Chapter 3: Evaluate Regional Context

Introduction

Transportation infrastructure are foundational structures and systems for transporting people and goods. This system supports the economy and directly impacts the competiveness of the nation and the NOACA region. Over the years, the United States has built one of the world's most extensive transportation systems, representing trillions of dollars of public investment. The transportation system is made up of many individual elements, which ideally, should be connected to provide ease of movement for all users. These individual elements are roads, bridges, sidewalks, bikeways, transit, rail, waterways, airports and intermodal connectors. These individual systems are described in this chapter, as well as how each provides an equally important role in providing access and mobility for the NOACA region.

State of Transportation Infrastructure

Roadway Network

Similar to other metropolitan areas with urban and rural configurations, the road network in the NOACA region is the most extensive transportation mode which connects all the land uses, i.e. activity locations, in communities to each other. This network is also an essential part for supporting the local and regional economy and residents' movements for work, social, education and other trip purposes. The NOACA region contains a significant portion of Ohio's interstate total lane miles with local Interstates routes including IR-71, IR-77, IR-80, IR-90, IR-271, IR-480, and IR-490. Typically, the interstate and freeway systems carry the highest volume of traffic in the region, requiring more travel lanes. The Interstate system was built in the late 1950's/ early 1960's is now 60+ years old.

Table 3-1 displays the lane miles of the road system except local streets by facility type. The data is based on the 2020 highway network of the NOACA travel forecasting model.

Table 3-1. Road Lengths by Facility Type

Facility Type	Lane Miles	Percent of Total
Freeway/ Expressway	1,879	18%
Highway Ramp	316	3%
Major Road (Arterial)	3,816	36%
Minor Road (Collector)	4,557	43%
Total	**10,568**	**100%**

The Federal-Aid Highway Program supports State highway systems by providing financial assistance for the construction, maintenance and operations of the Nation's 3.9 million-mile highway network, including the Interstate Highway System, primary highways and secondary local roads. The Federal Highway Administration (FHWA) is charged with implementing the Federal-aid Highway Program in cooperation with the States and local government.

Local government - primarily counties, cities and towns, or local Public Agencies (LPAs) - own and operate about 75 percent, or roughly 2.9 million miles, of the Nation's highway network. LPAs build and maintain this network using a variety of funding sources, including the Federal-aid Highway Program. An estimated 7,000 LPAs manage about $7 billion annually in Federal-aid projects, or roughly 15 percent of the total program. Understanding Federal-aid requirements is so important in the delivery of Federal-aid projects at the local level. Federal-aid Essentials highlights key components of the program to help LPAs and their State partners successfully manage locally administered Federal-aid projects.

Federal Aid System in the NOACA region includes Interstate Routes (SR), US Routes, State Routes (SR) and County Routes (CR). It should be noted that the Ohio Department of Transportation maintains roads such as Interstates, Freeways, and State Routes outside of municipal boundaries which are excluded from Table 3-2.

Table 3-2 illustrates the road and Federal Aid system lengths by County.

Table 3-2. Road Lengths by County

County	Lane Miles	Federal Aid Lane Mile	County Percent of Federal Aid Lane Miles
Cuyahoga	5,173	3,178	61.4%
Geauga	878	261	29.7%
Lake	1,230	574	46.7%
Lorain	2,037	755	37.1%
Medina	1,254	351	28.0%
NOACA Region	**10,570**	**5,119**	**48.4%**

Transit Network

Mobility choices are vital to the health and vibrancy of a region. Public transit options reduce congestion, personal transportation costs, and carbon output. A robust public transit system presents residents with a choice to travel within the region. Public transit is a form of alternative transportation for those with automobiles, as well as a primary service for those who do not have other options, primarily lower-income households, the elderly, the young, and people with disabilities. . Public transit provides access to employment, healthcare, entertainment, and educational facilities, among other daily activities and destinations.

Similarly to single occupancy vehicles, public transportation vehicles also operate on the road network. Furthermore, the transit system includes limited miles of a railway network, but the rail system is not comparable in scale to the road network, thus bus service is more expansive.

Transit Services

There are five different transit agencies operating within the NOACA region: Geauga County Transit (GCT), the Greater Cleveland Regional Transit Authority (GCRTA), Laketran, Lorain County Transit (LTC), and Medina County Public Transit (MCPT). The additional agencies (Portage Area Regional Transportation Authority, or PARTA; Akron Metro Regional Transit Authority; and Stark Area Regional Transit Authority) also operate in the seven-county Cleveland metropolitan area. As the region's population density has declined, and the population expanded outward into previously rural areas, serving within the shifting land use patterns has been a challenge. NOACA and the region's transit systems will need to continue to plan accordingly to meet the needs of the region's population. It will be necessary to prioritize limited transportation funding. The region must balance transit needs with demands, determining where to expand or reduce service, and where to strengthen core service.

Transit Infrastructure

In the NOACA region, bus services, including local, premium and Bus Rapid Transit (BRT), run through the existing highways and streets network with thousands of bus stops at different levels of passenger comfort. Additionally, rapid transit access is ensured through a network of light and heavy rail operated by the Greater Cleveland Regional Transit Authority (RTA) for passenger services and regional freight rail companies. The passenger rail services comprise of three lines known as the Red Line, Blue Line and Green Line.

In addition to the existing highway and rail infrastructure for the bus and rail services, there are currently 37 park and ride facilities in the NOACA region. The majority of these intermodal facilities are in Cuyahoga County (27); which are at rail stations (20), premium bus stations (4), shared BRT and Rail stations (2) and a BRT(1) station. The other park and ride facilities are in Lake (9) and Medina (1) counties and are for premium bus services.

Figures 3-1 and 3-2 show the existing transit services and the locations of the current intermodal facilities in the NOACA region.

Figure 3-1. The Current Transit Network

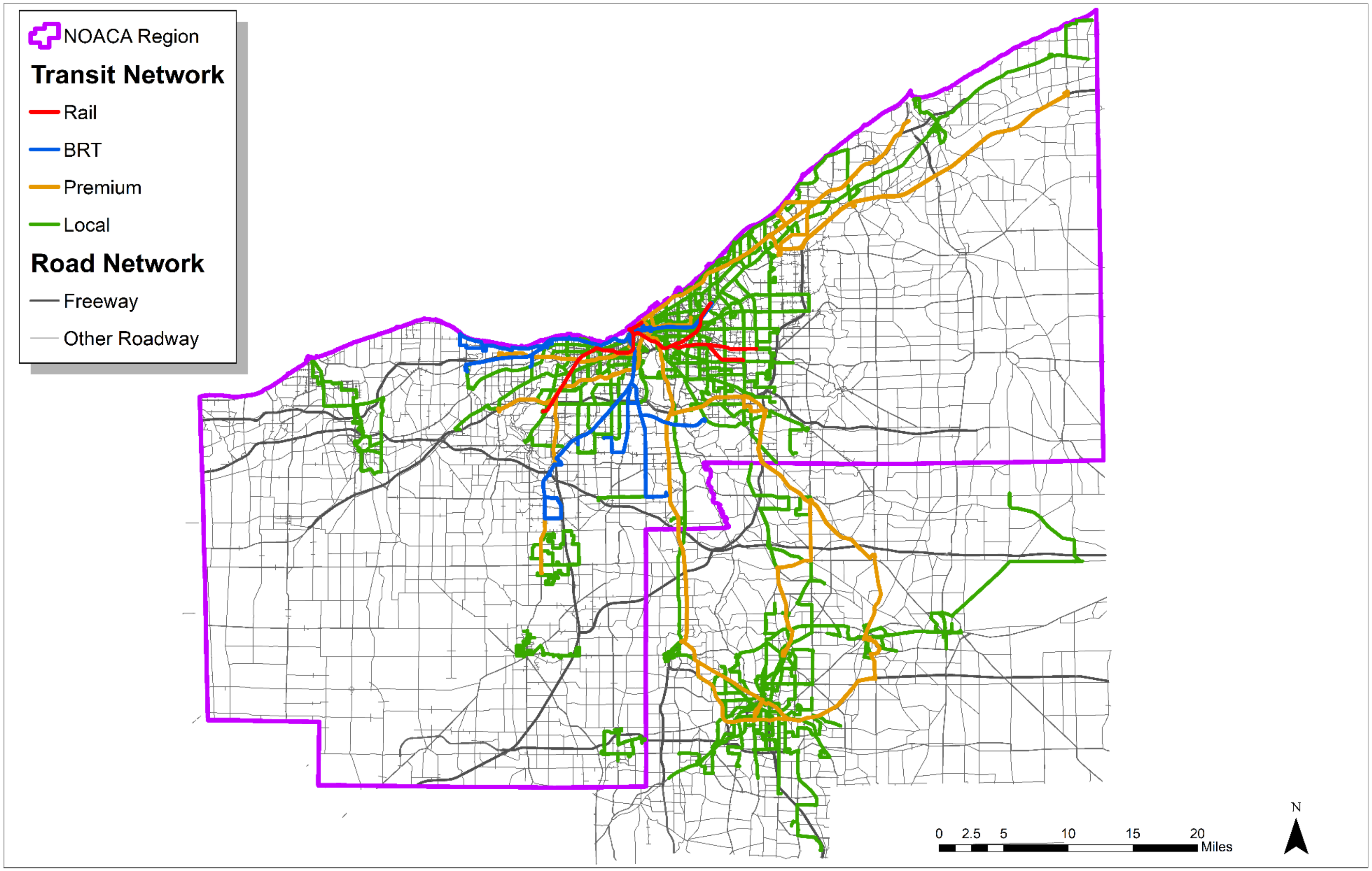
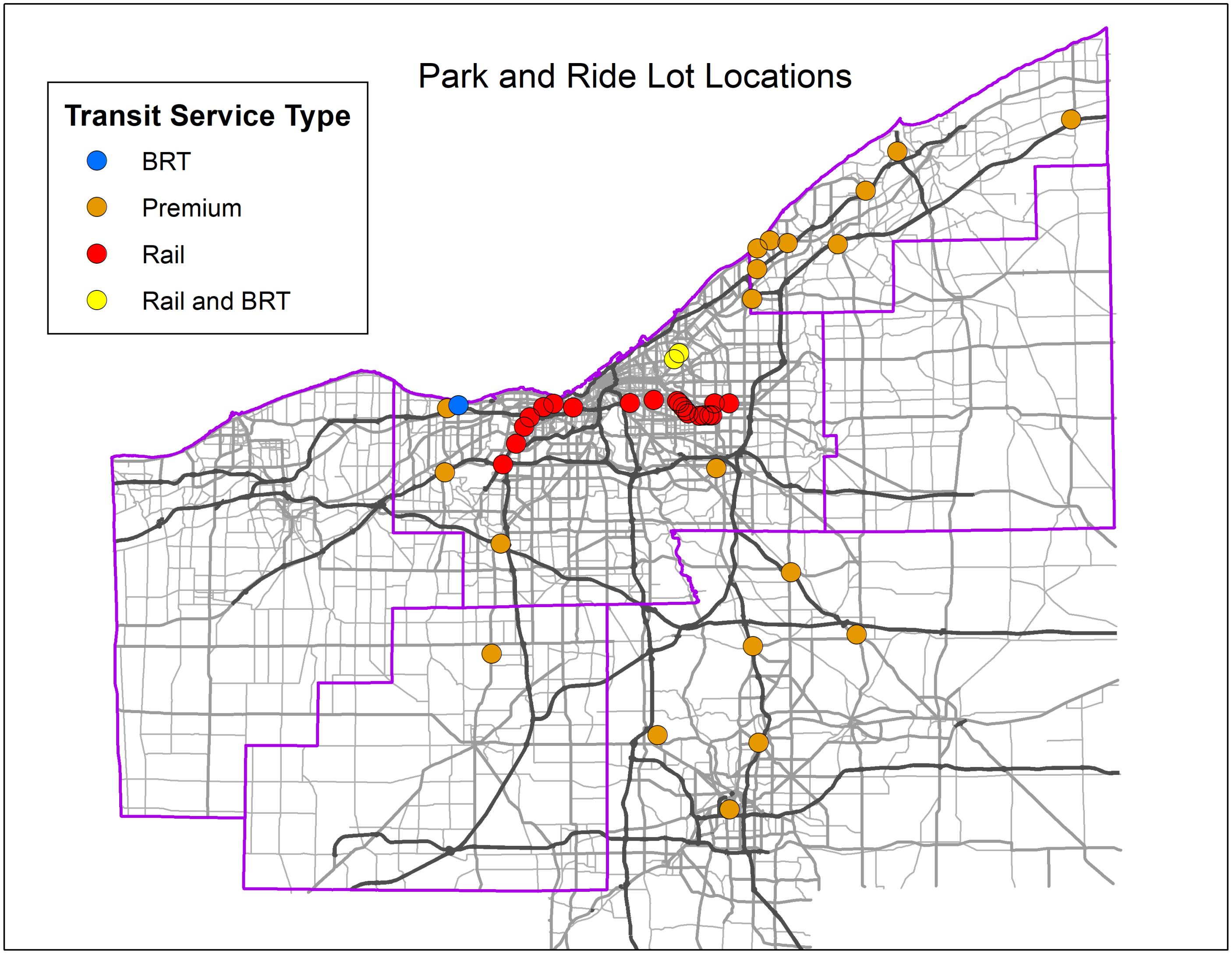


Figure 3-2. The Locations of the Current Intermodal Facilities



A central aspect of transit planning is improving the way that we move around the region and provide access to support development through transportation infrastructure. Choice means increasing both the number of destinations that are easily accessible and the use of mode accessed to arrive. All of the region's transit systems have plans to maintain and possibly expand their respective systems better to accommodate for these conditions.

Expanding public transit requires significant capital investment; however, the potential advantages of a well-planned project are often greater than the costs. Public transit benefits include:[1]

- Connecting people and jobs
- Improving mobility for people of all ages
- Stimulating and focusing new development on sites near transit
- Creating and supporting jobs by providing a reliable alternative to driving
- Moving more people in the same amount of road space
- Improving air quality and reducing greenhouse gas emissions
- Reducing household transportation costs

Non-Motorized Transportation

Non-motorized transportation or active transportation refers to being physically active for the purpose of transportation (typically biking and walking), and is distinct from being physically active for recreation. NOACA has been formally planning at the regional level for bicycling as a means of transportation since 1978, with the release of Phase I of a four-phase bicycle planning process that spanned from 1977 to 1989. The NOACA Regional Bicycle Plan has been updated: 1997, 2008, 2013 and is currently developing a new pedestrian and bicycle plan, ACTIVATE. This plan will provide a vision for increasing the use of bikeways and walkways for transportation and commuting and also serving as a guide for future bicycle and pedestrian improvements. This plan will also include a prioritization model based on a Connectivity Scoring Quantitative System (CSQS) for investing in non-motorized facility for accessing to the transit network.

Planning for bicycling and walking as modes of transportation is important for a variety of reasons. Improving travel safety is always important, but improving safety of bicycling and walking is especially important because these road users are most vulnerable to fatality and severe injury in a crash. Furthermore, perceived safety of these modes has a direct effect on how many people are willing to choose biking and walking. With limited federal and state transportation funding, encouraging mode shift to biking and walking is an important and underused travel demand management strategy that can alleviate traffic congestion. Increased biking and walking is a form of exercise and can improve health. In addition, because biking and walking are zero-emission modes of transportation, shifting trips to these modes can improve health by improving air quality. Specifically, biking and walking are ideal modes for replacing short trips (three miles or less), which are more polluting and less efficient, per mile,

[1] Northeast Ohio Sustainable Communities Consortium (NEOSCC), *Vibrant NEO2040*, - http://vibrantneo.org/wp-content/uploads/2014/04/Vibrant-NEO-Final-Report_3-31-14_lowres_ALL.pdf.

by car than longer trips.[2] Moreover, a significant percentage of the population in Northeast Ohio does not have access to a car, and providing viable transportation options is vital.

Planning for bicycle and pedestrian travel has also been established as a priority by the federal government. The United States Code requires that bicyclists and pedestrians be given due consideration in the comprehensive transportation plans developed by each metropolitan planning organization and state, in accordance with sections 134 and 135, respectively. Bicycle transportation facilities and pedestrian walkways are to be considered, where appropriate, in conjunction with all new construction and reconstruction of transportation facilities, except where bicycle and pedestrian use are not permitted. Transportation plans and projects must also provide due consideration for safety and contiguous routes for bicyclists and pedestrians.

Bicycle and Pedestrian Infrastructure

Bicycling is an important component of the transportation system. It is an important travel demand strategy that can alleviate traffic congestion and reduce emissions. Improving or increasing the bicycle infrastructure is important to the NOACA region, but especially for the population that does not have access to a personal vehicle.

NOACA, in coordination with partner agencies, maintains an inventory of 688.5 miles of existing bicycle facilities in all five counties. These facilities can be defined as separated and shared types:

<u>Separated</u>

- All Purpose Trails: Open to bicyclists and are fully separated from the roadways.
- Separated Bike Lanes: On-street bike lanes that have vertical separation from traffic in the form of posts or other barriers.
- Buffered Bike Lanes: are conventional bicycle lanes paired with a designated buffer space separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking.

<u>Shared</u>

- Bike Lanes: on-street bike lanes that are marked with a painted line and accompanying signage.
- Bike Routes: on street typically marked with sharrows and/or signs.

Table 3-3 summarizes the bike lane lengths by type and county.

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[2] M.L. Grabow, S.N. Spak, T. Holloway, B. Stone, Jr., A.C., Mednick, and J.A. Patz, "Air Quality and Exercise-Related Health Benefits from Reduced Car Travel in the Midwestern United States," National Center for Biotechnology Information Resources PubMed, https://www.ncbi.nlm.nih.gov/pubmed/22049372.

Table 3-3. The Bike lane Facilities Lengths by Type and County

COUNTY	ALL PURPOSE TRAIL	SEPARATED BIKE LANE	BUFFERED BIKE LANE	BIKE LANE	BIKE ROUTES*	TOTAL
Cuyahoga	201.9	0.9	5.5	71.0	107.9	387.2
Geauga	24.6					24.8
Lake	62.4			19.4	3.6	85.4
Lorain	87.2			23.8	49.7	160.6
Medina	30.5					30.5
NOACA Region	**406.6**	**0.9**	**5.5**	**114.2**	**161.3**	**688.5**

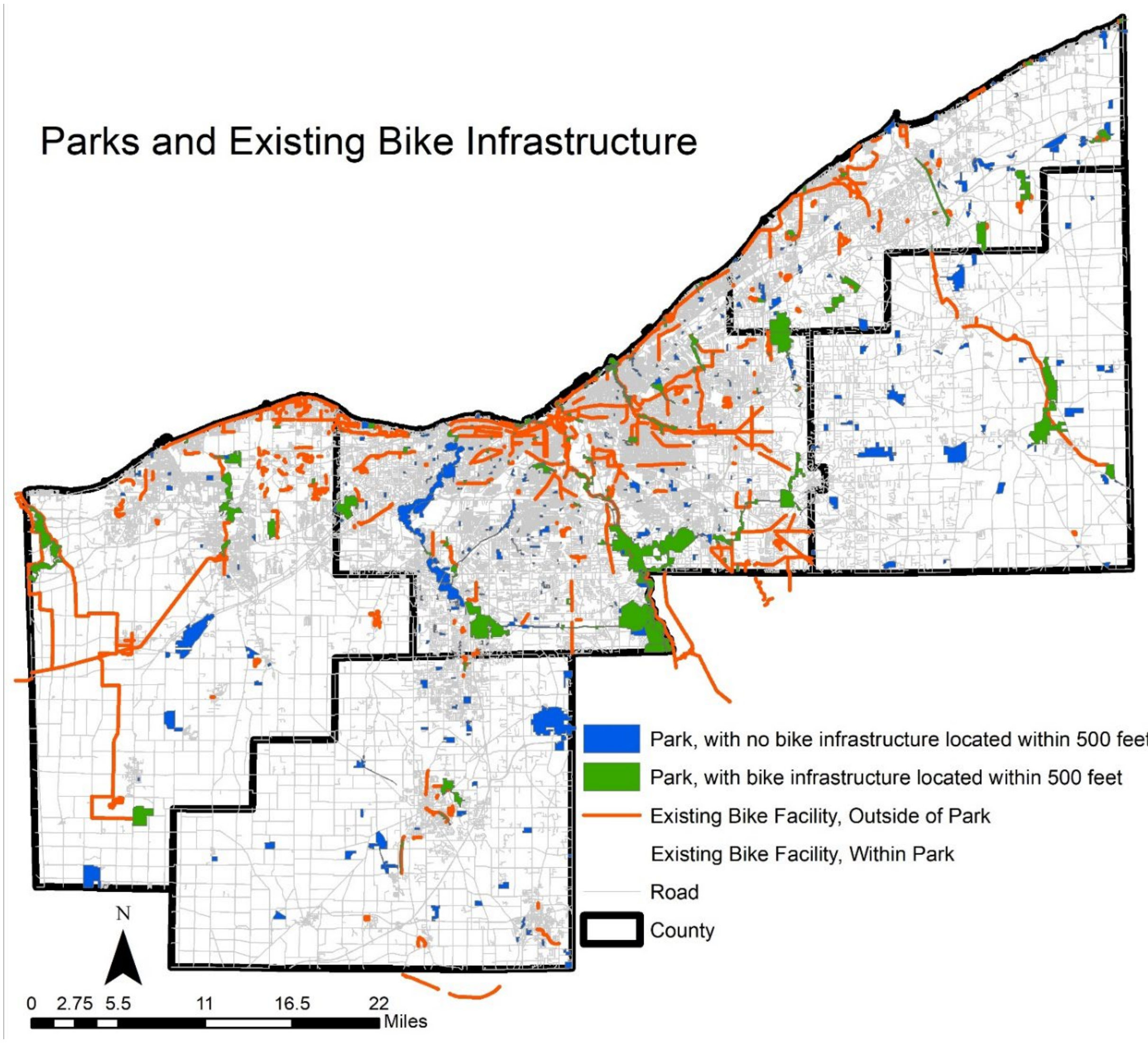
Source: NOACA Regional Bike Network, *Routes are typically marked with sharrows and/or signs

Bicycle Facility and Park Access

Northeast Ohio is home to many recreational biking trails within park facilities such as the Big Creek Parkway, the Towpath Trail, and the Black River Trail in Elyria. Recreational trails can become transportation assets when they are maintained throughout the year, have adequate lighting, and connect to other bike infrastructure. However, many of the region's parks do not have bike infrastructure within 500 feet of the park's boundary, which limits access to the park's interior trails and amenities from being used to support active transportation. These same parks often have significant trail infrastructure inside the park itself, such as the Valley Parkway and Rocky River Reservation.

