5. TRAVELED WAY DESIGN

(Credit: Kimley-Horn and Associates, Inc.)

INTRODUCTION

Wide, uninviting boulevard; a typical existing condition (Credit: Kimley-Horn and Associates, Inc.)

Streets and their geometric design have traditionally focused on the movement of motor vehicles, resulting in street environments that neglect other users. This emphasis can be seen in wide travel lanes, large corner radii, and turn lanes that severely impede the safety of pedestrians and the overall connectivity for non-automobile users. The geometric design of the traveled way and intersections has usually reflected the need to move traffic as quickly as possible. A paradigm shift needs to occur to reclaim the public right-of-way for pedestrians and bicyclists and create complete streets.

Traveled way design in this chapter is defined as the part of the street right-of-way between the two faces of the outside curbs and can include bicycle lanes, parking lanes, transit lanes, general use travel lanes, and medians. The traveled way contains the design elements that allow for the movement of vehicles, including bicycles, transit, automobiles, and trucks. The design of the traveled way is critical to the design of the entire street right-of-way because it typically utilizes the largest portion of the right-of-way and it affects not just the users in the traveled way, but those using the entire right-of-way, including the areas adjacent to the street. As a note on terminology, "traveled way" in this document is more or less the equivalent of "roadway" in most conventional design manuals: the curb-to-curb portion of a curbed street. The Manual on Uniform Traffic Control Devices (MUTCD) defines roadway as that portion of a highway improved, designed, or ordinarily used for vehicular travel and parking lanes, but exclusive of the sidewalk, berm, or shoulder.

> *"I (am) scared when I walk because cars (are) speeding and police catch them. I (am) scared to ride my bike because of cars."*
>
> - *Participant in Broward Complete Streets focus group with elementary students)*

ESSENTIAL PRINCIPLES OF TRAVELED WAY DESIGN

The following key principles should be kept in mind for a well-designed traveled way.

Design to accommodate all users.
Everyone from schoolchildren to the elderly should feel safe using our streets.
(Credit: Broward MPO)

- Design to accommodate all users. Street design should accommodate *all* users of the street, including pedestrians crossing the street, bicyclists, transit users, automobiles, and commercial vehicles. A well-designed traveled way provides appropriate space for all street users to coexist.
- Design using the appropriate speed for the surrounding context. The right design speed should respect the desired role and responsibility of the street, including the type and intensity of land use, urban form, the desired activities on the sidewalk, such as outdoor dining, and the overall safety and comfort of pedestrians and bicyclists. The speed of vehicles impacts all users of the street and the livability of the surrounding area. Lower speeds reduce crashes and injuries. When a roadway is being reconstructed or resurfaced, designers should select a design speed that respects these factors and should not simply default to the previous design speed of the roadway.
- Design for safety. The safety of all street users, especially the most vulnerable users (children, the elderly, and disabled) and modes (pedestrians and bicyclists) should be paramount in any design of the traveled way. The safety of streets can be dramatically improved through appropriate geometric design and operations.

Building on the momentum of complete streets that have been successfully implemented in different parts of the nation and around the world, there is a strong need for Broward County to retrofit existing streets and create new types of street environments that reflect the values and desires of all users. This chapter discusses different factors affecting traveled way design. Individual geometric design elements such as lane width and sight distance are examined in greater detail. The benefits and constraints of each element are examined and the appropriate location and correct use of each element is defined to maximize the creation of complete streets. Finally, a case study of La Jolla Boulevard in San Diego demonstrates the benefits of well-designed traveled ways.

FACTORS AFFECTING STREET DESIGN

USERS

Pedestrians

Walking is the most basic mode of transportation, yet pedestrian mobility is often significantly restricted in roadway design. These restrictions to pedestrian mobility are often based on a misplaced attempt at safety and a general unwillingness to sacrifice any amount of motor vehicle speed or level of service. Certain areas generate high pedestrian activity, such as downtowns, residential, commercial, and entertainment areas, and schools. Yet even in areas of low pedestrian activity, such as along commercial strip-developed arterials, pedestrian needs and safety must be addressed, as drivers usually don't expect pedestrians, who are more vulnerable if a crash occurs. Much of this is due to speed. As speeds increase, drivers are less attentive to what is happening on the side of the road, reaction time is increased, and the pedestrian has a higher chance of dying or becoming severely injured in case of a crash.

Most pedestrian crashes occur when a person crosses the road, and the most common crash type is a conflict between a crossing pedestrian and a turning vehicle at an intersection.

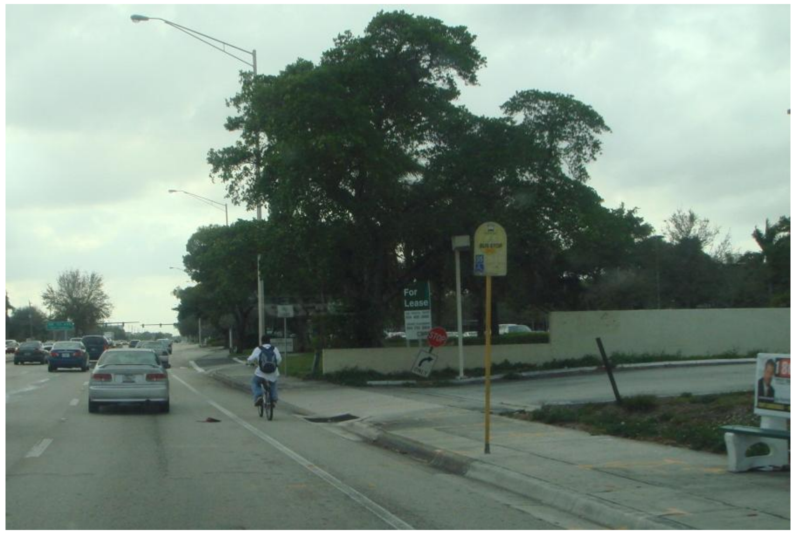
Pedestrian crossing a super-wide boulevard with very long block spacing (Credit: Kimley-Horn and Associates, Inc.)

But designing for pedestrians should not focus primarily on avoiding crashes; the goal of roadway and intersection design should be to create an environment that is conducive to walking, where people can walk along and cross the road, where the roadside becomes a place where people want to be. The two most effective methods to achieve these goals are to minimize the footprint dedicated to motor vehicle traffic and to slow down the speed of moving traffic. This approach allows the designer to use many features that enhance the walking environment, such as trees, curb extensions, and street furniture, which in turn slow traffic: a virtuous cycle. All streets should have sidewalks except for rural roads and shared-space streets.

See Chapter 7, "Universal Pedestrian Access," for specifics of sidewalk design and Chapter 8, "Pedestrian Crossings," for specifics of pedestrian crossings.

Bicyclists

All streets should be designed with the expectation that bicyclists will use them. This expectation is consistent with *Florida State Statute 316* and the Florida Department of Transportation (FDOT) Plans Preparation Manual (PPM). This does not mean every street needs a dedicated bicycle facility, nor will every road accommodate all types of bicyclists. Minimizing the footprint dedicated to motor vehicle traffic and slowing down the speed of moving traffic benefits bicyclists. Chapter 9, "Bikeway Design," describes in greater detail the various types of bikeways and their application. Ideally, all multi-lane streets should have bike lanes. On multi-lane streets where bike lanes aren't feasible because of space constraints, other bikeway treatments should be applied.



Bicyclist in Commercial Boulevard bike lane
(Credit: Kimley-Horn and Associates, Inc.)

Public Transportation

Designing for transit vehicles on roadways takes into consideration many factors. Buses have operational characteristics that resemble trucks - they usually operate in mixed traffic, they stop and start often for passengers, and they must be accessible to people boarding the bus. The consequences for roadway design include lane width (in most cases buses can operate safely in travel lanes designed for passenger cars), intersection design (turning radius or width of channelization lane),

Broward County Transit bus
(Credit: Kimley-Horn and Associates, Inc.)

signal timing (on several Broward corridors, signal timing is adjusted to give transit an advantage), pedestrian access (crossing the street at bus stops), sidewalk design (making room for bus shelters in the furniture zone), and bus stop placement and design (farside/nearside at intersections, bus pullouts, or bulb outs).

Chapter 10, "Transit Accommodations," describes in greater detail these and other design and operational considerations. Where express bus service or Bus Rapid Transit is provided, exclusive bus lanes are desirable. These have unique operating characteristics that are beyond the scope of this manual.

Emergency Vehicles

Major urban arterial boulevards and avenues are the primary conduits for emergency response vehicles including police, fire, and ambulance. Emergency vehicle access and operations should always be considered in traveled way design. Many factors affect emergency vehicle response time including congestion, width of street and travel lanes, geometric design of intersections, access management features, signal timing, and the presence of signal pre-emption devices.

The following principles should be considered in designing traveled ways to accommodate emergency vehicles.

- High levels of street connectivity improve emergency response time by providing alternate routes. Look for opportunities to improve overall network connectivity.
- When establishing new or reviewing existing access management configurations, care should be taken to permit direct routing capability to emergency vehicles.
- On streets with medians, traffic circles, tight corner radii, or other access management features, emergency response time may be reduced by the implementation of mountable curbs to allow emergency vehicles to cross.

