

difficulty for the development community has been in determining the factors for accumulation of vehicles at one land use when another is likely to peak. Although the PGM includes significantly more data than in the past, it often has few if any data points for nonpeak hours and little or no seasonal information. Further, the amount of data for many land uses remains statistically weak, and the separation of data into more specific but smaller groupings (for example, separating big-box retail uses into as many as 10 separate land use codes) makes determining the design day and hour more difficult because the data become less statistically reliable as they are subdivided.

The collective resources of NPA's PCC for this publication were used to test and adjust as well as to develop the factors for newly added land uses. Figure 2-3 shows the monthly adjustments, figure 2-4 shows weekday time-of-day adjustments, and figure 2-5 shows weekend adjustments.

#### Step 4: Develop Scenarios for Critical Parking Need Periods

As previously discussed, and with few exceptions, several scenarios should be developed for modeling parking needs to ensure that the peak hour is identified. For a shopping center with retail, dining, a cineplex, and a relatively small amount of entertainment uses, the following scenarios might be reviewed:

- weekend evening in July;
- weekend afternoon and evening in December before Christmas; and
- weekend afternoon and evening in Late December.

One should not presume that the peak hour for this shopping center is going to be a Saturday afternoon in December and run only that single scenario. Conversely, if office parking needs clearly will exceed the combined demand from other uses, it would be appropriate to review weekdays in October as well.

The first checkpoint in this process is to consider the demand that each land use would generate in a stand-alone mode. This is not simply the square footage or other quantity metric, but the quantity of land use times the parking ratio

before application of any factors. Certainly, any land use that generates less than, say, 20 percent of the parking demand is unlikely to drive the overall peak accumulation of vehicles. Then, knowing what the peak times of day and season are for each use, scenarios can be generated that could reasonably result in peak accumulations of vehicles.

For most land uses, the time-of-day and seasonality adjustments will have a greater effect on the accumulation of vehicles than driving and noncaptive adjustments. Therefore, it makes sense to evaluate the time-of-day and seasonality variables first, narrowing down the number of scenarios to be run before applying noncaptive and driving adjustments.

It may then be necessary to test several hours for each scenario to determine the peak hours of each of those days. Often this can be achieved by checking a key hour for the land uses that appear to drive demand, eliminating some scenarios and focusing on those that seem likely to result in peak demand by checking multiple hours on those days.

Note that in the SP Model associated with this publication, the application of time-of-day and seasonal adjustments is automatically calculated. One skips step 4 and goes to step 5. However, after completion of that step, one should revisit whether additional scenarios should be included in the analysis for understanding of the analysis, design and/or parking management planning, or appropriate communication to the various parties.

#### Step 5: Adjust Ratios for Modal Split and

All the parking ratios recommended in this book are intended to reflect conditions in suburban and smaller city settings with little or no transit, free or inexpensive parking, and minimal employee ride sharing. Adjustments for reduced use of automobiles owing to alternative modes of transportation, formal ride-sharing programs, or an atypical ratio of persons per car resulting from carpooling can be made by a driving adjustment. As previously defined, the driving adjustment reflects both modal split to automobiles and auto occupancy.

Nearly all the recommended ratios are based on observed accumulations of parked vehicles,

and thus the modal split and auto occupancy at that ratio are implicit in the number but not known. The *PGM* is careful to note that even in suburban settings, the sites studied may be served by transit to some degree. Moreover, there will often be a small number of dropoffs and walk-ins and some ride sharing, even where public transit is not available. Minuscule adjustments should be avoided. If data suggest that the actual employee split is precisely 98.5 percent private auto, they should be disregarded because some ride sharing (carpooling), dropoffs (including ride hailing), and walking are inherent in the base ratios for employee parking. The driving adjustments are intended for significant changes in modal split or auto occupancy.

Because of wider availability of census and transportation information, it is easier now to adjust for local modal splits for employees than in the past. Two recognized and easily accessible sources of modal split data, typically at a census tract, city, or county level, can be used to determine driving ratios. Those are the U.S. Census Bureau's ACS and the CTPP. The ACS data are collected annually and generally presented on a city or countywide basis, with a rolling five-year average. For example, as of 2019, the most recent data available from the ACS FactFinder website are 2013–2017.

