Parking Demand Component

Documentation for the Parking Demand App of Envision Tomorrow Plus

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Executive Summary

The Parking Demand component estimates the peak parking demand for a proposed development area. The model estimates parking demand based on the land use amounts for each of the four land use types: residential, retail, office, and industrial.

Peak parking demand is estimated from two nationally recognized sources that are commonly used by traffic engineers and transportation planners across the United States: *Parking Demand, 4th Edition* from the Institute of Transportation Engineers and *Shared Parking, 2nd Edition* from the Urban Land Institute and International Council of Shopping Centers. Mixed-use development (MXD) trip reduction factors and household vehicle ownership factors, both from 7D research, have been used to estimate a modified peak parking demand based on the mix of land uses in the proposed development.

The first process of the Parking Demand component produces separate peak parking demand estimates, using data from *Parking Demand, 4th Edition*, for the four land use types in the Envision Tomorrow (ET) scenario. The individual parking demands are aggregated to a total peak parking demand for the development area, which represents the parking demand assuming that parking supply for each land use type is segregated and exclusive. The peak parking demand is then modified for each land use type given the characteristics of the MXD, which influence the residential vehicle ownership and the amount of walk and transit trips.

As the second process of the Parking Demand component, a shared parking evaluation is conducted for the development area to account for a situation where parking supply would be shared by the land uses. The shared parking evaluation is conducted consistent with methodology presented in *Shared Parking, 2nd Edition*. The peak shared parking demand represents a theoretical minimum in parking demand as the evaluation assumed a convenient dispersion of parking supply that would be available to all uses and within easy walking distance by patrons and employees. The shared parking demand is then modified by the residential vehicle ownership and the amount of walk and transit trips due to the MXD characteristics.

The Parking Demand component produces a results table that summarizes the peak parking demand by land use type under five conditions, with separate results for both the *Parking Demand, 4th Edition* process and the *Shared Parking, 2nd Edition* process. The five separate conditions are: original peak parking demand, parking demand modified due to walk trips, parking demand modified due to transit trips, parking demand modified due to residential vehicle ownership, and a parking demand that aggregates the MXD-based modifications.

Important Considerations

> The Parking Demand component of ET+ produces approximate estimates for the peak parking demand. The estimates are intended for planning purposes only. The estimates should be used to inform the range of outcomes that may be expected from increasing land use mix, density, and changes in travel behavior. The Parking Demand component does not replace a detailed parking study. Prior to development, a detailed parking study should be conducted by a licensed traffic engineer, according to local standards.

Keywords

Parking Demand, Shared Parking, Transportation

Introduction

The Parking Demand component of Envision Tomorrow Plus (ET+) estimates the peak parking demand during a weekday for the land uses summarized in the scenario planning module. Parking demand of a proposed development site is based on state of the practice methodology. The results are intended to provide decision makers with an estimate of the peak parking demand during the highest demand hour of the day.

The mixed-use nature of ET+ scenarios is accounted for in the Parking Demand component. A modified parking demand for each proposed scenario is calculated separately assuming the mixed-use development (MXD) and 7D household vehicle ownership characteristics affect the number of vehicles parked on-site. The modified parking demand is summarized alongside the demand estimated using standard methodology to provide the user with a straightforward comparison of the effects on parking demand of the MXD.

The purpose of this documentation is to provide detail on the internal processes of the Parking Demand component and to present a users guide to be compiled with related ET+ documentation. The report presents a detailed description of the Parking Demand component in the following sections: review of the background literature, a description of the inputs and equations, a definition of terms, a process overview, and results.

Important Considerations

- The peak parking demand results should be considered a range of parking demands and not an exact prediction.
- Peak parking demand of a typical day is reported (the Parking Demand component excludes non-typical days such as the day after Thanksgiving or the day after Christmas).
- Parking demand does not equate to parking supply.
- Parking demand does not equate to a city/county required parking code.

Literature Review

Parking demand estimation is a traffic engineering process used to assess the parking needs of proposed developments. The procedures employed in the Parking Demand component are used extensively by traffic engineers and planners across the United States. In addition to the standard parking demand rates and equations, the Parking Demand component of ET+ references studies that address the shared-use nature and the estimated vehicle trip reductions of MXDs. The referenced research for the Parking Demand component is summarized in this section.