Design Vehicles

The design vehicle influences several geometric design features including lane width, corner radii, median nose design, and other intersection design details. Designing for a larger vehicle than necessary is undesirable, due to the potential negative impacts larger dimensions may have on pedestrian crossing distances and the speed of turning vehicles. On the other hand, designing for a vehicle that is too small can result in operational problems if larger vehicles frequently use the facility.

For design purposes, the WB-40 (wheel-base 40 feet) is appropriate unless larger vehicles are more common. On bus routes and truck routes, designing for the bus (CITY-BUS or similar) or large truck (either the WB-50 or WB-62FL design vehicle) may be appropriate, but only at intersections where these vehicles make turns. For example, for intersection geometry design features such as corner radii, different design vehicles should be used for each intersection or even each corner, rather than a "one-size-fits-all" approach, which results in larger radii than needed at most corners. The design vehicle should be accommodated without encroachment into opposing traffic lanes. It is generally acceptable to have encroachment onto multiple same-direction traffic lanes on the receiving roadway.

Furthermore, it may be inappropriate to design a facility by using a larger "control vehicle," which uses the street infrequently, or infrequently makes turns at a specific location. An example of a control vehicle is a vehicle that makes no more than one delivery per day at a business. Depending on the frequency, by under designing the control vehicle can be allowed to encroach on opposing traffic lanes or make multiple-point turns.

TRAFFIC VOLUME AND COMPOSITION

Traffic volume data collection is an integral part of transportation planning and decision making. Traffic volume data are collected for various periods of the day depending on the purpose for which the data is used. For most analyses it is necessary to collect peak period and daily traffic. Peak period traffic could be further divided into morning (a.m.), mid-day (m.d.), and evening (p.m.) peak periods. Daily traffic data is also called average daily traffic (ADT). Other types of data collected are annual daily traffic, average annual daily traffic, average weekday traffic, hourly traffic (usually at intersections), and short-term counts as required. There are special types of traffic volume counts such as vehicle classification counts and average vehicle occupancy. The traffic volumes collected are also used for a variety of studies, including forecasting. Traffic volume on a segment of a road or at an intersection can be collected either manually or by using tubes.

The ADT volume is the most commonly collected traffic volume data. The ADT provides both the peak period traffic and the total daily traffic for analysis purposes. Typical ADT data for a central business district (CBD) will show an a.m., mid-day, and p.m. peak volume, which clearly indicates the typical usage of the CBD.

Vehicle classification counts are conducted on a daily basis to determine the types of vehicles using the roadway. The vehicle classification devices currently in use accurately record axle impulses, but do not provide consistent and accurate interpretation of axle impulses into classification of vehicles when vehicles (typically in urban areas) are traveling at speeds below 25 mph. The Federal Highway Administration (FHWA) has classified trucks into several categories based on the number of axles.

Turning movement volumes are collected at intersections to record the various turning movements. The collection of data on turning movements allows determining the level of service and making improvements to the intersection to reduce delay and idling for all vehicles. The data collected on traffic volumes and turning movements helps to determine the number of travel lanes needed.

Design Speed

The application of design speed for complete streets is philosophically different than for conventional transportation practices. Traditionally, the approach for setting design speed is to use as high a design speed as practical. The intent of this approach when it was developed was to move people and goods in automobiles as efficiently as possible over long distances. In addition, it was thought that achieving similar speeds for all motor vehicles using a roadway would maximize safety by minimizing speed differentials. However, this approach has many negative effects. Speed kills places as well as people, and inherently places efficiency over access even though access is just as fundamental. Because high design speeds reduce access to places on foot, they degrade the social and retail life of a street and devalue the adjacent land. Local economies thrive on attracting people.

In contrast to this approach, the goal for complete streets is to establish a design speed that creates a safer and more comfortable environment for motorists, pedestrians, and bicyclists. This approach also increases access to adjacent land, thereby increasing its value, and therefore is appropriate for the surrounding context. For complete streets, design speeds of 20 to 35 mph are desirable. Alleys and narrow roadways intended to function as shared spaces may have design speeds as low as 10 mph. Design speed does not determine nor predict exactly at what speed motorists will travel on a roadway segment; rather, design speed determines which design features are allowable (or mandated). Features associated with high-speed designs, such as large curb radii, straight and wide travel lanes, ample clear zones (no on-street parking or street trees), guardrails, etc., degrade the walking experience and make it difficult to design complete streets. In the end, the design of the road encourages high speeds and creates a vicious cycle. A slower design speed allows the use of features that enhance the walking environment, such as small curb radii, narrower sections, trees, on-street parking, curb extensions, and street furniture, which in turn slow traffic: a virtuous cycle.

Movement Types

The following movement types are used to describe the expected driver experience on a given street and the design speed for pedestrian safety and mobility established for each of these movement types. They are also used to establish the components and criteria for design of complete streets.

- Yield: Drivers must proceed slowly and with extreme care and must yield in order to pass a parked car or approaching vehicle. This is the functional equivalent of traffic calming. With a design speed of less than 20 mph, this type should accommodate bicycling through the use of shared lanes.
- Slow: Drivers can proceed carefully with an occasional stop to allow a pedestrian to cross or another car to park. Drivers should feel uncomfortable exceeding design speed due to the presence of parked cars, a feeling of enclosure, tight turn radii, and other

design elements. With a design speed of 20 to 25 mph, this type should accommodate bicycling through the use of shared lanes.

- Low: Drivers can expect to travel generally without delay at the design speed; street design supports safe pedestrian movement at the higher design speed. This movement type is appropriate for streets designed to traverse longer distances or that connect to higher intensity locations. With a design speed of 30 to 35 mph, this type can accommodate bicycling with the use of designated bike lanes.

Design speeds higher than 35 mph should not normally be used within communities, or in Transects T3 and above. Speeds greater than 30 mph or 35 mph violate the principles of complete streets. Realizing actual average network travel speeds greater than 35 mph is very uncommon in urban environments due to traffic signal spacing and timing. Lowering the design speed to no more than 35 mph within Transects T3 through T6 would help reduce the "hurry up and wait" condition that often prevails in the urban driving experience.

Communities that have streets functioning at speeds greater than 35 mph may want to adopt a goal to re-design the corridor to reduce the speed to 35 mph or less, especially during reconstruction or resurfacing projects. The increase in motorist travel time due to the speed reduction is usually insignificant because communities designed with complete streets are generally compact. When the speed reduction cannot be achieved, measures to improve pedestrian safety for those crossing the corridor should be evaluated and installed where appropriate.

High automobile level of service, but poor multi-modal level of service (Credit: Kimley-Horn and Associates, Inc.)

MULTI-MODAL LEVEL OF SERVICE

Municipalities use qualitative assessments to describe the perceived service a street provides to the people using the facility. The quality of service has conventionally been obtained using Level of Service (LOS) measurements. LOS assesses delay for motorists along a roadway section or at a signalized intersection. The LOS is defined using letters A to F, where LOS F denotes the greatest delay and LOS A no delay. The LOS is used to develop solutions to improve the existing system to achieve the desired LOS. This convention considers quality of service for only automobiles and other vehicles (commercial) using the roadway system. The *Highway Capacity Manual* (HCM) provides details of the LOS computations for roadways and intersections.

Since traveled ways are used by different modes, the multimodal level of service (MMLOS) was developed under National Cooperative Highway Research Program (NCHRP) Project 3-70. The MMLOS was developed for urban streets and it is currently designed for analysis of steady state conditions during a specified analysis period. MMLOS applies to urban streets with all modes of travel (cars, pedestrians, transit, and bicycles) and assesses the impacts of facility design and operation on all users except for commercial vehicles. The MMLOS analysis provides a tool to predict travel perceptions of quality of service.

High multi-modal level of service
(Credit: Ryan Snyder)

The MMLOS for the four modal usages is output as numerical ratings, which are converted into the traditional A to F letter grade system. Table 5.1 indicates the MMLOS letter grade equivalents of the numerical values obtained.

Table 5.1 MMLOS Letter Grade Equivalents

MMLOS Modal Output	MMLOS Letter Grade
Model <= 2.0	A
2.0<Model <=2.75	B
2.75<Model <=3.50	C
3.50<Model <=4.25	D
4.25<Model <=5.00	E
Model>5.0	F

Source: NCHRP-Web Only Document 128: *Multimodal level of service analysis for urban streets: User Guide*, 2009.
Notes:
1. If any directional segment hourly volume/capacity ratio (v/c) exceeds 1.0 for any mode, that direction of street is considered to be operating at LOS F for that mode of travel for its entire length (regardless of the computed LOS).
2. If the movement of any mode is legally prohibited for a given direction of travel on the street, then the LOS for that mode is LOS "F" for that direction.

