KIPDA

KENTUCKIANA REGIONAL PLANNING & DEVELOPMENT AGENCY

FREIGHT DESIGN GUIDE

FEBRUARY 28, 2019

KIPDA Kentuckiana Regional Planning and Development Agency

HDR

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INTRODUCTION

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INTRODUCTION

This design guide was developed to provide project sponsors and transportation decision-makers guidance on how to better integrate freight into their roadway system, neighborhoods and future projects. As the region's freight industry continues to grow, it will be important that this growth be truly integrated in the community to mitigate impacts to the region's livability and to other transportation modes. This document has been designed as a reference guide that can be used to not only provide project level design suggestions but to serve as overall educational piece used to better understand the impacts and dynamics of freight in our communities.

The document details several freight design considerations within the context of urban, suburban and rural cross-sections. It provides examples of how freight design attributes could work as part of a total multimodal solution and identifies "best practices" for how this is done.

The guide is organized by the type of roadway – urban, suburban or rural, and then explores various concepts related to topics of interest including access management, innovative intersection design, interchanges, technology and navigation, and truck parking.

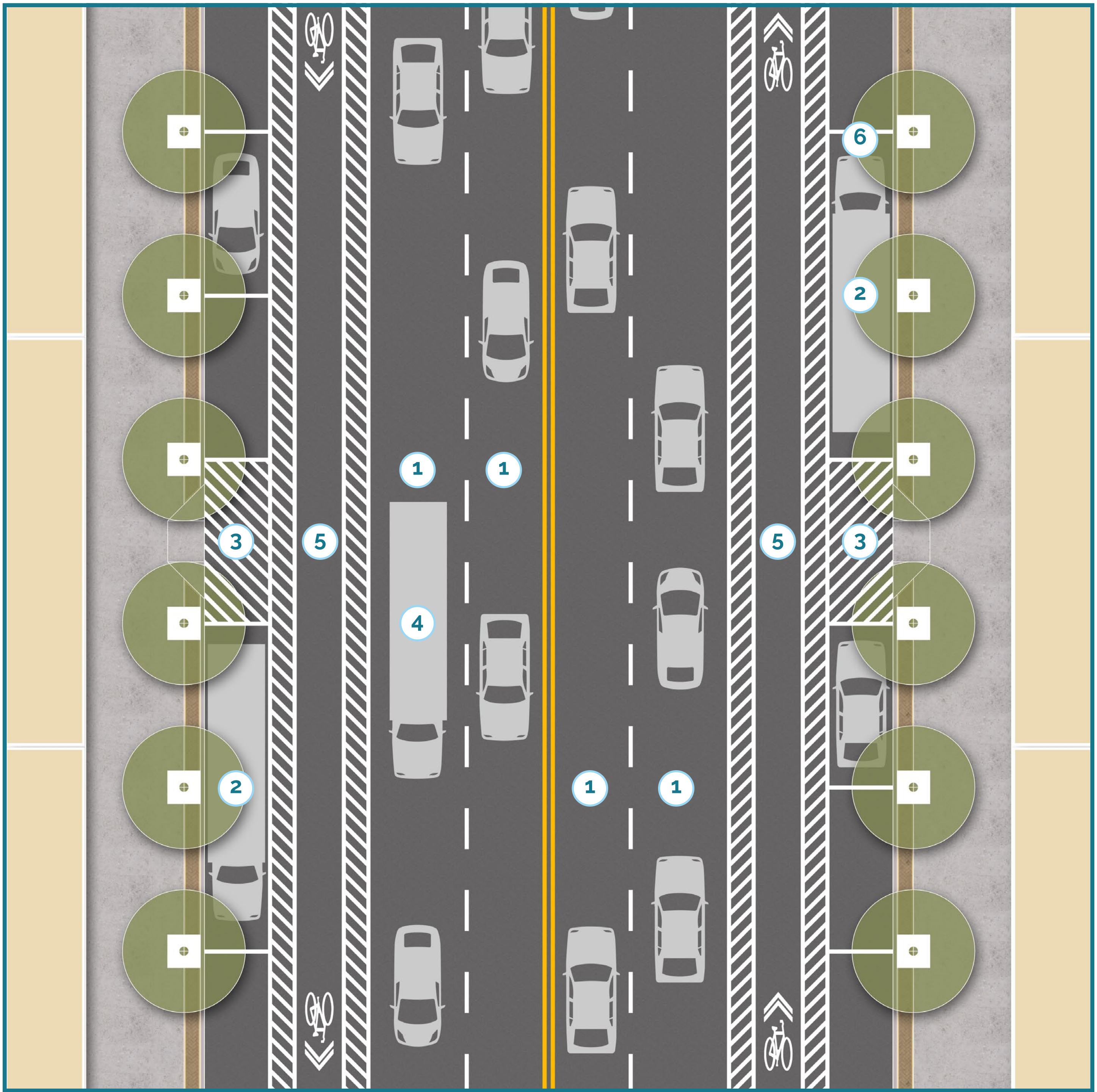
It is important that these recommendations are viewed within the context of the road itself – its users and ultimate purpose. For example, some roads should be designed to move regional truck flows quickly, while other streets may serve multimodal corridors with significant truck traffic. Both need considerations for freight, but in different ways to accommodate the context and needs of the land use and community. The KIPDA Freight Network was developed to identify roads that support regional freight movements – when designing projects on that network, care should be taken to ensure freight flow.

Even if the roadway is on the freight network, it may or may not of have all of the aspects in each example, and project sponsors also need to decide what can reasonably be accommodated by each project, which aspects are needed, and how those aspects work together to make the project better. Overall, the applicability of these recommendations depends on the roadway type, its operating conditions, physical location, and adjacent land uses patterns.

While not prescriptive, this guide should prompt project sponsors to consult other references, listed at the end, and to more fully examine one or more aspects of their projects to make needed improvements or accommodations for freight / trucks. Local project sponsors are also encouraged to consult **KIPDA's Transportation Planning Portal** for more information regarding the regional freight network, and other planning and design aspects to take note of or to otherwise consider in the their project planning.

SEGMENT DESIGN

TYPICAL PLAN VIEW



Numbers indicated on this plan correspond to the design considerations on the following pages.

DESIGN CONSIDERATIONS

WHAT IS AN URBAN ROADWAY SEGMENT?

Urban roadway segments include all roads serving densely-populated residential, commercial, or mixed-use districts. Urban streets experience high volumes of freight traffic and should accommodate truck circulation. According to the publication **Designing for Truck Movements and Other Large Vehicles in Portland**, urban streets, “Require lane widths, turning radii, and other street features that can accommodate trucks without impeding their access and ability to maneuver,” **(City of Portland, 2008, p.15)**. In urban areas, the trip frequency of all modes of travel, including pedestrian and bicycling activity, is expected to be high.

LANE WIDTH

Adequate lane width should be provided for freight to safely navigate without encroaching on adjacent lanes where other vehicles are traveling. Lane width varies based on whether the lane is an inside travel lane or an outside travel lane. Outside travel lanes are preferred for freight traffic because trucks travel slower than other vehicles and have large blind spots on the right side of the vehicle. Average truck width, including side mirrors, is approximately 10-feet. 12-foot travel lanes are recommended, but 11-foot travel lanes may be acceptable in areas constrained by setbacks and other physical features **(City of Portland, 2008, p.16)**.

TRUCK PARKING (DELIVERY)

Narrow curbside parking lanes make it difficult for trucks to find parking. Truck drivers may resort to parking on the curb where space is limited, reducing the width of the sidewalk **(FDOT, p.3.30)**. For short-term use, reserve designated parking spaces adjacent to the destination to prevent double parking. For long-term use, consider the “park once and walk” model. According to **NACTO**, “Some delivery drivers making multiple deliveries in one area will favor a slightly longer walk to destinations if they are given dedicated spaces and can park for longer,” **(NACTO, 2007, p.6)**.

LOADING/UNLOADING ZONES

As the amount of freight traffic grows, truck loading/unloading zones will be key to eliminating travel lane blockages. Providing opportunities for assigned truck loading/unloading spaces at the right time of day can keep freight traffic from interrupting overall traffic flow or encroaching on transit stops. In addition, freight loading zones on heavily travelled arterials can be structured with time restrictions during peak period travel. This will allow the curb lane can be used as a travel lane during peak commuting periods but as a loading/unloading zone during other times of the day, can help reduce traffic congestion **(FDOT, p.3.30)**.

URBAN SEGMENT DESIGN

DESIGN CONSIDERATIONS

SPEED

The appropriate travel speed along a roadway is influenced by several factors, including land use, multimodal use and truck movement. A safe environment should be provided for freight and other vehicles, pedestrians, and bicyclists. High levels of multimodal encounters are expected in urban areas due to the expected land use activity. Since pedestrian crash severity reduces at slower speeds, the posted speed limit should be as low as possible given the local context. Roadside design elements such as warning signs or markings, lane widths and the number of travel lanes, and wayfinding and landscaping, can help effectively communicate speed **(FDOT, p.2.19)**.

