Chapter 11: eNEO2050 Final Plan

Summary

In Chapter 9, Scenario 4, “TOTAL” resulted in the best cost-benefit ratio compared to the other three scenarios analyzed. This chapter illustrates the list of projects from Scenario 4 and their planned implementation decades for each project. The scenario effectiveness based on the selected performance measures is evaluated by comparing them with those of Scenario 1: MAINTAIN as the benchmark values. The evaluation results are then combined with the net present value of the total scenario-specific project costs, which produces an acceptable level of economic return indicator.

The rest of this chapter introduces the new eNEO2050+ projects with a succinct description. These projects are:

- **Interchange evaluation:** Four partial existing interchanges of Interstate 77 at Miller Road, Brecksville, Cuyahoga County; Interstate 480 at Granger Road, Garfield Heights, Cuyahoga County; US highway 422 at Harper Road, Solon, Cuyahoga County; State Route 44 at Jackson Road, Painesville, Lake County will be full diamond interchanges by 2050.
- **Congestion Management Plan (CMP):** CMP objectives in relation to the eNEO2050 goals and objectives are introduced and a set decennial targets is determined for a selected performance measures.
- **Principal Arterial Network:** Principal arterial corridors are evaluated and prioritized for the STOP and transit services. In this section the “TOP 10” corridors for STOP projects and transit are introduced.
- **Safety:** NOACA utilizes a systemic safety approach based on the formulas for predictive crashes from the Highway Safety Manual. This is primarily implemented through biannual community safety reports, which analyze the arterial segments and intersections within NOACA cities and villages to identify the ones that have the highest risk of crashes based on their roadway configurations and number of lanes, traffic levels, and estimated numbers of driveways (access points).
- **Pavement and Bridge Maintenance Management:** NOACA Pavement preservation plan based on the Maintenance & Rehabilitation (M&R) program is described and then applied to maintain the average pavement condition rating at 75 during the period of 2025 - 2050. This application is similar to the NOACA biennial pavement maintenance community approach.
- **Complete Transit Connectivity:** As a complement to existing modes for “First-Mile” and “Last-Mile” connections, autonomous shuttle feeder bus services in four counties are designed to provide complete connection for the major transit corridors.
- **Workforce Accessibility and Mobility:** The eNEO2050+ plan includes a set of transit and land use recommendations based on the NOACA recent Workforce Accessibility and Mobility study for work commutes during the morning peak period.
- **Non-motorized Facilities:** NOACA has completed a new pedestrian and bicycle plan, called ACTIVATE. This plan includes three usage categories of non-motorized modes; utilitarian trips, access to transit services, and recreational pursuits. Also eNEO2050+ Plan proposes 928 miles of bike facility, over 11,000 pedestrian ADA and safe crossings and 760 bike storage lockers for cyclist in the next three decades.
- **Emerging Technology in transportation:** The eNEO2050+ plan proposes a set of locations for Electric Vehicle (EV) charging ports and discusses the emerging electric vehicles in the NOACA roadway network in relation to air quality and equity.

- **Fiscally Unconstraint eNEO2050:** The future BRT network expansion did not satisfy the fiscal constraints of the long range plan. However, Scenario 4 (TOTAL) did include this expansion and it had the highest measure of effectiveness. Therefore, eNEO2050+ will include this project as a fiscally unconstrained project for the future plan amendments.
- **Illustrative Project:** The Hyperloop is an illustrative project of the eNEO2050+ plan.

The Journey

The journey of developing eNEO2050+ Long Rang Plan (LRP) began eight years ago following the board approval of NOACA AIM2040 plan with research, analysis, policy development, as well as the development of project and plan components. The more concentrated efforts to build and assemble the plan began in January 2018 with the launch of a public outreach campaign. The load for the journey was heavier than that of the previous plan as with the integration of land use, housing, environment, economic development, into the traditional Long Range of Transportation plan (LRTP). Also the time period for the plan was expanded to 2050, resulting in further visioning, forecasting, and modeling, but better reflected the possibility of the futuristic travel modes.

The vehicle of journey was equipped with the advance planning tools for considering all the available routes and the probable destinations. The vehicle used the engine of “Scenario Planning.” At several stations, the public were queried for the route ahead adjustments. However, the journey costs and the available budgets were the main determiners but similar to any other long trips there were hidden costs when turning any corners and stopping at any stations.

At the finish line, there were happy and cheering spectators, but demanding explanation for any design steps and occurring costs, as well as reports of all the places and happenings along the journey. Also, the planning vehicle, dusted for crossing the finish line, now looks shinny with lots of stories about the journey. Here we are; the story of eNEO2050+ Plan.

eNEO2050+: Scenario 4 “TOTAL”

Overview

This section summarizes Scenario 4 “TOTAL” and the list of its projects and the planned implementation decades of those projects. Section 11.3 completes the outlines of the scenario by discussing scenario performance measures, project costs and the economic return indicator. The following sections of this chapter, although titled differently, fill in others details of the outlined picture of the eNEO2050 plan. Each section describes some important projects of each category. In previous chapters, four scenarios with common and specific projects were introduced and simulated using the NOACA Travel Forecasting Model. The selected effectiveness measures were analyzed for evaluating the performance of scenarios from various angles. Those measures of effectiveness were combined with project costs and annual budgetary constraints to identify an economic return indicator. The scenario 1: MAINTAIN did not have any specific enhancement or expansion projects, therefore its performance measure values were assumed as the benchmark values. This scenario is similar to “Do Nothing” or “No Build” case in other planning projects. The scenario economic return values were calculated by combining the total measures of effectiveness values with the total scenario specific project costs and Scenarios 3 and 4 returned an acceptable level of economic return indicator, with Scenario 4 having the highest value. Therefore, Scenario 4 was selected as the preferred scenario for the eNEO2050+ plan. Table 11-1 displays the projects of the eNEO2050+ Plan in the four categories of “Roadway”, “Transit”, “Non-motorized Facilities”, and “Emerging Technologies in Transportation” and their planned implementation decades indicated by a grey box. This table also includes the workforce accessibility and mobility objectives for each decade, which will be discussed in the later section.

