Overcoming Barriers to Mixed-Use Infill Development: Let's Get Trip Generation Right

By: Matt Goyne, Mackenzie Watten, and Dennis Lee with Fehr & Peers
Please contact Matt Goyne at m.goyne@fehrandpeers.com with any questions.

Abstract

The methods most commonly used by transportation planners and engineers to estimate the trip generation of mixed-use or infill developments can exaggerate the traffic impacts for projects in locations with a balanced mix of land uses, compact design, good neighborhood connectivity and walkability, and a variety of transportation options. This misrepresentation can create a bias against these type of developments, by escalating development costs, skewing public perception, and raising government resistance to the types of development that tend to generate the fewest environmental impacts. Several trip generation methods have been developed to reduce this bias and more accurately portray the traffic impacts of mixed-use, compact, infill, and transit-oriented development proposals. This paper details three of these approaches that improve the accuracy of trip generation forecasts and how they relate to the changing regulatory environment, including Senate Bill (SB) 743 in California.

The Problem with Conventional Traffic Impact Analysis for Mixed-Use Infill Development

A traffic impact analysis is intended to inform planners, public officials, and community members of the potential impacts that a development project would cause to the surrounding environment. It also can be used to assist with designing infrastructure elements needed to support new development. Conventional traffic impact analyses rely on vehicle trip generation rates presented in the Institute of Transportation Engineers (ITE) *Trip Generation* manual. These rates were developed during an era when most new development was confined to single-uses, in isolated, highway-oriented, and suburban locations. Therefore, these rates are representative of developments whose primary means of access are those by private automobile and whose origins or destinations lie outside the development.

The problem of using conventional trip generation data for mixed-use infill developments is that it overestimates the amount of traffic generated by these developments. The rates within the *Trip Generation* manual rely on one variable, the size of the development, and ignore other variables that cause developments to generate fewer vehicle trips. This misrepresentation increases barriers to the type of development that actually generates the fewest traffic impacts, and can result in overbuilt automobile infrastructure, higher housing costs in desirable infill locations, and increased regional vehicle traffic as development is focused in suburban locations. These problems are inconsistent with the values of many communities, as well recent legislative changes governing new development in California and across the United States that outline goals to reduce regional traffic ("vehicle-miles traveled").

Conventional Traffic Impact Analysis for Mixed-Use Development

For well-designed mixed-use or multi-use developments (referred to collectively as "MXD sites" within this paper), shops, restaurants, offices, and residences are placed in close proximity to one another. This mix of land uses and connectivity within a site allows trips to remain internal to the

site and hence place no strain on the external street network. When these MXD sites are located in previously developed neighborhoods (infill locations) or transit-oriented locations, trips made by walking, biking, or transit are more likely to occur between the development and the surrounding land uses. Higher rates of walking, biking, or transit trips are common in many urban or suburban infill locations where established neighborhoods and transit systems provide connectivity between land uses without the need for a private automobile.

The ITE *Trip Generation Handbook,* 2nd Edition outlines a procedure for estimating the proportion of trips that remain within MXD sites. This procedure introduces a second variable in addition to the size of the development project – the mix of land uses. This procedure is based on the amount of office, retail, and residential land uses within the development and the corresponding internal trip share between the land use types. This methodology is based on studies of the internal trip capture relationships of three MXD sites in Florida.

New Research Evidence for Mixed-Use Infill Development Trip Generation

Several studies over the past 20 years have confirmed that the built environment affects travel patterns.[1] Recent research by organizations such as the U.S. Environmental Protection Agency (EPA) and the Transportation Research Board (TRB) have determined the relative influence of variables that reduce the amount of traffic generated by mixed-use and infill developments compared to conventional suburban developments. A growing body of evidence indicates that these variables quantifiably explain the number of vehicle trips and vehicle-miles traveled for development projects or even entire regions. The three methods described below include the National Cooperative Highway Research Program (NCHRP) Report 684 method, which is administered by the TRB, the U.S. EPA MXD method, and the MXD+ method, which is a hybrid of the other two methods.