BIKE LANES

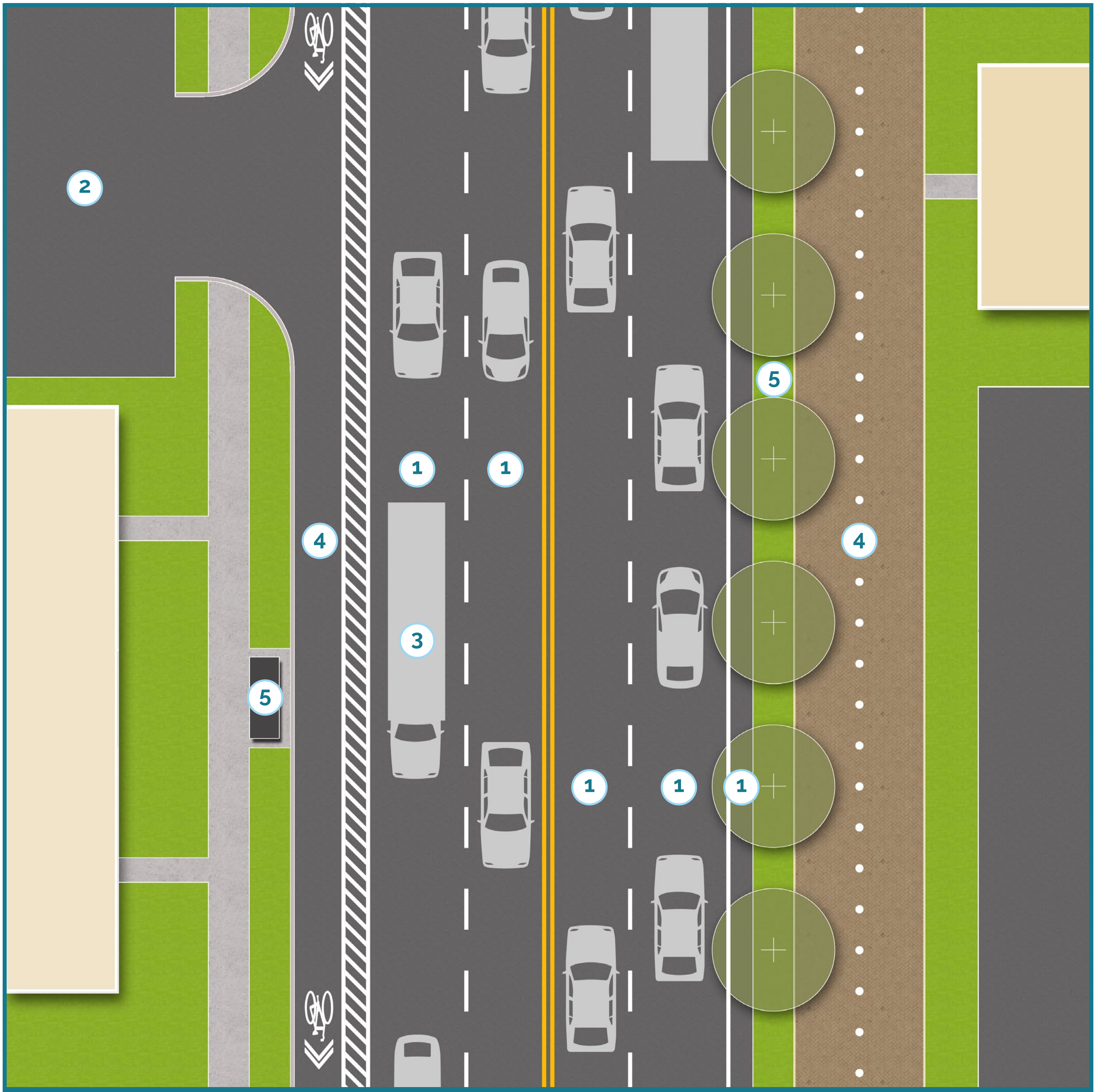
Protected bike lanes are defined by their physical separation from the sidewalk and the roadway to prevent encroachment. Lateral separation is provided between the protected bike lane and the nearest travel lane, while some type of raised physical feature is provided between the protected bike lane and the sidewalk. According to the **Seattle Right-of-Way Improvements Manual**, when bike facilities are located on major truck streets and no alternative routes are available, "A protected bike lane is recommended to provide high visibility and predictability for all travelers," **(City of Seattle)**.

HORIZONTAL AND VERTICAL CLEARANCE

As the freight industry continues to explore new vehicle and container types, warning systems for trucks have become increasingly important. Within the KIPDA region, truck strikes have been common on low clearance bridges. Vertical clearance on major truck corridors should be 16 feet or higher **(FHWA)** and at least "14-feet between the roadway and overhead fixed objects," on minor arterials and below **(City of Portland, 2008, p.16)**. Horizontal clearance to obstructions should be 1.5-feet or more from the curb and 3-feet near turning radii for intersections **(City of Portland, 2008, p. C-3)**.

SUBURBAN
SEGMENT DESIGN

TYPICAL PLAN VIEW



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SUBURBAN
SEGMENT DESIGN

DESIGN CONSIDERATIONS

WHAT IS A SUBURBAN ROADWAY SEGMENT?

Suburban roadway segments include all roads serving areas between the urban core and rural areas. Suburban streets generally experience high volumes of automobile, pedestrian, and bicycle traffic and low volumes of truck traffic. Most trucks entering suburban areas include retail deliveries, garbage trucks, fire trucks, and parcel delivery and moving trucks.

The needs of motorists, pedestrians, and bicyclists should be prioritized in these areas. Freight considerations in these areas should include slower speeds and accommodations for occasional on-street loading/unloading activity.

LANE WIDTH/SHOULDER WIDTH

While there are some suburban streets that may experience occasional large truck traffic, they are not designed for frequent thru truck trips and require only moderately wide travel lanes. In this way, truck maneuverability is accommodated without negatively impacting other users. 11-foot travel lanes are preferred, but 10-foot travel lanes may be acceptable in areas constrained by setbacks or other physical features **(City of Portland, 2008, p.21)**. Shoulder widths for suburban roads should be at least 2-feet, but 6 to 8-feet is preferred to provide space for enforcement, maintenance, and recovery activities **(FHWA, 2014)**.

TRUCK PARKING (DELIVERY)

Direct front or side access from alleys or other streets to onsite surface parking in suburban areas provides adequate parking space for truck deliveries. Small truck aprons and turn lanes accommodate slower turns are appropriate **(FDOT, p.3.28)**. In suburban areas where surface parking is limited, on-street truck parking introduces potential for conflict with other vehicles. In order to make deliveries in these locations, trucks may park in travel lanes and/or encroach on adjacent travel lanes to turn **(City of Portland, 2008, p.2)**.

SPEED

While in some conditions the level of freight traffic in suburban areas is expected to be low, the level of multi-modal encounters is expected to be high. The posted speed limit should preserve safety for all modes of travel and balance access and mobility to reflect the local context. Slower speeds are appropriate in suburban areas to reduce pedestrian crash severity and improve maneuverability for trucks. Roadside design elements such as warning signs or markings, lane widths and the number of travel lanes, and wayfinding and landscaping, can help effectively communicate speed **(FDOT, p.2.19)**.

BIKE LANES

Suburban areas are diverse activity zones that require accommodation for bicyclists. Pedestrian and bicyclist safety is emphasized through the design of protected bike lanes and shared use paths. Protected bike lanes provide space for on-road cycling and from the road, the adjacent travel lane, and the sidewalk **(City of Seattle)**. Shared use paths are designed for two-way travel and provide separate facilities for bicyclists and pedestrians. They are set back from the road and provide the most safety for bicyclists and pedestrians **(FDOT, p.3.7)**.

