CITY OF NEW HAVEN & SOUTH CENTRAL REGIONAL COUNCIL OF GOVERNMENTS

MIXED USE TRIP GENERATION MODEL

FINAL REPORT

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1 BACKGROUND

In the last 10 years, New Haven has evolved as the best example of transit-oriented development in Connecticut and one of the better examples on the east coast. Already blessed by frequent Amtrak, MetroNorth, and Shoreline East heavy rail service, the city also has an extensive network of bus transit service provided by CTTransit, Yale University, Yale-New Haven Medical Center, and other local shuttle providers. Meanwhile, and extensive on- and off-road biking and walking system has evolved recently to extend the reach of transit. Fueling this multi-modal system is a number of thriving downtown neighborhoods comprised of a mix of incomes and backgrounds, the large resident population of Yale University, and – most significantly – a diversified jobs base approaching 80,000 employees. New Haven's walkable transit-oriented assets have helped make it the only place in Connecticut that has seen job growth during the overall statewide jobs decline of the past 10 years. Meanwhile, the city has seen the largest percentage population gain of any large New England city.

While New Haven's multi-modal attributes have attracted jobs and residents, the effect of the resulting live-work mix has had a notable impact on vehicle trip generation. Even though the city has seen a number of new commercial and residential developments occur in downtown over the last 10 years, there has been no increase in traffic on downtown's arterials[1]. The City has realized spare lane capacity and begun adding bicycle lanes and improving the capacity of pedestrian phases at signals, helping to push more trips to biking and walking. The planned Downtown Crossing project will carry this to the next step with a notable shift from the highway orientation of Route 34 to a connected street grid. New Haven is on the cusp of seeing what other transit-oriented walkable downtowns such as Cambridge and Vancouver have seen: a decline in roadway volumes as built density increases.

Nonetheless, standards for evaluation of future development projects in New Haven have remained unchanged for decades. Traffic studies are central to many fundamental decisions impacting the city's transportation network, land use and urban form. By analyzing the number of trips the development proposal is expected to generate, and the consequent impact on traffic congestion at nearby intersections, the traffic study has a huge impact on roadway widths, street and intersection design and ultimately the feasibility of the proposed development. Indeed, in many cases, the traffic study determines a limit on the intensity of development and the type of uses that are possible on a given site, through establishing the constraints of the roadway network to accommodate vehicles.

The approved vehicle trip estimation methods in New Haven overestimate the amount of vehicle trips that will be made by new development in the city. The most recent development in New Haven is a glaring example. The 360 State Street mixed-use project in downtown was estimated

[1] Based on where historic traffic data is available: Union Street (1997-2005), Oak Street Connector (1997-2005), and South Frontage Road (2002-2005).

to produce 674 PM peak hour vehicle trips, requiring the construction of 500 parking spaces to accommodate the load. However, live monitoring data shows that it only produces 116 trips – only 17% of what was predicted. A new trip generation estimation methodology has been determined to be of critical need for the City to continue to move forward with its successful transit orientation without overbuilding automobile infrastructure.

THE STANDARD TRAFFIC STUDY

The Institute for Traffic Engineers' (ITE's) *Trip Generation* and the companion *Trip Generation Handbook* are the most definitive available sources for estimating the automobile traffic generated by different land uses. Now in its 8th edition, *Trip Generation* provides a wealth of data on the average number of vehicle trips generated at different times of day by hundreds of land uses, from office buildings to self-storage facilities.

Trip Generation is instrumental in traffic studies, as it is the most comprehensive source of empirical data on the traffic impacts of different land uses. That said, the information is generally well suited for auto-oriented, stand-alone suburban sites, from where the vast majority of data were collected. For downtown mixed use areas or neighborhoods with good public transportation, ITE advises that traffic engineers either collect local data, or adjust the ITE average trip generation rate to account for reduced auto use.

The traditional method of performing a traffic study often fails to account for a variety of potential conditions that have been shown to have significant impacts on vehicle trip rates such as parking pricing, transit service, or housing density. In this, the traditional method unfairly penalizes development proposals for sites in dense urban areas, or mixed-use developments where many conditions that have been determined to have substantial effects on the number of vehicle trips generated by the development are present. The City of New Haven wishes to establish a method of adjusting the vehicle trip rates used in these traffic studies to account the unique conditions present in New Haven and the mixed-use nature of many of the development proposals.

The methodology for conducting traffic studies is well established in the traffic engineering profession. The first step – which is the only element considered in this study – is to calculate the number of vehicle trips that will be generated by each land use. Subsequently, these trips are assigned to the roadway network and the impact on vehicle level of service is calculated. The results are then used to determine if the resulting impact to the transportation network is acceptable or requires mitigation, either in the form of transportation network improvements, changes to the development plan, introduction of demand management programs, or the payment of mitigation fees.

As stated above, this report is only concerned with the first step, calculating the number of vehicle trips generated by the project. Typically, the analyst uses the following procedure to calculate trip generation:

- Determine the land-use type(s) (e.g. "High-Rise Residential Condominium/Townhouse") in the development
- Determine the trip generation rate for each land-use type using *Trip Generation* or similar references. These publications provide average trip generation rates per unit of land use (e.g., per residential unit, per employee, per 1,000 square feet of gross floor area, or per theatre seat)
- Multiply the average trip generation rate by the number of units of development for each type of land use included in the project, and sum the different land-use components

- The total number of trips can be reduced to account for (i) "internal capture" (i.e., trips between different components of a mixed-use project such as a restaurant and cinema); and (ii) "pass-by trips" (such as a commuter stopping to buy groceries on the way home from work)

An important advantage of this simple approach is that very little information about a project is needed to predict trip generation, and trip generation calculations are simple. There are, however, several limitations of such two-variable formulas. Most importantly, they do not take into account the multitude of other variables, such as parking price, transit service, and the quality of the pedestrian environment, that transportation research has shown to strongly affect trip generation.

This means that the variation in trip rates *within* each land use category is frequently very high, indicating that quantity of development (e.g. number of units or gross floor area) is not sufficient to predict trip generation with any accuracy. For example, the highest-density residential developments in the San Francisco Bay Area generate 82% fewer trips than the lowest-density developments. For some land uses, such as office supply superstores and fast-food restaurants, *Trip Generation* finds no statistically significant correlation between the quantity of development and trip generation rates, or finds that the correlation is in the "wrong" direction (i.e., there is an inverse correlation) (Shoup, 2003).

Even where there is a strong correlation between the amount of development and trip generation rates, there is still considerable variation in the rates observed in different surveys. For the land use type "Single Family Detached Housing", for example, ITE reported rates ranged from a low of 4.31 daily trips per dwelling unit, to a high of 21.85 daily trips. The *Trip Generation* manual reports that, "This land use included data from a wide variety of units with different sizes, price ranges, locations and ages. Consequently, there was a wide variation in trips generated within this category."

Indeed, ITE frequently advises caution and the use of engineering judgment when determining the appropriate trip generation rates. Recognizing these points, the *Trip Generation* advises the reader:

> *The average trip generation rates in this report represent weighted averages from studies conducted throughout the United States and Canada since the 1960s. Data were primarily collected at suburban locations having little or no transit service, nearby pedestrian amenities, or travel demand management (TDM) programs. At specific sites, the user may wish to modify trip generation rates presented in this document to reflect the presence of public transportation service, ridesharing or other TDM measures, enhanced pedestrian and bicycle trip-making opportunities, or other special characteristics of the site or surrounding area (Institute of Transportation Engineers, 2010).*

Modifying the trip generation rates in this way is essential for transit-oriented, mixed-use, in-fill development and other projects that can expect lower rates of auto use. Otherwise, they will be disadvantaged by the traffic study, which in effect assumes a "worst case scenario" in terms of car use. The development may be asked to pay higher fees or fund infrastructure widening that may not be necessary – measures which often damage the quality of the pedestrian environment, not to mention affecting development feasibility.

The warnings from the ITE are often ignored and standard trip generation rates are used in inappropriate locations – with serious impacts on the character and financial feasibility of development and in particular, urban infill development such as development in New Haven. What has been missing is an alternative, established tool to modify the average trip generation rates. This is the purpose of the methodology described in this report. **At its heart, therefore, the proposed methodology is for adjusting the average trip generation rates reported in the Institute for Transportation Engineers' *Trip Generation* to more fairly reflect the particular characteristics of a proposed development.** It can be seen as a "plug in" to the standard traffic study methodology.

2 EXISTING TRIP GENERATION ESTIMATION

As mentioned above, the City of New Haven is taking significant effort to encourage smart infill growth within the city's downtown. Most resulting development proposals are required to conduct traffic impact studies in order to gain approval. In the case of smaller project proposals, the City can detemine the need for a traffic impact study, and they may waive the requirement. Larger projects along a state highway (or substantially affecting state highway traffic) that will be 100,000 square feet or larger, and/or have 200 or more parking spaces; or any existing development increasing parking capacity by 50 or more spaces, increasing floor area, or changing use categories (office, retail, residential, etc.); will be required to apply for a certificate of operation from the State Traffic Commission. This process, called the Major Traffic Generator certification process, requires the developer perform a traffic study of the existing traffic volumes and those expected from the project to determine the impact the project will have on the state transportation system (ConnDOT, 2010).

The traffic study submitted with the Major Traffic Generator certification application is subject to approval from the DOT Division of Traffic Engineering. According to a review of ConnDOT's written guidance on preparing the submission for the Major Traffic Generator application, a traffic study based on the standard unadjusted ITE trip rates will gain nearly immediate approval while any other methodology will be subject to approval (ConnDOT, 2012). In practice, ConnDOT has been known to approve traffic studies with trip generation estimates that include some adjustments to the average ITE rates. For instance, the approved traffic study for the 360 State Street mixed-use development included reductions for transit and pedestrian use, internal capture and pass-by trips.

The methodology explored in this report identifies reasonable measures that have been shown to impact vehicle trips in the empirical evidence. Ultimately, the goal is to have ConnDOT approve the methodology for use in New Haven, thereby avoiding the need to seek approval on each specific reduction factor.

3 ALTERNATIVE TRIP GENERATION REDUCTIONS

There are many measures that have been shown to have strong relationships with vehicle trip making. The following section reviews some of the most promising measures for application at the site level in New Haven. For a summary of impacts of these measures and the key references, please see Figure 1.