ITE Trip Generation Handbook, 3rd Edition (NCHRP Report 684 Trip Generation Method)

NCHRP Report 684 analyzed internal trip capture relationships of MXD sites and examined the travel interactions among six individual types of land uses: office, retail, residential, restaurant, cinema, and hotel.[2] The study looked at three master-planned developments in Texas and Georgia to go along with the original three sites in Florida presented in the ITE *Trip Generation Handbook,* 2nd Edition. Therefore, this report constituted an update and expansion of the conventional method and was included in the *Trip Generation Handbook,* 3rd Edition, published in 2014. This report added new land use types to the method and introduced a range variables to account for the proximity of complementary land uses.

Based on traveler and vehicle counts and interviews, the report ascertained interactions among the six land-use types and compared them with other site characteristics. It then examined the percentage of visitors to each land-use type who also visited each of the other uses during the same trip. This report produced a refined assessment of on-site land-use categories, specifically

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[1] Ewing, Reid, and Robert Cervero. 2010. "Travel and the Built Environment: A Meta-Analysis." *Journal of the American Planning Association* 76(3): 265–94. www.tandfonline.com/ doi/abs/10.1080/01944361003766766

[2] Bochner, Brian, Kevin Hooper, Benjamin Sperry, and Robert Dunphy. 2011. *NCHRP Report 684: Enhancing Internal Trip Capture Estimation for Mixed-Use Developments.* Washington, D.C.: National Cooperative Highway Research Program, Transportation Research Board. http:// onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_684.pdf

recognizing the roles of restaurants, theaters, and hotels within the site land-use mix, along with an adjustment to account for the spatial separations among individual land uses within the development site.

Researchers then performed validation tests by comparing the analysis results to six MXD sites. The validation confirmed that the reduced external trip rates were a reasonable match for actual counted traffic. This research has improved the state of the practice, but retains some of the shortcomings of the conventional methods: a limited number of sites used to derive the relationships and a lack of sensitivity to factors such as regional location, transit availability, density of development, walkability factors, and the socio-demographic profile of site residents and businesses.

EPA MXD Trip Generation Method

Many of these shortcomings are addressed in the U.S. EPA MXD trip generation method. EPA conducted a research study to account directly for these factors and more accurately quantify vehicle trip generation for MXD sites.[3] This study investigated trip generation, mode choice, and trip length for trips produced and attracted by MXD sites and how the location of a site affected these measures. Researchers selected six regions — Atlanta, Boston, Houston, Portland, Sacramento, and Seattle — to represent a wide range of urban scale, form, and climatic conditions. Regional travel survey data with geographic coordinates and parcel-level detail allowed researchers to isolate trips to, from, and within MXD sites and relate travel choices to fine-grained characteristics of these developments.

In each region, researchers worked with local planners and traffic engineers to identify a total of 239 MXD sites that met the ITE *Trip Generation Handbook* definition of mixed-use or multi-use development. The MXD sites ranged from compact infill sites near regional cores to low-rise freeway-oriented developments. They varied in size, population and employment densities, mixes of jobs and housing, presence or absence of transit, and locations within their regions. In total, this study compiled survey data on almost 36,000 trips.

The analysis found seven "D" variables that were statistically significant predictors of internal trip capture, external walking and biking, external transit use, and external vehicle trips. In addition to the seven D variables, an eighth variable, "Demand Management", has been since shown to be a statistically significant predictor of travel behaviors. These D variables are described in Table 1.

The accuracy of the EPA MXD method was validated through trip generation comparisons at 27 MXD sites across the country. These validation sites included a range of successful mixed-use developments that exhibited moderate to high levels of activity in terms of business sales, occupied residential units, property value, and household income, with average or above-average person trips, at the time of the surveys.