TRANSIT STOPS

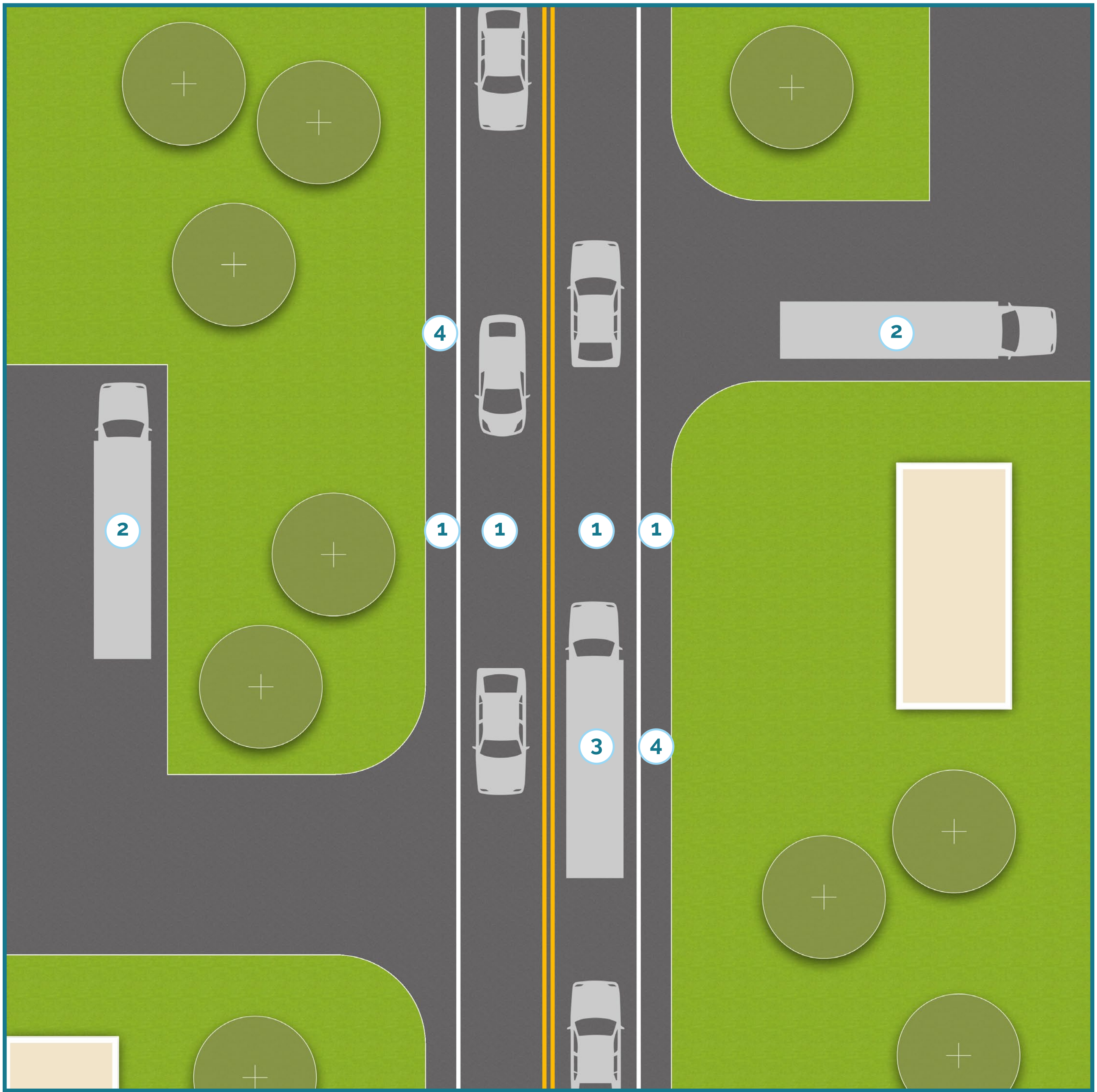
Streets designed for transit are often suited for freight traffic as well. Transit stops are located based on the overall travel time and the transit demand of the area. Land uses, signalized intersections, block lengths, development types and densities, and truck delivery zones must also be considered. The spacing range of bus stops in suburban areas ranges from 600 to 2,500-feet. Typical spacing is 1,000-feet. Provide adequate space for transit amenities, such as benches, shelters, and trash receptacles. Consider the importance of visual sight lines for freight trucks to see transit passengers **(TARC, p.19)**.

HORIZONTAL AND VERTICAL CLEARANCE

As the freight industry continues to explore new vehicle and container types, warning systems for trucks have become increasingly important. Curb side clearances for freight can be impeded by physical features **(City of Seattle)**. According to the **City of Portland**, "Trucks require a minimum vertical clearance of at least 14-feet between the roadway and overhead fixed objects," **(City of Portland, 2008, p.16)**. Horizontal clearance to obstructions should be 1.5-feet or more from the curb and 3-feet near turning radii for intersections **(City of Portland, 2008, p. C-3)**.

RURAL
SEGMENT DESIGN

TYPICAL PLAN VIEW



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DESIGN CONSIDERATIONS

WHAT IS A RURAL ROADWAY SEGMENT?

Rural roadway segments include all roads serving low-activity areas where the levels of trip generation by any mode of travel are low. According to the **Florida Department of Transportation (FDOT)**, these areas, "Are characterized by land uses that would generally be compatible with freight mobility, but actual freight activity (truck traffic) in these areas is low," **(FDOT, p.1.2)**.

Rural roadway segments are located outside of towns and cities. Rural areas with destinations for trucks should be targeted for freight investment **(FDOT, p.1.2)**.

LANE WIDTH/SHOULDER WIDTH

11-foot travel lanes are preferred on rural streets to provide space for driver correction and freight mobility, but 10-foot travel lanes may be acceptable in areas constrained by setbacks or other physical features **(City of Portland, 2008, p.21)**. Shoulder widths for rural roads should be at least 2-feet, but 6 to 8-feet is preferred to provide space for enforcement, maintenance, and recovery activities **(FHWA, 2014).** While shoulders provide satisfactory facilities for occasional pedestrian and bicycle use, they provide limited protection from vehicular traffic **(FDOT, p.3.5)**.

TRUCK PARKING (DELIVERY)

Direct front or side access from the main road to surface parking in rural areas provides adequate parking for truck deliveries. Small truck aprons and turn lanes to accommodate slower turns are appropriate **(FDOT, p.3.28)**. However, smaller driveway openings may create navigational complications for truck drivers. Encroachment into adjacent travel lanes or shoulders on main roads may occur when maneuvering in and out of driveways, which introduces potential conflict points with other modes of travel **(FDOT, p.3.29)**.

SPEED

Since levels of activity by any mode of travel and multimodal encounters are expected to be low, a modal emphasis on vehicles is appropriate in rural areas **(FDOT, p.2.19)**. These factors, combined with the lack of intense or dense land use activities and the economic value of goods movement, suggests that higher posted travel speeds are appropriate in rural conditions. However, consideration should be given to access rather than mobility. In areas with multiple access points, lower speeds should be considered to reduce potential for conflict **(FDOT, 2.20)**.

RURAL

SEGMENT DESIGN

DESIGN CONSIDERATIONS

BIKE LANES

Rural roads generally have significantly less bicycle traffic than suburban and urban roadways. Because of this paved shoulders are considered adequate facilities for bicyclists in rural areas. Road shoulders provide space for both pedestrians and bicyclists and are good alternatives on low traffic volume roads that do not require separate facilities. According to the **Cornell Local Roads Program (CLRP)**, , where road shoulders are intended to be used by pedestrians and bicyclists, they should be a minimum of 4-feet wide to provide plenty of separation between slow-moving bicyclists and pedestrians and fast-moving vehicles. These wide shoulders could serve as pull off areas for trucks with mechanical issues as well.

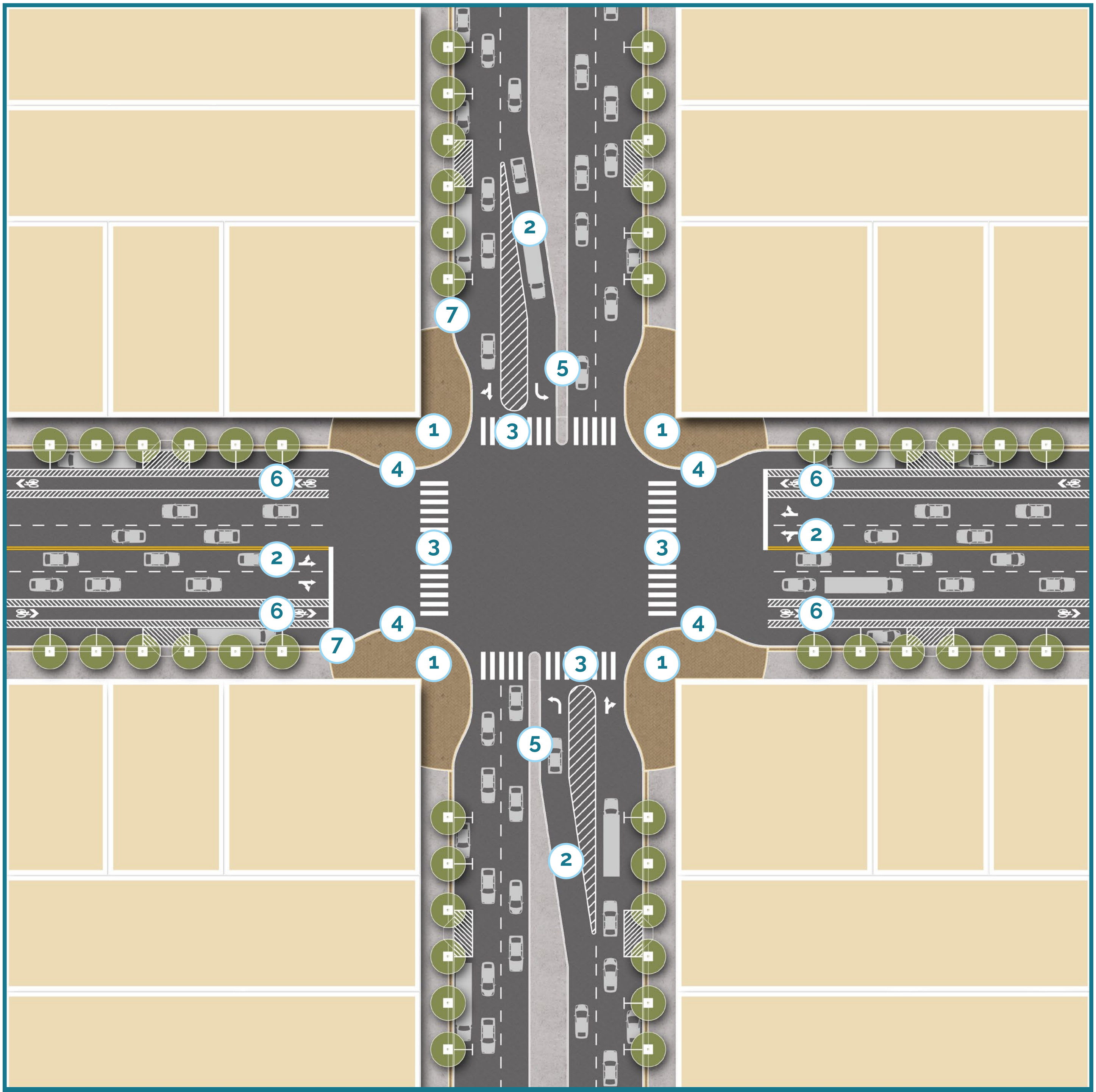
HORIZONTAL AND VERTICAL CLEARANCE

As the freight industry continues to explore new vehicle and container types, warning systems for trucks have become increasingly important. Curb side clearances for freight can be impeded by physical features **(City of Seattle)**. According to the **City of Portland**, "Trucks require a minimum vertical clearance of at least 14-feet between the roadway and overhead fixed objects," **(City of Portland, 2008, p.16)**. Horizontal clearance to obstructions should be 1.5-feet or more from the curb and 3-feet near turning radii for intersections **(City of Portland, 2008, p. C-3)**.

