Predicting Travel Impacts of New Development in America's Major Cities: Testing alternative trip generation models

District Department of Transportation

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URBAN TRIP GENERATION IS NOT WELL UNDERSTOOD

There is a widespread belief that the **available tools for estimating travel impacts of urban development are not as strong as they could be**. Implications include:

- cities may be hindered in developing appropriate travel impact mitigations
- cities lack good information to communicate to existing residents regarding potential travel impacts of proposed development
- cities, with better tools, would be able to make stronger policy based on more reliable understandings of development impacts.

Most cities rely on a variety of data sources to estimate impacts of new development on their transportation systems, including:

- Institute of Transportation Engineers' (ITE) trip generation rates
- Census data
- local ridership/ travel behavior surveys

Even when taken together, these sources fail to provide a robust idea of a development's transportation impacts.

This paper compares the estimated trip generation outputs of several models to field counts and surveys conducted for the District Department of Transportation (DDOT) at 16 locations in Washington, D.C.

Our finding supports the widely held belief that existing tools are not well suited to trip generation estimation in urban contexts.

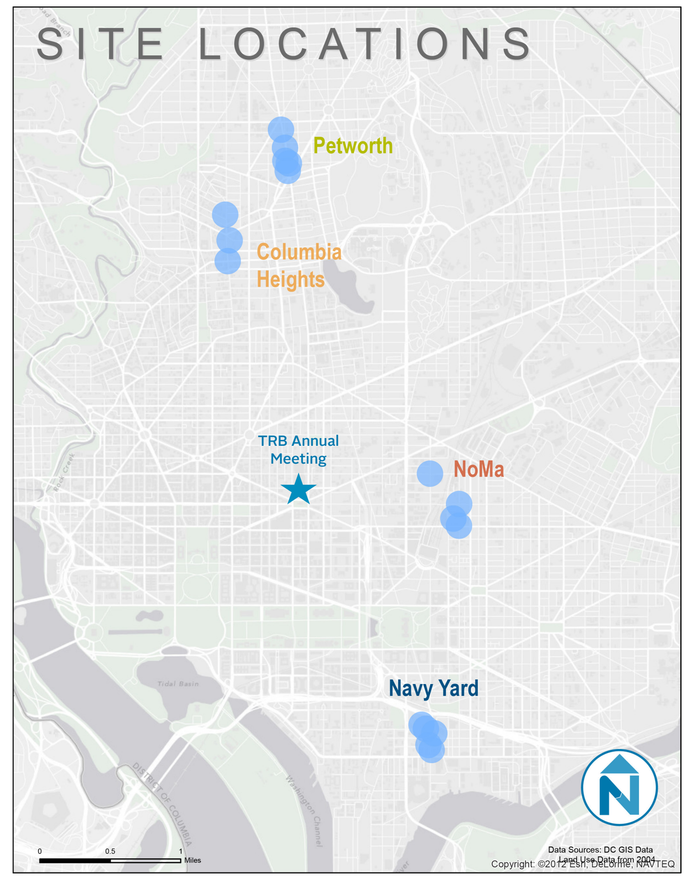
The paper is part of a larger study effort that seeks to develop a robust urban trip generation dataset that will be a foundation in the creation of better models.