Very few parks in the rural areas of the NOACA region appear to have bike facilities within 500 feet of the park boundary. In total, 199 (35%) of the region's 566 parks have bike facilities located within 500 feet of the park boundary. Figure 3-3 shows the parks in the region according to whether bike facilities are within 500 feet of the boundary of the park.

Figure 3-3. Bike Facilities and Park Access



NOACA conducts bicycle and pedestrian counts throughout the agency's five-county region in order to gauge regional and local levels of bicycling and walking, to identify trends to aid in the planning and design of transportation infrastructure and programming, and to calibrate walk and bike modes in the NOACA Travel Forecasting Model.

Manual counts have been conducted biannually since September 2011, and 160 different locations have been counted at least once through 2018. Counts have been conducted along a variety of roadway and bicycle facility types, including bike lanes, all purpose trails, and roadways without bicycle infrastructure or sidewalks. The majority of counts have been conducted in more populated areas of the region within Cuyahoga County, but counts were also done in smaller towns and rural areas throughout all five counties in the NOACA region. In addition to overall numbers of pedestrians and cyclists, the counts also tracked number of cyclists by helmet usage, sidewalk usage, gender, and weather conditions.

Automated Bicycle and Pedestrian Counts

NOACA collects data from permanently installed bike and pedestrian counters throughout the region (see Table 3-4). Fourteen counters use Miovision video-based technology, and two counters use EcoCounter infrared and under-pavement loop technology.

The Miovision counter equipment was purchased by NOACA using an ODOT Active Transportation grant, and has been installed and calibrated to collect data during 2020.

The Miovision counter equipment utilizes a 360 degree view to conduct turning movement counts at intersections, including motor vehicles, bikes, and pedestrians. The counters may also count specific bike and pedestrian-focuses zones including bike lanes and all-purpose trails where a full turning movement count is not possible or desired.

The EcoCounter equipment offers more targeted bike/ pedestrian-only counts of specific trails or bike lanes, including a heavily-used bridge trail in Downtown Cleveland and a bike lane near Case Western Reserve University.

Data is being collected continuously at these locations covering a variety of roadway classifications and bike facility types.

Table 3-4. Permanent Automated Counter Equipment

ID	Counter Type	Location	City
1	Miovision TrafficLink	Lake Shore Boulevard at East 149thStreet	**Cleveland**
2	Miovision TrafficLink	Superior Avenue East at East 21stStreet	**Cleveland**
3	Miovision TrafficLink	Euclid Avenue at East 105th Street	**Cleveland**
4	Miovision TrafficLink	Detroit Avenue at West 65th Street	**Cleveland**
5	Miovision TrafficLink	Veteran's Memorial Bridge - DetroitAvenue at West 25th Street	**Cleveland**
6	Miovision TrafficLink	Veteran's Memorial Bridge - Superior Avenue at Huron Road	**Cleveland**
7	Miovision TrafficLink	Cedar Glen Parkway at OverlookRoad	**Cleveland Hts**
8	Miovision TrafficLink	Madison Avenue at VictoriaAvenue	**Lakewood**
9	Miovision TrafficLink	Hilliard Boulevard at Clague Road	**Westlake**
10	Miovision TrafficLink	Maple Highlands Trail at SouthStreet	**Chardon**
11	Miovision TrafficLink	Center Road Trail at Munson Road	**Mentor**
12	Miovision TrafficLink	Lake Road at Shields Road	**Avon Lake**
13	Miovision TrafficLink	North Coast Inland Trail at SouthMain Street and Edison	**Oberlin**

		Street	
14	Miovision TrafficLink	Wadsworth Trail at Main Street andWright Street	**Wadsworth**
15	EcoCounter Urban Post	Lorain-Carnegie Bridge Trail	**Cleveland**
16	**EcoCounter Zelt Loop**	**Edgehill Rd. - Eastbound Bike Lane**	**Cleveland Hts**

Level of Traffic Stress (LTS)

Level of Traffic Stress (LTS) is a relatively new means of assessing who may feel comfortable biking on a particular road. LTS seeks to measure the traffic stress present on a roadway and identify the type of bicyclist who is likely comfortable biking on that road. When applied to a community or a region, it can result in a number of analysis tools that can assess overall connectivity and prevalence of low-stress biking facilities.

NOACA has been developing a regional Level of Traffic Stress analysis as part of its bicycle transportation maps since 2018. The regional analysis was completed for the ACTIVATE plan. The bike maps remain a natural complement to this work, as they seek to make cycling easier and less intimidating by providing information on where there are bike facilities and low-stress routes.

LTS is based on the premise that most people will generally avoid cycling on roads that they perceive are stressful and that traffic (speed, volume, and distance from cyclists) is the key factor in determining cyclist stress. The main source of bicyclist stress changes throughout the day, alternating between volume (during AM and PM peak) and speed (when volumes are low).1 Researchers have developed a set of measures to broadly capture a road's stress level by classifying it in one of four levels of traffic stress from low to high. LTS was first developed by the Mineta Transportation Institute in 2012 for the U.S. Department of Transportation in California. NOACA created a customized version of the LTS methodology that fits the region's characteristics with data that was easier to verify and gather, as well as adding a fifth LTS; a level to indicate roads that should be avoided by even expert-level cyclists.

Bicycle and Pedestrian Crash Data

The most recent analysis of crashes in the NOACA region (NOACA's State of Safety 2019 report) uses data for the five-year period from 2015 to 2019. Table 3-5 shows the regional priority corridors where 4 or more fatal and serious injury (FSI) crashes per mile have occurred.

Table 3-5. Regional Safety Priority Bicycle Corridors

Regional Safety Priority Corridors
Four or More Pedestrian and Bicycle FSI Crashes Per Mile
(2015 to 2019 Crash Data)

Rank	County	Community	Corridor	From	To	Ped Total	Ped FSI	Bike Total	Bike FSI	All Ped+Bike Crashes	Ped+Bike FSI
1	Cuyahoga	Cleveland	E 9th St	Sumner Ave	N Marginal Rd	30	6	6	0	36	**6**
2	Cuyahoga	Cleveland	Detroit Ave	W 95th St	W 65th St	17	4	7	1	24	**5**
3	Cuyahoga	Cleveland	W 25th St	Scranton Rd	Walton Ave	13	5	9	2	22	**7**
4	Cuyahoga	Cleveland	W 117th St	0.13 mi S of Lorain Ave	Berea Rd	12	3	9	3	21	**6**
5	Cuyahoga	Cleveland	St Clair Ave	E 93rd St	E 115th St	18	3	3	2	21	**5**
6	Cuyahoga	Cleveland	St Clair Ave	W 10th St/Old River Rd	E 13th St	18	7	1	0	19	**7**
7	Cuyahoga	Cleveland, Euclid	Euclid Ave	Hillview Rd	Grand Blvd (0.20 mi E of E 196th St)	16	4	3	1	19	**5**
8	Cuyahoga	Cleveland	Detroit Ave	W 114th St	W 95th St	11	4	5	1	16	**5**
9	Cuyahoga	Cleveland	E 131st St	Hoy Ave (0.14 mi S of Miles Ave)	Bartlett Ave	13	6	2	0	15	**6**
10	Cuyahoga	Cleveland	E 93rd St	Prince Ave (0.36 mi N of Harvard Ave)	Easton Ave (0.23 mi S of Kinsman Rd)	12	8	2	1	14	**9**
11	Cuyahoga	Euclid	Babbitt Rd	0.22 mi N of Lakeland Blvd	Lakeshore Blvd	11	5	3	0	14	**5**
12	Cuyahoga	Cleveland, East Cleveland	E Superior Ave	E 108th St	Hayden Ave	10	5	3	1	13	**6**
13	Cuyahoga	Parma	Ridge Rd	0.18 mi S of Regency Dr	Buckingham Dr (N of W Ridgewood Dr)	11	4	2	0	13	**4**
14	Cuyahoga	Cleveland	Miles Rd	E 99th St	E 124th St	10	4	2	0	12	**4**
15	Cuyahoga	East Cleveland	E Superior Ave/Euclid Ave	Hayden Ave	Wymore Ave	8	4	3	0	11	**4**
16	Cuyahoga	Cleveland	St Clair Ave	E 115th St	Casper Rd	9	4	1	0	10	**4**
16	Cuyahoga	Parma, Parma Hts	W Ridgewood Dr	York Rd	S Canterburry Rd (0.32 mi W of Ridge Rd)	7	4	3	0	10	**4**
16	Lake	Eastlake	Vine St	E 332nd St	E 359th St	5	2	5	2	10	**4**
17	Cuyahoga	Cleveland Hts, South Euclid	Warrensville Center Rd	Verona Rd (0.35 mi N of Cedar Rd)	Mayfield Rd	5	4	4	0	9	**4**

Traffic Control Devices

Traffic is the movement of a large number of individual drivers, cyclists and pedestrians through highways, streets, sidewalks, and transit networks from their origins to their destinations for completing their journeys. A traffic control system manages those journeys through physical networks based on two principals of safety and efficiency and utilizes physical devices signs, road markings, traffic signals, etc. See Table 3-6 for the number of signalized intersections by county in the NOACA region.

Table 3-6. Number of Signalized Intersections by County

County	Number of Signalized Intersections	Percent of Region
Cuyahoga	2621	76%
Lorain	340	10%
Lake	281	8%
Medina	147	4%
Geauga	67	2%
NOACA Region	**3,456**	**100%**

Transportation Safety and Operations

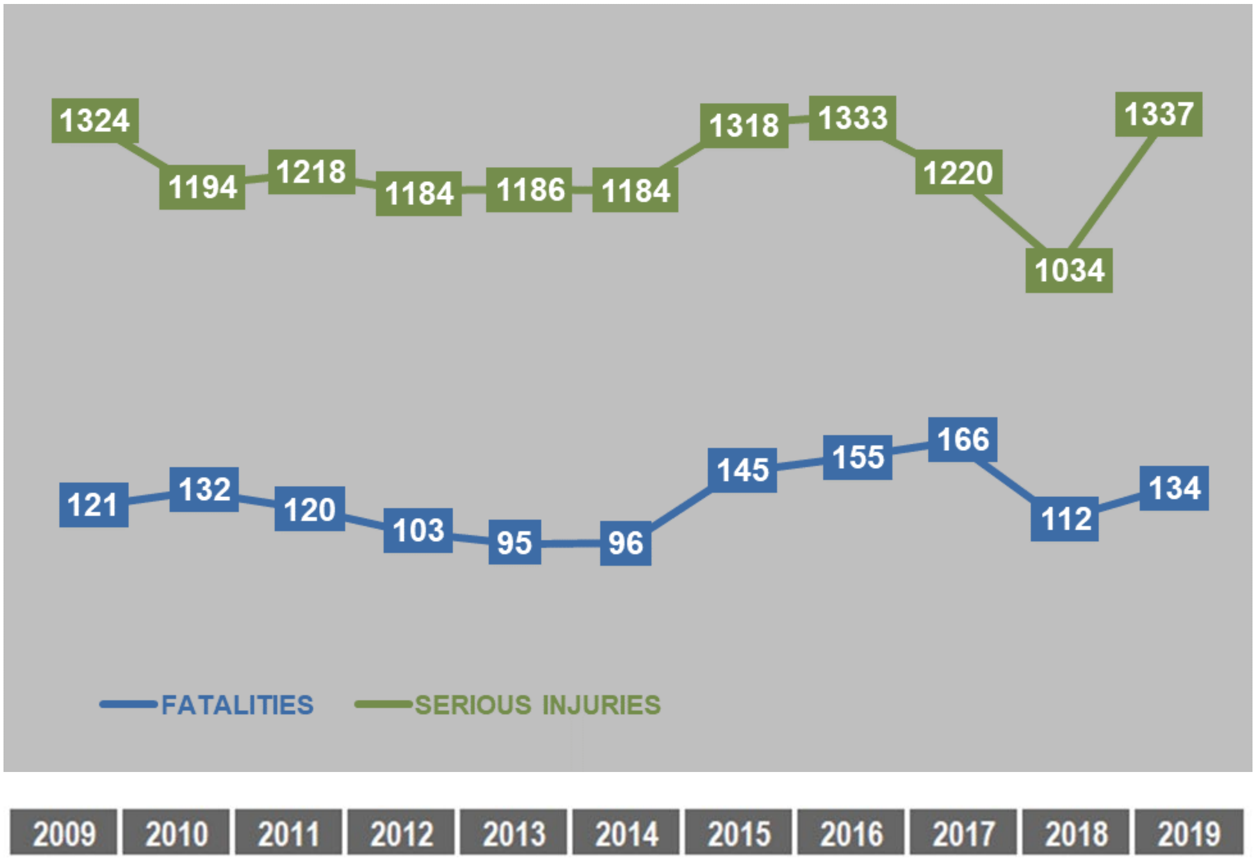
Introduction

One of NOACA's transportation planning goals is to preserve and improve the efficiency and safety of the existing transportation system, prioritize elements of the system, and ensure the system serves homeland security.

During 2019, there were 50,287 roadway crashes in the region, which resulted in 134 fatalities and 1,337 serious injuries (see Figure 3-4 and Tables 3-7 and 3-8). Both fatalities and serious injuries have significantly increased in 2019:

- A total of 22 more fatalities occurred versus 2018, a 20% increase.
- A total of 303 more serious injuries occurred versus 2018, a 29% increase.

Figure 3-4. Fatalities and Serious Injuries in the NOACA Region (2009-2019)



NOACA's Safety and Operations Council (SOC) to serve as an advisory group on the topic of safety planning, and to assist in the development and implementation of the SAVE Plan and provide recommendations regarding regional safety and operations programs to NOACA's Transportation Subcommittee. The SOC is made up of local planning and engineering staff, law enforcement, emergency responders, ODOT, FHWA, GCRTA, Ohio Traffic Safety Office, and community members.

Table 3-7. All Crashes by County, Per Year, with Averages

Year	Cuyahoga	Geauga	Lake	Lorain	Medina	NOACA Region Annual Total
2015	32,460	1,981	4,971	6,538	3,603	49,553
2016	33,395	1,929	4,974	6,454	3,481	50,233
2017	33,264	1,857	4,750	6,427	3,471	49,769
2018	33,510	1,878	4,683	6,496	3,502	50,069
2019	34,135	1,960	4,527	6,171	3,494	50,287
Average	**33,353**	**1,921**	**4,781**	**6,417**	**3,510**	**49,982**

Table 3-8. Crashes by Severity (2015-2019)

Year	All Crashes	PDO Crashes	Percent of All Crashes	Serious Injury Crashes	Percent of All Crashes	Fatal Crashes	Percent of All Crashes
2015	49,553	36,498	74%	1,075	2.2%	133	0.3%
2016	50,233	36,628	73%	1,108	2.2%	144	0.3%
2017	49,769	36,391	73%	1,026	2.1%	157	0.3%
2018	50,069	37,144	74%	878	1.8%	106	0.2%
2019	50,287	36,351	72%	1,072	2.1%	123	0.2%
Total	**249,911**	**183,012**	**73%**	**5,159**	**2.1%**	**663**	**0.3%**

The State of Safety Report helps to prioritize transportation safety concerns. It includes the top high-crash corridors in the region ranked by the number of serious injury and fatal crashes. Table 3-9 shows the top high-crash corridors based on the number of serious injury and fatal crashes of all types of crashes per mile that occurred during the five-year period 2015-2019. The State of Safety Report is updated each year to include the latest available five-year crash data.

Table 3-9. Regional Safety Priority Corridors

Regional Safety Priority Corridors Five or More Fatal or Serious Injury (FSI) Crashes per Mile (2015 to 2019 Crash Data)							
Rank	**County**	**Community**	**Corridor**	**From**	**To**	**Total Crashes**	**FSI**
1	Lake	Mentor	Mentor Ave	0.16 mi E of Hopkins Rd	Old Johnnycake Ridge Rd	229	**5**
2	Cuyahoga	Cleveland	St Clair Ave	E 93rd St	E 115th St	168	**12**
3	Cuyahoga	North Olmsted	Lorain Rd	Dover Center Rd	0.30 mi W of Great Northern Blvd	162	**5**
3	Cuyahoga	Cleveland	W 117th St	0.13 mi S of Lorain Ave	Berea Rd	162	**5**
4	Cuyahoga	Cleveland	St Clair Ave	E 115th St	Casper Rd (0.12 mi SW of Hayden Ave)	161	**12**
5	Cuyahoga	Cleveland, Euclid	Dille Rd/Nottingham Rd	Euclid Ave	S Waterloo Rd/I-90 EB Exit Ramp	160	**10**
6	Cuyahoga	Cleveland	W 25th St	0.10 mi N of Clark Ave	0.06 mi N of Lorain Rd	155	**5**
7	Cuyahoga	Cleveland, East Cleveland	E Superior Ave	E 108th St	Hayden Ave	153	**5**
8	Cuyahoga	University Hts, Cleveland Hts, South Euclid	Cedar Rd	Goodnor Rd (0.26 mi W of S Taylor Rd)	Fenwick Rd (0.21 mi E of Washington Blvd)	150	**5**
9	Cuyahoga	Cleveland	E 93rd St	Prince Ave (0.35 mi S of Aetna Rd)	Bessemer Ave	138	**9**
10	Cuyahoga	Cleveland	Detroit Ave	W 95th St	W 65th St	129	**5**
11	Cuyahoga	Cleveland	E Superior Ave	E 58th St	E 81st St	126	**7**
12	Cuyahoga	Cleveland	E 55Th St	Scovill Ave	Chester Ave (US-322)	118	**5**
12	Cuyahoga	Cleveland	Fulton Pkwy/Fulton Rd	Memphis Ave	I-71 South Ramps	118	**5**
13	Cuyahoga	Cleveland, Euclid	Euclid Ave	Hillview Rd (0.30 mi W of Green Rd)	0.28 mi W of Highland Rd/Dille Rd	106	**5**
14	Cuyahoga	Euclid	Euclid Ave/Chardon Rd	Grand Blvd (0.28 mi W of Highland Rd/Dille Rd)	E 226th St	104	**6**
15	Cuyahoga	Cleveland	W 117th St	Memphis Ave/Bellaire Rd	0.13 mi S of Lorain Ave	102	**5**
16	Cuyahoga	Cleveland	E 131st St	Hoy Ave	Farringdon Ave	100	**5**
17	Cuyahoga	Euclid	Euclid Ave	Chardon Rd	Sherwood Blvd	99	**5**
18	Cuyahoga	Cleveland	E Superior Ave	E 33rd St	E 58th St	94	**6**
19	Cuyahoga	Cleveland	E Superior Ave	E 81st St	E 108th St	93	**5**
20	Cuyahoga	Cleveland, Shaker Hts	Buckeye Rd/S woodland Rd	E 120th St	Warrington Rd	92	**5**
21	Cuyahoga	Cleveland	St Clair Ave	E 72nd St	E 93rd St	88	**5**
22	Cuyahoga	Bedford, Maple Hts	Broadway Ave	South Blvd	Glendale St	84	**5**
23	Cuyahoga	East Cleveland	E Superior Ave/Euclid Ave	Hayden Ave	Wymore Ave	76	**6**
24	Cuyahoga	Cleveland, Newburgh Hts	Harvard Ave	0.07 mi W of E 49th St	0.05 mi W of E 71st St	74	**5**
25	Cuyahoga	Strongsville	Prospect Rd	Royalton Rd	0.29 mi S of Albion Rd	72	**5**
25	Cuyahoga	Cleveland, Garfield Hts	Warner Rd	0.34 mi S of Garfield Blvd	Force Ave	72	**5**
26	Cuyahoga	Euclid	Lakeshore Blvd	E 219th St	E 244th St	67	**6**
27	Cuyahoga	Cleveland	Detroit Ave	W 114th St	W 95th St	66	**5**
28	Cuyahoga	Parma	Snow Rd	W 44th St	0.26 mi W of Broadview Rd	63	**5**
29	Cuyahoga	Cleveland	Broadway Ave	N of Aetna Rd	Booth Ave (N of Harvard Ave)	61	**5**
30	Cuyahoga	Maple Hts	Libby Rd	0.12 mi W of Broadway Ave	Cato St	57	**5**
31	Cuyahoga	Euclid	Lakeshore Blvd	E 244th St	E 272nd St	53	**5**
32	Cuyahoga	Cleveland	W 140th St	Viola Ave	0.09 mi S of Triskett Rd	51	**5**
33	Cuyahoga	Parma	Pearl Rd	0.07 mi S of Snow Rd (Parma/Parma Hts Corp Line)	Maysday Ave(E of Ridge Rd)	50	**5**
34	Cuyahoga	North Royalton, Parma	York Rd	Lynn Dr	Pleasant Lake Blvd	48	**7**
35	Lake	Painesville	E Erie St	Liberty St Ext	0.06 mi W of Nottingham Pl	42	**5**
36	Cuyahoga	Cleveland Hts	Mayfield Rd	Lee Rd	Yellowstone Rd	41	**5**
37	Cuyahoga	Gates Mills	Mayfield Rd	0.39 mi N of W Hill Dr	0.32 mi E of Chagrin River Rd	32	**5**
37	Cuyahoga	Parma	W Ridgewood Dr	State Rd (SR-94)	0.15 mi W of Yorktown Dr	32	**5**
38	Cuyahoga	Bedford	Northfield Rd	E Interstate St	Avery Ave	31	**5**
39	Lorain	Henrietta Twp	SR-113	Gifford Rd	0.25 mi E of Baumhart Rd	19	**5**

Road Safety Assessments

A road safety assessment (RSA) is a formal evaluation of the safety and performance of a road segment or intersection by an independent audit team. RSA team members have extensive experience with road design, traffic maintenance, roadway and intersection geometrics, and highway safety. NOACA staff work with the Ohio Department of Transportation (ODOT) and local communities to conduct RSAs at high-crash locations throughout Northeast Ohio. These high-crash locations are corridors and intersections identified in the State of Safety Report, where high frequency of serious injury and fatal motorized vehicle crashes or high frequency of bicycle and pedestrian crashes occurred over the past five years. The RSA team observes traffic and operating conditions; identifies hazardous conditions, deficiencies, equipment malfunctions, sight distance obstructions and other safety concerns; and considers the safety of all road users, including bicyclists, pedestrians, and people with physical challenges.