Figure 1 Alternative Trip Generation Reductions

Measure	Evidenciary Comparison	Typical Impacts in Evidence	
Density			
Net Residential Density	Vehicle Travel - Density	-0.04 to -0.10 [a]	*Elasticity*
Mix of Uses			
Jobs-Housing Balance	Vehicle Travel - Regional Population / Employment Balance	-0.03 to -0.05 [a] -0.051 [b]	*Elasticity*
Local Serving Retail	Vehicle Travel - Retail in Residential / Office Areas	-5% to -2% [c] -8% to -6% [d]	*Percentage*
Housing Affordability			
Below Market Rate Share	Vehicle Travel - Below Market Rate Households	-4% to 0% [e]	*Percentage*
Transit System			
Transit Service	Ridership - Transit Frequency	Typical +0.3 to +0.5 [f] Suburban systems +1.0 [f]	*Elasticity*
Transit Accessibility	Vehicle Travel - Proximity of Transit	-14% to -6% within 2.25 mi. rail [g] -6% to -2% within 0.75 mi. bus [g]	*Percentage*
Bicycle & Pedestrian Infrastructure			
Connectivity and Completeness	Vehicle Travel - Sidewalk Completeness, Route Directness & Network density	-0.12 [a]	*Elasticity*
Parking Management			
Parking Supply	Parking Availabliity - Transit Mode Share	-0.77 [h]	*Elasticity*
Parking Pricing	Price of Parking - Single Occupancy Vehicle Mode Share	-0.08 to -0.23 [i] -0.1 to -0.3 [j]	*Elasticity*
Parking Cash Out	Parking Cash Out - Vehicle Trips	-11% [j]	*Percentage*
Transportation Demand Management			
Free Transit Passes	Free Transit Pass - Vehicle Trips	-19% [k]	*Percentage*
Telecommuting / Compressed Schedules	Flextime & Telecommuting - Vehicle Trips	-20.1% to -15.9% [l]	*Percentage*
Support and Marketing Measures	Level of Employer Support - Vehicle Trips	-19% to -15% [j]	*Percentage*

Sources:

(a) - Ewing, R. & Cervero, R., 2010. Travel and the Built Environment: A Meta-Analysis. Journal of the American Planning Association, 76(3), pp. 265-294.
(b) - Criteron Planner/Engineers and Fehr & Peers Associates, 2001. Index 4D Method. A Quick-Response Method of Estimating Travel Impacts from Land-Use Changes, s.l.: US EPA.
(c) - Parsons Brinckerhoff Quade & Douglas, I., Cervero, R., Howard Stein-Hudson Associates & Zupan, J., 1996. Influence of Land Use Mix and Neighborhood Design on Transit Demand, Washington, DC: Transportation Research Board.
(d) - National Transit Institute, 2000. Coordinating Transportation and Land Use Course Manual, New Brunswick, NJ: Rutgers University.
(e) - Holtzclaw, J. et al., 2002. Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles and San Francisco. Transportation Planning and Technology, 25(1), pp. 1-27.
(f) - Evans, IV, J. E., 2004. Traveler Response to Transportation System Changes, Chapter 9 - Transit Scheduling and Frequency, Washington, DC: Transit Cooperative Research Program.
(g) - Boarnet, M. G. & Handy, S., 2010. Draft Policy Brief on the Impacts of Residential Density Based on a Review of the Empirical Literature, for Research on Impacts of Transportation and Land Use-Related Policies, s.l.: California Air Resources Board.
(h) - Morrall, J., and Bolger, D., 1996. "The Relationship Between Downtown Parking Supply and Transit Use." ITE Journal Vol. 66, No. 2.
(i) - Shoup, D. C., 1997. Evaluating the Effects of Parking Cash Out: Eight Case Studies, Sacramento, CA: California Air Resources Board.
(j) - Pratt, R. H., 2000. Traveler Response to Transportation System Changes. Chapter 13 – Parking Pricing and Fees. TCRP Report 95.
(k) - Nelson\Nygaard Consulting Associates, Inc., 2011. Mountain View Trip Reduction Strategies, Mountain View, CA: Prepared for the City of Mountain View.
(l) - Kumzyak, J. R., Evans, IV, J. E. (. & Pratt, R. H., 2010. Traveler Response to Transportation System Changes, Chapter 19 - Employer and Institutional TDM Strategies, Washington, DC: Transit Cooperative Research Program.

DENSITY

Non-Residential Density

Trip generation at the non-residential end is influenced by density, but to a much lesser degree than residential trips (Cervero, 1989; Kuzmyak, et al., 2003). There are also far fewer studies investigating this relationship, and there is no comparable dataset to that for residential density.

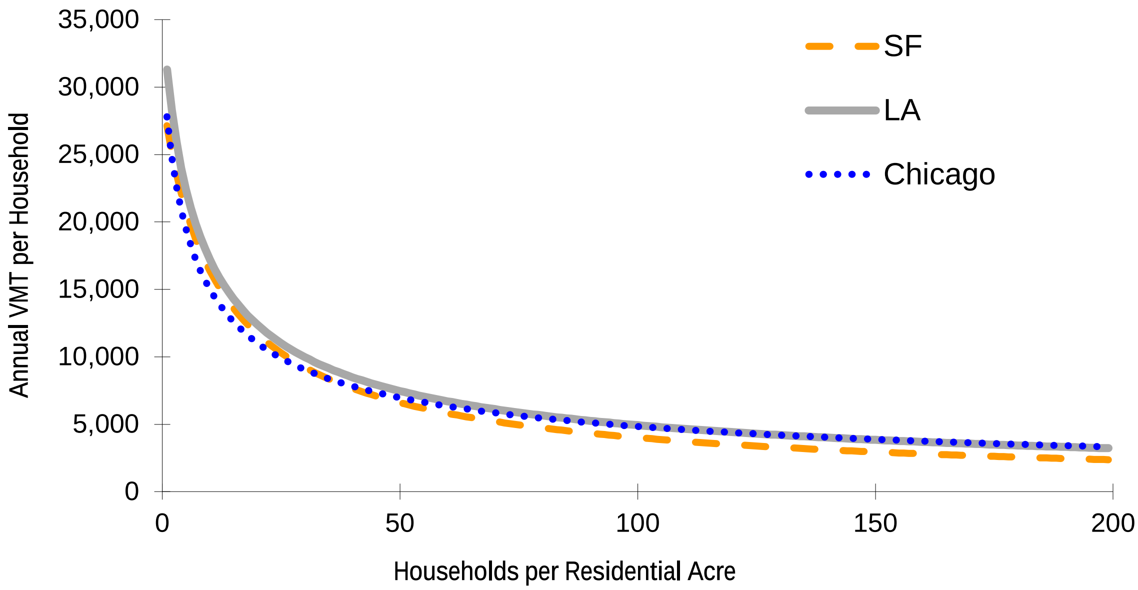
Residential Density

Residential density provides one of the strongest correlations of any variable with automobile use. While there is a similar relationship with non-residential land use density and vehicle travel, although there is far less research and the impact is less significant.

- According to a meta-analysis of a large pool of studies, typical elasticities for vehicular travel with respect to density are –0.04 to –0.1 (Ewing & Cervero, 2010). In further support, Bhat, et al., found that the elasticity of VMT with respect to population density ranges from -0.05 to -0.12 (Bhat & Guo, 2007).
- These elasticities refer to the effect of density itself, isolated from variables that tend to be correlated with density such as transit frequency, and are additive to elasticities of other built environment factors. When these factors are not isolated, typical elasticities for VMT with respect to density are –0.22 to –0.27 (Kuzmyak, et al., 2003; Bhat & Guo, 2007; Bento, et al., 2005).
- The elasticity of density, when isolated from three other variables (diversity, design and destinations), is –0.043 with respect to vehicle trips, and – 0.035 with respect to VMT (Criteron Planner/Engineers and Fehr & Peers Associates, 2001). However, this does not control for transit service levels.
- A decrease in residential density can increase vehicle travel. Brownstone and Golob found that a decrease in density equal to 1,000 fewer housing units per acre (1.56 unit/acre) results in an average increase in vehicle travel of 5% (Brownstone & Golob, 2009).

Holtzclaw et. al found that the best single variable equations to predict household vehicle travel (VMT per household, or VMT/Hh) relied on Households per Residential Acre (Hh/RA). Note that density has been shown to have a nonlinear relationship with vehicle travel, with a threshold value of 25-30 units per acre below which the travel impacts of increased density are particularly large ((Holtzclaw, et al., 2002)). For the Los Angeles region, San Francisco and Chicago regions, these equations varied only slightly, producing the curves shown in Figure 3. For the Los Angeles region, this formula takes the form found in Figure 4.

Figure 3 Residential Density Vs. Vehicle Travel



Source: (Holtzclaw, et al., 2002).

Figure 4 Sample Density and VMT Equation for Los Angeles

$$\frac{\text{VMT}}{\text{Hh}} = 19749\left(\frac{4.814 + \text{Hh/RA}}{4.814 + 7.140}\right)^{-0.639}$$

Source: (Holtzclaw, et al., 2002)

MIX OF USES

Many references point to the impact of "diversity" or mix of uses on travel behavior. This is true both at the macro-scale, e.g. jobs-housing balance, and the micro-scale, e.g. the availability of services within walking distance.:

- Higher densities are most beneficial to transit ridership when they result in a mix of residential, commercial and office uses (Lund, et al., 2004).
- The elasticity of vehicle trips with respect to "diversity" is –0.051. The elasticity of VMT is –0.032. In this case, "diversity" is a measure of how the project affects regional population/employment balance (Criteron Planner/Engineers and Fehr & Peers Associates, 2001).
- Typical elasticities for vehicle trips with respect to local diversity (mix) are –0.03, and those for VMT are –0.05 (Ewing & Cervero, 2001; Ewing & Cervero, 2010).
- A balance of 1.5 jobs per household is estimated to produce a bus mode share 2 percentage points over the share for a single use area, although the degree of mix is not a useful estimating variable (Messenger & Ewing, 1996; Kuzmyak, et al., 2003).
- Suburban activity centers with some on-site housing had 3-5% more transit, bike and walk commute trips(Cervero, 1989; Kuzmyak, et al., 2003).

- The presence of retail reduces auto mode share by 2-5%, depending on neighborhood density (Parsons Brinckerhoff Quade & Douglas, et al., 1996).
- At suburban activity centers, the presence of retail in office buildings lowers vehicle trip rates by 6-8% (National Transit Institute, 2000; Kuzmyak, et al., 2003).
- Employment sites with "good" nearby retail and commercial services have a vehicle trip rate 21.5% below the ambient rate. Sites with "fair" services showed an 8.3% reduction, and those with "poor" services a 5.3% reduction. This is attributed not just to the presence of these services, but the fact that they make TDM programs more likely to succeed (Comsis Corporation, 1994; Kuzmyak, et al., 2003).