MODE SHARE DATA COLLECTION AND RESULTS

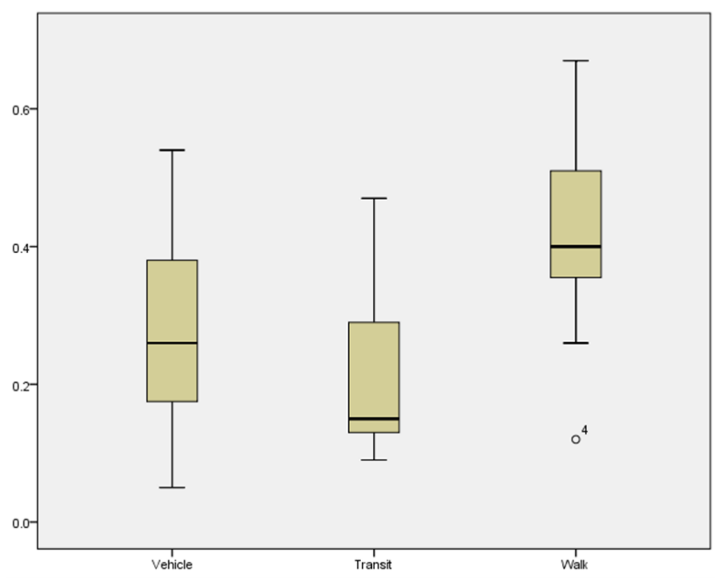
Data were collected during winter 2013-2014. Data collectors counted and surveyed people entering and exiting the sampled buildings during peak morning and evening hours of 7 a.m. – 10 a.m. and 4 p.m.-7 p.m. respectively.

TOTAL NUMBER OF PEOPLE ENTERING + LEAVING A BUILDING & INTERCEPT SURVEY TO DETERMINE SAMPLE MODE SHARE → TOTAL TRIPS BY MODE

Pilot Site Locations



Variability in Mode Share



Perhaps not surprisingly, **walking proved to be the dominant mode of travel with a median value for the sixteen sites of 40% and a maximum of 62%.** As shown to the right, private vehicle followed with a median of 26% and maximum of 54%. Transit is also very close with a maximum of 47%, but a lower median at only 16%.

The very compressed lower end of the transit boxplot indicates that transit usage at about half the sites is in a small range (in fact, between 11% and 16%) but the upper portion shows a much greater variation with transit shares ranging from 21% to 47%.

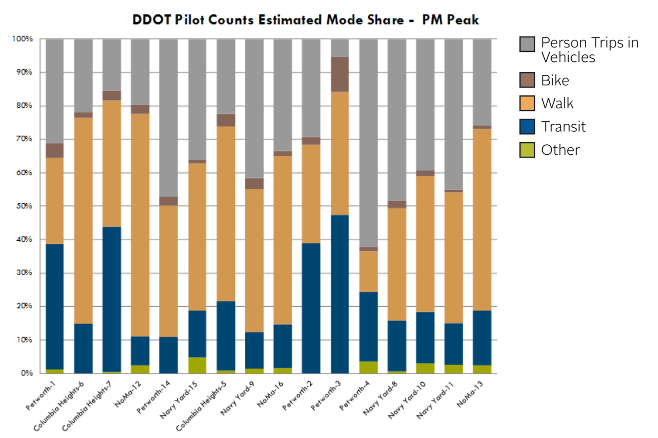
NOTE: For more information on data collection methodology, please see TRB Paper #15-4914 - *Methodology to Gather Multimodal Urban Trip Generation Data*

Consistent with findings reported in the literature, the research team found transit and drive share to be substitutes (PM correlation coefficient -0.6) while walk trips are complementary to both transit and driving.

As transit trips increase, private vehicle trips decrease sharply; as walk trips increase, private vehicle trips decrease but not as precipitously.

This finding suggests that transit and drive trips are substitutes while walk trips are complementary to both transit and driving.