URBAN

INTERSECTION DESIGN

TYPICAL PLAN VIEW



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URBAN INTERSECTION DESIGN

DESIGN CONSIDERATIONS

WHAT IS AN URBAN INTERSECTION DESIGN?

It is important to design urban interchanges within the context of the larger neighborhood. Generally, urban intersections should be designed to prioritize the pedestrian while accommodating vehicular traffic. In areas with heavy truck traffic it is important to balance freight mobility with designs for pedestrians. This often means accounting for the movement of a truck with a 53-foot trailer without encroaching upon multiple sending or receiving lanes of traffic or mounting curbs and sidewalks. Bicyclists may be directly adjacent to lanes with large trucks and should receive special consideration at urban intersections.

BUMP-OUTS (CURB EXTENSIONS)

Bump-outs, otherwise known as curb extensions, are paved extensions of the sidewalk that reduce the pedestrian crossing distance and increase pedestrian visibility. Bump-outs function as a traffic-calming measure by slowing vehicular traffic and "narrowing" the street. While effective for pedestrians, bump-outs may create maneuverability issues for large trucks, who may need to encroach upon multiple receiving lanes of traffic in order to turn. To accommodate freight, use a recessed stop bar set back from the intersection to allow for turning movements without conflicting with queuing vehicles in receiving lanes **(City of Seattle)**.

TURN LANES

In urban areas, shared thru/turn lanes for left and right turns are appropriate in order to provide safety and comfort for pedestrians and bicyclists. However, this may mean occasional encroachment into oncoming travel lanes and bike lanes for large trucks. In areas with heavy freight volume, exclusive left turn lanes with signal phasing and long lane tapers should be considered to decrease delays for through vehicles. Long tapers accommodate multiple trucks, while signal phasing allows drivers to turn without yielding to pedestrians **(FDOT, p.3. 11)**.

PEDESTRIAN CROSSING

Pedestrian safety is maximized through accommodations including curb ramps and crosswalks in areas where high volumes of multi-modal traffic are anticipated. At signalized urban intersections, signal phasing and timing should favor pedestrians over vehicles in order to reduce pedestrian wait time and increase comfort and convenience. Minimize crossing distances where possible through the use of shared left and right turn lanes. Larger intersections with dedicated left and/or right turn lanes (and heavy truck movements) should provide pedestrian refuge islands (medians and nose treatments) **(FDOT, p.3.33)**.

CURB RADII

Curb radii at urban intersections should accommodate trucks while using the smallest possible radius to provide pedestrian safety and mobility. In some cases, this may mean regular encroachment into adjacent bicycle lanes and multiple receiving lanes of traffic, as well as occasional encroachment into multiple sending lanes. At urban intersections with heavy freight traffic, larger curb radii may be used in conjunction with channelization (providing a corner island) to allow large trucks to accomplish right turns without encroaching upon opposing traffic or mounting curbs and sidewalks **(FDOT, p.3.16)**.

NOSE TREATMENT

Median nose treatments extend past the crosswalk at intersections and provide additional pavement where pedestrian safety and access are the highest priorities. They also provide opportunities for visual enhancements such as signage, light fixtures, and landscaping. Types of nose treatments include full curb, mountable, truncated, and painted. At urban intersections with high volumes of freight traffic, median nose treatments should be designed with slimmer noses or mountable curbs for added strength to accommodate turns for trucks **(FDOT, p.3.20)**.

BIKE LANES

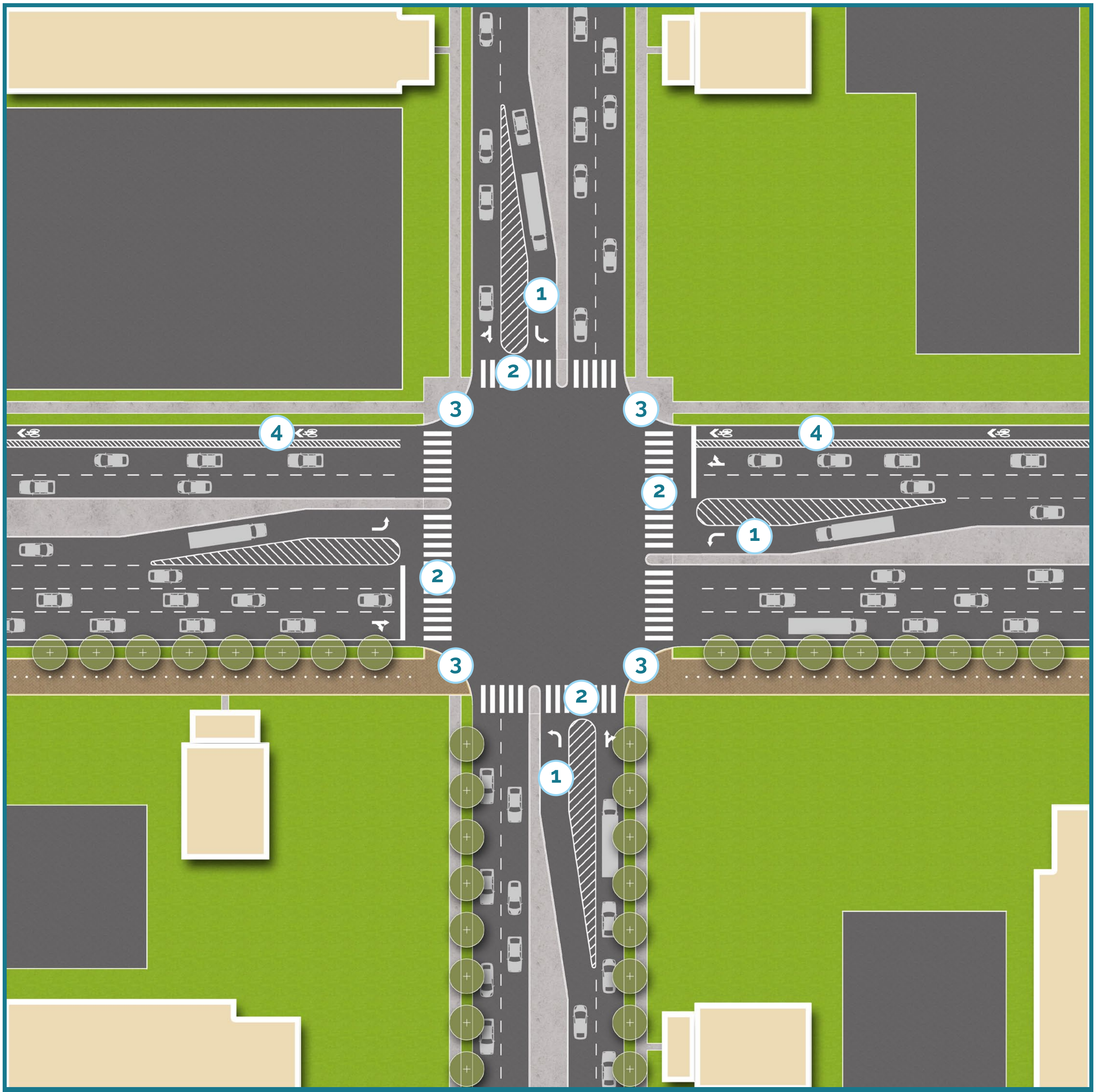
Large, left-turning trucks may swing into bike lanes and create conflict with cyclists. This can be mitigated by locating bike lanes away from the driving lane with a striped buffer area and protection barriers. Bike lanes should also be on the outside of a shared right/thru lane to increase the right turn radius to lessen encroachment onto lanes. According to the **Seattle Right-Of-Way Improvements Manual**, exclusive bike signals (allowing bicycles to move through intersections by separating turn and through movements) at urban intersections should also be considered in order to improve bike and truck safety.