Table 11-1. *eNEO2050+* Projects and their Planned Implementation Decades

Scenario Projects	Original Scenario	Time Periods		
		2025 - 2030	2030 - 2040	2040 - 2050
Objectives: Workforce Accessibility and Mobility				
Reducing the Average Auto Commute time to Major Job Hubs to 30 minutes	2 & 4			
Reducing Average Transit Commute Time to Major Job Hubs to 45 minutes	3 & 4			
Roadway				
Implementing 2024 TIP Highway and Transit Projects	All Scenarios			
Implementing Major Highway Capacity Projects	2 & 4			
Adding Harper Road, Jackson Street, Miller Road, and Granger Road Interchanges	2 & 4			
Reducing Highway Bottlenecks	2 & 4			
Reinvigorating Arterial Network	2 & 4			
Maintain Pavement Conditions with average of PCR = 75	All Scenarios			
Maintain Bridges in Good or Fair Conditions				
Addressing Location-specific Safety issues in order to Reduce Traffic Fatalities				

Table 11-1. *eNEO2050+* Projects and their Planned Implementation Decades (Continued)

Scenario Projects	Original Scenario	Time Periods		
		2025 - 2030	2030 - 2040	2040 - 2050
Transit				
Implementing Future Transit Agencies' Bus/BRT Routes	3 & 4			
Conduct feasibility studies and/or Environmental Impact Statement (EIS) for achieving the visionary rail scenario and the Great Lakes Hyperloop	3 & 4			
Maintain Transit Vehicles in Good State at the end of each Decade	2 & 4			
Non-Motorized Facility				
Creating Walk and Bike Access to the Transit Network	3 & 4			
Creating Walk and Bike Connections from Major Transit Hubs to Major Job Hubs	3 & 4			

Creating Walk and Bike Access from Major Residential Areas to Transit Network	3 & 4			
Implement Smart Pedestrian Crossings	All Scenarios			
Emerging Technologies in Transportation				
Installing EV Charging Ports	All Scenarios			
Adding POD and Shuttle CAV Services from Major Transit Hubs to Major Job Hubs	3 & 4			
Installing Extra EV Charging Ports	4			
Allocating Selected Smart Freeway and Arterial Lanes to Autonomous Vehicles	4			

Scenario Performance and Costs

In Chapter 9, a set of performance measure categories was introduced, and a comparative analysis was conducted based on a set of selected measures used for evaluating the performance of the four scenarios. Similarly, in this section, the performance of the eNEO2050+ scenario is evaluated based on those performance measures. Table 11-2 displays the eNEO2050+ performance measure values and compares them with those of the current base year of 2025, and also, as before, with those of Scenario 1 (“Do Nothing” case) shown in Chapter 9 as the benchmark values. In this Table, the performance measures highlighted in green should have higher values in order to be more effective. In contrast, the performance measures highlighted in brown should have lower values in order to be more effective.

Table 11-2. *eNEO2050+* Performance Measures

Performance Measure	Scenario 1	eNEO2050+ (Scenario 4: TOTAL)
Population within 15 Minutes Walk to any Transit Stop	61%	68%
Zero-Car Households within 15 Minutes Walk to any Transit Stop	71%	76%
Number of Jobs within 15 Minutes Walk egress from any Transit Stop	72%	81%
Population in 5-Mile Drive Access to Freeway System	91%	92%
Annual Transit Ridership (Including Transfer Trips) – Million Person Trips	22	38
Non-Single Occupancy Vehicle Work Commute during a Typical Morning Peak Period	21%	22%
Average Highway Network Pavement Condition Rating (PCR)	90.4	90.4
Daily Vehicular Trip Share of Autonomous, Electric Cars and Trucks	31%	56%
Total Annual Vehicle Miles Traveled per Capita	7,669	7,314
Total Annual Freeway Delay per Capita (in Hours)	2.58	2.66

Total Annual Principal Arterial Delay per Capita (in Hours)	5.41	6.57
Annual Person Hours of Excessive Delay (PHED) per Capita (in Hours)*	0.65	0.78
Average Auto Work Commute Time to All Major Job Hubs (in Minutes)	29	29
Average Transit Work Commute Time for Zero Car Households to All Major Job Hubs (in Minutes)	38	43
Average Work Commute Time for Households with Zero Cars (in Minutes)	41	39

*Calculated for the NOACA urbanized area per the FHWA performance measure guidelines for PHED.