PM Peak Mode Share



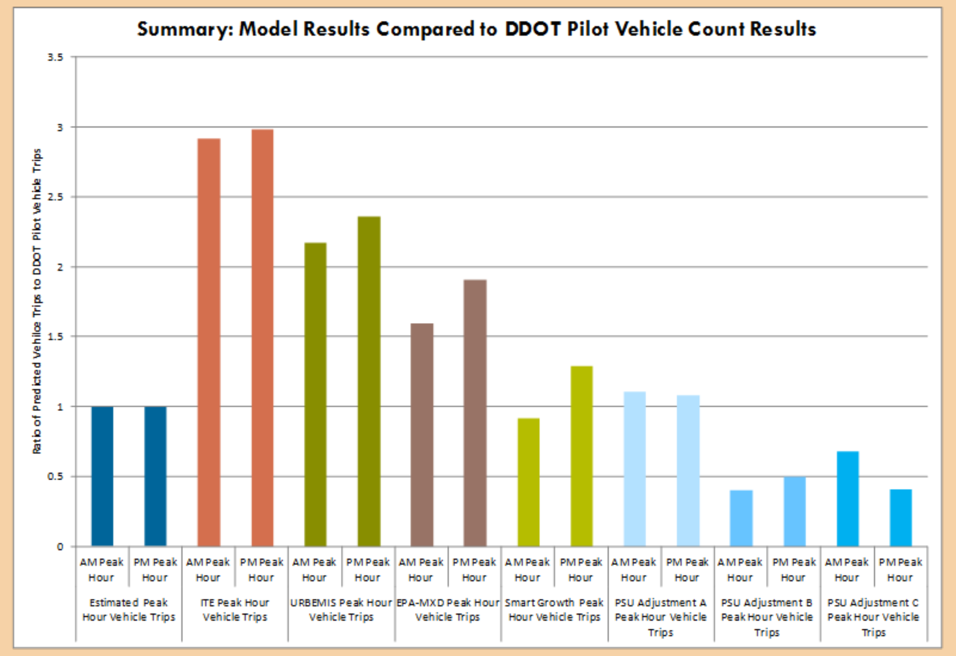
COMPARATIVE RESULTS

SUMMARY

Figure 5 shows overall results from the seven models. Data are presented as the ratio of predicted vehicle trips from each model to the vehicle trips estimated from the field work.

The overall finding that ITE under-predicts urban trips is consistent with the team's expectation. The finding that ITE over-predicts urban vehicle trips is also consistent. The array of models currently available predict slightly better than ITE but all do so by applying reductions to baseline ITE predictions.

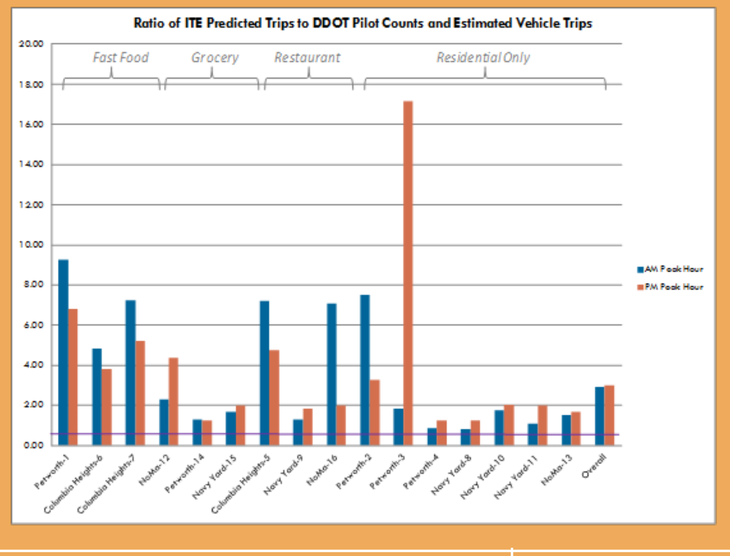
Since there is no theoretically compelling argument to suggest that single-use, suburban data would systematically translate to multi-use urban contexts, the finding underscores the importance of developing better tools to predict vehicle trips as well as trips by other modes. Furthermore, to adequately plan trip impacts in urban environments, trip generation must go beyond auto trips to include impacts on a broad set of travel modes.