TRANSIT STOPS

Bus transit drivers typically share the same maneuverability concerns as truck drivers at urban intersections. In urban areas, transit stops should be located at intersection corners to provide the most comfort and convenience for passengers walking to destinations. Wide buffers should be provided for stop amenities. However, in areas with heavy freight traffic, accommodating truck navigation with exclusive left and/or right turn lanes may mean locating the transit stop further from the intersection corner in order to increase maneuverability **(FDOT, p.3.17)**.

SUBURBAN & RURAL
INTERSECTION DESIGN

TYPICAL PLAN VIEW



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DESIGN CONSIDERATIONS

WHAT IS SUBURBAN & RURAL INTERSECTION DESIGN?

Intersections are one of the most difficult locations for freight to navigate in non-urban areas. According to the publication **Designing for Truck Movements and Other Large Vehicles in Portland**, "Truck movements are complicated by limited curb radii, narrow roadways, and parked vehicles near intersections," **(City of Portland, p.21)**. While the frequency of truck circulation in these areas is expected to be low, implementing truck mobility improvements at non-urban intersections, such as large curb radii and exclusive left/right turn lanes, can improve maneuverability **(FDOT, p.1.2)**.

TURN LANES

Since posted travel speeds in non-urban areas are anticipated to be slightly higher than those in urban areas, signals for thru-traffic may be longer than those for turning traffic. As such, in low-activity, non-urban areas, intersections should be provided with exclusive left and right turn lanes with short turn lengths to allow for the flow of thru-traffic without the stopping or delays created by turning vehicles. Since the occurrence of freight in these areas is infrequent, short turn lanes can accommodate low volumes of turning vehicles, including freight, while minimizing the construction costs associated with large intersections **(FDOT, p.3.10)**.

PEDESTRIAN CROSSING

At non-urban intersections where larger turning radii are required for most turning maneuvers, longer pedestrian crossing distances may require pedestrian refuge islands. Pedestrian refuge islands are located in the median of a street for wide intersections. According to the **Seattle Right-Of-Way Improvements Manual**, pedestrian refuge islands create "two-stage" crossings that allow for safer crossings. When pedestrian refuges are planned for an intersection, reasonable care should be taken to ensure they are designed in such a way to minimize risk to the pedestrian from wide truck left hand turn movements.

CURB RADII

Small curb radii can impede freight movements. Exclusive right turn lanes with large curb radii are recommended at non-urban intersections with significant truck traffic to provide accommodations for large trucks. A large curb radius provides maximum flexibility for freight to navigate turns without encroaching on multiple sending or receiving lanes of traffic. Consider utilizing an intersection shape that closely resembles the shape of a truck turning in order to optimize turning movements **(City of Portland, p.17)**.

SUBURBAN & RURAL
INTERSECTION DESIGN

DESIGN CONSIDERATIONS

BIKE LANES

Left turns at intersections require bicyclists to merge with vehicular traffic, including large trucks. Similarly, trucks making right turns can encroach on bike lanes adjacent to the curb as they have blind spots on the right side of the vehicle. These conditions pose significant safety concerns for bicyclists. To prevent potential conflict, clear signage and/or pavement markings, such as bicycle detection pavement or bicycle boxes, should be provided in advance to avoid driver confusion and prevent potential conflict. Bicycle boxes provide a place for bicycles to queue in front of vehicles to avoid right-turning trucks **(FDOT, p.3.13)**.

TRUCK APRONS

Truck aprons are an important consideration in the design of intersections to serve freight. Used on smaller intersections or roundabouts, truck aprons allow large trucks to navigate turns without encroaching upon adjacent travel lanes. Truck aprons are designed to handle the weight of large trucks with reinforced concrete. In slip turn lanes at intersections, the pavement may be slightly raised or painted. As illustrated, the pavement coloring and striping can clearly demarcate the truck apron area, minimizing confusion or incorrect use by other drivers and pedestrians **(FDOT, p.2.16)**.

TRANSIT STOPS

Bus transit drivers typically share the same maneuverability concerns as truck drivers at non-urban intersections. In non-urban areas, transit stops should be located further from the intersection corners to accommodate freight traffic navigation with larger turn radii and exclusive left and/or right turn lanes **(FDOT, p.3.17)**.

Bus route navigation signs identifying the location of transit stops (such as the one in the image above) can give advance warning to large trucks. Signs should be located 6-feet from the edge of the paved shoulder or 12-feet away from the travel way **(TARC, 41)**.

DESIGN CONSIDERATIONS

ACCESS MANAGEMENT

Access management is defined according to the Kentucky Transportation Cabinet (KYTC) as "the careful planning of the location, design, and operation of driveways, median openings, interchanges, and street connections. The purpose of access management is to provide access to land development in a manner that preserves the safety and efficiency of the transportation system." Similarly, the Indiana DOT defines access management as "…the process that manages access to land development while simultaneously preserving the flow of traffic on the surrounding public road system in terms of safety, capacity, and speed."

In a freight context, access management typically involves the placement of driveways and curb cuts into and out of a manufacturing or warehousing areas or other areas, and is highly dependent on where the area is located (urban, suburban, or rural) and the adjacent land use context. In urban areas, it is more desirable to have sufficient distances between curb cuts and to locate them so they do not conflict with truck parking (if available) or transit stops. In non-urban areas, spacing is typically less constrained, but other modes still need to be taken into account.

Since freight vehicles and flows compete for roadway and parking spaces with other vehicles, and modes, including transit and pedestrians, controlling and managing access are important. Designated spaces for truck parking that do not conflict with other movements is critical, especially for urban freight movements. Some other restrictions that deal with when freight can be delivered, for example daytime or nighttime delivery hours, bans or restrictions, can also play important roles in managing overall access and in maintaining quality of life.

Other access management techniques designed to restrict trucks to certain lanes and/or roads have been much less successful in Kentucky and are probably not feasible given the history of their implementation.

Some access guidance can be found in **NCFRP Improving Freight System Performance in Metropolitan Areas: A Planning Guide**. Additional guidance for Kentucky and Indiana Access Management can be found in **KYTC Access Management** and **Indiana DOT Access Management**.

DESIGN CONSIDERATIONS

ACCESS MANAGEMENT

ENTRANCES
Entrances (or driveways) necessary to provide access to property adjacent to the public roadway system should be evaluated. Some facilities could have multi-lane entrances, while others could have a single lane. Also important to consider is the access control needed and whether or not fencing or barriers to prevent unauthorized entry are needed. Lighting and security equipment needs (cameras, instruction detection / monitoring) are also appropriate considerations.

NUMBER OF ENTRANCES
The number of entrances necessary for property access is a function of the trip generation characteristics of the property. Having more than one entrance, prevents bottlenecks at a single location and where practical, projects should consider multiple entrances (where appropriate) to facilitate expedited flows to and from a location.

ENTRANCE SPACING
Entrances (or driveways) should be located and spaced appropriately taking into account factors such as the type of roadway (functional classification) and speed. KYTC in its **Model Access Management Ordinance** on page 14, provides guidance as a starting point for development of local standards on spacing.

ENTRANCE DESIGN
Entrances should be designed to accommodate the weight (where appropriate) of a fully loaded multi-axle truck, typically with a trailer that is 53 feet long and weighing around 80,000 pounds. The expected type of truck and frequency of truck should be known to determine the Equivalent Single Axis Load (ESAL). This, along with a proper soil analysis, should be used to determine the materials and depth of materials necessary to construct a durable entrance that will hold up against the heavy truck loading.

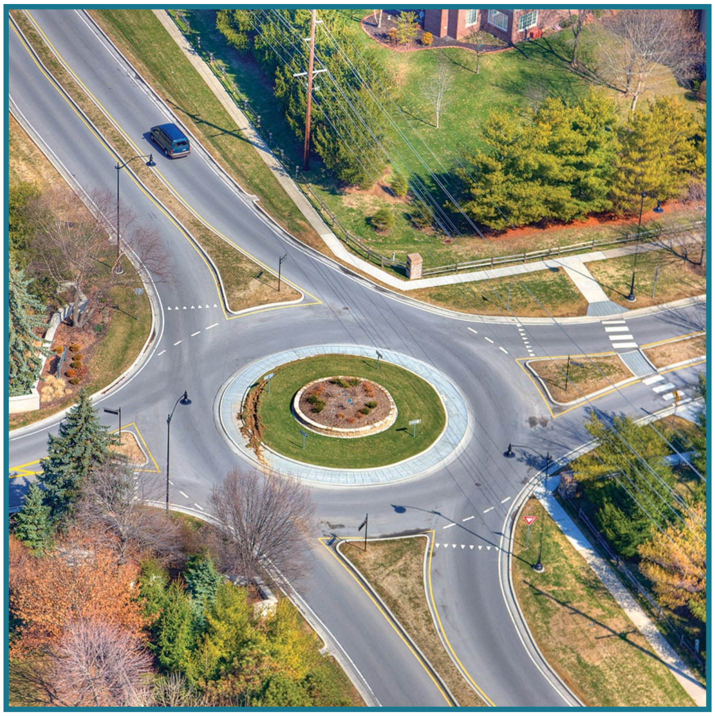
ENTRANCE LENGTH
For secure entrances, vehicle queuing and credential / vehicle check spaces should be taken into account. This is especially important so that queuing vehicles do not impact the through travel lanes. In this case, the actual entrance point needs to be set back from the roadway to provide adequate vehicle queuing / storage areas.