The RSAs recommend safety improvements to reduce the frequency and the severity of crashes. The recommendations focus on low-cost, short-term actions that can be implemented quickly while higher-cost, longer-term actions are being planned to improve overall safety.

Strategies to Improve Safety

A roadway crash is caused by one or more contributing factors. A driver can be distracted, the road could have an engineering flaw, the speed limit may be too high, or countless other factors. Achieving safety on the roads will require a coordinated effort between all aspects of the transportation system. The strategies established in NOACA's SAVE Plan use a comprehensive approach to address safety on the roads by including strategies from all of the six "Es" of transportation safety: Education, Enforcement, Engineering, Evaluation, Emergency Medical Services, and Equity.

The SAVE Plan identifies multiple strategies to reduce crashes in each of the ten emphasis areas:

- Intersection
- Roadway Departure
- Young Driver
- Speed
- Impaired Driving
- Older Driver
- Motorcycle
- Pedestrian
- Distracted Driving
- Bicycle

Along with the strategies, the SAVE Plan includes a list of action steps that should be taken to implement the strategies. The progress in transportation safety will be evaluated by the performance measures from year to year once the recommendations begin to be carried out.

As part of the SAVE Plan implementation, a Safe Routes to School (SRTS) Assistance Program has been developed, to provide jurisdictions and school districts with SRTS planning and implementation support.

Safe Routes to School (SRTS) is a program focused on making it safe, convenient and fun for kids and families, including those with disabilities, to walk or bicycle to school and in everyday life. The planning framework is safety- based, following the **6 E's of SRTS** – Education, Encouragement, Enforcement, Evaluation, Engineering and Equity. To learn more about this program,

Traffic Safety and Operations Technical Assistance

NOACA staff provides engineering assistance to communities to address safety and traffic operation concerns. Project sponsors are not required to provide any financial contribution or local match to receive Technical Assistance (TA). The TA project selection process takes place each year as NOACA develops its annual budget and Overall Work Program. NOACA staff evaluates each TA request based on criteria that demonstrates project need, relationship to NOACA's vision and goals, and the local sponsor's capacity to implement study recommendations.

Table 3-10 is a list of completed technical assistance plans and studies.

Table 3-10. Completed Technical Assistance Plans and Studies

Location	Study Name
City of Avon	Intersection Crash Frequency Study
City of Bay Village	Signal Warrant Analysis
City of Avon and Avon Lake	Segment Safety and Operational Analysis
Bainbridge Township	Washington Street Project Safety Analysis
City of Cleveland	Union Ave. Safety Analysis
	Vine Street Signal Warrant Analysis
City of North Royalton	Intersection Crash Evaluation

Operational Improvements

Today, there are more than 272,000 traffic signals in the United States. They play an important role in the transportation network and are a source for significant frustration for the public when not operated efficiently. As the era of freeway building draws to a close, urban arterials are being called upon to carry more users than ever before at a time when the users of these facilities are growing more complex (older drivers, more distractions, larger vehicles, etc.) and the demand for such use continues to outpace transportation supply. Traffic signal timing efficiency degrades over time as volume patterns and magnitude change, development occurs, or infrastructure changes. Outdated or poor traffic signal timing accounts for a significant portion of traffic delay on urban arterials and traffic signal optimization is one of the most cost effective ways to reduce emissions, improve mobility, reduce delays and improve corridor safety.

The solution to inefficient traffic signal timing is to develop a signal timing optimization program (STOP). In 2016, NOACA developed two pilot corridors to implement a signal timing corridor pilot project to improve the safe and efficient operation of traffic signal systems and corridors. The following is a summary of all projects benefits under STOP:
Corridors Optimized:

- Cedar Rd. (S Green Rd to Lander Rd)
- Pearl Rd (from W 130th St to Brookpark Rd)
- SOM Center Rd. (Vine St. to Chardon Rd.)

- Euclid Ave. (E. 345th St. to E 355th St)
- Ridge Rd. (Halle Dr. to SOM Center)
- Warren Rd./W 150th St (Madison Ave to Brookpark Rd)
- Madison Ave. (Victoria Ave/Reveley Ave to Lincoln Ave)
- Alger Rd. (Lakewood Heights Blvd. to South Marginal Dr)

Benefit Cost Ratio: 30:1
Delay Savings: 1,637,000 Hours
Emissions Savings: 11,990 Metric Tons
Fuel Savings: 1,415,530 Gallons

Implementation Action

NOACA will partner with ODOT, regional safety organizations, law enforcement agencies, and local communities throughout the region to implement the strategies and action plans for each emphasis area recommended in the SAVE Plan.

Since education and enforcement strategies make up the vast portion of the SAVE Plan action items, NOACA will engage in various efforts to promote safe road-users' behavior, educational campaigns, training, and the support of new legislations to achieve the region's safety targets.

NOACA endorses engineering safety improvements through the Transportation Improvement Program (TIP) projects prioritization. The TIP scoring criteria considers the potential reduction in the number of crashes expected when the project is implemented, based on the Highway Safety Manual methodology. The TIP scoring also takes into consideration whether the proposed project's location is identified as a high-crash corridor or intersection based on the latest State of Safety Report. Prioritizing projects that will improve safety will help the region reach the safety targets and the ultimate goal of Vision Zero.

Additionally, the five-year rolling averages for the following five safety performance measures will be tracked as required under the FAST Act:
• Number of fatal crashes.
• Number of serious injury crashes.
• Rate of fatalities per 100 million vehicle miles traveled.
• Rate of serious injuries per 100 million vehicle miles traveled.
• Number of non-motorized fatal and serious injury crashes.

NOACA will continue to conduct Traffic Safety and Operations technical assistance. NOACA will also guide communities to available funding sources to implement the recommended safety countermeasures.

Security

Introduction

The transportation system touches everyone in some way: personal mobility, the movement of raw materials or manufactured materials, and the delivery of agriculture and food products are just a few ways the nation depends on transportation for its livelihood and economic stability. The transportation sector has many interdependencies with critical infrastructure sectors, as shown in Figure 3-5.

Figure 3-5. Transportation Sector Interdependencies with Critical Infrastructure Sectors

The department of Homeland Security has developed a National Infrastructure Protection Plan (NIPP) that sets forth a comprehensive risk management framework and clearly defines critical infrastructure protection roles and responsibilities for the Department of Homeland Security; Federal Sector-Specific Agencies (SSAs); and other Federal, State, local, tribal, and private sector security partners. The NIPP provides the coordinated approach that will be used to establish national priorities, goals, and requirements for infrastructure protection so that funding and resources are applied in the most effective manner.

Protecting and ensuring the continuity of the critical infrastructure and key resources (CIKR) of the United States is essential to the Nation's security, public health and safety, economic vitality, and way of life. CIKR includes physical or virtual assets, systems, and networks so vital to the United States that the incapacity or destruction of such assets, systems, or networks would have a debilitating impact on security, national economic security, public health or safety, or any combination of those matters. The National Infrastructure Protection Plan (NIPP) provides the coordinated approach that is used to establish national priorities, goals, and requirements for CIKR protection so that Federal resources are applied in the most effective and efficient manner to reduce vulnerability, deter threats, and minimize the consequences of attacks and other incidents. It establishes the overarching concepts relevant to all CIKR sectors identified under the authority of Homeland Security Presidential Directive 7, and addresses the physical, cyber, and human considerations required for effective implementation of protective programs and resiliency strategies.[3]

Northeast Ohio is susceptible to many threats, such as severe winter storms, flooding, tornados, and severe thunderstorms. The region must also prepare for other risks such as terrorism. The unexpected and complex nature of these incidents requires extensive coordination, collaboration, and flexibility among all the agencies and organizations involved in planning, mitigation, response, and recovery. Regional coordination is critical to security and emergency preparedness. The region's many individual municipalities, villages, and townships, as well as extensive roadways and bridges, wide-ranging mass transit systems, rail, airports, and shipping

[3] https://www.dhs.gov/xlibrary/assets/NIPP_Overview.pdf

ports present significant challenges to coordinating and implementing effective security programs.

Current Conditions

NOACA is not directly involved in security or emergency projects. There are many city and county emergency/evacuation/disaster plans in place, such as those of the City of Cleveland, the five county governments, the Greater Cleveland Regional Transit Authority (GCRTA) and the other transit agencies in NOACA's region, municipal governments, Ohio State Patrol, Ohio Department of Transportation (ODOT), the Ohio Turnpike Commission, hospitals, and school districts. ODOT has also constructed an extensive intelligent transportation system (ITS) along the interstate system in the NOACA region. The system includes pan, tilt, and zoom cameras and dynamic message signs. GCRTA has its own police force that provides security for the GCRTA transit system, and closed circuit television (CCTV) cameras to monitor transit facilities, including transit stops.

The NOACA Regional ITS Architecture is a roadmap for transportation systems integration in the five county NOACA region (Cuyahoga, Geauga, Lake, Lorain, and Medina counties) over the next 10 years. ITS helps improve safety, efficiency, and mobility of ground transportation by collectively utilizing electronic devices, sensors, and communications. The architecture was developed through a cooperative effort by the region's transportation agencies and covers all modes of transportation and all roads in the region. This architecture is the third update of the NOACA Regional ITS Architecture. The first version of the architecture was developed in October 2000, and the comprehensive update was completed in 2019, which included Regional ITS Architecture Report, ITS Strategic Plan, Appendix D: 2020 Connected Vehicle / Automated Vehicle Update, ITS Strategic Plan, Needs Analysis and Gap Assessment Technical Memorandum, Architecture Database (RAD-IT Database).

The ITS Plan and architecture will:

1. Provide NOACA and other agencies with tools to ensure that the planning, deployment and integration of ITS systems throughout the region is done with a common framework through ITS architecture and standards development;
2. Maintain the region's compliance with requirements defined by the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) for development of ITS projects; and ultimately
3. Assist in the maintenance and operations of ITS projects throughout the five–county region.

The ITS projects that have been mapped to the regional ITS architecture are listed in Table 3-11.

Table 3-11. ITS projects mapped to the regional ITS architecture

Project	Status	Timeframe	Description
Ohio Statewide CV/AV Architecture	Planned	2020 – 2035	The Ohio Statewide Connected / Automated Vehicle (CV/AV) Architecture is a roadmap for the deployment and integration of CV / AV / ITS technologies throughout the state of Ohio for the next 15 years. The geographic boundary of the Architecture covers the entire state of Ohio. The Ohio Statewide CV/AV Architecture provides a framework for institutional agreements and technical integration of CV/AV technology implementation projects in the state. It supports effective and efficient deployment of CV/AV projects that address the transportation problems and needs in the state. The purpose of the Ohio Statewide CV/AV Architecture is to illustrate and document the integration of CV/AV technologies and ITS systems to allow planning and deployment to occur in an organized and coordinated process. The Architecture helps guide the planning, implementation, and integration of ITS and CV/AV technologies deployed and managed by multiple types of agencies that provide transportation services within the state.
S–01: Ohio DOT Freeway Management System Expansion	Planned	Short Term	The FMS Expansion project's objective is to extend ODOT FMS field devices and communications on the freeway system, including expansion of: the TMC, DMS, CCTV, flow detection, freeway service patrols, hybrid communications systems, HAR, ramp metering, web–based services, and inter–agency communications networks.
S–02: Ohio DOT Advanced Traffic Management System (ATMS)	Planned	Short Term	ODOT is seeking a commercial off–the–shelve Advanced Traffic Management System software package to replace and expand the current in–house system. The new system shall consolidate resources (including Playbook), enhance capabilities, capture and archive roadway, traffic, speed, and weather data, and provide functionality for forthcoming emerging technologies.
S–03: Ohio DOT Traffic Monitoring Management System Enhancements	Planned	Short Term	The objective of this project is to enhance/expand a Statewide Traffic Monitoring Management System created by ODOT.

S–10: Ohio DOT Expand Traveler Information Delivery Methods	Planned	Short Term	Enhancing traveler information dissemination methods may include enhancing OHGO, information provided through cable TV stations, and new connections to private sector dissemination methods.
S–11: Ohio DOT Maintenance Vehicle Upgrade	Planned	Short Term	Maintenance vehicle upgrades pertaining to ITS include the purchasing of new instrumented multi–subsystem data collection vehicles and associated software and maintenance.
S–12: Ohio DOT Expand Road Weather Information System (RWIS)	Planned	Short Term	RWIS expansion efforts may include installing additional RWIS stations at strategic locations. The project also considers testing mobile RWIS.
S–20: Ohio Turnpike ACV Testing	Planned	Short Term	The 241–mile Ohio Turnpike is DriveOhio's site for testing ACVs. The turnpike is outfitted – end to end – with fiber–optic cable, and it already has been a testing site for self–driving trucks. Roadside units were installed in a 60–mile stretch of the turnpike and onboard units were installed and operational in fleet vehicles during the first quarter of 2018, giving the Ohio Turnpike Commission the ability to produce traffic and weather alerts for digitally connected vehicles and to use vehicle and road condition data to make better decisions about treating roads and managing incidents.
S–21: DriveOhio City Use Cases	Planned	Short Term	ODOT is collaborating with Athens, Akron, Canton, Cincinnati, Cleveland, Dayton, Dublin, and Toledo for additional DriveOhio projects. Use cases that highlight each city's unique attributes are under development, ranging from workforce mobility, healthcare and education access, and mobility access for underserved, elderly and disabled populations.
S–22: I–90 Lake Effect Corridor	Planned	Short Term	ODOT is equipping 60 miles of I–90 with short–range digital communication units. It will also test wireless technologies designed to send and receive data from those units as well as units on public service vehicles. The data, combined with new variable speed limit signs, will help local officials and law enforcement better manage the roadway to reduce crashes and fatalities. The project considers an expansion to other corridors in the near future.
S–24: Ohio DOT Traffic Monitoring Permanent Count Program	Planned	Short Term	The effort advances the ODOT Traffic Monitoring Permanent Count Program, specifically by providing funding for items such as: supplies, utilities, software, counter maintenance, and an

			upgrade to the existing non–intrusive sensors and accessories.
S–25: Creation of a GIS Data Centralization Center	Planned	Short Term	The GIS Centralization Project will focus on an enterprise wide approach to managing geospatial resources providing for the development and integration of spatial data and GIS technology throughout ODOT.
S–28: Regional Alternate Routes Planning	Planned	Short Term	Develop a plan and operational strategy for alternate routes for traffic diversion due to major incidents with a focus on coordination between ODOT–operated freeways and locally–operated arterials. Plans would identify thresholds for when a specific segment of the roadway is considered affected, which alternate route(s) to implement; which agencies should be involved, how they communicate, and their roles and responsibilities in traffic control, timing adjustments, traveler information; and what ITS assets (CCTV, DMS, etc.) should be utilized to monitor the situation and provide en route traveler information.
S–29: GCRTA Computer Aided Dispatch (CAD)/Automatic Vehicle Location (AVL)	Planned	Short Term	The goal of this effort is to implement Computer Aided Dispatch using Automatic Vehicle Location technology for GCRTA, including: Automatic Passenger Counters, Closed Caption Television (CCTV) surveillance systems, automated stop announcements, and an enhanced Radio Communication system.
S–30: Laketran CAD/AVL	Planned	Short Term	The goal of this effort is to implement Computer Aided Dispatch using Automatic Vehicle Location technology for Laketran, including: Automatic Passenger Counters, Closed Caption Television (CCTV) surveillance systems, automated stop announcements, and an enhanced Radio Communication system.
S–31: County Transit Agency ITS Updates	Planned	Short Term	The objective of this effort is to update county transit vehicle ITS, including AVL systems for vehicles for Lorain and Medina counties as well as upgraded vehicle radios for Medina County. Medina County is also looking to install Mobile Data Terminals to communicate, track, and record vehicle and operational data.
S–32: GCRTA / Laketran Transit Vehicle Updates	Planned	Short Term	This effort will install wireless internet (Wi–Fi) on GCRTA/Laketran buses.

S–33: Enhance and expand GCRTA and Laketran Paratransit services	Planned	Short Term	This effort will implement an advanced para–transit scheduling and dispatch system at Laketran, coordinated with GCRTA.
S–37: NOACA Signal Timing Optimization Program (STOP)	Planned	Short Term	This effort will re–time traffic signals on arterial roadways of regional significance. NOACA will lead the effort to update signal operations across key corridors in the region, and across jurisdictional boundaries, seeking to minimize stops and delays, reduce fuel consumption and air pollution, maximize traffic flow along arterial roadways, and improve safety by reducing rear end crashes.
S–38: Automated Traffic Signal Performance Measures (ATSPMs)	Planned	Short Term	This project will collect data at signalized intersections and develop performance measures using ATSPMS technologies to proactively manage signals in the region.
S–39: Municipal Signal Preemption	Planned	Short Term	This effort will explore traffic signal preemption for emergency vehicles, which makes use of connected vehicle technology to preempt traffic signals so that emergency vehicle may safely and efficiently move through intersections.
S–40: Upgrade Traffic Signals in East Cleveland	Planned	Short Term	This project will upgrade traffic signals and signal systems along Euclid Avenue, Superior Avenue, Terrace Road, Noble Road, and Hayden Drive in East Cleveland.
S–41: Upgrade traffic signals along US–20 and US–322	Planned	Short Term	This project will upgrade traffic signals along US–20 (Center Ridge Road), from west of Stoney Ridge Road to Lear Nagle Road, in North Ridgeville as well as traffic signal improvements along US–322 (Mayfield Road), from Kenilworth Road to Warrensville Center Road, in Cleveland Heights
S–42: Rocky River Signals	Planned	Short Term	This project will upgrade traffic and pedestrian signals at 6 intersections along Center Ridge Road (US–20) from Pease Drive to Northview Road/Linden Road in the City of Rocky River.
S–43: Strongsville Signals	Planned	Short Term	This city–wide signal upgrade project will upgrade signals along SR–82 and US–42 in the City of Strongsville.
S–44: Lorain Traffic Signals	Planned	Short Term	This Lorain County project will replace nine signals throughout project limits as well as upgrade ADA ramps.
S–45: Mayfield Heights Signals	Planned	Short Term	This Cuyahoga County project will upgrade signals along the Mayfield Road corridor, from Iroquois Avenue to Gates Mills Towers Drive. It

			will replace four signals, partially upgrade 13 traffic signals, and install an advanced central control system.
S–46: Beachwood Signals	Planned	Short Term	This project will upgrade signals primarily along SR175 and Cedar Road in the City of Beachwood, north of the Chagrin Boulevard corridor.
S–47: Cleveland Heights Signals	Planned	Short Term	This project will reconstruct 12 signals in northern Cleveland Heights along Monticello Boulevard, Taylor Road, and Noble Road, as well as remove four unwarranted signals.
S–48: Painesville Signals	Planned	Short Term	This Lorain County project will replace signal controllers and vehicle detection at 14 intersections along the two corridors, Richmond Street (SR 283) and Mentor Avenue (US 20), and remove three unwarranted traffic signals.
S–49: University Heights Signals	Planned	Short Term	This project will upgrade twenty–one traffic signals within University Heights along Cedar Road, Warrensville–Center Road, Washington Boulevard, and S. Green Road, including complete reconstruction at four intersections.
S–50: City of Cleveland Special Event Traffic Planning	Planned	Short Term	Development of plans, procedures and systems to improve traffic conditions associated with special events such as concerts, sporting events, or festivals.
S–53: Cuyahoga County Evacuation Plan Updates	Planned	Short Term	Study and development of plan to evacuate Cuyahoga County in case of an emergency affecting mass area.