Parking Generation, 4th Edition

Parking Generation, 4th Edition (ITE, 2010 and referred to as *Parking Generation* in the remainder of this document) is the standard for vehicle parking demand estimation and is used across the US by traffic engineers, transportation planners, and city/county officials to estimate the number of parking spaces to be supplied by a development. *Parking Generation* is developed by the Institute of Transportation Engineers (ITE), and at the time development of ET+, was in its fourth edition.

ITE compiles parking studies for various sites and land uses, groups these studies into categories, and then develops rates and equations which can be applied to similar projects. The reference guide provides parking demand characteristics for hundreds of distinct land uses. *Parking Generation* is one of two nationally recognized parking demand datasets, with both being used as the basis for parking studies throughout the US.

Parking Generation provides methodology to estimate parking demand which represents the number vehicles that desire to park at a specific location and is typically provided as the maximum number of spaces demanded in the highest hour during the day. The parking demand estimated by *Parking Generation* is not equivalent to a parking supply; rather it is an estimate of the expected parking demand.

Shared Parking, 2nd Edition

Shared Parking, 2nd Edition (ULI, 2005 and referred to as *Shared Parking* in the remainder of this document) is used to estimate peak parking demand where spaces are shared by multiple land uses. The data and methodology in *Shared Parking* is produced by the Urban Land Institute (ULI) and the International Council of Shopping Centers and is the leading source for shared parking data in the US.

Shared parking is defined as one parking space used "to serve two or more individual land uses without conflict or encroachment" (ULI, 2005). The sharing of parking spaces is an event that has been occurring for decades in urban and suburban communities. Parking demand for different land uses have unique temporal distributions, allowing the same parking space to be occupied by the peak demand of different land uses throughout the day. For example, an office complex generates a peak parking demand during the day while a movie theater generates a peak parking demand after the office peak subsides. Therefore, a parking lot shared between the two land uses could accommodate demand with fewer physical spaces than if separate parking lots were provided for each land use. However, the benefit of sharing parking spaces in a lot/area greatly depends on the compatibility of the land uses sharing the parking.

Documentation provided by *Shared Parking* established rates, equations, and procedures to estimate shared parking demand for multiple land use types. The datasets in *Shared Parking* are different than those from ITE's *Parking Generation*.

Definitions

Proper estimation of parking demand for shared parking situations in MXDs requires an understanding of when both conditions are present in a development. Standard definitions are presented in this section to assist the user in identifying proper shared parking and MXD conditions.

Shared Parking

The definition of a shared parking condition is derived from the book *Shared Parking* from ULI, which defines shared parking as follows:

> Shared parking is the use of a parking space to serve two or more individual land uses without conflict or encroachment. The ability to share parking spaces is the result of two conditions: variations in the accumulation of vehicles by hour, by day, or by season at the individual land uses, and relationships among the land uses that result in visiting multiple land uses on the same auto trip.

The definition for shared parking is provided *Shared Parking* (ULI, 2005).

Mixed-Use Development

To accurately use parking demand modification factors from ET+, the study area should fit the definition of an MXD, as defined by the MXD Trip Generation component of ET+ and listed below.

> The study area boundary for the project site should include only mixed-use type development. The boundary should be established as close to the proposed scenario as possible; however, it should also include any immediately adjacent existing land use that would be considered part of the MXD. Mixed-use is defined as development consisting of two or more land uses between which trips can be made using local streets (including walk trips), without having to use major streets. The uses may include residential, retail, office, and/or entertainment.

For additional information on the boundaries and qualifications of an MXD refer to the MXD Trip Generation component documentation of ET+.

Inputs

The Parking Demand component of ET+ requires land use-based inputs to produce an estimate of the peak parking demand. All inputs required by the Parking Demand component are outputs of the ET+ package; many of the inputs to the component are outputs from the base package of Envision Tomorrow (ET), while several inputs required by the component are outputs of selected ET+ models.

The inputs required by the Parking Demand component of ET+ are summarized in Table 1.