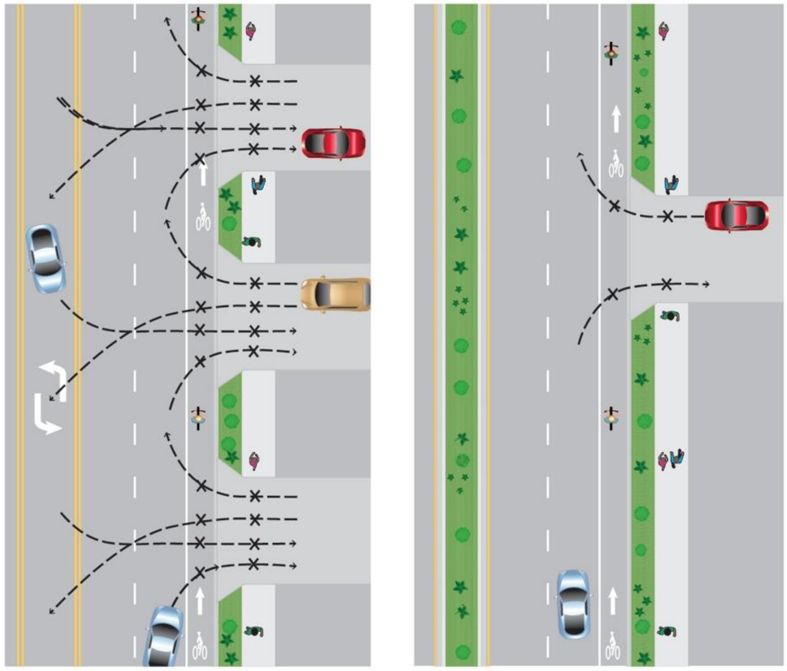
For conducting MMLOS it is necessary to select a roadway segment that has signalized intersections, transit usage, bicycle riders, and pedestrians. The segment could have 5 to 6 signals in the selected section. The data required for conducting MMLOS includes street geometrics, such as number of through lanes, width of lanes, median width, bike lane, shoulder width, parking lane width, sidewalk width, right turn lanes, transit stops, and signalized and un-signalized intersections. The methodology provides some basic default values for use, which can be found in the reference provided at the end of this chapter.

By conducting an MMLOS analysis of existing roadway segments, the agency will be able to identify the deficiencies in the system for all the modes. Using the results to change the analyzed street segment will improve the system for all users. The result should lead to very different decisions than would be made under the traditional LOS assessment. Using traditional LOS as the measurement, municipalities typically remedy low LOS by widening streets, flaring intersections, and other measures designed to improve the flow of motor vehicles only. In contrast, applying MMLOS can lead to improvements for pedestrians, bicyclists, and transit users. Since the development of the MMLOS, several other tools have been developed to capture other modes. Local jurisdictions are encouraged to research the most appropriate analysis method for their community prior to investing in one particular tool.

ACCESS MANAGEMENT

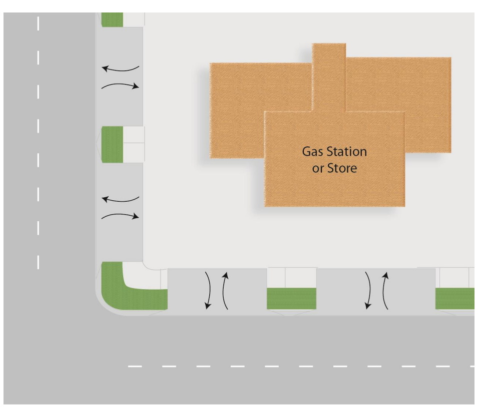
Access management refers to properly locating and designing access to adjacent land use (context) to preserve safety and reasonable traffic flow. A major challenge in street design is balancing the number of access points to a street. As discussed in Chapter 4, "Street Networks and Classifications," there are many benefits of well-connected street networks. On the other hand, most conflicts between users occur at intersections and driveways. The presence of many driveways in addition to the necessary intersections creates many conflicts between vehicles entering or leaving a street and bicyclists and pedestrians riding or walking along the street. When possible, new driveways should be minimized and old driveways should be eliminated or consolidated, and raised medians should be placed to limit left turns into and out of driveways.

Before After

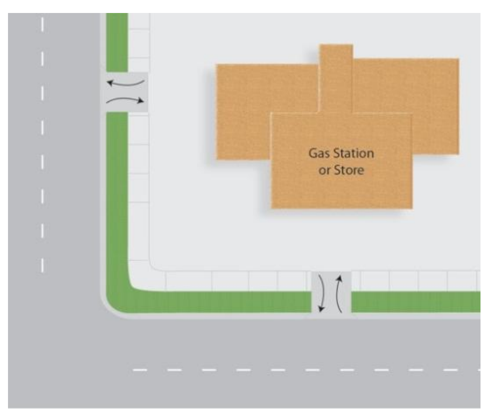


Adding medians and consolidating driveways to manage access
(Credit: Michele Weisbart)

Access management requirements often include public street intersection spacing, especially signalized intersection spacing. FDOT's access management guidelines generally restrict signalized intersection spacing to one every one-quarter mile (1,320 feet) on major thoroughfares. In dense urban centers (Transects T5 through T6), continuous thoroughfares (boulevards or avenues) should be spaced every one-quarter mile (1,320 feet), which is consistent with the FDOT policy. However, a grid network of streets should intersect the major thoroughfare between signalized intersections to provide access and locations for crossings.



Corner with many wide driveways
(Credit: Michele Weisbart)



Reconstructed corner with fewer, narrower driveways
(Credit: Michele Weisbart)

It has been demonstrated that good access management principles can reduce crashes by 50 percent or more, depending on the condition and the treatment used (*Access Management Manual*, Transportation Research Board, 2002). The following principles define good access management practices.

- Classify the street system by both function and context.
- Establish standards for intersection spacing. In urban areas, these standards should include both minimum spacing and maximum spacing. Access management studies should determine not only if minimum spacing standards are being violated, but also if maximum spacing standards are being violated (a.k.a. not enough connectivity within the network).
- Locate driveways away from intersections to minimize crashes and to minimize interference with traffic operations.
- Use curbed medians on boulevards (major thoroughfares) and locate median openings to manage access and minimize conflicts.
- Consolidate driveways in urban areas to reduce conflicts between vehicles, pedestrians, and bicyclists.

Access management through limiting driveways and providing raised medians has many benefits:

- The number of conflict points is reduced, especially by replacing center-turn lanes with raised medians since left turns by motorists account for a high number of crashes with bicyclists and pedestrians.
- Pedestrian crossing opportunities are enhanced with a raised median.
- Universal access for pedestrians is easier, since the sidewalk is less frequently interrupted by driveway slopes.
- Fewer driveways result in more space available for higher and better uses.
- Improved traffic flow may reduce the need for road widening, allowing part of the right-of-way to be recaptured for other users.

<u>Possible Negatives of Access Management</u>

The following possible negative effects of access management should be considered and addressed.

- Streamlining a street may increase motor vehicle speeds and volumes, which can be detrimental to other users.
- Reduced access to businesses may require out-of-direction travel for all users, including walkers and bicyclists.
- Concrete barriers and overly-landscaped medians act as barriers to pedestrian crossings. Medians should be designed with no more than normal curb height and with landscaping that allows pedestrians to see to the other side.

- Adjacent land uses can experience decreased access. This can impact businesses as well as residents. Careful planning of access management considers this.
- An overly protective approach to intersection spacing can lead to negative effects on network connectivity.

CROSS SECTIONAL ELEMENTS

Complete street design treats streets as part of the public realm. The street portion of the public realm is shaped by the features and cross section elements used in creating the street. Attention to what features are included, where they are placed, and how the cross section elements are assembled is necessary.

CONTEXT

The first design consideration that should be addressed when determining the optimum cross section for a traveled way is context. Determine the context zone and identify thoroughfare type based on the transect and classifications presented in Chapter 4, "Street Networks and Classifications." Identifying the context first establishes the general parameters for the cross section.

ON-STREET PARKING

On-street parking can be important in the urban environment (1) for the success of the retail businesses that line the street, (2) to provide a buffer for pedestrians, and (3) to help calm traffic speeds. On-street parking is efficient from a land use perspective because it occupies about half the surface area per car compared to off-street parking, which requires driveways and aisles for access and maneuvering. However, on-street parking cannot meet all of the parking demand in modern urban areas. Local jurisdictions should manage demand for on-street parking by charging market-rate prices. Free or underpriced parking encourages people to drive instead of taking transit, biking, or walking. Parking expert Donald Shoup recommends setting variable parking prices to target a 15 percent vacancy rate for curb parking. In addition to encouraging people to curtail driving, it also creates turnover that benefits retailers by making convenient parking available for short shopping trips.

General principles and considerations regarding on-street parking are presented below.

- On-street parking should be located based on the context of the urban roadway and the needs of the adjacent land use.
- On-street parking should be primarily parallel parking on urban arterial boulevards and avenues. Angle parking may be used on low-speed and low-volume commercially-oriented avenues and streets, primarily those serving as main streets.
- Orientation of parking should be determined based on design speed and ability of the right-of-way width to accommodate the desired elements.

- Where angle parking is proposed for on-street parking, designers should consider the use of reverse-in angle (or front out) parking in lieu of front-in angled parking. Motorists pulling out of reverse-in angled parking can better see the active street they are entering. This is especially important to bicyclists. Moreover, people exiting cars do so on the curb side and aren't likely to step into an active travel lane. However, reverse-in angle parking requires a wider edge zone to accommodate greater over-tracking of the rear of the vehicles.

Reverse-in angled parking: Boise, ID (Credit: Dan Burden)

- Use metered parking to enforce parking time limits that provide reasonable short-term parking for retail customers and visitors while discouraging long-term parking. Automated meter machines should be used for efficiency of parking management and to reduce street clutter and sidewalk obstacles.

Another tool for on-street parking is the park assist lane. Often when on-street parking is provided on busy roads, drivers find it difficult to enter and leave their parked vehicle. Where space is available, consideration should be given to adding a park assist lane between the parking lane and travel way to provide 3 feet of space so car doors can be opened and vehicles can enter or depart with a higher degree of safety and less delay. Bike lanes can serve this function as well. Parking assist lanes also narrow the feel of the travel lane and slow traffic.