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[3] "Ewing, Reid, Michael Greenwald, Ming Zhang, Jerry Walters, Robert Cervero, Lawrence Frank, and John Thomas. 2011. "Traffic Generated by Mixed-Use Developments — Six-Region Study Using Consistent Built Environmental Measures." *ASCE Journal of Urban Planning and Development* 137(3): 248–61. http://ascelibrary.org/ action/showAbstract?page=248&volume=137&issue=3& journalCode=jupddm&isAuthorized=no

Table 1: "D" Variables that Impact Travel Characteristics		
"D" Variable	**Attribute**	**Rationale**
Density	Dwellings, jobs per acre	Higher densities shorten trip lengths, allow for more walking and biking, and support quality transit.
Diversity	Mix of housing, jobs, retail	A diverse neighborhood allows for easier trip linking and shortens distances between trips. It also promotes higher levels of walking and biking and allows for shared parking.
Design	Connectivity, walkability	Good design improves connectivity, encourages walking and biking, and reduces travel distance.
Destinations	Regional accessibility	Destination accessibility links travel purposes, shortens trips, and offers transportation options.
Distance to Transit	Rail proximity	Close proximity to transit encourages its use, along with trip-linking and walking, and often creates accessible walking environments.
Development Scale	Residents, jobs	Appropriate development scale provides critical mass, increases local opportunities, and supports transit investment.
Demographics	Household size, income	Mixed-use development allows self-selection by households into settings with their preferred activities and travel modes, allows businesses to locate convenient to clients, and supports a socioeconomic "fit" among residents, businesses, and activities.
Demand Management	Pricing, incentives	Demand management ties incentives to the urban environment and allows alignment of auto disincentives with available alternate modes. It takes advantage of critical mass of travel resulting from density, diversity, and design.

MXD+ Trip Generation Method

As presented above, the NCHRP Report 684 method and EPA MXD method each derive from different research approaches and produce different methods of analyzing trip generation at MXD sites. They focus on overlapping but not identical aspects of MXD sites and their contexts and offer respective strengths and weaknesses in terms of factors considered and ease of application. To develop a method that captures the best of both sets of research findings, the authors of the two original studies collaborated to develop an integrated method that recognizes the full array of on-site and context characteristics that affect travel patterns.[4]

To develop an integrated approach, the results of the two methods were compared to actual traffic counts at the six sites studied for NCHRP Report 684 method and the 27 validation sites for the EPA MXD Trip Generation method. Based on each methods' performance at the sites, a regression analysis was used to identify the optimal weights and blend of each method to provide the best correlation with the traffic counts. Table 2 presents results from the regression analysis, listing the resulting proportion for each methods that provides the best correlation to the traffic counts at these sites.

[4] Jerry Walters, Brian Bochner, Reid Ewing. *Getting Trip Generation Right, Eliminating the Bias Against Mixed Use Development.* American Planning Association, Planning Advisory Service Memo. May 2013.

Table 2: Optimal Blend of NCHRP Report 684 and EPA MXD Methods			
	AM Peak Traffic	**PM Peak Traffic**	**Average Daily Traffic**
NCHRP Report 684	10.1%	36.5%	n/a*
EPA MXD	89.9%	63.5%	100%
*Note: *The NCHRP Report 684 does not address daily trip generation patterns.*			

Comparing the Effectiveness of the Three Methods

Table 3 compares the ability of each of the three methods to replicate the amount of traffic generated at the 27 validation sites. The statistical measures used for this comparison include percent root mean squared error, which measures the differences between predicted and observed values, and the coefficient of determination (or "R-squared"), which measures the ability of the analysis method to account for the variations in traffic generation. For peak hour traffic generation, MXD+ performs notably better, with lower average errors and root mean square errors, than either of the individual methods.