Table 11-2. *eNEO2050+* Performance Measures (Continued)

Performance Measure	Scenario 1	eNEO2050+ (Scenario 4: TOTAL)
Maximum Level of Travel Time Reliability (LOTTR) on Highways and Ramps	1.11	1.11
Maximum Level of Travel Time Reliability (LOTTR) on Arterials	1.10	1.11
Annual Congestion Cost per Capita (2050$)	588	639
All Estimated Fatalities and Serious Injuries for Motorized and Non-Motorized Modes (Vision-Zero)	0	0
Daily Volatile Organic Compounds (VOCs) (in Tons)	5.69	5.79
Daily Nitrogen Oxides (NO_x) (in Tons)	3.77	3.83
Annual Direct PM (in Tons)	129.19	131.44
Structurally Deficient Deck Areas of NHS Bridges	1.84%	1.84%
Structurally Deficient Deck Areas of All Bridges	5.29%	5.29%

The Measure of Effectiveness (MOE) for Scenario 4 TOTAL was estimated based on the weighting of the measures used in the scenario comparative analysis of Chapter 9. Table 11-3 shows the estimated total MOE of the eNEO2050+ scenario 4.

Table 11-3. Estimated Total Measures of Effectiveness of eNEO2050+ Scenario 4

Scenario	Ratio of Estimated SMOE
1: MAINTAIN	1
4: TOTAL	5.8

Table 11-4 displays the NPV (2025$) of estimated total project costs of the eNEO2050+ scenario 4 by project category.

Table 11-4. NPV (2025$) of Estimated Total Project Costs by Project Category *eNEO2050+* Scenario 4

Project Category	Net Present Value of Project Costs (2025$) Millions	Percent of the Total NPV (2025$)
Roadway	$4,492	82%
Transit	$805	15%
Non-Motorized Facility	$138	3%
Total	**$5,435**	**100%**

Tables 11-5 and 11-6 show the percent of NPV of the eNEO2050+ scenario 4 specific projects costs and the comparison ratio values.

Table 11-5. Percent of the Additional eNEO2050+ Scenario 4 Costs and Comparison Ratios

Scenario	Percent of NPV of Costs for Scenario Specific Projects	Ratio of Scenario Specific Project NPV Costs to Scenario 1 Specific Cost Percent
1: MAINTAIN	6.5%	1.0
4: TOTAL	24.0%	3.7

Table 11-6. Ratio of SMOE and Additional Quotients of eNEO2050+ Scenario 4

Scenario	SMOE Value Relative to Scenario 1 SMOE	Specific Project Cost Quotient Values	Ratio of SMOE Values and Corresponding Costs
1: MAINTAIN	1.0	1.0	1.00
4: TOTAL	5.8	3.7	1.57

Chapter 9 discussed the ratio of SMOE and the corresponding value as an economic return indicator. According to Table 11-6, the eNEO2050+ scenario 4 economic return is 1.57, and since that is greater than one, therefore this scenario has an acceptable level of economic return.

Roadway

Interchange Evaluation

Proposals for highway projects include a set of major high-capacity interstate projects, which will be added to the current highway network during the next three decades. Notably, eight interchanges, including four modifications to existing interchanges and four new interchanges, are assessed for inclusion in the plan. This evaluation utilized the “New or Modify Interchange” policy adopted by the NOACA Board in December 2020. The evaluated interchanges are:

- **Modifications to existing interchanges:**
  - Interstate 77 at Miller Road, Brecksville, Cuyahoga County
  - Interstate 480 at Granger Road, Garfield Heights, Cuyahoga County
  - US highway 422 at Harper Road, Solon, Cuyahoga County
  - State Route 44 at Jackson Road, Painesville, Lake County
- **New Interchanges:**
  - Interstate 71 at Boston Road, Strongsville, Cuyahoga County
  - Interstate 71 at State Route 57(or 162), Medina, Medina County
  - Interstate 271 at White Road, Highland Heights, Mayfield, Willoughby Hills, Cuyahoga, Lake Counties
  - State Route 10 at State Route 57, Elyria, Lorain County

Applying the approved board policy, the transportation planning criteria include “Interchange Spacing” and a “Cost-Benefit Analysis”. The “Cost-Benefit Analysis” is applied to three levels of geography: Influence subarea, NOACA region and if appropriate, the neighboring counties.

The “interchange spacing” criterion does not apply to the modified interchanges since they already exist. The proposed new interchanges along Interstate 71 at Boston Road and State Route 57 satisfy the interchange spacing criterion, but the proposed interchange at White Road does not. Also, adequate design information about the new interchange of State Route 10 was not available at the time of developing the *eNEO2050* plan to evaluate it.

Figure 11-1 displays the influence subareas of the proposed interchanges, which are identified based on the VMT difference density of the “Build” and “No Build” cases.