Parking assist lane (Credit: Michael Wallwork)

Curb extensions should be provided in place of on-street parking at mid-block crosswalks and intersection crosswalks. Curb extensions reduce the distance that pedestrians must cross within the traveled way, help to calm traffic, and serve as opportunities for rain gardens and other forms of aesthetic enhancement.

Curb extensions with rain garden (Credit: Unknown)

On-street parking should be prohibited within 20 feet of either side of fire hydrants, at least 20 feet from mid-block crosswalks, and at least 30 feet from the corner radius of intersections (or greater if required to meet engineering sight distance requirements).

Table 5.2 below details recommended parking lane widths for slow and low movement types.

Table 5.2 Parking Lane Widths

Movement Type	Design Speed	Parking Lane Width
Slow, Avenues and Streets (residential)	20-25 mph	Angle: 16.5’(60°); 15’(45°) Parallel: 7 feet
Slow, Avenues and Streets (commercial)	20-25 mph	Angle: 19.0’(60°); 17.7’(45°) Parallel: 8 feet
Low, Boulevard	30-35 mph	Parallel: 8 feet

Bicycle Facilities

Bicycle facilities within the traveled way may include conventional bicycle lanes, buffered bicycle lanes, contra-flow bicycle lanes on one-way streets, bicycle boulevards, other types of shared roadways (with or without shared lane markings), and cycle tracks. See Chapter 9, “Bikeway Design,” for design recommendations for these facilities.

Transit Facilities

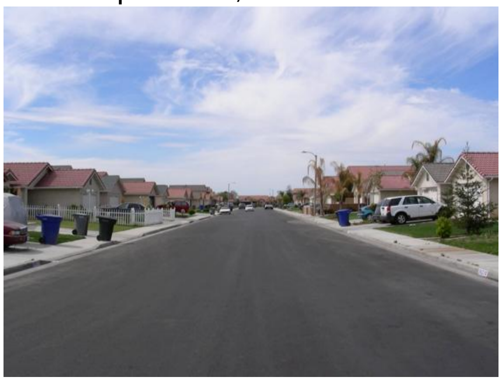
Transit accommodations within the traveled way may include dedicated transit lanes, bus bulbs, bus pullouts, and other features. See Chapter 10, “Transit Accommodations,” for design recommendations for these features.

Travel Lanes

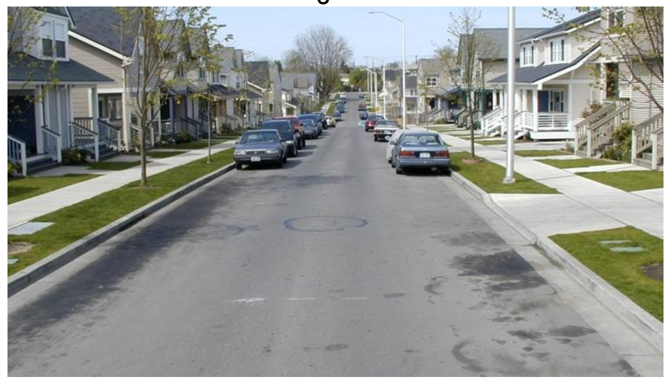
Travel lane widths should be provided based on the context and desired speed for the area that the street is located in. Table 5.3 shows lane widths and the associated speeds that are appropriate. In low speed urban environments, lane widths are typically measured to the curb face instead of the edge of the gutter pan. Consequently, when curb sections with gutter pans are used, the vehicle, bike, and parking lane all include the width of the gutter pan.

General principles and considerations in the selection of lane widths include the following.

- In order for drivers to understand how fast they should drive, lane widths have to create some level of driver discomfort when driving too fast. The presence of on-street parking is important in achieving the speeds shown in Table 5.3. When designated bike lanes or multi-lane configurations are used, there is more room for large vehicles, such as buses, to operate in, but car drivers will feel more comfortable driving faster than is desired.



Wide two-lane street (Credit: Ryan Snyder)



Narrow two-lane street (Credit: Michael Ronkin)

- Reducing travel lane width is one strategy of accommodating complete streets elements into the traveled way design, as required in the FDOT PPM, Volume I, Chapters 2 and 8.
- Where adjacent lanes in the same direction of travel are unequal in width, the outside lane should be the wider lane to accommodate bicyclists (only where bicycle lanes are not practical).
- Yield streets are typically residential two-way streets with parking on one or both sides. When the street is parked on both sides, the remaining space between parked vehicles (12 feet minimum) is adequate for one vehicle to pass through. Minimum width for a yield street with parking on both sides should be 26 feet curb face to curb face. Minimum width for a yield street with parking on one side should be 20 feet curb face to curb face.

Table 5.3 Travel Lane Widths and Associated Design Speeds

Movement Type	Design Speed	Travel Lane Width
Yield (shared space)	Less than 20 mph	12 feet
Slow, Avenue and Street (residential)	20-25 mph	9*-10 feet
Slow, Avenue and Street (commercial)	20-25 mph	10 feet
Low, Boulevard	30-35 mph	10-11** feet
Low, Boulevard Wide curb lane bicycle facility	30-35 mph	14 feet

- *9 feet requires a design exception, but could be considered in low volume settings where lane width narrowing would provide desired complete streets elements.
- **Generally, 10-foot lanes are preferred. On bus routes or where truck traffic exceeds 10 percent, 11-foot lanes should be considered for the outside motor vehicle travel lane only.

Alleys can be designed as one-way or two-way. Right-of-way width should be a minimum of 20 feet with no permanent structures located within the right-of-way that would interfere with vehicle access to garages or parking spaces, access for trash collection, and other operational needs. Pavement width should be a minimum of 12 feet. Coordination with local municipalities on operational requirements is essential to ensure that trash collection and fire protection services can be completed.

The lane widths presented in Table 4.3 are consistent with guidance provided by the American Association of State Highway and Transportation Officials (AASHTO), with the exception of the 9-foot lane consideration for slow speed avenues and streets in residential areas. In addition, the lane widths are consistent with FDOT's Transportation Design for Livable Communities (TDLC) in the PPM, Volume I, Chapter 21, also with the exception of the 9-foot lane consideration for slow speed avenues and streets in residential areas. It should be noted that it would be very unlikely that such as street would be an FDOT roadway. In addition, FDOT currently requires a minimum 11 feet for new construction or reconstruction; 10 feet is allowable for lane width narrowing on existing roadways when the purpose is to provide a designated bicycle facility.

Turn Lanes

The need for turn lanes for vehicle mobility should be balanced with the need to manage vehicle speeds, the need to provide continuous bicycle lanes, and the potential impact on the border width such as sidewalk width. Turn lanes tend to allow higher speeds to occur through intersections, since turning vehicles can move over to the turn lane, allowing the through vehicles to maintain their speed.

Left-turn lanes are considered to be acceptable in an urban environment. This is because without them there are negative impacts to roadway capacity, as cars turning left from a straight lane often block the through movement of other vehicles. Sometimes just a left-turn pocket is sufficient, just long enough for one or two cars to wait out of traffic. The installation of a left-turn lane can be beneficial when used to perform a road diet such as reducing a four lane section to three lanes with the center lane providing for turning movements.

In urban transects (T4, T5, and T6), normally no more than one left-turn lane should be provided. Dual and triple left-turn lanes are typically the result of poor street connectivity within the network. While right turns from through lanes may delay through movements, they also create a reduction in speed due to the slowing of turning vehicles. The installation of right-turn lanes increases the crossing distance for pedestrians and the speed of vehicles; therefore, exclusive right turn lanes should rarely be used except at "T" intersections. When used, they should be mitigated with raised channelization islands. See Chapter 6, "Intersection Design," for more details.

The desired turn lane width is 9 to 10 feet for right-turn lanes and 10 to 11 feet for left-turn lanes.

MEDIANS

Well-designed street medians bring multiple benefits (Credit: Dan Burden)

Medians are the center portion of a street that separates opposing directions of travel. Medians used on urban streets provide access management by limiting left turn movements into and out of abutting development to select locations where a separate left turn lane or pocket can be provided. The reduced number of conflicts and conflict points decreases vehicle crashes, provides pedestrians with a refuge as they cross the road, and provides space for landscaping, lighting, and utilities. These medians are usually raised and curbed. Landscaped medians enhance the street or help to create a gateway entrance into a community.

Medians can be used to create tree canopies over travel lanes, contributing to a sense of enclosure. As shown in Table 5.4, medians vary in width. Recommended widths depend on available right-of-way and function. Because medians require a wider right-of-way, the designer must weigh the benefits of a median with the issues of pedestrian crossing: distance, speed, context, and available roadside width.

In urban areas, it may be desirable to plant trees in raised curbed medians for aesthetic purposes. Small caliper trees can be healthy in medians that are at least 6 feet wide, as long as a critical root area is provided. Larger trees are only possible when the median is at least 10 feet wide. Consult an urban forester for guidance on health requirements for trees in medians. Crash mitigation strategies on trees within the public right-of-way can be found in *A Guide for Addressing Collisions with Trees in Hazardous Locations*, Transportation Research Board, 2003.