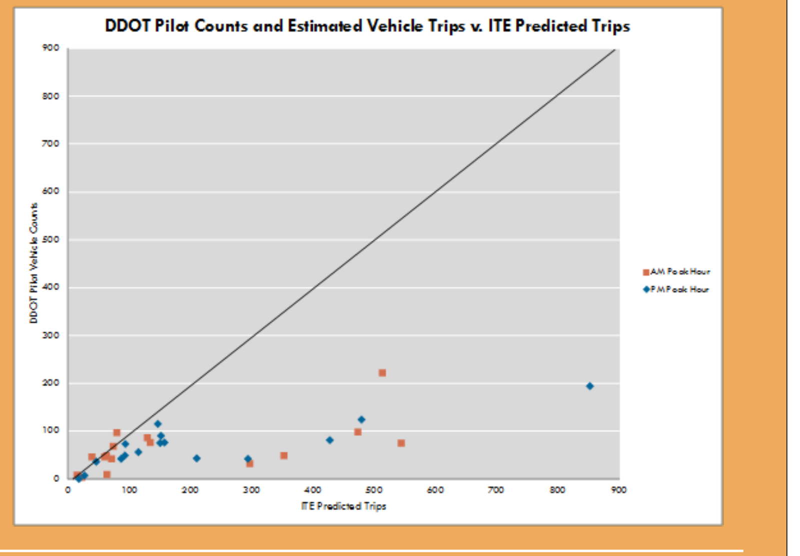


ITE

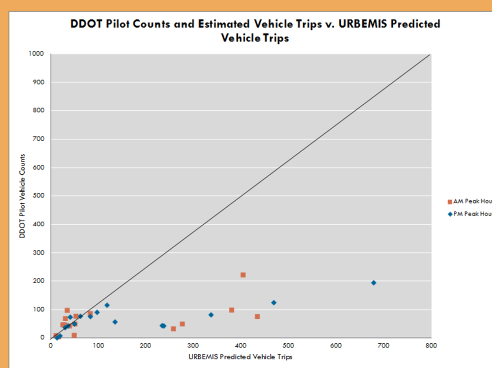
For most sites, ITE over-predicts the number of vehicle trips. Navy Yard-8 and Petworth-4 are exceptions, however both buildings have garages that are accessible by members of the general public, thus the high number of personal vehicle trips could be due to the parking lot function rather than to the residential use.

On average ITE over-predicts vehicle trips at the pilot sites by over 190% in both the AM and PM peak periods.





URBEMIS

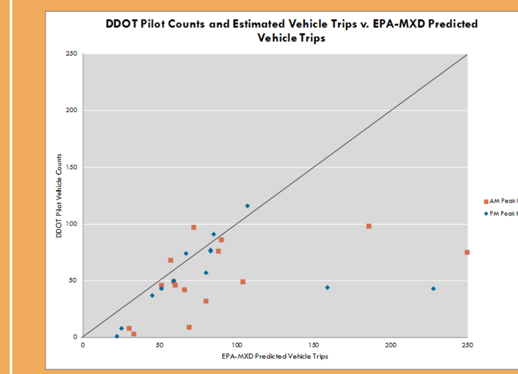


The California Air Resources Board developed the urban emissions model (URBEMIS) to quantify and evaluate emissions from development projects in California.

URBEMIS outputs are in the form of pollutant levels, which are a function of VMT. The trip generation module converts VMT to number of trips.

***URBEMIS* over-predicts vehicle trips by about 117% in the AM peak and slightly higher at 136% of the PM peak.**

EPA-MXD

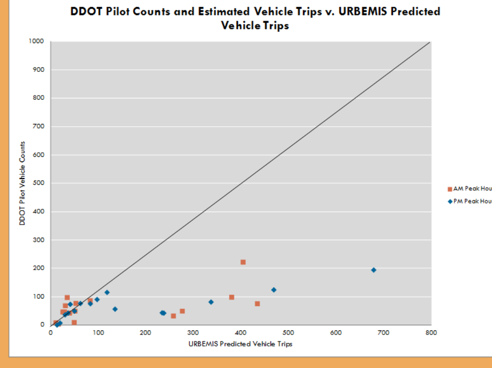


The Environmental Protection Agency Mixed Use Development model (EPA-MXD) is based on research published in Ewing et al. (2010). It is estimated based on observations from 239 mixed-use (or multi-use) developments in urban areas.

Though we apply the model to the DDOT data, the EPA-MXD is actually poorly suited to the current context. The model is designed to estimate trips across a minimum five-acre site, and alternative methodology required data that was unavailable at the time.

EPA-MXD generally over-predicted vehicle trips by factors of 91% and 122% in the AM and PM peak periods.