HOUSING AFFORDABILITY

A significant amount of evidence points to the fact that lower-income households and senior citizens own fewer vehicles and drive less.

- Based upon evidence from the San Francisco Bay Area travel survey, households earning under $25,000 per year make 5.5 vehicle trips per day, compared to a regional average of 7.6. High income households (earning more than $75,000 per year) make an average of 10.5 trips (Russo, 2001). Note that this data does not control for other factors, such as density and transit access.
- In the San Francisco Bay Area, Los Angeles and Chicago, income was one of four variables with sufficient independent explanatory power to include in the model of VMT and vehicle ownership (Holtzclaw, et al., 2002).
- A review of the 2001 National Household Travel Survey found that 26% of low-income households do not own a car and only 34% of all of their trips are made by car (Pucher & Renne, 2003).

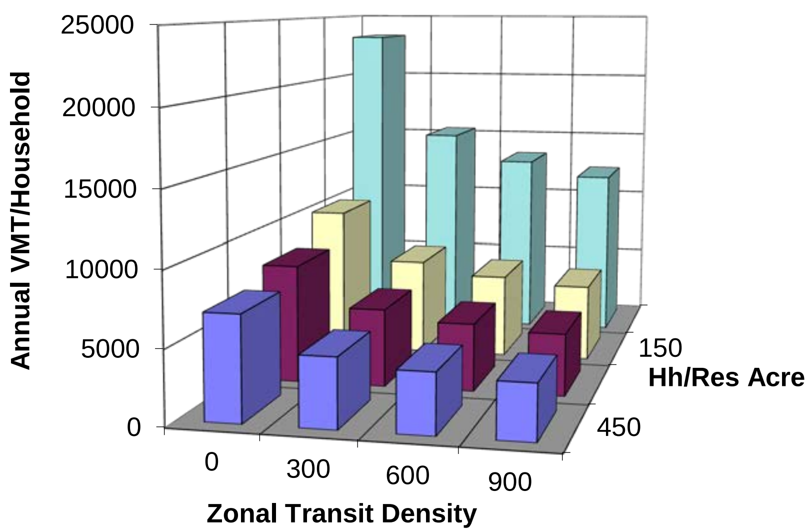
TRANSIT SYSTEM

Transit services offer travelers significant alternatives to the automobile. Current transit planning thinking emphasizes that frequency and speed are two of the most important factors determining mode choice, rather than whether the service is provided by bus, bus rapid transit, or rail. In addition to the speed and frequency of the service, there is a distance decay that is greater for bus than for rail service.

- The average elasticity of ridership with respect to frequency is +0.3 to +0.5. Higher elasticities of +1.0 have been observed in suburban systems, with the +0.3 value more typical of urban systems (Kittelsen & Associates et. al, 2003; Evans, IV, 2004).
- Ridership is most sensitive to frequency changes when the past service was infrequent. Elasticity of ridership with respect to service hours (i.e. a combined measure of frequency and service span) is estimated at +0.5(Kuzmyak, et al., 2003).
- Modeling in Massachusetts suggests that halving transit service headways from 30 to 15 minutes leads to an 8% drop in vehicle trips. A further decrease to 5 minutes leads to a further 4% drop in vehicle trips (Kuzmyak, et al., 2003).
- The maximum distance that people are willing to walk to transit tends to be 0.25 miles for bus, and 0.5 miles for rail and presumably bus rapid transit (Kittelsen & Associates et. al, 2003).

- Average vehicle travel declines 6% per 1 mile closer to a rail station, beginning at 2.25 miles and reduces by 2% per ¼ mile closer to a bus stop beginning at ¾ mile (Boarnet & Handy, 2010).
- Holtzclaw et. al. (2002) show that vehicle travel falls as transit service levels increase, even when holding density constant (Figure 5). In the San Francisco Bay Area, a doubling of transit service from 300 to 600 (using the Equation 6described below) is associated with a 13% drop in VMT. An increase from 300 to 900 is associated with a 20% drop in VMT. In the Los Angeles region, the decreases in VMT are 12% and 18% respectively. However, the variable was omitted from the vehicle travel model presented in this paper, since density was used as a proxy for transit service.

Figure 5 VMT vs. Residential Density and Transit Use, San Francisco Bay Area



Source: (Holtzclaw, et al., 2002)

BICYCLE AND PEDESTRIAN INFRASTRUCTURE

Research for the Florida Department of Transportation, FHWA and other organizations has shown that there are numerous statistically significant factors that can assess the quality of the bicycle and pedestrian environment. These include motor vehicle volumes and speeds, truck volumes, roadway widths, urban design, and lateral separation between pedestrians and motor vehicles (Federal Highway Administration, 1998; Landis, et al., 2001; Dill, 2003).

- A composite indicator, the "Pedestrian Environment Factor," provides a statistically significant correlation with trip generation and VMT. It is comprised of four inputs (Parsons Brinckerhoff Quade and Douglas, Inc., with Cambridge Systematics, Inc., and Calthorpe Associates, 1993):
  - Ease of street crossings
  - Sidewalk continuity
  - Local street characteristics (grid vs. cul de sac)
  - Topography

- In Portland, OR, an increase in the PEF from "pedestrian hostile" to "almost average" reduces daily vehicle trips by 0.4 per household (7%). An increase from "almost average" to "fairly good" provides a daily reduction of 0.2 trips (Parsons Brinckerhoff Quade and Douglas, Inc., with Cambridge Systematics, Inc., and Calthorpe Associates, 1993).
- For a high degree of walkability, block lengths of approximately 300 feet are recommended. Short blocks provide more pedestrian crossing opportunities and direct walking routes, and mean that traffic is more likely to be dispersed. Downtown Los Angeles, for comparison, has about 150 intersections per square mile (Ewing, 1999).
- Sidewalk completeness, route directness and network density together have a vehicle trip elasticity of –0.05 (Ewing & Cervero, 2001).
- Intersection / street density or percent of four-way intersections both have an elasticity of -0.12 with respect to vehicle travel (Ewing & Cervero, 2010).

PARKING MANAGEMENT

Parking Pricing

Parking pricing (on-street parking meters, garage pricing, or priced permits) have been shown to have a large impact on vehicle trips and parking demand.

- Employer TDM programs that include parking fees demonstrate an average 24.6% vehicle trip reduction compared to only 12.3% for programs without parking fees (Kumzyak, et al., 2010).
- According to a review of eight case studies of sites with and without employer subsidized parking, elasticity of drive alone rates with respect to parking pricing range from -0.08 to -0.23 (Shoup, 1997).
- Parking price elasticities of –0.1 to –0.3 have been reported (Pratt, 2000).
- Customer parking demand was shown to be initially less inelastic to price than commuter parking demand; only -0.08 for customer parking while -0.27 for commuter parking. Although, after time has passed, customers are able to adjust their travel and exhibit an elasticity of -0.25 while employees stay roughly even with an elasticity of -0.26 (Pratt, 2000).

Parking Cash-Out

Parking cash-out programs, where an employer offers to pay commuters to not drive, have been shown to enhance the impact of parking pricing on vehicle trip rates.

- Parking cash-out programs have been shown to reduce vehicle trips by 17% (Shoup, 1997).
- Studies indicate that approximately 12 percent of eligible employees, on the average, will take the cash-out offer, based on an average parking subsidy of $80 (Shoup, 1997)
- Travel allowances, which include parking cash-out programs, have been shown to reduce vehicle trips by upwards of 19% (Kumzyak, et al., 2010).

TRANSPORTATION DEMAND MANAGEMENT

Transportation Demand Management programs have been shown to have a major impact on travel behavior. For instance, site-level employee vehicle trip reductions of up to 38% have been achieved, particularly for programs that have included parking pricing (Shoup & Willson, 1990; Comsis Corporation, 1993; Valk & Wasch, 1998; Pratt, 2000; Kumzyak, et al., 2010).

Free Transit Passes

Many transit agencies have Universal Transit Pass or similar programs, whereby employers or property managers bulk-purchase transit passes for (free) distribution to their employees or tenants. These programs have been shown to increase transit ridership and reduce vehicle trips.

- Universal transit pass programs have been shown to increase transit ridership by 50-79% (Caltrans, 2002),
- Free transit passes have been shown to reduce vehicle trips by 19% (Shoup, 1999; Nelson\Nygaard Consulting Associates, Inc., 2011). Note that many of these new riders were making new trips, or ones previously made by walking or cycling.
- Universal transit pass programs have been shown to increase ridership between 50% On average, employer TDM programs that include modal subsidies, such as free transit passes, demonstrate a 19.5% vehicle trip reduction compared to only 7.9% reduction for programs without modal subsidies (Kumzyak, et al., 2010).
- Transit subsidies, such as free transit passes, as part of a TDM program have been shown to reduce vehicle trips by 20.6% compared to only 13.1% for TDM programs without transit subsidies (Kumzyak, et al., 2010).
- In areas with high levels of transit availability, transit subsidies have been shown to reduce vehicle trips by up to 27.4% (Kumzyak, et al., 2010).

Telecommuting

Telecommuting, where employees are allowed to work from home for a certain number of days, and compressed work schedules, where the employee works longer hours but for fewer days per week, have been shown to reduce vehicle trips on the average workday.

- TDM Programs that include telecommuting, flexible work schedules, and compressed work weeks demonstrate an average trip reduction of 18% with the potential for a 29.5% reduction (Kumzyak, et al., 2010).

Support and Marketing Measures

TDM marketing and support strategies (see Figure) such as bicycle support facilities (showers/changing rooms, secure bicycle storage, etc.), ride matching services, Guaranteed Ride Home programs, providing commuter information, or preferential carpool or vanpool parking (reserved convenient locations, discounted cost, etc.) have been shown to reduce vehicle trips.

- TDM marketing and support strategies have been shown to independently increase the average passenger occupancy in vehicles from 3.4% to 9% for each measure, with an average increase of 4.6%. According to Teal (1993), this 4.6% increase in average passenger occupancy can be reasonably considered a normal vehicle trip reduction impact for a marketing and support TDM program(Teal, 1993).
- TDM programs that incorporate only such marketing and support measures demonstrated an average vehicle trip reduction of 4.1%, similar to Teal's findings(Kumzyak, et al., 2010).