Figure 11-1. Influence Subarea of the Proposed Interchanges

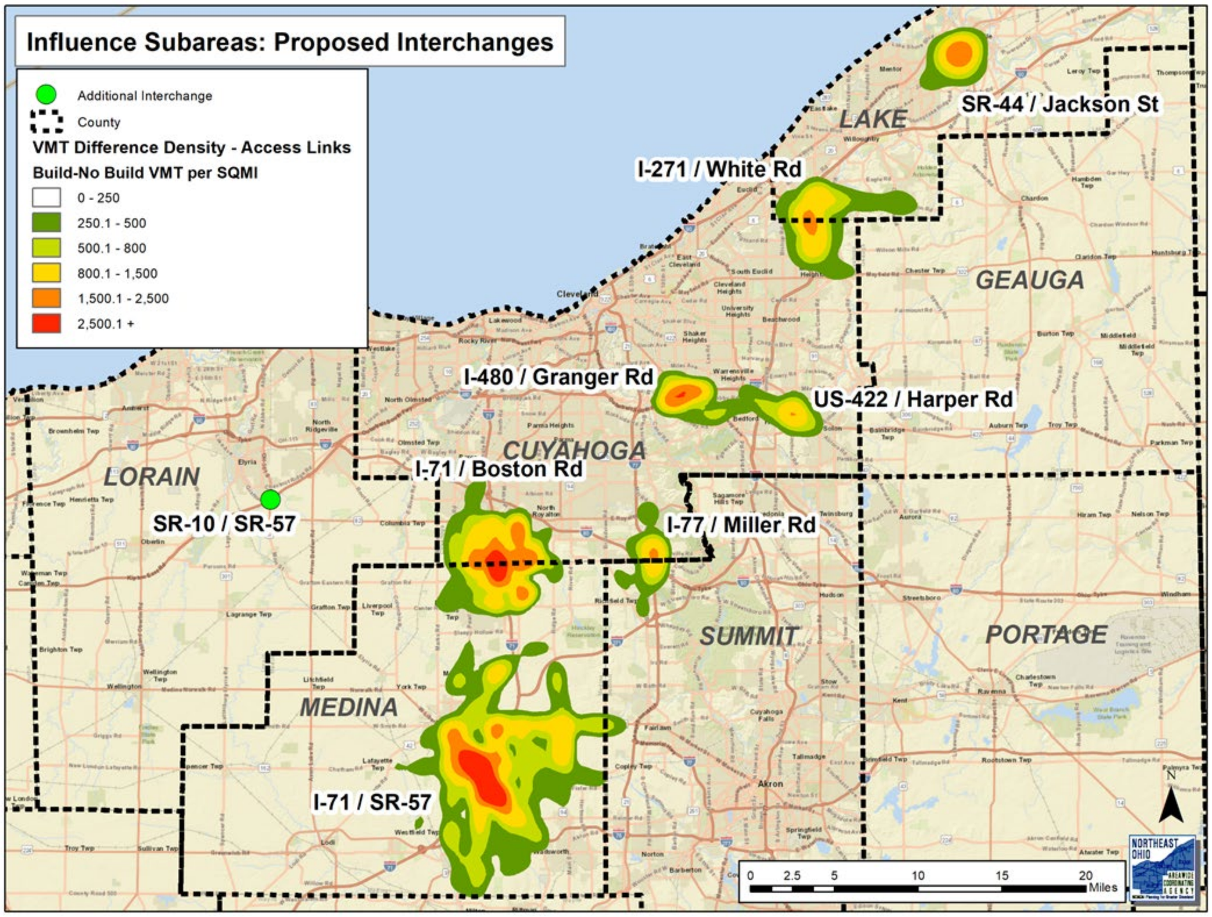


Figure 11-2 shows the cost items and procedure of the “Cost-Benefit” analysis.

Figure 11-2. Cost-Benefit Analysis Procedure

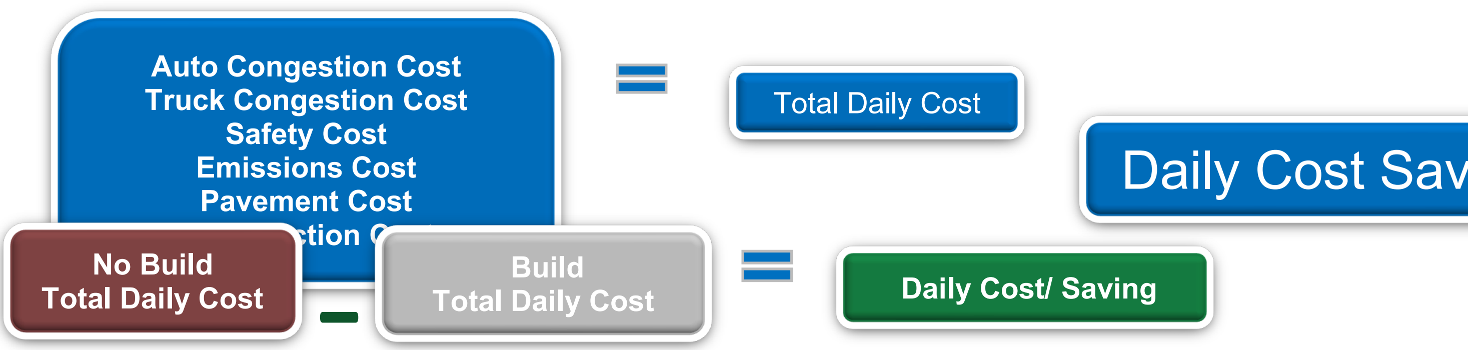


Table 11-7 shows the “Cost-Benefit Analysis” results for the influence subarea proposed interchanges.

Table 11-7. Cost-Benefit Analysis Results for the Influence Subareas

Interchange	Daily Cost / Saving (2050$)	Margin of Error (2050$)		Investment Return Threshold (2050$)
Granger Road	+$9,890	-$25,870	+$25,870	$0 (Break/Even)
Miller Road	-$6,766	-$18,277	+$18,277	$0 (Break/Even)
Jackson Street	+$9,913	-$10,956	+$10,956	$0 (Break/Even)
Harper Road	+$14,696	-$27,251	+$27,251	$0 (Break/Even)
Boston Road	-$776	-$38,818	+$38,818	$77,636
White Road	-$5,396	-$18,524	+$18,524	$37,048
SR 57 (or 162)	-$3,144	-$60,449	+$60,449	$120,897

As shown in Table 11-7, the "Cost-Benefit" analysis produces several values for each interchange. The positive values in the second column indicate that the total benefit for each interchanger is higher than its total cost. The third and fourth columns provide a range for the margin of errors. The margin of error is assumed to be 5% of the total cost of the "No Build" case. The last column shows the minimum values for the investment returns, and it is assumed that the break-even value for the modified interchanges and 10% of the total cost of the "No Build" case for the new interchanges.