SGTG



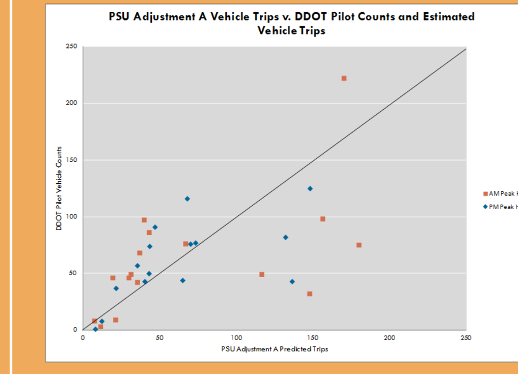
Smart Growth Trip Generation (SGTG) is a methodology and spreadsheet tool that estimates vehicle, transit and walking trip generation rates at smart-growth developments. It is based on trip-generation data at 30 smart growth sites in California.

Though we apply the model to the DDOT data, only four out of the sixteen sites fit the Smart Growth model criteria.

Looking only at sites that fit the SGTG model criteria (Navy Yard-10, Navy Yard-11, and NoMa-13), the model consistently under-predicted vehicle trips in the DDOT context.

Although the model under-predicted morning trips by 62%, it was much closer for the evening, under-predicting by just 22%. The chart above shows the results for all locations.

PSU



There are three different PSU models: A, B, and C. Adjustment A estimates trips by mode based on mode shares developed for different urban density ranges. Adjustment B is based on intersection density, while Adjustment C looks at other land use variables such as distance from the CBD and whether the site is near a TOD.

The advantage to these models is that their data requirements are relatively few and the data required are fairly accessible.

PSU Adjustment B and C underestimated vehicle trips overall.

Adjustment A over-predicted vehicle trips, but by a small margin of 11% and 8% for the morning and evening peak hour, respectively.

TRIP GENERATION ESTIMATION TOOLS*

Multiple tools that seek to provide trip and/or parking generation estimates for a variety of site types, have been developed in recent years. Most efforts are in response to the concern that ITE trip generation rates are not well suited to urban infill, transit-oriented development, smart growth and other high density development types that are increasingly common. In spite of the critique, most, like NCHRP Report 758 (44) and the California Smart-Growth Trip Rates Study (17), adjust ITE rates in an effort to better fit the different contexts. These tools are summarized below:

Tool	Applicability	Dataset	Associated Publications	Input Summary	Output Summary
NCHRP Report 684 (2011)	Mixed-Use Developments (at least three uses)	Intercept surveys and door counts at three mixed use developments in Florida, and one each in Dallas, Atlanta, and Plano (TX)	n/a	Square footage of multiple uses Proximity of uses (not required)	ITE-based vehicular trip reductions due to internal capture
EPA- MXD Trip Generation for Mixed-Use Developments (2010)	Mixed-Use Developments	Travel surveys from 239 mixed-use developments in 6 urban regions in the US	Ewing et al., 2011 (13) SANDAG, 2010 (45) Fehr & Peers model overview (46)	Multiple context variables Size of uses	ITE-based vehicular trip reductions ITE-derived transit trips ITE-derived walking trips Internally captured trips
SANDAG MXD Trip Generation for Smart Growth (2010)	An adaptation of the EPA-MXD model. Used for Smart Growth developments in California	Based on the above		Multiple context variables Size of uses	ITE/San Diego Traffic Generators vehicular trip rates
California Smart Growth Trip Generation Rates (SGTG) (2012)	Smart growth developments (particular criteria given)	Door counts and intercept surveys at 30 smart growth locations in California	Handy et al., 2012 (17) Schneider et al., 2013 (47)	Multiple context variables Size of uses	ITE-based vehicular trip reductions
URBEMIS2007 (2007)	All	Based on previous research	n/a	Context and programmatic variables Size of uses	ITE-based vehicular trip reductions
Portland State University (PSU) Models A, B and C (a)	All	195 travel surveys from Oregon, Washington and Baltimore.	Currans and Clifton, 2014 (39)	Simple lookup table of activity density OR multiple context variables	ITE-based vehicular trip reductions (Adjustments A, B and C) and trips by mode (Adjustment A only)
CAPCOA (2010)	All	Based on previous research	n/a	Context and programmatic variables Size of uses	Quantification of pollution mitigation due to transportation measures. Could be translated to trip reduction.
TRIMMS (2012)	All	Based on previous research	n/a	Context, some demographic, and travel demand management programmatic variables	Social benefits including trip generation and reduction
Tripgenie (2012)	All	Based on previous site-specific counts	n/a	Place type, land use	Trips by mode
NCHRP Report 758 (2013)	Infill development (particular criteria given)	n/a – Methods recommendations rather than a model	n/a	Regional travel demand model data	ITE-based vehicular trip reductions