Regional Security Goals, Objectives, and Performance Measures/Targets

The ITS Strategic Plan aligns with the regional goals, defining a project vision that supports the defined Strategic Goals. The ITS Strategic Plan vision is to develop a roadmap to encourage efficient technology deployment to better utilize the region's infrastructure, enhance communication across regional stakeholders, and position the region for emerging technology. To reach this vision, the ITS Strategic Plan defines five general objectives, that at same time align with NOACA's Regional Strategic Plan goals. Table 3-12 presents a summary of the ITS Strategic Plan objectives, and maps these objectives to their corresponding regional goals.

Table 3-12. ITS Strategic Plan Objectives

	Regional Strategic Plan Goals				
ITS Strategic Plan Objectives	STRENGTHEN regional cohesion	PRESERVE existing infrastructure	BUILD a sustainable, multi-modal transportation system	SUPPORT economic development	ENHANCE quality of life in Northeast Ohio
Develop a complete inventory of current ITS equipment and technology	✓	✓			
Collaborate with regional stakeholders to identify regional transportation gaps and needs	✓		✓		
Identify planned and proposed ITS projects to address regional needs and emerging technology	✓		✓	✓	✓
Update the region's ITS Architecture to incorporate ITS Strategic Plan			✓	✓	✓
Develop an initial assessment of projects and a proposed project implementation strategy			✓	✓	✓

Source: AECOM and Cambridge Systematics, Inc.

Based on the objectives defined in Table 3-12, expected outcomes for this effort are as follows:

- Reflect current and future ITS systems in the region
- Facilitate ITS deployment to meet regional transportation needs
- Identify opportunities and strategies to integrate ITS systems
- Provide structured and strategic approach to future ITS investments
- Support interoperability among systems and jurisdictions
- Position to leverage emerging technology
- Support eNEO 2050, Regional Strategic Plan and USDOT ITS Strategic Plan
- Provide better customer service to the public

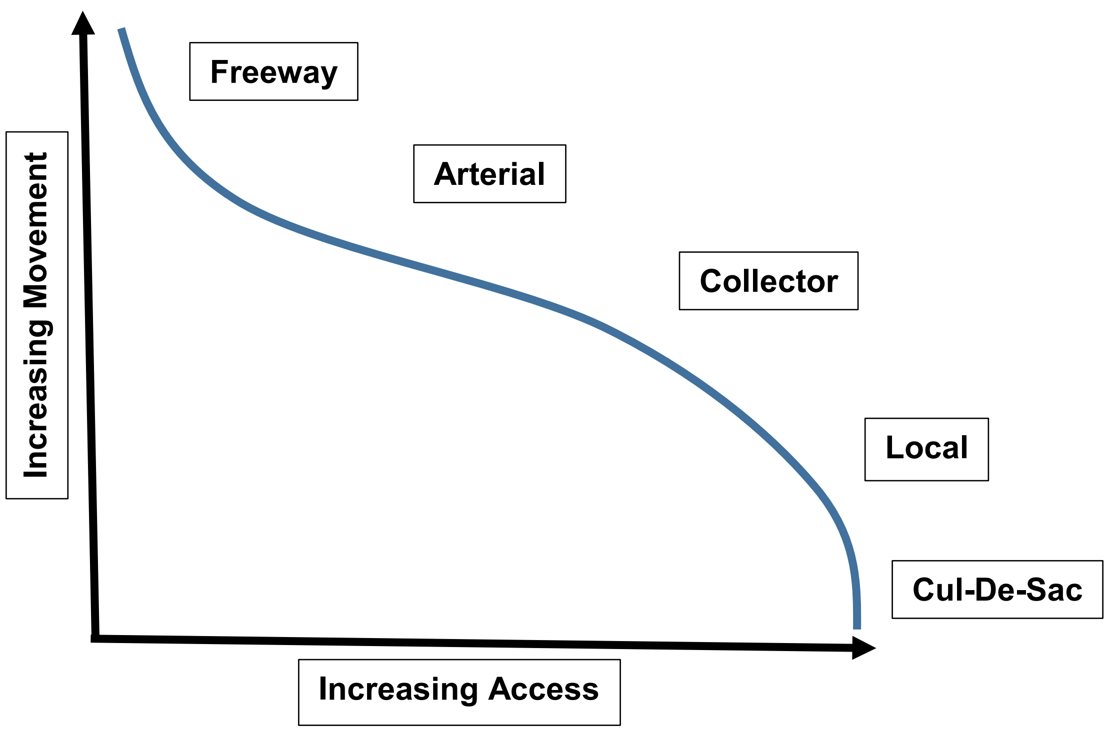
Definition of Access and Mobility

Some transportation modes, such as air transportation, have a clear separation between access and mobility. Access to an aircraft begins by passengers boarding and once the cabin doors are closed, the aircraft is transferred from an access function to a mobility function. In the highway mode, access and mobility do not have such a clear boundaries. Road and street functional classification attempt to define these boundaries by grouping roads, streets, and highways in a hierarchy based on the type of highway service they provide.

Generally, how closely a highway or street actually functions compared to the defined service plays a crucial role in reducing congestion, promoting safety, and increasing transportation system efficiency. Streets and highways are part of an interconnected network, and each one plays a role in moving traffic throughout the system by a specified degree of access and a level of movement.

Figure 3-6 indicates the degree to which different road functional classes should accommodate movement and access. The shape of the curve in this figure illustrate the defined relation between access and mobility for each road function class.

Figure 3-6. Relationship between Access and Movement Functions of Roads & Streets



In the recent years, travel behavior has substantially changed. The journeys with a single purpose, such as work, shopping or returning home, have been replaced by trip chains. These new characteristics of travel demand have led to widespread use of the private cars. Combining private motorized vehicle usages with trip chain behavior have affected transportation mode choice and made the access and mobility relationship more complex for road function class.

In the following sections, access to the existing highway and transit systems and level of mobility through these networks are evaluated as benchmarks for shifting travel demand from a mainly single mode, i.e. private motorized vehicles, to other mode choices in a more equitable transportation system.

Access

People travel from an origin to a destination for the primary purposes of economic, social, recreational and other activities. Although the physical act of traveling is the secondary function, it is a necessary task for conducting the primary functions. Traveling is possible if travelers have safe, timely and affordable access to the existing transportation infrastructure components. Without access to the transportation platform, trips may not be made in a safe and efficient manner.

The following sections attempt to analyze the state of access in the NOACA region. A critical question is whom has access to which part of transportation system. This section summarizes the existing access to the current transportation system in the NOACA region that will be a benchmark for planning and investing on an equitable transportation infrastructure in the next three decades.

Access to Freeway System

In the NOACA road network, the role of highways with controlled access, such as Interstate 71, Interstate 77, Interstate 480, etc., is to provide a connectivity platform for mainly long regional and inter-county vehicular traffic at a high speed. The controlled access to interstate highways is designed by on-ramps or off-ramps and interchanges. The ramp and interchange spacing is critically important in the origins and destinations of trips traveling through those highways, mobility role, safety, and traffic management.

An excessive number of access facilities such as interchanges in a freeway network diverts many short trips from the arterial and collector street network to the freeway system. This diversion has two negative impacts;

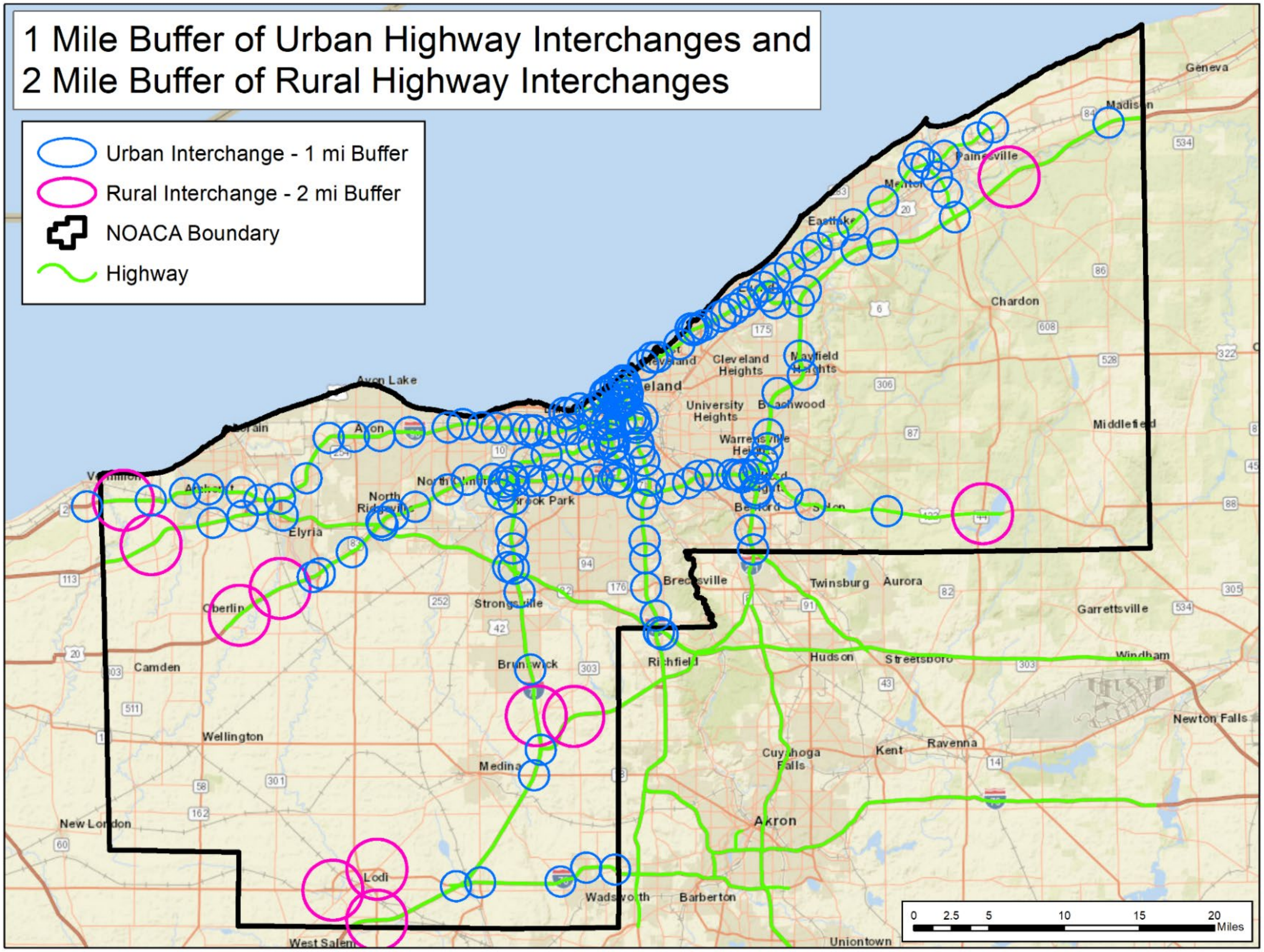
- Freeways will be congested by short vehicular trips entering from one interchange and leaving the freeway system at the next interchange,
- Reduces street network throughput and streets operate under capacity and consequently seem over invested.

The American Association of Highway Transportation Officials' (AASHTO's) design guidelines (Green Book) recommends the following passage regarding interchange spacing:

In areas of concentrated urban development, proper spacing usually is difficult to attain because of traffic demand for frequent access. Minimum spacing of arterial interchange (distance between intersecting streets with ramps) is determined by interchange form, lane configuration, weaving volumes, signing, signal progression, and lengths of speed-change lanes. A general rule of thumb for minimum interchange spacing is 1 mi [1.5 km] in urban areas and 2 mi [3.0 km] in rural areas. In urban areas, spacing of less than 1 mi [1.5 km] may be developed by grade-separated ramps or by adding collector–distributor roads.

In response to the trip chain travel demand over the last decades and the implication of the above guideline, as illustrated on Figure 3-7, the existing interchange locations in the NOACA region indicates that there may have been over investments in providing access to the freeways rather than paying attention to their mobility purposes.

Figure 3-7. Existing Interchange Spacing in the NOACA Region



In the literature, transportation accessibility is mainly measured by three components: trip coverage, spatial coverage, and temporal coverage. In this section, each facility access point is measured by a circular buffer with a specific radius for identifying its existing coverage area and analyzing the future requirement for a transportation facility.

Figures 3-8 through 3-10 depict the five-mile travel distance coverage for each freeway access point and access coverage in relation to the urbanized area and Environmental Justice (EJ) neighborhoods in the NOACA region.

Figure 3-8. Access to Highway System

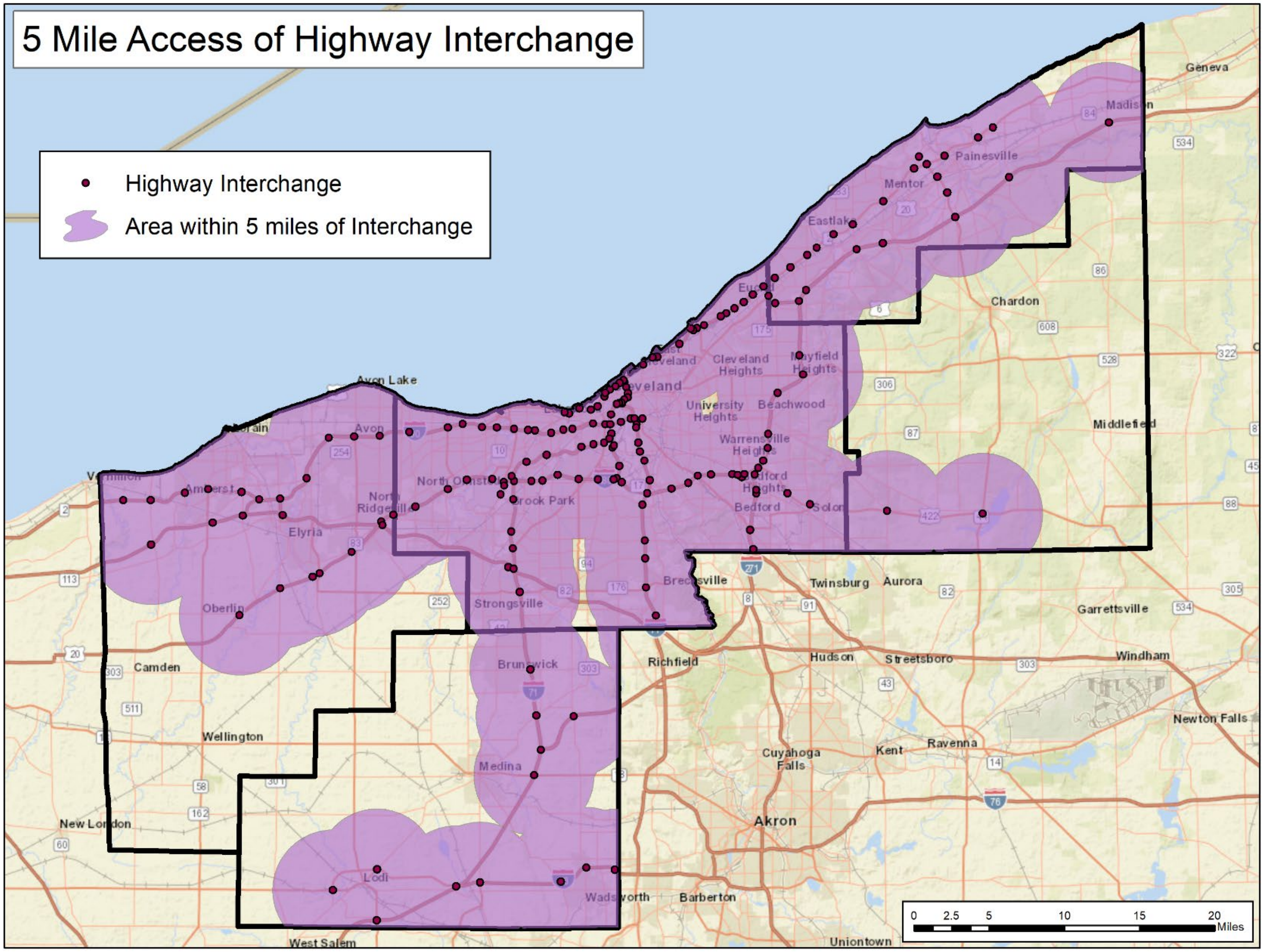


Figure 3-9. Urbanized Area Access to Highway System

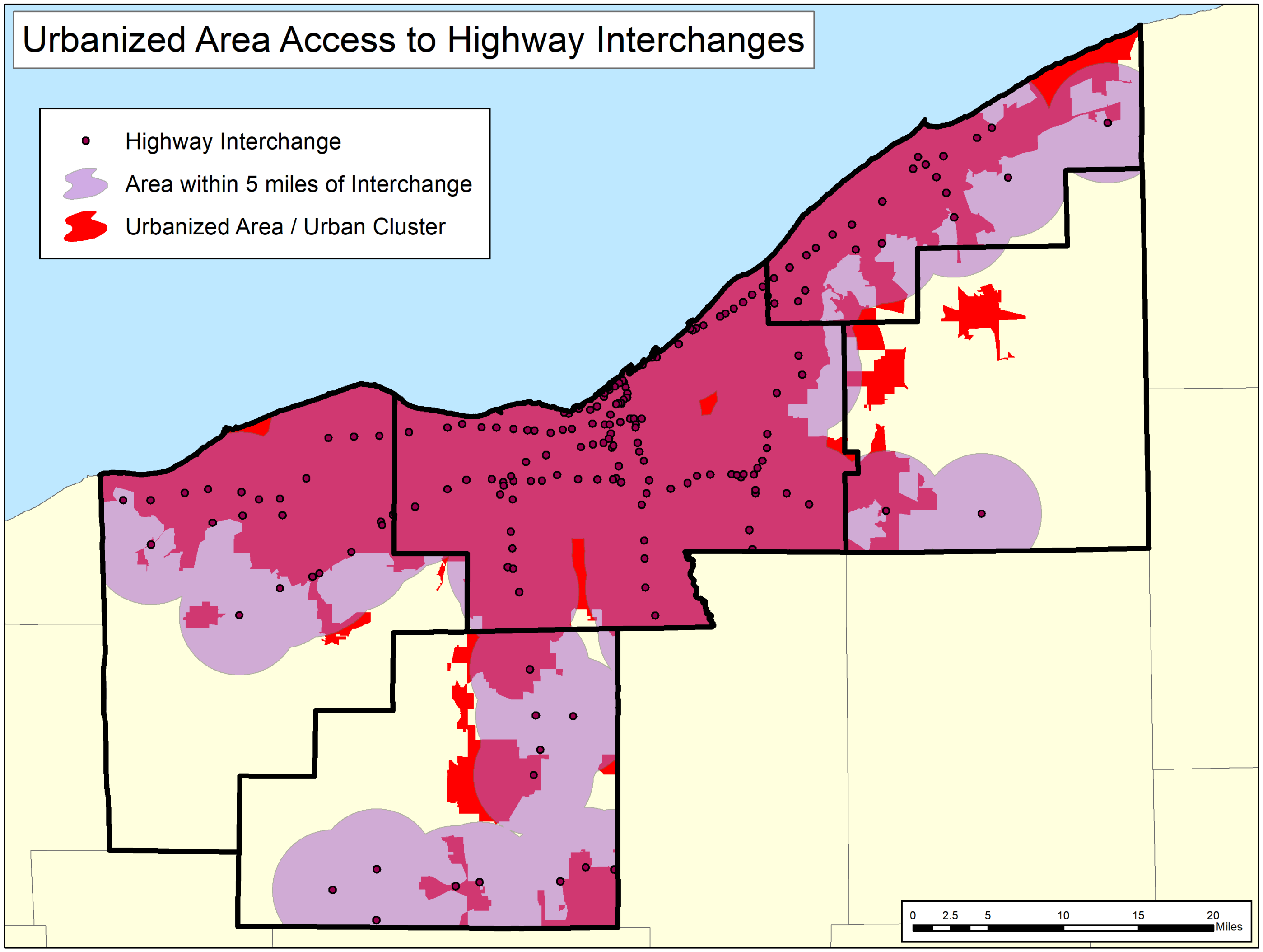
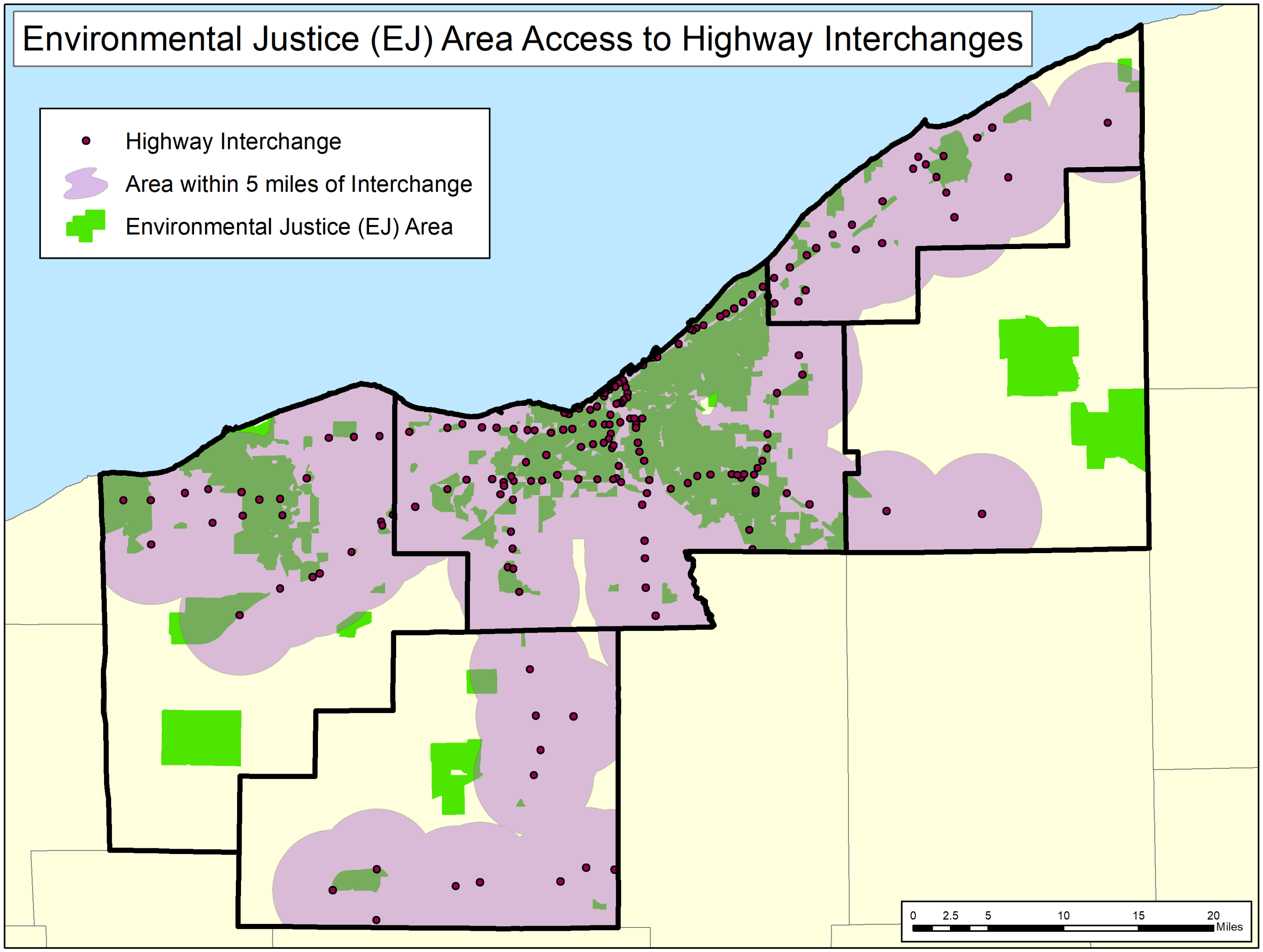


Figure 3-10. EJ Area Access to Highway System



As illustrated, most of the urbanized area has quick access to the freeway system. Even the urbanized EJ areas also have quick access to freeway system. The overlapping areas of the 5-mile circles may be assumed as indications of excessive access and overinvestments.

