OZARKS TRANSPORTATION ORGANIZATION
A METROPOLITAN PLANNING ORGANIZATION

2208 W. CHESTERFIELD BOULEVARD, SUITE 101, SPRINGFIELD, MO 65807
417-865-3047

# Street Typology Working Group

December 2, 2021

9:30 am to 11:00 am

In-Person at OTO - Large Conference Room

and Online with Zoom via link to be provided

1. Welcome and Purpose
2. MTP History and *Destination 2045* Recommendations
3. Discuss Local Application of Major Throughfare Plan
4. Complete Streets and Safe Systems Approach
5. Establish Goals for Design Standards
6. Develop Working Group Schedule
7. Adjourn

Si usted necesita la ayuda de un traductor, por favor comuníquese con Andy Thomason al (417) 865-3042, al menos 48 horas antes de la reuníon.

Persons who require special accommodations under the Americans with Disabilities Act or persons who require interpreter services (free of charge) should contact Andy Thomason at (417) 865-3042 at least 24 hours ahead of the meeting.

If you need relay services please call the following numbers: 711 - Nationwide relay service; 1-800-735- 2966 - Missouri TTY service; 1-800-735-0135 - Missouri voice carry-over service.

OTO fully complies with Title VI of the Civil Rights Act of 1964 and related statutes and regulations in all programs and activities. For more information or to obtain a Title VI Complaint Form, see www.ozarkstransportation.org or call (417) 865-3042.

Destination 2045

Ozarks Transportation Organization

# DESIGN Standards

## Adopted Standards

The Board of Directors most recently amended these Design Standards on April 20, 2017. The Major Thoroughfare Plan may be amended separately from the standards. The most recent version can be found on the OTO website.

## Learn More

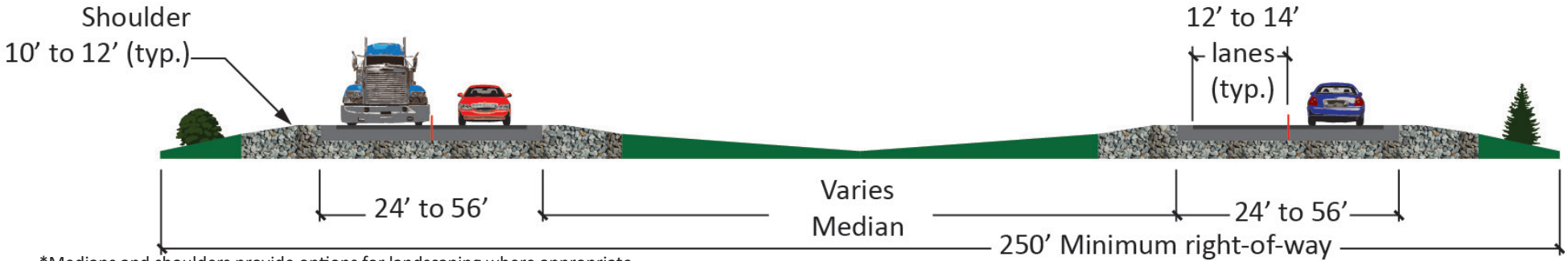
The Ozarks Transportation Organization's Major Thoroughfare Plan (MTP) provides guidelines for designing a roadway network for the efficient movement of people and goods throughout the metropolitan area. The MTP classifies roadways based on their intended function and shows both existing and future roadways. These future major transportation corridors should serve as a general guide for securing street rights-of-way, though the locations are general in nature and final alignments will depend on a detailed location study. The classifications shown on the MTP map direct the application of the OTO Design Standards.

The OTO adopted design standards are desired minimums based on the recommendations of the MTP. These standards are intended for new construction or the retrofitting of existing roadways. In the event that a roadway project has not been constructed, but it has been designed and right-of-way has been purchased to previous standards, the project is not required to meet these standards. Otherwise, deviations from the OTO design standards require a variance from a special subcommittee of the OTO Technical Planning Committee.

## About the OTO

The Ozarks Transportation Organization is the Springfield-regional Metropolitan Planning Organization, or MPO. The MPO is a body of elected and appointed members who work together with local, state, and federal elected officials and policy-makers, serving to make funding and planning decisions for transportation within the Springfield, MO region.

# Freeway




*Medians and shoulders provide options for landscaping where appropriate.

## Description

| | |
|---|---|
| **Design Service Volume** | 20,000 - 100,000 |
| **Design Speed** | 55 - 70 mph |
| **Traffic Flow/Access Priority** | 99/1 |
| **Facility Spacing** | 4 - 8 miles |
| **Trip Length** | Between cities and across metropolitan area (2+ miles) |

## Basics

| | |
|---|---|
| **Minimum Right-of-Way** | 250’ minimum |
| **Number of Lanes** | 4 - 8 |
| **Lane Width** | 12’ to 14’ per lane |
| **Drainage/Shoulders** | Variable. Minimum 10’ - 12’ shoulder |

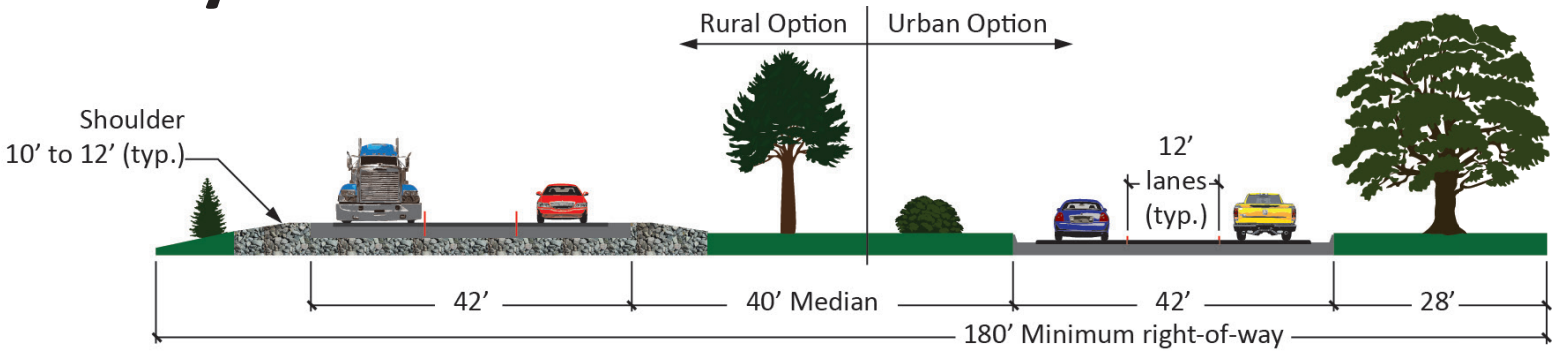
## Access

| | |
|---|---|
| **Median** | Varies |
| **Full Median Break Spacing** | Not permitted |
| **Directional Median Break Spacing** | Not permitted |
| **Interchange Spacing** | 1 - 3 miles |
| **Full Access Intersection Spacing** | Not permitted |
| **Residential Driveway Spacing** | Not permitted |
| **Commercial Driveway Spacing** | Not permitted |

## Multi-Modal

| | |
|---|---|
| **On-Street Parking** | Not permitted |
| **Pedestrian Provisions** | Pedestrians prohibited (no sidewalks required) |
| **Bicycle Provisions** | Bicycles not recommended |
| **Transit Provisions** | No stops, express routes only |

# Expressway




*Medians and shoulders provide options for landscaping where appropriate.

## Description

| | |
|---|---|
| **Design Service Volume** | 20,000 - 50,000 |
| **Design Speed** | 40 - 55 mph |
| **Traffic Flow/Access Priority** | 90/10 |
| **Facility Spacing** | 3 - 5 miles |
| **Trip Length** | Across metropolitan area and between major activity centers (2+ miles) |

## Basics

| | |
|---|---|
| **Minimum Right-of-Way** | 180’ + 40’ each side if frontage roads are needed |
| **Number of Lanes** | 4 - 6 |
| **Turning Lanes** | At intersections only |
| **Lane Width** | 12’ (plus shoulders in rural areas only) |
| **Drainage/Shoulders** | Curb and gutter or shoulders (rural areas) |

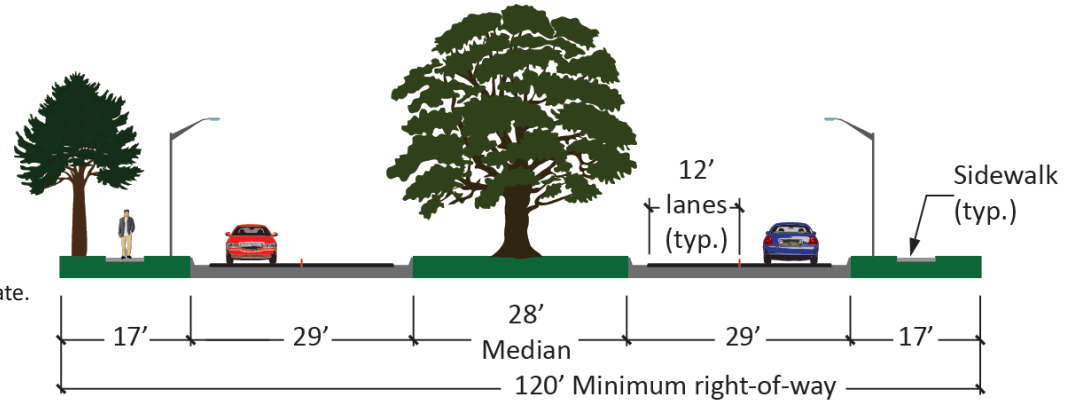
## Access

| | |
|---|---|
| **Median** | 40’ landscaped |
| **Median Breaks** | Allowed at signalized intersections only |
| **Full Access Intersection Spacing** | 1/2 mile |
| **Intersection** | Left and right turn lanes desired |
| **Residential Driveway Spacing** | No residential drives permitted |
| **Commercial Driveway Spacing** | 660’ (right-in/right-out only) |

## Multi-Modal

| | |
|---|---|
| **On-Street Parking** | Not permitted |
| **Pedestrian Provisions** | Sidewalks required on frontage roads |
| **Bicycle Provisions** | Bicycle lane provided on frontage roads |
| **Transit Provisions** | Turnouts at major generators |

# Boulevard




*Medians and shoulders provide options for landscaping where appropriate.
*Utility and greenspace areas may switch locations if needed.
*Utilities may be placed under sidewalks.

## Description

| | |
|---|---|
| **Design Service Volume** | 10,000 - 40,000 |
| **Design Speed** | 35 - 45 mph |
| **Traffic Flow/Access Priority** | 70/30 |
| **Facility Spacing** | 3 - 5 miles |
| **Trip Length** | Across metropolitan area and between major activity centers (2+ miles) |

## Basics

| | |
|---|---|
| **Minimum Right-of-Way** | 120’ plus intersection triangles |
| **Number of Lanes** | 4 |
| **Turning Lanes** | At intersections only; left and right turn lanes desired |
| **Lane Width** | 12’ per lane |
| **Minimum Area Behind Curb** | 17’ used for sidewalks, utilities, and landscaping (where appropriate) |
| **Drainage/Shoulders** | Curb and gutter; 6’ -10’ for shoulders (if used) |

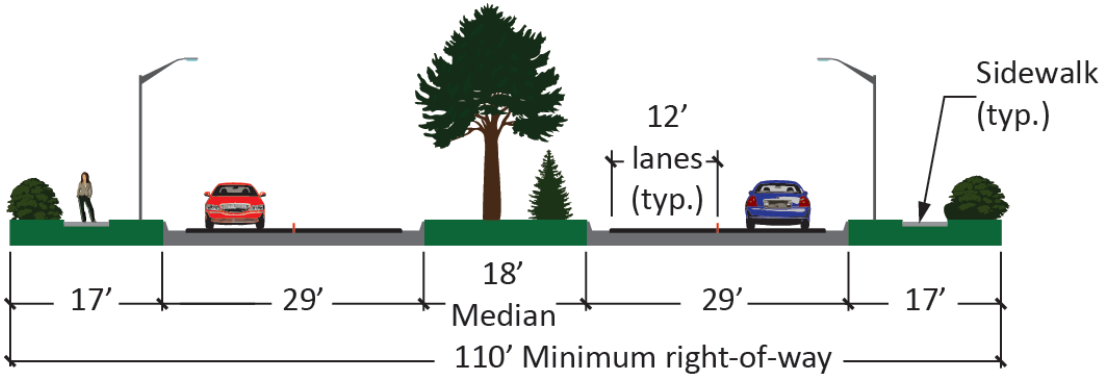
## Access

| | |
|---|---|
| **Median** | 28’ (landscaping desired) |
| **Median Breaks** | Allowed at signalized intersections only |
| **Directional Median Break Spacing** | 660’ |
| **Full Access Intersection Spacing** | 1/4 mile |
| **Intersection** | Left and right turn lanes desired |
| **Residential Driveway Spacing** | No residential drives permitted |
| **Commercial Driveway Spacing** | 330’ center-to-center (right-in/right-out only). Allowed only if internal circulation, cross access, and minimum driveway radii and grade are provided. |

## Multi-Modal

| | |
|---|---|
| **On-Street Parking** | Not permitted |
| **Pedestrian Provisions** | 4’ - 6’ (minimum) sidewalks on both sides |
| **Bicycle Provisions** | Bicycle facilities provided according to adopted bicycle plan |
| **Transit Provisions** | Turnouts at major generators |

# Primary Arterial




*Medians and shoulders provide options for landscaping where appropriate.
*Utility and greenspace areas may switch locations if needed.
*Utilities may be placed under sidewalks.

## Description

| | |
|---|---|
| **Design Service Volume** | 10,000 - 30,000 |
| **Design Speed** | 35 - 45 mph |
| **Traffic Flow/Access Priority** | 70/30 |
| **Facility Spacing** | 1 - 2 miles |
| **Trip Length** | Between and through major activity centers (2 - 8 miles) |

## Basics

| | |
|---|---|
| **Minimum Right-of-Way** | 110’ plus intersection triangles |
| **Number of Lanes** | 4 - 6 |
| **Turning Lanes** | At intersections only |
| **Lane Width** | 12’ per lane |
| **Minimum Area Behind Curb** | 17’ used for sidewalks, utilities, and landscaping (where appropriate) |
| **Drainage/Shoulders** | Curb and gutter; shoulders permitted in rural areas (6’ - 10’) |

## Access

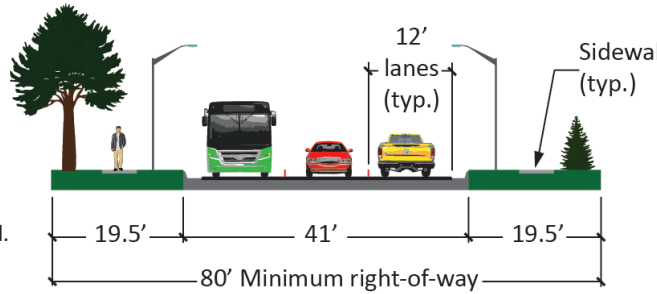
| | |
|---|---|
| **Median** | 18’ |
| **Median Breaks** | Allowed at signalized intersections only |
| **Directional Median Break Spacing** | 660’ |
| **Full Access Intersection Spacing** | 1/4 mile |
| **Intersection** | Left and right turn lanes desired |
| **Residential Driveway Spacing** | No residential drives permitted |
| **Commercial Driveway Spacing** | 330’ center-to-center (right-in/right-out only). Allowed only if internal circulation, cross access, and minimum driveway radii and grade are provided. |

## Multi-Modal

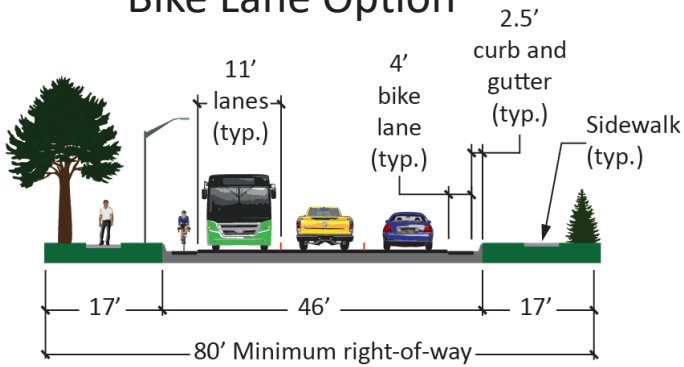
| | |
|---|---|
| **On-Street Parking** | Not permitted |
| **Pedestrian Provisions** | 4’ - 5’ (minimum) sidewalks on both sides |
| **Bicycle Provisions** | Bicycle facilities provided according to adopted bicycle plan |
| **Transit Provisions** | Scheduled stops every 1/4 mile (where transit service is provided) |

# Secondary Arterial

*Medians and greenspace provide options for landscaping where appropriate.
*Utility and greenspace areas may switch locations if needed.
*Utilities may be placed under sidewalks.




Bike Lane Option




## Description

| | |
|---|---|
| **Design Service Volume** | 6,000 - 20,000 |
| **Design Speed** | 30 - 35 mph |
| **Traffic Flow/Access Priority** | 60/40 |
| **Facility Spacing** | 1/2 - 1 mile |
| **Trip Length** | Between and within activity centers (1 - 4 miles) |

## Basics

| | |
|---|---|
| **Minimum Right-of-Way** | 80’ plus intersection triangles |
| **Number of Lanes** | 2 - 3 |
| **Turning Lanes** | Left turn lane |
| **Lane Width** | 12’ (bicycle routes: 11’ vehicle and 4’ bicycle lanes) |
| **Minimum Area Behind Curb** | 19.5’ (17’ when bicycle lanes are provided) used for sidewalks, utilities, and landscaping (where appropriate) |
| **Drainage/Shoulders** | Curb and gutter; shoulders permitted in rural areas (6’ - 10’) |

## Access

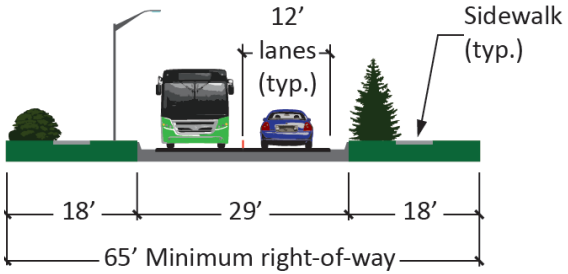
| | |
|---|---|
| **Median** | Not required |
| **Full Access Intersection Spacing** | 660’ |
| **Intersection** | 4 lanes |
| **Residential Driveway Spacing** | No residential drives permitted |
| **Commercial Driveway Spacing** | 210’ center-to-center. Allowed only if internal circulation, cross access, and minimum driveway radii and grade are provided. |

## Multi-Modal

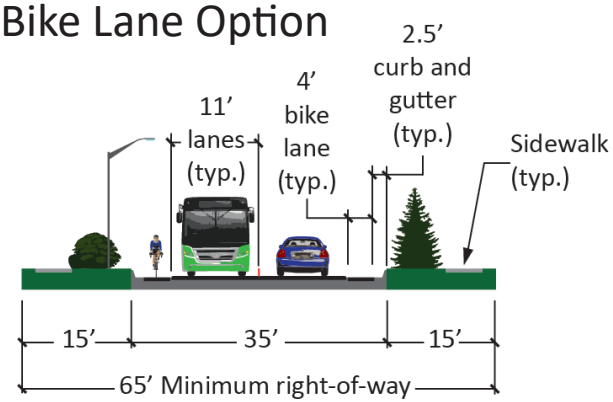
| | |
|---|---|
| **On-Street Parking** | Not permitted |
| **Pedestrian Provisions** | 4’ - 5’ (minimum) sidewalks on both sides |
| **Bicycle Provisions** | Bicycle facilities provided according to adopted bicycle plan |
| **Transit Provisions** | Scheduled stops every 1/4 mile (where transit service is provided) |

# Collector

*Medians and greenspace provide options for landscaping where appropriate.
*Utility and greenspace areas may switch locations if needed.
*Utilities may be placed under sidewalks.




Bike Lane Option




## Description

| | |
|---|---|
| **Design Service Volume** | 1,500 - 8,000 |
| **Design Speed** | 30 mph |
| **Traffic Flow/Access Priority** | 30/70 |
| **Facility Spacing** | 1/4 - 1/2 mile |
| **Trip Length** | Local street to arterial street (1/2 to 2 miles) |

## Access

| | |
|---|---|
| **Median** | Not required |
| **Full Access Intersection Spacing** | 660’ |
| **Intersection** | Up to 4 lanes |
| **Residential Driveway Spacing** | No residential drives permitted |
| **Commercial Driveway Spacing** | 160’ center-to-center |

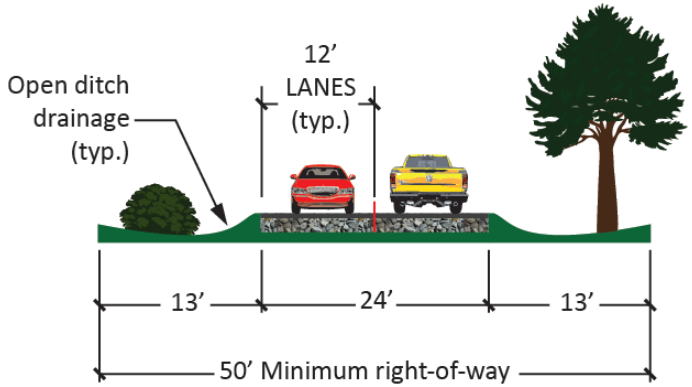
## Basics

| | |
|---|---|
| **Minimum Right-of-Way** | 65’ plus intersection triangles |
| **Number of Lanes** | 2 |
| **Turning Lanes** | Left turn lane when needed |
| **Lane Width** | 12’ (bicycle routes: 11’ vehicle and 4’ bicycle lanes) |
| **Minimum Area Behind Curb** | 18’ (15’ when bicycle lanes are provided) used for sidewalks, utilities, and landscaping (where appropriate) |
| **Drainage/Shoulders** | Curb and gutter; shoulders permitted in rural areas (6’ - 10’) |

## Multi-Modal

| | |
|---|---|
| **On-Street Parking** | Not permitted |
| **Pedestrian Provisions** | 4’ - 5’ (minimum) sidewalks on both sides |
| **Bicycle Provisions** | Bicycle facilities provided according to adopted bicycle plan |
| **Transit Provisions** | Scheduled regular and paratransit service |

# Rural Collector




## Description

| | |
|---|---|
| **Design Service Volume** | 1,500 - 8,000 |
| **Design Speed** | 30 mph |
| **Traffic Flow/Access Priority** | 30/70 |
| **Facility Spacing** | 1/4 - 1/2 mile |
| **Trip Length** | Local street to arterial street (1/2 to 2 miles) |

## Basics

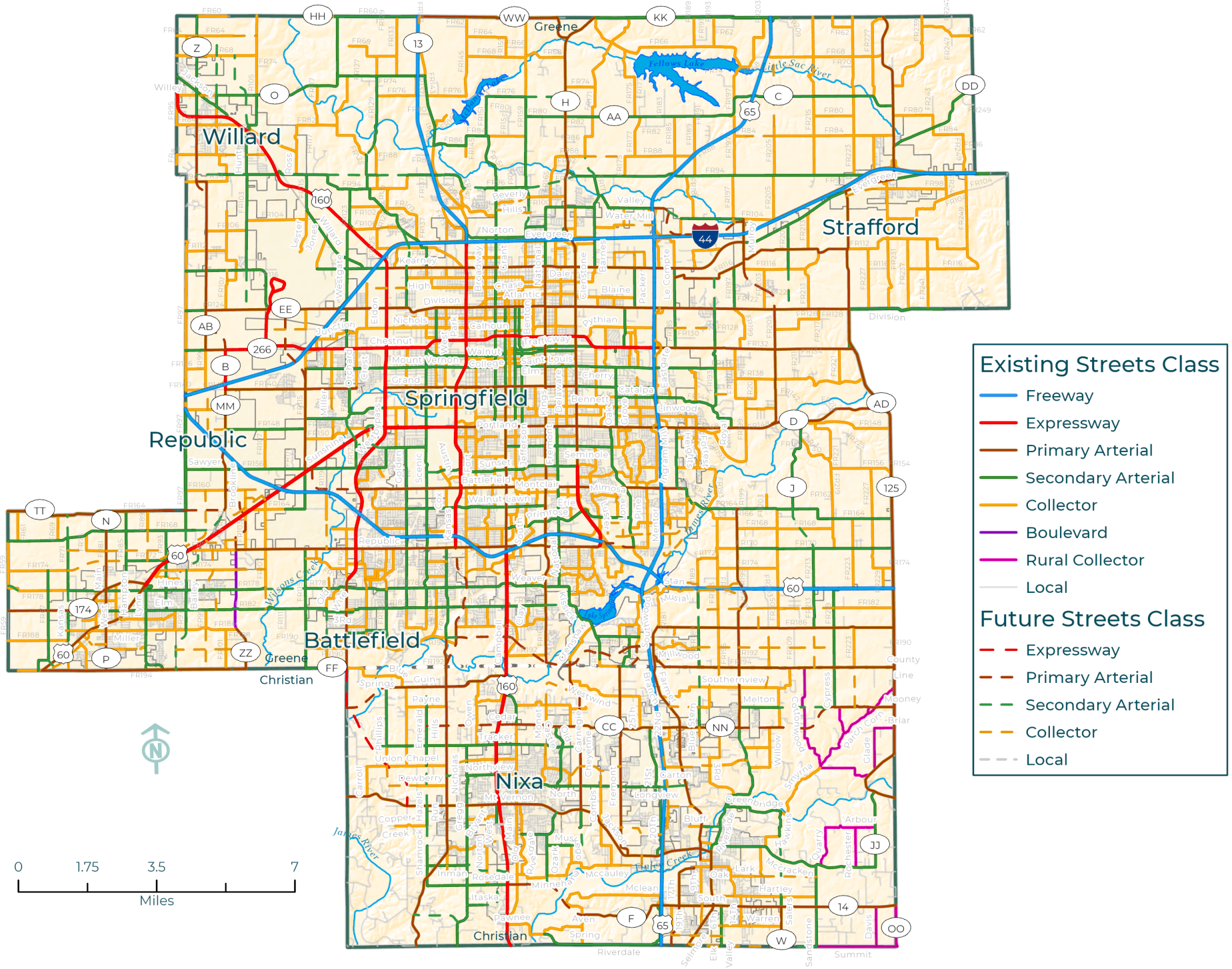
| | |
|---|---|
| **Minimum Right-of-Way** | 50’ |
| **Number of Lanes** | 2 |
| **Turning Lanes** | Left turn lane when needed |
| **Lane Width** | 12’ |
| **Minimum Area Behind Curb** | 13’ used for utilities and open ditch (where appropriate) |
| **Drainage/Shoulders** | Open ditch |

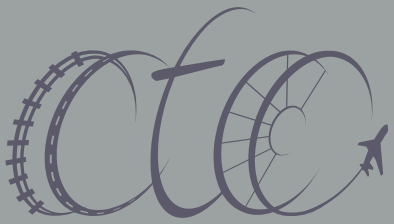
## Access

| | |
|---|---|
| **Median** | Not required |
| **Full Access Intersection Spacing** | 660’ |
| **Intersection** | up to 4 lanes |
| **Residential Driveway Spacing** | Residential driveways are discouraged; 200’ center-to-center if no other alternative is available |
| **Commercial Driveway Spacing** | 160’ center-to-center |

## Multi-Modal

| | |
|---|---|
| **On-Street Parking** | Not permitted |
| **Pedestrian Provisions** | No sidewalks required |
| **Bicycle Provisions** | Bicycle facilities provided according to adopted bicycle plan |


Willard
Springfield
Republic
Battlefield
Nixa
Strafford
Greene
Christian
Existing Streets Class
Freeway
Expressway
Primary Arterial
Secondary Arterial
Collector
Boulevard
Rural Collector
Local
Future Streets Class
Expressway
Primary Arterial
Secondary Arterial
Collector
Local
0
1.75
3.5
7
Miles



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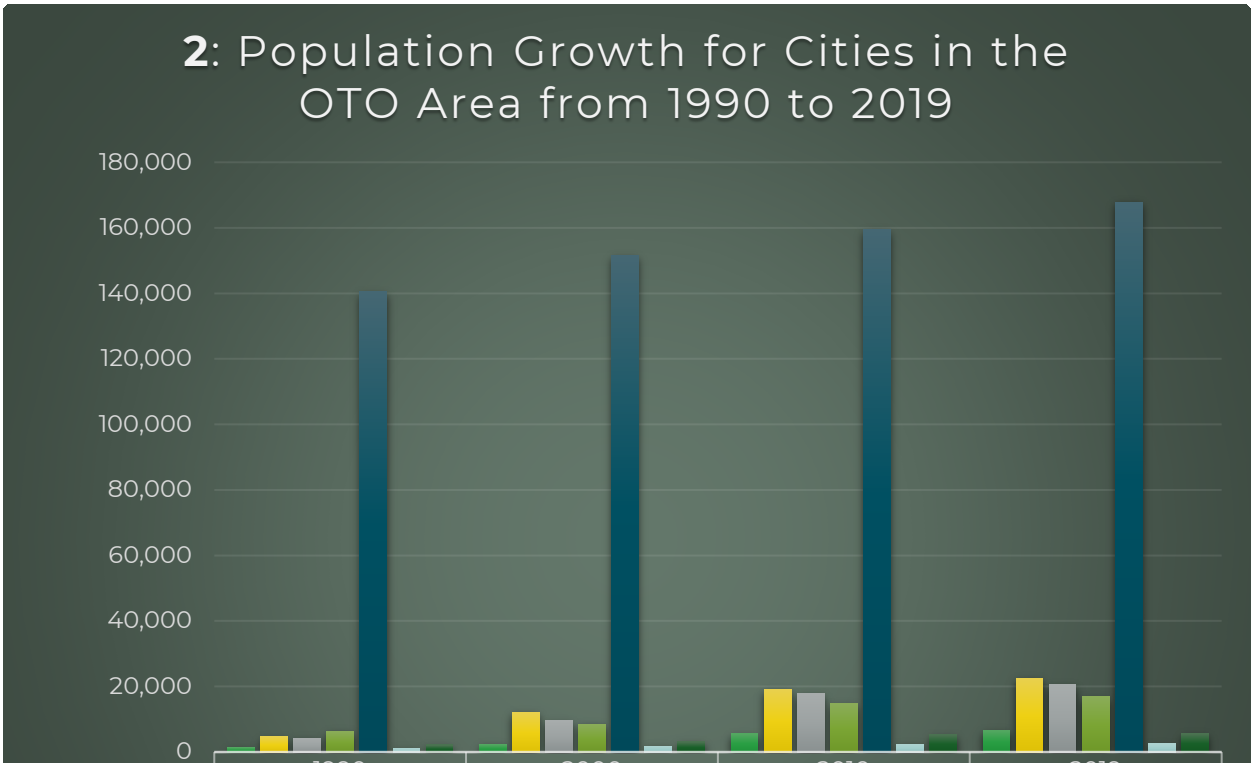
**417-865-3042**

**This report was prepared in cooperation with the USDOT, including FHWA and FTA, as well as the Missouri Department of Transportation. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Missouri Highways and Transportation Commission, the Federal Highway Administration or the Federal Transit Administration.**

