# Synthesis of J-Turn Design Standards And Criteria

*December 2010*

***Final Draft Report***

MDOT
MISSISSIPPI DEPARTMENT OF TRANSPORTATION

ABMB 25
ENGINEERS, INC.

# Contents

# I. Abstract

Transportation professionals today are faced with the challenge to meet the mobility needs of an ever increasing population with limited resources. One potential treatment to mitigate congestion and safety problems at rural expressway intersections, while trying to avoid signalization or grade-separation, is the J-Turn intersection treatment, which has been successfully implemented in Michigan, Florida, Maryland, New Jersey, and Louisiana.

The treatment involves the prohibition of left-turn and through movements from the side-street approaches and accommodates them by requiring drivers to turn right onto the main road and then make a u-turn maneuver at a one-way directional median opening downstream. Left-turns from the main road approaches are executed in a manner similar to left-turns at a conventional intersection and are unaffected. Although this type of intersection treatment is typically considered a corridor-wide treatment, the concept has been successfully used at isolated intersections to improve traffic flow and enhance safety

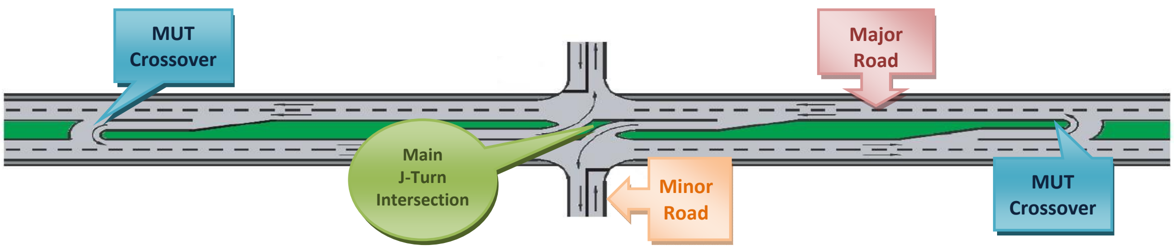
This synthesis presents design guideline recommendations for the implementation of J-Turn intersection treatments in Mississippi. Specific items addressed in this document include general design elements, cross-sectional elements, intersection and crossover design details, pedestrian accommodations, traffic control devices, lighting, signing, historical safety performance, construction costs and phasing, and public involvement efforts. The recommendations herein should be considered as minimums. The recommendations contained in this document cannot apply to all situations as every project is unique and typically require their own variations to site-specific conditions.

Many of the design elements recommended for the J-Turn intersection and MUT crossovers match the current MDOT practices for arterials. All references contained in this document refer to the 2001 edition of the *MDOT Roadway Design Manual,* which is currently undergoing a major revision. Therefore, the designer should verify that the most recent design criteria is being used prior to beginning a design.

# II. Summary of J-Turn Intersection Concept

A J-Turn intersection, shown in **Figure 1**, is a variant of the Restricted Crossing U-turn (RCUT) intersection in that both the main intersection and the two crossovers are unsignalized. The J-Turn intersection design is usually recommended for low volume divided expressways. It involves the elimination of direct left turns from an intersection's minor approach using a directional median (which allows direct left-turns from the major road, but prohibits minor road traffic from entering the median) with downstream median u-turn (MUT) crossovers. Although this type of intersection treatment is typically considered a corridor-wide treatment, the concept has been successfully used at isolated intersections to improve traffic flow and enhance safety. This type of intersection design is a conflict point management treatment that eliminates and controls intersection conflict points. The J-Turn intersection treatment should not be mixed with other indirect or direct left turn strategies on corridor level implementations.

**Figure 1 - Typical J-Turn Intersection**




The J-Turn intersection design concept has been successfully used in Michigan and other states for over four decades. The term "J-Turn" for this style of intersection was coined by the Maryland State Highway Administration (MSHA). This intersection design is also known by other names in other states such as the "Superstreet" intersection in North Carolina or the "Right-Turn U-Turn" (RTUT) intersection in Florida.

**If traffic signals are warranted at either the main intersection or the median u-turn (MUT) crossovers the J-Turn intersection design may not wholly apply and is not specifically addressed in this report.**

Advantages of the J-Turn intersection design include:

+ Allows the major arterials through traffic to proceed without stopping.
+ Eliminates the need for traffic signals that will not fit into existing time-space (progression) patterns along arterial roadways.
+ Reduces the number of conflict points when compared to conventional intersection designs.
+ Crashes occurring at the conflict points are expected to be less severe than at conflict points of conventional intersections.

Disadvantages of the J-Turn intersection design include:

- Possible driver confusion.
- May be perceived to adversely affect roadside business access.
- Combined median right-of-way and lane width requirements for loon construction can be required for u-turning vehicles.

Situations suitable for a J-Turn intersection:

- Relatively low to medium side-street through volumes and heavy left-turn volumes from the major road.
- The minor road total volume to total intersection volume ratio is typically less than or equal to 0.20.
- Areas where median widths are larger than 64 ft. Narrower medians will require additional design considerations for accommodating large u-turning vehicles (see **Section IV.A**).
- Intersections that experience a high number of far-side right-angle collisions.
- Intersections where minor road crossing traffic gap times are insufficient to complete the maneuver safely and cause multiple vehicles to stack into the median opening.

For intersections with very high left-turn and through volumes from the side road approaches, the J-Turn intersection design is not the optimum choice. The J-Turn intersection design better serves an intersection with more major road left turns than minor road through movements. The AASHTO publication *A policy on Geometric Design of Highways and Streets* (a.k.a. Green Book) currently discourages the use of a J-Turn type intersection on high-speed or high-volume highways due to “the difficulty of weaving and the long lengths involved” in the indirect minor road movements, unless “the volumes intercepted are light and the median is of adequate width.”

# III. Design Elements

A J-Turn expressway is basically a principal arterial with the indirect left-turn treatment implemented on a corridor basis. Therefore, many of the design elements recommended for the J-Turn intersection and MUT crossovers match the current MDOT practices for arterials. All references contained in this document refer to the 2001 edition of the *MDOT Roadway Design Manual,* which is currently undergoing a major revision. Therefore, the designer should verify that the most recent edition of the manual is being referenced.

## A. Design Speed

For J-Turn intersection and MUT crossover treatment designs on multi-lane rural arterials and collectors, **the recommended design speed is 65 mph**. This applies to both new construction and 3R projects. In urban areas the design speed varies widely and the designer should refer to the MDOT Roadway Design Manual for the appropriate design speed.

## B. Design Vehicle

The appropriate design vehicle should be determined by restrictions placed on the intersecting roadway. According to the current edition of the *MDOT Roadway Design Manual,* the minimum design vehicle for rural collectors and urban arterials is a WB-40 and for rural arterials is a WB-50. However, upcoming revisions to the design manual increase the size of the minimum design vehicle for rural arterials to a WB-62. Therefore, all J-Turn intersection and MUT crossover designs recommended in this document were developed using a WB-62 as the design vehicle. At locations with narrow median widths, the WB-62 may not be viable and the design vehicle selection should be based upon all relevant considerations for the specific site.

## C. Superelevation

For most situations where the J-Turn intersection treatment is implemented, the typical maximum superelevation rate is 10%. However, the designer should refer to the latest edition of the *MDOT Roadway Design Manual* for each specific location.

## D. Clear Zone

The roadside clear zone is the distance beyond the edge of traveled way that should be clear of any non-traversable hazards or fixed objects. The clear zone is variable and should be determined based on design speed, traffic volume and roadway classification as according to *MDOT Roadway Design Manual – Section 9-2.0.* **A clear zone distance of 30 ft is recommended** for practicality and to provide a consistent roadway template.

## E. Sight Distance

Sufficient sight distance should be provided at the J-Turn intersections as well as the MUT crossovers. The design of the J-Turn intersection must meet the intersection sight-distance requirements for an at-grade intersection as set forth in the *MDOT Roadway Design Manual*. MUT crossover designs must meet the stopping-sight distance requirements set forth for median openings in the MDOT Roadway Design Manual.

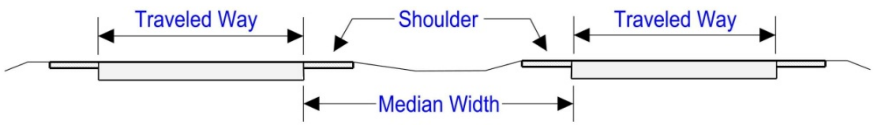
According to the *FDOT Median Handbook*, the sight distance for u-turns at unsignalized median openings for speeds of 60 mph should be no less than 1,540 ft.

# IV. Cross-Sectional Elements

## A. Median Widths

As illustrated in **Figure 2,** the median width should be measured between the inside edges of the two traveled ways of the opposing roadways. **Median widths greater than or equal to 64 ft are recommended** to accommodate large trucks and minimize shoulder encroachment when making u-turn maneuvers. In rural areas the typical MDOT median width is 101 ft and in urban areas is 64 ft.

**Figure 2 - Median Width Measurement**




Existing roadways with median widths of 64 ft or less will require additional design considerations to allow large trucks to execute u-turns at the MUT crossovers. Alternative median design treatments to accommodate u-turns by large trucks include:

- Allow vehicles to turn onto the existing or widened shoulder, which could have strengthened full-depth pavement.
- Add pavement outside the travel lane to allow the design vehicle to complete the u-turn maneuver and merge back into traffic stream (**Figure 3**). The added pavement is known as a *loon*.
- Widen the median, median "bulb-out", using reverse curves in the vicinity of the crossover to better accommodate u-turns (**Figure 4**).

The expected design vehicle u-turn lane destinations for common MDOT median widths are provided in **Table 1**. The possible u-turn lane destinations include the inside lane, outside lane, shoulder, or loon and are illustrated in **Figure 5**.