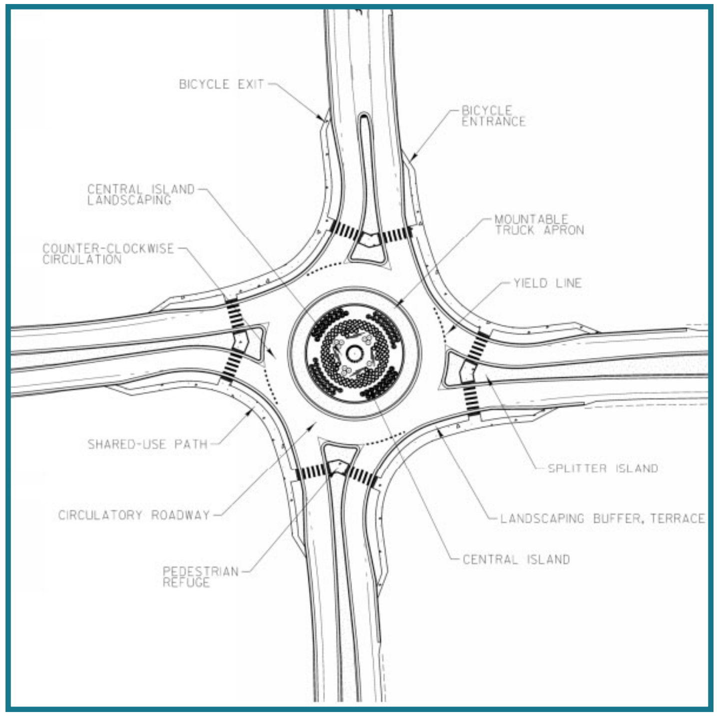
BREAKOVER ANGLE
At driveway access locations, the Breakover angle must be considered to prevent the undercarriage of long commercial vehicles from striking the roadway. It is defined as the maximum possible supplementary angle (usually expressed in degrees) that a vehicle, with at least one forward wheel and one rear wheel, can drive over without the apex of that angle touching any point of the vehicle other than the wheels.

This is typically important at entrances that intersect a railroad crossing or at intersections that have a potential to have excessive grade changes transverse to the centerline (intersections where a superelevation on the mainline has been introduced, for example). At existing public highway locations where vehicles might have a chance of getting stuck, the W10-5 warning sign may be needed and should be installed in advance of the area of concern. This is a standard sign per the **Manual on Uniform Traffic Control Devices (MUTCD)**.

Design guidance for proper grades at railroad crossings can be found in the AASHTO publication, **A Policy on Geometric Design of Highways and Streets**. Various other research documents exist for design guidance on entrance design, such as the NCHRP document, **Geometric Design of Driveways**.

INNOVATIVE INTERSECTION DESIGN





INNOVATIVE INTERSECTION AND INTERCHANGE DESIGN FOR TRUCKS

Over the last decade, several innovative interchange and intersection designs have become more widely used around the nation because they can improve traffic safety and/or capacity. Some of these designs include roundabouts, restricted-crossing U-turns (RCUT), median U-turns (MUT), displaced left turns (DLT), and diverging diamond interchanges (DDI also referred to as double crossover interchanges). Each of these designs requires special considerations to sufficiently accommodate truck traffic, especially oversize overweight trucks. Techniques in innovative design can be used in rural areas because of the ability to purchase right of way.

ROUNDABOUTS

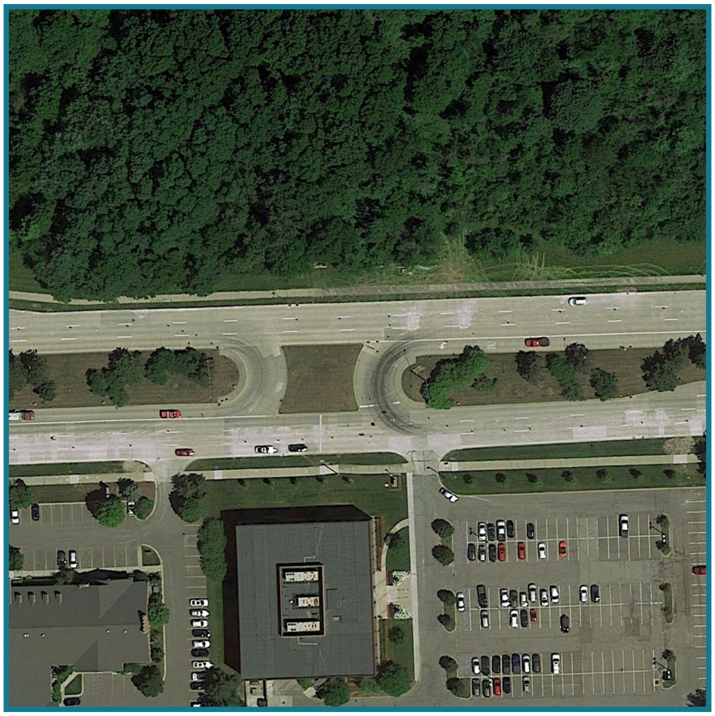
Roundabouts can be used to provide improved intersection safety and traffic operations; however, it is important to take truck needs into consideration. By giving specific attention to the needs of trucks it is possible to design effective and safe roundabouts even with large truck volumes.

Roundabout truck aprons are important to accommodate truck turning radii, while maintaining a reasonable roundabout size. At interchanges and major intersections it is often desirable to design for very large trucks (WB-67). WB-67 trucks are a typical, 53-foot long trailer. The intent is to accommodate a vehicle that is of these dimensions with a "dynamic envelope" and also via a requisite turning template as well. Turning radii for the truck design vehicle should be examined in detail, considering the splitter islands, central island, and all required lanes.

Multi-lane roundabouts require additional expertise and consideration of whether lane encroachment is an issue. Signing, striping, and lines of sight for trucks should also be considered. If over-height and overweight trucks are expected to pass through the intersection, then additional review of the clearances is recommended. **Roundabouts: An Informational Guide Second Edition (NCHRP Report 672, TRB, 2010)** provides extensive guidance on the design of roundabouts, including specific guidance on incorporating the needs of trucks.

DESIGN CONSIDERATIONS

INNOVATIVE INTERSECTION DESIGN



RESTRICTED CROSSING U-TURNS (RCUT)

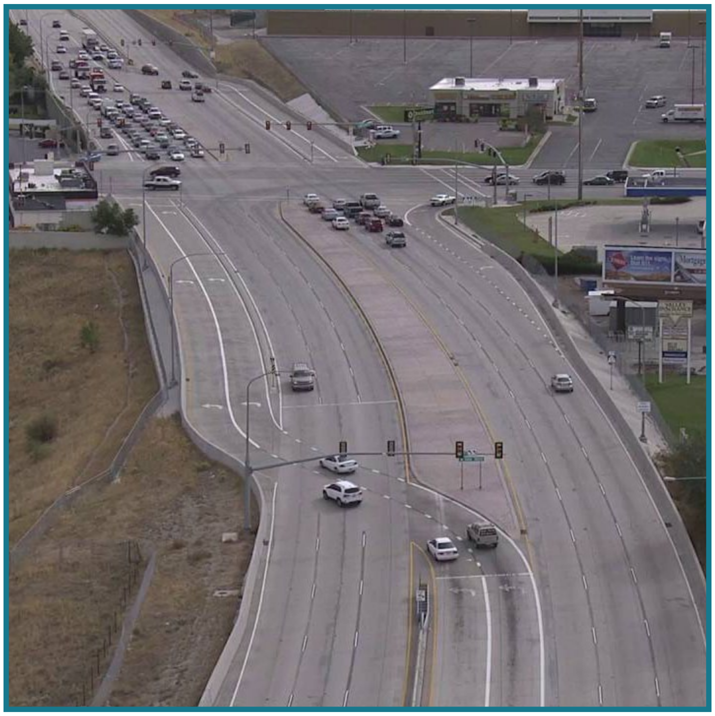
Restricted Crossing U-Turn intersections increase the major street capacity and intersection safety by reducing side-street traffic conflicts. Through traffic and left-turns on the side-street turns right and then makes a U-turn before either continuing on the major street or turning right back onto the side street. The main intersection and U-turn movements can be signalized (Superstreet") or left un-signalized ("J-turn Intersection", sometimes used in rural expressway conditions).

Overall, this design can substantially improve intersection safety and main street capacity. Accommodating trucks at these intersections requires that special attention be paid to turning radii for the U-turns. Requirements depend on the median width, presence of a shoulder, and the number of U-turn lanes. Sometimes an additional paved area ("loon") is required to facilitate truck U-turns. For additional information, see the **FHWA publication Restricted Crossing U-Turn Intersection**, which provides a summary on RCUT intersections as an alternative intersection design.

MEDIAN U-TURN INTERSECTIONS (MUT) AND THRU U-TURN INTERSECTIONS

These intersections restrict all left-turns at an intersection to improve capacity and safety. Left turns from the major street pass through the intersection and then U-turn back to turn onto the side street. Side street left turns turn right and then make a U-turn to travel back on the major street (similar to an RCUT intersection). The **FHWA report Median U-Turn: Informational Guide** provides general information and guidance on median U-turn intersections.