4 PROPOSED NEW HAVEN TRIP GENERATION METHODOLOGY

An extensive body of research has been compiled on the impacts of particular mitigation strategies on travel behavior. However, in general, this has either had an academic focus, or been undertaken for the purposes of developing citywide or regional travel models. There is extremely little guidance on how to use this data in the type of application needed for New Haven – namely, to provide quantitative estimates of the impact on trip generation at the site development level.

The following trip generation methodology is an attempt to bridge the gap between academic studies and complex regional or area-wide models on the one hand and more site-specific traffic assessments on the other hand. The emphasis is on providing the best possible estimate based on quantitative measures while minimizing data requirements.

Most measures included in the proposed methodology apply to both residential and non-residential uses. The exceptions are density and affordable housing (which apply to residential uses only), and parking supply, parking pricing, telecommuting and other TDM programs (which apply to non-residential uses only).

URBEMIS BASED APPROACH[i]

As an update to the trip reduction credit module of the Federal URBEMIS air quality model, the proposed trip generation methodology for New Haven is a simple yet powerful tool; it employs standard traffic engineering methodologies, but provides the opportunity to adjust ITE average rates to quantify the impact of a development's local context, neighborhood transportation service and infrastructure, and any demand management programs. In this way, it provides an opportunity to fairly evaluate developments that minimize their transportation impact, for example, through locating close to transit or providing high densities and a mix of uses.

Figure 2 Summary of Trip Reduction Credits

	Measure	Measure for Maximum Reduction	Impact Range	Trip Type / Land Use Type
Density				
	Net Residential Density	3,000 units per acre	-60% to +60%	All Trips / ONLY Residential Land Uses
Mix of Uses				
	Jobs-Housing Balance	1.5 jobs per 1 household	-9% to +3%	All Trips / All Land Uses
	Local Serving Retail	Yes	-2% or 0%	All Trips / All Land Uses
Housing Affordability				
	Below Market Rate Share	100% below market rate / senior housing	-4% to 0%	All Trips / ONLY Residential Land Uses
Transit System				
	Transit Service	Rapid transit trips (x2) + local transit trips = 900 trips per day	-7.5% to 0%	All Trips / All Land Uses
	Transit Accessibility	Max bicycle & pedestrian score	-7.5% to 0%	All Trips / All Land Uses
Bicycle & Pedestrian Infrastructure				
	Connectivity and Completeness	1,300 intersection legs per square mile, & 100% sidewalk coverage, & 100% suitable bicycle facility coverage	-9% to 0%	All Trips / All Land Uses
Parking Management				
	Parking Supply	100% reduction of ITE Parking Generation calculated supply	-50% to 0%	All Trips / Only Land Uses with Constrained Supply[1]
	Parking Pricing	Daily charge of $7.50 (2012 dollars)	-25% to 0%	All Trips[2] / Only Non-Residential Land Uses
	Parking Cash Out	Parking cash out program & Daily charge of $7.50 (2012 dollars)	-12.5% to 0% *(1/2 Pricing impact)*	Only Employee Trips / Only Non-Residential Land Uses
Transportation Demand Management				
	Free Transit Passes	Max transit reduction and free transit pass	-3.75%	Only Resident and/or Employee Trips / All Land Uses[3]
	Telecommuting / Compressed Schedules	Limited only by participation	Limited only by participation	Only Employee Trips / Only Non-Residential Land Uses
	Support and Marketing Measures	At least 5 TDM measures, & maximum transit impact, & maximum bicycle/pedestrian impact	-2% *(+10% of transit impact and bicycle & pedestrian impact)*	Only Employee Trips / Only Non-Residential Land Uses

Footnotes:
[1] - Parking supply reductions only impact the land use for which the parking supply is below ITE, and only if it is a larger reduction than all other reductions combined.
[2] - Parking pricing reduction is determined by the audience subject to parking pricing. If only employees are charged, only employee trips are impacted; if employees and customers are charged, all non-residential trips are impacted.
[3] - Free transit pass reduction is determined by the audience targeted for free passes. If a free pass is offered to residents and employees, it applies to all land uses, if it is offered only to residents, only residential land uses, etc.

Relationship to ITE Residential Trip Generation Rates

It should be noted that, to some extent, ITE average trip generation rates for residential uses implicitly account for the level of transit service, density and other factors that influence trip generation. This is because ITE publishes average trip generation rates for several types of residential development, which vary considerably. A single-family detached house generates more than twice as many trips as a high-rise apartment unit, according to *Trip Generation*. Rather than being a function of the inherent characteristics of the different types of housing, this is largely due to the different types of environments in which the housing types are found; high-rise apartments, for example, are often located in dense neighborhoods with good transit.[2]

In order to avoid double counting, the proposed methodology therefore assumes various default values for measures such as residential density, mix of uses and transit service. These defaults are set so that results from an analysis using this method are consistent with ITE average trip generation rates for those residential land uses.[3] In other words, the same trip generation result

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[2] ITE's *Trip Generation* manual states that data are collected primarily from suburban locations having little or no transit service, nearby pedestrian amenities, or travel demand management (TDM) programs. While little information is available about the precise characteristics of individual study sites, it appears from the sources referenced that this is not the case for some land uses, particularly higher density residential land uses. For the "High-Rise Residential Condominium/Townhouse", for example, the manual's text shows that sites were surveyed in such cities as Vancouver, Canada: a city where it is difficult to find high-density condominiums that lack sidewalks, transit service, and a mix of uses nearby.
[3] These default values were estimated using two methods. First, Nelson\Nygaard reviewed the literature and held discussions with professionals in the fields of architecture and town planning, to ascertain typical ranges for density and other characteristics of each land use type (Calthorpe, 1993; Local Government Commission, 2002). Second, these

will be generated by this method regardless of the type of residential use selected (such as low- or high-rise apartment buildings), assuming that the mitigation measures are the same. The type of residential use *does* matter if the analysis results are compared to the results of standard ITE trip generation.

Figure 2 shows the default values for each land use type. For single-family detached housing, for example, some of the default values include a residential density of 3 units per residential acre, a transit service index score of 0 (representing no transit service within one-quarter mile of the site), and an intersection density of 250 intersection approaches per square mile (typical of post-war cul-de-sac residential subdivisions). Assuming the development proposal is single-family detached housing, if these default measures are matched, the model will assume a 9.57 trip rate and show no reduction from ITE rates for single-family detached housing.

Alternatively, if this housing was instead classified as residential townhouse and the other measures remained the same, the model would assume a 9.57 trip rate and show an increase in trips compared to the default ITE rate for residential townhomes. For the residential townhouse project to show the default 5.81 trip rate, residential density must be at least 17 units per net residential acre, the transit service index must be at least 0.12, and intersection density must have 275 intersection approaches per square mile.

Figure 2 Default Environmental Variables for Residential Uses

DEFAULT ENVIRONMENTAL VARIABLES			LOCAL CONTEXT										TRANSPORTATION SYSTEM								
			Residential Density			Mixed-Use				Local Retail			Transit Service			Bicycle & Pedestrian Environment					
Code	Land Use	Standard ITE Rate	Houses / Acre	Density Credit	Density Rate	Jobs	Housing	Mixed-Use Credit	Mixed-Use Rate	Retail	Retail Credit	Retail Rate	Transit Service Index	Transit Credit	Transit Rate	Intersection Density	Sidewalks	Bike Lanes	Bike-Ped Factor	Bike-Ped Credit	Bike-Ped Rate
210	Single-Family	9.57	3	0.0%	0.00	17	100	0.6%	0.05	no	0%	0.00	0.00	0.0%	0.00	250	0%	0%	0.06	-0.6%	-0.06
221	Apartments Low Rise[(a)]	6.59	16	4.7%	0.31	26	100	-0.5%	-0.05	no	0%	0.00	0.06	-0.6%	-0.05	250	50%	0%	0.23	-2.1%	-0.20
223	Apartments Mid Rise[(b)]	4.68	38	23.2%	1.09	60	100	-3.9%	-0.37	yes	-2%	-0.19	0.14	-1.5%	-0.14	400	100%	0%	0.44	-3.9%	-0.38
222	Apartments High Rise	4.20	62	25.8%	1.09	60	100	-3.9%	-0.37	yes	-2%	-0.19	0.14	-1.5%	-0.14	400	100%	0%	0.44	-3.9%	-0.38
230	Residential Condos & Townhouses	5.81	17	17.2%	1.00	60	100	-3.9%	-0.37	yes	-2%	-0.19	0.12	-1.2%	-0.12	275	90%	0%	0.37	-3.3%	-0.32
232	High Rise Condos & Townhouses	4.18	64	25.8%	1.08	60	100	-3.9%	-0.37	yes	-2%	-0.19	0.14	-1.5%	-0.14	400	100%	0%	0.44	-3.9%	-0.38

Default Value Estimation Method

1. Typical ranges for the environmental characteristics of each land use type were established based on review of the literature and discussions with professionals in the fields of architecture and town planning (useful discussion in Calthorpe, 1993; Local Government Commission, 2002).
2. The baseline values for each environmental characteristic were adjusted within the typical ranges for each land use type using the model calculations until the resulting rate equaled the average ITE trip generation rates (ITE, 2010).

Notes

(a) - This rate is for occupied dwelling units. No rate is listed for total units.

(b) - ITE's Trip Generation provides no daily trip generation rate. The 4.68 rate is extrapolated from the daily trip rate for the "High-Rise Apartment" land use type and the PM peak hour mid-rise apartment.

Sources

Calthorpe, P., 1993. *The Next American Metropolis: Ecology, Community and the American Dream.* New York: Princeton Architectural Press.

Local Government Commission, 2002. *Compact Development Compact Disc: A Toolkit to Build Support for Higher Density Housing,* Sacramento: Local Government Commission.

Kimley-Horn and Associates, Inc., 2009. *Trip-Generation Rates for Urban Infill Land Uses in California, Phase 2: Data Collection,* Sacramento, CA: California Department of Transportation (Caltrans).

ITE. (2010) *Trip Generation: An Informational Report* , 8th Edition. Washington, D.C. Institute of Transportation Engineers.

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ranges of values were plugged into the formulas for the measures, and adjusted until the baseline values for each characteristic equaled the average ITE trip generation rates for each land use.