**Figure 3 - Loon Illustrations**

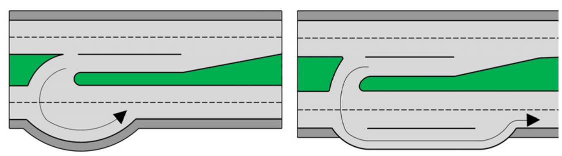


**Figure 4 - Median "Bulb-Out" Illustration**

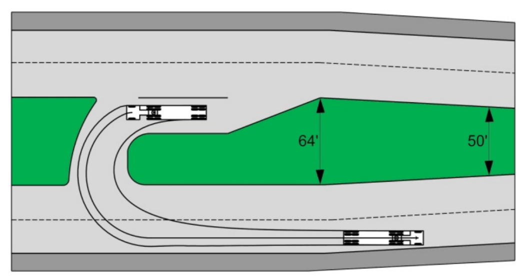
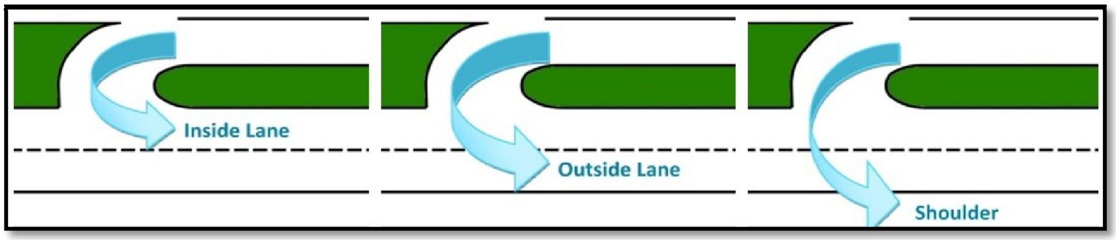



**Table 1 – Design Vehicle U-turn Lane Destinations by Median Widths**

| DESIGN VEHICLE (length, ft) | MEDIAN WIDTH 40' | 64' | 101' + |
|---|---|---|---|
| BUS (40') | Shoulder | Inside Lane | Inside Lane |
| WB-40 (40') | * | Outside Lane | Inside Lane |
| WB-50 (50') | * | Shoulder | Inside Lane |
| WB-62 (62') | * | Shoulder | Inside Lane |
| WB-67 (67') | * | Shoulder | Inside Lane |

* U-turn cannot be completed within usable roadway width.
*- 12 foot-wide lanes have been assumed. All turns begin from median u-turn lane.*
*- U-turn lane destinations shown on roadway without improvements.*

**Figure 5 – U-Turn Lane Destination Possibilities**




## B. Lane Widths

For both rural and urban areas, **it is recommended that the travel lanes and auxiliary lanes be 12 ft wide**. On existing roadways, auxiliary lane widths of 11 ft are acceptable if lane widening is not possible.

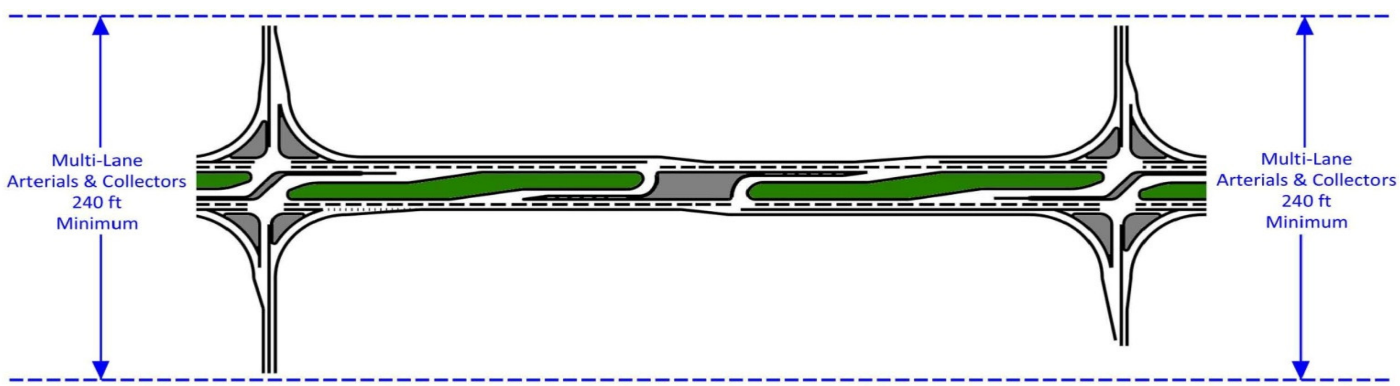
## C. Shoulder Widths

Shoulder widths are variable and should be determined based on traffic volume and roadway classification as according to the latest edition of the *MDOT Roadway Design Manual*. If the design includes loons at the MUT crossovers, a total outside shoulder width of 6 ft, with a minimum of 4 ft paved, is recommended in the vicinity of the loons.

## D. Right-of-Way

In accordance with the *MDOT Roadway Design Manual* for rural multi-lane arterials and collectors, **the recommended standard minimum right-of-way width is 240 ft** and is illustrated in **Figure 6**. In restrictive areas, it may not be possible to obtain the 240 ft right-of-way needed for the desired median width to accommodate u-turn maneuvers by large trucks. Some design alternatives for areas with restricted right-of-way are discussed in **Section IV.A** of this report.

**Figure 6 - J-Turn Intersection Right-of-Way Requirements**



# V. Intersection Design Elements

The recommended typical designs for the J-Turn intersection treatment with MUT crossovers are shown in **Figures 16 – 19** for commonly used MDOT median widths.

## A. J-Turn Intersection Design

The minor road approaches of the J-Turn intersection should be designed for all right turn movements since all through and left-turning vehicles are converted to right-turning vehicles. The J-Turn intersection has only one-way median openings for exclusive use of left-turning traffic from the main road. Turning radii treatments for J-Turn intersection designs should accommodate the design vehicles appropriate for the area type and functional classification of the intersecting roadways. Curbs should be mountable, Type 2, to allow emergency vehicles to cross the curb if required. The recommended geometric design details of the main J-Turn intersection for commonly used MDOT median widths are shown in **Figures 7 -10**.

**Figure 7 - Recommended J-Turn Intersection Design Detail for 40 ft Medians**

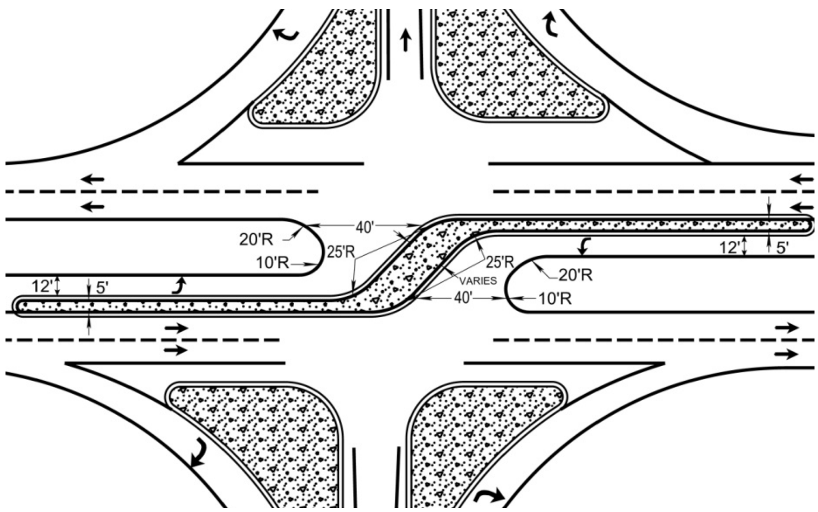



**Figure 8 - Recommended J-Turn Intersection Design Detail for 64 ft Medians**

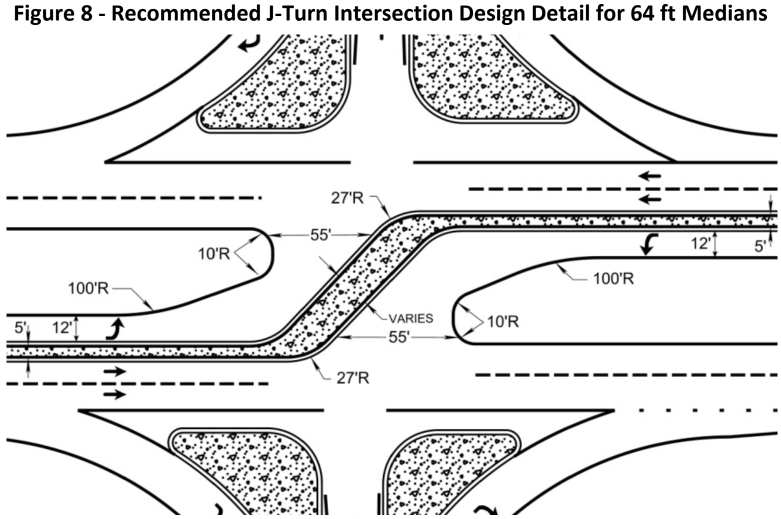


**Figure 9 - Recommended J-Turn Intersection Design Detail for 101 ft Medians**

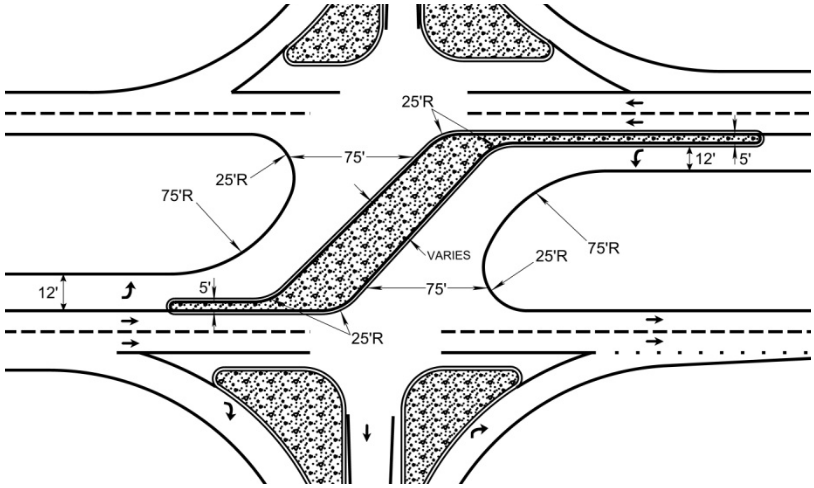
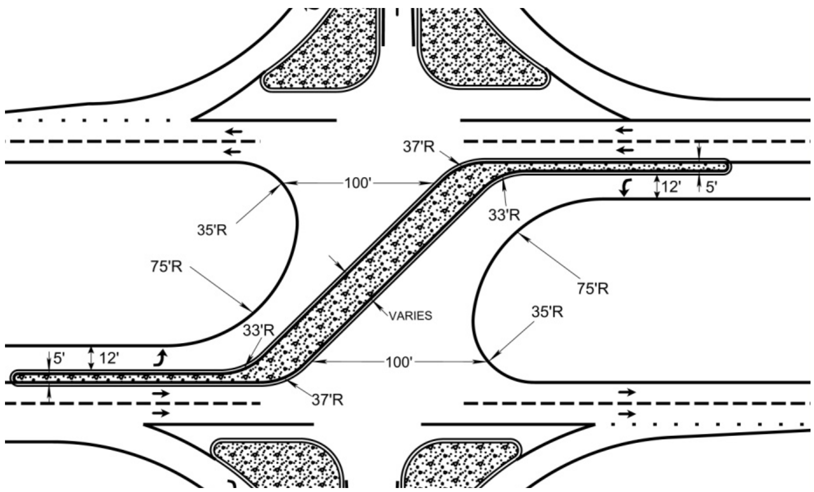



**Figure 10 - Recommended J-Turn Intersection Design Detail for 126 ft Medians**




## 1. Access Management

Driveways should not be allowed near the main intersection or on the opposite side of arterial from the MUT to reduce the chance of wrong-way movements in the MUT crossover and main J-Turn intersection.