Therefore, using the "Cost-Benefit" analysis, the completion of the existing interchanges at Granger Road, Miller Road, Jackson Street, and Harper Road satisfied the transportation planning criteria and then were considered for the regional impact analysis. The proposed new interchanges did not satisfy the transportation planning criteria at the influence subarea level; therefore, they were not further considered for the regional impact analysis. However, if conditions change, and as new data becomes available, the interchanges will be evaluated for amendment to *eNEO2050+*.

Table 11-8. Cost-Benefit Analysis Results for the NOACA Region

Interchange	Daily Cost / Saving (2050$)	Margin of Error (2050$)		Investment Return Threshold (2050$)
Granger Road	+$4,122	-$1,039,849	+$1,039,849	$0 (Break/Even)
Miller Road	-$44,738	**-$1,040,053**	**+$1,040,053**	$0 (Break/Even)

Jackson Street	-$138,223	**-$1,039,882**	**+$1,039,882**	$0 (Break/Even)
Harper Road	-$7,127	**-$1,039,849**	**+$1,039,849**	$0 (Break/Even)

As Table 11-8 indicates, an evaluation was conducted at the NOACA regional level for those interchanges as well, which included another "Cost-Benefit" analysis, as well as other regional impact criteria such as equity, environmental, and economic. Although the daily cost is higher than the benefits, the difference is within the margin of error, thus meeting the threshold. The Interchange of Miller Road at I-77 is located close to the border of the NOACA region, and its influence subarea is extended to the neighboring county. Therefore, it warrants conducting the "Cost-Benefit" analysis for the seven-county region, which also meets the threshold and satisfies the criteria.

Table 11-9. Cost-Benefit Analysis Results for the Seven-County Region

Interchange	Daily Cost / Saving (2050$)	Margin of Error (2050$)		Investment Return Threshold (2050$)
Miller Road	-$44,738	**-$1,040,053**	**+$1,040,053**	$0 (Break/Even)

As indicated in Table 11-9, although the daily cost is higher than the benefits, the difference is within the margin of error; therefore, the Miller Road interchange modification fully satisfies the "Cost-Benefit" Criteria.

Evaluation of Congestion Management

Congestion management is the application of strategies to improve transportation system performance and reliability by reducing the adverse impacts of congestion on the movement of people and goods. A CMP, as defined in federal regulation, is an objective-driven and performance-based process that intends to integrate effective management and safe operation of the existing multimodal transportation facilities.

The CMP is intended to be an ongoing process and fully integrated into the LRTP of the eNEO2050$^+$ plan. The CMP is continually evolving to improve transportation system performance measures, address concerns of communities and ultimately achieving NOACA objectives and goals.

The purpose of the NOACA congestion management plans is to:

- Identify the spatial and temporal characteristics of traffic congestion in the region,
- Measure the congestion severity, duration, extent, and variability, and
- Develop congestion mitigation strategies for enhancing the mobility of people and goods in the NOACA region.

In consonance with the FHWA's purposes, three of the eNEO2050$^+$ regional strategic plan goals have been adopted as the main focus of the NOACA congestion management plans, and they are;

- System preservation,

- Provision of a safe and efficient multimodal transportation system for all travelers, and
- Advance the region's economic conditions and improve quality of life based on sustainable development.

The current planning demi-decade and future planning decades for the NOACA congestion management are 2025 -2030, 2031-2040, and 2041-2050 and each plan will be evaluated during the third and sixth years of its implementation.

Congestion management objectives define what the NOACA region intends to achieve regarding the traffic congestion management process every decade cycle. A set of Specific, Measurable, Agreed, Realistic, and Time-bound (SMART) objectives were established for each planning decade. These regional and local objectives of each planning decade are also the continuation of the prior planning decade's objectives, and the continuity will eventually fulfill the NOACA regional strategic goals. It should be noted that the congestion management objectives are a subset of the NOACA long-range objectives and goals, and thus focus on providing a multimodal transportation system and strategies to alleviate traffic congestion.

During the third and sixth years of each decade cycle, a monitoring procedure will be invoked to evaluate the progress and effectiveness of the implementation of the congestion management plans, and adjust or update their objectives, if necessary.

Figure 11-2 depicts the relation between the congestion management objectives and eNEO2050 goals and objectives.

Figure 11-2: Congestion Management Plan Objectives and eNEO2050+ Goals and Objectives Relation

The congestion management plan objectives have been developed based on the following guidelines:

- Reduce average delay per traveler during peak periods,
- Increase the percentage of Non-Single occupancy vehicles,
- Regulate the flow of traffic entering freeways,

- Increase the efficiency of interchanges,
- Increase capacity of non-freeway corridors,
- Increase transit accessibility, and
- Increase transit and non-motorized mode shares.

Table 11-5 displays the congestion management objectives for the planning timeframes of 2025-2030, 2031-2040, and 2041-2050.