Currently over 1.8 million of the total NOACA region population reside in the 5-mile driving distance from an interchange. This is over 90 percent of the residents and indicates that the freeway network is accessible by a short distance regardless of what neighborhood one lives in.

There are over 380 thousand households in EJ areas within a 5-mile driving distance from an interchange. Vehicle ownership percentage in these neighborhoods is about 80%.

The Location Quotient (LQ) method is a useful quantitative screening for potentially disparate impacts of indicators that are associated with particular geographic areas such as EJ neighborhoods.

The LQ for the EJ area population within a 5-mile driving distance from an interchange is calculated by applying the following formula:

$$LQ = \frac{\frac{EJ\ Population\ with\ 5\ mile\ Driving\ Distance\ from\ an\ Interchange}{Total\ Population\ with\ 5\ mile\ Driving\ Distance\ from\ an\ Interchange}}{\frac{EJ\ Population\ in\ the\ NOACA\ Region}{Total\ Population\ in\ the\ NOACA\ Region}}$$

The LQ for the EJ area population within a short driving distance to the freeway system is 1.05, which indicates that the concentration of the EJ area population in the 5-mile freeway coverage area is slightly higher relative to the entire population in the NOACA region. Conversely, it is worth noting that the vehicle ownership in these neighborhoods is lower than that of the NOACA region.

LQ calculations for EJ households and workers with regards to freeway access have a similar results.

Arterial Network Accessibility

The arterial network consists of major (or principal) and minor arterials. The major arterial network is a network of roads and streets that serve large amounts of traffic traveling relatively long distances at higher speeds. Considering the function class of the major arterial network, this network may play an alternative role to the freeway network in reducing traffic congestion. Arterials generally connect residential areas to many employment centers and intersects with freeways.

Major arterials are usually congested, and the Level of Service (LOS) measure indicates overcapacity and is calculated as

$$\frac{\text{Volume}}{\text{Capacity}} > 1$$

This means that the traffic volume is higher than the road capacity and improvement strategies generally are directed at improving the capacity (i.e., increasing the denominator) to alleviate congestion.

In contrary, the LOS measures for the exiting arterial corridors in the NOACA region, generally are under capacity.

$$\frac{\text{Volume}}{\text{Capacity}} < 1$$

Capacity-improving strategies, such as signal timing optimization, attempt to increase capacity, not to reduce the ratio above, but to attract more through traffic. This would increase use of the road and restore it as an alternative to congested highways.

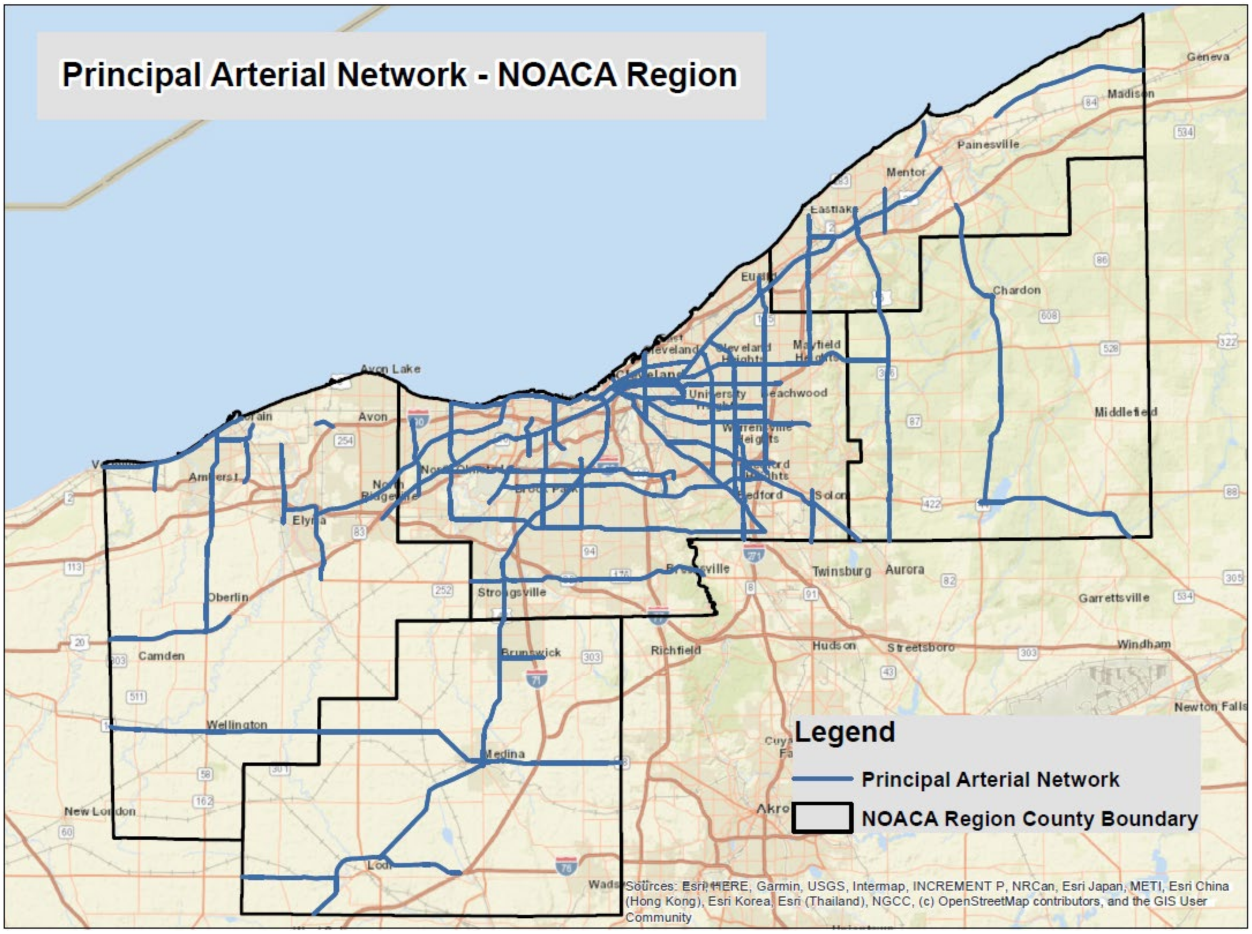
Generally, the arterial corridors are radial (originating from the center of Cleveland) or tangential (running “around” the periphery of downtown Cleveland at increasingly distant intervals). At further distances, the radial and tangential corridors tend to intersect with the centers of other large communities in the NOACA region.

Transit riders are often divided into two categories: “choice” riders (individuals who own cars but choose to ride transit) and “captive” riders (individuals who do not own cars and must use transit). In these corridors, transit routes operate through the arterial network providing an alternative travel mode to passenger vehicles for residents’ daily commutes. Some of these corridors run through the EJ neighborhoods, which are likely to have a high concentration of zero-vehicle households. Therefore, public transportation along these corridors is a travel necessity for some of the residents.

Most travelers are concerned about the length of their travel time on the major arterial network, which is generally affected by intersection delays and posted speed limits. However, higher accessibility of these corridors has the potential to attract more motorists to travel through the arterial network as an alternative to the existing congested freeways during the morning and afternoon peak periods. This would benefit the business along these corridors and also reduce the traffic congestion on freeways.

Figure 3-11 displays the major arterial network in the NOACA region.

Figure 3-11. Major Arterial Network in the NOACA Region

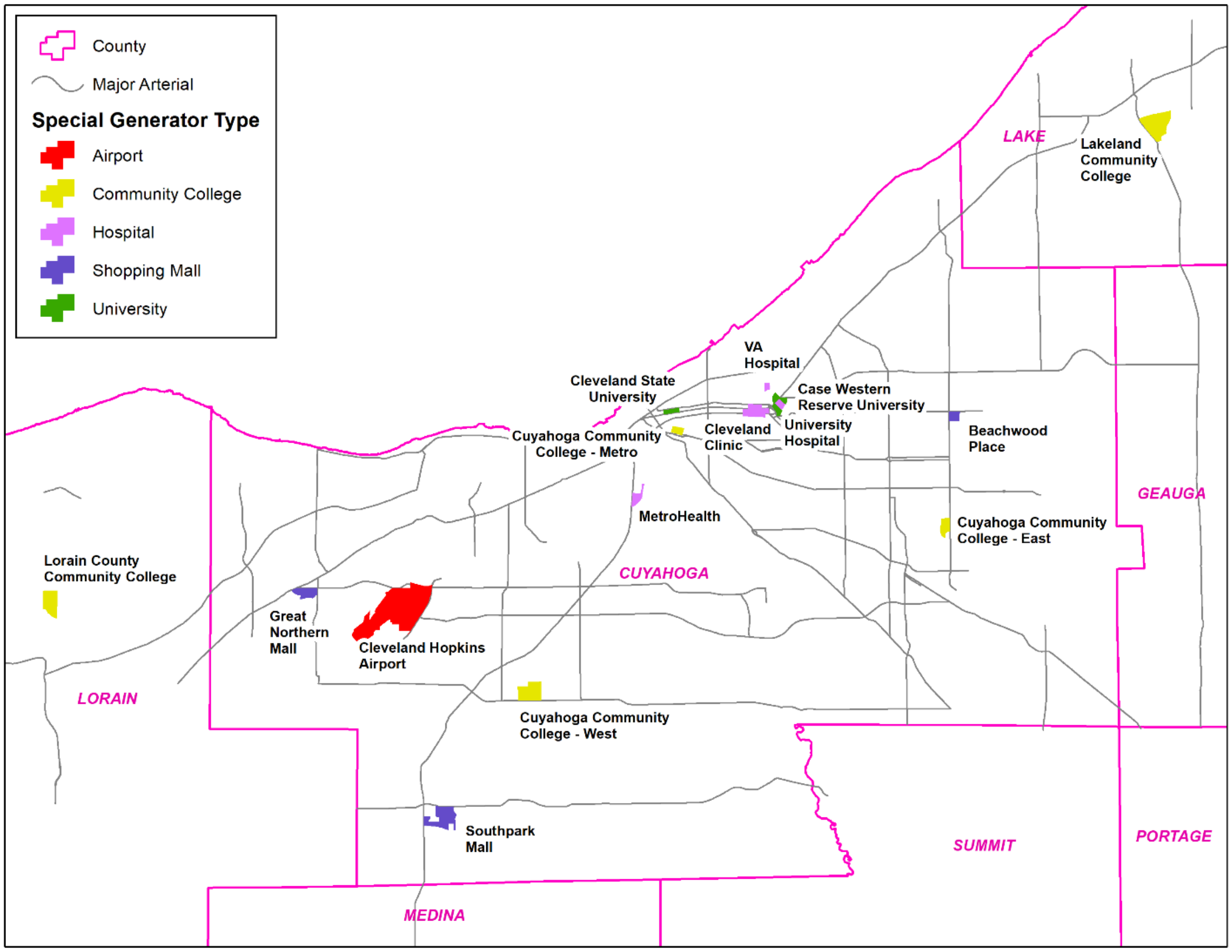


Access to Important Trip Generators

Access to regionally significant origins/ destinations, such as healthcare, education, and shopping, is highly dependent upon the major arterial network. Many of the regionally significant locations for healthcare, education, and shopping are found along major arterials. As previously discussed, arterials are used for both mobility and access. Therefore, it makes sense that many regionally significant trip generators would be located on major arterials, as these roadways provide the transportation assets for residents traveling from near or far.

The NOACA travel forecasting model takes into account all different types of land uses, and those that are regionally significant in terms of employment and person trips have been identified as "Special Generators". These locations are unique in the fact that they attract and generate many more trips and from much farther distances compared to other similar land uses. Almost all of the special generators fall into the major trip generator categories of healthcare, education and shopping (with Cleveland Hopkins Airport being the lone exception). As can be seen on Figure 3-12, all of the special generators are located on or near a major arterial, with many being located near the intersection of two major arterials. Therefore, the reinvigorating of the arterial network is important for accessing the major and minor activities locations.

Figure 3-12. Special Generators and the Major Arterial Network



Irishtown Bend

Irishtown Bend is a vast, underdeveloped hillside along the west bank of the Cuyahoga River. Its rich cultural history dates from First Nation settlements, to European colonists, early American pioneers, and most recently, the 19th century heart of the Irish immigrant community (see Figures 3-13 and 3-14).

Figure 3-13. Historical Photograph of Irishtown Bend

Figure 3-14. Contemporary Photograph of Irishtown Bend

The site known as Irishtown Bend has a recent history of geotechnical instability. Dredging and widening of the Cuyahoga River necessitated the clearing of the Irishtown Bend settlement in the mid-20th century, and the site has largely since remained vacant. This hillside is at risk for catastrophic structural failure, which would cause it to collapse into the adjacent Cuyahoga

River shipping channel and block freighters from reaching the upstream recipients of bulk commodities causing immense economic consequences.

In 2016, NOACA, the Port of Cleveland, Ohio City, Inc., and LAND Studio partnered to conduct a Transportation for Livable Communities Initiative (TLCI) comprehensive study to begin planning for Irishtown Bend's future as a vital and connected public space. The full vision plan, which includes a refreshed streetscape, public green space, and trail connectivity in addition to the restored bulkheads, was completed in 2018.

Also in 2018, NOACA and the Port secured $9.02 million funding through the highly competitive United States Department of Transportation (USDOT) Infrastructure for Rebuilding America (INFRA) program to allow for the stabilization project to move closer toward implementation.

Irishtown Bend Bank Stabilization Project

Project Description

The project installs 2,600 linear feet of sheet steel bulkheads and regrades the hillside along the shoreline of the Cuyahoga Ship channel along the section know as Irishtown Bend (between River mile 1.39 and 1.93). Due to wear and tear and lack of existing functional bulkheads, this hillside section along the Cuyahoga ship channel is at high risk for failure. Such collapse would block movement by freighters that deliver bulk commodity cargos to upstream manufacturing sites. The project would also secure the adjacent hillside allowing for the full potential of the site as a 17-acre park with a riverfront boardwalk, links to multi-use trails, and spectacular views to be realized.

This project will have the following impacts on the economy, community, and environment:

- Protection of over 20,000 jobs by maintaining a viable shipping channel on the Cuyahoga River
- Preservation of nearly $5 B growth engine for the regional and national economy assuming a new bulkhead and dredging could be completed within one-year of failure (Table 9)
- Improvement of community recreation by:
  - Securing future land use opportunities to connect residents to the river via a new hillside park with cultural site, walking trails, and views of downtown Cleveland
  - Allowing for a key link in the regional trails network to be completed
  - Providing continued river access for fishing, boating, sailing, rowing, and kayaking

Key Implementation Partners

NOACA	Cleveland-Cuyahoga County Port Authority
City of Cleveland	Cuyahoga County
Cleveland Metropolitan Housing Authority	Northeast Ohio Regional Sewer District
Cleveland Metroparks	West Creek Conservancy
Ohio City, Inc.	Ohio Department of Transportation

Project Funding

NOACA Federal INFRA Grant	$9.02M
NOACA (stabilization)	$3.5M
NOACA (trail link)	$3.3M
NOACA/Port Crowdfunding	$3.2M
Northeast Ohio Regional Sewer District (sewer repair)	$7M
State of Ohio (engineering)	$5M
Cuyahoga County (Franklin Blvd.)	$1.72M
Clean Ohio Grant (land purchase)	$1.43M
City of Cleveland	$1.13M
TOTAL AMOUNT COMMITTED	**$35.3M**
Estimated Remaining Funding Gap	**$8.3M**
TOTAL PROJECT COST	**$43.6M**

Access to Transit Network

Bicycle and pedestrian access to transit is an important aspect of a cohesive, multimodal transportation network. These connections to the transit network are often referred to "first mile-last mile trips", those short trips that get commuters from their homes to a bus or train, or from the bus or train to their place of work. Because bus routes and rail stations cannot pick all riders up right at their front doors, most people must travel some distance before boarding a bus or train. Riders should be able to safely and conveniently get to and from transit stops and stations via a well-connected system of pedestrian and bicycle infrastructure.

The potential connectivity of residents and commuters to the regional transit network via walking and biking can be gauged by the presence and prevalence of quantifiable characteristics. For example, intersection density is an established indicator of walkability and connectivity. Grid pattern development with many intersecting perpendicular streets usually offers multiple routes between origins and destinations, while cul-de-sac developments or areas with fewer roadways and intersections can hinder direct shortest distance movement. Similarly, a high density of low stress roadways offer pedestrians and cyclists a greater number of safer and more comfortable opportunities to move along roadways and through intersections, while a greater proportion of higher stress roadways may discourage pedestrian and cyclist travel.

Measuring the quality and quantity of access to transit services is important in evaluating existing transit services, travel demand, allocating transportation investments and making decisions on land use development. In this regard, the ability to walk to transit is important for access to jobs and vital services, like education and healthcare, especially for those who do not have access to a car. To measure accessibility, a distance of three quarters of a mile or equivalent to 15 minutes walking time (assuming 3 mile per hour as walking speed) is often utilized to represent a reasonable walking distance/time to reach a transit stop.

Currently the walk accessibility to transit is not evenly distributed throughout the five counties of the NOACA region. In many counties, access to transit by walking is sparse and very limited. Geauga County has no fixed-route transit and, as a result, none of its population is within a reasonable walking distance. When the entire NOACA region is taken into account, just over two thirds of the regional population is within a reasonable walking distance of a transit stop.

Lorain County only has a few transit lines between the cities of Lorain and Elyria and thus has a small percentage of its population within a reasonable walking distance, coming in at approximately 29%. Medina and Lake Counties have more transit lines within their large population centers and that results in around half of their population within 15 minutes walking distance of a transit stop (Medina at 49% and Lake at 64%). Cuyahoga County has the most extensive transit network covering most of the county and thus has a large majority of its population (87%) within a reasonable walk to transit.

Table 3-13 displays the existing transit stop coverage by numbers and percentages of people living within a 15-minute walking distance from transit stops.

Table 3-13. Transit Walk Accessibility Measure by County

County	Population within 15 Minutes' Walk to Transit Stop	Walk Accessibility to Transit Percentage
Cuyahoga	1,054,754	87%
Geauga	0	0%
Lake	146,034	64%
Lorain	87,715	29%
Medina	87,936	49%
NOACA Region	**1,376,439**	**68%**

Figures 3-15 and 3-16 display the current regional and EJ areas transit walk accessibility. In these maps, neighborhoods are considered as Traffic Analysis Zones (TAZ).