## 2. Channelization and Boulevards

If the side roads are not of the boulevard or expressway type, **it is highly recommended that right-turn channels be installed for the minor road right-turn movements** to minimize wrong way maneuvers. If right-turn channels are included in the design, the distance to the MUT crossover may need to be increased.

## 3. Auxiliary Lanes

Auxiliary lanes should be provided at the main J-Turn intersection. The J-Turn intersection must be designed with exclusive right-turn lanes on the main roadway with sufficient length and width to accommodate the additional volume of right-turning vehicles (those that were the minor road through vehicles.) **It is recommended that the exclusive right-turn lanes on the main roadway are to be a minimum of 200 ft in length with a 150 ft taper if right-of-way allows. The exclusive left-turn lanes on the main roadway are**

**recommended to be a minimum of 250 ft with 150 ft taper.** For median widths less than 64 ft, a minimum taper length of 75 ft is acceptable if there is insufficient distance to accommodate a 150 ft taper as recommended. To accommodate the additional right-turning traffic from the minor road approach dual right-turn lanes are acceptable.

## B. Median U-turn Crossover (MUT) Design

J-Turn intersection design treatments include two unsignalized one-lane directional medians located upstream and downstream from the main J-Turn intersection. Locations where the median width is 64 ft or less, design modifications discussed in **Section IV.A** may be needed near the MUT crossovers to safely accommodate oversized vehicle u-turn maneuvers. Furthermore, if the traffic composition includes a high number of longer vehicles, such as logging trucks, then the design of any required loons should be done such that these trucks do not block each other's line-of-sight when entering the through lanes from a loon area. A loon width of 10 ft is recommended for designs on median widths of less than 64 ft. The recommended geometric design details of the MUT crossovers for commonly used MDOT median widths are shown in **Figures 11 – 14.**

**Figure 11 – Recommended MUT Crossover Design Detail for 40 ft Medians**

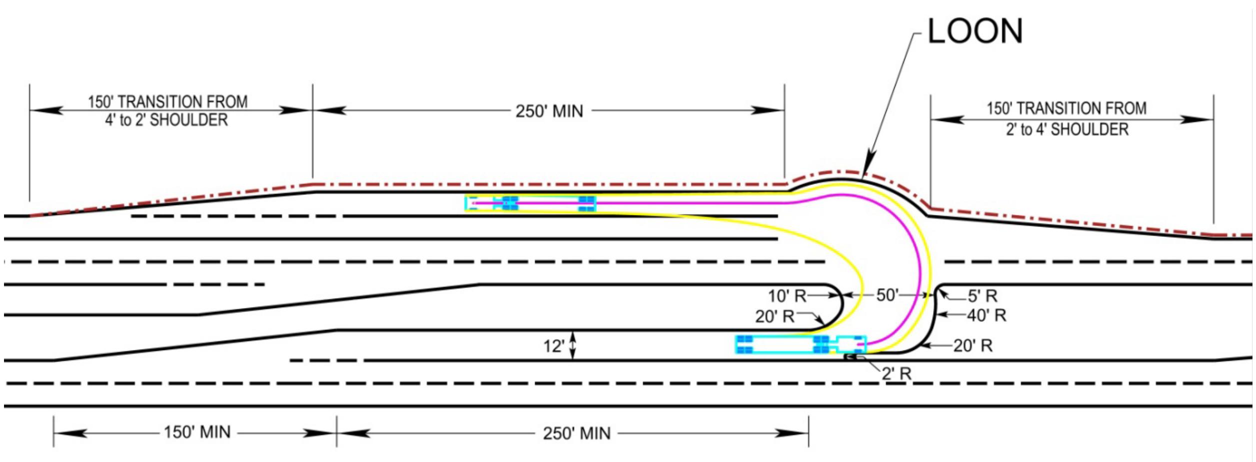



**Figure 12 - Recommended MUT Crossover Design Detail for 64 ft Medians**

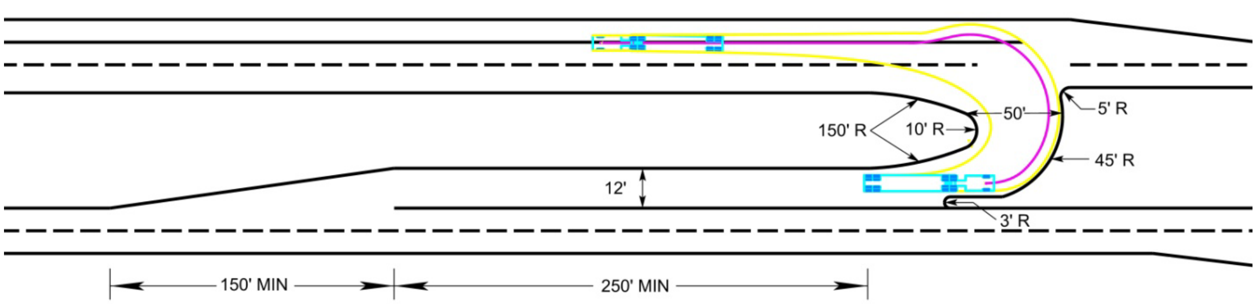


**Figure 13 - Recommended MUT Crossover Design Detail for 101 ft Medians**

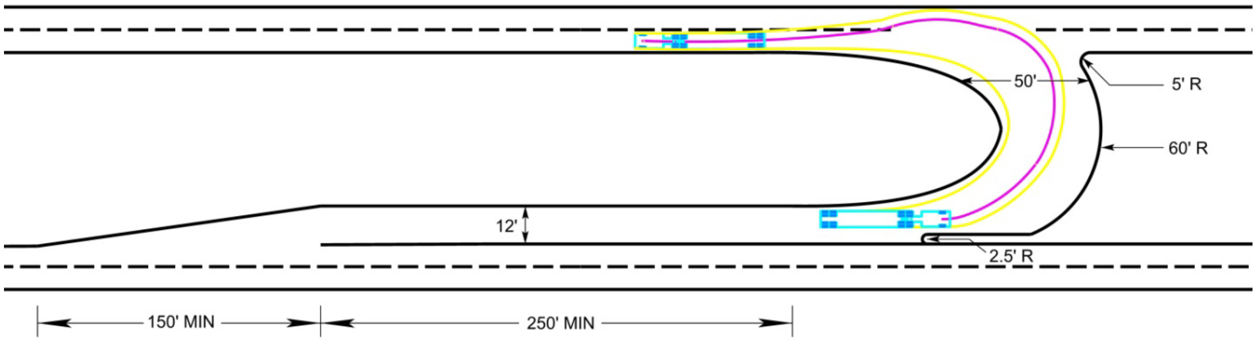
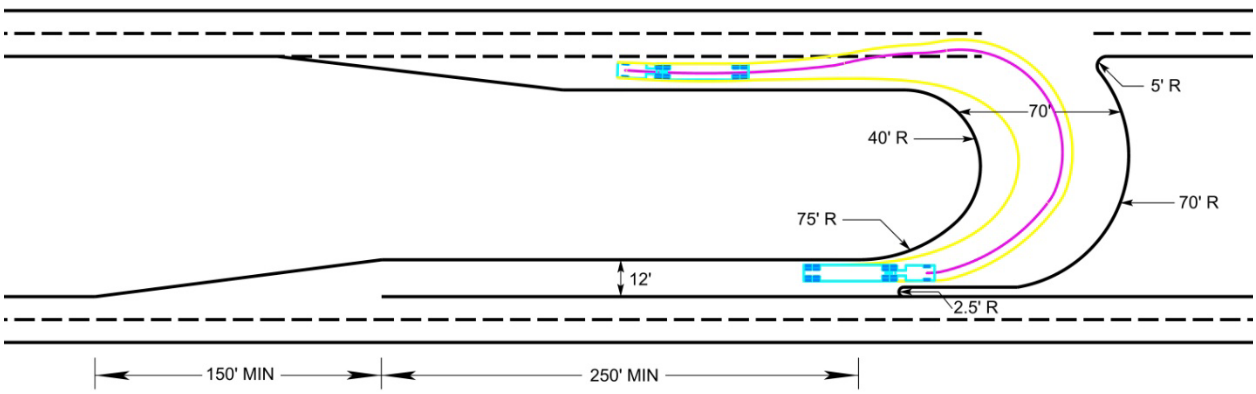



**Figure 14 - Recommended MUT Crossover Design Detail for 126 ft Medians**




Typically, a common profile grade line is used for both roadways of divided highways where the median width is 64 ft or less. For median widths in excess of 64 ft, independent profile grade lines may be desireable because of the natural terrain. However, an appreciable grade differential between the divided roadways should be avoided at the MUT crossovers as well as at the J-Turn intersection. Traffic entering from the crossroad may make a wrong-way maneuver if the pavement of the far roadway is obscured because of grade differential. In general, the grade of the crossover connections should not exceed 6%. **Table 2** provides the maximum elevation differential between adjacent roadways for various horizontal distances between centerlines. Typical gap acceptance times for a conventional intersection design are provided in **Table 3.**

**Table 2 - Maximum Elevation Differential Between Adjacent Roadways**

| Horizontal Distance ℄ to ℄ (ft) | Maximum Profile Grade Differential With Crossover (ft) |
|---|---|
| 64 | 1.0 |
| 88 | 2.0 |
| 125 | 4.2 |
| 150 | 5.7 |
| 200 | 8.7 |
| 250 | 11.7 |

*Source: MDOT Roadway Design Manual*

**Table 3 - Typical Gap Acceptance Times for Conventional Intersections (seconds)**

| | 2-Lane Facility Gap Times | | | 4-Lane Facility Gap Times | | |
|---|---|---|---|---|---|---|
| | Passenger Car | Single-Unit Truck | Tractor/Semi-Trailer | Passenger Car | Single-Unit Truck | Tractor/Semi-Trailer |
| Left-Turn from Minor Road | 7.5 | 9.5 | 11.5 | 8.0 | 10.2 | 12.2 |
| Right-Turn from Minor Road | 7.5 | 9.5 | 11.5 | 7.5 | 9.5 | 11.5 |
| Crossing | 6.5 | 8.5 | 10.5 | 7.5 | 9.9 | 11.9 |
| Left-Turn from Major Road | 5.5 | 6.5 | 7.5 | 6.0 | 7.2 | 8.2 |

## 1. Crossover Spacing

MDOT *Roadway Design Manual* policy regarding median opening spacing states that median openings should be no closer than 880 ft apart in urban areas and 1,760 ft in rural areas. Based on existing information, utilizing existing median spacing required by MDOT design standards should be adequate and provide a safe distance for acceleration, weaving, and deceleration movements. However, access should never be allowed at MUT crossover locations, **therefore utilizing existing 880 ft (urban spacing) and 1760 ft (rural spacing) can be allowed if no access right-of-way can be provided adjacent to the MUT crossovers and other site conditions allow**. Generally, no access limits are preferred within 100 ft of the centerline of MUT crossovers. If the existing median openings are not suitable for conversion to MUT crossovers, **then new MUT crossover sites should be constructed no less than 800 ft and no more than 1,320 ft from the centerline of the J-Turn intersection.**

***Recommended MUT Crossover Spacing Requirements:***

**MIN = 800 ft**
**MAX = 1,320 ft**

*Based on existing MDOT design criteria and historical highway construction by MDOT.*

Several factors should be considered when selecting the appropriate spacing from the main J-Turn intersection to the two MUT crossovers. Longer spacing between the J-Turn intersection and MUT crossovers decrease spillback probabilities, providing more time and space for drivers to maneuver into the proper lane and react to highway signs. Shorter spacing between the J-Turn intersection and MUT crossovers translates into shorter weaving distances and travel times. Typical MUT crossover spacing requirements set forth by other agencies ranged from 560 ft to 1,320 ft and are provided in **Table 4**. Currently, criteria for a minimum weaving length for this treatment do not exist. The Type C weaving maneuver, as described in the *2000 Highway Capacity Manual*, is most closely compared to the weaving maneuver of a right-turn followed by a u-turn and may be applicable.