DENSITY

Non-Residential Density

The proposed methodology does not take non-residential density into account nor does density impact the trip rates for non-residential land use

Residential Density

Care needs to be taken when calculating the impact of density on trip generation, since only some of this effect is due to the inherent effects of density, as opposed to factors for which density serves as a proxy, such as parking price, local retail, transit service frequency and pedestrian friendliness. The URBEMIS based method would therefore use the nonlinear equation developed by Holtzclaw *et. al.*(shown in Figure **Error! Reference source not found.**), but reduces the credit by 40% to avoid double counting with transit service, mix of uses and bicycle and pedestrian facilities, all of which correlate with density.

The input required is *net residential density*, which excludes the area devoted to arterials, open space and other land uses, but includes local streets. The baseline net residential density is three units per acre: URBEMIS provides trip reductions for higher density, and also increases trip generation rates for lower densities (e.g. large-lot housing). The baseline assumed to correspond to a zero percent trip reduction is three units per acre, at which density the Holtzclaw formula results in 25,914 annual vehicle miles traveled per household.

Equation 1 Residential Density Trip Reduction

$$ResidentialTripRateReduction =$$

$$60\% \times \left(1 - \frac{19749 \times \left(\frac{4.814 + \text{ households per residential acre}}{4.814 + 7.14}\right)^{-0.639}}{25914}\right)$$

Note

- While this is based on the equations from the Holtzclaw study, the impact is reduced by 40% to avoid double-counting the effects of measures for which density likely serves as a proxy, such as transit service, bicycle and pedestrian facilities, etc.

An apartment development of 16 units per residential acre, for example, would be estimated to generate 28% fewer trips than a three unit per acre project. The maximum reduction using this formula is 60%, although this is only obtained with extreme residential densities.[4]

[4] This is because the formula uses a nonlinear equation, with an asymptote of 60%.

MIX OF USES

Jobs-Housing Balance

The analysis is complicated by the fact that some of the most beneficial developments from this perspective may be single-use, in an area where another use is predominant (e.g. residential in an employment area). For this reason, the mix of uses in the wider neighborhood (within one-half mile of the project center) is considered, where this area is larger than the project area itself.

This reduction takes into account overall jobs-population balance. The proposed method would use the formula shown in Equation 2 below (Criteron Planner/Engineers and Fehr & Peers Associates, 2001). This formula assumes an “ideal” housing balance of 1.5 jobs per household (Messenger & Ewing, 1996), and a baseline diversity of 0.25. The maximum possible reduction is 9%.

Equation 2 Land Use Mix Trip Reduction

$$TripRate\ Reduction = \frac{1 - \left(\frac{ABS(1.5 \times (h - e))}{1.5 \times (h + e)}\right) - 0.25}{0.25} \times 0.03$$

Where
h = study area Households (or housing units)
e = study area Employment

Note
- Negative trip reductions of up to 3% can result, and are included by URBEMIS

Local Retail

The presence of local serving *retail* can be expected to bring further trip reduction benefits, therefore, the proposed method would award an additional credit of 2%. This is towards the lower end of the range given in published research (Parsons Brinckerhoff Quade and Douglas, Inc., with Cambridge Systematics, Inc., and Calthorpe Associates, 1993; Parsons Brinckerhoff Quade & Douglas, et al., 1996; Kuzmyak, et al., 2003), in order to avoid double counting with the jobs-housing balance measure.

Equation 3 Local Serving Retail Trip Reduction

$$Trip\ Rate\ Reduction\ =\ 2\%$$

HOUSING AFFORDABILITY

Obviously, it is difficult if not impossible to account for the exact incomes of residents in a trip generation model, because the occupants are not known at the pre-development stage. However, the percentage of deed-restricted below-market-rate (BMR) housing does offer a way to incorporate this effect.

The proposed method would award a 5% reduction in vehicle trips for each deed-restricted BMR unit. This reduction factor is calculated based on Holtzclaw calculations (Holtzclaw, et al., 2002) as shown in Equation 4.

Equation 4 Calculating the Maximum Affordable Housing Trip Reduction

$$Maximum\ Trip\ Reduction\ for\ Affordable\ Housing =$$

$$(-0.0565 \times \$41{,}663) \times \left(\frac{0.25}{11{,}915}\right) = 5\%$$

Where
Coefficient = -0.0565[a]
Median per capita income (2011) = $41,663[b]
Average annual VMT per vehicle (2007) = 11,915[c]

Sources
(a) - Calculated by Holtzclaw(Holtzclaw, et al., 2002).
(b) - $41,663 per capita personal income is total personal income divided by total mid-year population based on U.S. Dept. of Commerce, Bureau of Economic Analysis data released March 2012 (Bureau of Business and Economic Research, University of New Mexico, 2012).
(c) - 11,915 average vehicle miles traveled per vehicle in 2007 (Federal Highway Administration, 2011).

Therefore, calculating the expected VMT reduction within URBEMIS is as follows in Equation 5 below. Using this equation, a development with 20% BMR units would thus gain a 1.0% reduction. A development with 100% BMR units would gain a 5% reduction.

Equation 5 Housing Affordability Trip Reduction

$$Residential\ Trip\ Rate\ Reduction\ = (\%\ units\ that\ are\ BMR) \times 5\%$$

TRANSIT SYSTEM

Unfortunately, the elasticity of service with respect to transit ridership is difficult to convert to vehicle trip reduction, firstly because the baseline ridership needs to be known, and secondly because only a proportion – between 18% and 67% (Kuzmyak, et al., 2003)- of new transit trips were formerly made by private auto. While it is clear that there is a direct correlation between transit service and vehicle trips, it is difficult to employ these elasticities directly. For this reason, the approach here assumes a maximum percentage reduction for transit of 15%, and then reduces this based on a transit environment factor.

Transit Service

Various frequency-based transit service indices have been developed which have shown strong correlations with ridership. For example:

- In Los Angeles, the quality of four components of transit service (MTA rail, Rapid Bus, local bus and regional services) were rated on a scale of 0-3 for each community area, and then summed to provide the Transit Service Index on a scale of 0-12(Nelson\Nygaard Consulting Associates, 2002).
- The studies by Holtzclaw et. al. (2002) used Zonal Transit Density, defined as the daily average number of buses or trains per hour times the fraction of the zone within 1/4 mile of the bus stop, or 1/2 mile of the rail station or ferry terminal, summed for all transit routes in or near the zone.

Any index of transit service needs to consider two fundamental issues: the amount of service (i.e., frequency and service span), and quality (particularly speed), which have a strong relationship with ridership. The index used by URBEMIS therefore places the emphasis on frequency, but gives greater weight to rail service (in view of greater speed and comfort) and dedicated shuttles (which will be targeted to the needs of the specific development). It considers the quantity of bus service within ¼ mile, and rail service within ½ mile. The index is determined as follows:

- Number of average daily weekday buses stopping within 1/4 mile of the site; plus
- Twice the number of daily rail or bus rapid transit trips stopping within 1/2 mile of the site
- Twice the number of dedicated daily shuttle trips
- Divided by 900, the point at which the maximum benefits are assumed. (This equates to a BART station on a single line, plus four bus lines at 15-minute headways.)

Equation 6 Transit Service Index

$$Transit\ Service\ Index = \frac{b + 2 \times (r + s)}{900}$$

Where
b = average daily weekday Buses stopping within ¼ mile
r = average daily weekday Rail or rapid transit trips stopping within ½ mile
s = average daily weekday dedicated Shuttle trips

Notes
- In addition to existing service, planned and funded transit services are included in the calculation.
- Purely demand responsive service is not included.
- Developments that are larger than 0.5 miles across in any direction must be broken into smaller units for purposes of determining the transit service index. The average of all units is then used.

Figure 6 shows some examples of how service frequencies translate into Transit Service Index scores (note these are additive, if a location has more than one component).

Figure 6 Example Transit Service Index Scores

Transit Service	Score	Assumptions
BART (single line)	0.33	150 trips per day (15-20 minute headways in each direction from 4 AM-12 AM)
15-minute bus, 5AM–12AM	0.17	152 trips per day (76 in each direction)
30-minute bus, 5AM–7PM	0.06	56 trips per day (28 in each direction)
Amtrak San Joaquin	0.03	12 trips per day (6 in each direction)
Dedicated commute shuttle	0.02	5 trips per commute period (single direction)

Transit Accessibility

A 15% maximum trip reduction is assumed for existing and planned transit service. In order to achieve the maximum reduction, the accessibility of the area is considered. To account for non-motorized access to transit, half the reduction is dependent on the pedestrian/bicycle friendliness score (described in the following section). This ensures that places with good pedestrian and bicycle access to transit are rewarded.

Equation 7 Transit Trip Reduction

$$Trip\ Rate\ Reduction = (t \times 7.5\%) + (t \times b \times 7.5\%)$$

Where
t = Transit service index
b = Bike & pedestrian reduction (see Equation 8)

Note
- Maximum reduction of 15%, with full bicycle and pedestrian reduction.

BICYCLE AND PEDESTRIAN INFRASTRUCTURE

There is a strong tradeoff here between simplicity and low data requirements on the one hand, and robustness and accuracy on the other. Pedestrian and bicycle level of service work for the Florida Department of Transportation and FHWA, for example, has shown that there are numerous statistically significant factors that can be included to assess the quality of the bicycle and pedestrian environment. These include motor vehicle volumes and speeds, truck volumes, roadway widths, urban design, and lateral separation between pedestrians and motor vehicles (Federal Highway Administration, 1998; Landis, et al., 2001).

Many of the data inputs required for these indices are highly complex to gather, particularly prior to occupancy. Therefore, in order to keep data requirements to a minimum, two of the street design indicators discussed by Dill (Dill, 2003) and Ewing and Cervero (Ewing & Cervero, 2001) are used, together with a single bicycle measure. Since both bicycle and pedestrian use depend on similar neighborhood characteristics, such as a fine-grained street grid, a single factor is used to account for both modes. This model would use network density (inversely related to block size) plus sidewalk and bicycle network completeness to calculate the quality of the bicycle and pedestrian environment, as follows:

- Intersection density, which measures street connectivity. A well-connected grid (high intersection density) provides better opportunities for pedestrian travel than cul-de-sacs and "loops and lollipops" (low intersection density)
  - URBEMIS assumes an "ideal" intersection density of 1,300 legs per square mile. This roughly equates to a dense grid with four-way intersections every 300 feet, per the recommendation of Ewing (Ewing, 1999).
- Sidewalk completeness
- Bike network completeness

The proposed method grants a maximum trip reduction of 9%, using the following formula:

Equation 8 Bicycle & Pedestrian Environment Trip Reduction

$$Trip\ reduction = \frac{i + s + b}{3} \times 9\%$$

Where
i = Intersection density = intersection legs per square mile[5] / 1300 (or 1.0, whichever is less)
s = Sidewalk completeness = % streets with sidewalks on both sides + 0.5 * % streets with sidewalk on one side
b = Bike lane completeness = % arterials and collectors with bicycle lanes, or where suitable, direct parallel routes exist

Notes
- Maximum reduction of 9% with full sidewalk and bicycle lane completeness, and 1,300 intersection approaches per square mile.
- No reduction should be allowed if the entire area within a half-mile walk of the project center consists of a single use. This applies to a ½ mile walk, rather than straight-line distance, to account for barriers such as freeways.
- The bike/ped factor is used to calculate pedestrian access to transit, as part of the transit measure (see Equation 7) even if there is only a single use within walking distance.