Figure 3-15. Transit Walk Accessibility in the NOACA Region

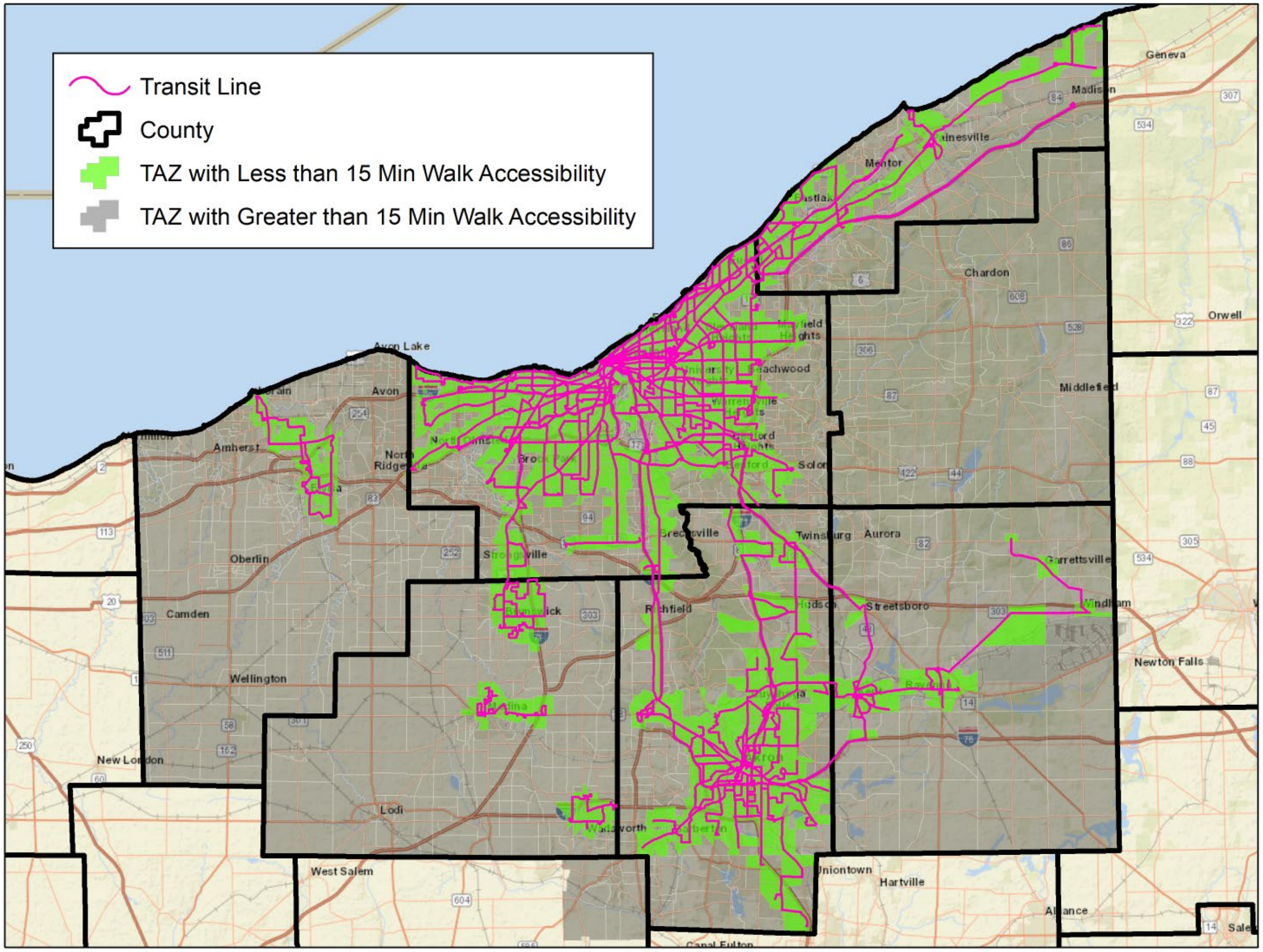
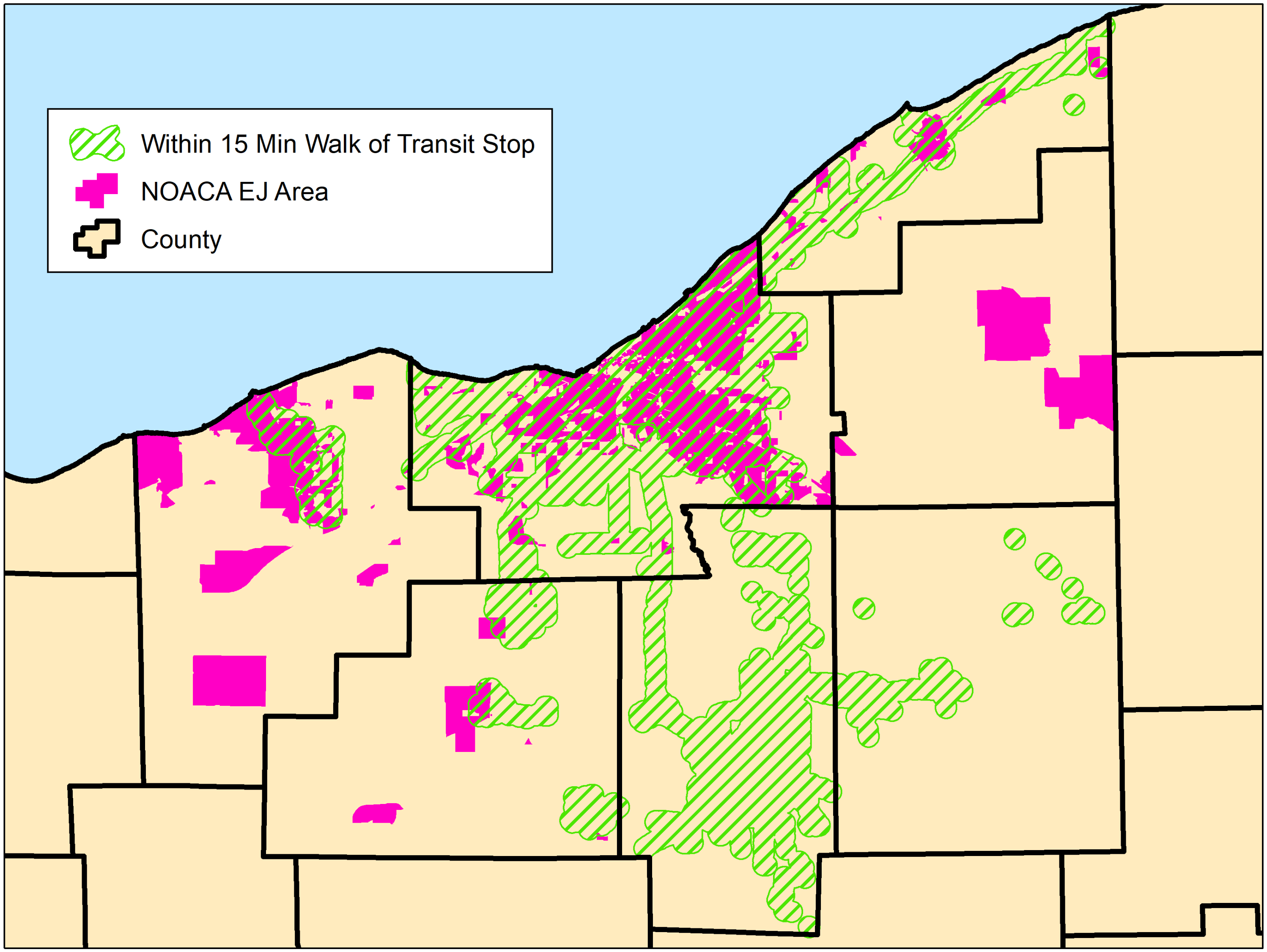


Figure 3-16. EJ Area Walk Accessibility to Transit Stops



Similar to the freeway access discussed in the previous section, Table 3-14 summarizes LQ values for the EJ population and workers' access to the freeway system and different types of transit stations.

Table 3-14. LQ Values for Population and Workers of EJ Neighborhoods

Access Type	LQ Value	
	EJ Population	EJ Workers
5-Mile Driving Distance to a Freeway Interchange	1.05	1.05
15 Minutes Walking Distance to a Bus or Rail Stop	1.31	1.32
15 Minutes Walking Distance to a Rail Station	1.94	1.98
5-Mile Driving Distance to a Premium Bus Park & Ride	0.84	0.85
5-Mile Driving Distance to a Rail Park & Ride	1.74	1.77

All the rail stations, including rail park and ride facilities, are in Cuyahoga County, as are most of the EJ neighborhoods. As indicated in Table 3.6, the EJ population and workers with a short walking distance or short driving distance to rail stations are over represented relative to the total EJ population in the NOACA region.

Considering any type of transit stop, including bus and rail stops, the LQ values result in less concentrated indications for EJ population and workers, 1.31 and 1.32 respectively compared with those of the rail stations. Similarly, this is due to the fact that most transit stops are located in Cuyahoga County.

In contrast to bus and rail stations, most premium bus park and ride facilities are located in outer counties and therefore LQ values for the total EJ population and workers with short driving to a bus park and ride station are 0.84 and 0.85 respectively. These values indicate less of a concentration of EJ area population and workers within a short driving access to premium bus stations compared with the entire population in the NOACA region.

In fact, the most urbanized EJ areas have short walk and drive access to transit stops. However, high concentration of EJ area population around the transit stations does not guarantee a reasonable work commuter time by transit. The long work journey is due to low frequencies of transit services and consequently long waiting and transfer times for riders. The next section will illustrate the long transit commute times to job hubs.

Access to Jobs

In a region, trips are categorized by their purposes: work trips, school trips, shopping trips, social trips, etc. The work trip category includes the most important mandatory trips and reducing work commute time from workers residents to employment locations is a major transportation planning challenge. Economic vitality of a region is an important factor in the current competitive global economy and providing access to jobs for workers at any income level improves the entire region socially and economically.

In order to measure the current job accessibility in the NOACA region, six major job hubs were identified based on a research brief produced by NOACA in 2016, entitled “Major Employment Hubs in the Cleveland MSA.” These employment areas have the highest employment density compared to other areas in the region and they are:

1. Downtown/Near East Side
2. University Circle, including Midtown between E. 105th Street and E. 83rd Street
3. Solon Cochran Corridor
4. Chagrin Highlands
5. I-77 and Rockside Road Area
6. Hopkins Airport Area

The regional characteristic of a job hub, including the number of jobs and its centralized or decentralized location are important factors in the accessibility measure. There are many local job centers, as well as jobs not within any hub or center throughout the region, but the regional job hubs account for 30% of the jobs in the region. The six major job hubs include about one quarter (25%) of current jobs in the region. Workers commute to these regional job hubs from various distances: short, medium, long distance from across the region. The majority of work trips to local and minor job hubs generally are only short trips and generally trip time data to these job hubs are biased. Therefore this section discusses work commute times to the major regional job hubs as representative of all the work trip times. A pilot analysis for legacy and minor job hubs was complete for Medina County at the same time as the regional hubs, with an analysis for the remaining three counties still underway, but yet to be completed. To summarize, Figure 3-17 shows the locations of the regional job hubs (major, minor and legacy) in the NOACA region. In addition to regional job hubs there are also local job centers that have been considered but cannot be reliably modeled for various transportation analyses due to their disjointed characteristics and therefore not included in this work.

Figure 3-17. Locations of the Major Regional Job Hubs

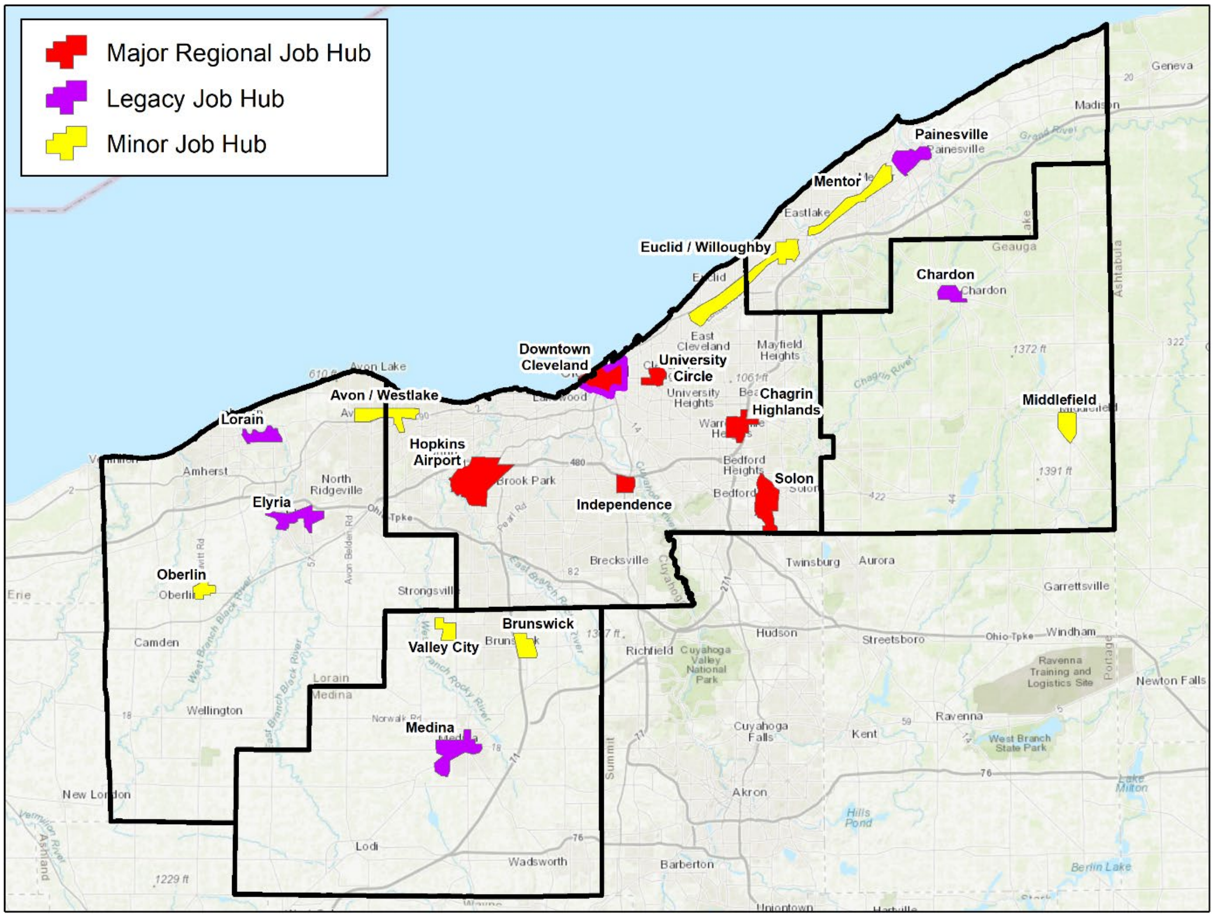


Table 3-15 illustrates the minimum, maximum and average commute times of the current work trips during the morning peak period of a typical day from workers' homes to the regional major job hubs by auto and transit.

Table 3-15. Regional Statistical Values of Morning work Commute Times by Auto and Transit

Auto & Transit Work Commute Times During 2020 AM Peak Period		Origin					
		Region					
		Morning Work Commute Time by Transit (Minutes)			Morning Work Commute Time by Auto (Minutes)		
Destination	Major Job Hub	Min	Average	Max	Min	Average	Max
	Cleveland Downtown	17	76	249	3.1	38	102
	University Circle	17	71	271	2.6	42	107
	Solon	35	106	236	3.5	42	92
	Chagrin Highlands	26	97	294	3.2	38	89
	Independence	40	106	292	2	35	89
	Hopkins Airport Area	48	106	262	4	35	92

Source: NOACA Travel Forecasting Model

As discussed previously, the transit system has an acceptable level of coverage in Cuyahoga County, but due to low frequency of transit services, low speed on the arterial streets, long waiting and transfer times, work commute time is still much higher than that of the auto mode. All the statistical values of minimum, average and maximum of transit mode are more than twice of those of the auto mode.

Most people seem to enjoy a certain amount of personal travel, about 30 minutes a day, and dislike devoting more than about 90 minutes a day. Adding travel times of the return home trips similar to the average transit travel time shown in the above table, results in daily work trip travel time outside an acceptable range for most residents in the NOACA region. Therefore, high transit travel time is a critical factor in choosing private vehicle mode for daily work trips. The implications of this analysis are far-reaching. On the workforce development side, the analysis and data could be used to identify undersupplies of workers types residing in areas with good accessibility to major job hubs. In order to reduce the worker and employer locations mismatch in this region, more frequent transit services to the major job hubs, more park-and-ride locations throughout the region, implementation of low cost traffic engineering to remove arterial bottlenecks and more bike facilities to access major transit stations.

EJ population is more dependent on transit services than other population sectors. Therefore, transit accessibility and travel time are critical for some of the EJ area population for work-related journeys. Table 3-16 displays similar statistical patterns for EJ neighborhoods.

Table 3-16. Statistical Values of Morning work Commute Times for Origins in EJ Areas by Auto and Transit

Auto & Transit Work Commute Times During 2020 AM Peak Period		Origin					
		EJ Areas					
		AM Work Commute Time by Transit (Minutes)			AM Work Commute Time by Auto (Minutes)		
Destination	Major Job Hub	Min	Average	Max	Min	Average	Max
	Cleveland Downtown	17	53	219	3.1	25	69
	University Circle	18	56	241	2.6	27	76
	Solon	38	93	217	3.7	36	81
	Chagrin Highlands	27	83	264	3.3	30	77
	Independence	45	90	263	5.7	27	66
	Hopkins Airport Area	52	101	181	4.3	27	73

Source: NOACA Travel Forecasting Model

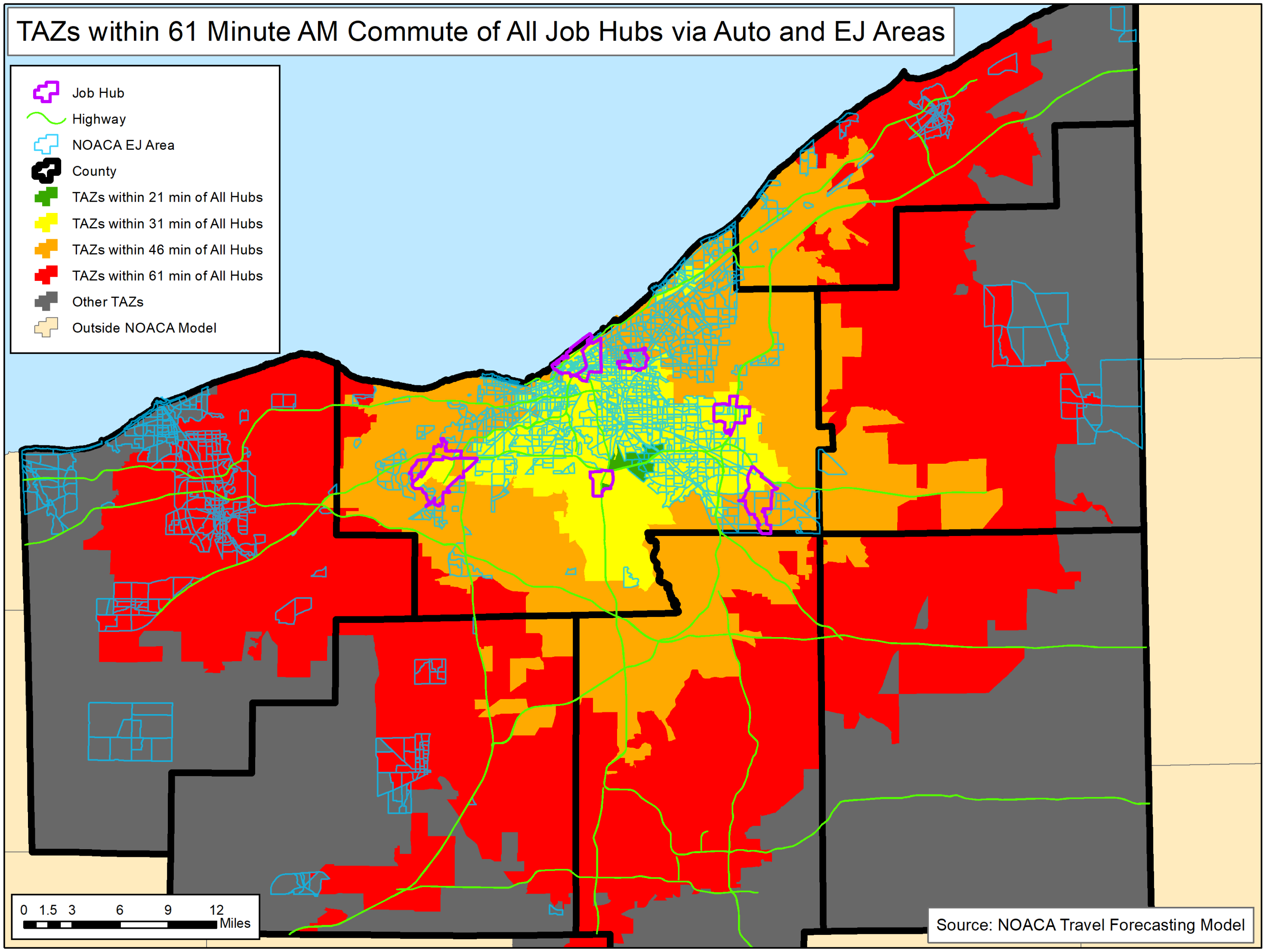
Comparing the work commute times from residential areas to the regional major job hubs by auto and transit in Tables 3.15 and 3.16 indicates that the average transit work commute times from the EJ areas are higher than the regional average auto work commute times to major job hubs. The range of the average transit times is wider than the range of the regional average auto travel time: 52-101 minutes compared with 35-42 minutes.