**Table 4 - Other Agencies MUT Crossover Spacing Requirements**

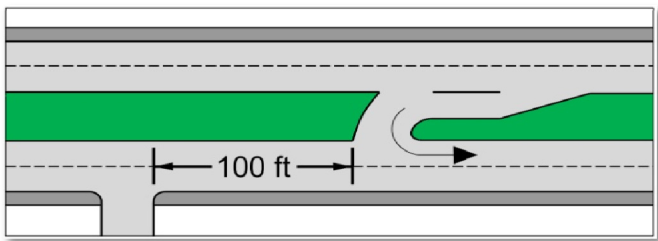
| | Minimum | Maximum |
|---|---|---|
| AASHTO* | 400 ft | 600 ft |
| TRB Access Management Manual | 660 ft | 1,320 ft |
| North Carolina | 800 ft | 1,000 ft |
| Michigan | 560 ft | 760 ft |
| Oregon | 990 ft | 1,320 ft |
| Missouri** | 600 ft | 1,000 ft |

** Based on signalized intersection treatment*
*** Specific location to be determined via capacity analysis*

## 2. Access Management

When selecting a MUT crossover location for the J-Turn intersection design, the highway access type must be considered. The MUT crossover should be designed and built for single-direction u-turns only. At crossovers where u-turns are permitted at the same time as right-turns from a driveway, the potential for conflicts exists and should be considered. **Allowing roadway access near an existing median crossover is undesirable because of the increase in the number of conflict points.** If the desired location of the MUT crossover is located at an existing median opening of Type 2B or Type 3, access rights purchase should be considered to avoid potential access adjacent to the MUT crossover. **Reconfiguration of an existing median crossing should be designed to provide single-direction u-turns only**. Driveway access should be located a minimum of 100 feet away from the MUT crossovers, as illustrated in **Figure 15,** to discourage wrong way maneuvers and minimize conflicts.

**Figure 15 – Minimum Driveway Spacing Near MUT Crossovers**




## 3. Auxiliary Lanes

Auxiliary lanes should be provided at both of the MUT crossovers located downstream from the main J-Turn intersection. The MUT crossovers must be designed with exclusive deceleration/storage lanes on the main roadway with sufficient length and width to accommodate the expected volume of u-turning vehicles. **It is recommended that the exclusive u-turn/left-turn lanes at the MUT crossovers be a minimum of 250 ft in length with a 150 ft taper.** One-lane or two-lane crossovers for u-turns may be needed depending on traffic volume demands and the number of receiving lanes. ***However, if two-lane crossovers are used it is recommended that the crossover be signalized and therefore the J-Turn intersection design set forth in this report may not wholly apply.***

To better accommodate trucks and older drivers, acceleration lanes are recommended at the MUT crossover locations to provide traffic with the opportunity to enter the travel lanes at or near the speed of through traffic. The minimum acceleration lane length should be based on *MDOT Roadway Design Manual* requirements. **For situations where auxiliary lanes serving the J-Turn intersection are located downstream from a loon at a distance of 150 ft or less, it is recommended that an auxiliary lane be constructed to connect the loon and existing auxiliary lane.**

For median widths less than 64 ft, a minimum taper length of 75 ft is acceptable if there is insufficient distance to accommodate a 150 ft taper as recommended.