PARKING MANAGEMENT

Parking Supply Constraint

In addition, incorporating data on parking supply can capture the effects of a range of measures that are not included in URBEMIS.

URBEMIS uses the Institute of Transportation Engineers' *Parking Generation* handbook as the baseline[6] figure for parking supply. Since ITE parking generation rates use the same land use codes as the trip generation rates, these could be provided within the model itself. The ITE *Parking Generation* rates are assumed to equate to unconstrained demand.

Theoretically, it is possible to reduce parking provision to below the level of actual demand, should drivers park in neighboring lots or on-street in surrounding areas. However, the

[5] Intersections with dedicated routes for pedestrians and/or bicyclists should be included in this calculation. In most GIS applications, intersections are counted based on the number of line segment terminations, or each "valence." Intersections have a valence of 3 or higher – a valence of 3 is a "T" intersection, 4 is a four-way intersection, and so on. Therefore, if intersections are counted manually on a map or project plan, care needs to be taken to distinguish between 3-, 4- and 5-way intersections, and factor them up accordingly.
[6] For land uses with rates for both weekday and weekend, URBEMIS will use whichever rate is higher.

development approval process and market realities will generally prevent this from occurring. As such, a credit is only granted if measures to control overspill are in place, such as parking pricing (meters or permits), time limits, or a Residential Permit Parking program.

To avoid double counting with other trip reduction measures, the impacts of parking supply are proposed to be assessed in conjunction with all other non-residential trip reduction measures as follows:

- If the percentage reduction from all other non-residential trip reduction measures is equal to or greater than the parking supply reduction, no additional credit is granted. For example, if parking supply is reduced 10% from ITE levels, and transit, mixed use and pedestrian/bicycle trip reductions amount to 20%, the 20% figure would be used.
- In effect, the parking supply reduction is only used if it is greater than the impact from other trip reduction measures, and the difference is discounted by 50%. For example, if parking supply is reduced 20% from ITE levels, and transit, mixed use and bicycle/pedestrian trip reductions amount to 10%, the parking supply reduction impact of 5% = ((20%-10%)/2) is used.
- The *Parking Generation* handbook covers most common land uses; however, for some land uses no parking generation rates are available. In these cases, the ITE parking supply would be lower than if ITE had rates, making it harder for the project supply to be lower than the ITE supply (making it harder for this measure to be applied).

Equation 9 Parking Supply Trip Reduction

$$\text{Trip Reduction} = \frac{p - (m + t + b)}{2}$$

Where

p = Parking supply factor $= \frac{\text{Actual Parking Provision}}{\text{ITE Parking Generation Calculated}}$

m = Mixed-use reduction impact (see Equation 2)

t = Transit reduction impact (see Equation 7)

b = Bicycle & pedestrian reduction impact (see Equation 8)

Note

- Maximum reduction of 50%, assuming no parking is provided and there are measures in place to manage overspill such as residential parking permits, parking time-limits, parking pricing, etc.

Dedicated Parking

If each land use has a dedicated parking supply, the reduction would only be applied to the specific land uses with a known parking supply below the ITE supply.

Shared Parking

If the parking is shared by the entire project, the reduction measure would then be applied to all land uses sharing the supply. Similarly, if there are certain land uses sharing a supply, the reduction would be applied only to those sharing the constrained supply.

Parking Pricing

A maximum trip reduction of 25% should be applied to projects that commit to introducing parking pricing. This is based on the approximate midpoint of observed reductions, which range from 15% to 38% (Shoup & Willson, 1990; Comsis Corporation, 1993; Valk & Wasch, 1998; Pratt, 2000; Kumzyak, et al., 2010). Note that most of these studies apply to before-after or with-without comparisons, with no increase in transit service or other measures to reduce vehicle trips.

This maximum reduction should apply to prices of $7.50 per day or greater (in 2012 dollars).If the parking charge is more than $7.50, the 25% reduction is taken. If parking charges do not apply to all trips to a site (e.g. customers are exempt), the reduction is pro-rated by the percentage of trips that the charges apply to. If little or no on-site parking is provided, the parking charges should be the average of those of surrounding public facilities.

Cash Out

Parking cash-out programs are eligible for 50% of the reduction for direct parking charges, in recognition of the fact that they are dependent on parking fees and that cash-out programs tend to have significantly lower impacts (Pratt, 2000).

Equation 10 Parking Pricing and Cash-Out Trip Reduction

Parking Pricing

$$Employee\ and\ /\ or\ Customer\ Trip\ Reduction = \left(\left(\frac{daily\ parking\ charge}{\$7.50}\right) * 25\%\right)$$

Cash-Out Bonus

$$Employee\ Trip\ Reduction = (parking\ pricing\ reduction) \times 50\%$$

Notes

- Maximum of 25% reduction at $7.50 a day.
- The parking pricing reduction applies to whichever group is subject to the payment such as only employees, only customers, or employees & customers.
- The parking cash-out bonus only applies to employees, as they are the only ones who would be eligible for cash-out.

TRANSPORTATION DEMAND MANAGEMENT

The proposed methodology provides trip reductions for a range of TDM program elements, provided that they form part of a legally enforceable agreement. None of these reductions should be permitted unless they form part of a legally enforceable agreement specifying, for example, minimum parking prices and other TDM measures. This might form part of a development agreement, be enforced through any TDM ordinance in the local jurisdiction, or consist of another mechanism mutually agreed by the approving body and project proponent. Otherwise, there is little to guarantee that some of the promised measures (e.g. parking pricing) will actually be implemented and maintained.

Free Transit Passes

Any project committing to providing free transit passes would see an additional trip reduction equivalent to 25% of the reduction granted for transit service. Thus, the credit is more valuable in places that have good transit service. This reduction would only apply to the portion of trips generated by those granted the free transit passes (e.g. residents and/or employees, but excluding shoppers and other visitors).

Equation 11 Free Transit Pass Trip Reduction

$$Resident\ and\ /\ or\ Employee\ Trip\ Reduction = (t) \times 25\%$$

Where
t = Transit reduction impact (see Equation 7)

Note
- Maximum reduction of 3.75% with a full 15% transit service credit and 9% bicycle and pedestrian credit.
- Free transit pass reduction only applies to trips of those granted the free passes, such as just residents and/or employees but excluding customers and visitors.

Telecommuting

This method reduces employee vehicle trips based on the percentage of employees that telecommute, or have a 'free' day gained through a compressed schedule, on an average day.

There are two stipulations:

- As with the reductions for other measures, there must be an enforceable commitment (e.g. development agreement), which covers both the take-up rate (employees actually telecommuting or using compressed work schedules) as well as the provision of the option.
- The percentage reduction should not be additive (in contrast to most other trip reduction measures). For example, if 20% of employees telecommute, and other trip reduction measures are estimated to reduce vehicle trips from 1,000 to 800 per day, the 20% reduction would apply to the 800 trips, not the original 1,000.

Equation 12 Telecommuting Trip Reduction

$$\begin{aligned} &Employee\ Trip\ Reduction \\ &= \left((\%\ emp\ telecommuting) * \left(\frac{avg\ telecommuting\ days\ per\ wk}{5}\right)\right) \\ &+ \left((\%\ emp\ compressed\ 3\ day, 36\ hour\ week) * \left(\frac{2}{5}\right)\right) \\ &+ \left((\%\ emp\ compressed\ 4\ day, 40\ hour\ week) * \left(\frac{1}{5}\right)\right) \\ &+ \left((\%\ emp\ compressed\ 9\ day, 80\ hour\ bi\ weeks) * \left(\frac{1}{10}\right)\right) \end{aligned}$$

Support and Marketing Measures

Other TDM program elements, that do not include financial incentives, tend to have a smaller impact on travel behavior. Given the difficulty associated with identifying the individual impact of each of these TDM program elements (shown in Figure 6) on vehicle trips when these are most frequently combined with other TDM elements, the reduction is determined based on the number of these elements included in the TDM program.

Figure 6 Potential Support and Marketing Elements

Non-Financial Transportation Demand Management Elements
▪ Secure bicycle parking (at least one space per 20 vehicle parking spaces) ▪ Showers/changing facilities ▪ Guaranteed Ride Home ▪ Car-sharing services ▪ Information on transportation alternatives, such as bus schedules and bike maps ▪ Dedicated employee transportation coordinator ▪ Carpool matching programs ▪ Preferential carpool/vanpool parking

This URBEMIS based methodology therefore categorizes the support and marketing TDM program in three tiers based on the number of elements included, as shown in Figure 7.

Figure 7 Support & Marketing Program Categories

Category	Number of Elements
Major	5 or more elements
Minor	3 to 4 elements
No program	0 to 2 elements

The impact of a TDM program will also depend on the travel alternatives available. A program will have more impact if the site is served by frequent transit, for example. For this reason, THIS

PROPOSED METHOD adjusts the TDM reduction based on the reductions granted for transit service and pedestrian/bicycle friendliness.

Equation 13 Support & Marketing Trip Reduction

Major TDM Program (5 or more elements)

$$Employee\ Trip\ Reduction = \left(2\% + (10\% \times t) + (10\% \times b)\right)$$

Minor TDM Program (3 to 4 elements)

$$Employee\ Trip\ Reduction = \left(1\% + (5\% \times t) + (5\% \times b)\right)$$

Where
t = Transit reduction impact (see Equation 7)
b = Bicycle & pedestrian reduction impact (see Equation 8)

Note
- Maximum reduction of 4.4% with a full 15% transit service credit and 9% bicycle and pedestrian credit.