Downtown is served by fairly adequate bus and rail services and the transit commute time from EJ areas is the lowest average. As the transit services moves farther from downtown, the transit commute times from the EJ areas to job hubs increase. For instance, a worker employed at the Solon job hub, would be commuting about three hours daily from home to work by transit on average. An equitable transportation system would have less gap between the auto and transit commute times.

The average auto time values to the major job hubs are similar since all the job hubs are located close to the highway system and the maps in the previous section revealed there are abundant freeway interchanges which provide quick access from residential areas to the existing freeway system and subsequently job hubs.

Figure 3-18 illustrates the time sheds to all the major job hubs. Also it indicates that the most of EJ areas are within 30 minutes of any major job hub. As mentioned before, many EJ residents are transit dependent and therefore living close to highways does not result in an average short work commute time for areas with low car ownership.

Figure 3-18. Auto Time Sheds to All Major Job Hubs



Mobility

Typically, the interstate and freeway systems carry the highest volume of traffic in the region, requiring more travel lanes. In the NOACA region, lane-miles length of the existing freeway/expressway system is about 2,200 miles which is about 20% of total roadway lane-miles.

Vehicle Miles Traveled (VMT) is a measure used extensively in transportation planning for a variety of purposes. VMT is the leading measure of both personal and commercial vehicle travel demand. VMT data are also useful in policy decision for infrastructure investment. Since VMT measures travel demand, it is useful in determining where resources are most needed, and it is an important measure to monitor and forecast.

The current VMT percent of the freeway/expressway system is about 54 based on the typical daily vehicle trips in the NOACA region (Source: NOACA Travel Forecasting Model). The 2020 daily VMT share of the freeway system for auto and truck trips separately are about 47% and 70% respectively.

The VMT per capita illustrates the relationship between population growth and the length of travel in the NOACA region. The current annual personal VMT estimate per capita is about 6,600 and the annual commercial VMT per capita is about one tenth of that.

Comparing the lanes miles percentages of the freeway/expressway system with the major arterial shown in Table 3-17, indicates that although the total lane miles are almost the same, the VMT percent of the freeway network is more than three times that of the major arterial network. This disproportionate shares result in daily delay on the freeway network twice than that of the major arterial network. This is additional evidence for reinforcing the argument that the major arterial network as a mobility alternative to the freeway system is currently underutilized in the NOACA region.

Table 3-17. Percentages of Lane miles, VMT and delay by Facility Type

Facility Type	Main Function	Total Lane Miles Percent	Total of Personal & Commercial Vehicles VMT Percent	Total Daily Delay Percent
Freeway/ Expressway	Mobility	20%	54.1%	44.8%
Major Arterial	Mobility & Access	18%	15.5%	22.8%
Minor Road	Access	62%	30.4%	32.4%

Traffic Congestion

Following the access to the transportation facilities, a journey begins from an origin to a destination. The journey may be measured qualitatively and quantitatively by various travel attributes: travel time, delays due to routine or unexpected congestion, travel mode, journey route, safety, trip quality, etc.

It is to be expected that large numbers of people are all trying to reach their destinations at the same time, usually during peak hours, which causes congestion and delay. If the congestion and delay is a daily routine, most travelers accept and plan for it. However, the unexpected delays are less tolerated. Delay is a quantity that indicates where the problems are, what the solutions might be and how beneficial the investment will be.

Transportation authorities continuously take actions to benefit travelers by balancing between land use access and mobility and also reducing the time spent in traveling. On the contrary, actions in pursuit of other goals, such as improving safety, may also have the unintended or unavoidable consequence of slowing travel. The purpose of this section is to evaluate reductions or increases in passenger and goods travel time that result from such actions.

As discussed in previous sections, accessibility, mobility and congestion are the main measures for evaluating the performance of the highway system in terms of how efficiently users can traverse. Mobility and congestion represent similar concepts and the same metrics, such as travel time, may be used to measure them.

Congestion describes the travel conditions on facilities and the Federal Highway Administration (FHWA) defines seven sources for traffic congestion and unreliable travel time:

Category 1: Traffic Influencing Events

- Traffic incidents,
- Work zones,
- Weather

Category 2: Traffic demand

- Fluctuation in normal traffic
- Special events

Category 3: Physical Highway Features

- Traffic control devices
- Physical bottleneck ("Capacity")

Congestion spreads in time and space. In some areas of the NOACA region, congestion now last more than the traditional morning and evening peak hours and queues from physical bottleneck are extended to a mile or two. The following section documents the existing recurring freeway, interchange and intersection bottlenecks in the NOACA region as sources of congestion and ranks them based on their localized congestion severity. This discussion also makes a relation between the demand and supply sides of the highway system.

Bottlenecks

FHWA offers the following definitions for a traffic bottleneck:

- A critical point of traffic congestion evidenced by queues upstream and free flowing traffic downstream
- A location of a highway where there is loss of physical capacity, surges in traffic volumes, or both
- A point where traffic demand exceeds the normal capacity
- A location where demand for usage of a highway section periodically exceeds the section's physical ability to handle it, and is independent of traffic distributing events that can occur on the roadway

The highway network in the NOACA region was assessed by using the NOACA travel forecasting model and the following congestion criteria to identify the bottleneck locations. Only "over capacity" freeway segments (a volume over capacity (V/C) ratio above 1) were considered when identifying highway bottleneck locations.

Congestion Criteria

Volume over Capacity Ratio (V/C)

The volume over capacity ratio during peak periods is one of the primary criteria for evaluating traffic congestion characteristics. The Highway Capacity Manual (HCM) provides different measures for various road classifications and intersection control types; however, these measures are generally divided into six ranges and assigned a Level-Of-Service (LOS) category A through F, with LOS F being indicative of severe congestion. LOS is a qualitative measure used to relate the quality of traffic service. Table 3-18 shows highway LOS ranges that have been used to locate the intensity of traffic congestion.

Table 3-18. Volume over Capacity Ranges

Volume over Capacity Ratio (V/C)	LOS	Description
V/C < 0.3	A	Free Flow Condition
V/C < 0.5	B	Reasonably Free Flow Condition
V/C < 0.7	C	Under Capacity
V/C < 0.85	D	Near Capacity
V/C = < 1	E	At Capacity
V/C > 1	F	Over Capacity

Travel Time Index (TTI)

The Travel Time Index (TTI) is one of the primary metrics used to measure congestion. It is the ratio of the actual travel time divided by the travel time under free flow conditions. A TTI of 1.2 means that a trip takes 20 percent longer than it would under ideal conditions.

Speed and Travel Time

Speed is distance traveled per unit time. In traffic operations, two measures of average speed are Space Mean Speed (SMS) and Time Mean Speed (TMS). SMS is the average speed of all vehicles occupying a defined section of roadway at a point in time. TMS is the average speed of all vehicles passing a point on a roadway for a defined period of time.

NOACA Congestion Assessment

Figures 3-19 and 3-20 present the existing freeway bottleneck locations during the AM and PM peak periods.

Figure 3-19. Existing Freeway Bottleneck Locations during the AM Peak Period

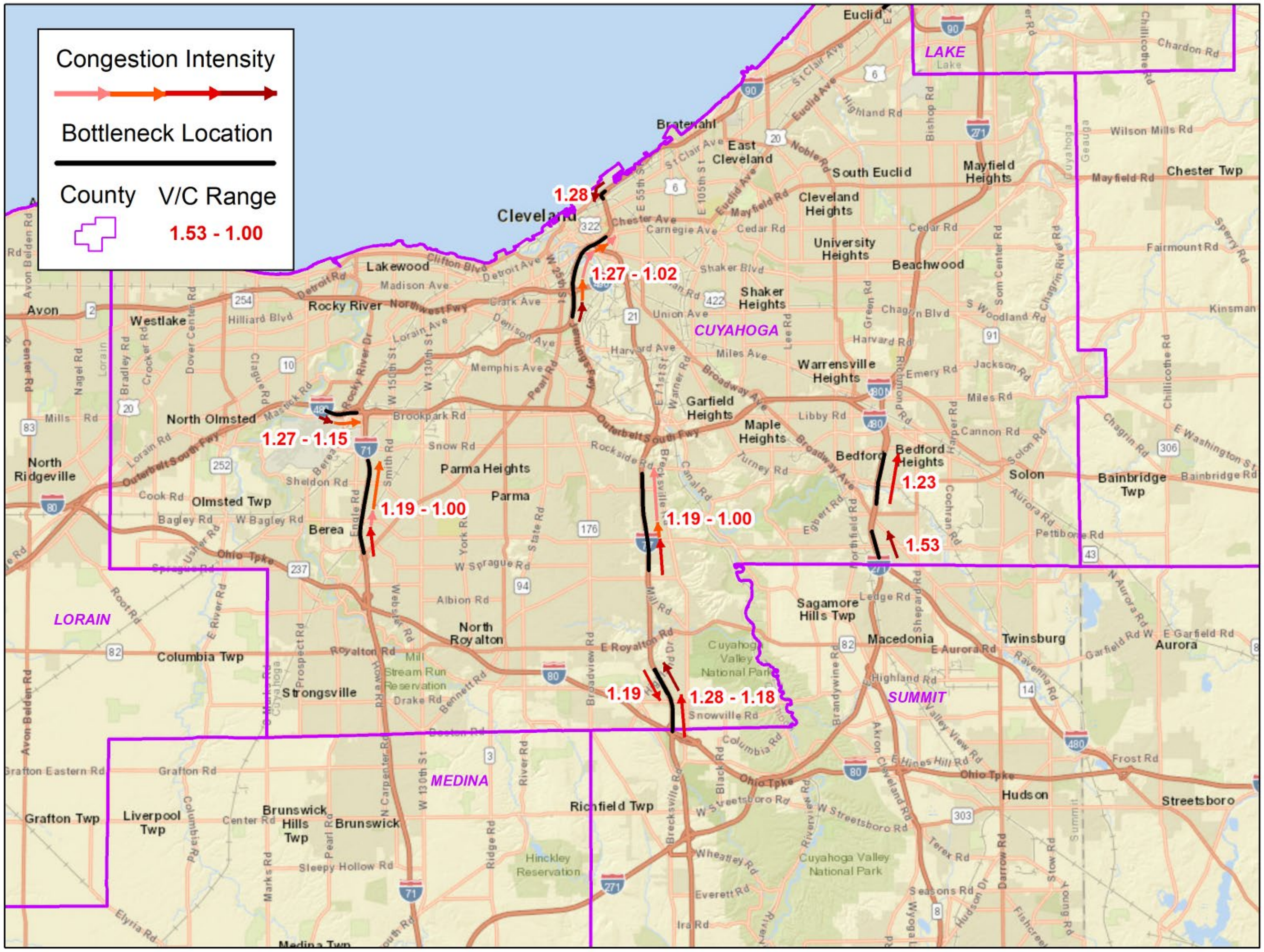
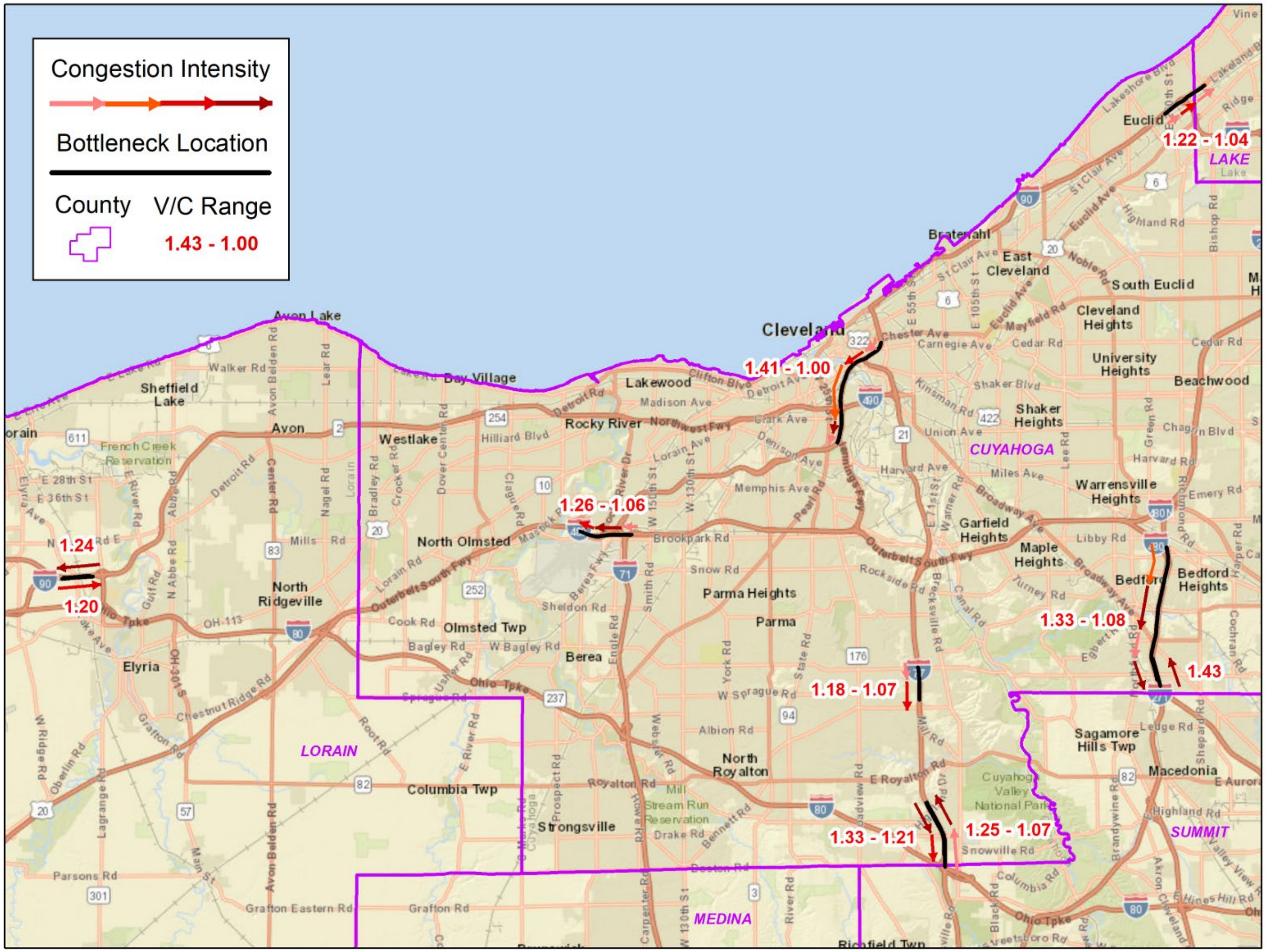


Figure 3-20. Existing Freeway Bottleneck Locations during the PM Peak Period



Tables 3-19 and 3-20 present the V/C, TTI, and speed ranges for the identified freeway bottleneck locations during the AM and PM peak periods.

Table 3-19. Existing Freeway Bottleneck during the AM Peak period

No.	Freeway	Direction	From	To	V/C Range	TTI Range	Actual Speed (mph) Range
1	I-271and I-480	NB/ WB	I-271 /I-480 Merge	Fairoaks Rd/Broadway Ave. Exit Ramp	1.53	7.5	8
2	I-77	NB	I-80 Entrance Ramp	Oakes Rd/Valley Pkwy	1.28 - 1.18	2.46 – 1.70	35 – 24
3	I-90	WB	SR-2 WB Split	SR-2 EB Entrance Ramp	1.28	2.27	22
4	I-480	EB	Grayton Rd/ Brookpark Rd Entrance Ramp	SR-237 Entrance Ramp	1.27 - 1.15	2.99 – 1.59	38 - 20
5	I-71 and I-90	NB/ EB	W 14th St Exit Ramp	Carnegie Ave Exit Ramp	1.27 - 1.02	2.33 – 1.02	49 - 26
6	I-271 and I-480	NB/ WB	Forbes Rd Entrance Ramp	I-271/I-480 split	1.23	1.99	30
7	SR-2 and I-90	WB	Lakeland Blvd Entrance Ramp (near Lloyd Rd)	N Lakeland Blvd Exit Ramp (near E 260th St)	1.21 - 1.02	1.92 – 1.19	50 – 31
8	I-77	NB	Wallings Rd Entrance Ramp	Rockside Rd Exit Ramp	1.19 - 1.00	1.77 – 1.19	51 - 34
9	I-77	SB	Oakes Rd/Valley Pkwy	Miller Rd Exit Ramp	1.19	1.77	34
10	I-71	NB	Pearl Rd Entrance Ramp	Snow Rd Exit Ramp	1.19 - 1.00	1.71 – 1.14	53 - 35

Note: NB: Northbound, SB: Southbound, WB: Westbound, and EB: Eastbound.

Table 3-20. Existing Freeway Bottleneck during the PM Peak period

No.	Freeway	Direction	From	To	V/C Range	TTI Range	Actual Speed (mph) Range
1	I-271 and I-480	NB/ WB	I-271/I-480 merge	Fairoaks Rd/Broadway Ave Exit Ramp	1.43	4.58	13
2	I-90 and I-71	WB/ SB	Prospect Ave Exit Ramp	W 25th St Exit Ramp	1.41 - 1.00	4.27 – 1.09	51- 14
3	I-77	SB	Oakes Rd/Valley Pkwy	I-80 Exit Ramp	1.33 - 1.21	2.99 – 1.87	32 - 20
4	I-271 and I-480	SB/ EB	Rockside Rd Exit Ramp	I-271/I-480 Split	1.33 - 1.08	2.88 – 1.30	46 - 21
5	I-480	WB	I-71 NB Entrance Ramp	Grayton Rd Exit Ramp	1.26 - 1.06	2.25 – 1.26	48 - 27
6	I-77	NB	I-80 Entrance Ramp	Oakes Rd/Valley Pkwy	1.25 - 1.07	2.19 – 1.30	46 - 27
7	I-90 and SR-2	WB	Lorain Blvd Entrance Ramp	I-90/SR-2 Split	1.24	2.73	24
8	I-90 and SR-2	EB	Lakeland Blvd Entrance Ramp (near E 260th St)	Lakeland Blvd Exit Ramp (near Lloyd Rd)	1.22 - 1.04	1.93 – 1.26	47 - 31
9	I-90 and SR-2	EB	I-90/SR-2 Merge	Lorain Blvd Exit Ramp	1.20	2.21	29
10	I-77	SB	Pleasant Valley Rd Exit Ramp	Wallings Rd Exit Ramp	1.18 - 1.07	1.68 – 1.29	47 - 36

Note: NB: Northbound, SB: Southbound, WB: Westbound, and EB: Eastbound

In order to identify the top interchange and intersection bottleneck locations, a calculation based on the following equation, was performed to average the volume over capacity (V/C) values for all approaches of a given interchange or intersection.

$$WVC = \frac{\sum_{i=1}^{n} VOL_i \times (V/C)_i}{\sum_{i=1}^{n} VOL_i}$$

Where

WVC = Weighted V/C values
n = Number of approaches
VOL = Approach traffic volume (weighting factor)

For example, a four-legged intersection has four approaches, each with their own V/C value. A weighted average of each approach's V/C value was calculated, using the total volume of each approach as the weighting factor. Weighting was used in order to give a more heavily traveled roadway's congestion level more influence over the intersection's final calculated value. The locations with the highest weighted V/C values were then identified as the top bottleneck interchanges and intersections in the region.

A number of the bottleneck locations were grouped together based on their proximity and interactions with each other. For example, in Medina County three bottleneck locations were identified along the SR-94 corridor (Ridge Rd). Since these locations are located along the same corridor, congestion at one location leads to increased congestion at a nearby location. It was determined that these locations should be grouped together and discussed as one due to these inter-relationships. Similar groupings can be seen on the map (indicated with black circles) showing bottleneck locations that have some relationship between each other, such as neighboring interchanges along the same freeway and intersections in a similar geographic area, like downtown Cleveland.

Figures 3-21 and 3-22 present the existing interchange and intersection bottleneck locations during the AM and PM peak periods.