**Figure 16 - 40 ft Median Intersection Design**

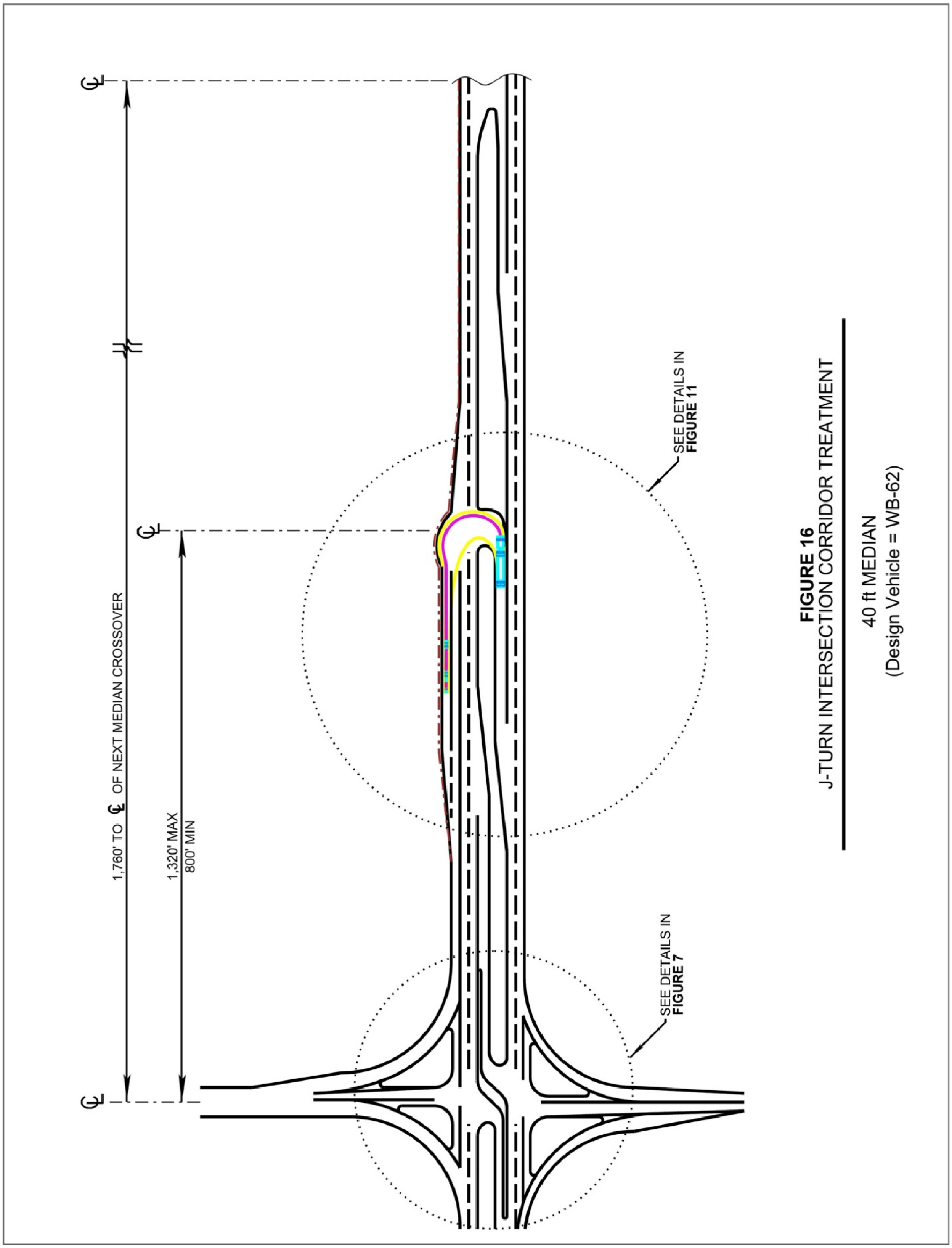


**Figure 17 - 64 ft Median Intersection Design**

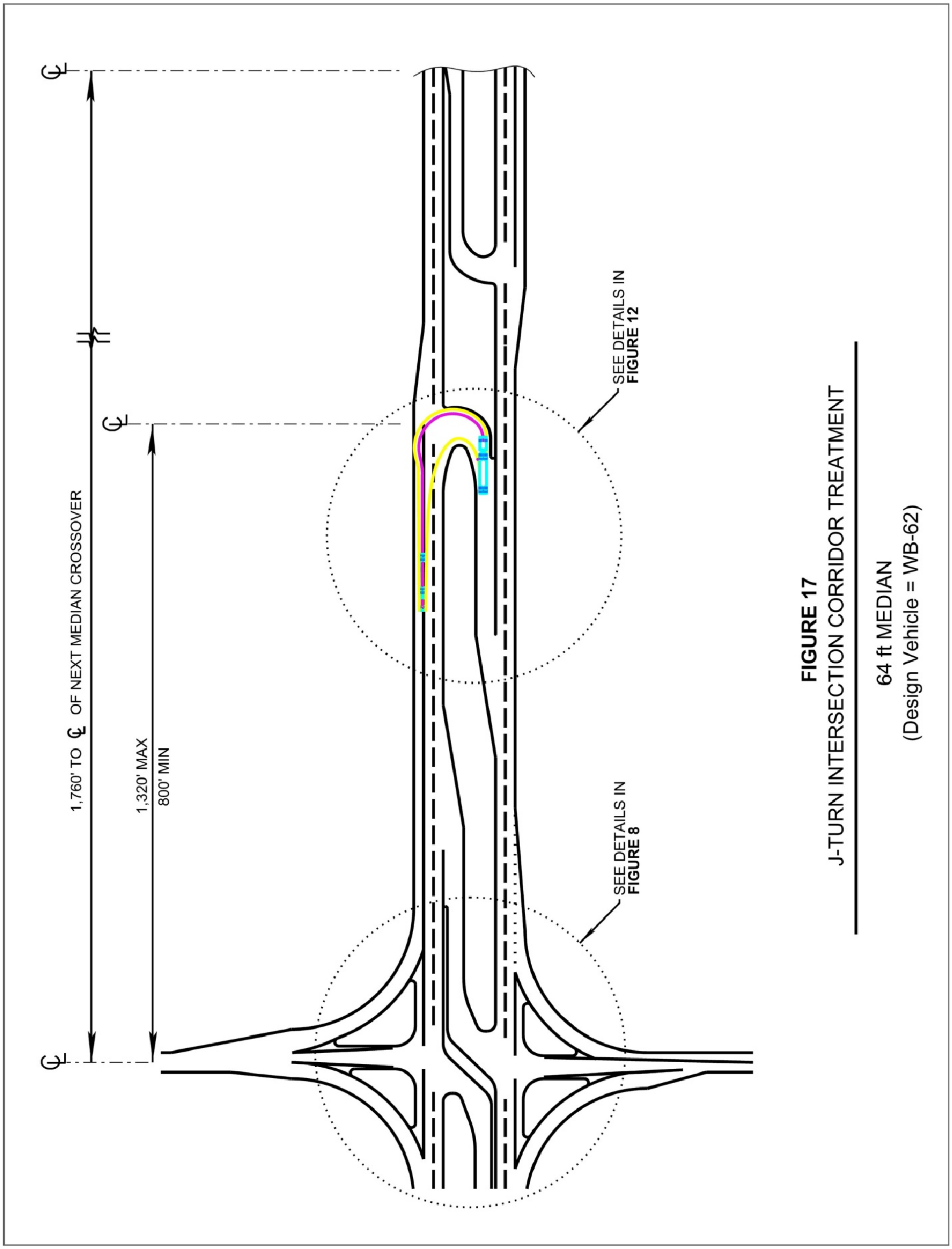


**Figure 18 - 101 ft Median Intersection Design**

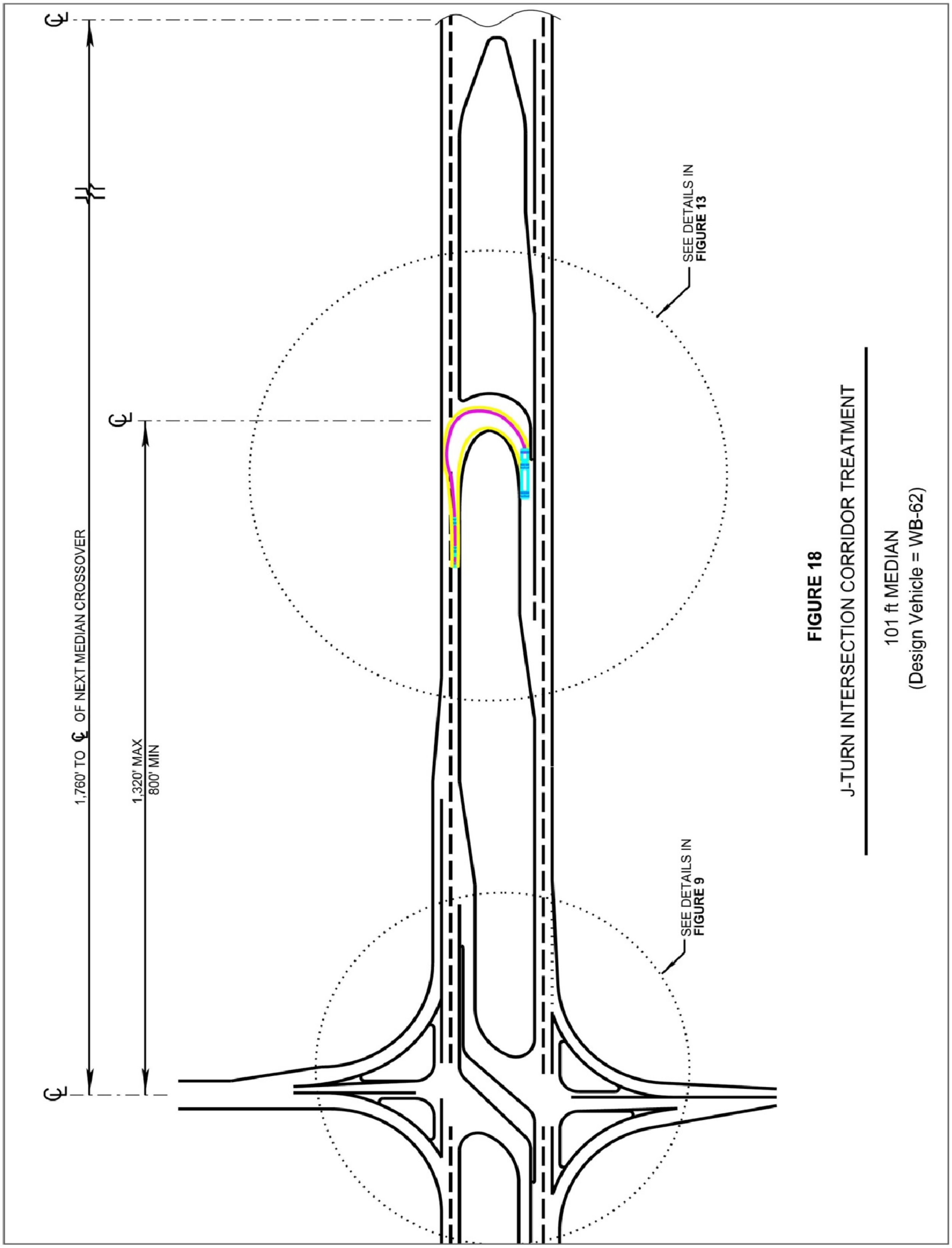
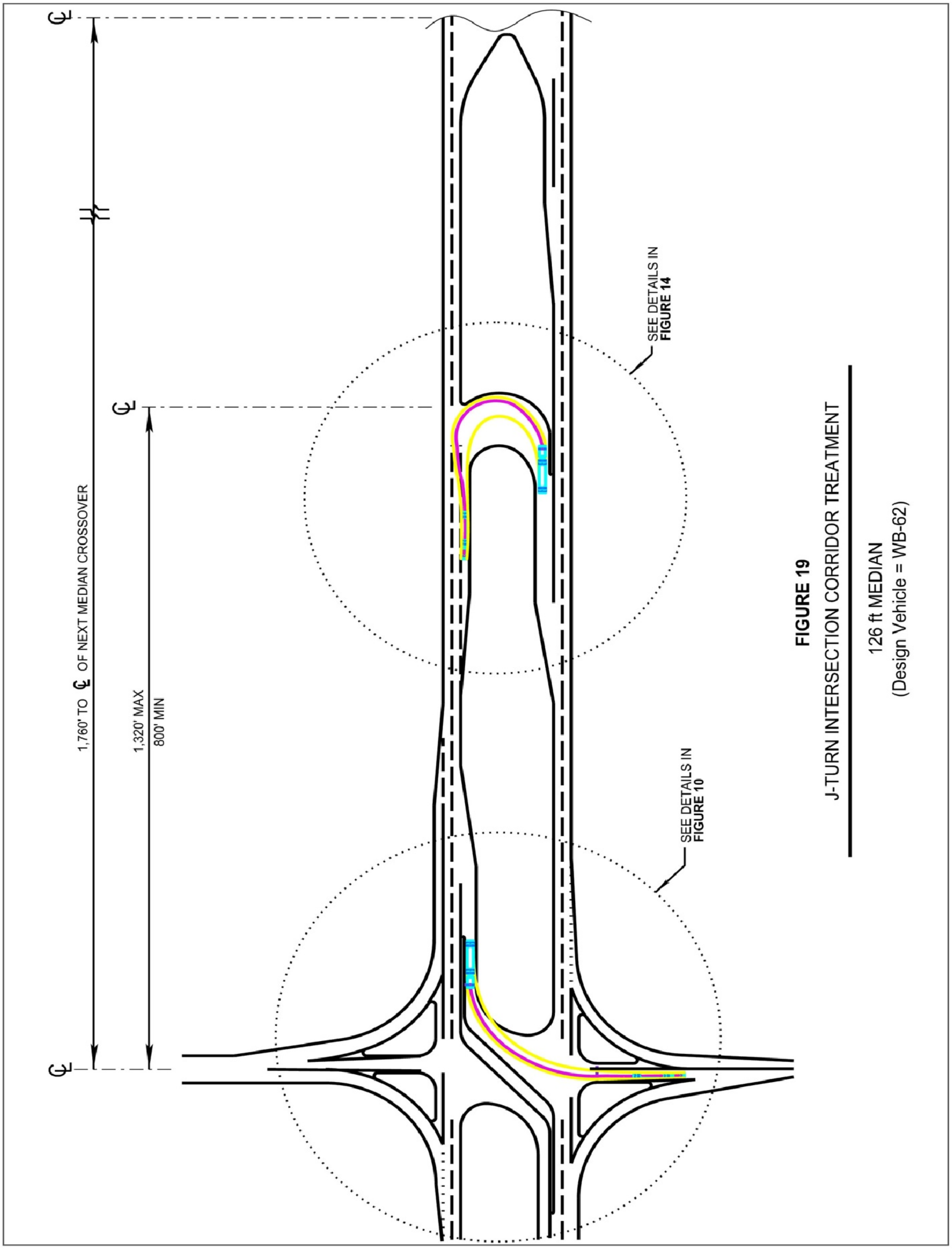


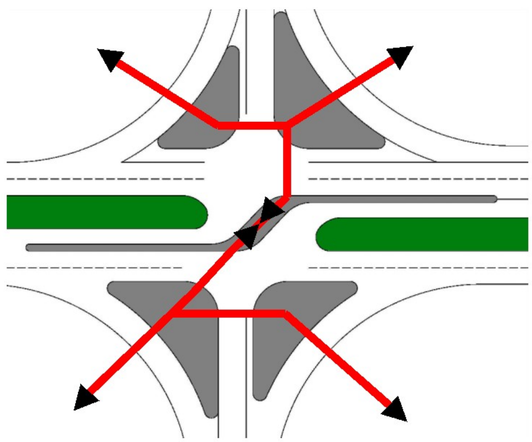
**Figure 19 - 126 ft Median Intersection Design**



# VI. Pedestrian and Bicyclist Accommodations

**Pedestrian crossings at a J-Turn intersection are discouraged** due to the unsignalized complex crossing maneuvers required to traverse the intersection. The complex maneuvers required for pedestrians to cross a J-Turn intersection are shown in **Figure 20**. Should pedestrians be expected, the J-Turn intersection design may need to be modified to better accommodate them. The J-Turn intersection design may be modified such that the pedestrian crossing distances are shorter. Reducing the pedestrian crossing distance may be achieved by the elimination of right-turn lanes and/or channels, and using the tightest turning radii.

**Figure 20 - Typical RCUT Pedestrian Crossings**



Bicyclists desiring to make left turns from the side road face a choice of using pedestrian crosswalks to cross the major road and then the far side road or using the MUT crossovers in a manner similar to drivers of motor vehicles. Bicyclists on the major road approaches who want to turn left onto the side road are faced with a similar decision. They can use the pedestrian crosswalks to cross the side road leg and then the far major road leg. It is recommended agencies design the intersection to accommodate most left-turning bicyclists using the crosswalks. In urban areas, curb-cuts with ADA compliant ramps are recommended even if pedestrian crosswalks are not installed so they may be utilized by bicyclists who choose to walk across the intersection pushing their bicycle.