# Existing Conditions

## Demographics and Socioeconomics

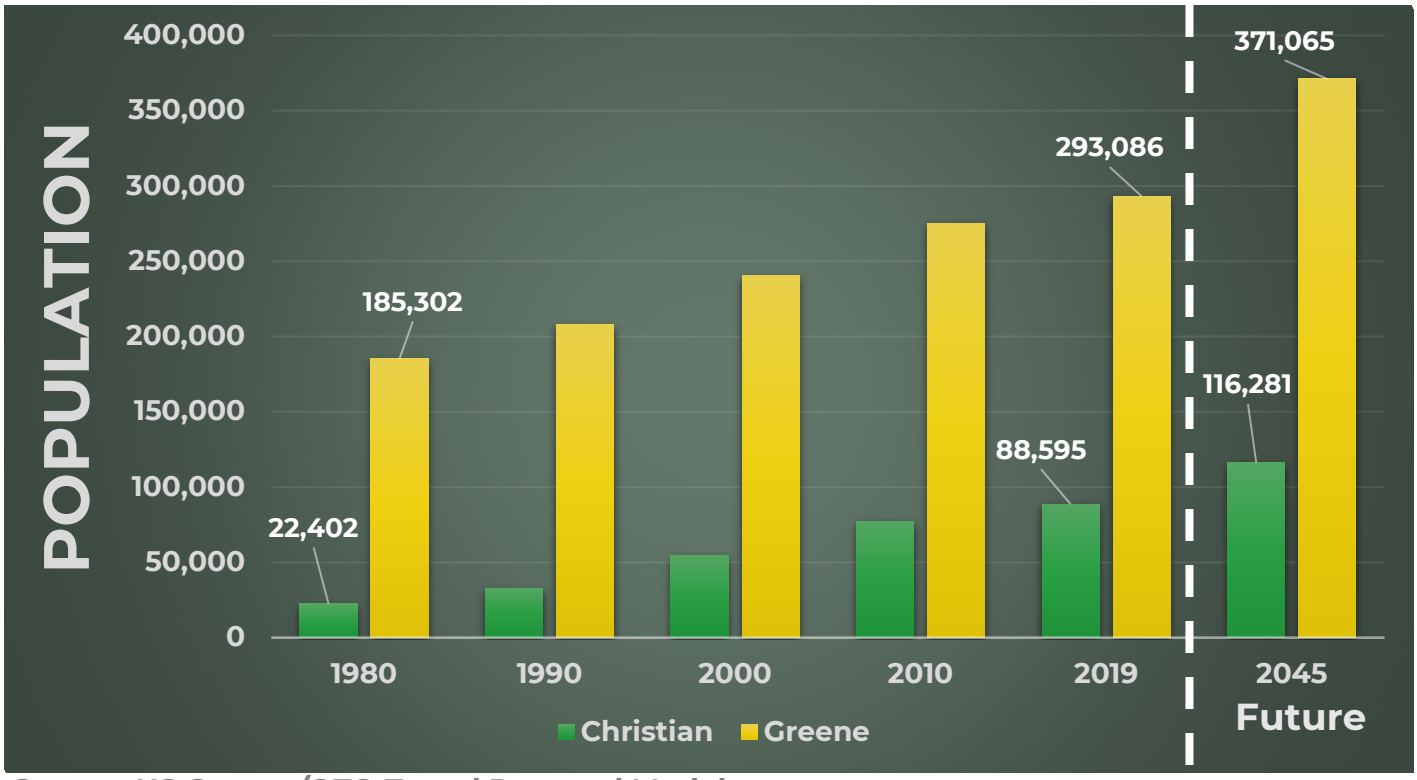
The Springfield metropolitan statistical area includes Christian and Greene counties, as well as Dallas, Polk, and Webster counties. From 2010 to 2019, the MSA population increased from 436,712 to 470,300. This is an overall increase of 7.7 percent, or 0.77 percent annualized. Christian County was the fastest growing county in the MSA in terms of percent change over the past 29 years, adding 55,951 people. Greene County grew the most in terms of raw numbers, adding 85,137 people. The City of Springfield has experienced steady growth since 2010 and remains the employment and activity hub for the OTO area.




| | 1990 | 2000 | 2010 | 2019 |
|---|---|---|---|---|
| Battlefield | 1,526 | 2,385 | 5,590 | 6,622 |
| Nixa | 4,707 | 12,124 | 19,022 | 22,515 |
| Ozark | 4,243 | 9,665 | 17,820 | 20,482 |
| Republic | 6,292 | 8,438 | 14,751 | 16,938 |
| Springfield | 140,494 | 151,580 | 159,498 | 167,882 |
| Strafford | 1,166 | 1,845 | 2,358 | 2,460 |
| Willard | 2,177 | 3,193 | 5,288 | 5,632 |

***Source: OTO 2020 Growth Trends***

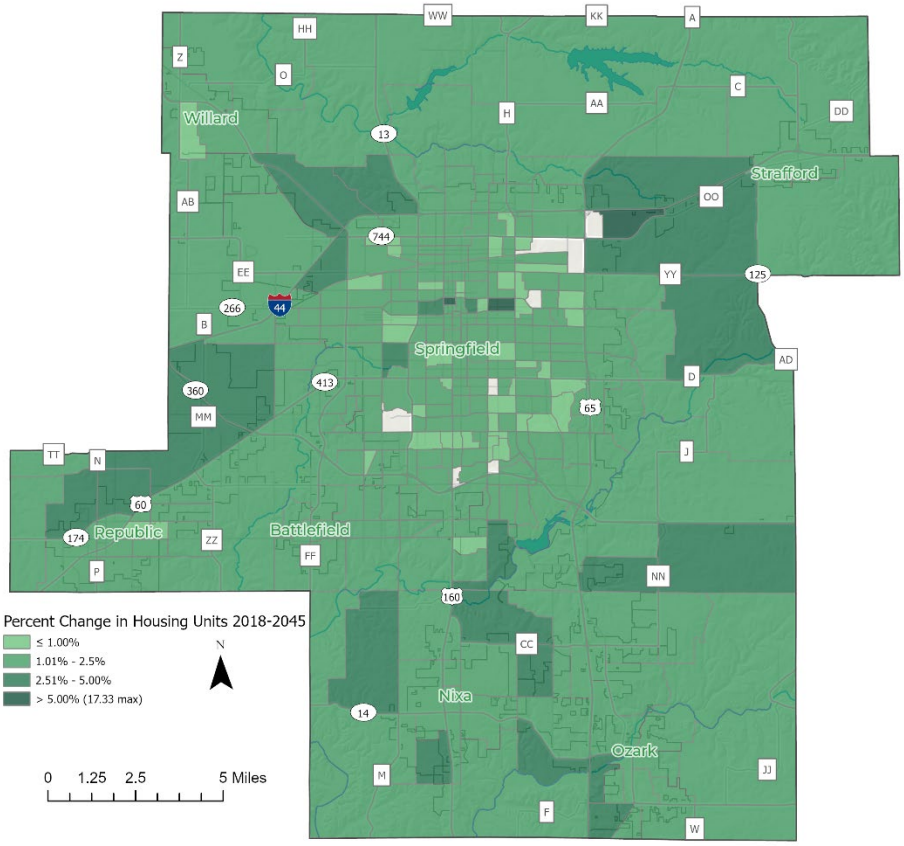
**3**: Two-County Area Population

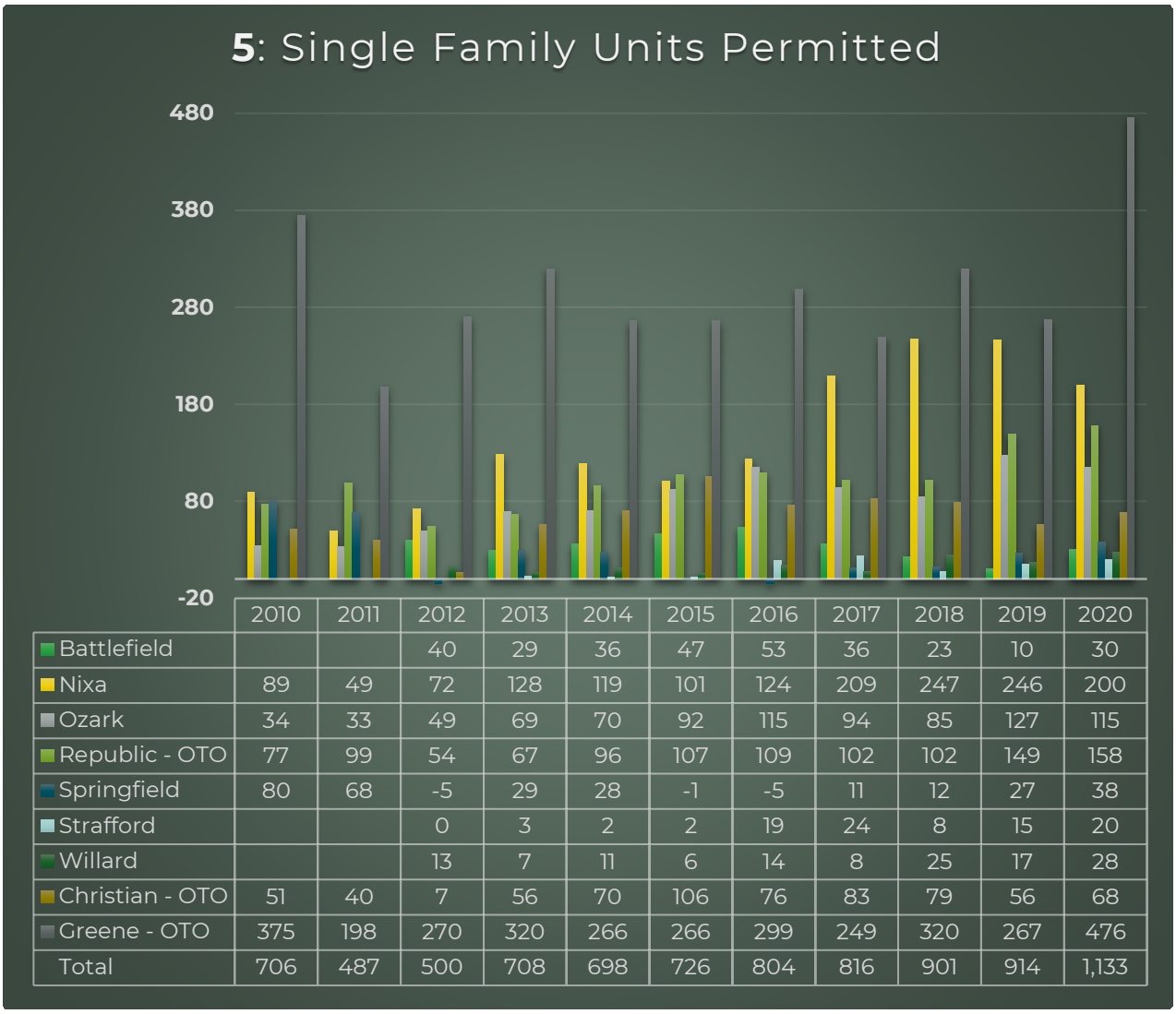



*Source: US Census/OTO Travel Demand Model*

The region is projected to grow through 2045, as well, adding over 100,000 to Christian and Greene Counties, with the majority of this growth expected to be within the OTO region. Housing unit density is expected to change the most in the immediate center city of Springfield, followed by the edges of OTO's municipal jurisdictions. This is demonstrative of the land available for new housing construction.

**4**: Percent Change in Housing Units 2018-2045



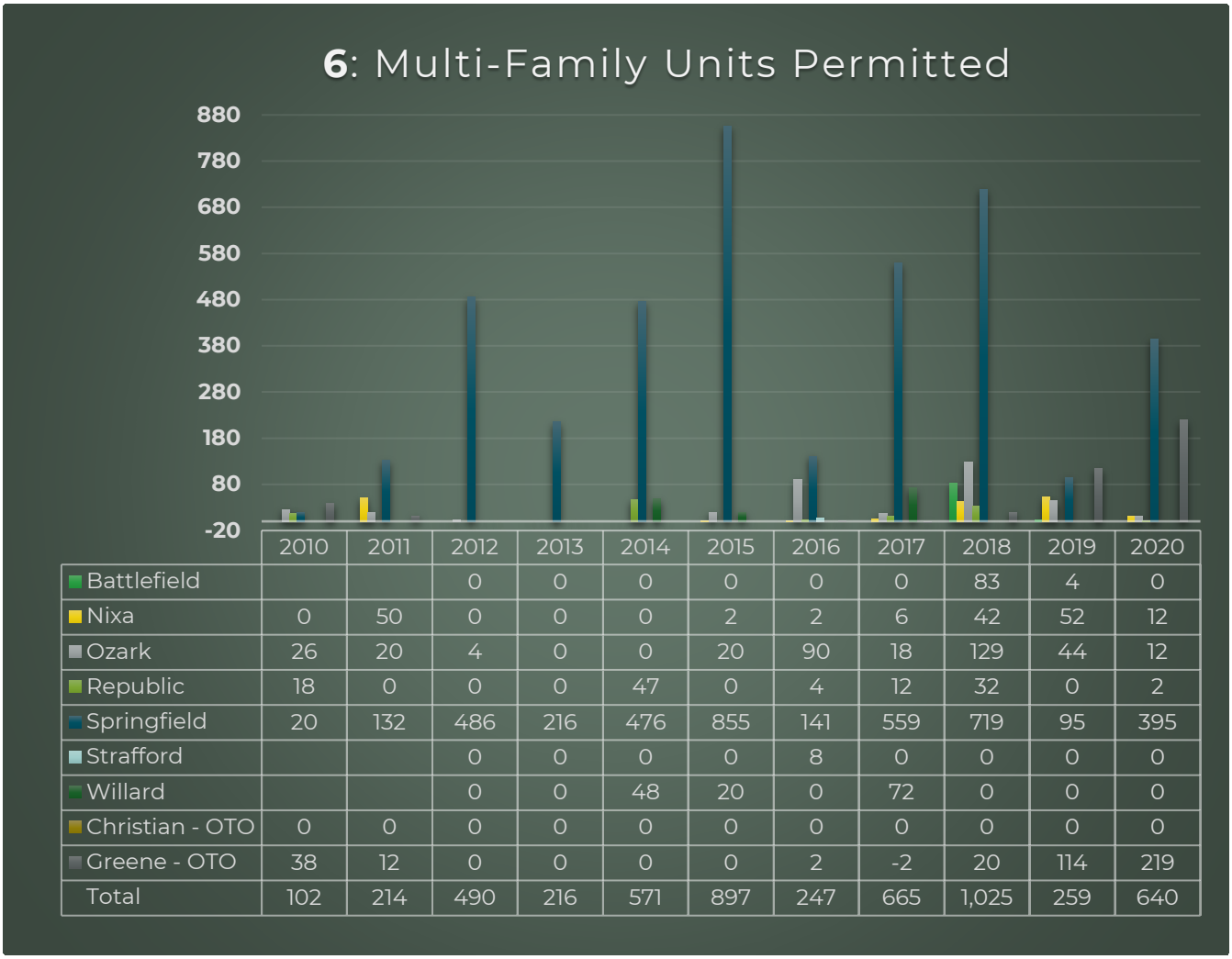



| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Battlefield | | | 40 | 29 | 36 | 47 | 53 | 36 | 23 | 10 | 30 |
| Nixa | 89 | 49 | 72 | 128 | 119 | 101 | 124 | 209 | 247 | 246 | 200 |
| Ozark | 34 | 33 | 49 | 69 | 70 | 92 | 115 | 94 | 85 | 127 | 115 |
| Republic - OTO | 77 | 99 | 54 | 67 | 96 | 107 | 109 | 102 | 102 | 149 | 158 |
| Springfield | 80 | 68 | -5 | 29 | 28 | -1 | -5 | 11 | 12 | 27 | 38 |
| Strafford | | | 0 | 3 | 2 | 2 | 19 | 24 | 8 | 15 | 20 |
| Willard | | | 13 | 7 | 11 | 6 | 14 | 8 | 25 | 17 | 28 |
| Christian - OTO | 51 | 40 | 7 | 56 | 70 | 106 | 76 | 83 | 79 | 56 | 68 |
| Greene - OTO | 375 | 198 | 270 | 320 | 266 | 266 | 299 | 249 | 320 | 267 | 476 |
| Total | 706 | 487 | 500 | 708 | 698 | 726 | 804 | 816 | 901 | 914 | 1,133 |

***Source: OTO 2020 Growth Trends***

In 2020, single-family housing permits reached the highest level since 2007 (1,558). The increase is mostly attributable to development in Greene County and the cities of Nixa and Republic. The permit total for new single-family structures in the OTO Area was offset by the demolition 113 houses. Most demolitions occurred in Springfield (67) and Greene County (24).

From 2010 to 2020, most multi-family housing construction permits were issued in the city of Springfield. In 2020, the total number of multi-family units permitted climbed to the 4th highest total in the last ten years. The largest number of the 640 multi-family units added in the OTO area were in the city of Springfield. Greene County issued its highest number of multi-family units since 2009 (237).

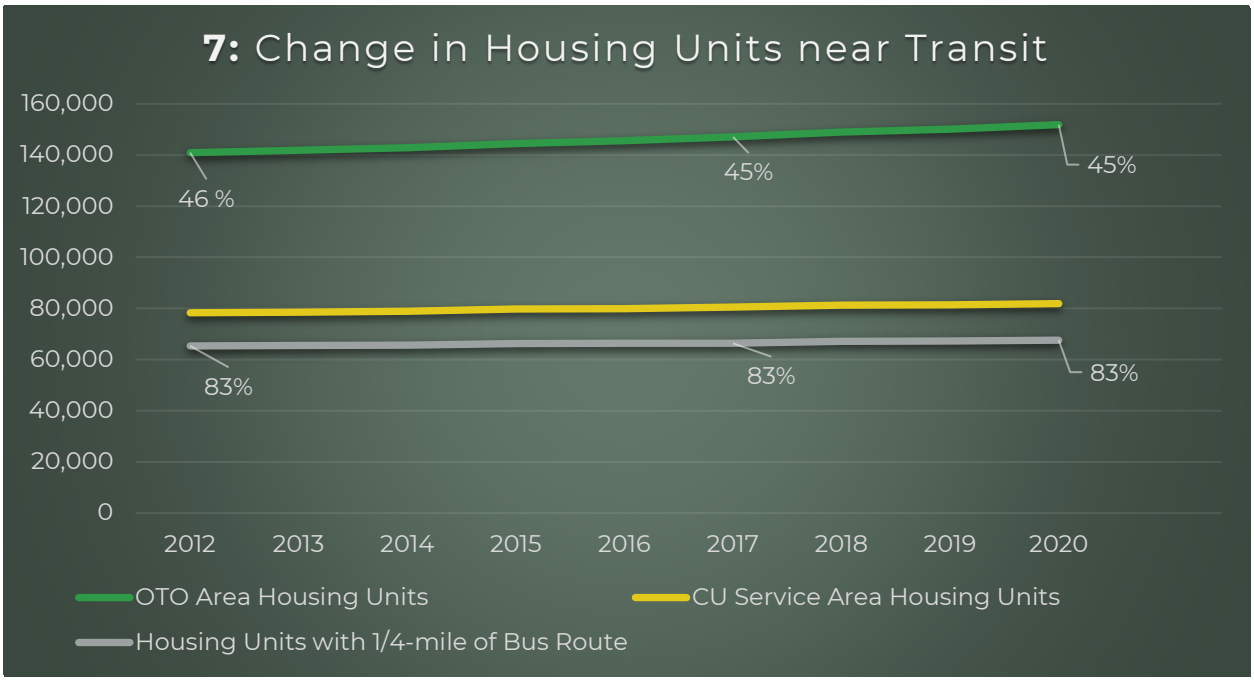



| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Battlefield | | | 0 | 0 | 0 | 0 | 0 | 0 | 83 | 4 | 0 |
| Nixa | 0 | 50 | 0 | 0 | 0 | 2 | 2 | 6 | 42 | 52 | 12 |
| Ozark | 26 | 20 | 4 | 0 | 0 | 20 | 90 | 18 | 129 | 44 | 12 |
| Republic | 18 | 0 | 0 | 0 | 47 | 0 | 4 | 12 | 32 | 0 | 2 |
| Springfield | 20 | 132 | 486 | 216 | 476 | 855 | 141 | 559 | 719 | 95 | 395 |
| Strafford | | | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 |
| Willard | | | 0 | 0 | 48 | 20 | 0 | 72 | 0 | 0 | 0 |
| Christian - OTO | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greene - OTO | 38 | 12 | 0 | 0 | 0 | 0 | 2 | -2 | 20 | 114 | 219 |
| Total | 102 | 214 | 490 | 216 | 571 | 897 | 247 | 665 | 1,025 | 259 | 640 |

***Source: OTO 2020 Growth Trends***

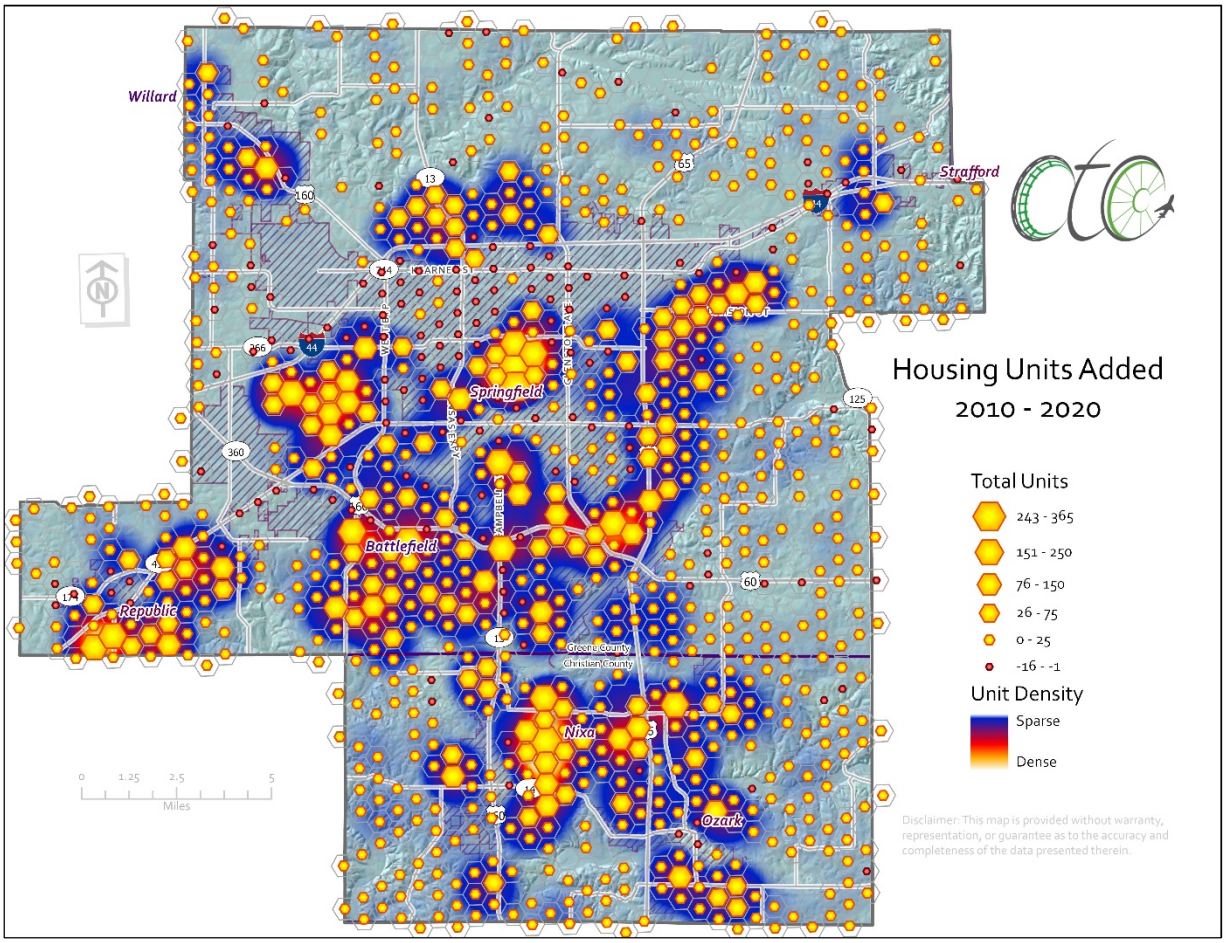
OTO analyzes these changes in housing units alongside proximity to CU Transit fixed-route bus service. This demonstrates whether or not density in the OTO area is locating near transit. Since 2012, the percentage of households within the CU Service Area (the Springfield city limits) has remained steady at 83 percent, however, that number has slighly reduced for the OTO area from 46 to 45 percent. While these numbers show that housing growth in the region is not densifying near transit, the majority of households in Springfield do have access to transit and the outlying growth is only having a minimal effect.

OTO produces an annual growth trends report that examines recent and historical growth patterns, as well as a variety of demographic and socioeconomic characteristics. This information and more can be found on the OTO website.

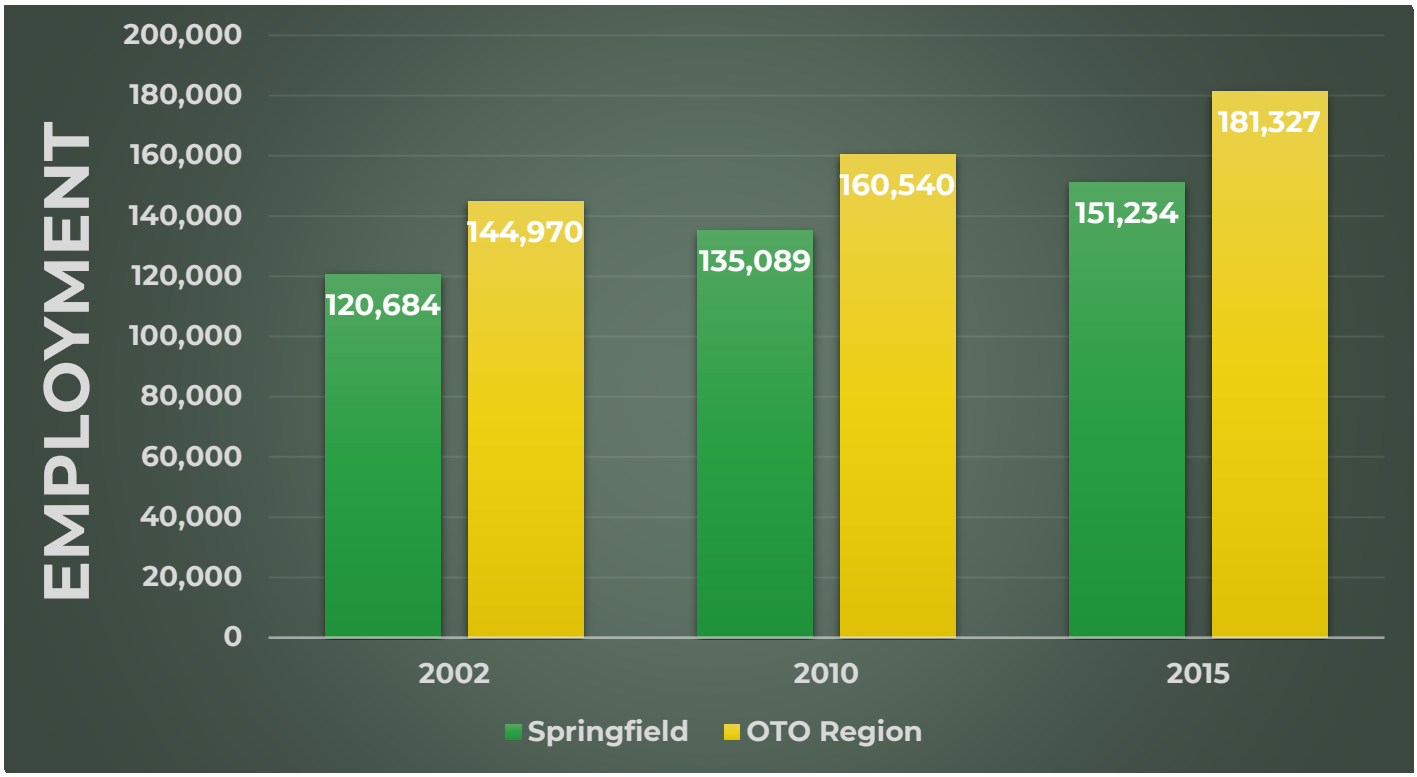



***Source: OTO 2020 Growth Trends***

**8**: Housing Units Added 2010-2020



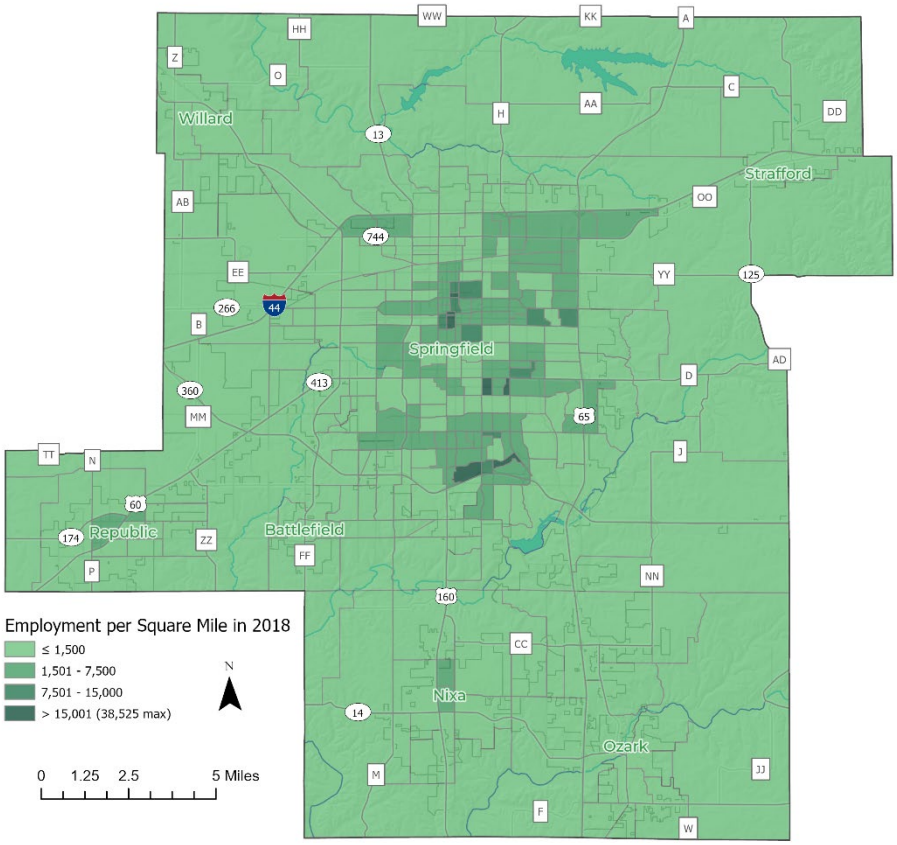
**9**: Two-County Area Employment




***Source: US Census Bureau***

**10**: 2018 Employment per Square Mile

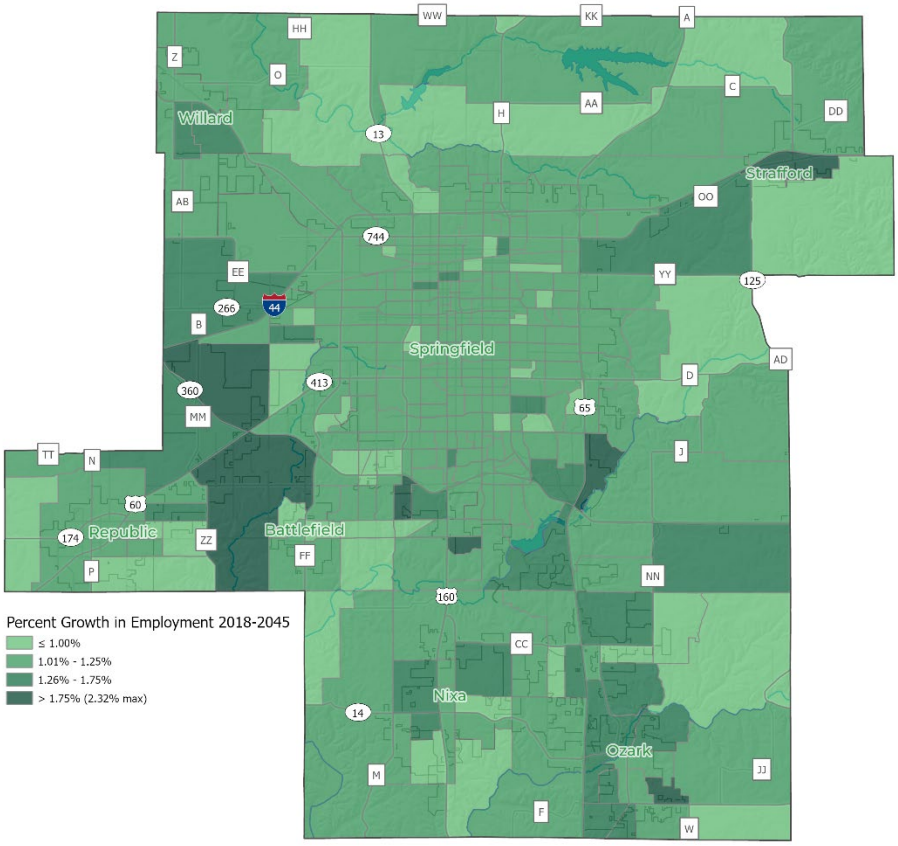
The proportion of employment in Springfield compared to the OTO region has stayed stable at around 83 percent. Current employment density is concentrated in Springfield, especially surrounding the hospitals and universities.