Table 1. Parking Demand Component Inputs

Input	Source	Description
Land Use Amount	ET Scenario Summary	Residential land use amounts to be provided in dwelling units. Non-residential land use amounts to be provided in square feet.
7D Household Vehicle Ownership Rate	ET+ Mixed-Use Development Component	"Single family" rate to be provided for single family parking demand. "Other" rate to be provided for multi-family parking demand.
Mixed-Use Development Walk and Transit Trip Probabilities	ET+ Mixed-Use Development Component	Walk and transit trip probabilities for internal and external trips separated by trip purpose.
Trips by Purpose Percentage	ET+ Mixed-Use Development Component	Static percentages embedded in Mixed-Use Development Trip Generation component.

Equations

Equations and inputs contained within the Parking Demand component are based on national, published research and have been utilized by traffic engineers and transportation planners for decades, as summarized in the literature review.

The discussions of equations and inputs in this section are grouped into four categories: the first category presents those required to produce an ITE *Parking Generation* demand, the second presents those required to produce a ULI *Shared Parking* demand, the third category introduces the 7D household vehicle ownership model, and the final category presents the MXD model. The latter two models are separate components already contained in ET+ and are used by the Parking Demand component to estimate a modified parking demand based on household vehicle ownership, walk trips, and transit trips resulting from a mix of land uses in the development.

ITE *Parking Generation*

An estimate of the peak parking demand based on ITE *Parking Generation* rates and equations requires the following land use information:

- Existing and scenario square feet of retail, office, and industrial (if present)
- Existing and scenario dwelling units of single family residential, townhomes, multi-family residential, and mobile home park (if present)

The land use inputs required for the ITE *Parking Generation* estimates are provided by the scenario planning component of ET.

Equations and rates from *Parking Generation* that are utilized in the Parking Demand component are presented in this section. The following equations and rates are detailed: single family residential, townhomes, multi-family residential, retail, office, and industrial. Effort has been made to utilize rates and equations from *Parking Generation* that correspond to the same land use types in *Trip Generation, 8th Edition* (ITE, 2008) that were used by the MXD Trip Generation component of ET+.

Single Family Residential (ITE Land Use Code 210)

$P = 1.83 * X$

P = peak parking demand (spaces)
X = dwelling units

Townhomes (ITE Land Use Code 230)

$P = (1.26 * X) + 9$

P = peak parking demand (spaces)
X = dwelling units

Multi-Family Residential (ITE Land Use Code 221)

$P = (1.42 * X) - 38$

P = peak parking demand (spaces)
X = dwelling units

Retail (ITE Land Use Code 820)

$P = (3.62 * X) + 120$

P = peak parking demand (spaces)
X = 1,000 square feet of gross leasable area

Office (ITE Land Use Code 701)

$P = 1.27 * X$

P = peak parking demand (spaces)
X = 1,000 square feet of gross leasable area

Industrial (ITE Land Use Code 130)

$P = (2.51 * X) + 26$

P = peak parking demand (spaces)
X = 1,000 square feet of gross leasable area

For additional information on ITE parking generation estimating equations, rates, and procedures, refer to *Parking Generation*.

Important Considerations

- Weekday peak parking demand is reported in number of spaces.
- Data for mobile home park is not available. The equation for single family residential is used in place of mobile home park in instances where the land use is a part of the evaluated scenario.
- Parking demand for retail is based on data from a non-Friday weekday in December.
- Office building in a suburban location was used to estimate parking demand for the office land use.
- Low/Mid-Rise apartment residential parking demand estimated for suburban locations.

ULI *Shared Parking*

An estimate of the peak parking demand based on ULI *Shared Parking* rates, equations, and procedures requires the following land use information:

- Existing and scenario square feet of retail, office, and industrial (if present)
- Existing and scenario dwelling units of single family residential, townhomes, multi-family residential, and mobile home park (if present)

The land use inputs required for the ULI *Shared Parking* estimates are provided by the scenario planning component of ET.