Table 11-5: Congestion Management Objectives

Objective/Planning Decade	2025 Base	2025 - 2030	2031 - 2040	2041 - 2050
Reduce Percentage of Total Vehicle Delay During a Typical AM and PM Peak Periods	9%	Decrease by 1%	Decrease by 2%	Decrease by 2%
Annual Hours of Peak Hour Excessive Delay (PHED)*	2.4 Million	Reduce to 2.2 Million	Reduce to 1.7 Million	Reduce to 1.3 Million
Annual Hours of Peak Hour Excessive Delay (PHED) Per Capita*	1.3	Reduce to 1.2	Reduce to 1.0	Reduce to 0.8
Increase the Percentage of Non-Single Occupancy Vehicle Work Commutes during the AM Peak Period	21%	Increase by 1%	Increase by 1%	Increase by 2%
Reduce Average Auto Work Commute Time to Regional Major Job Hubs During the AM Peak Period	28	Reduce to 28 Minutes	Reduce to 27 Minutes	Reduce to 26 Minutes
Reduce Average Walk Access Transit Work Commute Time to Regional Major Job Hubs During the AM Peak Period	37	Reduce to 36 Minutes	Reduce to 35 Minutes	Reduce to 34 Minutes
Reduce Average Walk Access Transit Work Commute Time for Zero-Car Households to Regional Major Job Hubs During the AM Peak Period	41	Reduce to 40 Minutes	Reduce to 39 Minutes	Reduce to 38 Minutes

*Calculated for the NOACA urbanized area per the FHWA performance measure guidelines for PHED.

Table 11-5: Congestion Management Objectives Cont.

Objective/Planning Decade	2025 Base	2025 - 2030	2031 - 2040	2041 - 2050
Reduce Average Transit Work Commute Time for Zero-Car Households to All Jobs During the AM Peak Period	42	Reduce to 41 Minutes	Reduce to 40 Minutes	Reduce to 39 Minutes
Reduce Average Drive Access Transit Work Commute Time to Regional Major Job Hubs During the AM Peak Period	42	Reduce to 41 Minutes	Reduce to 40 Minutes	Reduce to 39 Minutes
Implement Signal Timing Optimization Program (STOP)	12 Corridors	5 Additional Corridors	10 Additional Corridors in each Decade	
Implement Diverging Diamond Interchange (DDI)	1	2 more Locations		
Increase the Percentage of Population within 5-Mile Drive Access to a Park & Ride Station	65%	Increase to 66%	Increase to 68%	Increase to 70%
Increase the Percentage of Population within 15-Minute Walk Access to a Transit Stop	66%	Increase to 67%	Increase to 69%	Increase to 70%
Increase the Mode Share of AM Peak Period Work Commutes via Transit and Non-Motorized Modes	4.7%	Increase to 5.5%	Increase to 7.5%	Increase to 9.5%

As discussed, the congestion management plans lay out the objectives for each decade cycle, and to achieve those targets, a congestion management process has been adopted, which includes the following steps:

1. Define the current and future transportation system networks.
2. Develop multimodal performance measures.
3. Collect data and evaluate system performance.
4. Analyze traffic congestion problems.
5. Identify and assess congestion mitigation strategies.
6. Prioritize and program the selected congestion mitigation strategies; and
7. Monitor the effectiveness of congestion management and evaluate the progress.

Figure 11-3 illustrates the cyclical nature of the congestion management process.