Avoid providing overly wide medians in urban contexts (T4, T5, and T6) at the expense of bicycle lanes or unreasonable reductions in roadside widths for elements such as sidewalks.

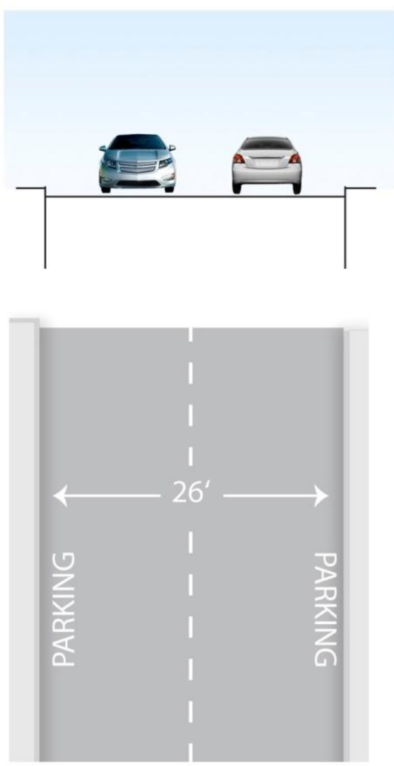
Table 5.4 Median Types and Widths

Median Type	Minimum Width	Recommended Width
Median for access control	4 feet	6 feet
Median for pedestrian refuge	6 feet	8 feet
Median for trees and lighting	6 feet [1]	10 feet [2]
Median for single left-turn lane	10 feet [3]	10 feet [2]
Median for single left-turn lane and pedestrian refuge	16 feet [4]	16 feet

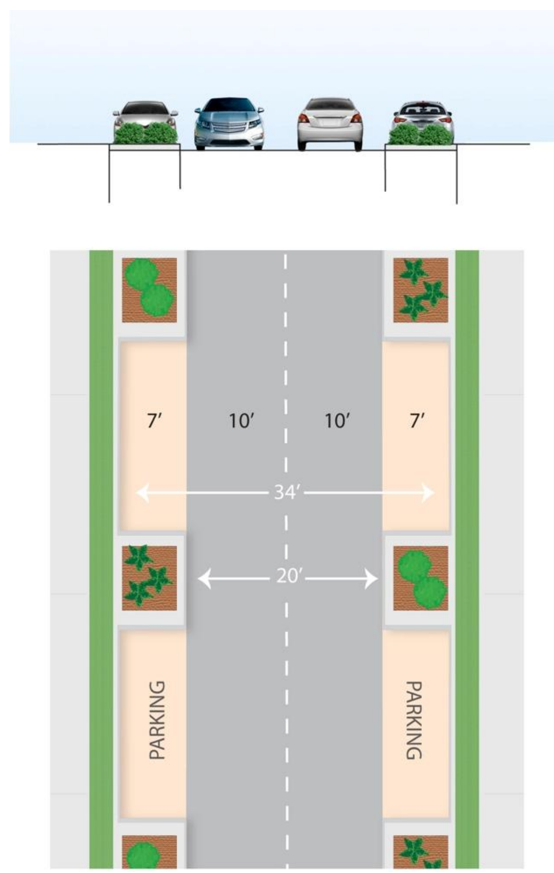
[1] Six feet measured curb face to curb face is generally considered the minimum width for proper growth of small caliper trees (less than 4 inches).
[2] Wider medians provide room for larger caliper trees with better shade and more extensive landscaping.
[3] A 10-foot median provides for a turn lane without a concrete traffic separator.
[4] Includes a 10-foot turn lane and a 6-foot pedestrian refuge.

SAMPLE CROSS SECTIONS

Local governments that are developing new subdivisions or brand new streets through second-generation development (see Chapter 15, "Retrofitting Suburbia") can create new street standards based on the information above. Sample curb-to-curb cross sections for the basic street typologies are shown in the diagrams below. These are only samples; other cross sections using the above guidance are also acceptable. When adopting standards for new streets, local jurisdictions should also include the sidewalks as an integral part of the street and use the guidance provided in Chapter 7, "Universal Pedestrian Access." In built out areas (most of Broward County that is within the T-3 to T-6 context), rigid street standards are impractical because curb-to-curb widths are already set. In these cases, local governments should reconfigure streets by reassigning space to make streets more closely meet the principles of complete streets presented herein. The following diagrams provide examples of how some of these apply.