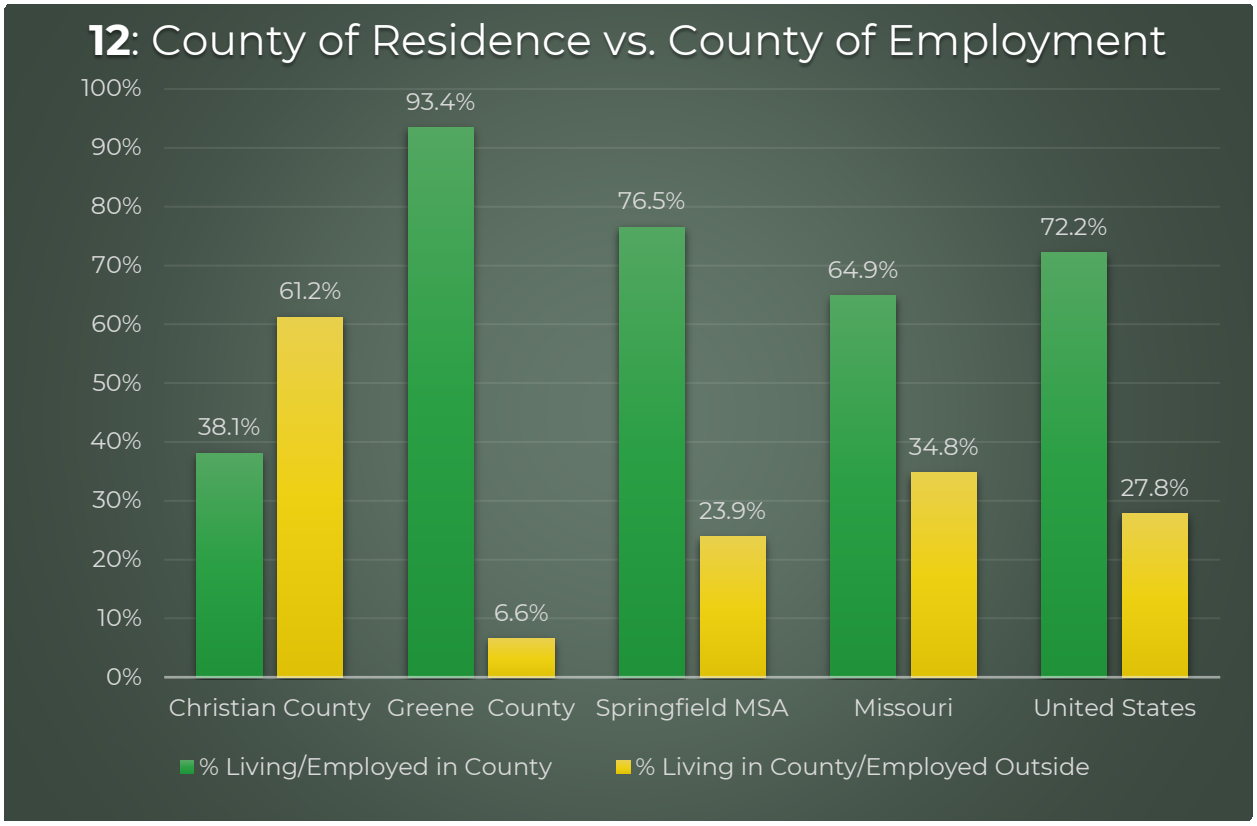


The greatest growth in employment density is expected in the surrounding areas, near the highways which traverse the region.

Of the people who work in Greene County, 93.4 percent also live in Greene County. Conversely, the majority (61.2%) of Christian County residents commute to another county for work. The MSA percentage of workers living in the same county as they are employed is comparable to that of the United States but over ten percent more than Missouri.

**11**: Employment Growth 2018-2045




***Source: 2015-2019 American Community Survey***

OTO tracks the average commute-to-work time reported through the American Community Survey by the US Census Bureau. While this information is unavailable for 2020 and the impacts of COVID-19 are yet unknown, the commute time has been slowly growing for the region. The average commute time for all of Christian and Greene Counties is 22.9 minutes and for the cities in OTO, the average commute time is 23.1 minutes. The goal is to keep OTO's average commute time, as calculated by an average of cities in the OTO, below 25 minutes. While Nixa, Ozark, and Christian County are above that time, the average for the region has not grown quickly. With employment growth throughout the region, this should enable more commuters to live near where they work.

**13**: Journey to Work (in Minutes)

| | 1990 | 2000 | 2015-2019 | Difference in Minutes, 2000 to 2015-2019 |
|---|---|---|---|---|
| Christian | 27.4 | 25.1 | 25.8 | 0.7 |
| Greene | 17.6 | 19.2 | 20 | 0.8 |
| Battlefield | 22.6 | 23.1 | 22.5 | -0.6 |
| Fremont Hills | 17 | 19.8 | 22.1 | 2.3 |
| Nixa | 19.1 | 23.8 | 25.1 | 1.3 |
| Ozark | 19.2 | 21.6 | 25.4 | 3.8 |
| Republic | 21.6 | 25.1 | 24.3 | -0.8 |
| Springfield | 15.7 | 17 | 18.2 | 1.2 |
| Strafford | 20.4 | 22.4 | 22.7 | 0.3 |
| Willard | 23.2 | 23 | 24.1 | 1.1 |
| Average of Greene/Christian | 22.5 | 22.2 | 22.9 | 0.7 |
| Average of OTO Cities | 19.9 | 22 | 23.1 | 1.1 |

***Source: 2015-2019 American Community Survey***

## Current System Condition

OTO uses a variety of tools to analyze the current state of the system. Much of this ties into the OTO project prioritization process and informs decision making.

### High Volume Corridors

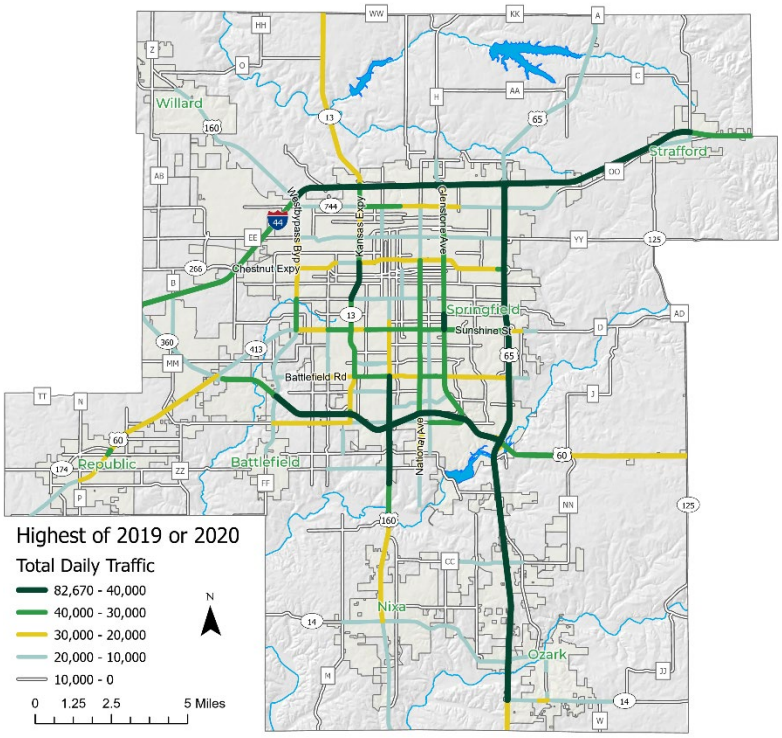
OTO's highest volume corridors are I-44 and US 65, as well as James River Freeway, S. Campbell, and small portions of Kansas Expressway and Glenstone inside the City of Springfield.

### Safety

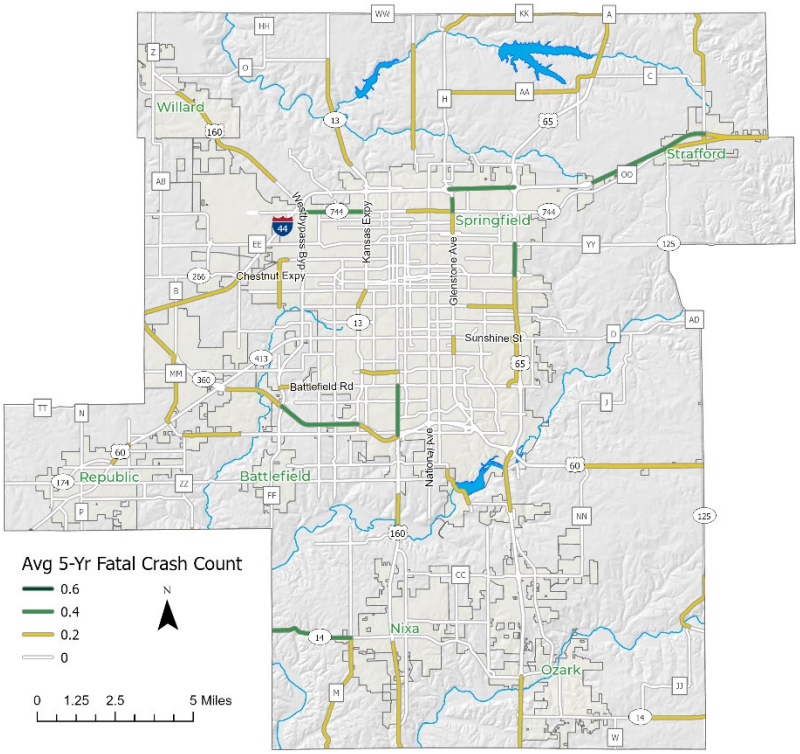
OTO reviews safety data from a variety of perspectives. Besides the system-wide information reported via the national performance measures, it's important to understand which segments are hot spots for various crash types. The OTO five-year fatal crash numbers are trending upwards. These crashes tend to be on higher speed routes, including I-44, US 65, and James River Freeway. Higher fatal crash locations can also be seen on west Kearney and MO 14 west of Nixa.

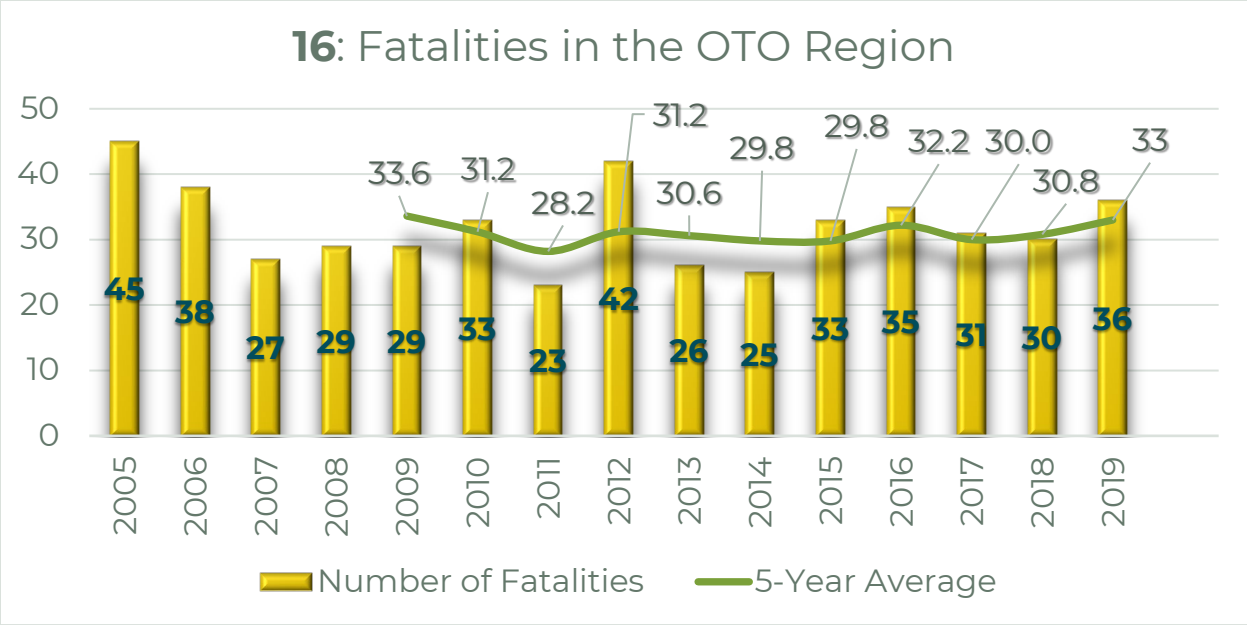
This map of fatal crash locations shows the average number of fatal crashes on a segment over a five year period. No segment is averaging even one crash per year, with the highest segment average at 0.6.

**14**: High Volume Corridors




**15**: Fatal Crash Locations (2015-2019)

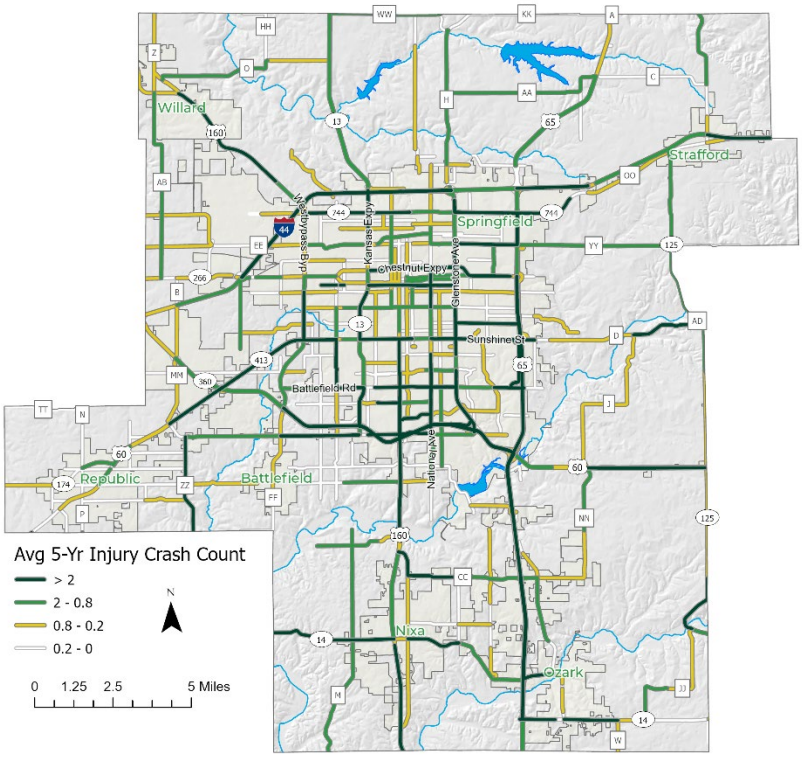





***Source: MoDOT***

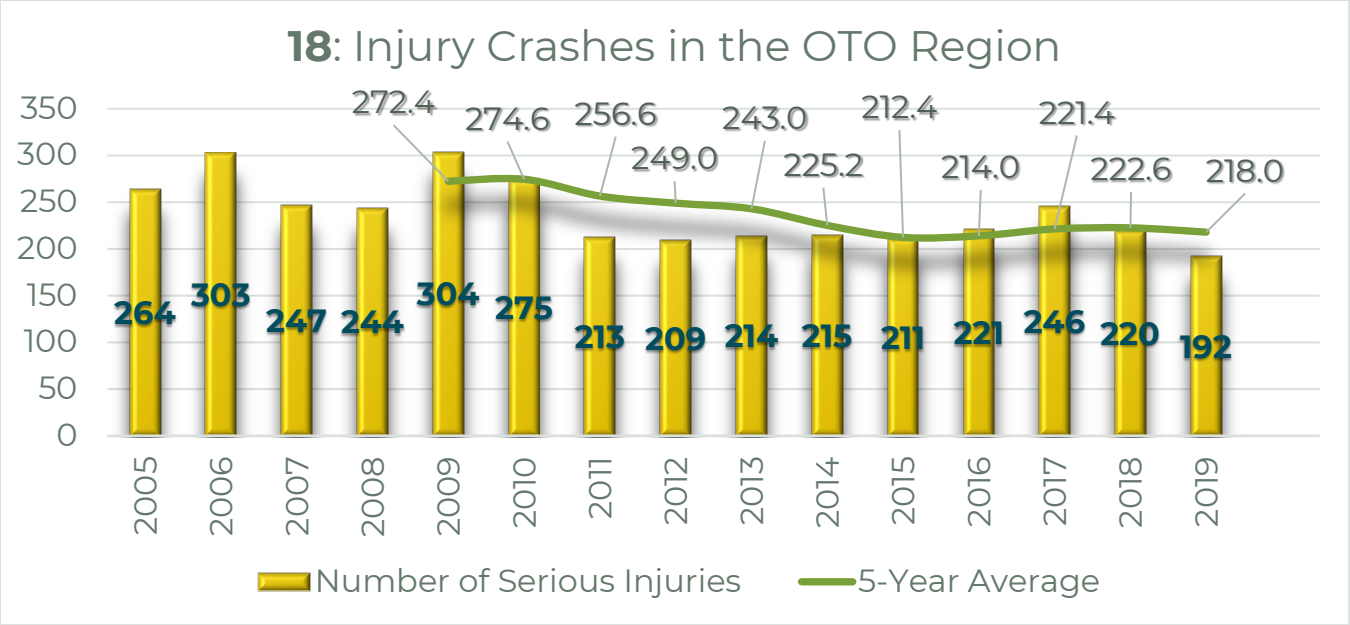
Injury crashes appear throughout the OTO region, though still seen more frequently on higher speed and higher volume routes. This includes I-44, US 65, James River Freeway, US 160 both north and south, MO 14, and arterials such as Kearney, Chestnut, Sunshine, Glenstone, and south National and Campbell. This map shows the average number of injury crashes on a segment over five years.

**17**: Injury Crash Locations (2015-2019)




The number of injury crashes have been fairly steady, however 2017 saw a spike in injury crashes, also with slightly higher years in 2016 and 2018.

Several improvements in recent years have targeted some of these locations, however, distracted driving is a contributing factor in many crashes throughout Missouri.




Show-Me Zero

***Source: MoDOT***

*Show-Me Zero* is MoDOT's Strategic Highway Safety Plan. This has replaced the Blueprint for Roadway Safety. OTO has agreed to plan and program in support of MoDOT's safety targets and supporting *Show-Me Zero*, promoting safer roadways in the OTO region. The plan has four emphasis areas which go beyond engineering solutions:

- Occupant Protection
- Distracted Driving
- Speed and Aggressive Driving
- Impaired Driving

Also receiving special attention in the plan are pedestrians and other non-motorized road users. Recommended strategies for metropolitan planning organizations from *Show-Me Zero* are included with the recommendations of *Destination 2045*.

## Congestion

OTO uses a number of tools to determine congested corridors. Through FHWA and MoDOT partnerships, OTO has access to HERE and INRIX travel time data, mostly along freeways and major arterials. Local partnerships with MoDOT and the City of Springfield utilize strategically placed wi-fi-based travel time units, which provide information on additional roadways. A number of projects along identified corridors of concern are under construction or programmed in the FY 2022-2025 Transportation Improvement Program, with anticipated benefits not yet reflected.

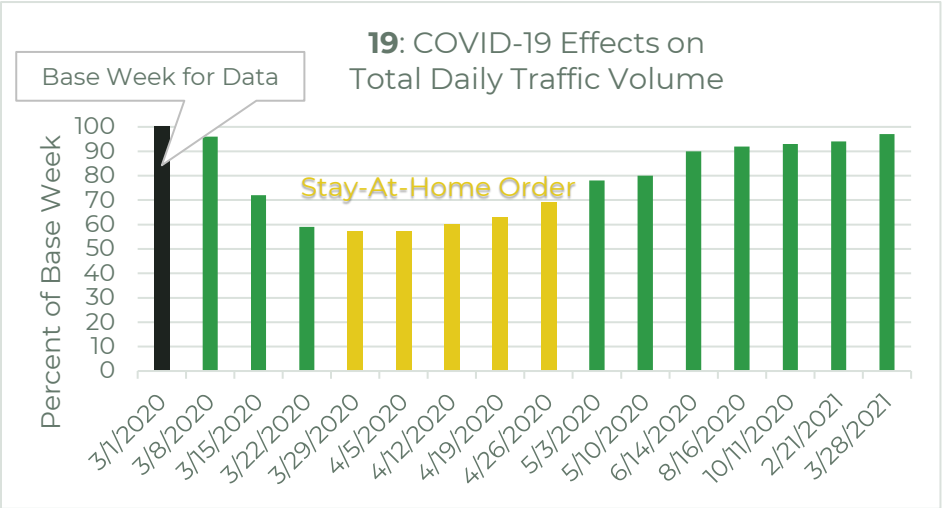
### Travel Delay

Travel delay is analyzed for the AM and PM peaks. Different thresholds are used on arterials versus freeways to accommodate the differing traffic controls and user expectations of those facilities. Travel delay in the AM is minimal with most impact on US 160 in Nixa to south of Battlefield Road, Route CC, MO 14 through Ozark,

Division in center Springfield/west of Springfield, east Kearney, Glenstone north of Sunshine, Battlefield west of Kansas Expressway, Kansas Expressway north of Kearney/south of Grand, West Bypass, portions of Sunshine, and US 60 west of Republic.

Travel delay in the PM is more severe with the worst locations along Sunshine/413/60 from center Springfield through Republic, Campbell south of Battlefield Road, James River Freeway, Kansas Expressway north of Kearney, MO 14 through Ozark, I-44, US 160 between Willard and Springfield, and MO 125 from Route D to Strafford.

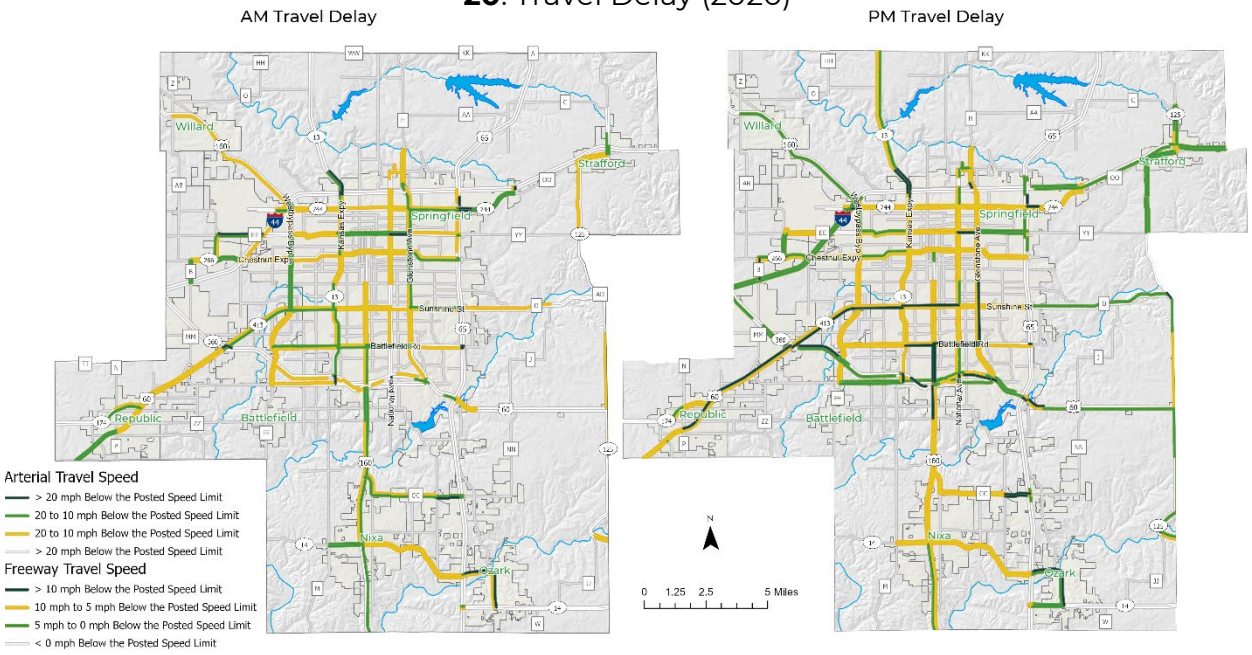
COVID-19 provided a snapshot of how increased travel demand management can free capacity on the roadways. FHWA, MoDOT, and Missouri MPOs are looking into ways to capture these results long-term. Increased telework can reduce demand on the roadways, especially during peak travel times. Consequences, however, can include increased traffic speeds and aggressive driving. Alternately, COVID-19 slowed carpool usage as social/physical distancing became a tool to prevent the spread. While COVID-19 initially seemed a short-term disrupter of typical travel patterns, its effects may be felt long term and aren't yet fully known.




**19**: COVID-19 Effects on Total Daily Traffic Volume

***Source: City of Springfield***

**20**: Travel Delay (2020)

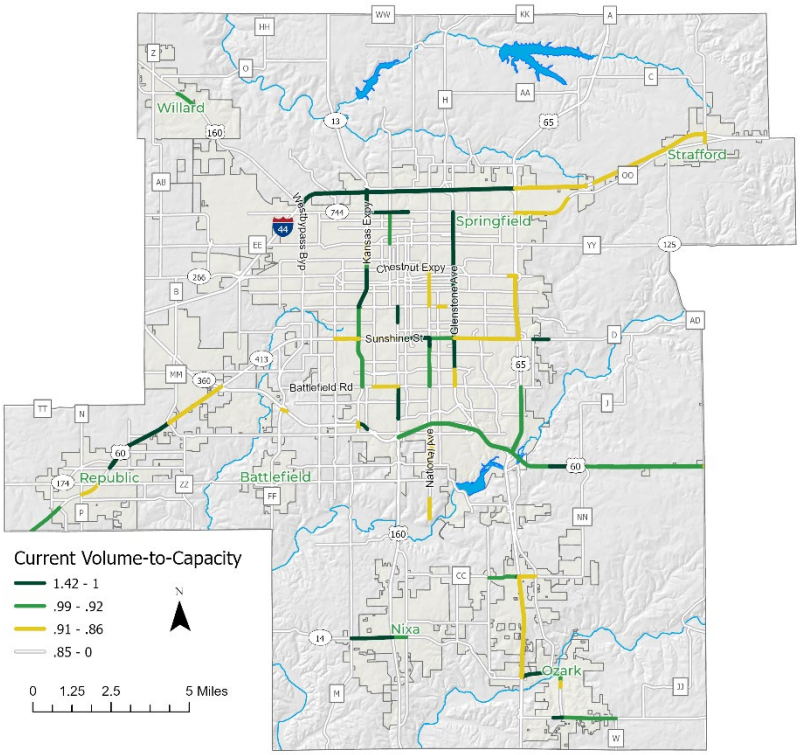


## Current Volume-to-Capacity Ratio

The capacity of each roadway has been determined for use in the travel demand model. Traffic volumes are then compared to these capacities to determine if a roadway is nearing or over capacity. This has a direct impact on travel time and roadway safety. Commercial truck traffic also plays a role, with each commercial vehicle receiving an equivalency of three passenger cars.

Current analysis shows that OTO's most congested roadways include I-44, Kansas Expressway, Kearney, Glenstone, and US 60 near Republic, with further congestion shown on Sunshine, US 65, US 60 in east Springfield, as well as east of Springfield. In Nixa and Ozark, MO 14 also shows localized congestion.

**21**: 2019/2020 Volume-to-Capacity

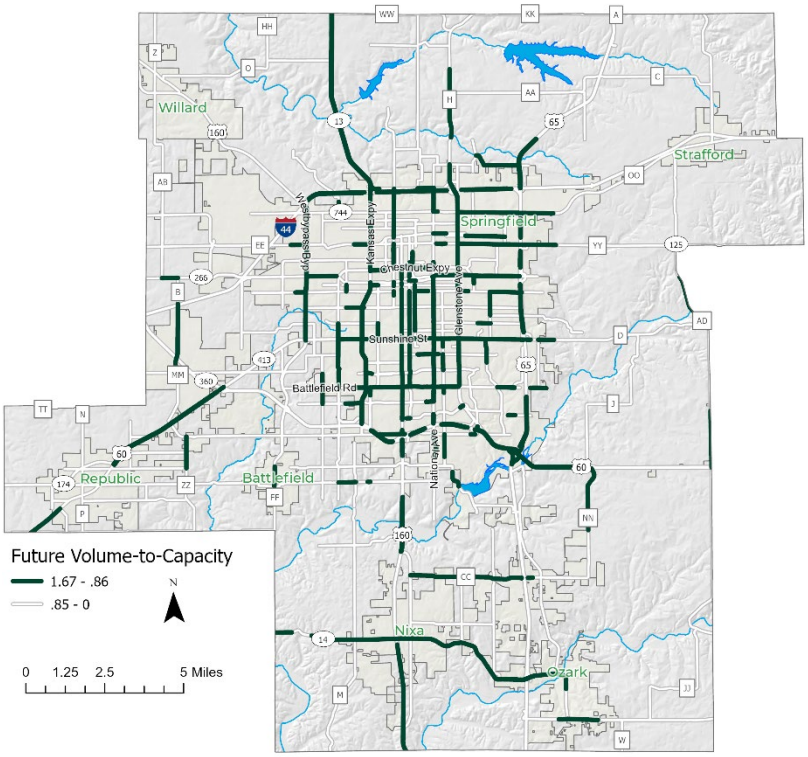



## Future Volume to Capacity Ratio

The travel demand model projects future traffic volumes to 2045 based on assumptions regarding population and employment growth, as well as changes to the roadway network. The 2045 Volume-to-Capacity map shown here assumes a no-build scenario where no more improvements are made to the roadway network beyond those committed in 2018.

Congestion in 2045 is expected to grow throughout the region if no improvements are made to the network, especially on the arterial network and on regional connections outside of the area.

**22**: 2045 Volume-to-Capacity



## Aviation and Goods Movement

### Aviation

The main air facility in southwest Missouri is the Springfield-Branson National Airport. This is the primary air connection to the national and international markets. The region also has a private aircraft airport, the Downtown Airport, which coupled with the general aviation facility at the Springfield-Branson airport, serves the charter and private aircraft needs for the community.

The midfield terminal at the Springfield-Branson National Airport opened in 2009 and was built with expansion in mind. The new terminal was built with 10 gates in operation and can grow to 60 gates at full operation. A number of roadway improvements were also made with the opening of the new terminal.

The general aviation facility at the Springfield-Branson National Airport serves all the additional flights at the airport that are not part of the scheduled passenger flights or related to cargo. Supporting cargo, the airport is also considered part of a 23-county Foreign Trade Zone, allowing for the deferment of U.S. Custom's duty payment until goods are sold in the United States. With nearby Partnership Industrial Center West, freight and intermodal transfers are important considerations for this area of the OTO region.

In 2018, the Springfield-Branson National Airport experienced over 1 million passengers for the first time in airport history. This number was exceeded in 2019, however, COVID-19 made a major impact on the airline industry, and it may take two to three years for passenger flights to fully recover. One concern, however, is that the advent of online meetings during COVID-19 will continue to impact business travel in the future. The prior balance of travel was heavily business-biased, so recovery will likely depend upon the return of that travel. Cargo was less impacted by COVID, with weights in 2020 less than 2019, but higher than 2017 and close to 2018. As of June 30, 2021, year-to-date cargo levels were up 9 percent over 2019.

The long term plans for the airport include a secondary runway, though the existing runway would likely be expanded first. Asset management is a concern for the Airport, just as it is for other transportation facilities. In 2019, the Airport conducted a pavement condition study and identified areas in need of improvement.

One area of concern is providing room for additional hangar development and connecting that with the appropriate facilities. There has been recent growth in large hangar development. This includes expansion of a maintenance facility for Envoy, who flies for American Airlines, as well as several others that have yet to be announced. The airport is also working to expand their cargo apron to support this growth.

A foremost goal of the airport is to protect their easements and air space needs. They are continually working with area communities to protect these needs as growth continues.

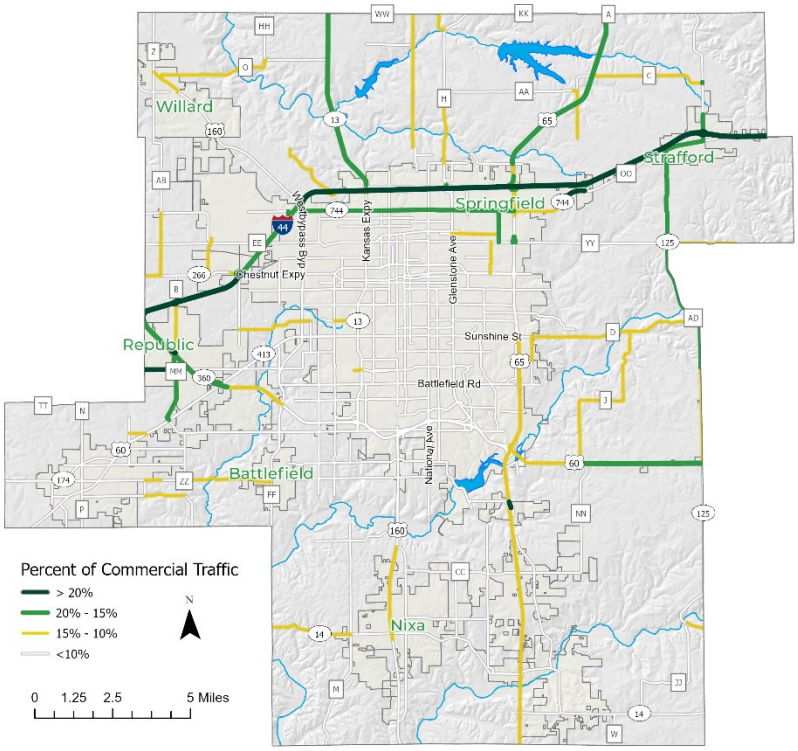
## Goods Movement

Freight has an impact on the capacity and operational movements of the roadway. Those connections that connect the OTO area to the broader region, state, and beyond are those that have the highest percentage of commercial traffic, including I-44, US 65 north of I-44, MO 13 north of I-44, US 60 east of Springfield, MO 125, Kearney, and the US 360/MM area.