Truck turning movements must be given specific attention in the design of the U-turn locations in a manner similar to that of the RCUT intersections. The truck turning radii must be accommodated through the use of a wide median, multiple lanes to turn into, shoulder, use of an adjacent intersection, or a paved "loon" as shown in the image. Additional information can be found in the **FHWA publication Median U-Turn Intersection**, which provides a summary on MUT intersections as an alternative intersection design.



DISPLACED LEFT-TURN INTERSECTIONS (DLT) OR CONTINUOUS FLOW INTERSECTION (CFI)

These intersections use well-timed upstream signals to shift major street traffic to the left side of the opposing through lanes in advance of a main intersection. This allows the left and through traffic to move simultaneously, removing the major street left-turn phase from the intersection. The right turns typically stay outside of the new left turn lanes. The **FHWA report Displaced Left Turn: Informational Guide** provides general information and guidance on displaced left-turn intersections.

It is critical that trucks be taken into consideration in the design of the cross-over location as it can be difficult to accommodate large trucks if the right-of-way is limited. The same is true for the completion of the left-turn at the main intersection. Sometimes it is not possible for the design to accommodate large trucks in a single lane.

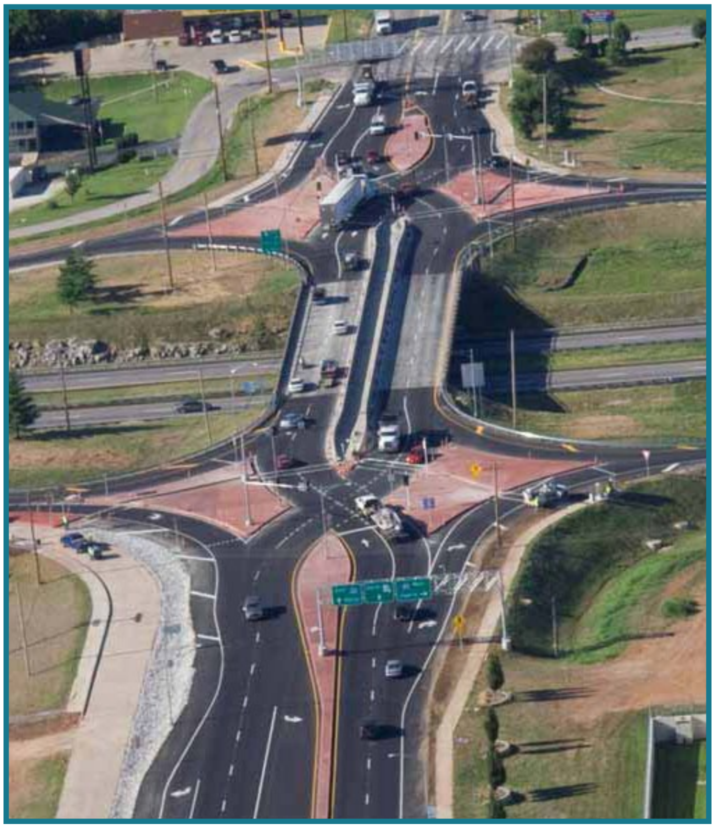
DESIGN CONSIDERATIONS

INNOVATIVE INTERSECTION DESIGN

DIVERGING DIAMOND INTERCHANGE (DDI) OR DOUBLE CROSSOVER DIAMOND INTERCHANGE (DCD)

This interchange design can provide substantial capacity and safety benefits over typical diamond interchanges. It shifts the traffic to the left side of the road through the middle of the interchange to reduce left turn conflicts and improve traffic flow at the ramp terminals. The **FHWA report Diverging Diamond Interchange: Informational Guide** provides general information and guidance on diverging diamond interchanges.

It is critical that truck paths be checked through the interchange and at each intersection to make sure that there is sufficient width for truck movements. Lane marking and signage should also be given particular attention, taking truck needs into account.



INTERCHANGE AREA DESIGN

Interchanges often have high truck volumes as they are the major connection points between the Interstate system and the local street system. Freight companies and services related to freight often locate near interchanges as well, making them critical design components of the truck freight system. It is very important to follow access management best practices in the vicinity of interchanges and to examine all aspects of interchanges with respect to truck turning radii, paths through the interchange, signage and striping, etc. Several of the treatments described previously in this guidance document apply to interchanges.

One key consideration is the length of queues when there are large numbers of trucks. This means that adjacent intersections should be spaced appropriately from the ramp terminal intersections, such that trucks do not block movements at either intersection. Driveways should also be spaced far enough away with consideration given to adequate turn lane and storage needs. Both operational and safety issues may result if these topics are not considered in sufficient detail with appropriate truck forecasts.

DESIGN CONSIDERATIONS

TECHNOLOGY & NAVIGATION

TECHNOLOGY

Technology is a multifaceted subject and covers the use of technology to provide pre trip and in route information to commercial vehicle drivers via intelligent transportation systems (ITS), but also includes technologies to collect real-time information and includes emerging technologies for connected and autonomous vehicles (C/AVs). For this Design Guide, we are focusing on ITS components because those are typically deployed by local government agencies. ITS upgrades improve ways to get vehicles to their intended destinations on time, to help them avoid congestion and to help them avoid impedances (low bridges, weight restricted bridges, sharp curves, etc.).

KIPDA has a **Regional ITS Architecture**. It provides "a roadmap for transportation systems integration in the Louisville-Jefferson County Metropolitan Planning Area of southern Indiana and north central Kentucky over the next 20 years". The architecture provides linkages to **Service Packages**, many of which relate directly or indirectly to freight and commercial vehicles.

Local governments and agencies that wish to integrate technology into projects, whether they be stand-alone technology-focused ones or others where technology may be a component, should consult these documents to ensure that their projects are compatible with the overall ITS Architecture and align with the various Service Packages identified. Also, in the KIPDA region the **TRIMARC** provides a regional and integrated platform of ITS devices to assist travelers in the region.

TRIMARC (Traffic Response and Incident Management Assisting the River City) is a project of the Kentucky Transportation Cabinet. TRIMARC was a part of the original national initiative to deploy Intelligent Transportation Systems (ITS) to 75 of the nation's largest metropolitan areas.

The TRIMARC system includes an integrated system of sensors, cameras, dynamic message signs, highway advisory radio and computers monitoring more than 100 miles of interstate traffic in the Louisville Metro area. Once collected, the information then is disseminated to motorists via dynamic message signs, highway advisory radio, local media and internet service providers. Project sponsors should consider TRIMARC's operations and tying into their systems and communications protocols whenever possible.

Technology also has implications for the vehicles themselves as well, especially with regard to the advancement of autonomous vehicles and in this case autonomous trucks. As technology advances and evolves, there is greater potential that some trucks in the future might not have a human driver and that sensors, radar, and other technology will completely operate the vehicles. Right now, some trucks are capable of operating together as a platoon on the interstates and some companies have been experimenting with various degrees of driverless trucks.

What ultimately becomes of this technology how widespread the usage is, and what implications this technology has for local agencies and projects in the future has yet to seen. The physical operating dimension of the autonomous vehicles might largely be the same as their actively driven counterparts. However, changes will likely be needed in their operating policies and regulations and in the interface(s) with public infrastructure. Project sponsors and local governments should be part of those on-going discussions so they and their projects are not left out as the technology evolves and advances.

NAVIGATION

Navigation in the context of this design guide really refers to wayfinding and directional information specifically aimed at freight / trucks. This is especially important for first and last mile segments, but also pre and post trip to provide information on closures, congestion, incidents, and truck parking. Sometimes in the case of signage, the information is specific to an individual port, business park or other specific location. Guidance here is not intended to replace regulatory and warning signs which are governed exclusively by the **Manual of Uniform Traffic Control Devices (MUTCD)**.

Wayfinding signs are often used to get drivers and trucks to a particular location well in advance of where it actually is. Often they start as soon as a driver gets onto the network or roadways leading to a destination, sometime as early as the off ramp from an interstate. The signs point drivers in the general direction of their destination and are continued, and continue to provide turn by turn navigation, reinforcement and directions until the destination is reached. Placement of signs, excessive sign messaging and information overload, are concerns that designers and project sponsors need to be aware of when placing new signs in an existing operating environment.

Signs, where they are and what information they convey, need to be logically thought out in a cohesive plan and system to give drivers appropriate cues ahead of decision points. Standards for sign spacing and letter height should be taken into account as well as site and roadway characteristics, including roadway and approach speeds. Drivers' visual and cognitive abilities vary greatly and these affect how easily a sign can be read and understood. The legibility standards established in the MUTCD are based on extensive research into all of these areas and can act as a guide. Similarly, where signs are placed, especially next to roadways also need to be considered. And if necessary a permit may need to be grant by a regulatory or state DOT. Additional information may be found at KYTC **Highway Design** and INDOT **Indiana Design Manual**. Freight specific trip and route directional information in the vehicle is often handled by private sector providers who provide pre, enroute and post trip information. Some of this is often accessed through commercially available systems via subscription or through proprietary systems specific to large trucking companies who pay for tailored information specific to their needs or have their own systems or applications. Smaller owner - operators may rely on commercially available information often also marketed to the general public, although this is not often freight specific.