5 MODEL VALIDATION

In order to test the validity of the proposed trip generation model for New Haven, two methodologies have been proposed to ConnDOT to gain approval for future use in traffic studies: a.) site-specific trip count comparisons, and b.) area-wide traffic volume comparisons. The site-specific approach most closely matches the underlying methodology behind the ITE Trip Generation Manual. However, collecting total trips by automobile destined for a building or buildings in an urban location can be very difficult due to a number of factors, including capturing remotely parked cars, isolating trips by use in mixed-use buildings, correcting for vacancy rates, subtracting spill-over parking from other uses, and other typical urban interdependencies. Many of these factors that reduce site-specific data quality are the very factors that contribute directly to reduced trip-making by cars, but isolating and correcting for their impacts is difficult. A typical approach would be to count on-site parking while surveying every person walking into the building(s). However, off-site parking impacts cannot be easily counted, and high survey compliance is nearly impossible. Fortunately, some sites are relatively self-contained, and the recent 360 State Street mixed-use development in New Haven is a good case study that can be evaluated below to test the proposed trip generation model's validity.

One of the other problems with relying upon site-specific data is controlling for individual variations in travel characteristics. No two similarly-sized and occupied developments will produce the same amount of automobile trips, and controlling for this variability requires numerous site-specific studies, which can exceed available data collection resources. The alternative approach to counting and surveying specific sites is to look across a larger geography where the occupied floor area and use of a number of buildings is known. By surrounding an entire district, such as a downtown neighborhood, with a cordon "net" that captures all vehicle trips entering and leaving, the total number of auto trips can be easily counted. With accurate land use data, a direct comparison to ITE rates can be made, however, this approach is also subject to the same inaccuracy of a site-specific approach *PLUS* the impact of through traffic. However, it can be simple to find an area-wide boundary across which few, if any, uses interact and potential trips may park then walk across. Meanwhile, standard methodologies exist for counting and subtracting through trips during traffic counts. Therefore, this approach will also be used below test the trip generation model's validity.

A.) SITE-SPECIFIC TRIP GENERATION COMPARISON STUDY

The Shartenberg Redevelopment Project (360 State Street) was selected as a good candidate for a trip generation comparison study due to its compact location in downtown New Haven with a single vehicle access point set back from surrounding street parking and other off-street parking. It includes a mix of residential units, a grocery store, a daycare center, and retail space. In addition to the land uses in the redevelopment project, there was an agreement with Chase to move 175 spaces into the new 500 space garage provided on-site.

Figure 3 360 State Street Land Uses

ITE Code	Land Use	Units	Measure
221	Apartments Low Rise	81	Housing Units
222	Apartments High Rise	379	Housing Units
565	Day Care Center	7,660	Square Feet
820	Shopping Center	28,023	Square Feet
850	Supermaket	12,248	Square Feet
710	General Office Building	175	Employees

The site is downtown at the intersections of State Street and Chapel Street. The New Haven State Street commuter rail station brings 41 daily Metro-North Rail and Shore Line East trains directly across the street from the site. In addition to the rail, there is significant bus service with 1,314 daily bus trips stopping within ¼ mile of the site. There is great network connectivity with sidewalks on both sides of nearly every street and there are roughly 580 intersection approaches within ½ mile of the site.

The project included the construction of a 500 space parking garage open to the public. Parking is priced for all users, $12 a day for general use but with discounts for employees equaling $8 a day or $4.5o a day for residents of the building. There are also discounts for members of the grocery coop and rail commuters.

The project did provide space for 3 ZipCar carshare vehicles to be stored in the garage, available for use by all ZipCar members. There is secured bicycle storage space for at least 200 bicycles and a bike shop occupied a portion of the retail space.

Standard Traffic Assessment Study

The traffic study prepared for the mixed-use development at 360 State Street incorporated a few ConnDOT approved trip reduction factors. These include:

- **10% reduction of residential trips** for transit and pedestrian use.

- **5% reduction of all trips** for the internal usage in the site.
- **20% reduction of retail trips** for pass-by trips, the assumption that some trips are already on the roadway system.

To compare this method to the real data, the pass-by trips must be added back in because these are still vehicle trips for the purposes of this comparison. The traffic assessment anticipated a weekday AM peak of 398 vehicle trips and a PM peak of 674 trips.

Figure 4 360 State Street Traffic Assessment Results

		Weekday A.M. Peak			Weekday P.M. Peak		
Land Use	Size (S.F)/Units	In	Out	Total	In	Out	Total
Grocery	12,248	24	16	**40**	91	87	**178**
Retail	28,023	45	28	**73**	130	140	**270**
Day Care	7,660	52	46	**98**	47	54	**101**
Low-Rise Apartment	81	10	36	**46**	36	20	**56**
High-Rise Apartment	379	29	85	**114**	82	52	**134**
TOTAL SITE TRAFFIC		160	211	**371**	386	353	**739**
CHASE AGREEMENT (175 employees)	175	74	10	**84**	14	67	**81**
TOTAL TRAFFIC		234	221	**455**	400	420	**820**
PASS BY TRIPS (20% of Retail)		11	11	**23**	45	45	**90**
INTERNAL CAPTURE (5% of Total)		10	9	**19**	19	18	**37**
TRANSIT (10% of Residential)		4	12	**16**	12	7	**19**
NET NEW TRAFFIC		209	189	**398**	324	350	**674**

Source: Shartenberg Redevelopment Project Traffic Assessment Study. Table 1: Anticipated Site Generated Traffic Volumes, page 8.

Proposed New Haven Methodology

The proposed method calculates numerous trip reductions based on the project features. They are as follows:

- **0.96% reduction of all trips** for the net residential density
- **11.35% reduction of all trips** for the jobs – housing mix and local serving retail
- **18.2% reduction all trips** for transit
- **9.27% reduction of all trips** for the bicycle and pedestrian infrastructure
- **32.96% reduction of all trips** for the parking pricing and unbundling
- **0.10% reduction of all trips** for the support and marketing programs

The proposed method would result in 198 AM peak trips and 269 PM peak trips or 1,566 daily trips.

Figure 5 360 State Street Proposed Methodology Trip Generation Results

ITE Code	Land Use	Units	Measure	Residential Density		Jobs-Housing Mix		Local Retail		Transit Service		Bicycle & Pedestrian		Parking Pricing		Support & Marketing		AM Peak Reductions	PM Peak Reductions	AM Peak Trips	PM Peak Trips
221	Apartments Low Rise[(a)]	81	Housing Units	-169	-32%	-48	-9%	-16	-3%	-101	-19%	-52	-10%	-174	-33%			-39	-49	-2	-2
222	Apartments High Rise	379	Housing Units	114	7%	-223	-14%	-73	-5%	-473	-30%	-241	-15%	-816	-51%			-122	-143	-9	-10
565	Day Care Center	7,660	Square Feet			-37	-6%	-12	-2%	-79	-13%	-40	-7%	-152	-25%	-1	0%	-55	-56	49	50
820	Shopping Center	28,023	Square Feet			-74	-6%	-24	-2%	-157	-13%	-80	-7%	-301	-25%	0	0%	-15	-55	13	49
850	Supermaket	12,248	Square Feet			-77	-6%	-25	-2%	-163	-13%	-83	-7%	-313	-25%	0	0%	-23	-68	21	61
710	General Office Building	175	Employees			-36	-6%	-12	-2%	-76	-13%	-39	-7%	-145	-25%	-4	-1%	-145	-140	126	121
	Summary Trip Totals			-55	-1.0%	-494	-8.6%	-161	-2.8%	-1,049	-18.2%	-535	-9.3%	-1,901	-33.0%	-6	-0.1%	-400	-511	198	269

Observed Trips

The parking facility associated with the 360 State Street development has an electronic control arm that collects data on the time of each entry and exit. The data from a week in April 2012 was collected to compare to the predicted trips.

Since the parking is not restricted to users of the site and visitors to the site may park on a nearby street, this is not perfect trip data but it still provides a real world comparison for the existing and proposed trip generation methodologies.

Based on the data from Tuesday through Thursday, there are an average 111 vehicle trips in the AM peak and 116 vehicle trips in the PM peak or 1,175 daily trips.

Comparison

While the proposed methodology does not precisely match the observed trips, it is closer to the observed trips than the current methodology results. The results of the traffic assessment are between 258% and 481% above the observed trips. The results from the proposed methodology are only 79% to 132% above the observed trips, still conservative compared to the observed trips but closer to the actual trips than the current methodology.

Figure 6 Observed Trips vs. Model Results

	Traffic Study Trips		URBEMIS Trips		Observed Garage Trips	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
Total Trips	398	674	198	269	111	116
Compared to Observed	258%	481%	79%	132%		

B.) AREA-WIDE TRAFFIC VOLUME COMPARISON STUDY

In order to count all vehicle trips associated with a given set of land uses, a Cordon Count is used to determine the number of vehicles entering and leaving the area. These would be determined by capturing all vehicles entering and exiting the area on all roadways within a defined timeframe. License plate review would also be completed to remove through traffic from these calculations. The Cordon Count area is defined on a large enough scale to be able to capture the trip generation reduction factors accounted for in the proposed trip generation model and other literature. Vehicle trips will be compared to known land use within the defined area, and hopefully used as a basis for future trip generation estimation.