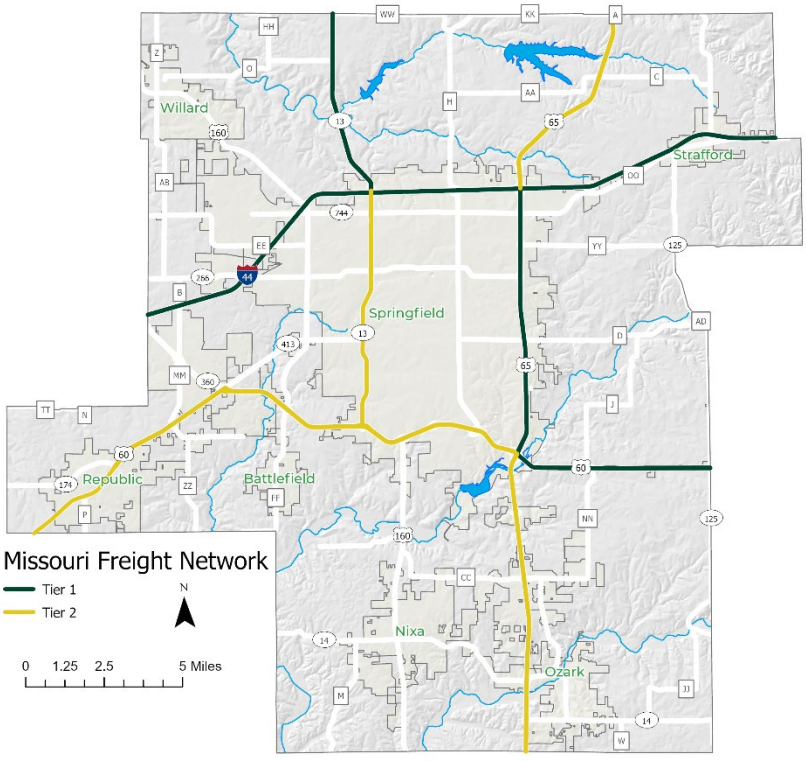
This corresponds with the top two tiers of the Missouri Freight Network. The Missouri 2017 Freight Plan identified Tier 1 and Tier 2 freight corridors, signifying importance. The primary criteria include functional classification and freight tonnage.

OTO participated with a multi-state committee to develop the Heartland Freight Technology Plan, concluding in October 2020. This plan includes findings on the assessment, management, and regional harmonization of emerging freight technologies. It is recommended that OTO continue to participate in similar studies and promote participation in freight decision-making with representation from southwest Missouri.

**23**: Percent Commercial Traffic




**24**: Missouri 2017 Freight Network



MoDOT is currently drafting the 2021 Missouri Statewide Freight and Rail Plan. This plan is comprehensive and provides guidance at the regional level in coordination with statewide objectives. The 2021 Plan will focus on:

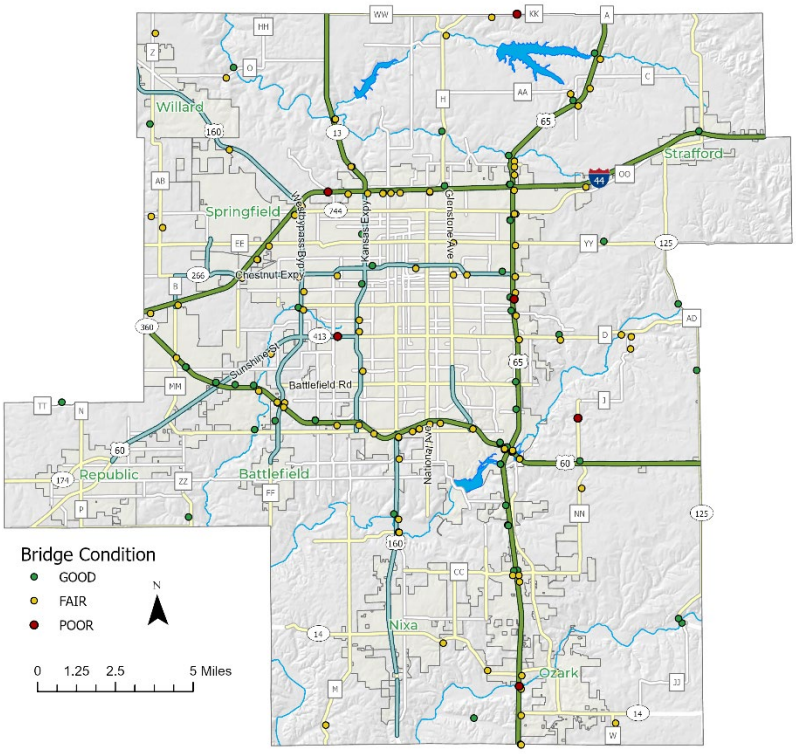
- The Safety of all who use Missouri's transportation
- Mobility and the Reliability of the entire system so that freight can move efficiently
- System Preservation to minimize maintenance and repair costs
- Enhancing Missouri's Economic Competitiveness, bringing greater revenue to the state
- Promoting Choice for how businesses ship their goods

OTO has participated in stakeholder meetings and will continue to monitor the outcomes of this planning process.

## Bridge/Roadway Condition

Bridge condition ratings are calculated by taking the lowest sub-rating of the super-structure, sub-structure, and deck. Ratings range from 3 to 9. At a bridge rating of 3, bridges are closed to the public. A bridge rating of 5 is considered Fair, with all primary structural elements as sound, though they may have minor section loss, cracking, spalling, or scour. A bridge rating of 9 is Excellent.

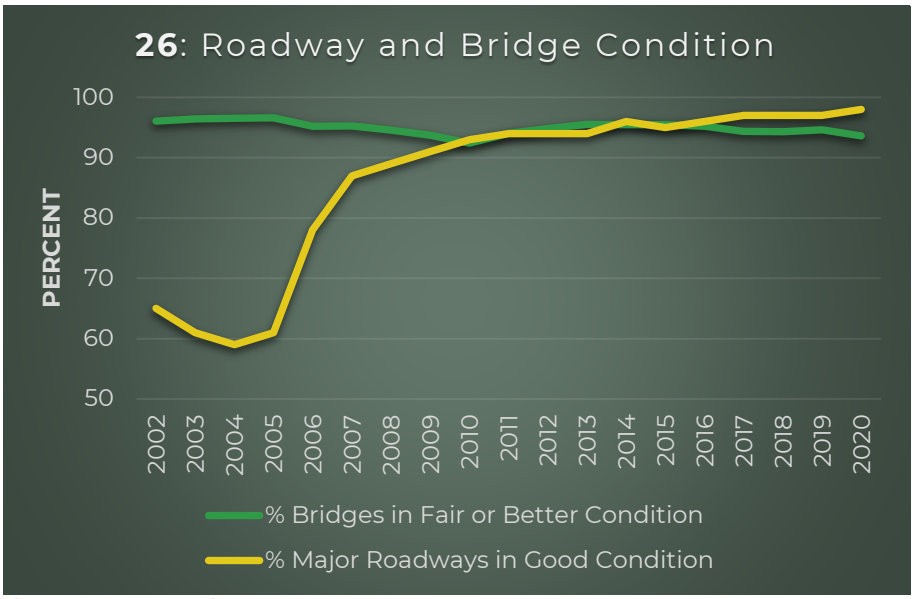
**25**: Bridge Condition (2020)




Most of the bridges in the OTO area are in fair or better condition, with just a few classified as poor. Unfortunately, the majority of bridges are classified as fair, and the next bridge inspection can change that rating. Many of the bridges in the OTO region are along major roadways such as I-44, US 65, and James River Freeway. It is important that upcoming projects work to preserve or rehabilitate these bridges, limiting further issues in the future.

Roadway condition ratings use factors such as smoothness and physical distress to determine quality. As of 2020, 98 percent of OTO's major roadways were in good condition. Major roads include principal arterials, interstates, freeways, and

expressways. As seen in the adjacent chart, bridge conditions have been maintained and roadway conditions have improved due to a focus on asset management and increased investment mechanisms available through Amendment 3 bonds authorized by Missouri voters in 2004.




***Source: MoDOT***

## Congestion Management Plan

OTO updated the Congestion Management Process Monitoring report in 2019. This report pulls together a variety of data to determine which roadways in the OTO are congested, why they are congested, and what strategies are most effective at mitigating congestion. The 2019 report has confirmed the prior trends of lower congestion in the AM peak and higher congestion in the PM peak.

There are four elements OTO reviews to determine congested roadways and intersections:

- Volume-to-Capacity Ratio
- Crash Frequency
- Average Travel Speeds
- Intersection Level-of-Service

These four elements are combined to identify congested roadways (crashes, volume-to-capacity ratio, travel speed) and congested intersections (intersection level-of-service, volume-to-capacity ratio, travel speed). Similar measures are also considered in the OTO Prioritization Criteria, as seen in Appendix 2.

The 2019 report identified congested roadways and intersections. OTO is working with MoDOT and its members to address these congestion issues as feasible. Additionally, MoDOT and the City of Springfield partner to improve operations along these roadways through the Traffic Management Center of the Ozarks and through MoDOT's Transportation Systems Management and Operations (TSM&O) focus areas of traffic incident management, work zone management, and advancing technology and roadway operations.

### MoDOT TSM&O Primary Focus Areas

- Traffic Incident Management
- Work Zone Management
- Advancing Technology and Roadway Operations

### Congested Roadways Identified in 2019

- Campbell
  - Primrose to Republic ..... *Destination 2045* Unconstrained List
- Glenstone ..... Operational/Safety Improvements in FY 2022-2025 TIP
  - At Kearney
  - Chestnut to Monroe
  - Portland/Cinderella to Battlefield
- Kansas Expressway ..... *Destination 2045* Constrained List
  - Talmage to Kearney
  - Bennett to Sunshine
  - Battlefield to James River Freeway
- Kearney ..... *Destination 2045* Constrained List
  - US 65 to Le Compte
- National ..... No Improvements Currently Planned
  - At Battlefield
- Sunshine ..... Scoping for Operational/Safety Improvements in FY 2022-2025 TIP
  - At Campbell
  - National to Glenstone
  - Lone Pine to Oak Grove
  - Deeswood to US 65
- US 160
  - Rt. AA to Rt. CC..... Programmed in FY 2022-2025 TIP
- US 60
  - MO 174 to Oakwood ..... MM Relocation Programmed in FY 2022-2025 TIP

### Congested Intersections Identified in 2019

- Campbell and Republic ..... Under Construction
- Kansas and Sunshine ..... Programmed in FY 2022-2025 TIP
- Kansas and Walnut Lawn ..... Programmed in FY 2022-2025 TIP
- Kansas and WB James River Freeway..... Programmed in FY 2022-2025 TIP
- Sunshine and National ..... Scoping for Operational/Safety Improvements in FY 2022-2025 TIP
- US 60 and Rt. MM/M..... MM Relocation Programmed in FY 2022-2025 TIP

## Traffic Incident Management

As recommended in *Transportation Plan 2040*, OTO coordinates a Traffic Incident Management Committee for the region. The committee adopted the *TIM Strategic Plan, Phase I* in 2016. This plan saw progress toward the adoption of response procedures, the regular debriefing of major incidents, the acquisition of safety equipment for local responders, and surveying of local towing providers. Phase II, adopted in 2020, formalizes the committee's structure and increases the integration of response efforts:

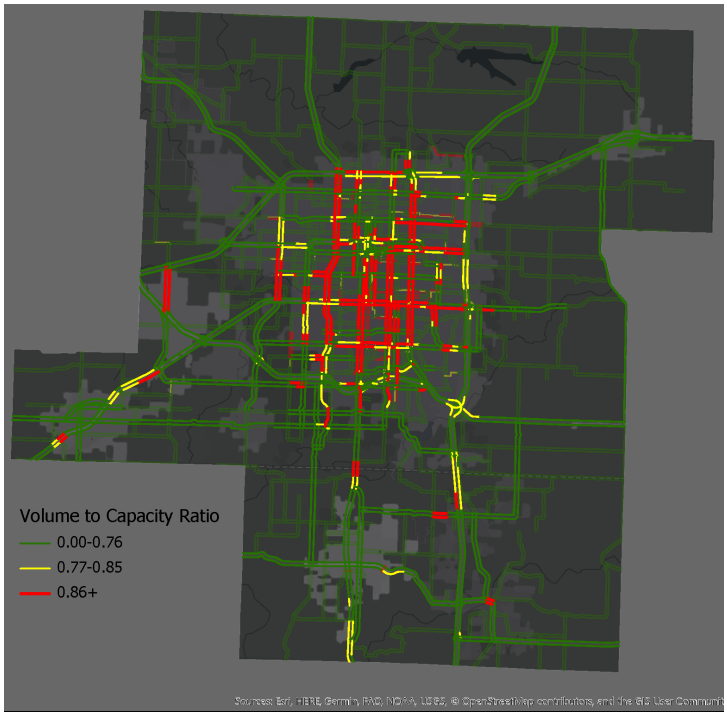
- Endorsement of OTO TIM Operations Guidelines by Local Jurisdictions
- MOU with Examiner's Office Concerning Vehicle Movements
- Site Visits with Agency Leadership
- Formalize Incident Clearance Time Target
- Formalize Roadway Clearance Time Target
- Hold TIM Training Quarterly in the OTO Area
- Bi-Annual Training Survey to Determine Training Needs
- Conduct Annual TIM Exercise
- Formalize Regional Exercise Procedures
- Establish Bylaws
- Identify Future Co-Chairs

## Travel Demand Model Base and No-Build Scenario

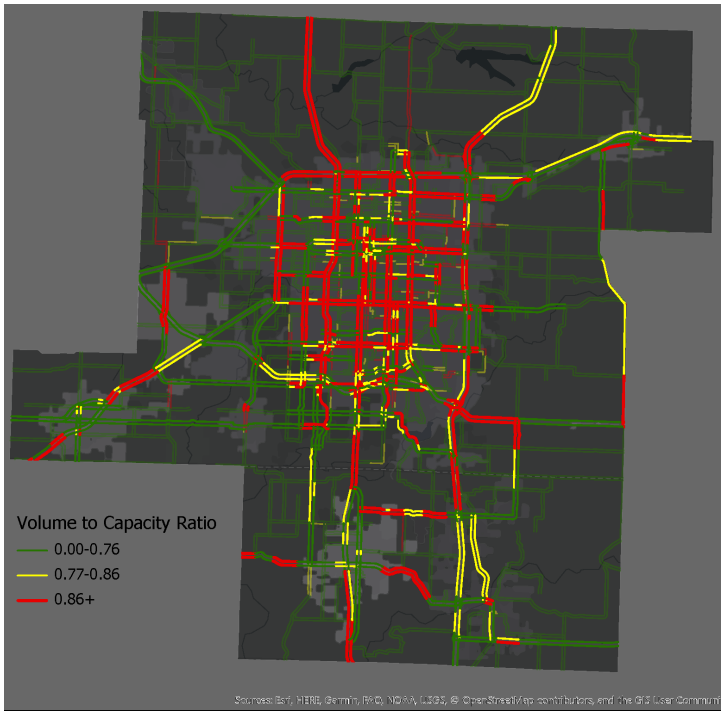
OTO developed a new travel demand model in preparation for *Transportation Plan 2040*, which was adopted in 2016. This model incorporated several unique features, including consideration for node delay, link delay, dynamic trip assignment and distribution, and the use of cellular data to provide information on internal/external trips. OTO contracted with the Bureau of Economic Analysis at Missouri State University to project population and employment for 2040.

To develop the model for *Destination 2045*, OTO staff revised the population and employment projections for 2045. This information is supplied in the previous Demographic and Socioeconomic discussion. OTO staff also updated the

**27**: Travel Demand Model
2018 Existing + Committed Base Year Result




**28**: Travel Demand Model
2045 Existing + Committed Result



transportation network to be used in the model, as well as supplied a listing of projects that had been committed through the Transportation Improvement Program. This information supplied a base year model result for 2018, as well as a 2045 no-build scenario. The results of the constrained project list on the system are included later with that range of alternatives.

Compared to the base year, congestion on OTO's arterials and the majority of freeways is expected to be more widespread. It is important that OTO watch these high volume routes for necessary improvements. The increased congestion corresponds also to those areas where population and employment are expected to grow. Managing the land use and transportation connection will be key to keeping traffic moving throughout the region.

## Transit

Information regarding types of funding available for transit programs can be found later in the *Destination 2045* Investment Plan.

### Providers

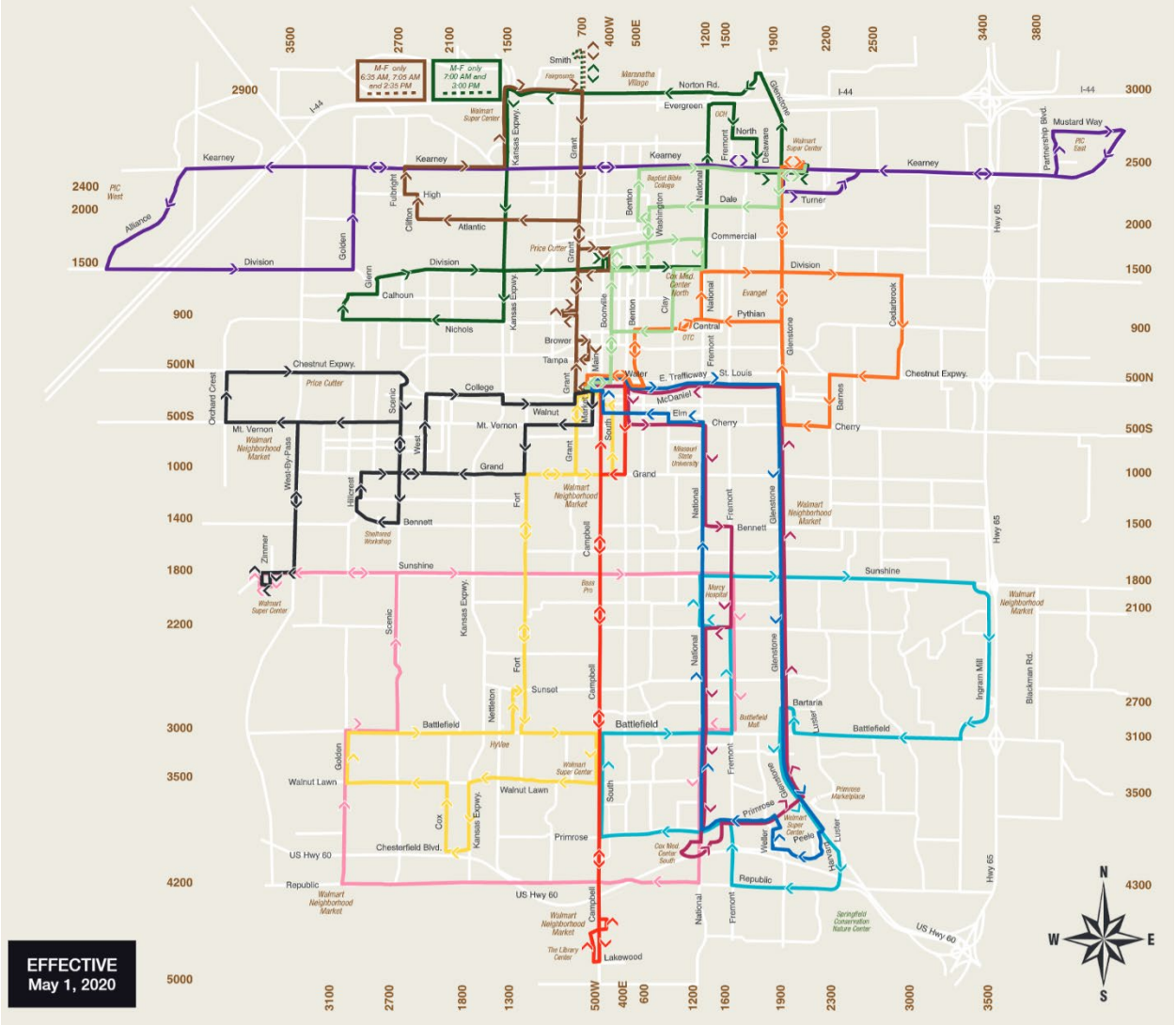
#### City Utilities

City Utilities is the primary fixed-route transit operator in the OTO region. Fixed route service is provided within the City of Springfield seven days a week. City Utilities also offers paratransit service for those who cannot ride the fixed-route bus due to a disability or health condition. CU Transit operates both day and night routes, as well as on weekends and holidays. Routes and schedules may be found at http://www.cityutilities.net/transit/transit.htm.

| CU Service Operates 365 days a year on this schedule: | |
|---|---|
| Monday to Friday Day Routes | 6:00 am to 6:35 pm |
| Monday to Friday Evening Routes | 6:10 pm to 11:10 pm |
| Saturday Day/Evening Routes | 6:00 am to 11:10 pm |
| Sunday Day/Evening Routes | 7:10 am to 11:10 pm |
| Holiday Routes (no Evening) | 8:10 am to 6:10 pm |

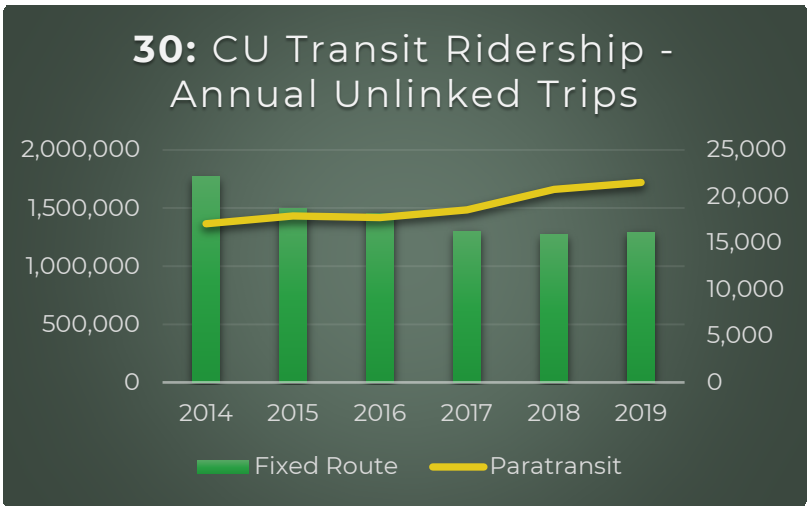
City Utilities has 25 fixed-route buses and 6 paratransit buses, as well as nearly 100 shelters and 200 benches. Hours of operation for transit in Springfield are Monday through Friday, 6:00 a.m. to 6:35 p.m. and Saturday is 6 a.m. to 11:10 p.m., while night service is 6:10 p.m. to 11:10 p.m., Sundays are 7:10 a.m. to 11:10 p.m., and holidays are 8:10 a.m. to 6:10 p.m. The paratransit hours are the same as the fixed route. City Utilities operates 365 days a year. There are 12 day routes, 7 Saturday and evening routes, and four Sunday and holiday routes. Route maps can be found on the City Utilities website - https://www.cutransit.net/routes/. There is also an app and desktop tracker available called "RouteShout 2.0." This allows users to select their route and see the location of the bus, helping riders better plan their transit trips.

**29**: City Utilities Day Route Map




***Source: City Utilities Transit***

In 2016, City Utilities started operating out of a new Transfer Station located at College and Main in downtown Springfield. This replaced a station built in the 1980s. The new station allows for more and bigger buses when needed, as well as additional technology for bus ticketing and operations, including the utilization of real-time traveler information. The new station was also built to accommodate connections




***Source: National Transit Database***

with other services, such as the MSU Bear Line, when such connections become desired.

Generally in the transit industry, route changes or fare increases in result in a 20 percent reduction in ridership that can take a minimum of 2-3 years to recover. The opening of the new Transit Center in 2016 required a system redesign of all routes. Ridership was not only impacted from the historical perspective but also increased efficiencies. Passengers are able to reach destinations with fewer trips and transfers. Ridership had been trending toward 1.4 million rides in FY 2020 prior to the pandemic, however, it will take several more years for ridership to return following the pandemic.

While fixed-route ridership has decreased, CU Transit's increased use of ADA paratransit service has followed industry-wide trends. It is also thought that the paratransit service has become more well known throughout the community, especially as other services have been discontinued.

Beyond operating the transit system, City Utilities has partnered with the City of Springfield and MoDOT to build sidewalks along bus routes and to construct ADA accessible bus stops. Using their Enhanced Mobility of Seniors and Individuals with Disabilities (Section 5310) funding, this partnership has allowed for improved access along several major routes and near critical facilities.

COVID-19 has had a significant impact on City Utilities transit service. During FY 2020, City Utilities Transit took several unprecedented measures to protect both employees and passengers from COVID-19, including an extended modified service during the City of Springfield "stay-at-home" orders, masking enforcement and the installation of both temporary and permanent driver barriers. These protective measures allowed transit to continue to operate during the pandemic without any significant interruption in service. In FY 2020, unlinked passenger trips dipped below 1 million for the first time in over 20 years. While ridership is gradually beginning to recover in FY 2021, it is anticipated that pre-COVID-19 ridership will not be achieved until FY 2023.

Current initiatives at City Utilities transit includes electrification of the fixed-route fleet. CU Transit will receive and deploy two electric buses in 2021, as well as a training simulator. This will allow CU Transit to see if current electric bus technology will support the route needs of Springfield. Another goal is to add lighting at bus stops to improve safety. Finally, CU Transit will introduce hybrid minivans into the fleet to supplement the paratransit service, promoting agility in the program.

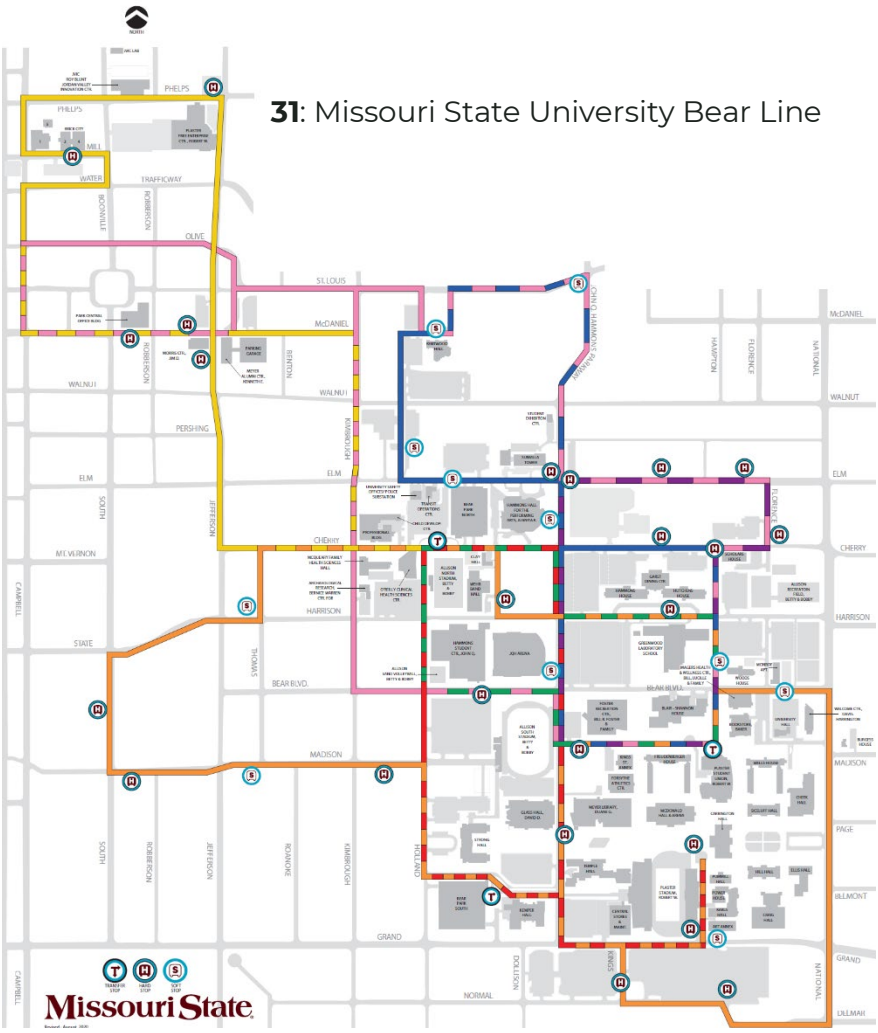
City Utilities Transit is planning to survey and analyze the system in the near future upon completion of *Forward SGF* and *Destination 2045*, as these plans will inform the direction of that survey process.

Upcoming projects include improving training and customer service. Digital signage is under consideration on the buses, at the Transit Center, and off the buses

to provide information on bus arrival times and occupancies. Discussion on how the system can grow also relies on how that growth can be funded. It is recommended that a strategic plan be developed to examine these topics.

### Missouri State University

Missouri State University contracts with a private provider for regular shuttle service in and round the MSU campus. This service is available to the public at no charge. The MSU routes run days and evenings, with limited service when school is not in session.




**31**: Missouri State University Bear Line

Though service is now running at full availability, COVID-19 has reduced ridership, partially because fewer students are on campus. While 2019 saw 950,000 passengers, 2020 had just over 220,000 and the service did not run from the end of March to the beginning of August. Meanwhile, the passenger counting system has been recently upgraded and allows for more analysis on current operations.

MSU has multiple multi-modal parking facilities and transfer stations located across campus. The shuttle connects with downtown Springfield to service the University's expansion into the downtown area. Drivers do make announcements regarding stops to meet accessibility requirements.

Future plans for the MSU Bear Line include an update to the look and branding of the Bear Line for marketing purposes, with inclusivity of the University and the community in line. Increases in ridership is expected with improvements downtown, such as the daylighting of Jordan Creek, that will impact MSU parking lots in downtown. Students are also less likely to be licensed drivers when compared to the past and are more environmentally conscious, trending toward multimodal transportation. Other plans include geofencing announcements and LED lights to

help those who are hearing or visually impaired. Finally, MSU is looking to overhaul routes, connect better with CU Transit, and improve accessibility at stops.

### OATS Transit

OATS Transit is a non-profit serving 87 counties in Missouri, providing specialized transportation, including the rural general public, senior citizens, and people with disabilities. OATS Transit offers a shared-ride, demand-response, door-to-door service.

OATS offers a mix of service to southwest Missouri and the service provided depends on location, day of the week, and type of service, including medical, veteran, elderly, and general public. Transportation is available throughout Greene County, as well as Barry, Newton, Stone, Taney, and Wright Counties. In these counties, OATS offers routine transportation to Springfield on specified weekdays. Pickup points are established along the routes, however the bus will go off route up to 3 miles. Pick-up and drop-off points are at the curb.

### Human Service Transportation Providers

Numerous agencies provide additional human-service transportation throughout the region. Some serve only their specific clients, and others, like OATS, Inc., provide demand-response service for the disabled and elderly in Springfield, and the general public in southwest Missouri.

## Intercity Surface Transportation

The OTO region is currently served by two inter-city bus companies, Greyhound Lines, Inc., which serves over 2,400 destinations in North America and Jefferson Lines, which has stops in fourteen states and twenty stops in Missouri, including Springfield. There are 31 cities with Greyhound locations in Missouri, including Springfield, Kansas City, and St. Louis. Hollister, near Branson, is also served by Greyhound. The Greyhound bus station in Springfield is moving to the western edge of Springfield. Greyhound's service to Jefferson City, Kansas City, and St. Louis provides a connection to Amtrak service. Jefferson Lines uses the Greyhound station in Springfield as a stop.

Southwest Missouri is not served by passenger train service, though a desire for such service is brought up repeatedly, as seen in the survey responses for this Plan. Current studies, including one commissioned by MoDOT in 2007, have yet to demonstrate the feasibility of passenger train service.

### Regional Intercity Bus Service

As described, OATS Transit fills a need for intercity transportation throughout the region and Missouri. Providing service for both medical and general transportation, OATS reduces the number of trips that would otherwise be taken individually by its riders. OTO has further explored a limited stop circulator in the 2012 Route Study, described below. As density and demand increases, there is a benefit to the region

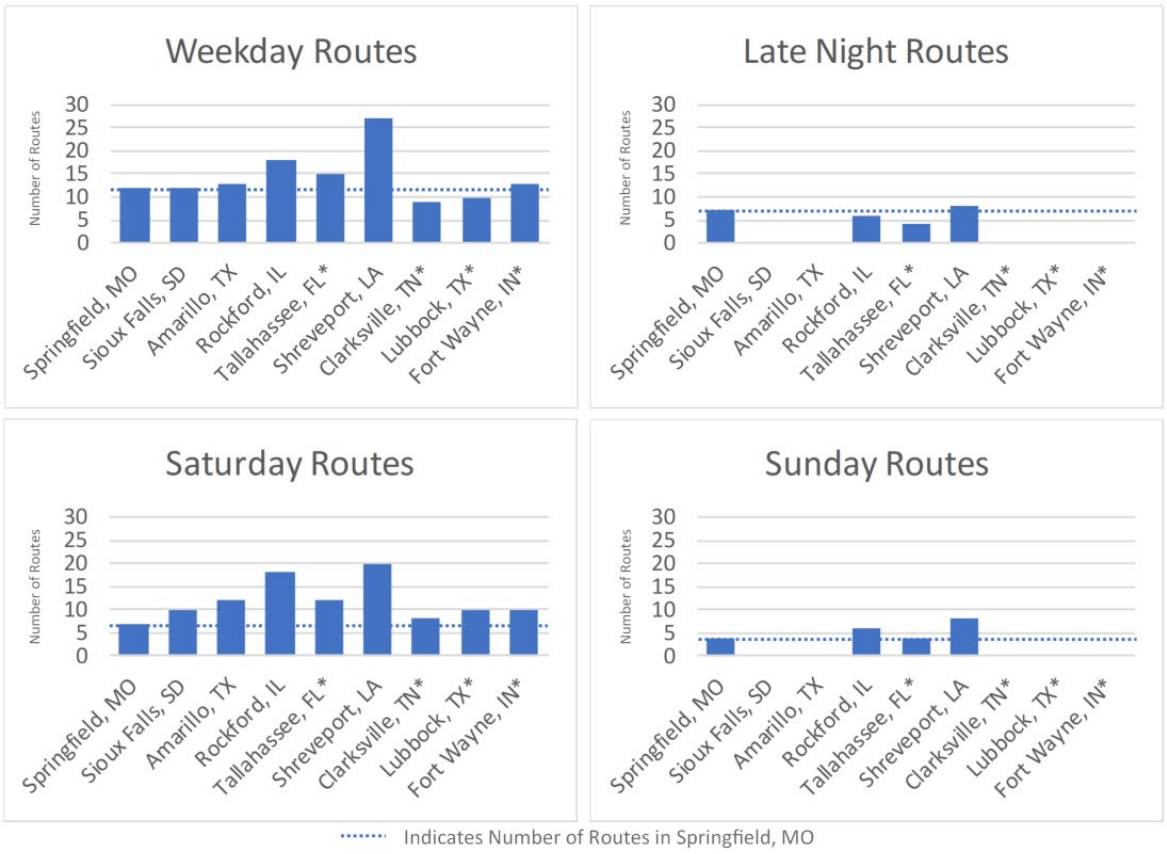
in the promotion of stronger intercity bus service. Given low commute times in the region, though, it will likely continue to be an option for non-drivers as opposed to a replacement for passenger car commuting and even carpooling.

