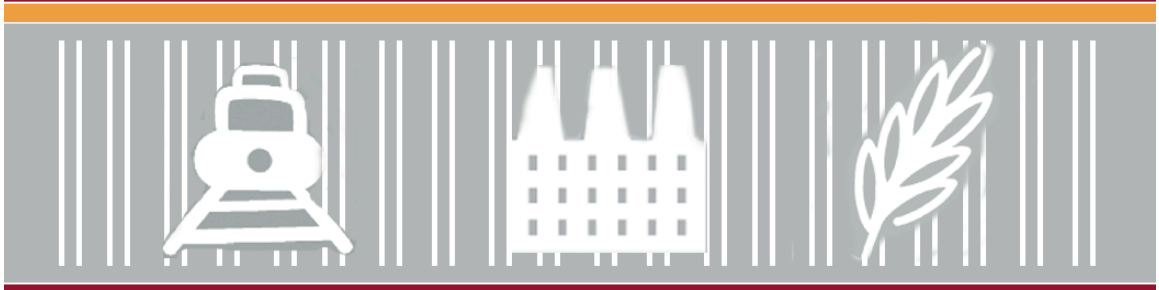
MID-AMERICA



FREIGHT COALITION

# Benefits and Limitations of J-Turn Intersections

Ernest B. Perry, Eric Oberhart, Steven Wagner, and Teresa Adams
Mid-America Freight Coalition
National Center for Freight and Infrastructure Research and Education
University of Wisconsin-Madison

January 27, 2016

CFIRE

NATIONAL CENTER FOR FREIGHT & INFRASTRUCTURE RESEARCH & EDUCATION

# Table of Contents

# Introduction

This report provides a review of the safety and operational dimensions, including benefits and limitations, of J-turn intersection designs. Special accommodations and limitations of J-turn intersections for trucks, buses, and oversize/overweight (OSOW) vehicles are noted where identified in the literature.

Transportation agencies have implemented J-turn intersection designs as a way of increasing traffic capacity and improving highway safety. These intersection types go by a variety of names, including Median U-Turn Intersection Treatment (MUTIT), Restricted Crossing U-Turn Intersection (RCUT), and Michigan Left. In the Mid-America region, Michigan has employed J-turn intersections since the 1960s (earning them the Michigan Left moniker) and Missouri has studied the performance of five experimental J-turn intersections compared against a control group of similar four-way intersections.

J-turn intersections have the potential to reduce crashes and fatalities, increase traffic speeds, and decrease overall travel time while costing less than a grade-separated interchange. J-turns have also been associated with slightly longer travel times and potentially increased confusion relative to conventional four-way intersections. Use of J-turns is also associated with a higher rear-end and fixed-object crash frequencies. J-turn intersections may also interfere with the operation of large vehicles. A number of modifications such as extended pavement aprons, mountable curbs, and movable gates can make J-turns navigable for commercial motor vehicles (CMVs) and OSOW vehicles. In the case of extreme over-length and over-width OSOW loads, the overall general design of the roadway and typical intersection designs can limit truck operation as least as much as alternative turning designs. So while J-turns could provide limited additional operational benefits for large loads, they are not specifically designed to accommodate these loads nor does this design tend to limit truck movements.

# Description of J-Turn Design

The key feature of J-turn intersections is displacing or removing left turn and/or straight maneuvers from the center of the intersection, and moving them one-half to one mile away from the intersection. This design also requires controlling or restricting how traffic from minor streets may cross major streets. Traffic wishing to turn left onto a major street from a minor street will be required to turn right and then perform a U-turn at some point further down the major road (Figure 1). Intersections such RCUTs completely prohibit direct crossing of the major street, requiring drivers to turn right, make a U-turn, and turn right again to continue on the minor street (Figure 2).