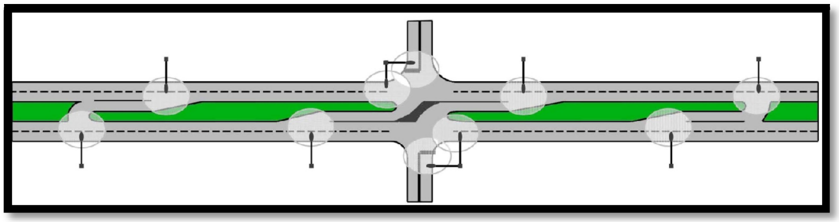
# VII. Signals

For existing J-Turn intersections or MUT crossovers, traffic signal warrants contained in the MUTCD should be used in deciding whether or not to install a traffic signal. In this case, the higher major street left-turn volume or median u-turn volume can be treated as the minor street higher volume approach. **If either the J-Turn intersection or MUT crossovers warrant a traffic signal, then RCUT intersection design criteria should be evaluated.** RCUT intersection design criteria can be found in the FHWA publication *FHWA-HRT-09-060, Alternative Intersections/Interchanges: Informational Report (AIIR).*

## VIII. Lighting

Since the J-Turn intersection design involves a relatively complex maneuver for left-turning vehicles, there may sometimes be the need to provide lighting at the J-Turn intersection and MUT crossovers. Particular consideration should be given to rural intersections where there may be a substantial need to enhance the visibility of drivers. Individual sites should be evaluated for lighting needs using guidelines such as the *NCHRP Report 152 – "Warrants for Highway Lighting"*. An example J-Turn corridor lighting treatment is illustrated in **Figure 21**.

**Figure 21 – Typical Lighting for J-Turn Intersection and MUT Crossovers**



## IX. Signing

Signing at a J-Turn intersection and MUT crossovers is critical because the design may not meet the expectations of left-turning drivers unfamiliar with the intersection or intersection type. Therefore, a J-Turn intersection may require additional signing compared to a conventional intersection design. Positive guidance communicated through additional signs and pavement markings may be beneficial in reducing driver confusion and ensuring higher rates of driver compliance. The recommended MUT crossover signing is shown in **Figure 22** and the recommended J-Turn intersection signing is shown in **Figure 23**.

**It is recommended that parking be proactively prohibited in and near loons.** If loons or "bulb-outs" are included in the design, parking in those areas must be proactively prohibited through the use of regulatory signs such as R7-1 "No Parking Any Time".

Customized guide signs are recommended for inclusion in the J-Turn intersection and MUT crossover signing plans.

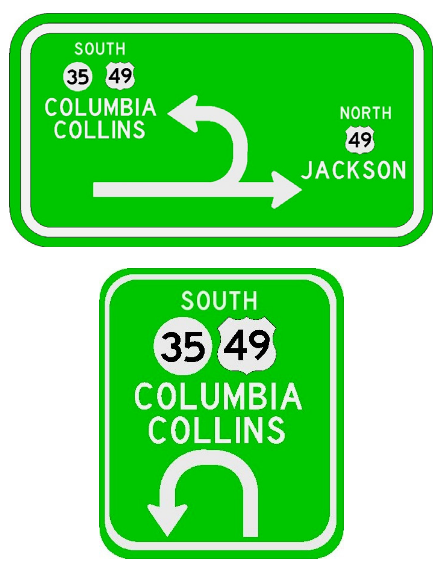


**Figure 22 - Recommended MUT Crossover Signing Treatment**

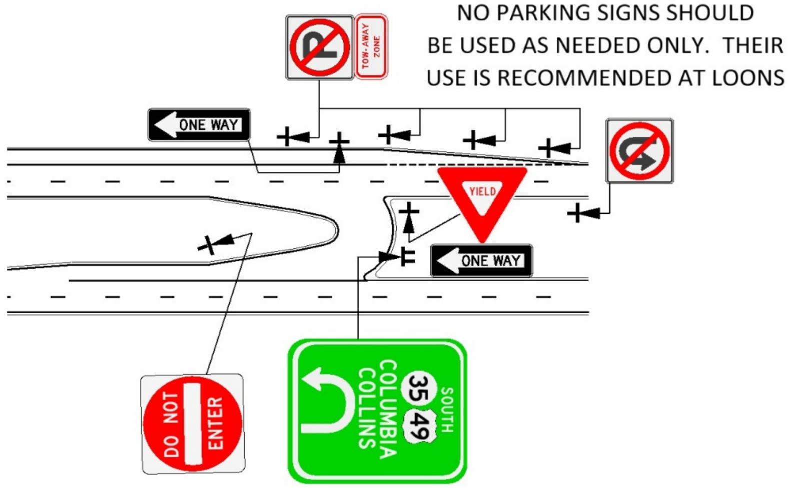
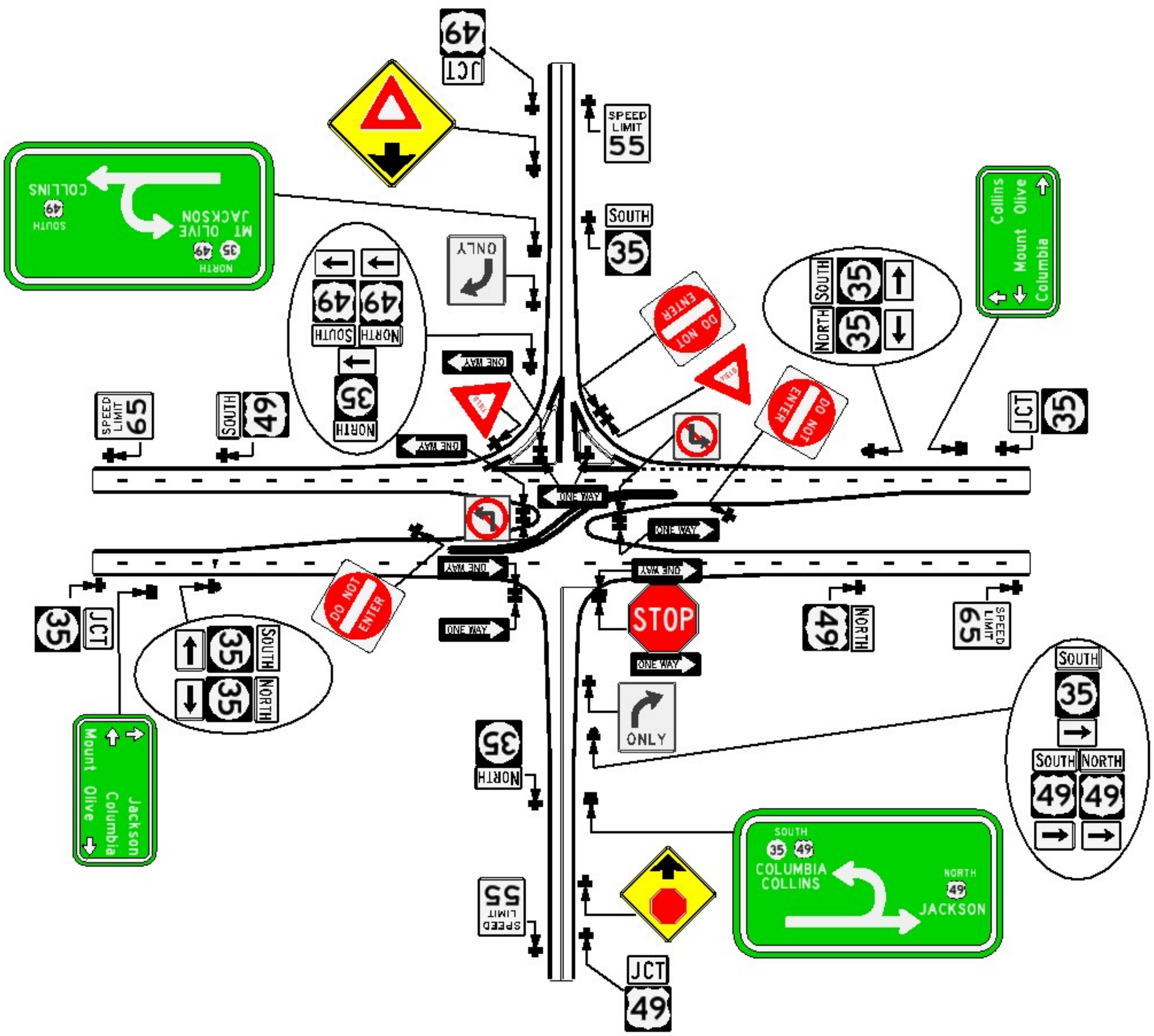



**Figure 23 – Recommended J-Turn Intersection Signing Treatment**

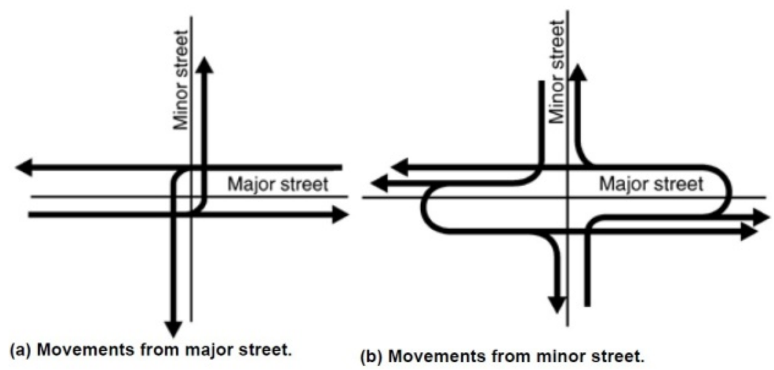


# X. Safety Performance

## A. Conflict Points Comparison

The assumed safety benefit of J-Turn intersections is that they reduce the potential for right-angle collisions (particularly far-side right-angle collisions) by eliminating direct crossing and left-turn maneuvers from the minor roads at two-way stop controlled (TWSC) expressway intersections. Minor road traffic wishing to turn left or cross straight through the intersection is forced to make these maneuvers indirectly by turning right, weaving to the left, making a downstream u-turn, and then returning to the intersection to complete their desired maneuver (illustrated in **Figure 24**). However, J-Turn intersections may potentially lead to an increase in rear-end and sideswipe collisions related to weaving maneuvers and u-turns when compared to a typical TWSC intersection.