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Figure 3-21. Existing Interchange/ Intersection Bottleneck Locations during the AM Peak Period

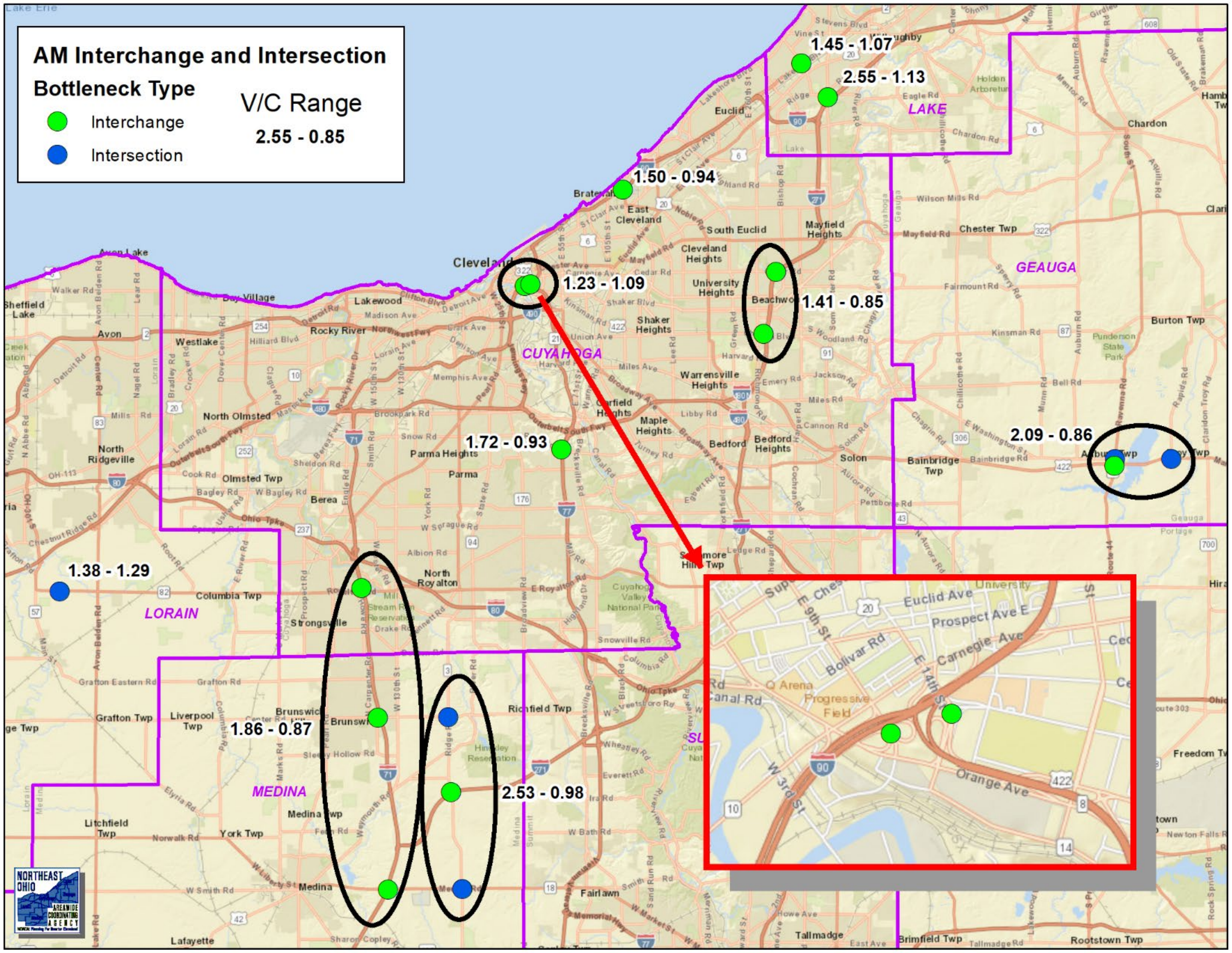
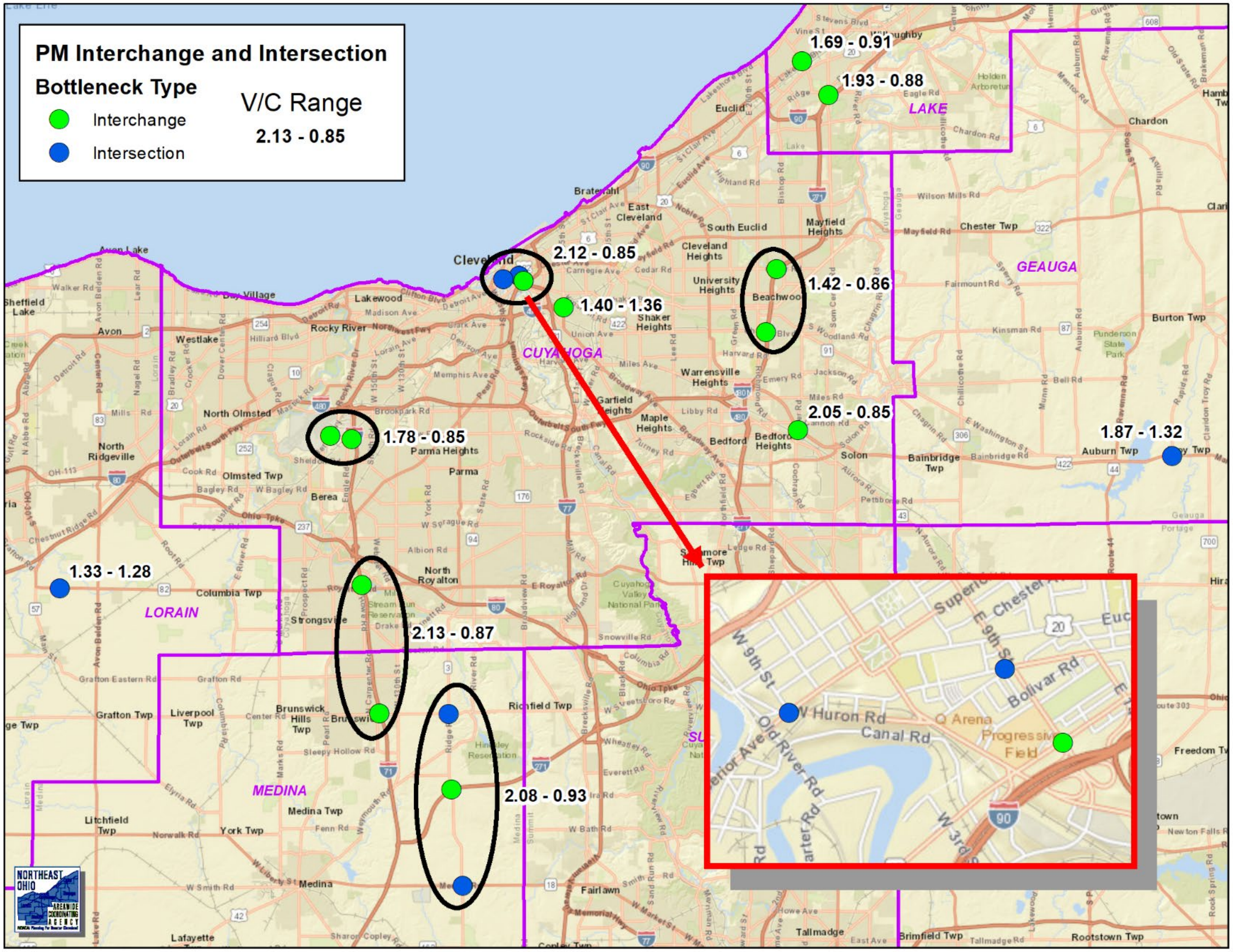


Figure 3-22. Existing Interchange/ Intersection Bottleneck Locations during the PM Peak Period



Tables 3-21 and 3-22 present the V/C values for the identified interchanges and intersection bottleneck locations during the AM and PM peak periods.

Table 3-21. Existing Interchange/ Intersection Bottleneck during the AM Peak Period

No.	Location	County	Type	Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity Ratio Range
					AM Peak Period
1	**Ridge Rd (SR-94) Corridor**	**Medina**	**Interchange/ Intersection**	**1.91 - 1.11**	**2.53 - 0.98**
-	*I-271 / Ridge Rd (SR-94)*	*Medina*	*Interchange*	*1.91*	*2.53 - 0.98*
-	*Center Rd (SR-303) / Ridge Rd (SR-94)*	*Medina*	*Intersection*	*1.15*	*1.29 - 1.11*
-	*Medina Rd (SR-18) / Ridge Rd (SR-94)*	*Medina*	*Intersection*	*1.11*	*1.28*
2	**I-90 / SOM Center Rd (SR-91)**	**Lake**	**Interchange**	**1.76 - 1.09**	**2.55 - 1.13**
3	**I-71 Corridor**	**Medina / Cuyahoga**	**Interchange**	**1.53 - 1.14**	**1.86 - 0.87**
-	*I-71 / Center Rd (SR-303)*	*Medina*	*Interchange*	*1.53 - 1.21*	*1.84 - 0.87*
-	*I-71 / Royalton Rd (SR-82)*	*Cuyahoga*	*Interchange*	*1.39 - 1.26*	*1.86 - 1.39*
-	*I-71 / Medina Rd (SR-18)*	*Medina*	*Interchange*	*1.14*	*1.39 - 0.94*

No.	Location	County	Type	Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity Ratio Range
					AM Peak Period
4	**US-422 and Ravenna Rd (SR-44) area**	**Geauga**	**Interchange/ Intersection**	**1.44 - 1.17**	**2.09 - 0.86**
-	*US-422 / Ravenna Rd (SR-44)*	*Geauga*	*Interchange*	*1.44*	*2.09 - 0.86*
-	*Main Market Rd (US-422) / Rapids Rd*	*Geauga*	*Intersection*	*1.34*	*1.51 - 1.21*
-	*Ravenna Rd (SR-44) / E Washington St*	*Geauga*	*Intersection*	*1.17*	*1.32 - 1.24*
5	**I-271 Corridor**	**Cuyahoga**	**Interchange**	**1.24 - 0.89**	**1.41 - 0.85**
-	*I-271 / Cedar Rd / Brainard Rd*	*Cuyahoga*	*Interchange*	*1.24 - 0.89*	*1.41 - 0.86*
-	*I-271 / Chagrin Blvd (SR-87)*	*Cuyahoga*	*Interchange*	*1.12 - 1.07*	*1.23 - 0.85*
6	**Royalton Rd (SR-82) / Durkee Rd**	**Lorain**	**Intersection**	**1.24**	**1.38 - 1.29**
7	**Innerbelt at E. 9th and E. 14th**	**Cuyahoga**	**Interchange**	**1.23 - 0.88**	**1.23 - 1.09**
-	*I-77 NB / E 14th St / E 22nd St*	*Cuyahoga*	*Interchange*	*1.23 - 1.07*	*1.23 - 1.09*
-	*I-90 EB / E 9th St*	*Cuyahoga*	*Interchange*	*1.09 - 0.88*	*1.11 - 1.09*
8	**I-77 / Rockside Rd**	**Cuyahoga**	**Interchange**	**1.19 - 1.04**	**1.72 - 0.93**

No.	Location	County	Type	Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity Ratio Range
					AM Peak Period
9	SR-2 / E 305th St	Lake	Interchange	1.14 - 0.85	1.45 - 1.07
10	I-90 / Eddy Rd	Cuyahoga	Interchange	1.10	1.50 - 0.94

Table 3-22. Existing Interchange/ Intersection Bottleneck during the PM Peak period

No.	Location	County	Type	Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity Ratio Range
					PM Peak Period
1	**Downtown Cleveland Area**	**Cuyahoga**	**Interchange/ Intersection**	**1.64 - 1.17**	**2.12 - 0.85**
-	*I-90 WB / E 9th St / Carnegie Ave*	*Cuyahoga*	*Interchange/ Intersection*	*1.64*	*2.12 - 0.85*
-	*Prospect Ave / Huron Rd (west of E 9th St)*	*Cuyahoga*	*Intersection*	*1.18*	*1.42 - 0.92*
-	*Superior Ave / Huron Rd / W 9th St*	*Cuyahoga*	*Intersection*	*1.17*	*1.70 - 0.93*
2	**Ridge Rd (SR-94) Corridor**	**Medina**	**Interchange/ Intersection**	**1.64 - 1.15**	**2.08 - 0.93**
-	*I-271 / Ridge Rd (SR-94)*	*Medina*	*Interchange*	*1.64*	*2.08 - 0.93*
-	*Center Rd (SR-303) / Ridge Rd (SR-94)*	*Medina*	*Intersection*	*1.23*	*1.52 - 1.06*
-	*Medina Rd (SR-18) / Ridge Rd (SR-94)*	*Medina*	*Intersection*	*1.15*	*1.49 - 1.10*
3	**Main Market Rd (US-422) / Rapids Rd**	**Geauga**	**Intersection**	**1.61**	**1.87 - 1.32**
4	**I-71 Corridor**	**Medina / Cuyahoga**	**Interchange**	**1.53 - 0.92**	**2.13 - 0.87**
-	*I-71 / Royalton Rd (SR-82)*	*Cuyahoga*	*Interchange*	*1.53 - 1.45*	*2.13 - 0.87*
-	*I-71 / Center Rd (SR-303)*	*Medina*	*Interchange*	*1.15 - 0.92*	*1.26 - 0.89*

No.	Location	County	Type	Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity Ratio Range
					PM Peak Period
5	**SR-2 / E 305th St**	**Lake**	**Interchange**	**1.44 - 0.86**	**1.69 - 0.91**
6	**I-271 Corridor**	**Cuyahoga**	**Interchange**	**1.30 - 0.86**	**1.42 - 0.86**
-	*I-271 / Cedar Rd / Brainard Rd*	*Cuyahoga*	*Interchange*	*1.30 - 0.86*	*1.42 - 0.86*
-	*I-271 / Chagrin Blvd (SR-87)*	*Cuyahoga*	*Interchange*	*1.16 - 1.09*	*1.35 - 0.87*
7	**I-90 / SOM Center Rd (SR-91)**	**Lake**	**Interchange**	**1.30 - 1.22**	**1.93 - 0.88**
8	**Snow Rd Corridor**	**Cuyahoga**	**Interchange**	**1.29 - 1.15**	**1.78 - 0.85**
-	*I-71 / Snow Rd*	*Cuyahoga*	*Interchange*	*1.29*	*1.78 - 0.85*
-	*SR-237 / Snow Rd*	*Cuyahoga*	*Interchange*	*1.15*	*1.45 - 0.91*
9	**US-422 / Harper Rd**	**Cuyahoga**	**Interchange**	**1.26**	**2.05 - 0.85**
10	**I-490 / E 55th St**	**Cuyahoga**	**Interchange**	**1.25**	**1.40 - 1.36**
11	**Royalton Rd (SR-82) / Durkee Rd**	**Lorain**	**Intersection**	**1.22**	**1.33 - 1.28**

The next paragraphs discuss some of the identified freeway, interchanges and intersection bottleneck locations, their congestion severity and reoccurring causes.

Interstate 271/Interstate 480: The northbound of I-271 is used by commuters from the southwest of the region and the westbound of I-480 connects the region to the counties in the southeast. The merging segment of the two freeways are congested during the AM and PM peak periods. The freeway bottleneck stretches with less intensity along the north of the merge segment during the AM peak period. During the PM peak period, the severity of congestion begins from the similar location at the southbound direction. The length of this bottleneck is over three miles and its TTI range is about 5 and even up to 7 with actual speed of 13 as low as 8 mph during the AM peak period. This is a typical freeway bottleneck location where two highway with two lanes each and high volumes merge into a highway with three lanes.

Interstate 77: The segment from the ramp of I-80 for about 2 miles is congested in both direction during the AM and PM peak periods. The residential neighborhoods, as trip production locations, and employment centers, as trip attraction, around this area generated heavy traffic in the both direction during the AM and PM peak periods. The TTI values during the AM and PM Peak periods are about 1.7 to 3 and actual speeds are between 20 to 30 mph. The other causes of traffic intensity is due to the number of lanes in both direction of this segment. Widening this segment to three lanes will reduce traffic intensity and may eliminate the bottleneck.

Interstate 90: Most morning commuters from north and south of Lake County to Cleveland downtown travel through State Route 2 and Interstate 90 and the joining segment of these highways is one of the freeway bottleneck location in the NOACA region. The TTI value for this segment is around 2.5 and the actual speed is about 25 mph. Reinvigorating arterials as a multimodal corridor in this area may mitigate the congestion in this spot.

Interstate 480: Congestion of the short segment of I-480 from Grayton Road to State Route 237 entrance is mainly due to the closeness of the merging and diverging ramps in this area. The other factor of congestion on this segment is its proximity to the I-71 and I-480 interchange. The TTI ranges for this segment is 1.5 to 3 in both directions and AM and PM peak periods. The actual speed may reach as low as 20 mph. Enhancing transit to major trip generators such Hopkins airport in the vicinity of this segment may mitigate the congestion or at the very least reduces the its intensity.

Interstate 71/Interstate 90: The segment of this freeway from W 14th St entrance ramp to Carnegie Ave exit ramp is heavily used by morning work commuters and therefore congested during the AM peak period. The length of this segment is about 1.5 miles and its TTI is about 2. Although, this short stretch of the freeway has five lanes in the eastbound direction, but due to existence of several ramps, weaving traffic, its close proximity to the Cleveland downtown as the major regional job hubs, the congestion is severe on this segment of freeway. During the PM peak period, the opposite direction has a similar level of congestion during the PM peak period. Promoting a multimodal system for accessing to Cleveland downtown job hub may reduce the congestion at this bottleneck since this segment is constructed almost to the highest number of possible lanes.

Interstate 77: The length of I-77 from Wallings Road on-ramp to Rockside Road off-ramp is about two miles and there are three ramps along this stretch of highway. Several on and off ramps in a short segment of a freeway generate heavy weaving traffic and that is the main cause for the reoccurring the congestion at this location. The TTI values of this segment are around 1.5.

Interstate 71: The segment of I-71 between State Route 42 and Snow Road has the same length as I-77 described in the previous paragraph. This similarity causes same traffic issues and the TTI value range is 1.71 to 1.14.

The main sources for this analysis were the results of the NOACA travel forecasting model and the field observation. Congested interchanges and intersections were identified based on number of approaches with the volume over capacity ratio higher 0.85, indicating the road is approaching over capacity. There is a broad spectrum of approaches with V/C values over the capacity borderline. In some cases, there are a high number of approaches with high volume over capacity and there are other cases with only a few approaches with high ratios.
For instance, there are about seven approaches at the I-71 and Center Road (State Route 303) interchange with V/C value of over 0.85 during the AM peak period. The approach from South Carpenter Rd heading east to the I-71 southbound on-ramp has the highest V/C value of 1.84 for that interchange area.

There are three interchanges with seven or more high V/C approaches during the PM peak period. These interchanges are: I-271 and Cedar Road, I-271 and Chagrin Blvd, and I-71 and Center Road. The other identified interchanges and intersections have two or more approaches with V/C value over 0.85.

During the PM peak period, the approach from Remsen Rd heading south towards the southbound ramps at the I-271 and Ridge Road interchange has the highest V/C value of 2.08 in the entire region.

Fuel, Delay and Congestion Costs

As demand approaches the capacity of a freeway (or of the interchanges along the highway), extreme traffic congestion sets in. Traffic congestion impacts the operation and performance of the freeway and causing longer trip times, slower speed and increased delay. As traffic engineering and financial performance indicators, combination of travel delay and wasted fuel due to congestion is considered as the congestion cost.

This combined measure was calculated based on;

- Average fuel cost per gallon; this measure may be considered as the quotient of total daily Vehicle Miles Traveled (VMT) divided by total daily gasoline consumption.
- Median value of time per hour; according to the US Department of Transportation and other sources the value of time measure is a range of 30 to 60 percent of average earnings.
- Average Auto occupancy during peak and off-peak periods of a day.

Congestion Cost Estimation Procedure

The following steps are used for calculating the total congestion cost for the road segments in the considered influence subarea.

- The ***average road segment delay*** is the difference between the estimated travel time under actual (often congested) conditions and under uncongested conditions.

$$Average\ Road\ Segment\ Delay\ (hr) = \frac{Length\ of\ the\ road\ Segment\ (miles)}{Road\ Segment\ congestedspeed\ (mph)} - \frac{Length\ of\ the\ road\ Segment\ (miles)}{Free\ Flow\ Speed\ (mph)}$$

- The ***total delay on a road segment*** is product of the average delay and total vehicles traveling this segment.

$$Road\ Segment\ Delay\ (hr) = Average\ Road\ Segment\ Delay\ \times Total\ Traffic\ Volume$$

- The ***road segment delay cost*** is calculated by multiplying the estimated road segment delay by average passenger car occupancy and the occupants' average value of time.

$$Road\ Segment\ Delay\ Cost\ (\$) = Road\ Segment\ Delay\ \times Average\ auto\ occupancy\ \times Average\ Value\ of\ time$$

- Vehicles waste additional fuel when they are under congested conditions. The ***additional consumed fuel cost*** can be estimated using the below calculated delay and auto operating cost.

$$Road\ Segment\ Fuel\ Cost\ (\$) = Road\ Segment\ Delay\ \times Road\ Segment\ Congested\ Speed\ \times\ auto\ Operating\ cost$$

- The ***average auto operating cost*** is estimated by dividing the fuel cost per gallon by the average miles a vehicle can travel on one gallon of fuel.

$$Average\ Auto\ Operating\ Cost\ (\$) = \frac{Fuel\ Cost\ per\ gallon}{Average\ miles\ a\ vehicle\ can\ travel\ on\ one\ gallon\ of\ fuel}$$

- Finally, the ***total road segment congestion cost*** comprises of two elements; delay cost and fuel cost.

$$Road\ Segment\ Congestion\ Cost\ (\$) = Road\ Segment\ Delay\ Cost + Road\ Segment\ Fuel\ Cost$$

Table 3-23 displays the estimated 2020 daily and annual congestion costs.

Table 3-23. Estimated 2020 Daily and Annual Congestion Costs

Cost Item	Unit	Estimated 2020 Value
Daily Wasted Fuel	Gallon	115,000
Daily Wasted Fuel Cost	2020$	313,000
Total Daily Delay	Hour	127,000
Total Daily Delay Cost	2020$	2,615,000
Total Daily Congestion Cost	2020$	2,928,000
Total Annual Congestion Cost	2020$	732,076,000

Assumptions

Fuel Cost per Gallon (2020$): 2.72

Average Traveled Miles per Gallon: 24.14

Average Values of Time (2020$): 13.74