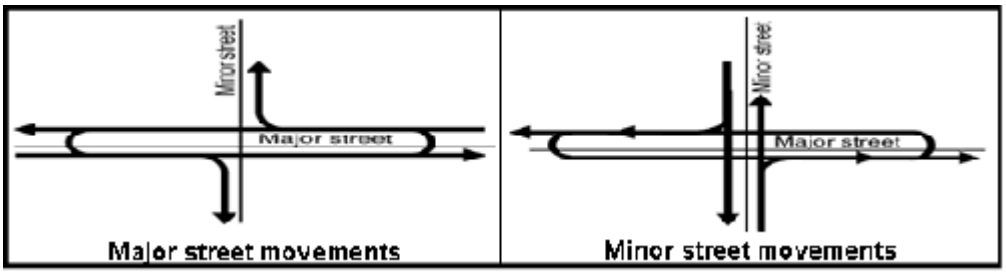



**Figure 1: MUTIT operations**

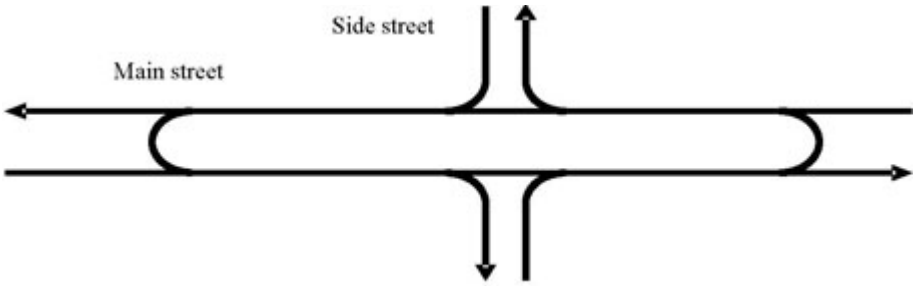



**Figure 2: Basic RCUT operations**

If the median on the major roadway is narrow or there are only two lanes of traffic in each direction larger vehicles such as trucks and buses may not have enough space to complete the U-turn maneuver. Installation of a “loon”—a pavement pad adjacent to the roadway apron—helps accommodate the wide turning radii of trucks, buses, and OSOW vehicles (Figure 3). J-turn intersections can be signal-controlled at the main junction between streets as well as at the U-turn areas.

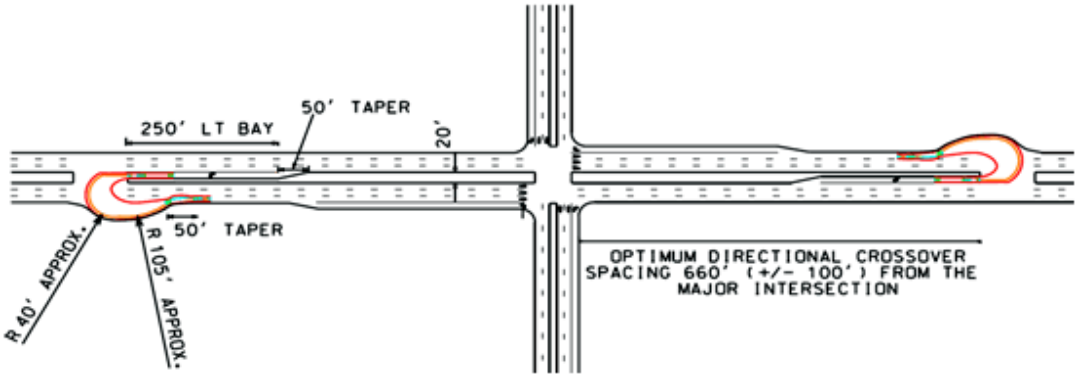



**Figure 3: Schematic of a loon implementation for a Michigan MUTIT**

## Benefits of J-turn Intersections

The design of J-turn intersections improves roadway safety by reducing the number of conflict points where collisions are likely and reducing the severity of collisions. A conventional two-way stop controlled (TWSC) intersection with a divided highway has 42 conflict points. By comparison, a J-turn has only 24 conflict points which are spread out over a much wider area (Bared and Zhang, 2012). Because traffic intending to turn left is forced to follow the flow of cross traffic, the potential for especially severe crashes is lessened; the J-turn design has fewer opportunities for severe right angle (t-bone) collisions compared to a TWSC design.

Because J-turns have fewer conflict points, they are associated with a crash frequency between 34 and 60 percent when compared to TWSC designs (Edara et al., 2013). The severity of crashes is also reduced: crash frequency for injuries and fatalities decreased between 53 and 75 percent (Bared and Zhang, 2012). A 2013 Missouri study found that J-turns reduced disabling injury crashes by 86 percent and reduced right-angle crashes by 80 percent. Fatalities were completely eliminated at the five trial intersections, and left-turn right angle crashes (one of the most fatal types) were eliminated entirely as well (Edara et al., 2013). Other measures of safety such as average time to collision (increased by factor of 4) also improved (Edara et al., 2013).