The CTPP is a state department of transportation (DOT)-funded, cooperative program maintained by the American Association of State Highway and Transportation Officials that produces special tabulations of ACS data by "small geography" (census tract) for transportation planning, analysis, and strategic direction.<sup>5</sup> The information is available by place of residence, workplace, and trip from home to work. The latest CTPP, published April 1, 2019, is based on the 2012–2016 ACS data. The aging of the CTPP data toward the end of a cycle is a minor issue; the last update used data from 2006 to 2010, which was on average over a decade old when the 2019 CTPP update was issued. As is further discussed in the next chapter, as of this publication date, no significant change in commuting by car in the United States and only very minor change in vehicle ownership are indicated in at least the past two decades. Therefore, the CTPP typically yields

similar results to ACS for city or countywide data. If a significant change in transportation availability has taken place, such as opening of a new rail, light rail, or bus rapid-transit line at the site, one would have to modify results from the CTPP.

Figure 2-6 presents sample journey-to-work data from the CTPP for a census tract in Schaumburg, Illinois.

To calculate the modal split, which is by person, the number of person-trips in each modal category is divided by the total employees (5,596 in this sample). The number of car trips is then calculated by dividing the number of persons in each carpool category by the size of the carpool. For five- or six-person carpools, the number of persons is divided by 5.3, assuming that more of the pools were five persons than six persons. Similarly, the seven-or-more-person carpool figure is divided by seven; at that point it is not going to materially affect the overall number of cars.

In the figure 2-6 data, the average auto occupancy is 1.04 for those arriving by private vehicle. Also calculated is the figure for cars generated by the total employees in this census tract, which is 5,061 / 5,596, or 0.9 cars per total employee. However, one still must account for those who work from home, which should be deducted because they will not commute to a place of employment in the tract. Remember that the base ratios already reflect a typical presence of persons in a space. Telecommuters are not present, similarly to workers on vacation or away from the workplace for business purposes. Leaving telecommuters in the driving adjustment would be "double-dipping." Thus, the drive adjustment is 5,061 cars / (5,596 – 165 telecommuters), resulting in a drive adjustment of 93.2 percent for commuting to a workplace in this census tract. This is slightly below the modal split to cars of 93.7 percent.

Understanding the types of employees generally associated with a land use is also important in adjusting ratios. For example, hotel and retail employees are more likely to use bus transit, to carpool, to walk or to be picked up and dropped off than office employees at the same location.

The available ACS data for a location can also include overall modal splits by the type of employment as seen in figure 2-7.

FIGURE 2-7 **Modal Split Data by Type of Employment**  
Bethesda, Maryland

	Drove alone	Carpool	Drive adjustment <sup>a</sup>	Public transit	Walked	Worked at home	Other <sup>b</sup>
Management, business, science, and arts occupations	63%	9%	69%	19%	3%	4%	2%
Service occupations	59%	9%	65%	24%	3%	3%	2%
Sales and office occupations	65%	9%	71%	19%	3%	3%	1%
Natural resources, construction, and maintenance occupations	64%	22%	73%	13%	1%	0%	0%
Production, transportation, and material moving occupations	68%	7%	71%	20%	0%	1%	4%
Military-specific occupations	56%	17%	63%	10%	11%	7%	6%
<b>All occupations</b>	<b>63%</b>	<b>10%</b>	<b>69%</b>	<b>19%</b>	<b>3%</b>	<b>4%</b>	<b>2%</b>

Source: U.S. Census Bureau, 2013–2017 American Community Survey Five-Year Estimates.

<sup>a</sup>Drove alone + carpool adjusted for persons per car.

<sup>b</sup>Includes taxi, ride sharing, motorcycle, and bicycle.

This district is in downtown Bethesda, Maryland. Interestingly, the “drove alone” data are 4 percent lower for service employees than for office employees. The service employee data would be appropriate for retail and hotel employees, and the office employee data for the office.

However, remember that the parking ratios already reflect the typical modal splits for a particular type of use, and minor adjustments are automatically made when adjusting from modal split to driving ratio as defined herein. Only when the modal data look unusual or distinctly different should a special adjustment, beyond what is

calculated using the data for the tract, be made for auto occupancy. An example is if it is known that the employees will be bused from special housing or a particular neighborhood, that is, if a large tenant in Silicon Valley will run a shuttle specifically to San Francisco for employees; this probably is not reflected in the 2012–2016 CTPP data for the census tract in which the project is located.

