	6	15
36–44	1.6	8	20
45–56	1.7	10	25
57–70	1.8	13	32
71–89	1.9	17	41
90–110	2.0	22	52
111–140	2.1	29	65
141–180	2.2	40	80
181–220	2.3	52	100
221–280	2.4	65	125
281–350	2.5	79	160
351–450	2.6	97	205
451–560	2.7	114	260
561–710	2.8	140	330
711–890	2.9	170	415
891–1,100	3.0	220	520
1,101–1,400	3.1	290	650
1,401–1,800	3.2	380	800
1,801–2,200	3.3	500	1,000
2,201–2,800	3.4	650	1,300
2,801–3,500	3.5	825	1,700
3,501–4,500	3.6	1,025	2,200
4,501–5,600	3.7	1,250	2,800
5,601–7,100	3.8	1,500	3,500
7,101–8,900	3.9	1,800	4,300
8,901–11,000	4.0	2,300	5,300
11,001–14,000	4.1	3,000	6,500
14,001–18,000	4.2	4,000	8,000
18,001–22,000	4.3	5,200	10,000
22,001–28,000	4.4	6,600	13,000
28,001–35,000	4.5	8,200	17,000
35,001–45,000	4.6	10,000	22,000
45,001–56,000	4.7	12,200	28,000
56,001–71,000	4.8	14,800	35,000
71,001–89,000	4.9	18,000	43,000

Source: Goodrich Traffic Group, based on curve shapes found in work by Donald Appleyard at the University of California, Berkeley, and consideration of earlier thoughts by Buchanan of the Ministry of Transport, England.

Each 0.1 change in the TIRE index represents a change in traffic levels that will have a noticeable effect on local residents' perceptions of their neighborhood livability. The TIRE index is logarithmic scale, so the proportion change in traffic volumes that causes a significant negative effect is the same regardless of the existing volume levels. For any given existing volume level, the % change in volumes that corresponds to a significant 0.1 change in the TIRE index is 25%; so,the significance threshold is a 25% increase in auto trips regardless of facility type or existing volume level.

A 25% increase in traffic volumes is a lenient threshold. Most projects would not individually generate a 25% increase in trips on a San Francisco arterial. Another challenge to using the threshold provided by the TIRE index is that the geographic unit of analysis is a single link. As discussed under the mobility threshold, a link-level geographic unit of analysis is not always the most appropriate unit for analyzing the impacts of projects, which may generate trips on multiple links or themselves encompass an area including multiple links.

A number of approaches could convert the link-based mobility threshold to an area-based threshold (such as at a tract or TAZ level). Converting the TIRE threshold to an area-based unit also provides the opportunity to express it in the same denominator as the safety and mode share thresholds, providing the opportunity to create a composite threshold.

The first potential conversion is to compare project-generated auto trips to the average volume on all project-area (census tract or TAZ) links. The auto trips generated by a proposed project would be compared to the *average* trip volume on all links in the tract to determine whether the 25% increase threshold is exceeded. The drawback of this approach is that a non-normal distribution of street volumes could skew the denominator. Another option is to use the median or mode auto volume on project area streets as the denominator for comparison. With this approach, low-volume, small streets (the majority of street types for all but the most urbanized, downtown neighborhoods) may skew the denominator.

ADDITIONAL CONSIDERATIONS

Option: Auto Mode Share Measure

An alternative to capturing system performance impacts with the BPR equations is to refer to a project's mode share as a supplement to a safety or neighborhood livability threshold. A mode share threshold may have advantages over an auto trips generated threshold because it inherently adjusts for project size. An auto trips generated impact measure could be considered biased against larger projects – which could have high transit mode shares – over smaller projects which generate relatively few auto trips, but could also have low transit mode shares.

The mode share measure threshold could be set for a "neighborhood" unit - an agglomeration of census tracts or TAZs. The mode share threshold for each area could be set at the existing auto mode share for the tract or neighborhood, so that a project with an auto mode share greater than the average auto mode share in the project area would trigger a significant impact. This method has the advantage of simplicity, reduced burden for the Planning Department and project sponsors, and is consistent with Transit First policies.

However, a mode share impact measure would ideally require project sponsors to use mode choice rates that take into account site design, parking supply, pedestrian and bicycle amenities, and other variables that affect mode choices. Sophisticated mode choice rates would allow project sponsors to internalize project designs and mitigations that minimize auto mode shares. Mode choice rates that incorporate these factors are not developed at this time for San Francisco.

One-Trip Threshold Tied to Transportation Impact Mitigation Fee Program

In deriving potential auto trips generated thresholds for safety and mobility, the project team noted that San Francisco's current volume levels may exceed the thresholds of significance in the existing condition in many cases. Although carbon emissions are not under consideration as a basis for the auto trips generated threshold, the city's standards for this effect also support the conclusion that the existing auto volume levels are deficient and that only absolute reductions in vehicle use are acceptable to meet the City's goals for safety, mobility, and carbon emissions. This observation suggests that a single additional auto trip generated by a project constitutes a significant negative environmental impact on San Francisco streets.

Theoretically, this approach is allowable under CEQA. Other California jurisdictions have adopted so-called "zero tolerance" thresholds for CEQA impact areas other than transportation – schools, open space, emergency services – when the existing condition is considered deficient. A one-auto-trip threshold would also simplify the process of establishing project significance and avoid extended negotiations between project sponsor and the City over the precise number of auto trips generated by a project.