As an example of the data from *Shared Parking* that is utilized in the Parking Demand component, equations and rates for the following select land uses are presented: single family residential and retail. The remainder of the equations, rates, and temporal distributions are embedded in the Parking Demand component of ET+ and are described in detail in *Shared Parking*.

Single Family Residential (Resident)

$P = 1.70 * X$

P = peak parking demand (spaces)
X = dwelling units

Single Family Residential (Visitor)

$P = 0.15 * X$

P = peak parking demand (spaces)
X = dwelling units

Retail less than 400,000 square feet (Customer)

$P = 2.90 * X$

P = peak parking demand (spaces)
X = 1,000 square feet of gross leasable area

Retail less than 400,000 square feet (Employee)

$P = 0.70 * X$

P = peak parking demand (spaces)
X = 1,000 square feet of gross leasable area

Separate retail parking demand equations exist for land use amounts of less than 400,000 square feet, between 400,000 and 600,000 square feet, and greater than 600,000 square feet. For brevity only one set of equations has been shown in this section.

For additional information on ULI shared parking demand estimating equations, rates, and procedures, refer to *Shared Parking*.

Important Considerations

- Weekday peak parking demand is reported in number of spaces.
- Data for mobile home park is not available. The equation for single family residential is used in place of mobile home park in instances where the land use is a part of the evaluated scenario.
- Single family residential assumed to be entirely occupant owned.
- Multi-family residential and townhome assumed to be entirely occupant rented.
- Data for industrial land use is not available; therefore, the equation for industrial land use from ITE *Parking Demand* is used.

7D Household Vehicle Ownership Model

The 7D household vehicle ownership model has been developed to estimate the number of vehicles owned by households and is based on local land use and geographic characteristics. The rate of the number of vehicles per household is used to modify the residential peak parking demand; the Parking Demand component sets the residential peak parking demand rate at the number of vehicles owned per household based on the 7D household vehicle ownership model.

The number of vehicles per household, as developed by the 7D household vehicle ownership model, is part of the MXD Trip Generation component of ET+. For additional information on the 7D household vehicle ownership model refer to the documentation accompanying the MXD Trip Generation component.

Mixed-Use Development Model

The amount of walk trips and transit trips generated by the development affect the peak parking demand. An estimate of the number of walk and transit trips is developed by the MXD model in the MXD Trip Generation component of ET+ and used to account for walking and transit trips on the parking demand of the development.

An estimation of trips associated with an MXD requires the completion of a separate set of equations with distinct inputs. The MXD equations predict the number of walk and transit trips for both internal and external trips. For additional information on the MXD model refer to the documentation accompanying the MXD Trip Generation component.

Process

The parking demand estimates are developed through a combination of ET and ET+ scenario inputs, empirically based research coefficients, and standard transportation rates and equations. An overview of the process for developing parking demand estimates is presented in the following, in which steps are summarized in the order they are completed in the ET+ Parking Demand component:

1. Calculate an ITE *Parking Generation* estimate and a ULI *Shared Parking* estimate of the peak parking demand by land use type for each development in the scenario summary.
2. Summarize the individual land use peak parking demands to arrive at the total parking demand for the scenario.
3. Apply a modification to the residential peak parking demands to account for the 7D household vehicle ownership rates.
4. Apply modifications to the peak parking demands of the individual land use types based on the proportion of external walk trips and external transit trips to the site.
5. Apply modifications to the peak parking demands of the individual land use types based on the proportion of internal walk trips of the site.
6. Summarize the individual land use modified peak parking demands to arrive at the total modified parking demand for the scenario.

Each step of the process is described in greater detail in this section. The intent of describing the individual process is to provide the user insight into the general operations of the Parking Demand component. The component has been developed to operate transparently, allowing the user to examine and follow each step of the model, if desired.

The 7D household vehicle ownership factors, MXD factors for external walk and external transit trips, and MXD factors for internal walk trips are applied equally to both parking demand estimates from ITE *Parking Generation* and ULI *Shared Parking*. Modification factors and application procedures are only

described once in this section; however, a separate modified peak parking demand is estimated for both the initial ITE *Parking Generation* and ULI *Shared Parking* estimating procedures.