## Springfield Fixed-Route Peer Analysis

In 2019, OTO conducted a peer analysis comparing City Utilities Transit fixed-route service with that offered by peer communities. This analysis used 2017 data from the National Transit Database. It was concluded that City Utilities Transit offers local residents a level of service similar to that found in the peer communities:

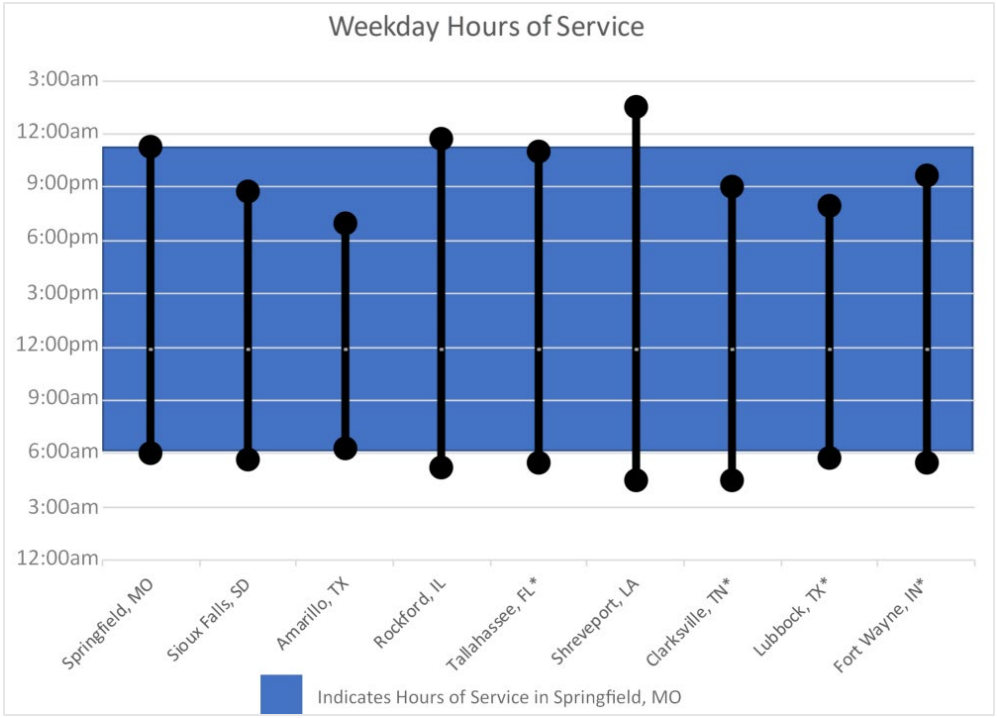
- Operates a comparable number of Weekday Routes
- One of few communities to offer dedicated late-night routes/Sunday routes
- One of the few to operate past 10 p.m.
- Only agency to offer service on all major holidays
- All peer communities offered more Saturday service
- Offers less total service than many peers, but is effective in providing the services it does offer
- Charges comparable single ride fares and monthly passes
- Provides the highest percentage of operating funds from local services compared to the eight peer communities

**32**: CU Transit Peer Service Route Types



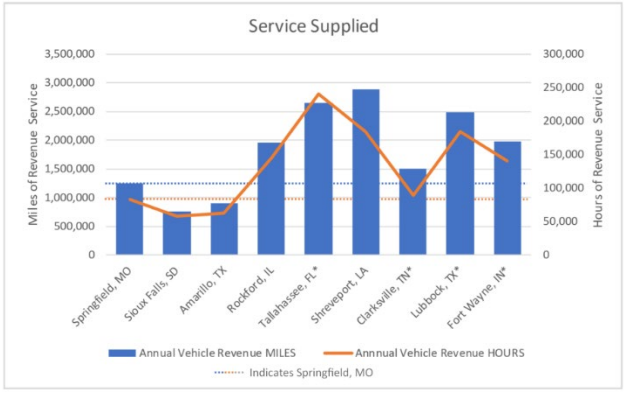

***Source: OTO 2019 CU Transit Peer Analysis***

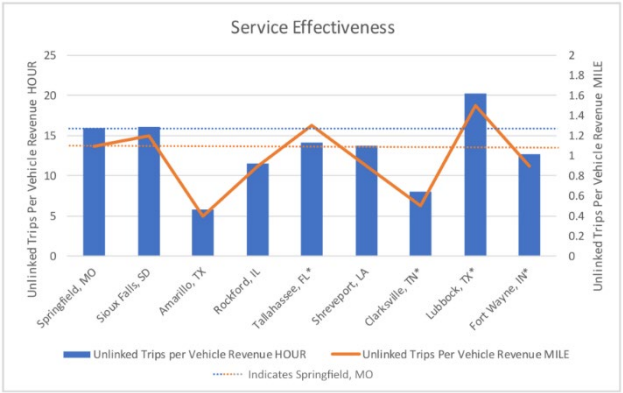
**33**: CU Transit Peer Service Hours




***Source: OTO 2019 CU Transit Peer Analysis***

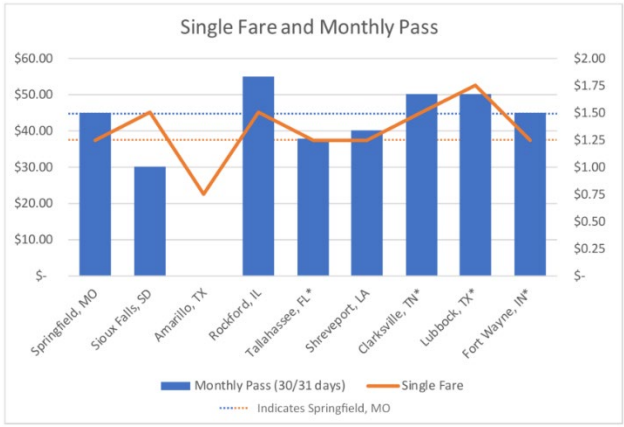
**34**: CU Transit Peer Service Statistics

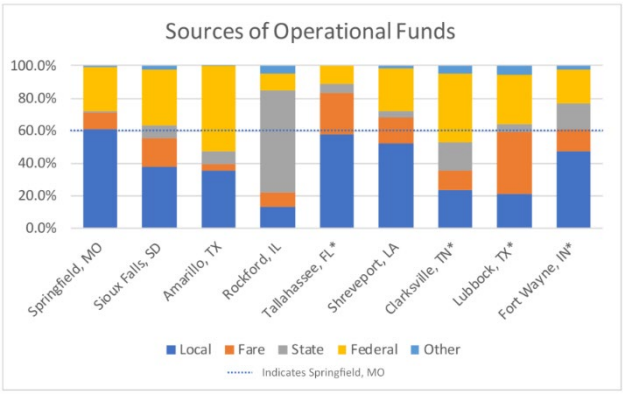



***Source: OTO 2019 CU Transit Peer Analysis***

**35**: CU Transit Peer Revenue




***Source: OTO 2019 CU Transit Peer Analysis***

## 2012 Route Study

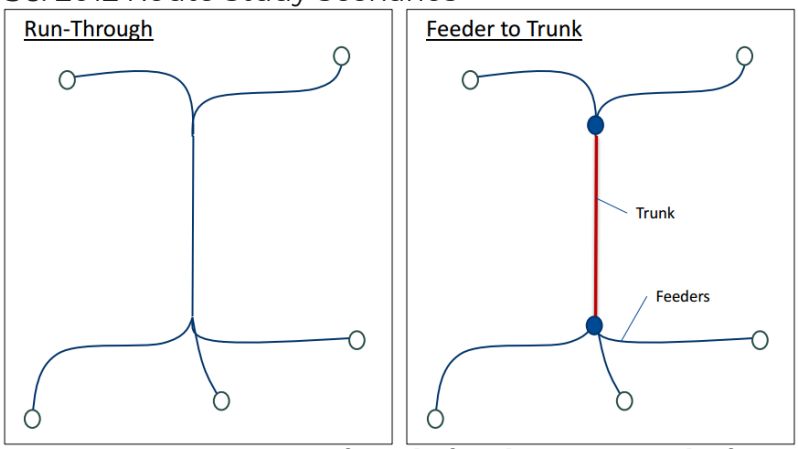
OTO, in partnership with City Utilities Transit, conducted an in-depth transit analysis of both the existing system and a proposed regional system in 2012. The purpose of the study was to determine how well the current fixed-route serves local needs, identify opportunities for improvement, test scenarios, and evaluate a regional service concept. The studies can be found here https://media.ozarkstransportation.org/documents/Fixed-Route-Oporations-Analysis-April-2012.pdf and here https://media.ozarkstransportation.org/documents/Regional-Service-Analysis-April-2012.pdf.

The study recommended five different levels of improvement:

1) Improve reliability
2) Improve frequency
3) Expand east-west options on far south side
4) Additional frequency improvements and limited stop service
5) 15-minute frequency and ½-mile spacing

Each scenario presents specific improvements and the estimated necessary capital costs for implementation.

**36**: 2012 Route Study Scenarios




***Source: OTO 2012 Regional Fixed Route Analysis***

The regional service analysis reviewed eleven candidate communities and two service designs: run-through and feeder-to-trunk. Eight routes were eventually selected for cost and route analysis:

1) Branson
2) Fair Grove
3) Nixa-Ozark
4) Rogersville
5) Republic-Battlefield
6) Strafford
7) Walnut Grove-Ash Grove-Willard
8) Limited Stop Circulator

From this plan, the Limited Stop Circulator has been identified as most feasible. Using National, this route connects the Medical mile with MSU, OTC, Government Plaza and the downtown Transfer Station. The new transfer station at Main and College was not finalized at the time of this study, but that should not impact the findings related to this proposed route.

This route and variations on it are receiving additional attention through the City of Springfield's Impacting Poverty Initiative. This route should effectively serve the

public's needs.

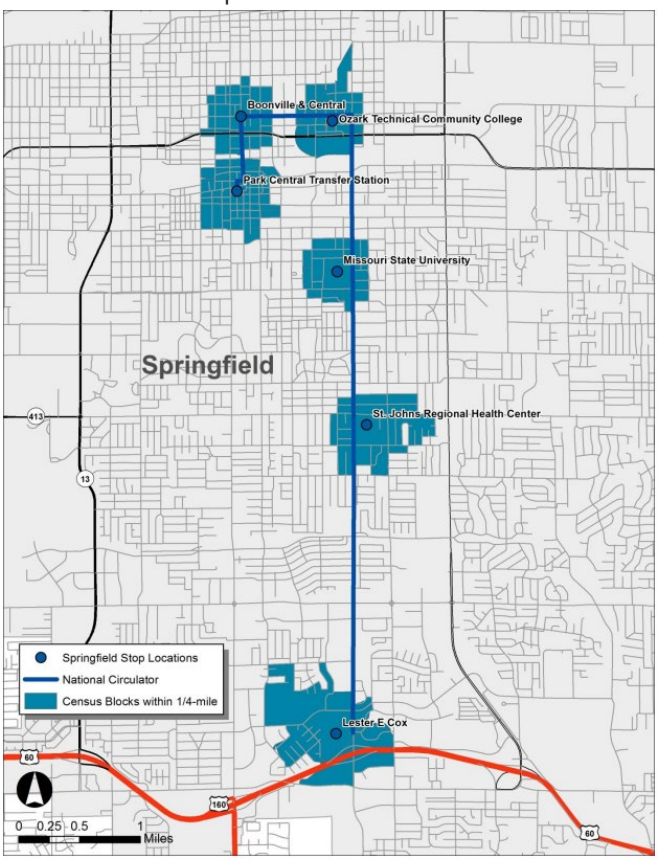
The Springfield Comprehensive Plan, Forward SGF, though not finalized, is planned to recommend supporting land use that supports transit, and in particular, improved service along National Avenue.

There has been much discussion for what transit could look like in Springfield and throughout the region, but less discussion regarding the steps required to get there. It is recommended that a strategic plan outline implementation actions.

## Transit Coordination Plan

The most recent Transit Coordination Plan (TCP) was adopted in 2017 and the update is just getting underway. The TCP fulfills the federal requirements of a Human Services Transportation Plan enacted in the surface transportation reauthorization bill, most recently the FAST Act. The TCP is intended to identify needs and gaps in human service transportation services for seniors and individuals with disabilities in the OTO region. The TCP is also used to guide the use of Federal Transit Administration Section 5310 Enhance Mobility for Seniors and Individuals with Disabilities program funding. Actions from the 2017 TCP were prioritized for implementation importance:

**37**: Limited Stop Circulator




***Source: OTO 2012 Regional Fixed Route Analysis***

**38**: Transit Coordination Plan Prioritized Actions

| Action | Priority |
|---|---|
| Update and expand distribution of OTO's transit provider brochure | Medium |
| Deploy and market OTO's '*Let's Go Smart*' and '*Ozarks Commute*' websites | High |
| Investigate feasibility of mobility management program in OTO planning area | Low |
| Resolve to support existing Medicaid transportation funding by educating local and state leaders | Medium |
| Policy changes allowing will-call return trip scheduling | Medium |
| Policy changes allowing expanded opportunity for same-day scheduling | Medium |
| Advocate for additional funding for recreational funding for area senior centers and human service agencies | Low |
| Continue Section 5310 funding for replacement vehicles | High |
| Continue Section 5310 funding for non-traditional projects that improve ADA accessibility | High |
| Investigate feasibility of funding passenger facilities in conjunction with vehicle purchases | Medium |
| Continue Section 5310 funding for new vehicles | High |
| Create new Section 5310 scoring criteria to prioritize weekend/ after-hours services | Medium |
| Create new scoring criteria to prioritize intercity connections | Medium |
| Continue Section 5310 funding for non-traditional projects that expand ADA accessibility | High |
| Investigate feasibility of funding passenger facilities in conjunction with vehicle purchases | Medium |
| Encourage use of available space at CU Transit Center by MSU and OATS | Low |
| Create new Section 5310 scoring criteria to prioritize intercity connections | Medium |

## Active Transportation

### Trail Priorities

OTO has an active Bicycle and Pedestrian planning program, with guidance from the OTO Bicycle and Pedestrian Advisory Committee (BPAC). Recent planning efforts have focused on creating a regionally connected trail system. In 2017, OTO adopted the Regional Bicycle and Pedestrian Trail Investment Study (RBPTIS) and subsequent Nixa addendum, provides guidance toward implementation of more than 80 miles of trails throughout the OTO region. The Study reviewed alternate alignments, as well as natural environment and cultural concerns, recommending a preferred alignment, planning-level cost estimates, and segmentation for each route. While segments were proposed in $500,000 increments, the overall cost, upwards of $125 million, will take much funding and many years to implement.

Focusing on the goal of connecting the OTO communities via regional trails, a more targeted plan has been developed, *Towards a Regional Trail System*. Developed concurrently with the *Destination 2045* planning process, this is meant to be a standalone regional trail plan that identifies investment levels needed to create a trail system with continuous linkages that connects communities by 2045.

## 45 by '45

### Direct OTO Action

- Identification of sustained and expanded trail funding
- Provide regional trail planning supports
- Target specific corridors and trails for OTO funding
- Create trail system dashboard

### Supports offered to OTO Member Jurisdictions

- Support expansion of local funding options
- Support establishment of trail maintenance program/funding

*Towards a Regional Trail System* identifies successful implementation as 45 miles of trail by 2045. This can be achieved through direct actions by OTO and supports OTO can offer to member jurisdictions. Funding is the most significant factor toward implementation. Three scenarios are provided for additional regional trail funding:

- Allocate any increase in Surface Transportation Block Grant (STBG) funding in next reauthorization bill to trails
- Allocate any increase in STBG-Set Aside (formerly Transportation Alternatives Program in the next reauthorization bill to trails
- Modify existing distribution of STBG-Urban funds to direct funding toward trails

These will also need to be matched through private fundraising and community and outside grants.

When including the full extent of regional trails and all the loop trails in area parks, one could count over 100 miles of trail on the ground. OTO tracks miles of existing greenway trails that can be used for transportation; trails that connect places and aren't used only for exercise. Since 2012, nearly 15 miles of trail have been built by members, Ozark Greenways, and with OTO funds.


***Source: OTO 2020 State of Transportation***

## Bicycle and Pedestrian Priorities

Beginning with the first dedicated Bicycle/Pedestrian Plan in 2006, OTO has been working toward the implementation of livable and complete streets. Planning efforts have oscillated between standalone plans and incorporation with the long range transportation plan. Alongside the trail planning efforts, OTO has been working with the Bicycle and Pedestrian Advisory Committee (BPAC) to document priorities for the development and maintenance of sidewalk and on-street bicycle and pedestrian infrastructure at the local level throughout the region.

Past plans have attempted to document all existing facilities with recommendations for locating any new infrastructure. With technology allowing for the constant update of existing inventory within a geographical information system and the potential for improvements innumerable, OTO instead plans to focus on policies that can provide clear guidance to members and MoDOT for the placement and design of future bicycle and pedestrian improvements. As OTO examines ways to overlay street typologies upon the Major Thoroughfare Plan, these policies will be incorporated with context in mind.

It is important that the local bicycle and pedestrian network interface and parallel the roadway network. The drafted priorities under consideration are included here and express OTO's bicycle and pedestrian goals. These will be finalized through BPAC as part of a broader infrastructure plan.

### Structure of Local Bicycle and Pedestrian Networks

- Urban Expressways, Primary Arterials, and Secondary Arterials should include bicycle and pedestrian infrastructure, incorporating sidewalks on both sides, multi-use sidepaths and/or bicycle accommodations consistent with established best practices
- Freeway corridors should include a parallel network of continuous sidewalks, bike lanes, bike boulevards, and/or other industry standard low-stress accommodations along outer roads or other parallel minor streets to facilitate bicycle and pedestrian movement along the freeway corridor
- Local bicycle and pedestrian networks should be identified to facilitate movement between neighborhoods, local institutions, schools, and commercial areas, and be built according to established best practices

### Integration of Local Bicycle and Pedestrian Networks and the Regional Hard Surface Trail Network

- The region's Hard Surface Trail Network will be integrated into the fabric of each community through numerous neighborhood-level sidewalk and bicycle connections
- Local bicycle and pedestrian networks should be identified and constructed to facilitate movement between trails included in the region's Hard Surface Trail Network

- Local bicycle and pedestrian networks should be identified and constructed to facilitate movement between local institutions, schools, and commercial areas and the region's Hard Surface Trail Network

### Funding

- Local jurisdictions should prioritize the construction and long-term maintenance of their local bicycle and pedestrian network in their annual budgets and capital improvement programs
- Local jurisdictions and MoDOT should negotiate in good faith to find opportunities for cost sharing and beneficial long-term maintenance agreements

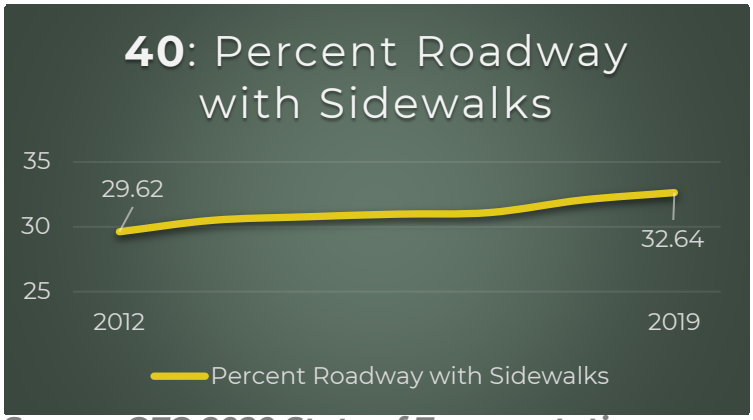
## Complete Streets

A Complete Street is designed with every user in mind, whether a pedestrian, bicyclist, motorist, or user of public transportation, of any age. A complete street ensures the entire right-of-way enables safe access for all users. No two complete streets will look the same. The inclusion and placement of elements such as crosswalks, bike lanes, bus lanes, sidewalks, medians, or curb extensions depends upon the surrounding land use and users' needs. Smart Growth America has an extensive library of materials relating to the implementation of Complete Streets.

The OTO Design Standards recommend pedestrian and bicycle accommodations on a number of roadway classifications. Guidelines for those accommodations are included in the Design Standards found in Appendix 3. OTO has also assembled a variety of resources members can use to implement complete streets best practices through a Complete Streets Toolbox.

Through the implementation of the OTO Major Thoroughfare Plan, Design Standards, and Bicycle/Pedestrian Priority Policies, OTO strives for implementation of complete streets concepts. Jurisdictions within the OTO area are encouraged to consider all users when designing projects, regardless of funding source.

In 2011, OTO set its first performance measures and targets, including the goal that by 2035, 35 percent of roadways (excluding freeways and expressways) have sidewalk on at least one side of the street. Since 2012, that percentage has grown from 29 to 32. Sidewalk has even been added to streets not traditionally considered accommodating of pedestrians, such as Kansas Expressway. With the continued effort to connect and complete an



***Source: OTO 2020 State of Transportation***

active transportation network, the region will benefit from the availability of transportation options.

## Ongoing Studies and Reports

OTO produces several reports on an ongoing basis, which provide continual feedback on the planning process. Below is a summary of each document and its update schedule.

### Performance Measures Report

This is an annual report produced for the performance measures contained in the long range transportation plan. This report provides an overview of each performance measure, how that measure is trending, and factors which may affect that trend.

### Congestion Management Process Report

Every three years, the OTO reviews recurring and non-recurring congestion throughout the region in accordance with federal requirements. This congestion is compared to transportation improvements made throughout the region, allowing for evaluation of strategies that address congestion.

### Annual Transportation Report Card

OTO is in the process of developing an annual transportation report card that reviews additional statistics about transportation in the region beyond those included in the performance measures report.

### Growth Trends Report

Each year, OTO works with local jurisdictions to track new building permits and demolition permits to determine growth in housing units throughout the region. This effort culminates in a report outlining the growth of the region, as well as provides Census information regarding income and employment throughout the region.

### LRTP Implementation Plan

*Destination 2045* includes a list of actions that OTO should perform in order to address the goals of this Plan. OTO will annually review progress toward this implementation plan and how those efforts are helping the region attain its vision of an excellent transportation system.

# 8 Implementation Plan

## Major Thoroughfare Plan

The OTO Major Thoroughfare Plan (MTP) provides guidelines for designing a roadway network for the efficient movement of people and goods throughout the metropolitan area. The MTP was first adopted by the OTO Board of Directors in October 2004, with several amendments since then. The MTP has also been extensively reviewed with each long range transportation plan update.

The MTP classifies roadways based on their intended function and shows both existing and future roadways. These future major transportation corridors should serve as a general guide for securing street rights-of-way, though the locations are general in nature and final alignments will depend upon a detailed location study. The classifications shown on the MTP map direct the application of the OTO design standards, found in Appendix 3. Additional considerations should be made regarding the application of the MTP roadway classifications besides potential function, including alignment and corridor preservation, as well as land use and development.

### Network Updates

With the adoption of *Transportation Plan 2040*, over 300 changes were made to the major thoroughfare plan. Since then, it has been amended six more times. *Transportation Plan 2040* introduced the concept of rural collectors and also amended the OTO design standards. With *Destination 2045*, OTO is recommending minor changes to address the realignment of MM across US 60 and that associated roadway network. OTO has also added the extension of 4th Street in Battlefield to correspond to projects submitted for consideration on the constrained project list. Two collectors south of west Sunshine have also been removed. These changes can be found in Appendix 6.

### Street Typologies

Most modifications and variances to the Major Thoroughfare Plan are the result of incongruencies between proposed functional classifications, and associated design standards, and the physical limitations of the surrounding land use. It has become clear that one-size does not fit all.

Functional street classifications take into account both the design characteristics of the roadway network and the character those roadways are meant to provide. The OTO Major Thoroughfare Plan implements functional class as a hierarchy of roadways that range from high travel mobility (arterials) to high access (local or residential). Street typologies supplement the traditional functional classification

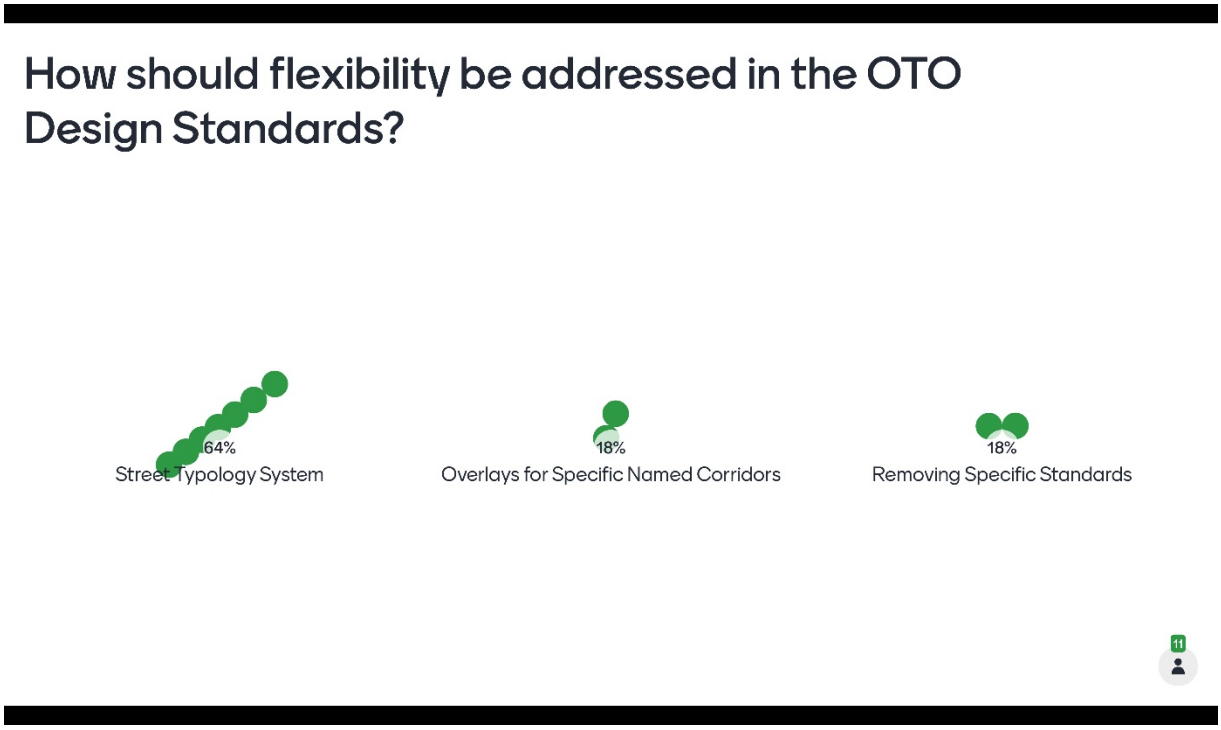
system to better emphasize a more balanced street function, considering land use and all users – pedestrians, cyclists, transit users, and motorists. Where sufficient public right-of-way exists, all design elements may be accommodated. Within constrained public-right-of-way, trade-offs must be balanced and should encourage healthy and active transportation options.

### Incorporating into MTP

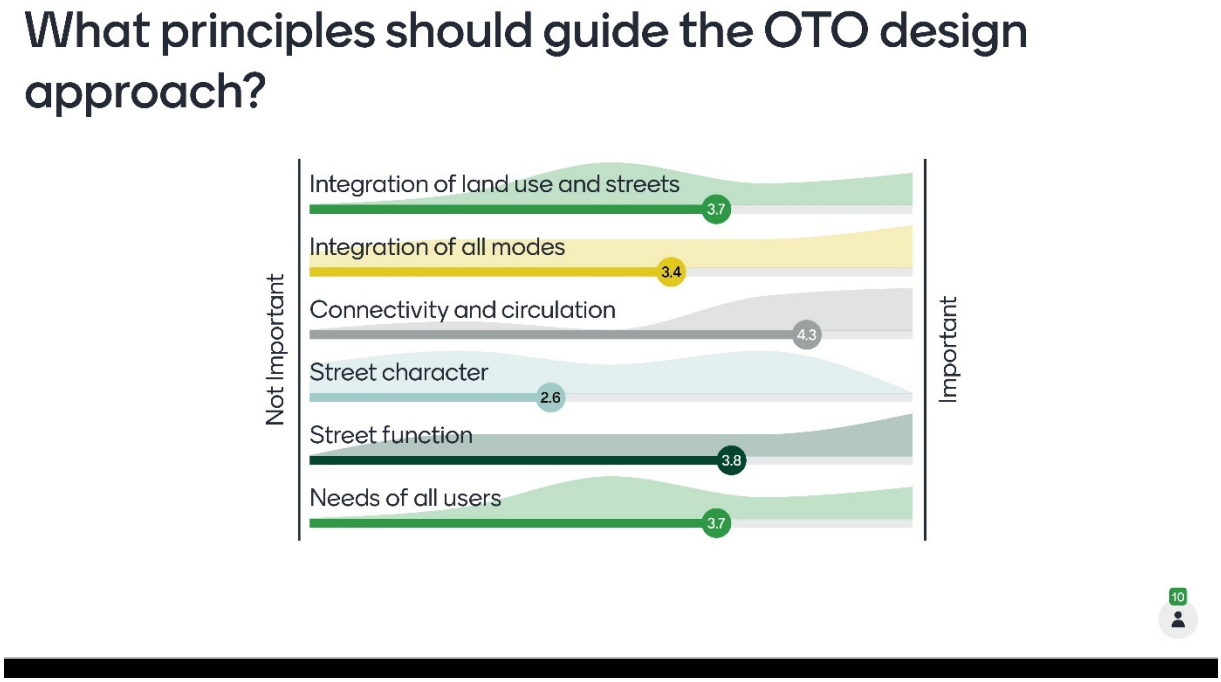
OTO worked with the *Destination 2045* planning committee to determine how street typologies could be integrated into the OTO Major Thoroughfare Plan.

First, the committee was asked to consider how generalized flexibility should be incorporated. There was a definite preference for implementing a street typology system, compared to adjusting specific corridors or limiting the design standards.

**105**: Flexibility in the OTO Design Standards




Next, the committee was asked which principles should guide the OTO design approach. Connectivity and circulation were identified as most important, followed by street function, and then a tie between integration of land use and streets and needs of all users. Street character ranked lowest, but was still slightly weighted toward important.




OTO also separately asked how each community implements the OTO Major Thoroughfare Plan and Design Standards. Just over 60 percent responded that they serve as guidance for how to functionally classify streets, but the community uses their own design standards. A quarter stated that the MTP serves as the Major Street Plan and is directly implemented through code. Just over 10 percent stated that they are useful to enforce some things but not everything. No one said they do not use them at all.