J-turns are more efficient than TWSCs and are associated with faster traffic speeds, less congestion, and fewer delays. A FHWA study found use of J-turns was associated with a 17 percent decrease in total travel time when compared to TWSCs, and average traffic speeds increased by 25 percent (Bared and Zhang, 2012). The five Missouri experiment sites had a wait time about half that of control group TWSCs (Edara et al., 2013). Higher speeds and less wait time results in more efficient operations and higher capacity: conversion to J-turns on a Michigan corridor increased corridor traffic capacity between 20 and 50 percent (Bared and Zhang, 2012). Drivers wanting to turn left on to a major road will have to travel farther, but overall network travel time savings outweigh this increase.

J-turn intersections are also easier to construct and less expensive than a grade-separated interchanges such a diamond interchange or a cloverleaf, making it ideal for states working to create high speed rural highway corridors while maintaining or improving current levels of safety (Hochstein et al., 2008).

## Constraints

Potential limitations of J-turns include driver confusion, higher rear-end and fixed object crash rates, and a slightly higher installation cost than two-way intersections in cases where J-turn intersections are signalized.

The most common concern with J-turns comes from their complex operation (relative to a TWSC). Drivers must adjust their driving habits to accommodate the new design. However, while a J-turn intersection may be confusing at first, effective signage can help drivers to interpret the new intersection. Drivers who are unfamiliar with J-turn intersections may find them more challenging. However, Michigan (which has used J-turns since the 1960s) notes that “we have not received many complaints from non-residents. Non-Michigan drivers do not appear to have significant difficulties with [J-turns]” (MDOT, 2015). The FHWA recommends that J-turns *not* be combined with TWSCs and other types of intersections in a corridor, in order to limit driver confusion.

While J-turns improve safety overall, their use is associated with higher crash rates for two specific collision types relative to TWSCs. In Michigan, where J-turns have been used for about 50 years, these intersections are associated with a 25 percent increase in non-left-turn rear-end crashes and a 20 percent increase in fixed object crashes. MDOT hypothesizes that the 20 percent increase in fixed-object crashes comes from vehicles sliding into the gutter and curb at crossovers during snowy and icy conditions (MDOT, 2015). While these two crash rates are higher, the fact remains that J-turns bestow significant safety benefits by reducing overall collision frequency and severity.

While J-turns are less expensive than grade-separated interchanges, they are still more expensive than traditional TWSC intersections (Bared and Zhang, 2012). J-turns require a wide median or, if the median is too narrow, loons at crossovers to accommodate wide-turning vehicles such as trucks and buses. Again, the safety and capacity improvements from J-turns may outweigh the additional cost of more pavement and additional signals.

## Considerations for CMVs and OSOW Vehicles

States, counties, and cities considering adoption of alternative intersection designs such as J-turns should be aware of the needs of commercial motor vehicles (CMVs) and OSOW vehicles. Space for U-turns, the length of acceleration and deceleration lanes, and variations in pavement heights and slopes should be considered. Additional modifications such as mountable curbs and movable gates may be required for J-turns to accommodate OSOW vehicles.

J-turns may not be able to accommodate large trucks, especially if the median is narrow, or there are only two lanes to turn onto. In areas like these, transportation designers will need to consider installation of a loon to give large vehicles enough space to turn. The Michigan Department of Transportation suggests minimum median widths for U-turn maneuvers such as those required with a J-turn (Table 1). Information such as this can help planners determine if a loon is required.

**Table 1: Minimum Median Widths for U-turn Maneuvers by Vehicle Type (Bared and Zhang, 2012)**

| Type of Maneuver | P | SU | BUS | WB-50 | WB-60 |
|---|---|---|---|---|---|
| | Length of Design Vehicle, m (ft) | | | | |
| | 5.8 (19) | 9.1 (30) | 12.2 (40) | 16.8 (55) | 21.3 (70) |
| Left Lane to Inner Lane | 13.4 (44) | 23.2 (76) | 24.4 (80) | 25 (82) | 25 (82) |
| Left Lane to 2nd Lane | 9.8 (32) | 19.5 (64) | 20.7 (68) | 21.3 (70) | 21.3 (70) |
| Left Lane to 3rd Lane | 6.7 (22) | 16.5 (54) | 17.7 (58) | 18.3 (60) | 18.3 (60) |
| Where:<br>P = passenger car<br>SU = single-unit truck<br>WB-50 = semi truck medium size<br>WB-60 = semi truck large size | | | | | |

Planning software such as AutoTURN can also help designers ensure that J-turns and loons have enough space to accommodate larger vehicles (OTA, 2010). The distance between the main intersection and U-turn in the median should also be considered, as trucks may require longer distances to accelerate and switch lanes after merging onto the main road. AASHTO publishes guidelines for acceleration and deceleration distances that can inform the proper design of J-turn areas (Maze et al., 2010).