BUILT ENVIRONMENT IMPACTS ON TRIP GENERATION*

Literature Review

In addition to a review of previous trip and parking generation studies, **the literature review focused on connecting trip-making and mode choice with the built environment**, even if the studies in question were not specifically about trip generation.

To be relevant, the work had to address place-based, rather than person- or household-based trip generation.

The key indicators for travel behavior identified in this review are density, land-use mix, parking price and availability and the quality of non-automobile modes.

Density

Several researchers found correlations between residential and/or employment density – but not always both.

Zhang et al. (2012) found that residential density was correlated with a decrease in VMT in the four major metropolitan areas they studied, but that employment density was statistically related to VMT in just two of the four (2).

In a meta-analysis comparing the built environment and travel behavior, Ewing and Cervero (2010) found that household or population density had a negative correlation with VMT and a positive relationship with transit and walking trips (12).

Land Use Mix

Land-use mix is usually measured as jobs/ housing balance (13), commercial to residential square footage (23), or by some kind of entropy measure that indexes land-use diversity (13),(5).

Studies generally find greater land-use mix to be a predictor of lower VMT (13),(23),(2),(5), or of mode choice reflected as lower auto-trips or more transit and walk trips (2), (3), (12),(24).

Parking

Several studies have looked at parking price and availability and find that parking pricing is a reasonable tool for managing travel demand.

Using household travel surveys in Seattle, Frank et al (2011) found that per-trip parking charges had a negative influence on VMT while transit price had a positive influence on VMT (3).

In addition, the overall availability of parking can drive mode choice – it is more burdensome to drive when one is not assured a parking space. In particular, Cervero et al. (2010) found that reducing parking by 0.5 spaces per unit can lower peak demand for parking by 0.11 parked cars per unit in a suburban multi-family residential TOD.

Non-Auto Modes

Transit Quality is measured by frequency of service (17),(3),(31),(26),(35), presence of transit lines or stops (14),(36),(37) and stop/ station density (13),(5). Invariably researchers find correlations between these measures and transit ridership. Arguably, the presence of transit is a necessary, if insufficient, condition for transit usage.

Intersection density is the most frequently considered variable to predict walking, and it is a good proxy for block length as well (e.g. (13), (14),(38)). Some researchers found intersection density to be a good predictor of other modes as well (13),(39) and/or reduced VMT (2).

Bicycling Quality

In their survey of the literature, Heinen et al. (2010) found that there are myriad ways that researchers have evaluated the built environment and its impact on cycling trips, from the type of facility to the number of vehicular lanes on a road to the presence of stop signs and traffic lights (39).

One of the most common variables is the presence of bicycle facilities. Carr and Dill (2003) found that the mileage of bicycle lanes in a city was correlated with Census journey-to-work bicycle shares (41). The causality is unclear but the presence of bicycle facilities may be robust as a heuristic to predict mode shares.

*NOTE: FOR ALL CITATIONS, PLEASE SEE COMPLETE PAPER: R. Weinberger, S. Dock, L. Cohen, J. Rogers, and J. Henson, "Predicting Travel Impacts of New Development in America's Major Cities: Testing alternative trip generation models," Submit. TRB 9th Annu. Meet., Aug. 2014.

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