Table 3: Comparison of Three Methods at Validation Sites			
	ITE Trip Generation Handbook, 3rd Edition Method	**EPA MXD Method**	**MXD+ Method**
Daily Traffic Generation			
R-squared	89%*	96%	96%
Average Error	16%*	2%	2%
Root Mean Square Error	27%*	17%	17%
AM Peak Traffic Generation			
R-squared	93%	97%	97%
Average Error	30%	12%	12%
Root Mean Square Error	33%	21%	21%
PM Peak Traffic Generation			
R-squared	81%	95%	97%
Average Error	18%	8%	4%
Root Mean Square Error	36%	18%	15%
*Note: * ITE Handbook internalization statistics (NCHRP 684 method does not address daily trip generation. Values from the ITE Trip Generation Manual are used for the daily traffic comparison.)*			

As shown in Table 3, the MXD+ method performs better than its two predecessors but still overestimates actual traffic by four percent, remaining slightly conservative and unlikely to understate impacts. Overall, the MXD+ method improves traffic generation estimates by considering the full array of site development and context characteristics shown to influence internal capture and mode share.

Changing Regulatory Environment

In 2013, the State of California passed State Senate Bill 743 (SB 743), which will eliminate auto delay, Level of Service (LOS), and other similar measures of vehicle capacity or traffic congestion as a basis for determining significant transportation impacts. According to the legislative intent contained in SB 743, these changes to current practice were necessary to more appropriately balance the needs

of traffic congestion management with statewide goals related to infill development, promotion of public health through active transportation, and reduction of greenhouse gas emissions. These goals are consistent with those that many states are developing throughout the nation.

SB 743 requires the Governor's Office of Planning and Research (OPR) to develop revisions to the California Environmental Quality Act (CEQA) that include alternative metrics to LOS. OPR recently published a set of draft guidelines, which recommend use of VMT and safety as preferred metrics.[5] OPR is currently reviewing public comments on these draft guidelines and will produce a revised draft sometime later in 2015. The use of VMT instead of LOS will change the focus of transportation impact studies, especially with regards to mitigation. LOS impact analysis concentrated mitigation on expanding the external transportation network to accommodate new projects. Under SB 743, studies that identify potential VMT impacts will likely focus on how to modify the project to reduce VMT.

The MXD trip generation methods presented in this paper reduce the overestimation of vehicle trips and VMT that occurs when conventional trip generation methods are applied. This allows for a more accurate assessment of the impacts of mixed-use developments and related forms of infill, compact, and transit-oriented development, consistent with the stated goals and intent of SB 743.

Another benefit of these new trip generation methods is that they can be combined with vehicle trip length estimates to quickly calculate VMT for land use projects. For example, MXD+ produces vehicle trip generation estimates by trip purpose. These estimates can be multiplied by vehicle trip lengths by purpose available through household travel surveys or travel demand models.[6] These types of estimates will likely be required for future transportation impact studies in California and other states that want to better understand environmental impacts of transportation projects or how transportation network efficiency is changing.

Conclusion

By combining and refining the two most advanced methodologies for estimating traffic generation for mixed-use development, the MXD+ trip generation method provides transportation planners and engineers a more accurate single approach that accounts for the most important factors that distinguish lower impact development from other forms. It offers the ability to assess the effects of spatial separation of uses and recognition of more specific land-use categories and to consider the dynamic influences of local development context, regional accessibility, transit availability, development density and walkability factors, and the demographics of the site and surrounding area. This approach advances development planning and impact assessment beyond the conventional practices that have, to date, unreasonably discouraged mixed-use and infill development, and are inconsistent with the current market trends and regulatory environment.

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[5] Governor's Office of Planning and Research. *Updating Transportation Impact Analysis in the CEQA Guidelines*: *Preliminary Discussion Draft of Updates to the CEQA Guidelines Implementing Senate Bill 743 (Steinberg, 2013)*. State of California. August 6, 2014.

[6] See the following websites for more information on this process: SB 743 – http://www.fehrandpeers.com/sb743/
MainStreet Powered by MXD+ website – http://asap.fehrandpeers.com/mainstreet/