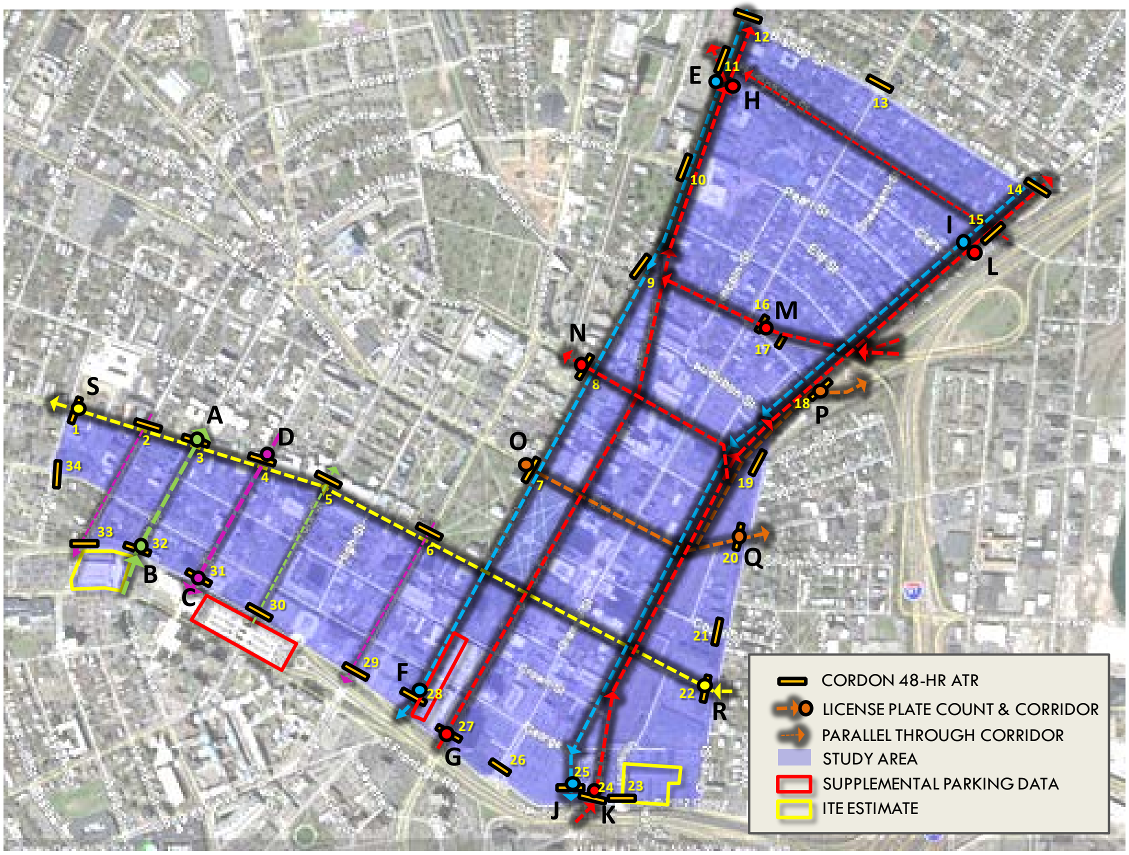
Geographic Extent

The first step in conducting the Cordon Count is to define the boundaries. These should be large enough to encompass the desired study area, which should be large enough to capture the full effect of the mix of land uses, transit accessibility, walking, biking and shared parking that naturally occurs in a downtown. Figure 7 shows the identified Cordon Count area, which also has been determined based to meet the following characteristics.

- Matches the boundaries of TAZ's (839, 840, 854 & 867) in ConnDOT's travel demand model, which is used for many Major Traffic Generator certificates.
- Captures the Park & Walk areas, i.e. no one will park outside the Cordon Count boundary and walk to the inside (or vice-versa)

- Uses hard boundaries (Rte 34, Yale University) to reinforce the Park & Walk areas; and
- Minimizes the data collection points to the extent possible.

Figure 7 Area-Wide Cordon Count Boundary



Data Collection Strategy

The overall strategy in conducting the Cordon Count is to define the overall study area with Automatic Traffic Recorder (ATR) counts. In the aggregate this information can be used to determine overall vehicle trip activity over a multi-day period. At key locations, these would be augmented during the peak periods by license plate counts. License plate counts are used primarily to understand the level of through traffic in the Cordon Count area. Through traffic should not be counted as part of the area's trip generation but can be used for other transportation analysis purposes.

Figure 7 also shows the proposed locations of the ATR counts and the paired locations for license plate counts. Additional details on this proposed methodology are described below:

General

- All counts will be conducted by a certified data collection firm
- Counts will be taken or adjusted to reflect a normal week, when schools (New Haven Public Schools and Yale University) are in session

ATR Counts

- ATR counts will be conducted for a minimum of 48 hours
- The consecutive 48 hour period will be exclusively on a Tuesday, Wednesday, and/or Thursday, though additional data may be collected on other days
- ATR counts will be set to capture vehicle classification, speed and direction

License Plate Counts

- License Plate counts will be conducted for a minimum of 1 hour during the AM or PM peak as defined below
- Personnel will record the license plates of all vehicles that cross their defined boundary location.
- The exact hour of the counts within the peak will be determined locally with guidance as defined below
- All AM counts should be taken on the same day, All PM counts should be taken on the same day, but AM & PM counts can be taken on different days
- License plate counts must be taken on days simultaneously with the ATR counts

AM Counts (refer to Figure 7)

- Pink license plate counts (C & D) - During the peak traffic movement to the medical center
- Blue license plate (E & F, I & J) - During the peak traffic movement to the medical center and Union Station
- Red license plate (G & H, K & L, M & N) - During the peak traffic movement in to Yale

PM Counts (refer to Figure 7)

- Green license plate counts (A & B) - During the peak traffic movement from the medical center
- Orange license plate (O & P, Q) - During the peak traffic movement out of Yale and cross-town
- Yellow license plate (R & S) - During the peak traffic movement cross-town

Data Review and Compilation

Once all data is collected, it will be processed to determine the overall number of vehicle trips to the Cordon Count area. Data will be processed using the following steps:

Count Analysis

- An hourly summary of all entries and exits for the 48 hour period will be summarized in table form.
- Daily volumes, and thus trip generation, will be developed and mapped (with volumes at entry and exit points) for a 24 hour period (as determined from the lowest overall hour of combined traffic volumes)

- For the AM & PM peak hours, license plate count information will be used to subtract through traffic from overall entering and exiting trips in the Cordon Count area on the corresponding pair(s) of ATRs.
- Overall vehicle traffic volumes and through traffic volumes will be presented in graphic and tabular form by entry/exit point
- Overall entering and exiting vehicle traffic will be determined for each peak hour for the entire Cordon Count area, and will be representative of AM & PM Peak Hour vehicle trip generation for the defined area of downtown New Haven.

Comparative Analysis

The vehicle trips generated as determined from the Cordon Count will be compared to standard ITE as well as the proposed trip generation methodologies. These comparisons will be presented on a daily, and AM & PM peak hour basis and summarized in tables.

Land Use Comparison

- Based on existing land use, Peak Hour and Daily Trip Generation will be developed using standard ITE methodology
- A trip generation estimate for the same uses will also be completed using the proposed methodology that reflects the local characteristics of the Cordon Count area.
- A summary of the expected daily and peak hour trip generation from the ConnDOT model will also be provided for the TAZ's that comprise the Cordon Count area (839, 840, 854 & 867).

Next Steps

The City of New Haven is coordinating with ConnDOT to conduct the area-wide cordon count protocol in the Summer of 2012. Data will be compared to ITE and proposed trip generation methodologies under separate contract.

6 CONCLUSIONS

Based on the results of the comparison studies, the City of New Haven will develop an overall proposed vehicle trip generation rate for Downtown. This report and analysis provides a baseline analytical platform and supporting spreadsheet-based software for the comprehensive review of new proposals, based on a model that reflects the TOD characteristics of downtown New Haven. Working with ConnDOT, the City hopes to develop a factor that can be applied to future traffic analyses. It is likely that these may need to be parsed separately for different categories of use - residential, office, retail, commercial - but all will be grounded in the analysis completed for the proposed methodology and supported by the comparison studies.

Ultimately, the City of New Haven is expecting to use this information to assist in its significant efforts to encourage infill growth within its downtown. Establishing this methodology for determining and analyzing trips will assist in creating more accurate transportation studies for new development in New Haven, helping to simplify City, State and environmental permitting processes for any proposed project.

7 APPENDIX A: MODEL INSTRUCTIONS

Software instructions to be inserted.

8 APPENDIX B: BIBLIOGRAPHY

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[i] Considerations with the URBEMIS Approach

It must be stressed that these trip reductions are subject to considerable uncertainty. They should be interpreted as the mid-point of a range, rather than as a single, precise value. However, although the methodological dangers are obvious, there is generally no question about the *direction* of the relationship between trip generation and a given measure, only the size of the relationship and the appropriate variable to use as a model input. Some adjustment is better than none at all – which is what most conventional trip generation methodologies provide (Ewing & Cervero, 2001; Ewing & Cervero, 2010). In addition, existing project-level trip generation methodologies, even though well-accepted within the transportation planning and engineering profession, are themselves subject to considerable uncertainty, and results are reported with unwarranted precision (Shoup, 2003).

Other considerations that should be noted include:

- Vehicle Trips & Vehicle Miles Traveled

  The key output that is sought here is reduction in vehicle trips. Research results, however, often report results in terms of VMT. Where no alternative is available, URBEMIS assumes that VMT is proportional to vehicle trips.

- Elasticity

A measure of elasticity is generally used to make the calculations, since when used with care, they provide a satisfactory, means of preparing first-cut aggregate response estimates for various types of transportation system changes (Pratt, 2000). Elasticity measures also provide a transparent and accessible method of reporting results that can be transferred from one region to another (Ewing & Cervero, 2001; Ewing & Cervero, 2010).

- Causality

  There are major theoretical issues regarding the direction of causality that have still to be resolved in the research. For example, does an increase in density lower vehicle trip generation rates, or do more dense places attract people who tend to make fewer vehicle trips? In recent years, some analysis has been performed that attempts to control for this "self-selection" factor, providing a more accurate understanding. Nonetheless, for the purposes of this analysis, the distinction is unimportant. The key issue (using the same example) is that more dense places are associated with fewer vehicle trips.

- Reasonableness

  Local planning controls and development economics are assumed to provide an important "reasonableness" check on the recommended trip reductions. For example, reductions in parking supply will not normally be allowed unless the local jurisdiction is confident that complementary trip reduction measures will be applied. Equally, it is unlikely that frequent transit service will be provided to a destination with low potential ridership, given competing demands on an agency for service.

Previous URBEMIS Model Validity

Recognizing that travel behavior is complex and difficult to predict, it is recommended that the original URBEMIS methodology approach be refined every few years, as more data become available. This update for the City of New Haven is the most recent effort following a 2007 version which updated and expanded a 2002 version, originally developed by Dave Mitchell and Terry Parker. The 2007 update was developed by Nelson\Nygaard, in association with Jones & Stokes, for the San Joaquin Valley Air Pollution Control District.

Peer Review

The work on the URBEMIS 2007 update was peer reviewed by Dr. Richard Lee of Fehr & Peers Associates and John Holtzclaw of the Sierra Club, and overseen by the URBEMIS Working Group.

Legal Challenge

In addition to peer review, the model has withstood challenges in the courts. Most recently, in *California Building Industry Assoc. v. San Joaquin Valley Unified Air Pollution Control District* issued in February 2008, URBEMIS was upheld as a sophisticated computer model capable of determining the impact of a development and the application of mitigating factors when applying a mitigation fee to a developer.