The public sector contributes information about maintenance, closures and other incidents to this information set which is often widely shared with the private and public sectors. For example, **Kentucky partners with the Waze app** to provide information on maintenance, incidents and other conditions affecting travel in Kentucky. In Indiana, the Indiana DOT provides information about road conditions, closures and width/ weight restrictions across two platforms- **TrafficWise** and **CARS 511**.

Locally in KIPDA region, the **Notify Every Truck (NET)**, is part of the region's intelligent transportation system (ITS) network and is an initiative which seeks to notify commercial vehicle operators of conditions that may interrupt travel on Kentucky's major highways.

DESIGN CONSIDERATIONS

TRUCK PARKING

Since 2012, the American Transportation Research Institute's Top Industry Issues Report has listed truck parking as a top-ten issue facing the industry. Complicating this major challenge, recent changes in federal law (Hours of Service, Electronic Logging Devices) have resulted in increased parking demands.

Metropolitan areas often feature little to no truck parking capacity. As a result, many truck drivers deliberately give up potential driving hours (and revenue) to stage an hour or two outside of an urban area to avoid parking in an unsafe area due to insufficient parking opportunities. However, public and privately provided truck parking even outside of urban areas – generally – does not fulfill current truck parking demands. This often results in truck's parking in undesignated areas like highway interchange ramps. These areas were not designed to safely accommodate a parked truck. Additionally, drivers parked in undesignated areas expose themselves to assaults and theft.

While solving truck parking challenges have proven to be difficult, several public agencies have created new truck parking capacity by creating innovative solutions.

INTERSTATE HIGHWAY PARKING SOLUTIONS

TRUCK PARKING INSIDE AN EXISTING INTERCHANGE

Nebraska DOT converted the inside of the half-clover leaf interchange at I-80 and U.S. Highway into an illuminated gravel lot that can hold up to 100 trucks. While the facility does not have any additional facilities (restrooms, etc.), it provides additional truck parking capacity on the heavily travelled I-80 corridor.

TRUCK PARKING TURNOUTS

Wyoming DOT built 17 truck turnouts – within existing right-of-way – on I-20, I-80 and I-90. The turnouts provide parking for 10 to 15 trucks, but do not provide any other facilities – other than trash barrels. The facilities were built with the intention of serving corridors with low truck volumes or as surge capacity in areas where truck parking is in high demand.

REST AREA CONVERSIONS

As aging rest areas are renovated, an opportunity exists to retrofit these facilities to provide additional truck parking. Rest areas typically include parking for trucks and passenger vehicles. However, many of these facilities feature more passenger vehicle parking than demanded and also feature underutilized real estate that could be retrofitted into truck parking.

For example, Missouri DOT evaluated the use of a rest area on I-70 near Danville and determined the location was better utilized as a truck parking facility, and converted it into a truck only parking area.

Before

After

DESIGN CONSIDERATIONS

TRUCK PARKING

KYTC has installed similar signs along I-71 recently.

ITS SOLUTIONS

The State of Kansas partnered with Indiana, Iowa, Kentucky, Michigan, Minnesota, Ohio and Wisconsin to develop a Regional Truck Parking Information and Management System (TPIMS). The system provides truck drivers real-time parking availability information through variety of media outlets including dynamic signs, smart phone applications and traveler information websites. Most notably, signs like those found in the image above that highlight upcoming truck parking availability ahead – regardless of jurisdiction – allow truck drivers to proactively choose their parking locations.

SHORT TERM STAGING

TRUCK PARKING AT MANUFACTURING AND DISTRIBUTION CENTERS

Private sector shippers and receivers can provide on-site parking opportunities when truck volumes become excessive. For example, countertop maker Cambria's major production facilities is located in Le Sueur, Minnesota next to a public truck parking facility on U.S. Highway 169. However, the public facility was often at capacity and truck drivers had issues prepositioning for the delivery of supplies of shipment of completed goods. So, Cambria constructed a private truck parking area on-site at the manufacturing facility.

TRUCK PARKING AT MANUFACTURING AND DISTRIBUTION CENTERS

Similarly, Meijer Grocery Stores' major distribution center is located in Lansing, Michigan. The facility has constructed a "bullpen" just outside of the complex. When drivers arrive they are required to enter the "bullpen" and stage until needed – mitigating unnecessary mobility issues in the neighborhood or on the distribution center site itself.

INNOVATIVE PUBLIC INFRASTRUCTURE SOLUTIONS

Transit park and ride facilities are designed to handle the geometrics of moving large busses through areas with pedestrians and vehicular traffic. Understanding that urban truck solutions involve the same constraints, the City of Elmira, New York constructed a truck parking addition to an existing park and ride facility on I-86. The City leases each of the 25 spots to local trucking firms for $5/day or $50/month.

REFERENCES

REFERENCES

City of Portland
2008 *Designing for Truck Movements and Other Large Vehicles in Portland*. City of Portland Office of Transportation. Portland, OR

City of Seattle
2017 *Seattle Right-of-Way Improvements Manual*. City of Seattle. Seattle, WA

Cornell University
2013 *Accommodating Bicyclists and Pedestrians on Rural Roads*. Cornell University Local Roads Program (CLRP). Ithaca, NY

Federal Highway Administration (FHWA)
2009 *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways*. FHWA. Washington, DC.

Federal Highway Administration (FHWA)
2014 *Displaced Left Turn Intersection: Informational Guide*, Report No. FHWA-SA-14-068. FHWA. Washington, D.C.

Federal Highway Administration (FHWA)
2014 *Diverging Diamond Interchange: Informational Guide*, Report No. FHWA-SA-14-067. FHWA. Washington, D.C.

Federal Highway Administration (FHWA)
2014 *Median U-Turn Intersection: Informational Guide*, Report No. FHWA-SA-14-069. FHWA, Washington, D.C.

Federal Highway Administration (FHWA)
2009 *Median U-Turn Intersection*, Publication No. FHWA-HRT-09-057. FHWA. Washington, D.C.

Federal Highway Administration (FHWA)
2009 *Restricted Crossing U-Turn Intersection*, Publication No. FHWA-HRT-09-059. FHWA. Washington, D.C.

Federal Highway Administration (FHWA)
2014 *Shoulder Width*. FHWA. Washington, DC.

Federal Highway Administration (FHWA)
2014 *Vertical Clearance.* FHWA. Washington, D.C.

Florida Department of Transportation (FDOT)
2015 *Freight Roadway Design Considerations.* FDOT District 7 Office of Intermodal Systems Development. Tampa, FL.

Indiana Department of Transportation (INDOT)
2013 *Indiana Design Manual*. INDOT. Indianapolis, IN

Indiana Department of Transportation (INDOT)
2018 *Access Management*. INDOT. Indianapolis, IN

Indiana Department of Transportation (INDOT)
2018 *Travel Information*. INDOT. Indianapolis, IN

Kentuckiana Regional Planning (KIPDA)
2018 *KIPDA Regional ITS Architecture*. KIPDA. Louisville, KY.

Kentuckiana Regional Planning (KIPDA)
2018 Transportation Planning Portal. KIPDA. Louisville, KY

Kentucky Transportation Cabinet (KYTC)
2018 *Congestion Toolbox*. KYTC. Frankfort, KY

Kentucky Transportation Cabinet (KYTC)
2018 *Go KY*. KYTC. Frankfort, KY

Kentucky Transportation Cabinet (KYTC)
2018 *Highway Design*. KYTC. Frankfort, KY

Kentucky Transportation Cabinet (KYTC)
2004 *Kentucky Model Access Management Ordinance*. KYTC. Frankfort, KY

National Academy of Sciences, Engineering, and Medicine
2010 *Guide for the Geometric Design of Driveways*, The National Academies Press. Washington, DC.

National Academy of Sciences, Engineering, and Medicine
2015 *Improving Freight System Performance in Metropolitan Areas: A Planning Guide*. The National Academies Press. Washington, DC.

National Academy of Sciences, Engineering, and Medicine
2010 *Roundabouts: An Informational Guide*. The National Academies Press. Washington, D.C.

National Association of City Transportation Officials (NACTO)
2007 *Curb Appeal: Curbside Management Strategies for Improving Transit Reliability*. NACTO. New York, NY

National Association of City Transportation Officials (NACTO)
2018 *Urban Street Design Guide: Lane Width*. NACTO. New York, NY.

National Association of City Transportation Officials (NACTO)
2018 *Urban Street Design Guide: Crosswalks and Crossings*. NACTO. New York, NY.

National Association of City Transportation Officials (NACTO)
2011 *A Policy on Geometric Design of Highways and Streets*. NACTO. New York, NY

Transit Authority of River City (TARC)
2015 *Transit Design Standards Manual: A Reference Guide*. TARC. Louisville, KY

Traffic Response and Incident Management Assisting the River City (TRIMARC)
2018 *Major Reports and Construction / Road Work Map*. TRIMARC. Louisville, KY

Traffic Response and Incident Management Assisting the River City (TRIMARC)
2018 *Notify Every Truck (NET)*. TRIMARC. Louisville, KY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Compressed Natural Gas Vehicle
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