Figure 11-3: Congestion Management Process

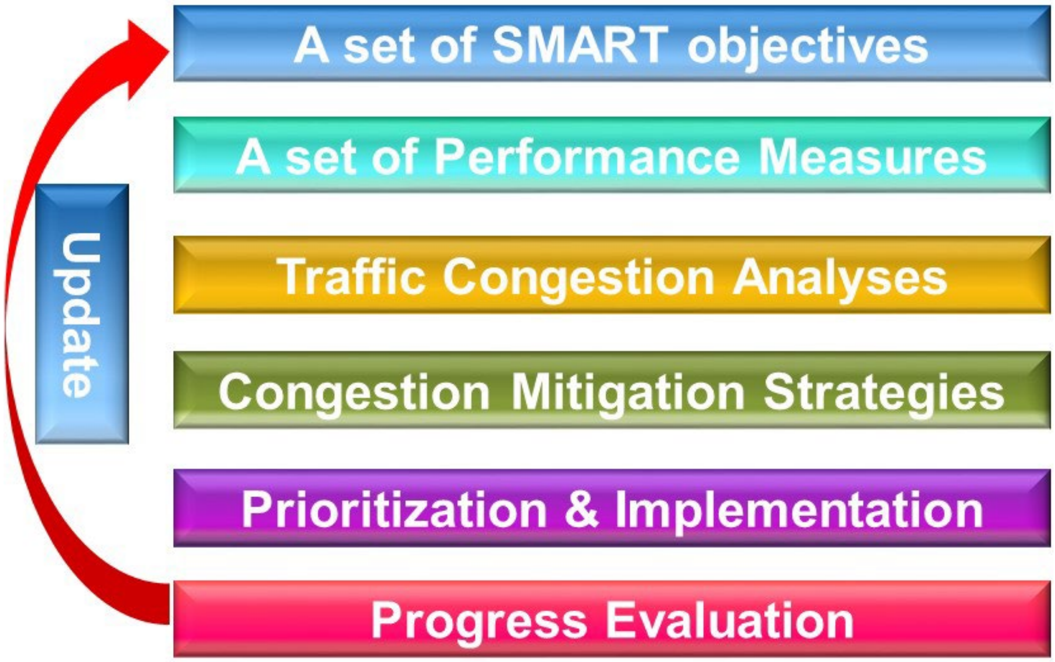


Figure 3-19. Existing Freeway Bottleneck Locations during the AM Peak Period

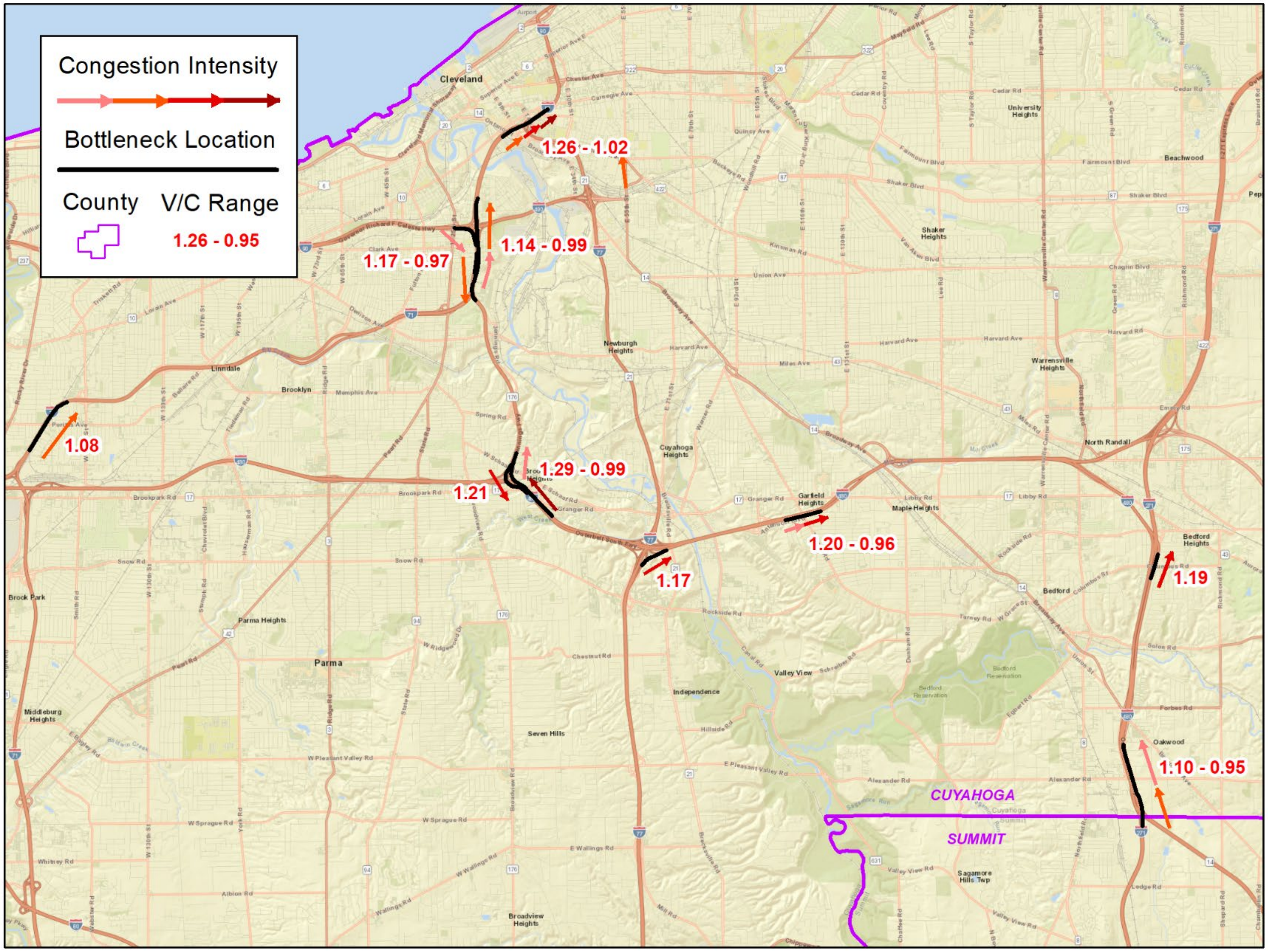
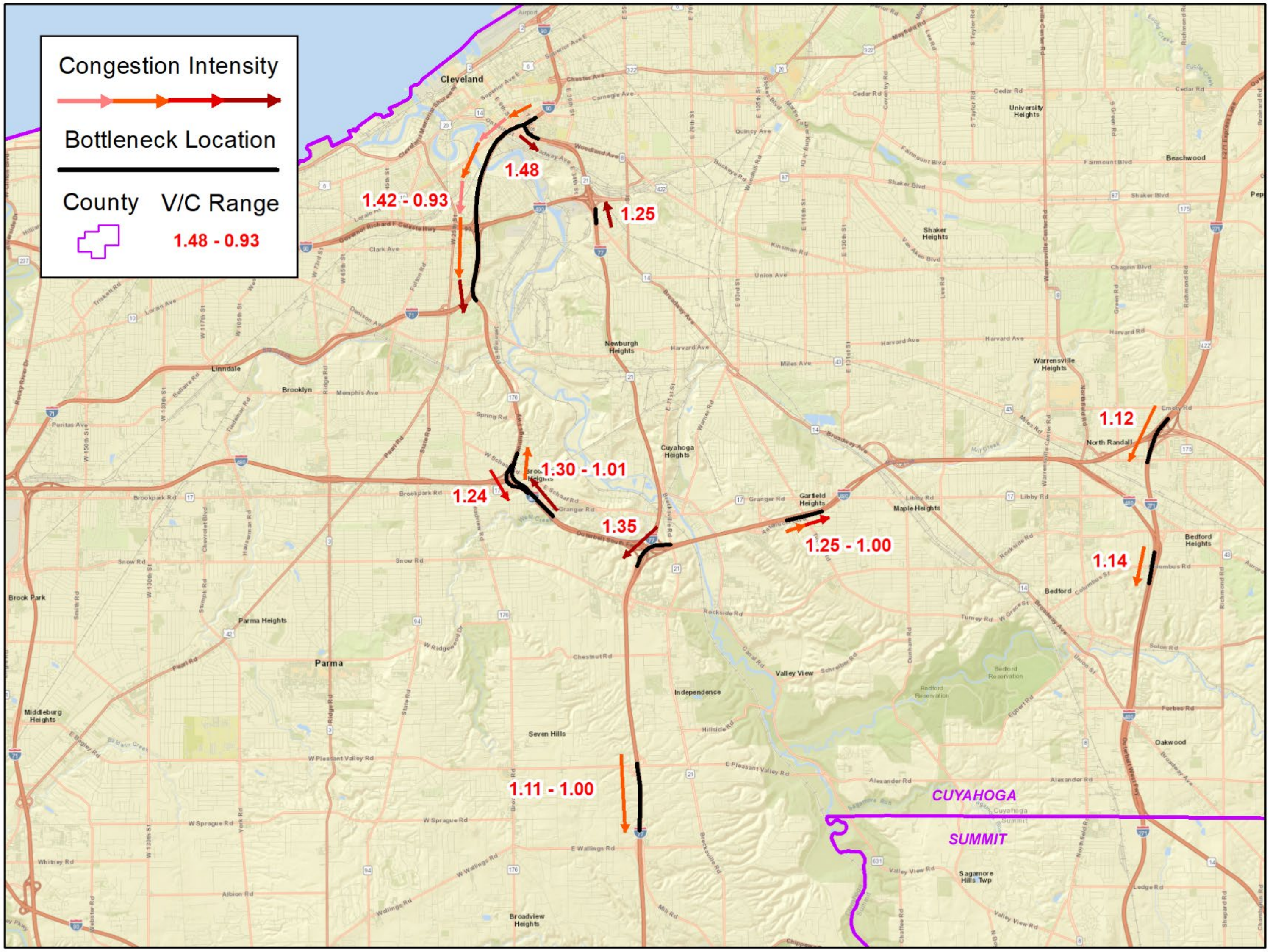