**Figure 24 - J-Turn Intersection Vehicle Maneuvers** (FHWA)




There is no suggestion that u-turns at unsignalized median openings exhibit increased crash potential; therefore, the J-Turn intersection design replaces the high risk, far-side conflict points associated with direct minor road left-turns and crossing maneuvers with less risky conflict points associated with right-turns, u-turns, and weaving maneuvers. Not only are the total number of conflict points reduced, but more importantly the J-Turn intersection eliminates 14 crossing path conflict points present at a TWSC intersection, greatly reducing the opportunity for right-angle collisions. The J-Turn intersection design exhibits 20 conflict points compared to 32 at a TWSC intersection. **Figure 25** shows a conflict-point diagram for a conventional TWSC intersection and **Figure 26** shows a conflict-point diagram for a J-Turn intersection.

**Figure 25 - Conflict-Point Diagram for Conventional Intersection** (FHWA)

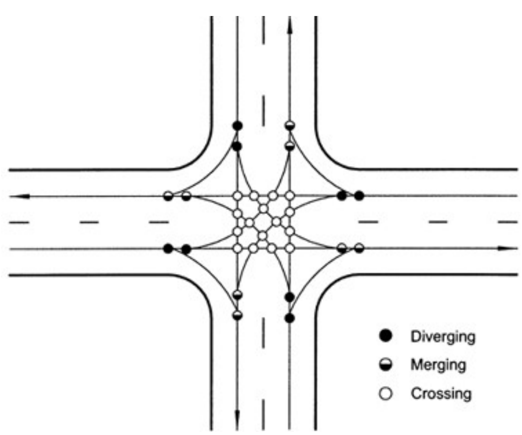
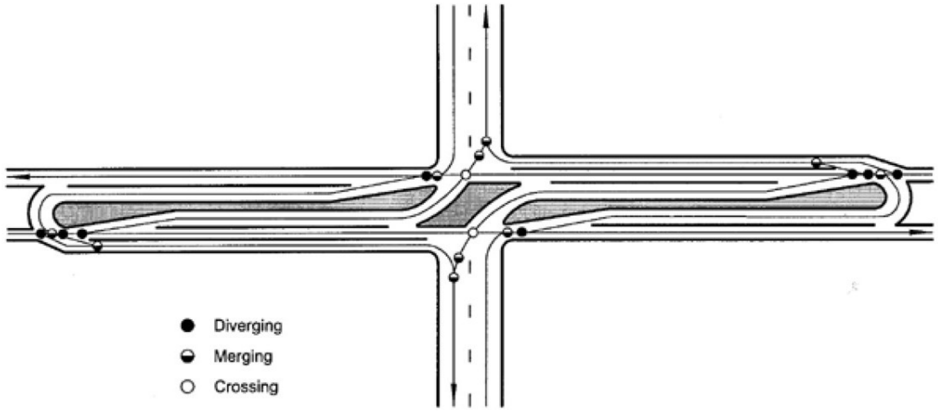


**Figure 26 - Conflict-point Diagram for J-Turn Intersection** (FHWA)




## B. Crash Risk

All movements through a typical TWSC expressway intersection do not have the same crash risk. The highest risk movements (i.e., those accounting for the largest share of severe crashes) tend to be minor road maneuvers across the far-side of the intersection (i.e., left-turn and crossing maneuvers from the minor roadway). Thus, elimination of these maneuvers and their associated conflict points can be an effective means of improving expressway intersection safety. *NCHRP Report 420* reports an estimated 20% reduction in accident rates by replacing direct left-turns from driveways with right-turn/u-turn treatments. **Table 5** provides the accident rate per million turning vehicles for both full and directional median openings.

**Table 5 - Median Accident Rate per Million Turning Vehicles**

| Median Opening Type | Accident Rate (per $10^6$ turning vehicles) |
|---|---|
| Directional Midblock | 0.29 |
| Directional 3-Leg | 1.40 |
| Directional 4-Leg | 2.57 |
| Full 3-Leg | 2.69 |
| Full 4-Leg | 3.01 |

*Source: NCHRP Report 524*

## C. Case Studies

The NCDOT Safety Evaluation Group performed *Spot Safety Studies* at various locations where conventional intersections and/or median crossovers were converted to J-Turn intersections and MUTs. The purpose of the study was to determine what effect the modifications had on the collision patterns at the subject intersection over a three year period. The study sites are listed below and a summary of the before and after collision results are provided in **Table 6** and **Table 7.**

- US 23/74 @ NC 1155 – Haywood County, North Carolina
- US 23/74 @ NC 1243/1158 – Haywood County, North Carolina
- US 29-70/I-85 Business @ SR 1774 – Davidson County, North Carolina
- US 74 Bypass @ US 74 Service Rd. (near NC 226) – Cleveland County, North Carolina

- US 70 @ SR 1731 (Piney Grove Rd.) – Wayne County, North Carolina

**Table 6 – Case Studies Collision Summary by Type**

| | BEFORE J-Turn | AFTER J-Turn | % CHANGE |
|---|---|---|---|
| **Rear End** | 13 | 8 | -38% |
| **Angle** | 47 | 0 | -100% |
| **Turning** | 32 | 10 | -69% |
| **Sideswipe** | 8 | 3 | -63% |
| **TOTAL** | **100** | **21** | **-79%** |

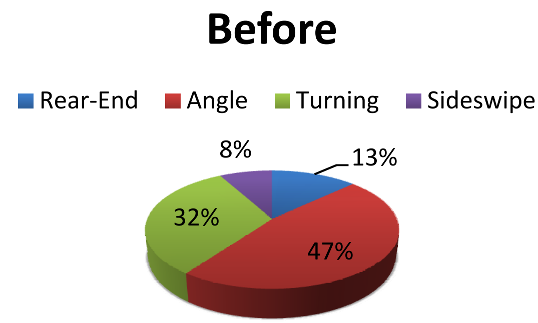
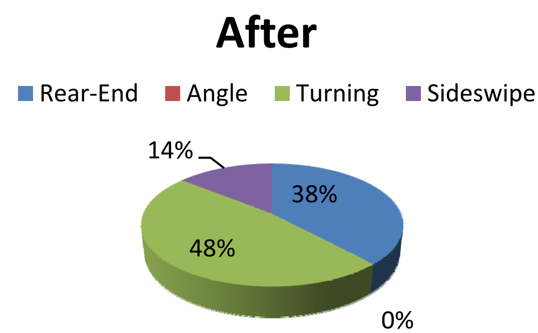



**Table 7 – Case Studies Collision Summary by Severity**

| | BEFORE J-Turn | AFTER J-Turn | % CHANGE |
|---|---|---|---|
| **Injury** | 56 | 10 | -82% |
| **Fatality** | 2 | 1 | -50 % |




***In order to track the results of J-Turn intersection treatments, it is recommended that post-implementation safety studies be performed and shared with other transportation agencies. A minimum 3-year post-implementation period for crash analysis is recommended.***

# XI. Project Budget Considerations

Mobilization, overhead lighting, pavement markings, grading and drainage costs were not significantly different between the J-Turn intersection design and a conventional intersection design. In most cases no special grading or features such as retaining walls are needed.

Additional utility relocations and right-of-way acquisitions may increase the cost of a J-Turn intersection to a slightly higher level than a conventional intersection. Additional pavement width or reinforced shoulders are common in J-Turn intersection designs and extra funds for those elements should be budgeted.

Additional permanent roadway signing is frequently required at a J-Turn intersection than at a conventional intersection. Additional regulatory signing and guide signs for the traffic using the crossovers for left-turn maneuvers can create substantial additional cost. Additional temporary signing and variable message signs may be desirable during the construction phase and initial period of operation to provide additional clarification to unfamiliar drives. Public involvement and media costs associated with driver education can also be a significant component of the project budget and should not be overlooked.

# XII. Construction Phasing

Maintenance of traffic during the construction of a J-Turn intersection is similar to that of conventional intersections, and other impacts such as to emergency vehicles, buses, and bicyclists are not likely to be major issues. The recommended stages of construction are as follows:

Phase #1 – Construction of elements necessary for the design vehicle to execute median u-turns.

1 A: Perform work along the outside of the outermost through lanes. This could include:
- Shoulder widening;
- Pavement structure reinforcement or reconstruction;
- Loon construction; and
- Right-turn lane construction (also used as a loon).

1B: Construct median deceleration lanes and u-turn crossovers.

Phase #2 – Construction at the main intersection to prohibit left turns from the minor roadway.

2A: Construction of channelization on the minor roadway that forces all traffic approaching from the minor roadway to turn right.

2B: Construction of median channelization that will ultimately prohibit turns from the minor road approaches but will allow left turns from the main roadway onto the minor roadway.

While the median channelization is under construction the median should be temporarily closed to all traffic. Any traffic desiring to access the minor roadway will be detoured straight through the intersection and then execute a u-turn at the downstream MUT crossover that was constructed under Phase #1.

Phase #3 – Final surface course pavement will be installed. Permanent striping and signing will be installed. Median will be reopened allowing left-turns form the main roadway onto the minor roadway.

# XIII. Public Involvement

The potential for confusion with the J-Turn intersection concept exists for any driver who is unfamiliar with the concept or any geographical area that has never been exposed to the concept. A public information campaign that is designed by a team of transportation and media professionals is recommended if it is believed that confusion may occur with the J-Turn intersection implementation. The media campaign should be implemented with sufficient time to educate the public about the design concept and to prepare for a successful opening of the new intersection.

As with any change in traffic operations, driver confusion and acceptance is a concern. The design of a media campaign should be done in coincidence with the roadway design efforts. The execution of the media campaign may need to begin prior to roadway construction activities. That decision may be driven by the estimated construction time and may also depend on construction phasing needed for the specific project. Previous experiences with J-Turn intersection installations in Maryland and at RCUT intersection installations in North Carolina indicate that drivers adapt well to the J-Turn intersection design.

It is sometimes difficult to illustrate unfamiliar traffic operation concepts to the public using traditional drawings and written or verbal descriptions. The implementation of a microsimulation model may be worthwhile for achieving clear public understanding.

Microsimulation modeling software is a tool that is now commonly used to graphically illustrated concepts. The conceptual and operational illustration of a J-Turn intersection design and may be considered useful in any J-Turn media campaign.

A typical J-Turn intersection microsimulation model can be developed and used over and over in media campaigns and public involvement meetings to provide clear illustrations of the J-Turn concept at most any proposed location.

# XIV. Summary of Recommendations

*Situations most suitable for the J-Turn Intersection treatment:*

- Low volume divided expressways.
- Low to medium side-street through volumes and heavy left-turn volumes from the major road.
- Minor road total volume to total intersection volume ratio is typically less than or equal to 0.20.
- Median widths are 64 ft and larger.
- High number of far-side right-angle collisions.
- Minor road crossing traffic gap times are insufficient.
- Intersections with more major road left-turns than minor road through movements.