Even with this type of data in hand, adjusting for mode still requires careful thought and professional judgment. It is certainly appropriate to look

for workplace and destination surveys available through local sources.

As previously noted, the CTPP data on modal splits are available by place of work and by place of residence. Place-of-residence data include all employed residents living in an area, even if they commute an hour or more to a larger city. Place-of-residence data are thus more appropriate for analyzing residential land uses, whereas the place-of-work data are more reliable for assessing employment at destinations.

Figure 2-8 shows similar data on vehicles per household and commuting to work by those who live as well as those employed in Schaumburg, Illinois, as seen in figure 2-6. The data are shown both for one census tract and citywide, in order to show the benefit of using data by census tract.

The tract selected is not one near the Schaumburg rail station for commuting to Chicago but rather an area that has both mid-rise office buildings lining a freeway and typical single-family suburban neighborhoods for the rest of the tract. Thus, it has higher vehicle ownership and modal split to auto than the citywide data.

The driving ratio for those who commute to work in Schaumburg in this census tract (93 percent) is only a little higher than for the entire city (92 percent); as previously noted, the driving ratio for those who live in this census tract have the driving ratio of 94 percent to wherever they work. However, the driving ratio for all those who live in the village is lower at 88 percent.

One might even further adjust for a specific location. For example, if the site is just inside one tract but the Metro station is in the adjacent tract, one might average the two tracts' driving ratios. Or if the site is immediately adjacent to the Metro station one might adjust the driving ratio downward, depending on how big the census tract is geographically.

Another concern is the reliability of survey data. Census and ACS data are typically for the "usual" commuting mode, which may not be the appropriate driving adjustment for an average day. The National Household Transportation Survey is based on an inventory of all trips by persons in a household (over the age of five) in a 24-hour period. It found that while those who "usually" drive alone are quite loyal to the mode, other

modes show more variation. If the usual mode is walking, for example, the average of those using the mode of walking on a particular day may be significantly higher or lower and thus could affect the appropriate reduction.

### Reserved Parking Adjustments

It would seem logical that when a parking space is reserved for residents or office employees, the driving adjustment for the reserved parkers is 100 percent. However, the reserved parkers are one part of those who drive; that is, they are a component of the total staff or residents with the driving ratio applying to all of them in the aggregate. Applying the driving adjustment calculated from ACS or CTPP data to the remaining parking only will result in an overestimate of parking demand.

Therefore, one should apply the same driving ratio to both, then tweak the percent reserved to get the number of reserved spaces desired.

A simple example with "manual" calculations follows:

Correct calculation:

Assuming 100,000 square feet of office, the base parking ratio for employees is 3.15 spaces/ksf. In a suburban location with 100 percent driving, the number of employee parkers reflected in that ratio is roughly

$$3.15 \div 0.85 \text{ presence} = 371 \text{ employees.}$$

Assume the client wants reserved spaces for 20 percent of the employees, or 64 spaces.

The CTPP data for the site indicate that the driving ratio (after carpooling and telecommuting calculations) for the urban location of the specific project is 75 percent.

$$\text{So total employee parking demand is } 3.15 \times 0.75 \times 100 \text{ ksf} = 236 \text{ spaces.}$$

Therefore, the percent reserved should be  $64 \div 236 = 27$  percent of the parking spaces reserved, to end up with 20 percent of the employees having reserved parking.

When using the SP Model for this calculation, one would enter the reserved factor as 0 percent reserved, and then put in the 75 percent driving ratio; the model automatically applies that to both the reserved and unreserved components. One would then go back to the Land Use Densities sheet. To facilitate this calculation, the model

FIGURE 2-8 **Vehicles per Household and Commute to Work by Residents and Employees**  
Schaumburg, Illinois

Households	One tract	Citywide
Households	2,403	30,171
No vehicles available	4%	5%
1 vehicle available	30%	39%
2 vehicles available	45%	42%
3 vehicles available	19%	11%
4 or more vehicles available	2%	3%
Average vehicles per household	1.87	1.70

Source: U.S. Census Bureau, 2012–2016 American Community Survey Five-Year Estimates.