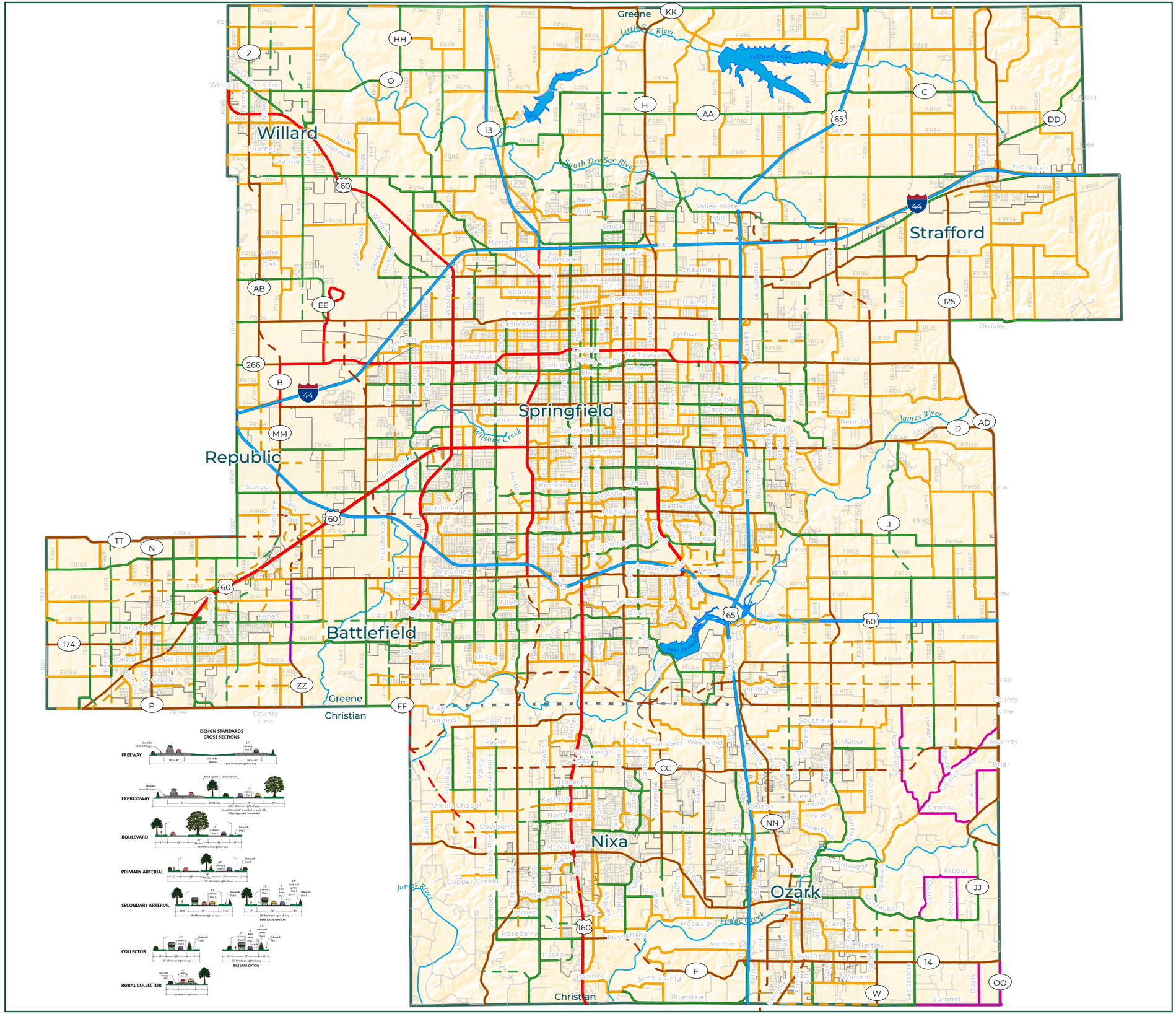
## Next Steps

Implementation of street typologies is a recommendation in the City of Springfield *Forward SGF* Comprehensive Plan, which will be finalized in later 2021. Coupled with place types, these concepts will introduce another tool for assessing the transportation and land use connection.

*Destination 2045* will carry forward the functional classification and proposed road system of the OTO Major Thoroughfare Plan with some amendments as described. It is recommended that OTO work with the region to apply the street typology recommendations to the OTO Major Thoroughfare Plan, providing flexibility and limiting the need for future variances and amendments. It is recognized that multiple OTO members use the OTO Major Thoroughfare Plan as their Major Street Plan. It will be important to maintain this use of the MTP as well.

Destination 2045

# 107: Major Thoroughfare Plan




DESIGN STANDARDS
CROSS SECTIONS




## Existing Streets Class

- Freeway
- Expressway
- Primary Arterial
- Secondary Arterial
- Collector
- Boulevard
- Rural Collector
- Local

## Future Streets Class

- Expressway
- Primary Arterial
- Secondary Arterial
- Collector
- Local

0 1.25 2.5 5
Miles

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OTO

# 5-Year Implementation Guide

By **Calendar Year** from 2022 through next plan adoption in 2026

## Ongoing

### Education

- Communicate unfunded needs to elected officials and the public
- Communicate funding shortfalls to elected officials and the public
- Educate public on transportation planning process
- Continue education of elected officials on the positive effects of local control of federal suballocated funding
- Continue to prioritize improvements that improve safety
- Continue to work with Missouri Public Transit Association to educate elected officials regarding the benefits of transit investment
- Use Let's Go Smart website to communicate transportation options
- Sponsor training opportunities for members and partner trade organizations on complete street best practices and emerging trends
- Use SGF Yields as a regional model to promote pedestrian safety

### Prioritization

- Utilize MoDOT asset management plan and City Utilities Transit asset management plan to ensure adequate investment in the transportation system
- Prioritize investments that maintain and prolong the useful life of the existing system
- Prioritize projects that improve congestion on the freeway system
- Promote investment decisions that direct growth near appropriate transportation facilities
- Prioritize projects that encourage job creation, retention, and wage growth
- Continue to use the MoDOT Statewide Freight Plan to prioritize projects
- Make investment decisions that support performance targets

### Revenue-Seeking

- Support funding requests for all modes of transportation that fit within the regional vision
- Identify grant opportunities and use OTO staff to complete grant applications
- Identify and make application to federal discretionary programs

### Partnerships

- Continue to partner with MoDOT to identify unfunded needs
- Encourage participation in the statewide cost share program
- Partner with local agencies to make shared investments
- Continue to participate in Missouri Coalition for Roadway Safety meetings and activities
- Support implementation of MoDOT's TSM&O Program and Action Plan

- Support the efforts of the Transportation Management Center
- Continue to participate in MoDOT scoping and core team meetings

### Monitoring and Implementation

- Continue to publish an annual report on the state of transportation in the OTO region
- Monitor implementation of the TCP
- Monitor trail implementation through a dashboard
- Continue to monitor ADA investment in the OTO communities
- Monitor funding available for investment in the regional trail system
- Maintain a list of investments needed to complete the ITS network
- Identify technology and data needs to better monitor congestion
- Develop trail projects that advance trail construction readiness
- Continue to make investments in the regional trail system as outlined in the adopted plan
- Use travel time and other congestion measures to ensure reliability
- Monitor transportation technology advancements
- Monitor status of Alternative Fuel Corridors
- Continue to monitor transit accessibility to essential public services
- Build environmental mitigation early into the project development process, developing a process to ensure early communication with MoDOT, FHWA, and the appropriate agencies

### Committees and Community Involvement

- Serve on freight committees when available
- Regularly convene TIM meetings to identify incident response safety improvements
- Participate in Let's Go Smart: Transportation Collaborative
- Continue to participate in the Ozarks Clean Air Alliance to monitor air quality levels and identify ways to maintain Ozone attainment
- Be a resource to members for implementation at the community-level

### Project-Level

- Promote the use of traffic impact studies that ensure developers are sharing in the costs of growth
- Support a connected grid network that allows for ease of alternate travel routing
- Continue to use and maintain EnviroSmart, OTO's environmental database, to inform local project sponsors of environmental considerations in transportation projects
- Ensure complete street design is incorporated into transportation improvement projects
- Promote neighborhood level connections and discourage gated communities that limit transportation connections
- Encourage construction of sidewalks on most roadways

- Continue to invest in fiber connections to improve signal timing throughout the region
- Continue to make freeway and expressway investments that connect communities and maintain low commute times
- Support expansion of quality real-time traveler information

### Year One (2022)

- Continue to refine equity analysis tools available for project identification and prioritization in support of vulnerable road users and under-represented populations
- Analyze bicycle and pedestrian crash locations to scope improvements
- Establish an interdisciplinary safety committee to lead organizational actions for incorporating safety into all transportation related functions
- Educate member agencies on the significance of highway safety and how their agencies can contribute to a safer road system
- Educate public on rules of the road for all users
- Provide safety information on safe driving behaviors
- Develop a process for discretionary funding requests
- Utilize a website and other communication for centralized requests
- Anticipate federal funding priorities and develop ready-made analysis materials
- Review performance measures and targets to best direct investment decisions
- Update the Transit Coordination Plan and identify actions to enhance coordination
- Develop Trail Implementation Dashboards
- Identify connectivity gaps and provide a map for easy reference
- Develop a list of investments needed to complete the ITS network
- Provide better project descriptions that include context sensitive solutions in the STIP prioritization process
- Develop multimodal unfunded needs list

### Year Two (2023)

- Develop a public and elected official education campaign with identified focus areas
- Encourage members to adopt a Vision Zero (www.visionzeronetwork.org) approach to addressing transportation safety, including Complete Streets or Livable Streets
- Use OTO staff to support streamlined project administration
- Determine the next ready-to-construct trail project
- Develop standards for multi-modal accessibility
- Develop standards to improve aesthetics of transportation projects

- Identify, document, and map accessibility improvements with the greatest benefits
- Identify sidewalk network gaps that support local connections to essential services and transit stops
- Identify trail maintenance needs and develop a trail maintenance plan
- Implement a local 5310 administration program to ensure timely delivery of transit capital
- Identify and document large employers and assess the need for transit service
- Identify transit service options for employment needs and recommend service needs to City Utilities Transit
- Identify large employers and provide information on transportation tax incentives
- Connect vanpool providers with employers
- Assess feasibility of "mobility as a service" to supplement transit and other modes
- Conduct additional research on *Destination 2045* survey response regarding passenger rail and desire for inner-city versus inter-city transportation
- Using street typologies, develop an overlay plan that maximizes complete street investments
- Implement access management to preserve roadway capacity and improve safety
- Develop an electric vehicle charging infrastructure plan
- Work with the Transportation Management Center of the Ozarks to identify and implement technology to accommodate connected and automated vehicles
- Identify and develop a plan for improvements supportive of automated vehicles
- Create a connected vehicle infrastructure plan that identifies infrastructure needs
- Review local ordinances and provide recommended changes to regarding neighborhood level connectivity
- Research and catalog recommendations in area plans for a more uniform regional approach

### Year Three (2024)

- Survey the community to ascertain preference for transit coverage or frequency
- Continue to investigate integrated service between City Utilities Transit, Missouri State University, and OATS
- Work with the City of Springfield and City Utilities Transit to develop a high-frequency transit corridor
- Explore options for regional transit service
- Review and update EnviroSmart, consultation with environmental review agencies

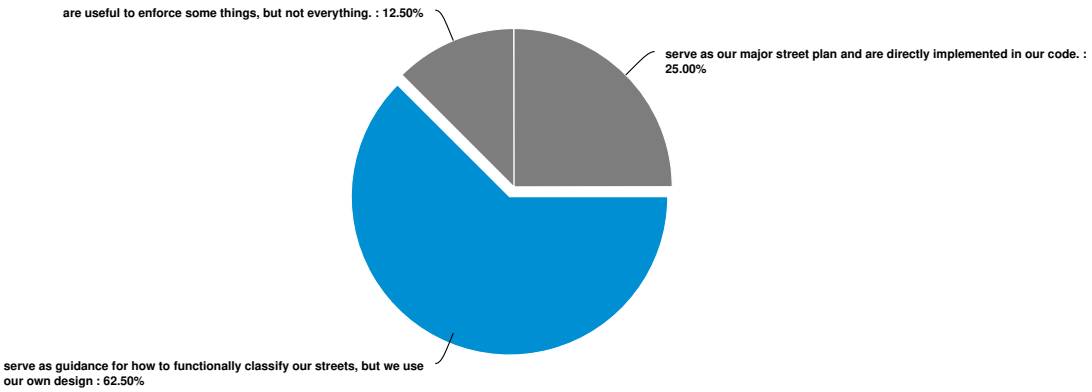
- Develop projects that address connectivity gaps
- Identify and find solutions to freight bottlenecks
- Identify and map transportation facilities that are susceptible to flooding
- Update TIM Strategic Plan
- Identify projects to improve signal timing, traffic bottlenecks, and capacity expansion needs
- Assist member communities with improving gateways to their cities and the region
- Use street typologies to better scope complete street projects

### Year Four (2025)

- Explore alternatives to fixed route bus transit, such as light rail, streetcar/trolley, micro transit
- Begin update of *Destination 2045* for 2050

### Year Five (2026)

- Adopt 2050 long range transportation plan update




| Answer | Count | Percent |
|---|---|---|
| are great for the region, but we don't use them. | 0 | 0% |
| serve as our major street plan and are directly implemented in our code. | 2 | 25% |
| serve as guidance for how to functionally classify our streets, but we use our own design standards. | 5 | 62.5% |
| are useful to enforce some things, but not everything. | 1 | 12.5% |
| Other | 0 | 0% |
| **Total** | **8** | **100%** |

The OTO Major Thoroughfare Plan and Design Standards - Text Data for Other

No Data To Display

# MAKING OUR ROADS SAFER

## One Countermeasure at a Time

The FHWA has identified and is promoting widespread use of a set of 28 Proven Safety Countermeasures that can offer significant, measurable impacts as part of any agency's data-driven, systemic approach to improving safety. These strategies are designed to enhance safety on all kinds of roads—from rural to urban, from high-volume freeways to less traveled two-lane State and county roads, from signalized crossings to horizontal curves, and everything in between. Each countermeasure addresses **speed management, intersections, roadway departures,** or **pedestrians/ bicyclists**—along with crosscutting strategies that address all four safety focus areas.

***Which Proven Safety Countermeasures Will You Use?***

For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures.

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A SAFE SYSTEM IS HOW WE GET THERE

https://safety.fhwa.dot.gov/

OFFICE OF SAFETY

# Proven Safety Countermeasures

## SPEED MANAGEMENT


Speed Safety Cameras


Variable Speed Limits


Appropriate Speed Limits for All Road Users

## ROADWAY DEPARTURE


Wider Edge Lines

Enhanced Delineation for Horizontal Curves

Longitudinal Rumble Strips and Stripes on Two-Lane Roads

SafetyEdge℠

Roadside Design Improvements at Curves

Median Barriers

## INTERSECTIONS

Backplates with Retroreflective Borders

Corridor Access Management

Dedicated Left- and Right-Turn Lanes at Intersections

Reduced Left-Turn Conflict Intersections

Roundabouts

Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections

Yellow Change Intervals

## PEDESTRIANS/BICYCLES


Crosswalk Visibility Enhancements


Bicycle Lanes


Rectangular Rapid Flashing Beacons (RRFB)

Leading Pedestrian Interval

Medians and Pedestrian Refuge Islands in Urban and Suburban Areas

Pedestrian Hybrid Beacons

Road Diets (Roadway Reconfiguration)

Walkways

## CROSSCUTTING


Pavement Friction Management


Lighting

Local Road Safety Plans

Road Safety Audit

FHWA-SA-21-082


# MAKING OUR ROADS SAFER

## One Countermeasure at a Time

*28 Proven Safety Countermeasures that offer significant and measurable impacts to improving safety*

U.S. Department of Transportation
**Federal Highway Administration**

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https://safety.fhwa.dot.gov/

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**16. ABSTRACT**

The Proven Safety Countermeasure Initiative (PSCi) is a collection of 28 countermeasures and strategies effective in reducing roadway fatalities and serious injuries on our Nation's highways. Transportation agencies are strongly encouraged to consider widespread implementation of PSCs to accelerate the achievement of local, State, and National safety goals. This booklet provides 1-page handouts for all 28 PSCs, broken into the focus areas of speed management, roadway departure, intersections, pedestrians/bicyclists, and crosscutting for countermeasures that apply across categories.

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| safety, countermeasures, speed management, roadway departure, intersections, pedestrian, bicyclist | No restrictions. |

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# Introduction

*Widespread use of the 28 Proven Safety Countermeasures (PSCs) identified in this booklet can offer significant, measurable impacts as part of any agency's approach to improving safety. These strategies are designed for all road users and all kinds of roads—from rural to urban, from high-volume freeways to less traveled two-lane State and county roads, from signalized crossings to horizontal curves, and everything in between. Each countermeasure addresses at least one safety focus area – speed management, intersections, roadway departures, or pedestrians/bicyclists – while others are crosscutting strategies that address multiple safety focus areas.*

*Between 2016 and 2019, 85 percent[1] of all public highway fatalities occurred on Federal-aid highways, which represent 25 percent[2] of the entire public highway network. FHWA's partner agencies have invested in highway safety through the Highway Safety Improvement Program (HSIP), which provides targeted safety funding that is eligible for use on all public roads. However, this dedicated funding source represents only about 6 percent of the total Federal-aid program.[3] Every transportation project, whether or not the specific project purpose is safety related, is a new opportunity to save lives on our roadways. The FHWA's Proven Safety Countermeasures are eligible under most Federal-aid highway funding programs, and can support state, local, and tribal agency efforts to effectively accomplish goals to reduce fatalities and serious injuries. These countermeasures should serve as the basis for what agencies consider and implement when designing any highway project to improve safety.*

*To assist practitioners with determining the most appropriate PSC for their location of interest, the PSC webpage includes a filter tool that allows users to obtain a tailored listing of potential PSCs. Users answer questions regarding area types, functional classification, traffic volumes, issue identified, targeted crash types, and other information to receive a list of PSCs meeting thecriteria. This search function is intended to better serve practitioners, including those with limited safety background, when identifying and considering treatments and strategies that can improve safety as part of their program or project.*

*Transportation agencies are strongly encouraged to consider widespread implementation of PSCs to accelerate the achievement of local, State, and National safety goals. Reaching our goal of zero deaths and serious injuries requires all of us to take ownership in safety. Together, we can consider the safety needs at every stage of the project development process, the safety impact of every investment decision, and the appropriate safety countermeasures for every Federal-aid project.*

1 NHTSA Fatality Analysis Reporting System (FARS) 2016-2018 Final and 2019 Annual Report File (ARF)
2 FHWA Highway Statistics 2019 (https://www.fhwa.dot.gov/policyinformation/statistics/2019/hm16.cfm)
3 Federal-aid apportioned programs under the Fixing America's Surface Transportation (FAST) Act (https://www.fhwa.dot.gov/fastact/funding.cfm)

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# Speed Safety Cameras

Safe Speeds is a core principle of the Safe System Approach since humans are less likely to survive high-speed crashes. Enforcing safe speeds has been challenging; however, with more information and tools communities can make progress in reducing speeds. Agencies can use speed safety cameras (SSCs) as an effective and reliable technology to supplement more traditional methods of enforcement, engineering measures, and education to alter the social norms of speeding. SSCs use speed measurement devices to detect speeding and capture photographic or video evidence of vehicles that are violating a set speed threshold.

## Safety Benefits:

**Fixed units can reduce crashes on urban principal arterials up to:**

**54%** for all crashes.[4]

**47%** for injury crashes.[4]

**P2P units can reduce crashes on urban expressways, freeways, and principal arterials up to:**

**37%** for fatal and injury crashes.[2]

**Mobile units can reduce crashes on urban principal arterials up to:**

**20%** for fatal and injury crashes.[5]

**In New York City, fixed units reduced speeding in school zones up to 63% during school hours.[6]**

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/speedmgt/.**



FHWA-SA-21-070

## Applications

Agencies should conduct a network analysis of speeding-related crashes to identify locations to implement SSCs. The analysis can include scope (e.g., widespread, localized), location types (e.g., urban/suburban/rural, work zones, residential, school zones), roadway types (e.g., expressways, arterials, local streets), times of day, and road users most affected by speed-related crashes (e.g., pedestrians, bicyclists).

SSCs can be deployed as:

- **Fixed units**—a single, stationary camera targeting one location.
- **Point-to-Point (P2P) units**—multiple cameras to capture average speed over a certain distance.
- **Mobile units**—a portable camera, generally in a vehicle or trailer.

The table below describes suitable circumstances for SSC deployment.[1]

## Considerations

- SSCs can produce a crash reduction upstream and downstream, thus generating a spillover effect.[2]
- Public trust is essential for any type of enforcement. With proper controls in place, SSCs can offer fair and equitable enforcement of speeding, regardless of driver age, race, gender, or socio-economic status. SSCs should be planned with community input and equity impacts in mind.
- Using both overt (i.e., highly visible) and covert (i.e., hidden) enforcement may encourage drivers to comply with limits everywhere, not only at sites they are aware are enforced.
- Agencies should conduct evaluations regularly to determine if SSCs are accomplishing safety goals and whether changes in strategy, scheduling, communications, or public engagement are necessary.
- Agencies should conduct a legal and policy review to determine if SSCs are authorized within a jurisdiction and how the authorization and other traffic laws will affect a SSC program.
- Agencies should develop an SSC program plan with consideration of the USDOT SSC guidelines for planning, public involvement, stakeholder coordination, implementation, maintenance, evaluation, etc.[3]

| Considerations for Selection | Fixed | P2P | Mobile |
|---|---|---|---|
| Problems are long-term and site-specific. | X | X | — |
| Problems are network-wide, and shift based on enforcement efforts. | — | — | X |
| Speeds at enforcement site vary largely from downstream sites. | — | X | X |
| Overt enforcement is legally required. | X | X | X |
| Sight distance for the enforcement unit is limited. | X | X | — |
| Enforcement sites are multilane facilities. | X | X | — |

1 Thomas et al. Speed Safety Camera Program Planning and Operations Guide. FHWA, (2021).
2 Montella et al. "Effects on speed and safety of point-to-point speed enforcement systems". Accident Analysis and Prevention, Vol. 75, (2015). Note that this is an international study.
3 Speed Enforcement Camera Systems Operational Guidelines. NHTSA, (2008).
4 Shin et al. "Evaluation of the Scottsdale Loop 101 automated speed enforcement demonstration program." Accident Analysis and Prevention, Vol. 41, (2009).
5 Li et al. "A Before-and-After Empirical Bayes Evaluation of Automated Mobile Speed Enforcement on Urban Arterial Roads." Presented at the 94th Annual Meeting of the Transportation Research Board, Paper No. 15-1563, Washington, D.C., (2015). Note that this is an international study.
6 Automated Speed Enforcement Program Report 2014-2017. New York City DOT, (2018).

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# Variable Speed Limits

Selecting appropriate speed limits on roadways is important in maintaining a safe and efficient transportation network. Speed limits are established with an engineering study based on inputs like traffic volumes, operating speeds, roadway characteristics, and crash history. However, conditions on the roadway are susceptible to change in a short amount of time (e.g., congestion, crashes, weather). Drivers typically determine their operating speeds under normal weather conditions on a straight roadway section with good pavement quality and adequate sight distances. If ideal conditions do not exist and the roadway does not meet the driver's expectations, there is a greater chance that a driver error could result in a crash. Providing variable speeds limits (VSLs) capable of adapting to changing circumstances could reduce crash frequency and severity.

Speed management strategies, including VSLs, are integral to the Safe Speeds element of the Safe System Approach. Because humans are unlikely to survive high-speed crashes, VSLs reduce speeds so that human injury tolerances are accommodated in three ways: improving visibility, providing additional time for drivers to stop, and reducing impact forces.

## Safety Benefits:

**VSLs can reduce crashes on freeways up to:**

**34%**
for total crashes.[1]

**65%**
for rear-end crashes.[1]

**51%**
for fatal and injury crashes.[1]

**Benefit/Cost Ratios range between[1]**

**9:1 - 40:1**

## Applications

VSLs use prevailing information on the roadway, like traffic speed, volumes, weather, and road surface conditions, to determine appropriate speeds and display them to drivers. This strategy improves safety performance and traffic flow by reducing speed variance (i.e., improving speed harmonization). VSLs may also improve driver expectation by providing information in advance of slowdowns and potential lane closures, which could reduce the probability for secondary crashes. VSLs can mitigate adverse weather conditions or to slow faster-moving traffic as it approaches a queue or bottleneck.

Agencies can implement VSLs for the following applications:


CONGESTION


INCIDENTS


WORK ZONES


INCLEMENT WEATHER

## Considerations

- Particularly effective on urban and rural freeways and high-speed arterials with posted speed limits greater than 40 mph.
- Often implemented as part of Active Traffic Management (ATM) plans or incorporated into existing Road Weather Information Systems.
- When used with ATM, VSLs can mitigate rear-end, sideswipe, and other crashes on high-speed roadways.
- May be implemented as a regulatory and/or an advisory system.
- Can be applied to an entire roadway segment or individual lanes.

Source: WSDOT

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/speedmgt/ref_mats/.**

1 Avelar et al. Developing Crash Modification Factors for Variable Speed Limit. FHWA, (2020).

FHWA-SA-21-054

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# Appropriate Speed Limits for All Road Users

There is broad consensus among global roadway safety experts that speed control is one of the most important methods for reducing fatalities and serious injuries. Speed is an especially important factor on non-limited access roadways where vehicles and vulnerable road users mix.

A driver may not see or be aware of the conditions within a corridor, and may drive at a speed that feels reasonable for themselves but may not be for all users of the system, especially vulnerable road users, including children and seniors. A driver traveling at 30 miles per hour who hits a pedestrian has a 45 percent chance of killing or seriously injuring them.[1] At 20 miles per hour, that percentage drops to 5 percent.[1] A number of cities across the United States, including New York, Washington, Seattle and Minneapolis, have reduced their local speed limits in recent years in an effort to reduce fatalities and serious injuries, with most having to secure State legislative authorization to do so.

States and local jurisdictions should set appropriate speed limits to reduce the significant risks drivers impose on others—especially vulnerable road users—and on themselves. Addressing speed is fundamental to the Safe System Approach to making streets safer, and a growing body of research shows that speed limit changes alone can lead to measurable declines in speeds and crashes.[2]

## Safety Benefits:

Traffic fatalities in the City of Seattle decreased 26 percent after the city implemented comprehensive, city-wide speed management strategies and countermeasures inspired by Vision Zero. This included setting speed limits on all non-arterial streets at 20 mph and 200 miles of arterial streets at 25 mph.[5]

One study found that on rural roads, when considering other relevant factors in the engineering study along with the speed distribution, setting a speed limit no more than 5 mph below the 85th-percentile speed may result in fewer total and fatal plus injury crashes, and lead to drivers complying closely with the posted speed limit.[6]

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/speedmgt/ref_mats/.**

## Applications

Posted speed limits are often the same as the legislative statutory speed limit. Agencies with designated authorities to set speed limits, which include States, and sometimes local jurisdictions, can establish non-statutory speed limits or designate reduced speed zones, and a growing number are doing so. While non-statutory speed limits must be based on an engineering study, conducted in accordance with the *Manual on Uniform Traffic Control Devices* (MUTCD) involving multiple factors and engineering judgment, FHWA is also encouraging agencies to use the following:[3]

- Expert Systems tools.
  - USLIMITS2.
  - NCHRP 966: Posted Speed Limit Setting Procedure and Tool.
- Safe System approach.

Based on international experience and implementation in the United States, the use of 20 mph speed zones or speed limits in urban core areas where vulnerable users share the road environment with motorists may result in further safety benefits.[4]

## Considerations

When setting a speed limit, agencies should consider a range of factors such as pedestrian and bicyclist activity, crash history, land use context, intersection spacing, driveway density, roadway geometry, roadside conditions, roadway functional classification, traffic volume, and observed speeds.

To achieve desired speeds, agencies often implement other speed management strategies concurrently with setting speed limits, such as self-enforcing roadways, traffic calming, and speed safety cameras. Additional information is in the following FHWA resources:

- FHWA Speed Management website.
- Self-Enforcing Roadways: A Guidance Report.
- Noteworthy Speed Management Practices.
- Jurisdiction Speed Management Action Plan Development Package.
- Traffic Calming ePrimer.

1 Reducing the speed limit to 20 mph in urban areas: Child deaths and injuries would be decreased.
2 Lowering the speed limit from 30 to 25 mph in Boston: effects on vehicle speeds.
3 FHWA's Methods and Practices for Setting Speed Limits: An Informational Report, (2012).
4 Recommendations of the Academic Expert Group for the 3rd Global Ministerial Conference on Road Safety.
5 https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa20047/sec8.cfm#foot813
6 Safety and Operational Impacts of Setting Speed Limits below Engineering Recommendations.

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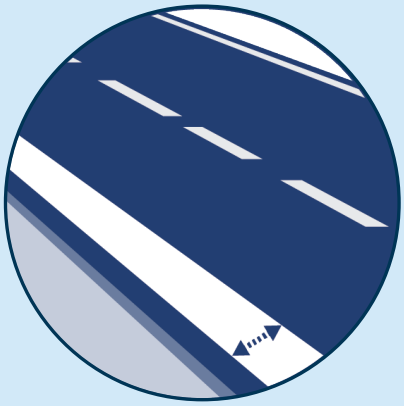

# Wider Edge Lines

Roadway departures account for over half of all traffic fatalities in the United States. If drivers cannot clearly identify the edge of the travel lanes and see the road alignment ahead, the risk of roadway departure may be greater. Wider edge lines enhance the visibility of travel lane boundaries compared to traditional edge lines. Edge lines are considered "wider" when the marking width is increased from the minimum normal line width of 4 inches to the maximum normal line width of 6 inches.[1]

## Safety Benefits:

**Wider edge lines can reduce crashes up to:**

**37%**
for non-intersection, fatal and injury crashes on rural, two-lane roads.[2]

**22%**
for fatal and injury crashes on rural freeways.[3]

**Benefit Cost Ratio**
**25:1**
for fatal and serious injury crashes on two-lane rural roads.[4]

## Applications

Wider edge lines increase drivers' perception of the edge of the travel lane and can provide a safety benefit to all facility types (e.g., freeways, multilane divided and undivided highways, two-lane highways) in both urban and rural areas.[2] Wider edge lines are most effective in reducing crashes on rural two-lane highways, especially for single-vehicle crashes.[3] Agencies should also consider implementing a systemic approach to wider edge line installation based roadway departure crash risk factors. Potential risk factors for two-lane rural roads include:

- Pavement and shoulder widths.
- Presence of curves.
- Traffic volumes.
- History of nighttime crashes.

## Considerations

- Wider edge lines are relatively low cost.
- Wider edge lines can be implemented using existing equipment during maintenance procedures like re-striping and resurfacing, with the only cost increase being the additional material.
- Paint may have a lower initial cost, but more durable materials (e.g., thermoplastic) may result in a lower life cycle cost based on their longer service life.
- As the number of automated vehicles increases on roadways, wider edge lines may provide better guidance for these vehicles' sensors.

Source: Texas Transportation Institute

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/night_visib/pavement-markings.cfm.**

1 Manual on Uniform Traffic Control Devices, Section 3A.06. FHWA, (2009).
2 Park et al. "Safety effects of wider edge lines on rural, two-lane highways." Accident Analysis and Prevention Vol. 48, pp.317-325, (2012).
3 Potts et al. Benefit/Cost Evaluation of MoDOT's Total Striping and Delineation Program: Phase II. Missouri Department of Transportation, (2011).
4 Abdel-Rahim et al. Safety Impacts of Using Wider Pavement Markings on Two-Lane Rural Highways in Idaho. Idaho Transportation Department, (2018).

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## Safety Benefits:

### Chevron Signs

**25%** reduction in nighttime crashes.[1]

**16%** reduction in non-intersection fatal and injury crashes.[2]

### Oversized Chevron Signs

**15%** reduction in fatal and injury crashes.[3]

### Sequential Dynamic Chevrons

**60%** reduction in fatal and injury crashes.[3]

### In-Lane Curve Warning Pavement Markings

**35 - 38%** reduction in all crashes.[4,5]

### New Fluorescent Curve Signs or Upgrade Existing Curve Signs to Fluorescent Sheeting

**18%** reduction in non-intersection, head-on, run-off-road, and sideswipe in rural areas.[1]

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/countermeasures/horicurves/.**

FHWA-SA-21-035

# Enhanced Delineation for Horizontal Curves

Enhanced delineation at horizontal curves includes a variety of potential strategies that can be implemented in advance of or within curves, in combination, or individually.

| Potential Strategies | In Advance of Curve | Within Curve |
|---|---|---|
| Pavement markings (standard width or wider) | ✓ | ✓ |
| In-lane curve warning pavement markings | ✓ | |
| Retroreflective strips on sign posts | ✓ | ✓ |
| Delineators | | ✓ |
| Chevron signs | | ✓ |
| Enhanced Conspicuity (larger, fluorescent, and/or retroreflective signs) | ✓ | ✓ |
| Dynamic curve warning signs (including speed radar feedback signs) | ✓ | |
| Sequential dynamic chevrons | | ✓ |

Enhanced delineation treatments can alert drivers to upcoming curves, the direction and sharpness of the curve, and appropriate operating speed.

Agencies can take the following steps to implement enhanced delineation strategies:

1. Review signing practices and policies to ensure they comply with the Manual on Uniform Traffic Control Devices (MUTCD) principles of traffic control devices. Consistent practice for similar curves sets the appropriate driver expectancy.
2. Use the systemic approach to identify and treat problem curves. For example, Minnesota uses risk factors that include curve radii between 500 and 1,200 ft, traffic volumes between 500 and 1,000 vehicles per day, intersection in the curve, and presence of a visual trap.[1]
3. Match the appropriate strategy to the identified problem(s), considering the full range of enhanced delineation treatments. Once the MUTCD requirements and recommendations have been met, an incremental approach is often beneficial to avoid excessive cost.