ITE *Parking Generation*

Land use amounts from ET are input into the Parking Demand component and ITE *Parking Generation* rates and equations are used to estimate the peak parking demand of each land use type separately. The procedure is conducted assuming that parking demand for a land use is completely isolated from nearby land uses. For example, the peak parking demand for one land use could occur in the late morning while a neighboring land use peaks in the afternoon. The *Parking Generation* portion aggregates the peak parking demands per land use, regardless of the temporal demand distribution. The parking demand estimates are produced consistent with standard traffic engineering protocol for isolated, stand-alone developments.

The aggregation of individual land use peak parking demands yields the straight ITE *Parking Generation*-based parking demand for the entire development scenario. The peak parking demand is reported in number of spaces assuming that each land use contains its own parking demand. The steps that follow (the ULI *Shared Parking* section) apply the modifications based on the MXD characteristics of the development to the ITE *Parking Generation*-based parking demand.

ULI *Shared Parking*

Shared Parking estimates a parking demand for every hour of the day (typical daylight hours) by land use type for each ET development scenario. The per hour parking demands are combined for a development to determine the shared parking demand for the peak hour of the peak day of the peak month.

A peak parking demand is estimated with *Shared Parking* rates and equations and then separated into a parking demand by hour based on known temporal distributions of parking demand by land use. The interim result is an estimated parking demand for each land use for every hour of the day, which can then be aggregated to determine the overall peak parking demand hour of the day.

The peak parking demand hour of the day may not coincide with the peak parking demand hour of the individual land uses; however, the parking is assumed to be shared among all uses and the largest demand for the entire scenario is identified as the overall peak parking demand. Therefore, the largest overall demand establishes the peak parking demand for the development scenario.

Shared parking assumes that the parking spaces can be used by all land uses in the scenario, with the exception of some residential parking; it has been assumed that one parking space per residential unit is reserved for the household. For example, if the scenario includes 200 residential dwelling units, then a demand of 200 parking spaces is reserved for the residential land use. Residential parking in excess of the 200 residential parking spaces is available for shared usage.

The peak parking demand, assuming shared parking, is summarized in the results table. The peak month, day, and time of day are listed in the summary table with the corresponding parking demands of individual land use types for that time of day also listed. The robust summary table allows users to identify which land use type has the most significant impact on parking demand during the peak hour of the peak day of the peak month.

The shared parking demand results are for demonstration purposes only. The actual amount of shared parking is highly dependent on site layout, location of parking spaces, the shared nature of parking spaces, and parking restrictions, among others. For example, for parking spaces to be truly shared between land uses, the parking lot should be located in close proximity to the land uses sharing the spaces, with convenient pedestrian routes, and lacking parking restrictions. Shared parking results in the Parking Demand component should be used only as a guide for planning purposes.

7D Household Vehicle Ownership Model

The 7D household vehicle ownership rates are input from ET+ and used in place of the ITE *Parking Generation* and ULI *Shared Parking* demand equations for residential land uses. The "single family" 7D household vehicle ownership rate is used instead of the ITE and ULI single family rate, while the "other" 7D household vehicle ownership rate is used instead of the townhome, multi-family, and mobile home equations. A visitor parking demand rate of 0.15 spaces per dwelling unit was applied to the 7D household vehicle ownership rates to account for visitor and other residential-related parking demands (which are not included in the 7D household vehicle ownership rates). The resulting residential parking demand is reported in the summary table.

The 7D household vehicle ownership rates are applied to the residential component of the peak parking demand for the ITE *Parking Generation* approach and the ULI *Shared Parking* approach. The locally adjusted 7D household vehicle ownership rates utilize detailed land use and demographic characteristics and may result in higher parking demands than the nationally averaged parking rates from ITE and ULI.

Mixed-Use Development Model

The MXD walking and transit usage factors from the MXD Trip Generation component of ET+ are applied to the parking demand of the retail and office land uses resulting in a modified peak parking demand. An estimate of the number of walk and transit trips is developed by the MXD model and affects the retail and office parking demand estimated by both the ITE *Parking Generation* approach and the ULI *Shared Parking* approach.