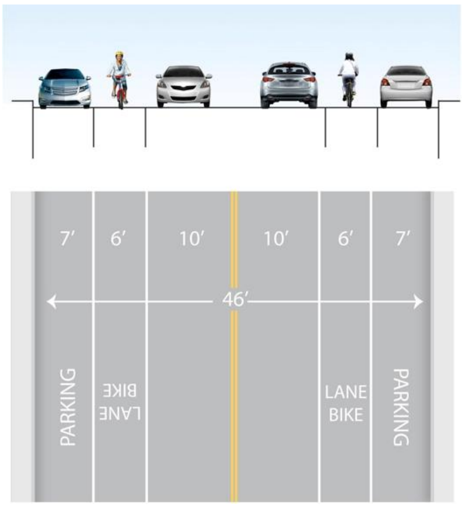


Residential street

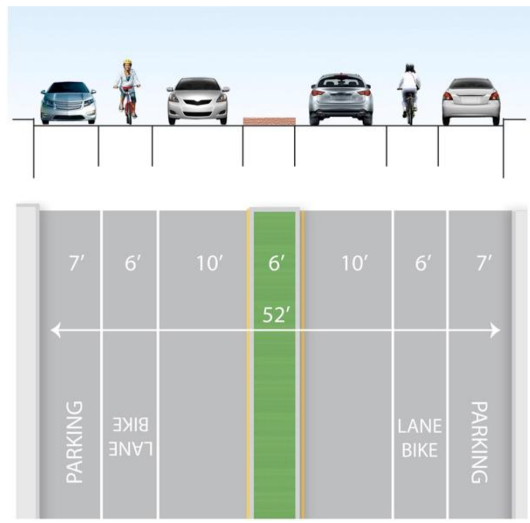


Residential street with inset parking

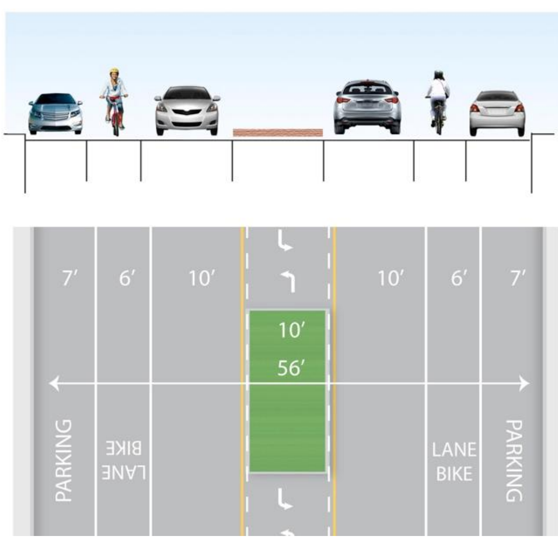
SAMPLE CROSS SECTIONS



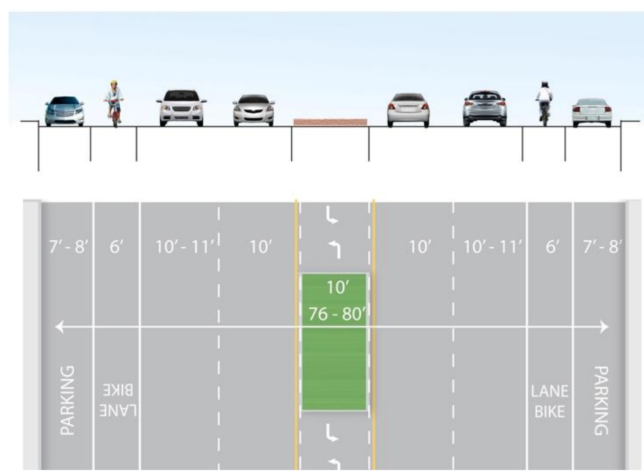
Avenue



Avenue with median

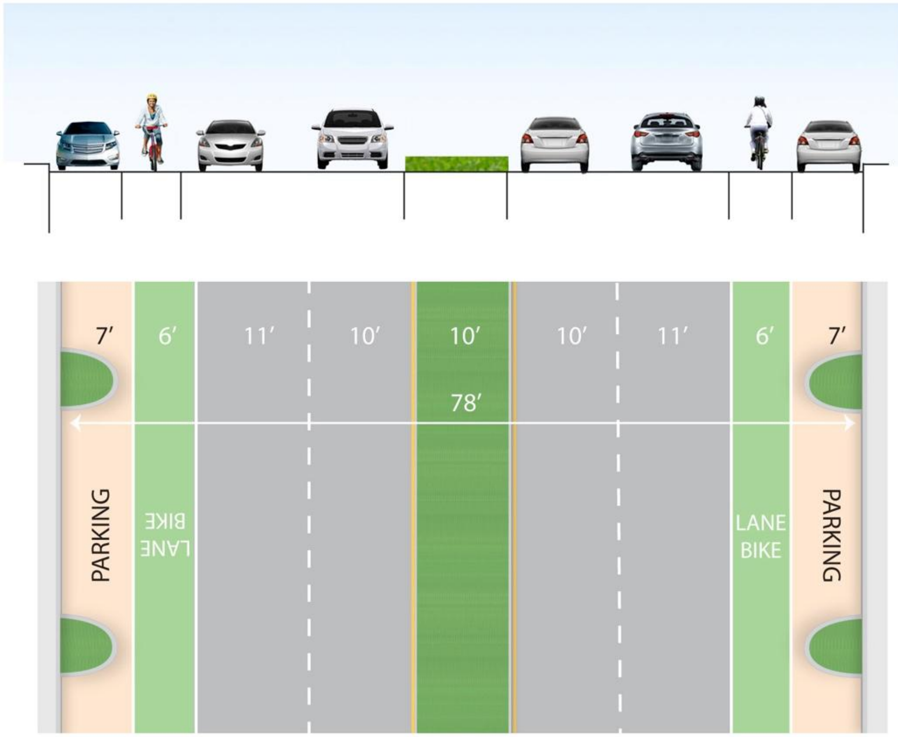


Avenue with medians interspersed with turn lanes

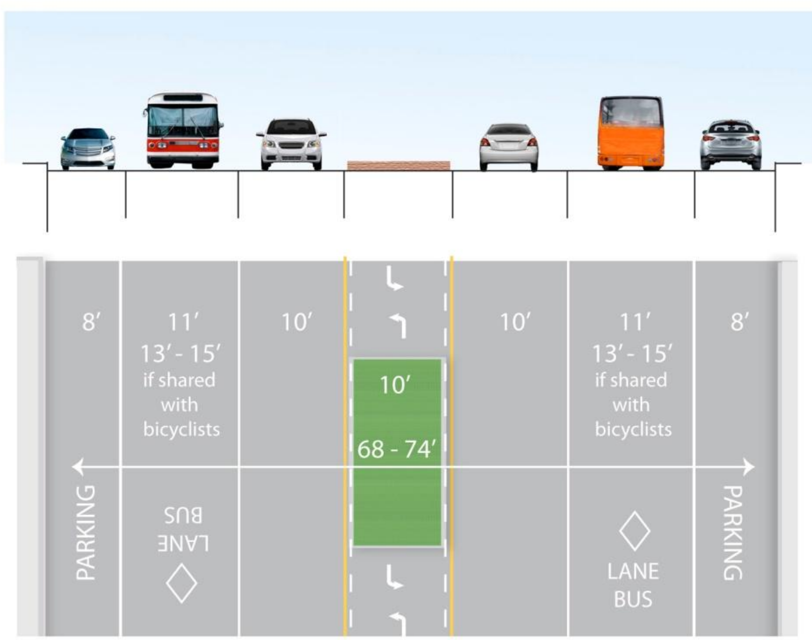


5-Lane Boulevard

SAMPLE CROSS SECTIONS



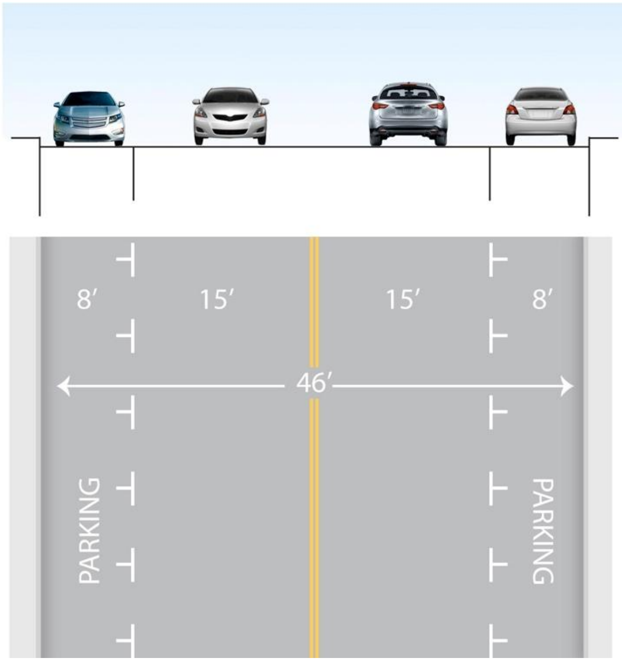
4-Lane Boulevard with colored bike lanes and inset parking



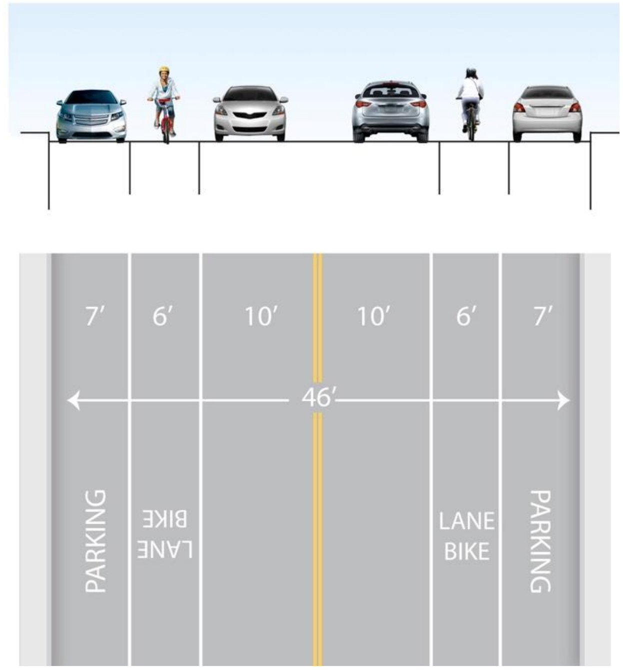
3-Lane Boulevard with bus lanes

Sample standard street cross sections
(Credit: Michele Weisbart)