Chevron signs with retroreflective strips on sign posts installed along a curve. Source: FHWA

1 Albin et al. Low-Cost Treatments for Horizontal Curve Safety 2016. FHWA-SA-15-084, (2016).
2 Srinivasan et al. Safety Evaluation of Improved Curve Delineation. FHWA-HRT-09-045, (2009).
3 Lyon et al. Safety Evaluation of Two Curve Warning Treatments: In-Lane Curve Warning Pavement Markings and Oversized Chevron Signs. Presented at the 96th TRB Annual Meeting, Paper No. 17-00432, (2017).
4 Hallmark, S. Evaluation of Sequential Dynamic Chevrons on Rural Two-lane Highways. FHWA, (2017).
5 Donnell et al. Reducing Roadway Departure Crashes at Horizontal Curve Sections on Two-lane Rural Highways. FHWA-SA-19-005, (2019).

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# Longitudinal Rumble Strips and Stripes

**Longitudinal rumble strips** are milled or raised elements on the pavement intended to alert drivers through vibration and sound that their vehicle has left the travel lane. They can be installed on the shoulder, edge line, or at or near the center line of an undivided roadway.

**Rumble stripes** are edge line or center line rumble strips where the pavement marking is placed over the rumble strip. This can increase the visibility and durability of the pavement marking during wet, nighttime conditions, and can improve the durability of the marking on roads with snowplowing operations.

## Safety Benefits:

**Center Line Rumble Strips**

**44-64%**

reduction in head-on fatal and injury crashes on two-lane rural roads.[4]

**Shoulder Rumble Strips**

**13-51%**

reduction in single vehicle, run-off-road fatal and injury crashes on two-lane rural roads.[4]

With roadway departure crashes accounting for more than half of the fatal roadway crashes annually in the United States, rumble strips and stripes are designed to address these crashes by alerting distracted, drowsy, or otherwise inattentive drivers who drift from their lane. They are most effective when deployed systemically.

Transportation agencies should consider milled center line rumble strips (including in passing zone areas) and milled edge line or shoulder rumble strips with bicycle gaps for systemic safety projects, location-specific corridor safety improvements, as well as reconstruction or resurfacing projects.

### Considerations

- Rumble strips are relatively low-cost, and economic analyses have indicated benefit/cost ratios that exceed 100.[1]
- Where rumble strips cannot be placed due to noise concerns, agencies may consider a design using an oscillating sine wave pattern (also known as "mumble strips") that reduces noise outside of the vehicle. However, the safety benefits of this design need more study.[2]
- Maintenance concerns:
  - Where rumble strips are placed along a pavement joint, there are typically no issues with joint stability if the pavement structure and joint was already in good condition.
  - Studies have shown no evidence of issues related to snow, ice, or rain build-up in the rumble strip.[3]

Shoulder rumble strips and center line rumble stripes are installed on this roadway. Source: FHWA

Example of an edge line rumble stripe. Source: Missouri DOT

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/.**

FHWA-SA-21-036

1 Himes, S., and McGee, H. Decision Support Guide for the Installation of Shoulder and Center Line Rumble Strips on Non-Freeways. Federal Highway Administration Report No. FHWA-SA-16-115. (August 2016).
2 Bedsole et al. *Did You Hear That?* Public Roads Magazine, Volume 80, No. 4. FHWA Publication No. FHWA-HRT-17-002, (2017).
3 NCHRP Synthesis 339: Centerline Rumble Strips – A Synthesis of Highway Practices, (2005).
4 NCHRP Report 641: Guidance for the Design and Application of Shoulder and Centerline Rumble Strips, (2009).

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OFFICE OF SAFETY

# Proven Safety Countermeasures

## SafetyEdge℠

The SafetyEdge℠ technology shapes the edge of the pavement at approximately 30 degrees from the pavement cross slope during the paving process. This safety practice eliminates the potential for vertical drop-off at the pavement edge, has minimal effect on project cost, and can improve pavement durability by reducing edge raveling of asphalt.

### Safety Benefits:

**11%**
reduction in fatal and injury crashes.[2]

**21%**
reduction in run-off-road crashes.[2]

**19%**
reduction in head-on crashes.[2]

### Benefit-Cost Ratio Range[3]

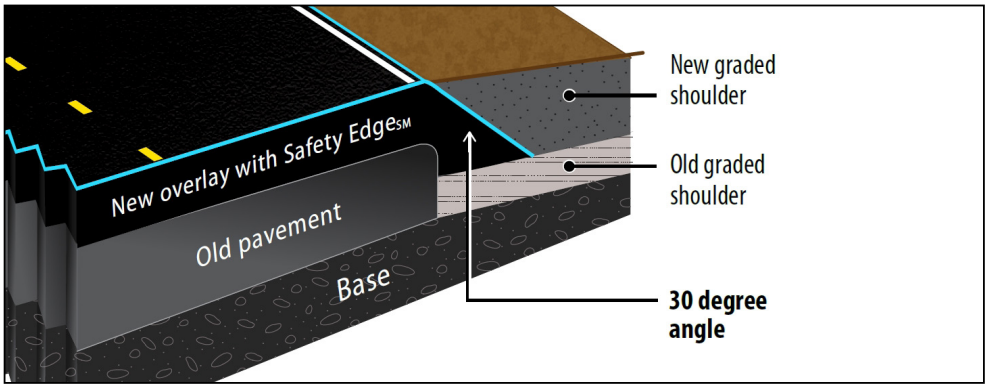
**700:1 to 1,500:1**

Rural road crashes involving edge drop-offs are 2-4 times more likely to include a fatality than other crashes on similar roads.[1] Vehicles may leave the roadway for various reasons ranging from distracted driver errors to low visibility, or to the presence of an animal on the road. Exposed vertical pavement edges can cause vehicles to become unstable and prevent their safe return to the roadway. The SafetyEdge℠ gives drivers the opportunity to return to their travel lane while maintaining control of their vehicle.

The SafetyEdge℠ technology only requires adding one of several commercially available devices to the screed or endgate when placing hot-mix asphalt. Forms for shaping the edge of concrete pavement are simpler and can be made on site by the contractor. Some agencies allow the SafetyEdge℠ to remain exposed while a segment is under construction, unlike conventional pavement edges. However, before construction ends, agencies should bring the adjacent roadside flush with the top of the pavement for both the SafetyEdge℠ and traditional pavement edge. Over time, regardless of the edge type, the edge may become exposed due to settling, erosion, and tire wear. When this occurs, the gentle slope provided by the SafetyEdge℠ is preferred versus the traditional vertical pavement edge.

Transportation agencies should develop standards for implementing the SafetyEdge℠ systemwide on all new asphalt paving and resurfacing projects where curbs and/or guardrail are not present, while also encouraging standard application for concrete pavements.

Example of the SafetyEdge℠ after backfill material settles or erodes. Source: FHWA




Cross-section view of an overlay with the SafetyEdge℠. Source: FHWA-SA-17-044

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/safetyedge/.**

1 Hallmark et al. Safety Impacts of Pavement Edge Drop-offs, (Washington, DC: AAA Foundation for Traffic Safety: 2006), p 93.
2 Donnell et al. Development of Crash Modification Factors for the Application of the SafetyEdge℠ on Two-Lane Rural Roads. FHWA-HRT-17-081, (2017).
3 Safety Effects of the SafetyEdge℠, FHWA-SA-17-044, (2017).

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

FHWA-SA-21-038

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## Safety Benefits:

**Flatten sideslope from 1V:3H to 1V:4H:**

**8%**

reduction for single-vehicle crashes.[2]

**Flatten sideslope from 1V:4H to 1V:6H:**

**12%**

reduction for single-vehicle crashes.[2]

**Increase the distance to roadside features from 3.3 ft to 16.7 ft:**

**22%**

reduction for all crashes.[3]

**Increase the distance to roadside features from 16.7 ft to 30 ft:**

**44%**

reduction for all crashes.[3]

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/countermeasures/safe_recovery/clear_zones/.**

FHWA-SA-21-029

# Roadside Design Improvements at Curves

Horizontal curves account for 27 percent of all fatal crashes and 80 percent of all fatal crashes at curves are roadway departure crashes.[1] Roadside design improvements at curves is a strategy encompassing several treatments that target the high-risk roadside environment along the outside of horizontal curves. These treatments can reduce roadway departure fatalities and serious injuries by giving vehicles the opportunity to recover safely and by reducing crash severity.

Roadside design improvements can be implemented alone or in combination, and are particularly recommended at horizontal curves—where data indicates a higher risk for roadway departure fatalities and serious injuries.

### Roadside Design Improvements to Provide for a Safe Recovery

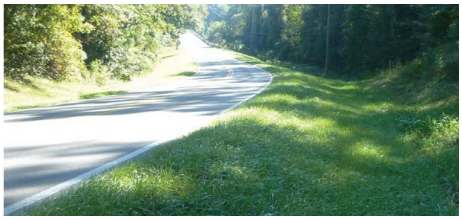
In cases where a vehicle leaves the roadway, having strategic roadside design elements, including an added or widened shoulder, flattened sideslopes, or a widened clear zone can provide drivers with an opportunity to regain control and re-enter the roadway in their lane or come to a safe stop before rolling over or encountering a fixed object.

- A **clear zone** is an unobstructed, traversable roadside area that allows a driver to stop safely or regain control of a vehicle that has left the roadway. Agencies should avoid adding new fixed objects such as trees and utility cabinets or poles in the clear zone. AASHTO's *Roadside Design Guide* details the clear zone width adjustment factors to be applied at horizontal curves.
- **Slope flattening** reduces the steepness of the sideslope to increase drivers' ability to keep the vehicle stable, regain control of the vehicle, and avoid obstacles. Slopes of 1V:4H or flatter are considered recoverable (i.e., drivers can retain control of a vehicle by slowing or stopping). Slopes between 1V:3H and 1V:4H are generally considered traversable, but non-recoverable (i.e., errant vehicle will continue to the bottom of the slope).
- **Adding or widening shoulders** gives drivers more recovery area to regain control in the event of a roadway departure.

### Roadside Design Improvements to Reduce Crash Severity

Since not all roadside hazards can be removed, relocated, or redesigned at curves, installing roadside barriers to shield unmovable objects or steep embankments may be an appropriate treatment. Three common types of roadside barriers are:

- **Cable barrier** is a flexible barrier made from steel cables mounted on weak steel posts. Flexible barriers are more forgiving and have the most deflection.
- **Metal-beam guardrail** is a semi-rigid barrier where a W-beam or box-beam is mounted on steel or timber posts. These deflect less than cable barriers, so they can be located closer to objects where space is limited.
- **Concrete barrier** is a rigid barrier that has little to no deflection.



Clear zone provided on the outside of the curve. Source: FHWA.

1 Fatality Analysis Reporting System.
2 NCHRP Report 617: Accident Modification Factors for Traffic Engineering and ITS Improvements, (2008).
3 Elvik, R., and Vaa, T. Handbook of Road Safety Measures, (2004).

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**8%**

of all fatalities on divided highways are due to head-on crashes.[1]

**Safety Benefits:**

**Median Barriers Installed on Rural Four-Lane Freeways**

**97%**

reduction in cross-median crashes.[2]

# Median Barriers

Median barriers are longitudinal barriers that separate opposing traffic on a divided highway and are designed to redirect vehicles striking either side of the barrier. Median barriers significantly reduce the number of cross-median crashes, which are attributed to the relatively high speeds that are typical on divided highways. AASHTO's ***Roadside Design Guide*** (RDG) recommends guidelines for the use of median barriers on high-speed, fully controlled-access roadways for locations where the median is 30 ft in width or less and the average daily traffic (ADT) is greater than 20,000 vehicles per day (vpd). For locations with median widths greater than 50 ft and where the ADT is less than 20,000 vpd, a median barrier is optional. For locations where the median is between 30 and 50 feet, the RDG suggests an analysis to determine the cost effectiveness of median barrier installation. Median barriers can be cable, metal-beam, or concrete.

- **Cable barriers** are flexible barriers, made from steel cables mounted on weak steel posts, resulting in less occupant impact force as it absorbs energy from the crash, capturing or redirecting the vehicle. Due to larger deflection, median width is an important consideration. These barriers are more adaptable to slopes typically found in medians. Cable barriers tend to require more frequent maintenance and repair than other barrier types.
- **Metal-beam guardrails** are considered semi-rigid barriers, where the W-beam or box-beam is mounted to steel or timber posts. When impacted, they are designed to deform and deflect, absorbing some of the crash energy and redirecting the vehicle. Metal-beam guardrails often do not require maintenance after minor impacts. They deflect less than cable barriers, so they can be located closer to objects where space is limited.
- **Concrete barriers** are usually rigid and result in little to no deflection. They redirect rather than absorb energy from the impact. Rigid concrete barriers seldom require repair or maintenance. Some agencies have used portable concrete barriers as median barriers. These barriers require repositioning after an impact but are typically less maintenance than a post mounted barrier.

To reduce cross-median crashes, transportation agencies should review their head-on crash history on divided highways to identify hot spots. Agencies should also consider implementing a systemic approach to median barrier placement based on cross-median crash risk factors. Potential risk factors include:

- Traffic volumes.
- Vehicle classifications.
- Median crossover history.
- Crash incidents.
- Vertical and horizontal alignment.
- Median terrain configurations.

Median cable barrier prevents a potential head-on crash.
Source: Washington State DOT

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/.**

1 Fatality Analysis Reporting System.
2 NCHRP Report 794: Median Cross-Section Design for Rural Divided Highways, (2011).

FHWA-SA-21-037

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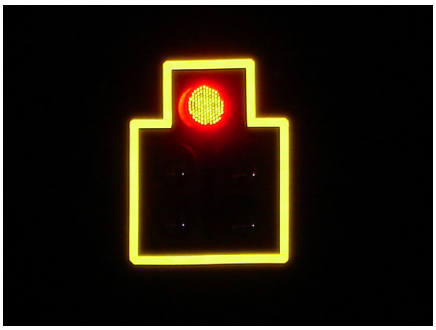
# Backplates with Retroreflective Borders

Backplates added to a traffic signal head improve the visibility of the illuminated face of the signal by introducing a controlled-contrast background. The improved visibility of a signal head with a backplate is made even more conspicuous by framing it with a 1- to 3-inch yellow retroreflective border. Signal heads that have backplates equipped with retroreflective borders are more visible and conspicuous in both daytime and nighttime conditions.

**Safety Benefits:**

**15%**
reduction in total crashes.[1]

This treatment is recognized as a human factors enhancement of traffic signal visibility, conspicuity, and orientation for both older and color vision deficient drivers. This countermeasure is also advantageous during periods of power outages when the signals would otherwise be dark, providing a visible cue for motorists to stop at the intersection ahead.



Retroreflective borders are highly visible during the night. Source: South Carolina DOT

## Considerations

Transportation agencies should consider backplates with retroreflective borders as part of their efforts to systematically improve safety performance at signalized intersections. Adding a retroreflective border to an existing signal backplate is a very low-cost safety treatment. This can be done by either adding retroreflective tape to an existing backplate or purchasing a new backplate with a retroreflective border already incorporated. The most efficient means of implementing this proven safety countermeasure is to adopt it as a standard treatment for signalized intersections across a jurisdiction or State.

Implementation challenges include minimizing installation time, accessing existing signal heads, and structural limitations due to added wind load in instances where an entire backplate is added. Agencies should consider the design of the existing signal support structure to determine if the design is sufficient to support the added wind load.


Signal backplate framed with a retroreflective border. Source: FHWA

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://rosap.ntl.bts.gov/view/dot/42807.**

1 Sayed, T., Leur, P., and Pump, J., "Safety Impact of Increased Traffic Signal Backboards Conspicuity." 2005 TRB 84th Annual Meeting: Compendium of Papers CD-ROM, Vol. TRB#05-16, Washington, D.C., (2005).

FHWA-SA-21-039

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**Safety Benefits:**

**Reducing driveway density**

**5-23%**
reduction in total crashes along 2-lane rural roads.[3]

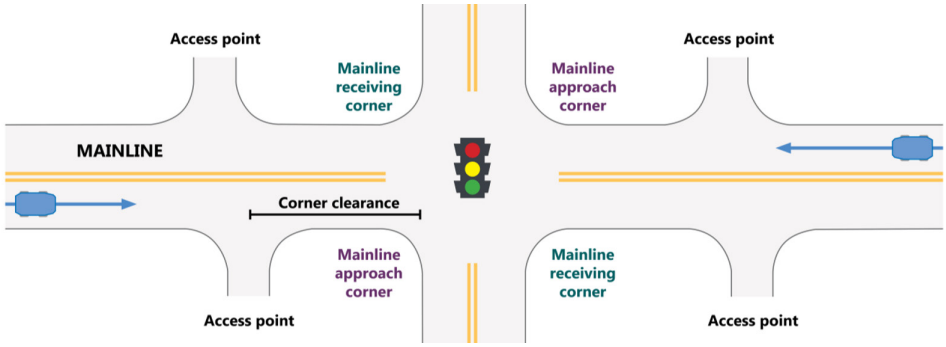
**25-31%**
reduction in fatal and injury crashes along urban/ suburban arterials.[4]

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/intersection/cam/index.cfm.**

FHWA-SA-21-040

# Corridor Access Management

Access management refers to the design, application, and control of entry and exit points along a roadway. This includes intersections with other roads and driveways that serve adjacent properties. Thoughtful access management along a corridor can simultaneously enhance safety for all modes, facilitate walking and biking, and reduce trip delay and congestion.



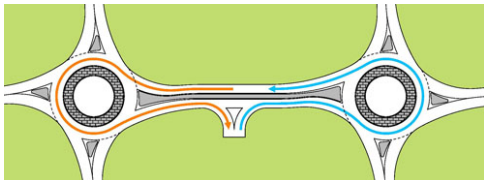

Schematic of an intersection and adjacent access points. Source: FHWA

Every intersection, from a signalized intersection to an unpaved driveway, has the potential for conflicts between vehicles, pedestrians, and bicyclists. The number and types of conflict points—locations where the travel paths of two users intersect—influence the safety performance of the intersection or driveway. FHWA developed corridor-level crash prediction models to estimate and analyze the safety effects of selected access management techniques for different area types, land uses, roadway variables, and traffic volumes.[1]

The following access management strategies can be used individually or in combination with one another:

- Reduce density through driveway closure, consolidation, or relocation.
- Manage spacing of intersection and access points.
- Limit allowable movements at driveways (such as right-in/ right-out only).
- Place driveways on an intersection approach corner rather than a receiving corner, which is expected to have fewer total crashes.[2]
- Implement raised medians that preclude across-roadway movements.
- Utilize designs such as roundabouts or reduced left-turn conflicts (such as restricted crossing U-turn, median U-turns, etc.).
- Provide turn lanes (i.e., left-only, right-only, or interior two-way left).
- Use lower speed one-way or two-way off-arterial circulation roads.

Successful corridor access management involves balancing overall safety and mobility for all users along with the needs of adjacent land uses.



Tandem roundabouts with a continuous raised median eliminates left-turn and across-roadway conflicts. Source: FHWA

1 Gross et al. Safety Evaluation of Access Management Policies and Techniques. FHWA-HRT-14-057, (2018).
2 Le et al. Safety Evaluation of Corner Clearance at Signalized Intersections. FHWA-HRT-17-084, (2018).
3 Harwood et al. Prediction of the Expected Safety Performance of Rural Two-Lane Highways. FHWA-RD-99-207, (2000).
4 Elvik, R. and Vaa, T., Handbook of Road Safety Measures. Oxford, United Kingdom, Elsevier, (2004).

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# Dedicated Left- and Right-Turn Lanes at Intersections

Auxiliary turn lanes—either for left turns or right turns—provide physical separation between turning traffic that is slowing or stopped and adjacent through traffic at approaches to intersections. Turn lanes can be designed to provide for deceleration prior to a turn, as well as for storage of vehicles that are stopped and waiting for the opportunity to complete a turn.

## Safety Benefits:

**Left-Turn Lanes**

**28-48%**

reduction in total crashes.[1]

**Positive Offset Left-Turn Lanes**

**36%**

reduction in fatal and injury crashes.[2]

**Right-Turn Lanes**

**14-26%**

reduction in total crashes.[1]


Left- and right-turn lanes on a two-lane road. Source: City of Greeley, CO

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://www.fhwa.dot.gov/publications/research/safety/02103/02103techbrief.pdf.**

FHWA-SA-21-041

While turn lanes provide measurable safety and operational benefits at many types of intersections, they are particularly helpful at two-way stop-controlled intersections. Crashes occurring at these intersections are often related to turning maneuvers. Since the major route traffic is free flowing and typically travels at higher speeds, crashes that do occur are often severe. The main crash types include collisions of vehicles turning left across opposing through traffic and rear-end collisions of vehicles turning left or right with other vehicles following closely behind. Turn lanes reduce the potential for these types of crashes.

Installing left-turn lanes and/or right-turn lanes should be considered for the major road approaches for improving safety at both three- and four-leg intersections with stop control on the minor road, where significant turning volumes exist, or where there is a history of turn-related crashes. Pedestrian and bicyclist safety and convenience should also be considered when adding turn lanes at an intersection. Specifically, offset left- and right-turn lanes will lengthen crossing distances for pedestrians.

### Offset Turn Lanes

Providing offset of left- and right-turn lanes to increase visibility can provide added safety benefits, and is preferable in many situations, particularly at locations with higher speeds, or where free-flow or permissive movements are possible.

At turn lanes with zero or negative offset, turning vehicles can block sightlines. For left-turn lanes, this usually involves opposing left-turning vehicles occupying the turn lanes at the same time. For right-turn lanes, this typically involves right-turning vehicles from the major road and vehicles entering the intersection from the minor road. In both scenarios, adding positive offset to turn lanes enhances the sight distance to approaching vehicles that conflict with the turning movement. Offset turn lanes should be considered when there is a high frequency of these types of conflicts in order to reduce the likelihood of a severe crash.

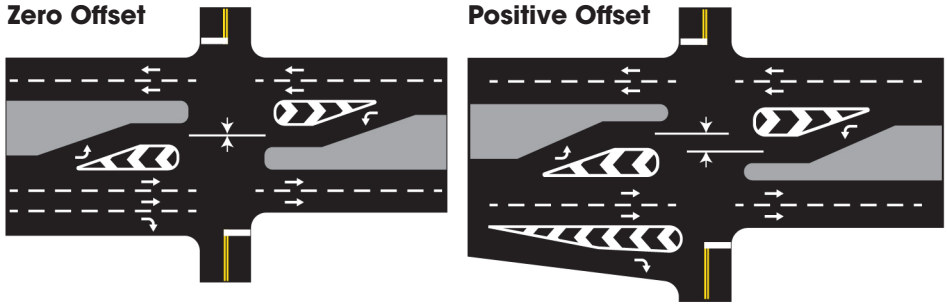


Illustration comparing zero offset to positive offset of left- and right-turn lanes. Source: FHWA

1 Harwood et al. Safety Effectiveness of Intersection Left- and Right-Turn Lanes. FHWA-HRD-02-089, (2002).
2 Persaud et al. Safety Evaluation of Offset Improvements for Left-Turn Lanes. FHWA-HRT-09-035, (2009).

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## Safety Benefits:

**RCUT**
**Two-Way Stop-Controlled to RCUT:**

**54%**
reduction in fatal and injury crashes.[2]

**Signalized Intersection to Signalized RCUT:**

**22%**
reduction in fatal and injury crashes.[3]

**Unsignalized Intersection to Unsignalized RCUT:**

**63%**
reduction in fatal and injury crashes. [4]

**MUT**

**30%**
reduction in intersection-related injury crash rate.[5]

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/intersection/rltci/index.cfm.**

FHWA-SA-21-030

# Reduced Left-Turn Conflict Intersections

Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur. These intersections simplify decision-making for drivers and minimize the potential for higher severity crash types, such as head-on and angle. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the Restricted Crossing U-turn (RCUT) and the Median U-turn (MUT).

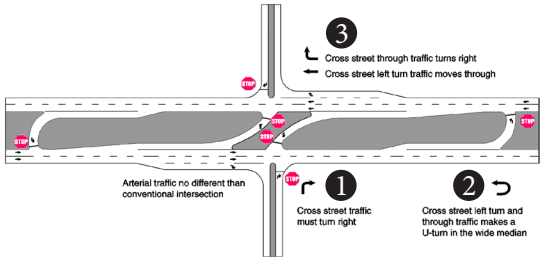
## Restricted Crossing U-turn

The RCUT intersection, also known as a J-Turn, Superstreet, or Reduced Conflict Intersection, modifies the direct left-turn and through movements from cross-street approaches. Minor road traffic makes a right turn followed by a U-turn at a designated location—either signalized or unsignalized—to continue in the desired direction. The RCUT is suitable for and adaptable to a wide variety of circumstances, ranging from isolated rural, high-speed locations to urban and suburban high-volume, multimodal corridors. It is a competitive and less costly alternative to constructing an interchange. RCUTs work well when consistently used along a corridor, but also can be used effectively at individual intersections. Studies have shown that installing an RCUT can result in a 30-percent increase in throughput and a 40-percent reduction in network intersection travel time.[1]

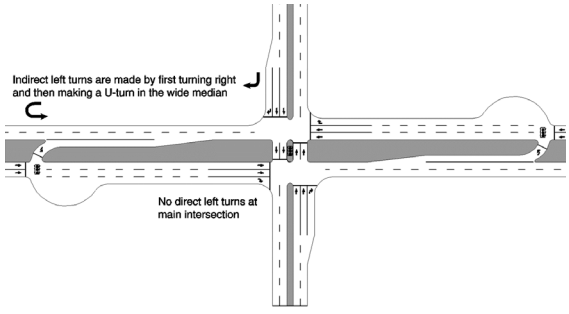
## Median U-turn

The MUT intersection modifies direct left turns from the major approaches. Vehicles proceed through the main intersection, make a U-turn a short distance downstream, followed by a right turn at the main intersection. The U-turns can also be used for modifying the cross-street left turns, similar to the RCUT.

The MUT is an excellent choice for intersections with heavy through traffic and moderate left-turn volumes. Studies have shown a 20- to 50-percent improvement in intersection throughput for various lane configurations as a result of implementing the MUT design. When implemented at multiple intersections along a corridor, the efficient two-phase signal operation of the MUT can reduce delay, improve travel times, and create more crossing opportunities for pedestrians and bicyclists.




Example of a unsignalized RCUT intersection. Source: FHWA




Example of a MUT intersection. Source: FHWA

1 Hugher and Jagannathan. Restricted Crossing U-Turn Intersection. FHWA-HRT-09-059, (2009).
2 Edara et al. Evaluation of J-turn Intersection Design Performance in Missouri. MoDOT, (2013).
3 Hummer and Rao. Safety Evaluation of a Signalized Restricted Crossing U-Turn. FHWA-HRT-17-082, (2017).
4 Hummer et al. Superstreet Benefits and Capacities. FHWA/NC/2009-06, NC State University, (2010).
5 Synthesis of the Median U-Turn Treatment, Safety, and Operational Benefits, FHWA-HRT-07-033, (2007).

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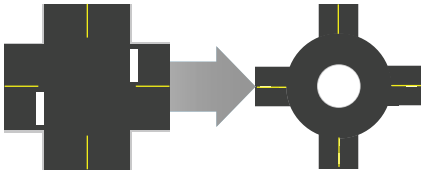
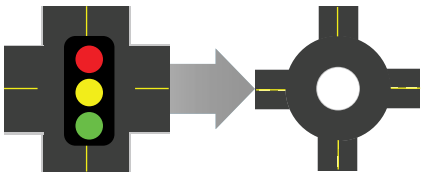
## Safety Benefits:

### Two-Way Stop-Controlled Intersection to a Roundabout



**82%**
reduction in fatal and injury crashes.[1]

### Signalized Intersection to a Roundabout



**78%**
reduction in fatal and injury crashes.[1]

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/intersection/roundabouts/index.cfm.**

FHWA-SA-21-042

# Roundabouts

The modern roundabout is an intersection with a circular configuration that safely and efficiently moves traffic. Roundabouts feature channelized, curved approaches that reduce vehicle speed, entry yield control that gives right-of-way to circulating traffic, and counterclockwise flow around a central island that minimizes conflict points. The net result of lower speeds and reduced conflicts at roundabouts is an environment where crashes that cause injury or fatality are substantially reduced.

Roundabouts are not only a safer type of intersection; they are also efficient in terms of keeping people moving. Even while calming traffic, they can reduce delay and queuing when compared to other intersection alternatives. Furthermore, the lower vehicular speeds and reduced conflict environment can create a more suitable environment for walking and bicycling.

Roundabouts can be implemented in both urban and rural areas under a wide range of traffic conditions. They can replace signals, two-way stop controls, and all-way stop controls. Roundabouts are an effective option for managing speed and transitioning traffic from high-speed to low-speed environments, such as freeway interchange ramp terminals, and rural intersections along high-speed roads.


Illustration of a multilane roundabout. Source: FHWA

Example of a single-lane roundabout. Source: FHWA

1 AASHTO. The Highway Safety Manual, American Association of State Highway Transportation Professionals, Washington, D.C., (2010).

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# Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections

This systemic approach to intersection safety involves deploying a package of multiple low-cost countermeasures, including enhanced signing and pavement markings, at a large number of stop-controlled intersections within a jurisdiction. These countermeasures increase driver awareness and recognition of the intersections and potential conflicts.

## Safety Benefits:

**10%**
reduction of fatal and injury crashes at all locations/types/areas.

**15%**
reduction of nighttime crashes at all locations/types/areas.

**27%**
reduction of fatal and injury crashes at rural intersections.

**19%**
reduction of fatal and injury crashes at 2-lane by 2-lane intersections.

**Average Benefit-Cost Ratio**

**12:1**

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/intersection/stop/fhwasa18047.pdf.**

There are several benefits to systemically applying multiple low-cost countermeasures at stop-controlled intersections, including,

- Resources are maximized because the treatments are low cost.
- A high number of intersections can receive treatment.
- Improvements are highly cost-effective, with an average benefit-cost ratio of 12:1, even assuming a conservative 3-year service life.

Example of countermeasures on the through approach.
Source: South Carolina DOT

Example of countermeasures on the stop approach.
Source: South Carolina DOT

The low-cost countermeasures for stop-controlled intersections generally consist of the following treatments:

### On the Through Approach

- Doubled-up (left and right), oversized advance intersection warning signs, with supplemental street name plaques (can also include flashing beacon).
- Retroreflective sheeting on sign posts.
- Enhanced pavement markings that delineate through lane edge lines.

### On the Stop Approach

- Doubled-up (left and right), oversized advance "Stop Ahead" intersection warning signs (can also include flashing beacon).
- Doubled-up (left and right), oversized Stop signs.
- Retroreflective sheeting on sign posts.
- Properly placed stop bar.
- Removal of vegetation, parking, or obstructions that limit sight distance.
- Double arrow warning sign at stem of T-intersections.

Source: T. Le et al. "Safety Effects of Low-Cost Systemic Safety Improvements at Signalized and Stop-Controlled Intersections," 96th Annual Meeting of the Transportation Research Board, Paper Number 17-05379, January 2017.

FHWA-SA-21-031

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**Safety Benefits:**

**36-50%**
reduction in red light running.[2]

**8-14%**
reduction in total crashes.[2]

**12%**
reduction in injury crashes.[2]

# Yellow Change Intervals

At a signalized intersection, the yellow change interval is the length of time that the yellow signal indication is displayed following a green signal indication. The yellow signal confirms to motorists that the green has ended and that a red will soon follow.

Since red-light running is a leading cause of severe crashes at signalized intersections, it is imperative that the yellow change interval be appropriately timed. Too brief an interval may result in drivers being unable to stop safely and cause unintentional red-light running. Too long of an interval may result in drivers treating the yellow as an extension of the green phase and invite intentional red-light running. Factors such as the speed of approaching and turning vehicles, driver perception-reaction time, vehicle deceleration, and intersection geometry should all be considered in the timing calculation.

Transportation agencies can improve signalized intersection safety and reduce red-light running by reviewing and updating their traffic signal timing policies and procedures concerning the yellow change interval. Agencies should institute regular evaluation and adjustment protocols for existing traffic signal timing. Refer to the *Manual on Uniform Traffic Control Devices* for basic requirements and further recommendations about yellow change interval timing. As part of strategic signal system modernization and updates, incorporating automated traffic signal performance measures (ATSPMs) is a proven approach to improve on traditional retiming processes. ATSPMs provide continuous performance monitoring capability and the ability to modify timing based on actual performance, without requiring expensive modeling or data collection.[1]

Appropriately timed yellow change intervals can reduce red-light running and improve overall intersection safety. Source: FHWA

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/intersection/signal/fhwasa13027.pdf.**

FHWA-SA-21-043

1 Federal Highway Administration. "Automated Traffic Signal Performance," (2020).
2 NCHRP Report 731: Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections, (2011).

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# Crosswalk Visibility Enhancements

Poor lighting conditions, obstructions such as parked cars, and horizontal or vertical roadway curvature can reduce visibility at crosswalks, contributing to safety issues. For multilane roadway crossings where vehicle volumes are in excess of 10,000 Average Annual Daily Traffic (AADT), a marked crosswalk alone is typically not sufficient. Under such conditions, more substantial crossing improvements could prevent an increase in pedestrian crash potential.

Three main crosswalk visibility enhancements help make crosswalks and the pedestrians, bicyclists, wheelchair and other mobility device users, and transit users using them more visible to drivers. These include high-visibility crosswalks, lighting, and signing and pavement markings. These enhancements can also assist users in deciding where to cross. Agencies can implement these features as standalone or combination enhancements to indicate the preferred location for users to cross.