Because a 1-auto trip significance threshold would be triggered by most projects, political acceptability of the concept could be increased by linking auto trips impacts, by ordinance, to a Transportation Impact Mitigation Fee (TIMF) program. The fee program would work like any impact mitigation fee program in which project sponsors may mitigate, in whole or in part, a significant impact pay contributing a fee in an amount demonstrably related to the mitigation of the impact.

In this case, an auto trips generated impact fee would apply an incremental charge to each trip generated by a project, and the amount of the fee would be based on the cost of each incremental auto trip. The fee amount could be based on the monetary cost of auto impacts (on mobility, safety, etc); there are numerous examples of studies that essentially estimate and add up the safety costs of automobile use and quantify the safety, productivity, and environmental costs of traffic. A second approach is to the fee program would be to tie the fee amount to the cost of implementing a countywide program of multimodal transportation improvements.

With either method, the payment of these fees could be used to satisfy, in whole of in part, the CEQA mitigation requirements for project auto trips impacts. Despite the theoretical feasibility and potential advantages of this approach to evaluating transportation impacts, it is not clear whether stakeholders and San Francisco decision makers would object to the option if recommended.

Congestion as a social, rather than environmental, impact

Finally, one of the additional issues that the project team encountered in developing an ATG measure and threshold is that there are potential legal complications to discontinuing the use of a measure – auto LOS – that has been applied for project evaluations and approvals for decades in San Francisco. In a number of lawsuits involving CEQA, courts have generally held that a public agency must analyze all potential environmental impacts for which it can be reasonably argued, using substantial evidence, that a project will have a significant effect. It may be concluded from the rulings that by ignoring or overlooking a particular potential environmental impact, a jurisdiction leaves itself vulnerable to legal challenges under CEQA. This is significant because San Francisco might be leaving itself legally exposed if it chose to discontinue the use of auto LOS as a threshold for traffic-congestion impacts without replacing it with another measure of congestion.

In light of the above, it is noteworthy that the San Francisco Planning Department views parking deficits not as physical or environmental impacts but as social ones and, therefore, not potentially significant under CEQA. (Section 15131 of the state's CEQA guidelines states that "[e]conomic or social effects of a project shall not be treated as significant effects on the environment.") Briefly, the department's rationale is that, because parking availability is constantly in flux, parking supply is not part of the permanent physical environment; and, moreover, that parking conditions change over time—and parking deficits resolve themselves—as people change their travel modes and habits in the absence of a ready supply of parking spaces. In other words, a lack of parking might be inconvenient or frustrating for drivers but does not constitute an environmental impact. (Of course, any indirect physical impacts from drivers looking for parking spaces, such as air pollution, would still need to be considered under CEQA.) The department's arguments were upheld by a court of appeals in 2002, in the case of San Franciscans Upholding the Downtown Plan v. City and County of San Francisco.

The reasoning concerning parking deficits may apply equally to traffic congestion; and in any case, the Transit First Policy argues that congestion is accepted as transit-supportive improvements are made. Travelers - and, consequently, traffic volumes —adjust with changes in traffic capacity by switching to alternative times of day or modes. San Francisco's own experience with the removal of the Embarcadero and Central freeways are but two local examples that of this phenomenon. Consequently, it might be possible for the Planning Department to discontinue use of its auto LOS threshold while protecting itself against legal challenges by extending its treatment of parking deficits under CEQA to traffic congestion. For that reason, the City may wish to make the case that "congestion" is a social rather than an environmental effect.

CONCLUSIONS AND NEXT STEPS

This paper has described an approach for defining a transportation impact measure based on the auto trips generated by a project, and has described several alternative auto trips generated threshold levels. The San Francisco County Transportation Authority is working with a multi-agency set of stakeholders, as well as other peers in the transportation planning profession, to evaluate these alternative approaches and develop a recommendation for a threshold of significant environmental impact based on the auto trips generated by a project. An additional evaluation step currently underway is an ex-post analysis of representative projects using the alternative thresholds. This exercise will provide stakeholders and San Francisco's decision makers with an illustration of how projects would be evaluated under a new threshold and how the evaluation results would compare with LOS-based analysis results. The Authority's project team has selected a range of project types, including large and small scale development projects with a range of uses and location characteristics, as well as transportation projects encompassing improvements to the City's bicycle, transit, and roadway networks. This work will be complete in August 2007.

In the meantime, San Francisco's Planning Commission has taken an active interest in replacing the existing LOS measure of transportation impact with an alternative. The San Francisco Board of Supervisors has delegated its Authority for adopting CEQA standards and thresholds of significant to the Planning Commission, and any change in methodology for transportation impact analysis would likely be recommended for formal Planning Commission approval. In July 2007, the Planning Commission held its second informational hearing on the subject and received testimony from local officials (from the City Planning department, regional Air Quality Management district, Department of Public Health, Metropolitan Transportation Agency, and Transportation Authority) on the merits of replacing LOS; and from other transportation planning stakeholders interested in marrying the City's implementation tools with its Transit First Policy. An action by the Planning Commission on this topic is expected in Fall 2007.

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