SAMPLE CROSS SECTIONS

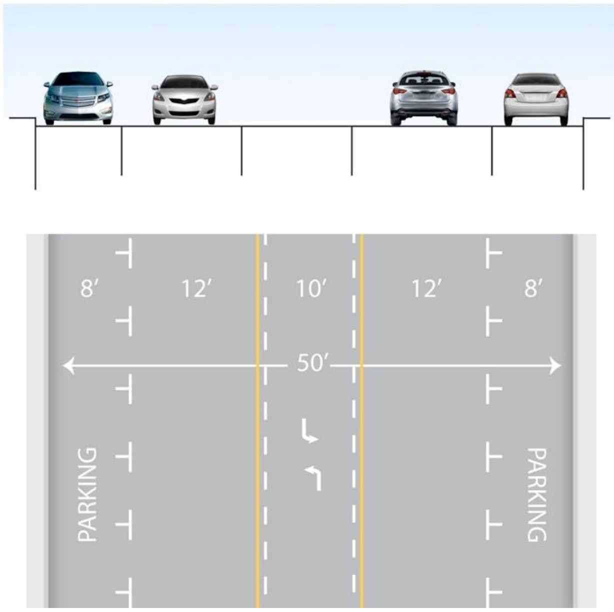


Existing 46'-wide avenue

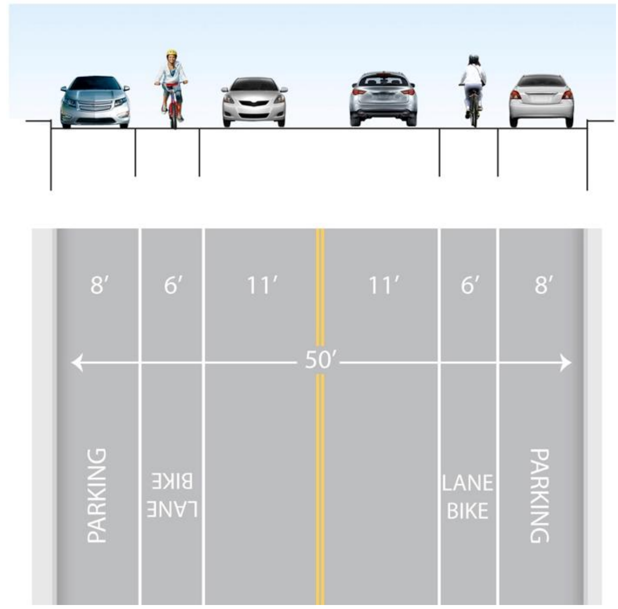


Restripe to add bike lanes

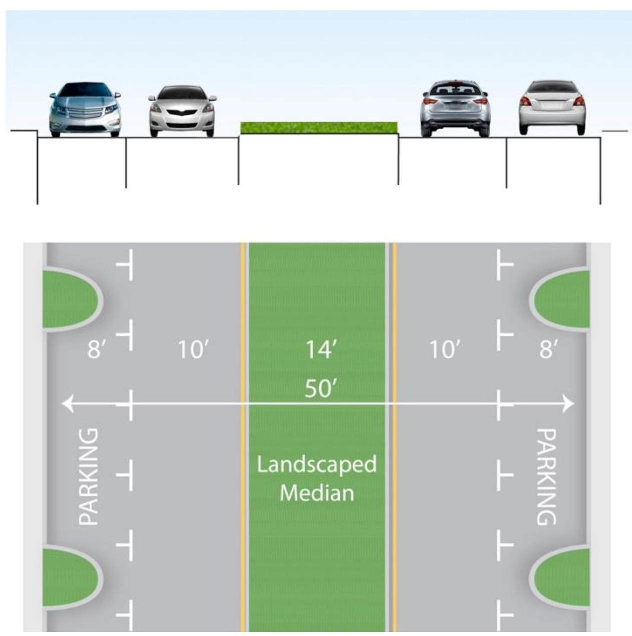
Sample Cross Sections



Existing 50' avenue

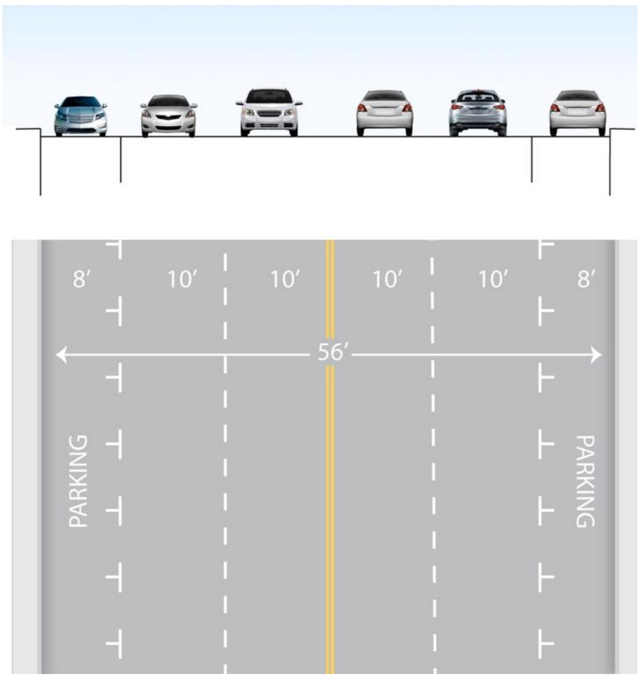


Option 1: Restripe to add bike lanes

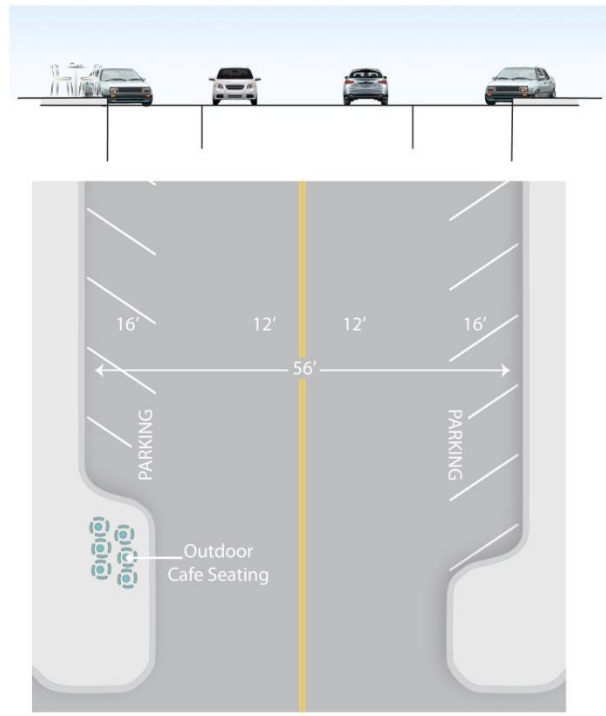


Option 2: Add median

SAMPLE CROSS SECTIONS

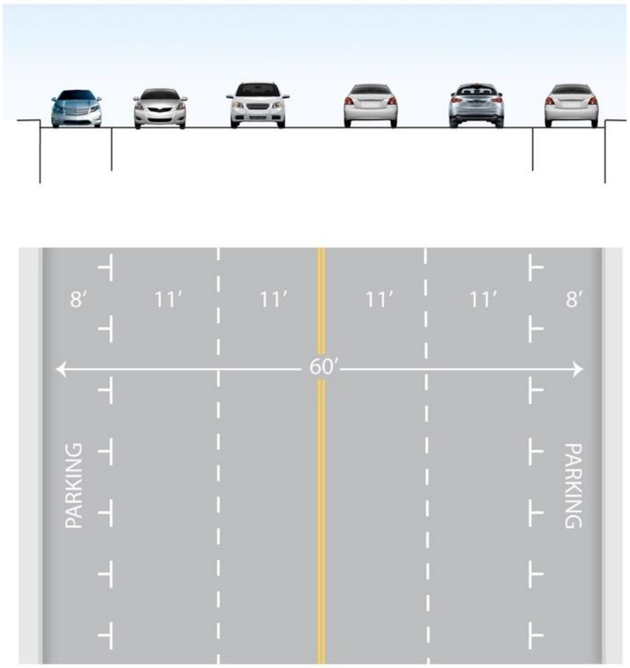


Existing 56'-wide main street

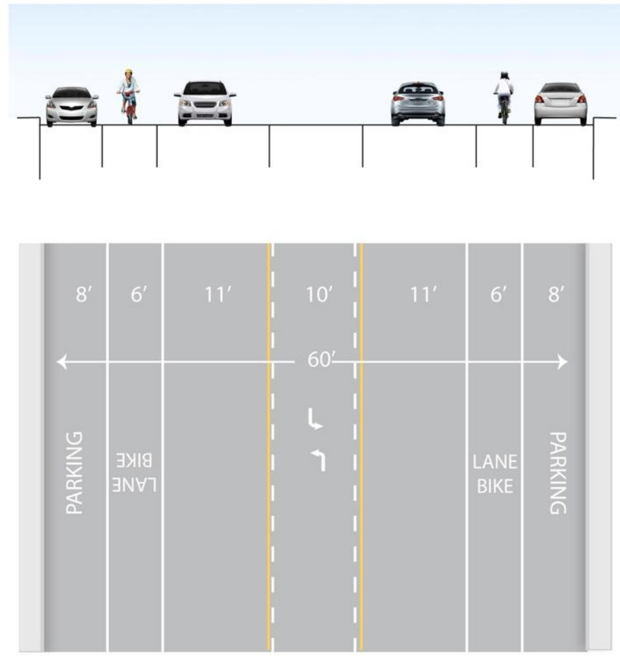


Reduce travel lanes and add reverse-in angled parking with curb extensions large enough for café seating

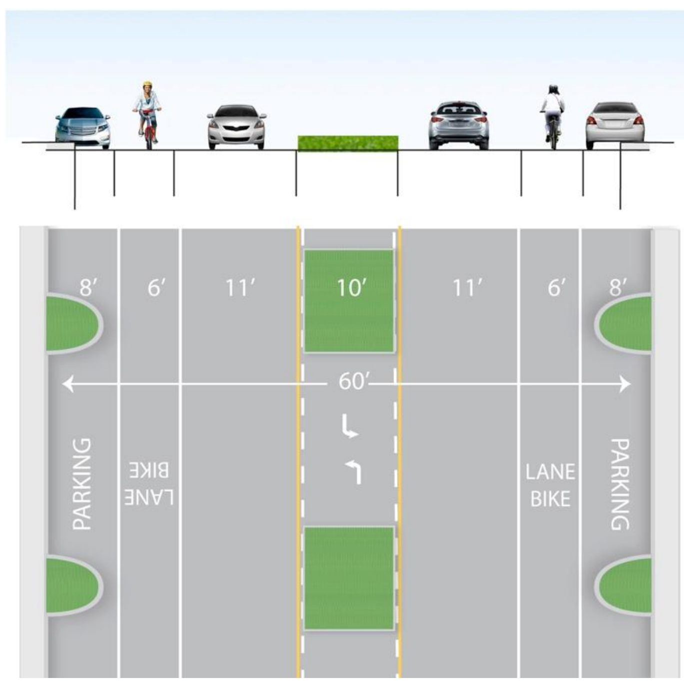
SAMPLE CROSS SECTIONS



Existing 60'-wide avenue or boulevard

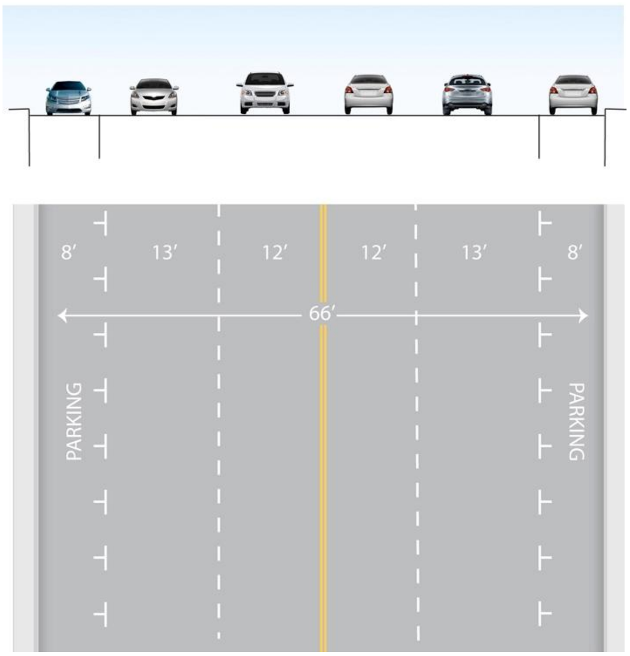


Option 1: Reduce travel lanes and add bike lanes

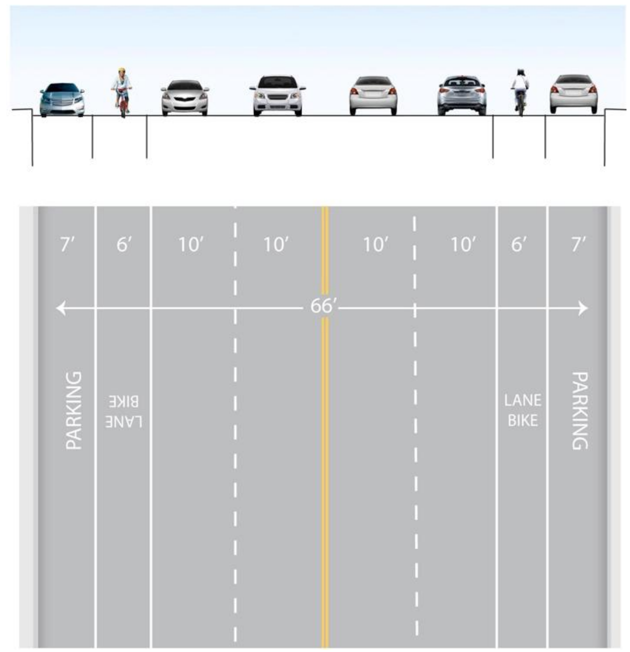


Option 2: Reduce travel lanes and add median islands interspersed with turn lanes; add interspersed landscaped curb extensions to inset parking