The process to account for MXD trip making characteristics is important because the estimated internal walk trips, external walk trips, and external transit trips affect the peak parking demand. For example, transit trips that arrive to the development from an external origin do not require a parking space, thus reducing the overall parking demand. The following steps discuss the process of addressing MXD trip making characteristics on the peak parking demand.

The first step of the process is to determine the total portion of the walk and transit trips estimated by the MXD Trip Generation component of ET+. The proportion of internal and external walking and transit trips are determined by multiplying the internal and external walk and transit rates with the internal and external total trip rates from the MXD model (internal rates are multiplied together and external rates are multiplied together).

Individual trip rates in the MXD model are distinguished by trip purpose. Therefore, the resulting proportions of internal and external walking and transit trips calculated in the Parking Demand component are initially separated by trip purpose. The separation of trips by purpose is used to better understand how trips are distributed within the development.

In the MXD Trip Generation component a unique set of trips by purpose percentages were used to separate the trip estimates into home-based work (HBW), home-based other (HBO), and non-home-based (NHB) trips. A distinct trip percentage is provided for each land use type as the trip making characteristics differ. Information from the Nationwide Personal Transportation Survey and the National Highway Cooperative Research Program 365 report was used to determine the percentage of trips based on purpose. The following unique percentages were used in the Parking Demand component and MXD Trip Generation component of ET+:

Table 2. Trips by Purpose

Land Use	HBW	HBO	NHB
Residential	25%	75%	0%
Retail	5%	45%	50%
Office / Industrial	65%	5%	30%

The next step of the process aggregates the proportion of internal and external walk and transit trips by trip purpose. Therefore, the interim results are separate HBW, HBO, and NHB rates for walk trips and for transit trips. The rates include both internal and external trips and are a represented as a proportion of the total trips estimated to be generated by the development.

Assumptions have been made to translate the proportion of walk and transit trips into a peak parking demand reduction as not all of the reduced trips will equate equally to reduced parking demand. Trip reductions are not directly equal to parking space reductions because the trip estimates are for daily trips and parking demand is calculated on a peak hour basis. To translate daily trip reduction factors to parking demand modification factors, several assumptions were made and are discussed in the following paragraphs.

It was assumed that 50 percent of all external walk trips would originate outside of the development and walk in to the site. The walk trips originating outside of the site would not require a parking space within the development and would affect the parking demand. However, the walk trips originating within the site would not affect parking demand as their vehicle would remain within the development, occupying a parking space.

The development-related trips are estimated on a daily basis while the parking demand is based on the peak hour. Therefore, an assumption was made to identify the number of the daily walk trips that entered the site from an external origin that occurred during the peak hour of the parking demand. To be aggressive in estimating potential parking demand reductions, it was assumed that 100 percent of the walks trips that entered the site from an external origin occur during the peak hour of the parking demand.

Identical assumptions were made for the external transit trips estimated to be generated by the development. Internal transit trips are not expected to occur in the development due to relatively small size and have not been estimated.

Internal walk trips remain entirely within the development and a parking demand reduction was applied accordingly. An internal walk trip originates at one land use with a destination at another land use; therefore, the trip would reduce the parking demand by 50 percent. The vehicle would remain at one parking space, and continue to occupy the parking space, while the walk trip did not occupy a parking space at the destination land use. Similar to the aggressive external trips assumption, it was assumed that 100 percent of the internal walks trips would occur during the peak hour of the parking demand.

For the next step of the process, the internal and external walk reduction factors and the external transit reduction factors are summed by trip purpose type. The result is a total HBW, HBO, and NHB reduction factor for walking and transit use. The intent of summing by trip purpose is to relate to land use types, as described in the following step.

The total walking and transit use reduction factors by HBW, HBO, and NHB trip purpose are separated into reduction factors based on land use type (retail and office) using the trips by purpose rates in Table 2. The final reduction factors, which are separated by land use type, are summarized for retail walk trip reduction factors, retail transit trip reduction factors, office walk trip reduction factors, and office transit trips reduction factors.