*Design Elements:*

- All references contained in this document refer to the 2001 edition of the *MDOT Roadway Design Manual*, which is currently undergoing a major revision. Therefore, the designer should verify that the most recent edition is being used.
- 65 mph design speed for multi-lane arterials and collectors.
- WB-62 design vehicle.
- Typical maximum superelevation rate of 10%.
- 30 ft clear zone.
- J-Turn intersection design must meet the intersection sight-distance requirements for an at-grade intersection as set forth in the *MDOT Roadway Design Manual*.
- MUT crossover design must meet the stopping-sight distance requirements set forth for median openings in the *MDOT Roadway Design Manual*.

*Cross-Sectional Elements:*

- Median widths should be greater than 64 ft.
- For median widths of 64 ft and less, additional design considerations such as shoulders with strengthened full-depth pavement or loons are needed.
- 12 ft travel lanes and auxiliary lanes.
- Shoulder widths are variable and should be determined according to the *MDOT Roadway Design Manual*.
- If loons are included in the design, the total outside shoulder width should be 6 ft, with a minimum of 4 ft paved in the vicinity of the loons.
- Right-of-way width should be a minimum of 240 ft.

*J-Turn Intersection Design Elements:*

- Turning radii treatments should accommodate the design vehicles appropriate for the area type and functional classification of the intersecting roadways.
- Curbs should be mountable, Type 2, to allow emergency vehicles to cross the curb if required.
- Driveways should not be allowed near the J-Turn intersection.

- If the side roads are not of the boulevard or expressway type, right-turn channels should be installed to minimize wrong way maneuvers. If right-turn channels are included in the design, the distance to the MUT crossover may need to be increased.
- Design must include exclusive right-turn lanes on the main roadway, at least 200 ft in length with a 150 ft taper.
- Design must include exclusive left-turn lanes on the main roadway, at least 250 ft in length with a 150 ft taper.
- Dual right-turn lanes are acceptable.
- In areas where the median width is less than 64 ft, a minimum taper length of 75 ft is acceptable.
- Appreciable grade differential between the divided roadways should be avoided.

*MUT Crossover Design Elements:*

- Turning radii treatments should accommodate the design vehicles appropriate for the area type and functional classification of the intersecting roadways.
- Driveways should not be allowed near or on the opposite side of arterial from the crossovers.
- Appreciable grade differential between the divided roadways should be avoided.
- Grade of the crossover connections should not exceed 6%.
- Utilizing existing 880 ft (urban spacing) and 1760 ft (rural spacing) can be allowed if no access right-of-way can be provided adjacent to the MUT crossovers and other site conditions allow.
- New MUT crossover sites should be constructed no less than 800 ft and no more than 1,320 ft from the centerline of the J-Turn intersection.
- If the desired location of the MUT crossover is located at an existing median opening of Type 2B or Type 3, access rights purchase should be considered.
- Reconfiguration of an existing median crossing should be designed to provide single-direction u-turns only.
- Driveway access should be located a minimum of 100 ft away from the MUT crossovers.
- Design must include exclusive u-turn lanes on the main roadway, at least 250 ft in length with a 150 ft taper.
- If the median is wide enough, design should include acceleration lanes in the median for u-turning vehicles.
- Where auxiliary lanes serving the J-Turn intersection are located downstream from a loon, at a distance of 150 ft or less, the auxiliary lane should be constructed to connect the loon and existing auxiliary lane.

*Other Considerations:*

- Pedestrian crossings at a J-Turn intersection are discouraged.
- In urban areas with a high number of bicyclists, curb-cuts with ADA compliant ramps should be included in the design even if pedestrian crosswalks are not installed.
- Individual sites should be evaluated for lighting needs using guidelines such as the *NCHRP Report 152 – "Warrants for Highway Lighting".*
- Signing is critical to help meet driver expectations.
- Positive guidance communicated through additional signs and pavement markings may be beneficial.

- Parking should be proactively prohibited in the vicinity of "bulb-outs" and loons.
- Customized guide signs specifically designed for this type of intersection treatment should be included in the signing plans.
- 3-year post-implementation safety studies should be performed for crash analyses and shared with other transportation agencies.
- If it is believed that driver confusion may occur, transportation and media professionals should design a public information campaign to educate those impacted. Use of microsimulation models can be helpful.
- Additional funds should be budgeted for items including added pavement widths, reinforced shoulders, custom signing, and driver education through public involvement and media campaigns.
- Stages of construction should be:
  Phase #1 – Construction of elements necessary for the design vehicle to execute median u-turns.
  Phase #2 – Construction at the main intersection to prohibit left-turns from the minor roadway.
  Phase #3 – Final pavement striping and signing installed.

**For typical MDOT median widths, the recommended geometric designs of the J-Turn intersection and MUT crossovers are shown on pages 15 – 18.**

# XV. Glossary

***AASHTO***

American Association of State Highway Transportation Officials

***Access***

A public or private roadway used to enter or leave a public highway from adjacent land using a legal motor vehicle. An access may be a driveway or a street.

***Arterial***

Roadway that provides the highest level of service at the greatest speed for the longest uninterrupted distance with some degree of access control.

***Auxiliary Lanes***

The portion of the roadway adjoining the traveled way for speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through-traffic movement.

***Clear Zone***

Term used to designate the unobstructed, relatively flat area provided beyond the edge of the traveled way for recovery of errant vehicles. The clear zone includes any shoulders or auxiliary lanes.

***Collector***

Roadway that provides a less highly developed level of service at a lower speed for shorter distances by collecting traffic from local roads and connecting them with arterials.

***Conflict-Point***

Represent locations where vehicle paths cross as they move from one intersection leg to another.

***Conventional Intersection***

A four-leg intersection with full median opening.

***Corridor***

A set of essentially parallel transportation facilities designed for travel between two points. A corridor contains several subsystems, such as freeways, rural (or two-lane) highways, arterials, transit, and pedestrian and bicycle facilities.

***Design Speed***

A selected speed used to determine the various geometric design features of the roadway.

***Design Vehicle***

Selected vehicles, with representative weight, dimensions, and operating characteristics used to establish highway design controls for accommodating vehicles of the designated classes.

***Directional Median Opening***

An opening in a restrictive median which provides for u-turns and/or left-turn ingress or egress movements.

***Downstream***
The direction of traffic flow.

***Expressway***
A high-speed (≥ 50 mph), multi-lane, divided highway with partial access control.

***FHWA***
Federal Highway Administration

***Full Median Opening***
An opening in a restrictive median that allows all turning and through movements to be made.

***Gap Time***
The time, in seconds, for the front bumper of the second of two successive vehicles to reach the starting point of the front bumper of the first vehicle.

***HCM***
TRB's Highway Capacity Manual

***J-Turn Intersection***
A directional median opening combined with two median u-turns that allow left-turning traffic off the expressway, but forces left-turning and crossing minor road traffic to turn right, merge left, make a u-turn, and return to the intersection.

***Loon***
Expanded paved aprons opposite a median crossover used to facilitate the larger turning path of commercial vehicles along roadways with narrow medians.

***Luminaire***
A lighting unit consisting of one or more electric lamps with all of the necessary parts and wiring.

***MDOT***
Mississippi Department of Transportation

***MUTCD***
Manual on uniform Traffic Control Devices

***Major Street***
The intersecting street with greater traffic volume, larger cross-section, and higher functional class.

***Median***
The portion of a divided highway separating the traveled ways for traffic in opposing directions.

***Median "Bulb-Out"***
Widened median near vicinity of MUT crossovers to facilitate the larger turning path of commercial vehicles along roadways with narrow medians.

***Median U-turn (MUT) Crossover***
Crossover median openings that allow u-turn maneuvers only that are located downstream in both directions from the main J-Turn intersection.

***Minor Street***
The intersecting street with less traffic volume, smaller cross-section, and lower functional class than the major street.

***NCHRP***
National Cooperative Highway Research Program

***Right-of-Way***
A general term denoting land, property, or interest therein, usually a strip, acquired for or devoted to transportation purposes.

***Roadway***
The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

***Shoulder***
The portion of the roadway contiguous with the traveled way that accommodates stopped vehicles, emergency use, and lateral support for subbase, base, and surface courses.

***Sight Distance***
The length of the roadway ahead that is visible to the driver.

***Signal Warrant***
A threshold condition to determine whether a traffic signal is justified based on satisfaction of an engineering study. There are eight warrants currently provided in the latest edition of the MUTCD.

***Superelevation***
An increase in the normal roadway cross slope or transitional removal of adverse crown or cross slope to flat before gradually increasing the roadway slope or tilting the roadway surface to partially counterbalance the centripetal force (i.e., lateral acceleration) on a vehicle that is negotiating a horizontal curve.

***TRB***
Transportation Research Board

***Traveled Way***
The portion of the roadway for the movement of vehicles, exclusive of shoulders.

***Upstream***
The direction from which traffic is flowing.

***Weaving***
The crossing of traffic streams moving in the same general direction accomplished by merging and diverging.

# XVI. Sources


- "A policy on Geometric Design of Highways and Streets," American Association of State Highway Transportation Officials, 2004.
- "FDOT Median Handbook," Florida Department of Transportation, 2006.
- "Manual on Uniform Traffic Control Devices," Federal Highway Administration, 2003.
- "MDOT Access Management Manual," Mississippi Department of Transportation, 2010.
- "MDOT Roadway Design Manual," Mississippi Department of Transportation, 2001.
- "Traffic Engineering Handbook," Institute of Transportation Engineers, 4th Edition, 1992.
- FHWA-HOP-08-024 "Traffic Signal Timing Manual," Federal Highway Administration, 2008.
- FHWA-HRT-09-060 "Alternative Intersections/Interchanges: Informational Report (AIIR)," Federal Highway Administration, 2010.
- FHWA-RD-01-051 "Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians," Federal Highway Administration, 2001.
- FHWA-SA-10-002 Technical Summary "Access Management in the Vicinity of Intersections," Federal Highway Administration, 2010.
- Hochstein, J., "The J-Turn Intersection: Design Guidance & Safety Experience." Iowa State University, 2008.
- NCHRP Report 152 "Warrants for Highway Lighting," National Cooperative Highway Research Program, 1974.
- NCHRP Report 420 "Impacts of Access Management Techniques," National Cooperative Highway Research Program, 1999.
- NCHRP Report 524 "Safety of U-Turns at Unsignalized Median Openings," National Cooperative Highway Research Program, 2004.
- NCHRP Report 548 "A Guidebook for Including Access Management in Transportation Planning," National Cooperative Highway Research Program, 2005.

- NCHRP Report 650 “Median Intersection Design for Rural High-Speed Divided Highways,” National Cooperative Highway Research Program, 2010.

- *Spot Safety Project # 02-00-208/02-00-209* “Spot Safety Project Evaluation,” North Carolina Department of Transportation Safety Evaluation Group, 2005.

- *Spot Safety Project # 11-99-210* “Spot Safety Project Evaluation,” North Carolina Department of Transportation Safety Evaluation Group, 2006.

- *Spot Safety Project # 14-97-018* “Spot Safety Project Evaluation,” North Carolina Department of Transportation Safety Evaluation Group, 2005.