## Safety Benefits:

**High-visibility crosswalks can reduce pedestrian injury crashes up to:**

**40%** [1]

**Intersection lighting can reduce pedestrian crashes up to:**

**42%** [2]

**Advance yield or stop markings and signs can reduce pedestrian crashes up to:**

**25%** [3]

### High-visibility crosswalks

High-visibility crosswalks use patterns (i.e., bar pairs, continental, ladder) that are visible to both the driver and pedestrian from farther away compared to traditional transverse line crosswalks. They should be considered at all midblock pedestrian crossings and uncontrolled intersections. Agencies should use materials such as inlay or thermoplastic tape, instead of paint or brick, for highly reflective crosswalk markings.

### Improved Lighting

The goal of crosswalk lighting should be to illuminate with positive contrast to make it easier for a driver to visually identify the pedestrian. This involves carefully placing the luminaires in forward locations to avoid a silhouette effect of the pedestrian.

### Enhanced Signing and Pavement Markings

On multilane roadways, agencies can use "YIELD Here to Pedestrians" or "STOP Here for Pedestrians" signs 20 to 50 feet in advance of a marked crosswalk to indicate where a driver should stop or yield to pedestrians, depending on State law. To supplement the signing, agencies can also install a STOP or YIELD bar (commonly referred to as "shark's teeth") pavement markings.

In-street signing, such as "STOP Here for Pedestrians" or "YIELD Here to Pedestrians" may be appropriate on roads with two- or three-lane roads where speed limits are 30 miles per hour or less.


Source: FHWA

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/ped_bike/step/docs/techSheet_VizEnhancemt2018.pdf.**

1 Chen, L., C. Chen, and R. Ewing. The Relative Effectiveness of Pedestrian Safety Countermeasures at Urban Intersections - Lessons from a New York City Experience. (2012).
2 Elvik, R. and Vaa, T. Handbook of Road Safety Measures. Oxford, United Kingdom, Elsevier, (2004).
3 Zeeger et al. Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments, FHWA, (2017).

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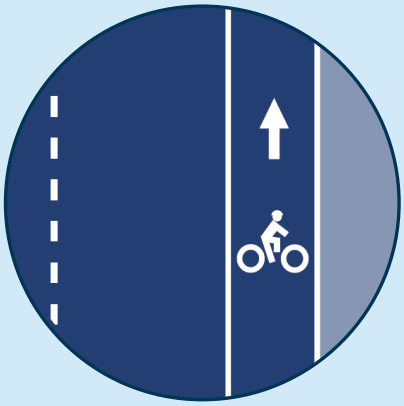

# Bicycle Lanes

Most fatal and serious injury bicyclist crashes occur at non-intersection locations. Nearly one-third of these crashes involve overtaking motorists[1]; the speed and size differential between vehicles and bicycles can lead to severe injury. To make bicycling safer and more comfortable for most types of bicyclists, State and local agencies should consider installing bicycle lanes. These dedicated facilities for the use of bicyclists along the roadway can take several forms. Providing bicycle facilities can mitigate or prevent interactions, conflicts, and crashes between bicyclists and motor vehicles, and create a network of safer roadways for bicycling. Bicycle Lanes align with the Safe System Approach principle of recognizing human vulnerability—where separating users in space can enhance safety for all road users.

## Safety Benefits:

**Bicycle Lane Additions can reduce crashes up to:**

**57%**
for total crashes on urban 4-lane undivided collectors and local roads.[6]

**30%**
for total crashes on urban 2-lane undivided collectors and local roads.[6]

Separated bicycle lane in Washington, DC. Source: Alex Baca, Washington Area Bicyclist Association

Separated bicycle lanes may provide further safety benefits. FHWA is anticipating completion of research in Fall 2022.

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf.**

## Applications

FHWA's *Bikeway Selection Guide* and *Incorporating On-Road Bicycle Networks into Resurfacing Projects* assist agencies in determining which facilities provide the most benefit in various contexts. Bicycle lanes can be included on new roadways or created on existing roads by reallocating space in the right-of-way.

In addition to the paint stripe used for a typical bicycle lane, a lateral offset with painted buffer can help to further separate bicyclists from vehicle traffic. State and local agencies may also consider physical separation of the bicycle lane from motorized traffic lanes through the use of vertical elements like posts, curbs, or vegetation.[2] Based on international experience and implementation in the United States, there is potential for further safety benefits associated with separated bicycle lanes. FHWA is conducting research on separated bicycle lanes, which includes the development of crash modification factors, to be completed in 2022 to address significant interest on this topic.

## Considerations

- City and State policies may require minimum bicycle lane widths, although these can differ by agency and functional classification of the road.
- Bicycle lane design should vary according to roadway characteristics (e.g., motor vehicle volumes and speed) in order to maximize the facility's suitability for riders of all ages and abilities and should consider the travel needs of low-income populations likely to use bicycles. The *Bikeway Selection Guide* is a useful resource.
- While some in the public may oppose travel lane narrowing if they believe it will slow traffic or increase congestion, studies have found that roadways did not experience an increase in injuries or congestion when travel lane widths were decreased to add a bicycle lane.[3]
- Studies and experience in US cities show that bicycle lanes increase ridership and may help jurisdictions better manage roadway capacity without increased risk.
- In rural areas, rumble strips can negatively impact bicyclists' ability to ride if not properly installed. Agencies should consider the dimensions, placement, and offset of rumble strips when adding a bicycle lane.[4]
- Strategies, practices, and processes can be used by agencies to enhance their ability to address equity in bicycle planning and design.[5]

1 Thomas et al. Bicyclist Crash Types on National, State, and Local Levels: A New Look. Transportation Research Record 673(6), 664-676, (2019).
2 Separated Bike Lane Planning and Design Guide. FHWA-HEP-15-025, (2015).
3 Park and Abdel-Aty. "Evaluation of safety effectiveness of multiple cross sectional features on urban arterials". Accident Analysis and Prevention, Vol. 92, pp. 245-255, (2016).
4 FHWA Tech Advisory Shoulder and Edge Line Rumble Strips, (2011).
5 Sandt et al. Pursuing Equity in Pedestrian and Bicycle Planning. FHWA, (2016).
6 Avelar et al. Development of Crash Modification Factors for Bicycle Lane Additions While Reducing Lane and Shoulder Widths. FHWA, (2021).

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

FHWA-SA-21-051

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# Rectangular Rapid Flashing Beacons (RRFB)

A marked crosswalk or pedestrian warning sign can improve safety for pedestrians crossing the road, but at times may not be sufficient for drivers to visibly locate crossing locations and yield to pedestrians. To enhance pedestrian conspicuity and increase driver awareness at uncontrolled, marked crosswalks, transportation agencies can install a pedestrian actuated Rectangular Rapid Flashing Beacon (RRFB) to accompany a pedestrian warning sign. RRFBs consist of two, rectangular- shaped yellow indications, each with a light-emitting diode (LED)-array-based light source.[1] RRFBs flash with an alternating high frequency when activated to enhance conspicuity of pedestrians at the crossing to drivers.

For more information on using RRFBs, see the Interim Approval in the *Manual on Uniform Traffic Control Devices (MUTCD)*.[1]

## Safety Benefits:

**RRFBs can reduce crashes up to:**

**47%**

for pedestrian crashes.[4]

**RRFBs can increase motorist yielding rates up to:**

**98%**

(varies by speed limit, number of lanes, crossing distance, and time of day).[3]

RRFBs used at a trail crossing.
Source: LJB

## Applications

The RRFB is applicable to many types of pedestrian crossings but is particularly effective at multilane crossings with speed limits less than 40 miles per hour.[2] Research suggests RRFBs can result in motorist yielding rates as high at 98 percent at marked crosswalks, but varies depending on the location, posted speed limit, pedestrian crossing distance, one- versus two-way road, and the number of travel lanes.[3] RRFBs can also accompany school or trail crossing warning signs.

RRFBs are placed on both sides of a crosswalk below the pedestrian crossing sign and above the diagonal downward arrow plaque pointing at the crossing.[1] The flashing pattern can be activated with pushbuttons or passive (e.g., video or infrared) pedestrian detection, and should be unlit when not activated.

## Considerations

**Agencies should:[2]**

- Install RRFBs in the median rather than the far-side of the roadway if there is a pedestrian refuge or other type of median.
- Use solar-power panels to eliminate the need for a power source.
- Reserve the use of RRFBs for locations with significant pedestrian safety issues, as over-use of RRFB treatments may diminish their effectiveness.

**Agencies shall not:[2]**

- Use RRFBs without the presence of a pedestrian, school or trail crossing warning sign.
- Use RRFBs for crosswalks across approaches controlled by YIELD signs, STOP signs, traffic control signals, or pedestrian hybrid beacons, except for the approach or egress from a roundabout.

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/ped_bike/step/docs/techSheet_RRFB_2018.pdf.**

1 *MUTCD* Interim Approval 21 - RRFBs at Crosswalks.
2 "Rectangular Rapid Flash Beacon" in PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System. FHWA, (2013).
3 Fitzpatrick et al. "Will You Stop for Me? Roadway Design and Traffic Control Device Influences on Drivers Yielding to Pedestrians in a Crosswalk with a Rectangular Rapid-Flashing Beacon." Report No. TTI-CTS-0010. Texas A&M Transportation Institute, (2016).
4 NCHRP Research Report 841 Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments, (2017).

FHWA-SA-21-053

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**Safety Benefits:**

**13%**

reduction in pedestrian-vehicle crashes at intersections.[1]

# Leading Pedestrian Interval

A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter the crosswalk at an intersection 3-7 seconds before vehicles are given a green indication. Pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn right or left.

**LPIs provide the following benefits:**

- Increased visibility of crossing pedestrians.
- Reduced conflicts between pedestrians and vehicles.
- Increased likelihood of motorists yielding to pedestrians.
- Enhanced safety for pedestrians who may be slower to start into the intersection.

FHWA's Handbook for ***Designing Roadways for the Aging Population*** recommends the use of the LPI at intersections with high turning vehicle volumes. Transportation agencies should refer to the ***Manual on Uniform Traffic Control Devices*** for guidance on LPI timing and ensure that pedestrian signals are accessible for all users. Costs for implementing LPIs are very low when only signal timing alteration is required.

An LPI allows a pedestrian to establish a presence in the crosswalk before vehicles are given a green indication. Source: FHWA


LPIs reduce potential conflicts between pedestrians and turning vehicles. Source: FHWA

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/ped_bike/step/resources/docs/fhwasa19040.pdf.**

FHWA-SA-21-032

1 Goughnour, E., D. Carter, C. Lyon, B. Persaud, B. Lan, P. Chun, I. Hamilton, and K. Signor. "Safety Evaluation of Protected Left-Turn Phasing and Leading Pedestrian Intervals on Pedestrian Safety." Report No. FHWA-HRT-18-044. Federal Highway Administration. (October 2018)

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# Medians and Pedestrian Refuge Islands in Urban and Suburban Areas

A **median** is the area between opposing lanes of traffic, excluding turn lanes. Medians in urban and suburban areas can be defined by pavement markings, raised medians, or islands to separate motorized and non-motorized road users.

A **pedestrian refuge island** (or crossing area) is a median with a refuge area that is intended to help protect pedestrians who are crossing a road.

## Safety Benefits:

**Median with Marked Crosswalk**

**46%**

reduction in pedestrian crashes.[2]

**Pedestrian Refuge Island**

**56%**

reduction in pedestrian crashes.[2]

Pedestrian crashes account for approximately 17 percent of all traffic fatalities annually, and 74 percent of these occur at non-intersection locations.[1] For pedestrians to safely cross a roadway, they must estimate vehicle speeds, determine acceptable gaps in traffic based on their walking speed, and predict vehicle paths. Installing a median or pedestrian refuge island can help improve safety by allowing pedestrians to cross one direction of traffic at a time.

Transportation agencies should consider medians or pedestrian refuge islands in curbed sections of urban and suburban multilane roadways, particularly in areas with a significant mix of pedestrian and vehicle traffic, traffic volumes over 9,000 vehicles per day, and travel speeds 35 mph or greater. Medians/refuge islands should be at least 4-ft wide, but preferably 8 ft for pedestrian comfort. Some example locations that may benefit from medians or pedestrian refuge islands include:

- Mid-block crossings.
- Approaches to multilane intersections.
- Areas near transit stops or other pedestrian-focused sites.

Example of a road with a median and pedestrian refuge islands. Source: City of Charlotte, NC


Median and pedestrian refuge island near a roundabout. Source: www.pedbikeimages.org / Dan Burden

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/ped_bike/step/docs/techSheet_PedRefugeIsland2018.pdf.**

1 National Center for Statistics and Analysis. (2020, March). Pedestrians: 2018 data (Traffic Safety Facts. Report No. DOT HS 812 850). National Highway Traffic Safety Administration
2 Desktop Reference for Crash Reduction Factors, FHWA-SA-08-011, September 2008, Table 11.

FHWA-SA-21-044

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**Safety Benefits:**

**55%**
reduction in pedestrian crashes.[2]

**29%**
reduction in total crashes.[3]

**15%**
reduction in fatal and serious injury crashes.[3]

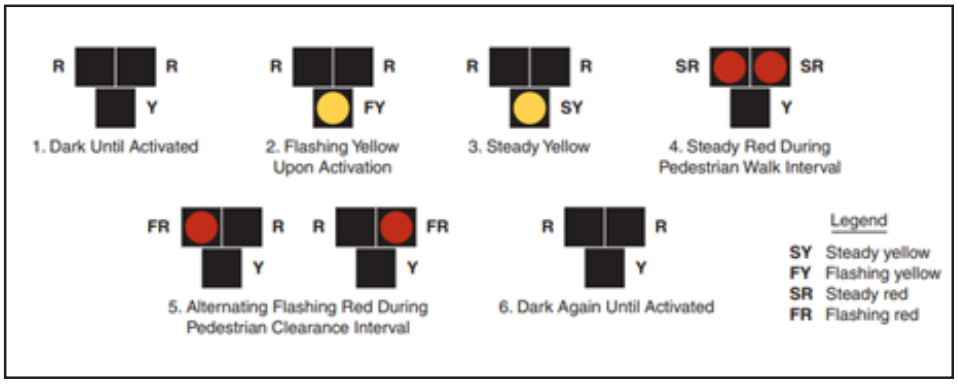

Example of PHBs mounted on a mast arm. Source: FHWA

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/ped_bike/step/resources/docs/fhwasa18064.pdf.**

FHWA-SA-21-045

# Pedestrian Hybrid Beacons

The pedestrian hybrid beacon (PHB) is a traffic control device designed to help pedestrians safely cross higher-speed roadways at midblock crossings and uncontrolled intersections. The beacon head consists of two red lenses above a single yellow lens. The lenses remain "dark" until a pedestrian desiring to cross the street pushes the call button to activate the beacon, which then initiates a yellow to red lighting sequence consisting of flashing and steady lights that directs motorists to slow and come to a stop, and provides the right-of-way to the pedestrian to safely cross the roadway before going dark again.




Sequence for a PHB. Source: MUTCD 2009 Edition, p. 511, FHWA

Nearly 74 percent of pedestrian fatalities occur at non-intersection locations, and vehicle speeds are often a major contributing factor.[1] As a safety strategy to address this pedestrian crash risk, the PHB is an intermediate option between a flashing beacon and a full pedestrian signal because it assigns right of way and provides positive stop control. It also allows motorists to proceed once the pedestrian has cleared their side of the travel lane(s), reducing vehicle delay.

Transportation agencies should refer to the *Manual on Uniform Traffic Control Devices* (MUTCD) for information on the application of PHBs.

In general, PHBs are used where it is difficult for pedestrians to cross a roadway, such as when gaps in traffic are not sufficient or speed limits exceed 35 miles per hour. They are very effective at locations where three or more lanes will be crossed or traffic volumes are above 9,000 annual average daily traffic. Installation of a PHB must also include a marked crosswalk and pedestrian countdown signal. If PHBs are not already familiar to a community, agencies should conduct appropriate education and outreach as part of implementation.

1 National Center for Statistics and Analysis. (2020, March). Pedestrians: 2018 data (Traffic Safety Facts. Report No. DOT HS 812 850). National Highway Traffic Safety Administration
2 Zegeer et al. NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. TRB, (2017).
3 Fitzpatrick, K. and Park, E.S. Safety Effectiveness of the HAWK Pedestrian Crossing Treatment, FHWA-HRT-10-042, (2010).

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**Safety Benefits:**

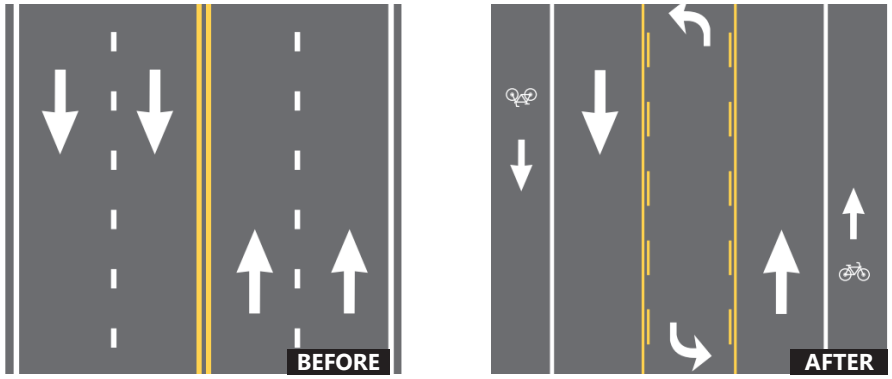
**4-Lane to 3-Lane Road Diet Conversions**

**19-47%**

reduction in total crashes.[1]

# Road Diets (Roadway Reconfiguration)

A Road Diet, or roadway reconfiguration, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life. A Road Diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL).




Before and after example of a Road Diet. Source: FHWA

## Benefits of Road Diet installations may include:

- Reduction of rear-end and left-turn crashes due to the dedicated left-turn lane.
- Reduced right-angle crashes as side street motorists cross three versus four travel lanes.
- Fewer lanes for pedestrians to cross.
- Opportunity to install pedestrian refuge islands, bicycle lanes, on-street parking, or transit stops.
- Traffic calming and more consistent speeds.
- A more community-focused, Complete Streets environment that better accommodates the needs of all road users.

A Road Diet can be a low-cost safety solution when planned in conjunction with a simple pavement overlay, and the reconfiguration can be accomplished at no additional cost. Typically, a Road Diet is implemented on a roadway with a current and future average daily traffic of 25,000 or less.

Road Diet project in Honolulu, Hawaii. Source: Leidos

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/road_diets/.**

1 *Evaluation of Lane Reduction "Road Diet" Measures on Crashes*, FHWA-HRT-10-053, (2010).

FHWA-SA-21-046

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## Safety Benefits:

**Sidewalks**

**65-89%**

reduction in crashes involving pedestrians walking along roadways.[3]

**Paved Shoulders**

**71%**

reduction in crashes involving pedestrians walking along roadways.[3]

# Walkways

A walkway is any type of defined space or pathway for use by a person traveling by foot or using a wheelchair. These may be pedestrian walkways, shared use paths, sidewalks, or roadway shoulders.

With more than 6,200 pedestrian fatalities and 75,000 pedestrian injuries occurring in roadway crashes annually,[1] it is important for transportation agencies to improve conditions and safety for pedestrians and to integrate walkways more fully into the transportation system. Research shows people living in low-income communities are less likely to encounter walkways and other pedestrian-friendly features.[2]

Well-designed pedestrian walkways, shared use paths, and sidewalks improve the safety and mobility of pedestrians. Pedestrians should have direct and connected network of walking routes to desired destinations without gaps or abrupt changes. In some rural or suburban areas, where these types of walkways are not feasible, roadway shoulders provide an area for pedestrians to walk next to the roadway, although these are not preferable.

Transportation agencies should work towards incorporating pedestrian facilities into all roadway projects unless exceptional circumstances exist. It is important to provide and maintain accessible walkways along both sides of the road in urban areas, particularly near school zones and transit locations, and where there is a large amount of pedestrian activity. Walkable shoulders should also be considered along both sides of rural highways when routinely used by pedestrians.

Example of a sidewalk in a residential area. Source: pedbikeimages.org / Burden

Paved shoulder used as a walkway. Source: pedbikeimages.org / Burden

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=1.**

FHWA-SA-21-047

1 National Center for Statistics and Analysis. (2020, March). Pedestrians: 2018 data (Traffic Safety Facts. Report No. DOT HS 812 850). National Highway Traffic Safety Administration.
2 Gibbs, et all. Income Disparities in Street Features that Encourage Walking. Bridging the Gap, (2012, March).
3 Gan et al. Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects. Florida DOT, (2005).

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## Safety Benefits:

**HFST can reduce crashes up to:**

**63%**
for injury crashes at ramps.[2]

**48%**
for injury crashes at horizontal curves.[2]

**20%**
for total crashes at intersections.[3]

Automated application of HFST.
Source: FHWA

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/high_friction/.**

FHWA-SA-21-052

# Pavement Friction Management

Friction is a critical characteristic of a pavement that affects how vehicles interact with the roadway, including the frequency of crashes. Measuring, monitoring, and maintaining pavement friction—especially at locations where vehicles are frequently turning, slowing, and stopping—can prevent many roadway departure, intersection, and pedestrian-related crashes.

Pavement friction treatments, such as High Friction Surface Treatment (HFST), can be better targeted and result in more efficient and effective installations when using continuous pavement friction data along with crash and roadway data.

### Continuous Pavement Friction Measurement

Friction data for safety performance is best measured with Continuous Pavement Friction Measurement (CPFM) equipment. Spot friction measurement devices, like locked-wheel skid trailers, cannot safely and accurately collect friction data in curves or intersections, where the pavement polishes more quickly and adequate friction is so much more critical. Without CPFM equipment, agencies will assume the same friction over a mile or more.

CPFM technology measures friction continuously at highway speeds and provides both network and segment level data. Practitioners can analyze the friction, crash, and roadway data to better understand and predict where friction-related crashes will occur to better target locations and more effectively install treatments.[1]

### High Friction Surface Treatment

HFST consists of a layer of durable, anti-abrasion, and polish-resistant aggregate over a thermosetting polymer resin binder that locks the aggregate in place to restore or enhance friction and skid resistance. Calcined bauxite is the aggregate shown to yield the best results and should be used with HFST applications.

### Applications

HFST should be applied in locations with increased friction demand, including:

- Horizontal curves.
- Interchange ramps.
- Intersection approaches.
  - Higher-speed signalized and stop-controlled intersections.
  - Steep downward grades.
- Locations with a history of rear-end, failure to yield, wet-weather, or red-light-running crashes.
- Crosswalk approaches.

### Considerations

- HFST is applied on existing pavement, so no new pavement is added.
- If the underlying pavement structure is unstable, then the HFST life cycle may be shortened, resulting in pre-mature failure.
- The automated installation method is preferred as it minimizes issues often associated with manual installation: human error due to fatigue, inadequate binder mixing, improper and uneven binder thickness, delayed aggregate placement, and inadequate aggregate coverage.
- The cost can be reduced when bundling installations at multiple locations.

1 Izeppi et al. Continuous Friction Measurement Equipment as a Tool for Improving Crash Rate Prediction: A Pilot Study. Virginia Department of Transportation, (2016).
2 Merritt et al. Development of Crash Modification Factors for High Friction Surface Treatments. FHWA, (2020).
3 NCHRP Report 617: Accident Modification Factors for Traffic Engineering and ITS Improvements, (2008).

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# Proven Safety Countermeasures

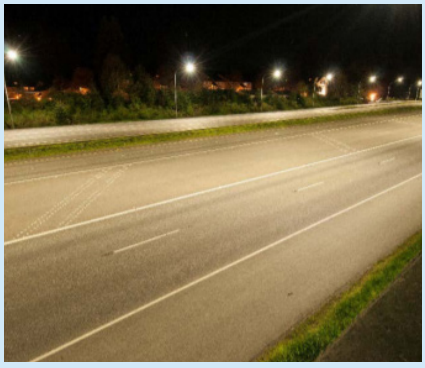
## Safety Benefits:

**Lighting can reduce crashes up to:**

**42%**
for nighttime injury pedestrian crashes at intersections.[1]

**33-38%**
for nighttime crashes at rural and urban intersections.[1]

**28%**
for nighttime injury crashes on rural and urban highways.[1]



Source: WSDOT

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/roadway_dept/night_visib/roadwayresources.cfm.**

FHWA-SA-21-050

## Lighting

The number of fatal crashes occurring in daylight is about the same as those that occur in darkness. However, the nighttime fatality rate is three times the daytime rate because only 25 percent of vehicle miles traveled (VMT) occur at night. At nighttime, vehicles traveling at higher speeds may not have the ability to stop once a hazard or change in the road ahead becomes visible by the headlights. Therefore, lighting can be applied continuously along segments and at spot locations such as intersections and pedestrian crossings in order to reduce the chances of a crash.

Adequate lighting (i.e., at or above minimum acceptable standards) is based on research recommending horizontal and vertical illuminance levels to provide safety benefits to all users of the roadway environment. Adequate lighting can also provide benefits in terms of personal security for pedestrians, wheelchair and other mobility device users, bicyclists, and transit users as they travel along and across roadways.

### Applications

#### Roadway Segments

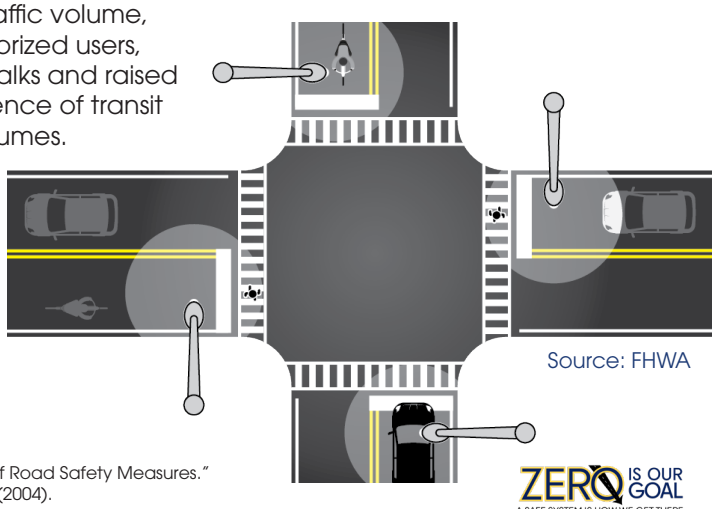
Research indicates that continuous lighting on both rural and urban highways (including freeways) has an established safety benefit for motorized vehicles.[1] Agencies can provide adequate visibility of the roadway and its users through the uniform application of lighting that provides full coverage along the roadway and the strategic placement of lighting where it is needed the most.

#### Intersections and Pedestrian Crossings

Increased visibility at intersections at nighttime is important since various modes of travel cross paths at these locations. Agencies should consider providing lighting to intersections based on factors such as a history of crashes at nighttime, traffic volume, the volume of non-motorized users, the presence of crosswalks and raised medians, and the presence of transit stops and boarding volumes.

### Considerations

Most new lighting installations are made with breakaway features, shielded, or placed far enough from the roadway to reduce the probability and/or severity of fixed-object crashes. Modern lighting technology gives precise control with minimal excessive light affecting the nighttime sky or spilling over to adjacent properties. Agencies can equitably engage with underserved communities to determine where and how new and improved lighting can most benefit the community by considering their priorities, including eliminating crash disparities, connecting to essential neighborhood services, improving active transportation routes, and promoting personal safety.



Source: FHWA

1 Elvik, R. and Vaa, T., "Handbook of Road Safety Measures." Oxford, United Kingdom, Elsevier, (2004).

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

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## Safety Benefits:

**Agencies have experienced the following benefits after LRSP implementation:**

**25%**
reduction in county road fatalities in Minnesota.

**17%**
reduction in fatal and serious injury crashes on county-owned roads in Washington State.

**35%**
reduction in severe curve crashes in Thurston County, WA.

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/LRSPDIY/.**

FHWA-SA-21-033

# Local Road Safety Plans

A local road safety plan (LRSP) provides a framework for identifying, analyzing, and prioritizing roadway safety improvements on local roads. The LRSP development process and content are tailored to local issues and needs. The process results in a prioritized list of issues, risks, actions, and improvements that can be used to reduce fatalities and serious injuries on local roads. FHWA has developed several resources including an LRSP Do-It-Yourself website which further explains the process and includes resources local agencies and their partners need to create and implement an LRSP.[1]

Approximately 75 percent of rural roads are owned by local agencies.[2] While local roads are less traveled than State highways, they have a much higher rate of fatal and serious injury crashes.[2] Developing an LRSP is an effective strategy to improve local road safety for all road users and support the goals of a State's overall Strategic Highway Safety Plan (SHSP).

Although the development process and resulting plan can vary depending on the local agency's needs, available resources, and targeted crash types, aspects common to LRSPs include:

- Stakeholder engagement representing the 4E's: engineering, enforcement, education, and emergency medical services.
- Collaboration among municipal, county, Tribal, State, and/or Federal entities to leverage expertise and resources.
- Identification of target crash types and crash risk with corresponding recommended proven safety countermeasures.
- Timeline and goals for implementation and evaluation.

Local road agencies should consider developing an LRSP to be used as a tool for reducing roadway fatalities, injuries, and crashes.[3] LRSPs can help agencies create a prioritized list of improvements. LRSPs are also a proactive risk management technique to demonstrate an agency's responsiveness. The plan should be viewed as a living document that can be updated to reflect changing local needs and priorities.


Infographic showing the LRSP process. Source: FHWA

1 https://safety.fhwa.dot.gov/LRSPDIY/
2 Anderson et al. Noteworthy Practices: Addressing Safety on Locally-Owned and Maintained Roads A Domestic Scan, FHWA-SA-09-019, (2010).
3 Developing Safety Plans: A Manual for Local Rural Road Owners, FHWA-SA-12-017, provides guidance on developing an LRSP.

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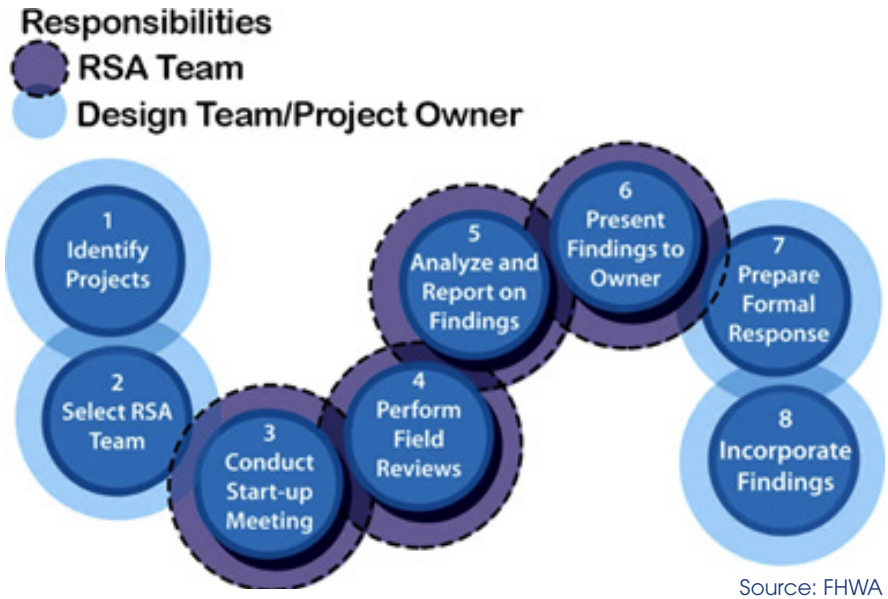
**Safety Benefits:**

**10-60%**
reduction in total crashes.[1]

# Road Safety Audit

While most transportation agencies have established traditional safety review procedures, a road safety audit (RSA) or assessment is unique. RSAs are performed by a multidisciplinary team independent of the project. RSAs consider all road users, account for human factors and road user capabilities, are documented in a formal report, and require a formal response from the road owner. (See the eight steps for conducting an RSA below.)




Source: FHWA

**RSAs provide the following benefits:**

- Reduced number and severity of crashes due to safer designs.
- Reduced costs resulting from early identification and mitigation of safety issues before projects are built.
- Increased opportunities to integrate multimodal safety strategies and proven safety countermeasures.
- Expanded ability to consider human factors in all facets of design.
- Increased communication and collaboration among safety stakeholders.
- Objective review by independent multidisciplinary team.

RSAs can be performed in any phase of project development, from planning through construction. Agencies may focus RSAs specifically on motorized vehicles, pedestrians, bicyclists, motorcyclists, or a combination of these roadway users. Agencies are encouraged to conduct an RSA at the earliest stage possible, as all roadway design options and alternatives are being explored.

Multidisciplinary team performs field review during an RSA. Source: FHWA

**For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures/ and https://safety.fhwa.dot.gov/rsa/.**

1 Road Safety Audits: An Evaluation of RSA Programs and Projects, FHWA-SA-12-037; and FHWA Road Safety Audit Guidelines, FHWA-SA-06-06.

FHWA-SA-21-048


https://safety.fhwa.dot.gov/provencountermeasures/

FHWA-SA-21-071