In addition to width and length, planners should consider the height and gradient of both the roadway and property immediately adjacent to J-turns. Long trucks, particularly those with low-clearance (e.g., gooseneck trailers, etc.) cannot accommodate as much variation in the height of the road surface, and may be at risk for clipping any features higher than the curb. The FHWA recommends keeping near-roadway curbs and landscaping less than one-foot-high to prevent potential clipping and improve visibility (Maze et al., 2010).

Little published research has focused on the operation of oversize/overweight vehicles with J-turns. However, work with roundabouts and traffic circles can inform planning for OSOW vehicles at J-turns. Devices such as pass-through gates at closed and roundabout intersections and mountable curbs can help smaller turns and roundabouts accommodate OSOW vehicles (OTA, 2010).

Properly-designed J-turns can have some benefits for trucks, especially on narrow-median rural highways. Instead of waiting for a gap in traffic in both directions, trucks can take one flow of traffic at a time, reducing waiting time and increasing safety.[*]

[*] For a truck operator perspective on J-Turns see the operational video at: http://www.modot.gov/general/J-Turns.htm (MoDOT, 2013).

# Summary

This report has provided a review of the safety and operational dimensions of J-turn intersection designs, with special consideration for CMVs and OSOW loads. This review has identified five areas of impact when considering the implementation of J-turn intersections for truck operations:

- **Fewer conflict points.** J-turn intersections have 24 conflict points instead of 48; this increases the safety of the intersection.
- **Accident rates.** J-turn intersections have decreased rates of 90-degree crashes, though there is the possibility of increased rear-end crashes and other accident types.
- **Construction and maintenance costs.** J-turn intersections are more expensive than non-signalized four-way intersections, but cost less than signalized or ramped intersections.
- **Travel times.** Travel times through J-turn intersections are comparable to or less than the waits at four-way intersections.
- **Trucker satisfaction.** J-turn intersections present no significant additional obstacles to general trucking or permitted OSOW loads. Truckers usually recognize the increased safety and efficiency benefits.

Given the importance of freight mobility to regional and national economies, transportation agencies considering the installation of J-turns should design these intersections with accommodations for CMVs and OSOW loads.

# References


Bared, Joe, and Wei Zhang (2012). Synthesis of the Median U-Turn Intersection Treatment. Technical. US Department of Transportation. http://www.fhwa.dot.gov/publications/research/safety/07033/index.cfm. Accessed July 3, 2015.

Edara, Praveen, Carlos Sun, and Sawyer Breslow (2013). Evaluation of J-Turn Intersection Design Performance in Missouri. Technical. Missouri Department of Transportation. http://epg.modot.org/files/d/dd/233.2.6_J-turn.pdf. Accessed July 3, 2015.

Hochstein, Joshua, Tom Maze, and Tom Welch (2008). The J-Turn Intersection: Design Concept Basics. Kentucky Transportation Cabinet. http://transportation.ky.gov/Congestion-Toolbox/Documents/J-Turn%20101.pdf. Accessed July 3, 2015.

Hughes, Warren, Ram Jagnannathan, Dibu Sengupta, and Joe Hummer (2009). Alternative Intersections/Interchanges: Informational Report (AIIR). Informational. US Department of Transportation. http://www.fhwa.dot.gov/publications/research/safety/09060/index.cfm. Accessed July 3, 2015.

Maze, TH, Joshua Hochstein, and Reginald Souleyrette (2010). NCHRP Report 650: Median Intersection Design for Rural High-Speed Divided Highways.National Cooperative Highway Research Program. . http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_650.pdf. Accessed July 3, 2015.

Michigan Department of Transportation (2015). Michigan Left. http://www.michigan.gov/mdot/0,4616,7-151-9615_44557-161777--,00.html.

Missouri Department of Transportation (2013). Introducing J-Turns: A Safer Alternative to a Typical Intersection.. http://www.modot.org/kansascity/major_projects/J_Turns.htm. Accessed July 3, 2015.

Ontario Trucking Association (2010). Accommodating Commercial Vehicles in Roundabouts. St. Catharine's. http://ontruck.org/wp-content/uploads/2015/04/OTA-Discussion-Paper-Accommodating-Commercial-Vehicles-in-Roundabouts_public.pdf. Accessed July 3, 2015.


# CFIRE

University of Wisconsin-Madison
Department of Civil and Environmental Engineering
1410 Engineering Drive, Room 270
Madison, WI 53706
Phone: 608-263-3175
Fax: 608-263-2512
cfire.wistrans.org

MID-AMERICA FREIGHT COALITION

midamericafreight.org