Commuting by residents		
Total persons over 16 years of age who are employed	3,465	40,406
Drove alone	88%	82%
Carpooled	3%	8%
Public transportation (excluding taxi)	3%	5%
Walked	1%	2%
Taxicab, motorcycle, bicycle, or other means	0%	1%
Worked at home	5%	3%
Drive adjustment	94%	88%

Source: U.S. Census Bureau, 2012–2016 American Community Survey Five-Year Estimates.

Commuting to workplace		
Total persons over 16 years of age who are employed	5,596	71,404
Drove alone	87%	87%
Carpooled	6%	8%
Public transportation (excluding taxi)	3%	1%
Walked	0%	1%
Taxicab, motorcycle, bicycle, or other means	0%	2%
Worked at home	3%	2%
Drive adjustment	93%	92%

Sources: 2012–2016 American Community Survey Five-Year Estimates (Citywide) and CTPP data set based on 2012–2016 American Community Survey Five-Year Estimates (one tract).

retrieves the parking calculation for reserved parking for office and residential uses from the Summary Sheet, which at this point should still be 0 percent reserved. One can insert percentages by trial and error to achieve the desired number or other goal for reserved parking. Remember to do this after inserting driving ratios.

Easy calculation:

Insert 20 percent reserved immediately and use 100 percent driving for reserved employee spaces. Those reserved spaces would be

$$3.15 \times 0.2 \times 100 \text{ ksf} = 63 \text{ spaces.}$$

The remaining demand is

$$3.15 \times 0.8 \times 0.75 \times 100 \text{ ksf} = 189 \text{ spaces}$$

Total demand is then 252 instead of 236 spaces, a 6.7 percent error. The overall driving ratio ends up higher than 75 percent with this approach . . . about 80 percent.

Therefore, using the same driving ratio for both reserved and unreserved parking and adjusting the percent reserved is the most accurate way to account for reserved parking, especially with larger land uses or higher percentages reserved.

For residential, it is particularly complicated, because the total parking demand for residents based on bedrooms must be calculated first and then the percentage of those spaces that are to be reserved (with less than 100 percent reserved) must be calculated. If one always assumes 100 percent driving adjustment for reserved parking, and 100 percent of the parking is reserved, then no adjustment will be made for the reserved parking in urban settings with lower vehicle ownership than suburban.

As another example, a client wants to have one space per residential unit reserved and segregated and to let the rest be shared. The overall mix of bedrooms for the 100 units results in 185 spaces, a ratio of 1.85 spaces per unit before driving adjustment. At 75 percent driving adjustment for the site, the overall demand would be 1.39 spaces per unit. The percentage reserved is then  $1 \div 1.39$ , or 72 percent, with both reserved and unreserved having a 75 percent driving adjustment.

## Step 6: Apply Noncaptive Adjustments

Both formal studies and general experience have proven that some reduction of customer

parking needs occurs in a mixed-use project because of patronage of multiple land uses. The term "captive market" has been borrowed from market researchers to describe people who are already present in the immediate vicinity and likely patrons of a second use. The key to noncaptive adjustments is thinking through whether a car would already be counted as parked at another land use *at the specific time* a person patronizes the other use. For example, employees in a complex or district who are counted as parked at another land use will not generate any parking demand when they patronize a coffee store, deli, or shop for a few minutes while on a break. The car of a resident of a mixed-use development would be counted as being parked at the residence, even when the resident is going to a movie in the complex.

Determining appropriate noncaptive factors is the step that requires the greatest professional judgment and experience.

The development community uses the term "captive" for patrons who are already nearby and may be more easily attracted to a land use. The traffic engineer similarly uses captive for patrons who are already present for another purpose and thus do not generate another vehicle trip to the site. It is important to understand the difference between sequential and simultaneous trips when estimating the effects of captive market influences on the parking supply. The parking planner must determine for each time period whether the captive patrons are already counted as parked for another land use and thus do not generate the need for additional parking spaces at that particular hour. The following examples further explain these issues.

- When a traffic engineer estimates that 20 percent of a cinema's patrons are also going to eat at the restaurants in a retail/entertainment center, it is clearly legitimate to reduce the number of inbound and outbound trips to the project to reflect the fact that new trips to the restaurants will not be made via automobile (but rather are already accounted for in the trip-generation estimates for the cinema). However, if a family goes to a movie and then goes to dinner (i.e., a sequential