The final reduction factors are applied to the peak parking demand estimates for both the ITE *Parking Generation* procedure and the ULI *Shared Parking* procedure. The reduction factors are applied individually to the retail land use parking demand and to the office land use parking demand, for walk trip and transit trip reductions, to allow the user to examine how the mix of land uses in the development affects the individual land use peak parking demands. In addition, the summary table aggregates the individual modified peak parking demands to arrive at an overall modified peak parking demand estimate for the entire development.

Important Considerations

- Parking demand modifications are only applicable when detailed MXD information is provided by the MXD Trip Generation component of ET+.
- Demand represents weekday parking demand in number of spaces.
- Parking demand estimations are not equivalent to parking supply.
- Office parking demand (ITE) estimated for suburban locations.
- A visitor parking demand rate of 0.15 spaces per dwelling unit was applied to the 7D household vehicle ownership rate to account for visitor and other residential-related parking demands (which are not included in the 7D household vehicle ownership rate).
- The 7D household vehicle ownership rate can increase the residential peak parking demand over ITE and ULI estimates.
- It is assumed that 50 percent of all external walk trips and transit trips originate outside of the development and travel in to the site.
- It is assumed that 100 percent of the walk trips and transit trips that enter the site from an external origin occur during the peak hour of the parking demand.
- It is assumed that 100 percent of the internal walk trips occur during the peak hour of the parking demand.
- Industrial parking demand is not reduced by MXD-related factors.
- Shared parking demand estimations are for demonstration purposes only. Actual amount of shared parking demand is highly dependent on site layout, location of parking spaces, the shared

nature of parking spaces, and parking restrictions, among others. Results should be used only as a guide for planning purposes.

Results

The Parking Demand component of ET+ estimates a peak parking demand of the development based on procedures outlined in *Parking Generation* and *Shared Parking*. Parking demand is based on the land use amounts for each of the four land use types: residential, retail, office, and industrial. In addition, a modified peak parking demand is estimated which accounts for the 7D household vehicle ownership model and the MXD travel characteristics relating to internal and external walk trips and external transit trips.

A peak parking demand is the estimated total number of parking spaces desired by patrons and residents in the development during the peak hour of the peak day of the peak month. Modifications to the peak parking demand based on MXD characteristics allows users to better understand the effects on parking demand of changing the mix of land uses in the development. In addition, a shared parking demand provides an estimate of the peak parking demand assuming that parking spaces within the development could be shared by all land uses.

The Parking Demand component produces a results table that summarizes the peak parking demand by land use type under five conditions, with separate results for both the ITE *Parking Generation* process and the ULI *Shared Parking* process. The five separate conditions are: original peak parking demand, parking demand modified due to residential vehicle ownership, parking demand modified due to walk trips, parking demand modified due to transit trips, and a parking demand that aggregates the MXD and 7D household vehicle ownership-based modifications.

Important Considerations

The Parking Demand component of ET+ produces approximate estimates for the peak parking demand. The estimates are intended for planning purposes only. The estimates should be used to inform the range of outcomes that may be expected from increasing land use mix, density, and changes in travel behavior. The Parking Demand component does not replace a detailed parking study. Prior to development, a detailed parking study should be conducted by a licensed traffic engineer, according to local standards.

References

Ewing, R., Greenwald, M., Zhang, M., Walters, J., Feldman, M., Cervero, R., Frank, L., and Thomas, J. (2011). Traffic Generated by Mixed-Use Developments – Six-Region Study Using Consistent Built Environmental Measures. *Journal of Urban Planning and Development*, 137, 3, 248-261.

Institute of Transportation Engineers. (2010). *Parking generation, 4th edition*. Washington, D.C., USA: Institute of Transportation Engineers.

Institute of Transportation Engineers. (2008). *Trip generation, 8th edition*. Washington, D.C., USA: Institute of Transportation Engineers.

National Cooperative Highway Research Program, Transportation Research Board, and National Research Council. (1998). "Travel estimation techniques for urban planning." Washington, D.C.: Transportation Research Board, National Research Council.

Urban Land Institute and International Council of Shopping Centers. (2005). *Shared parking, 2nd edition*. Washington, D.C.: ULI.

United States Department of Transportation. (2009). *National household travel survey*. Washington, D.C.: U.S. Department of Transportation.