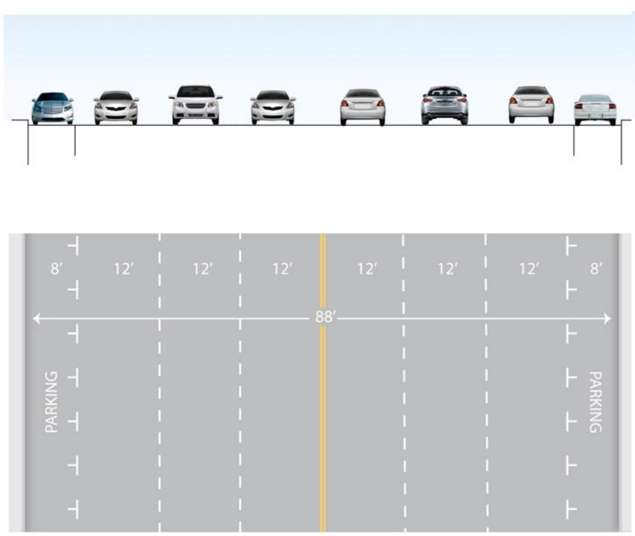
SAMPLE CROSS SECTIONS



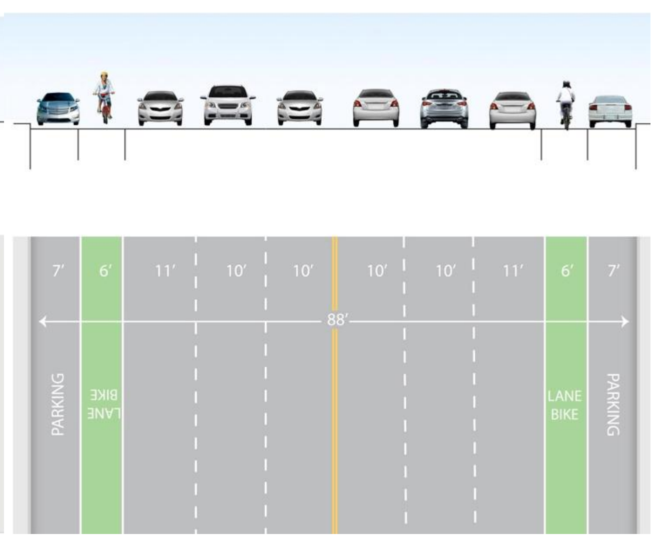
Existing 66'-wide boulevard



Narrow travel lanes to add bike lanes



Existing 88'-wide boulevard



Narrow travel lanes to add colored bike lanes

Sample redesigned street cross sections
(Credit: Michele Weisbart)

OTHER GEOMETRIC DESIGN ELEMENTS

VERTICAL ALIGNMENT

The American Association of State Highway and Transportation Officials (AASHTO) *Geometric Design of Highways and Streets* manual (AASHTO Green Book) provides acceptable values for designing vertical curves for complete streets. The values used in design of vertical curve design should be selected based on the design speed appropriate for the context of the street. Using higher values can contribute to increased vehicle speeds and may require increased modification to the natural terrain, increasing negative impacts to the natural environment.

HORIZONTAL ALIGNMENT

The AASHTO Green Book provides appropriate values for designing horizontal curves for complete streets. The values used in horizontal curve design should be selected based on the design speed appropriate for the context of the street. Using higher values can contribute to increased vehicle speeds and also impacts the character of the street. Larger horizontal curves also create a more “suburban” or “rural” highway feel.

TRANSITION DESIGN

Transitions refer to a change in context, right-of-way width, number of lanes, neighborhoods, or districts. Multi-modal accommodations should be continuous through transitions. If the purpose of the transition is to change context, neighborhood, or district, then the designer should provide a transition speed zone, visual cues to changes in context or environment, and change the width of the traveled way or travel lanes as appropriate for the context.

SIGHT DISTANCE

Stopping Sight Distance

The AASHTO Green Book provides appropriate values for designing stopping sight distance for complete streets. The 2004 AASHTO *Guide for Achieving Flexibility in Highway Design* is based on the latest research concerning the establishment of stopping sight distance. The document states that the established values for stopping sight distance are very conservative and provide adequate flexibility without creating increased crash risk. Consequently, appropriate design speed selection is critical to avoid overly negative impacts such as unnecessarily limiting on-street parking and tree planting.

Intersection Sight Distance

Intersection sight distance should be calculated in accordance with the AASHTO Green Book using the design speed appropriate for the street being evaluated. When executing a crossing or turning maneuver onto a street after stopping at a stop sign, stop bar, or crosswalk, drivers will move slowly forward to obtain sight distance (without intruding into the crossing travel lane) stopping a second time as necessary. Therefore, when curb extensions are used or on-street parking is in place, the vehicle can be assumed to move forward on the second step movement, stopping just shy of the travel lane, increasing the driver's potential to see further than when stopped at the stop bar. As a result, the increased sight distance provided by the two step movement allows parking to be located closer to the intersection.

Horizontal Clearance/Clear Zone

Horizontal clearance is the lateral distance from a specified point on the roadway, such as the edge of the travel lane or face of the curb, to a roadside feature or object. The clear zone is the relatively flat unobstructed area that is to be provided for safe use by errant vehicles.

In urban areas, horizontal clearance based on clear zone requirements for rural and suburban highways is not practical because urban areas are characterized by more bicyclists and pedestrians, lower speeds, more dense abutting development, closer spaced intersections and accesses to property, higher traffic volumes, and restricted right-of-way. Therefore, streets with curbs and gutters in urban areas do not have sufficiently wide roadsides to provide clear zones. Consequently, while there are specific horizontal clearance requirements for these streets, they are based on clearances for normal operation and not based on maintaining a clear roadside for errant vehicles. The minimum horizontal clearance is 1.5 feet measured from the face of the curb. This is primarily intended for sign posts, and bicycle parking racks, so they aren't hit by large vehicles with overhangs maneuvering close to the curb. The desired horizontal clearance for bicycle parking racks is 4 feet to minimize the likelihood that a bicycle parked at the rack will not be struck by a vehicle overhang maneuvering close to the curb.

Traveled Way Lighting

Pedestrians are disproportionately hit when visibility is poor: at dusk, night, and dawn. Many crossings are not well lit. Providing illumination or improving existing lighting increases nighttime safety at intersections and midblock crossings, as motorists can better see pedestrians. Pedestrian scale lighting along sidewalks provides greater security, especially for people walking alone at night.

Transit stops require both kinds of lighting: strong illumination of the traveled way for safer street crossing, and pedestrian scale illumination at the stop or shelter for security. FHWA-HRT-08-053, *Informational Report on Lighting Design for Midblock Crosswalks*, (April 2008) is a good resource. It also contains useful information about lighting design for pedestrians at intersections.

If bus stops are present between roadway sections, it is necessary to illuminate the roadway and the bus stop. The lighting at the bus stop is essential to provide safety for transit users. Bus stops have high pedestrian activity; therefore, it is necessary to provide adequate lighting at these facilities.

MODEL PROJECT

LA JOLLA

La Jolla Boulevard in the Bird Rock neighborhood of San Diego is an example of the conversion of a five-lane road. Due to parents' complaints that they had to drive their children across the road, a community charrette was organized in 2002. As a result, a new concept was developed that included a median, one 11-foot travel lane in each direction, park assist lanes next to the parallel parking lane on the east side, and a wider park assist lane next to the angled parking on the west side of the street. The five intersections that were controlled by two or four-way stop control and signals were converted to single lane roundabouts.

The project was opened in stages and completed in August 2008. Although the traffic volumes have decreased because of the recession from 22,000 vehicles per day to 17,000 vehicles per day, the pedestrian and bicycle volumes have increased enormously (City of San Diego traffic counts and traffic webcam, 2010).

La Jolla Boulevard intersection before and after roundabout: San Diego, CA
(Credit: Michael Wallwork)

ADDITIONAL RESOURCES

Institute of Transportation Engineers. *Designing Walkable Urban Thoroughfares : A Context Sensitive Approach*, 2010.

This page left blank intentionally.