Figure 3-20. Existing Freeway Bottleneck Locations during the PM Peak Period



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-480 Ramp to SR-176	WB / NB	E. Granger Rd. Exit Ramp	SR-176 NB	0.99 - 1.29	1.18 - 2.57	18 - 39
2	I-90	EB	Carnegie Ave. Exit Ramp	Ontario St. Exit Ramp	1.02 - 1.26	1.23 - 2.25	22 - 41
3	SR-176 Ramp to I-480	SB / EB	I-480 WB Ramp	Tuxedo Ave. Bridge	1.21	1.93	24
4	I-480	EB	Transportation Blvd Entrance Ramp	Granger Rd. Exit Ramp	0.96 - 1.20	1.43 - 4.00	16 - 45
5	I-480	WB	I-271 Split	Rockside Rd. Exit Ramp	1.19	1.8	26
6	I-77 Ramp to I-480	NB / EB	Ramp from I-77 NB to I-480 WB	Ramp from I-77 SB to I-480 EB	1.17	1.69	28
7	I-90 Ramp / I-71 / SR-176 Ramp	EB / SB	Ramp from I-90 EB to I-71 SB	Ramp to SR-176 SB	0.97 - 1.17	1.16 - 1.68	23 - 36
8	I-71	NB	Ramp to W. 14th St.	I-90 Merge	0.99 - 1.14	1.37 - 1.89	23 - 45
9	I-271 / I-480	NB / WB	I-271 / I-480 Merge	Fairoaks Rd. / Broadway Ave. Exit Ramp	0.95 - 1.10	1.27 - 1.92	32 - 49
10	I-71	NB	Ramp from I-480 EB / SR-237 NB	W. 150th St. Exit Ramp	1.08	2.23	28

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-90 Ramp to I-77	WB / SB	E. 14th St. Entrance Ramp	Bridge over E. 22nd St.	1.48	5.71	6
2	I-90 / I-71	WB / SB	I-77	SR-176	0.93 - 1.42	1.11 - 4.21	11 - 47
3	I-480 Ramp to I-77	WB / SB	Ramp from I-480 WB to I-77 NB	Ramp from I-480 EB to I-77 SB	1.35	3.23	18
4	I-480 Ramp to SR-176	WB / NB	E. Granger Rd. Exit Ramp	SR-176 NB	1.01 - 1.30	1.21 - 2.68	17 - 38
5	I-77 Ramp to I-490	NB	Broadway Ave Bridge	I-490 EB and WB Ramps	1.25	2.23	16
6	I-480	EB	Transportation Blvd Entrance Ramp	Granger Rd. Exit Ramp	1.00 - 1.25	1.60 - 5.47	12 - 41
7	SR-176 Ramp to I-480	SB / EB	I-480 WB Ramp	Tuxedo Ave. Bridge	1.24	2.12	22
8	I-480	EB	Rockside Rd. Entrance Ramp	I-271 Merge	1.14	1.56	30
9	I-271	SB	I-271 Express Lane Merge	Ramp from I-480 WB	1.12	2.06	29
10	I-77	SB	Pleasant Valley Rd. Exit Ramp	Wallings Rd. Exit Ramp	1.00 - 1.11	1.39 - 2.00	31 - 45

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 downtown Cleveland, three PM peak period bottleneck locations were identified along Euclid Ave and E 14th St. Since these locations are located along the same corridors, 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 with 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 per

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

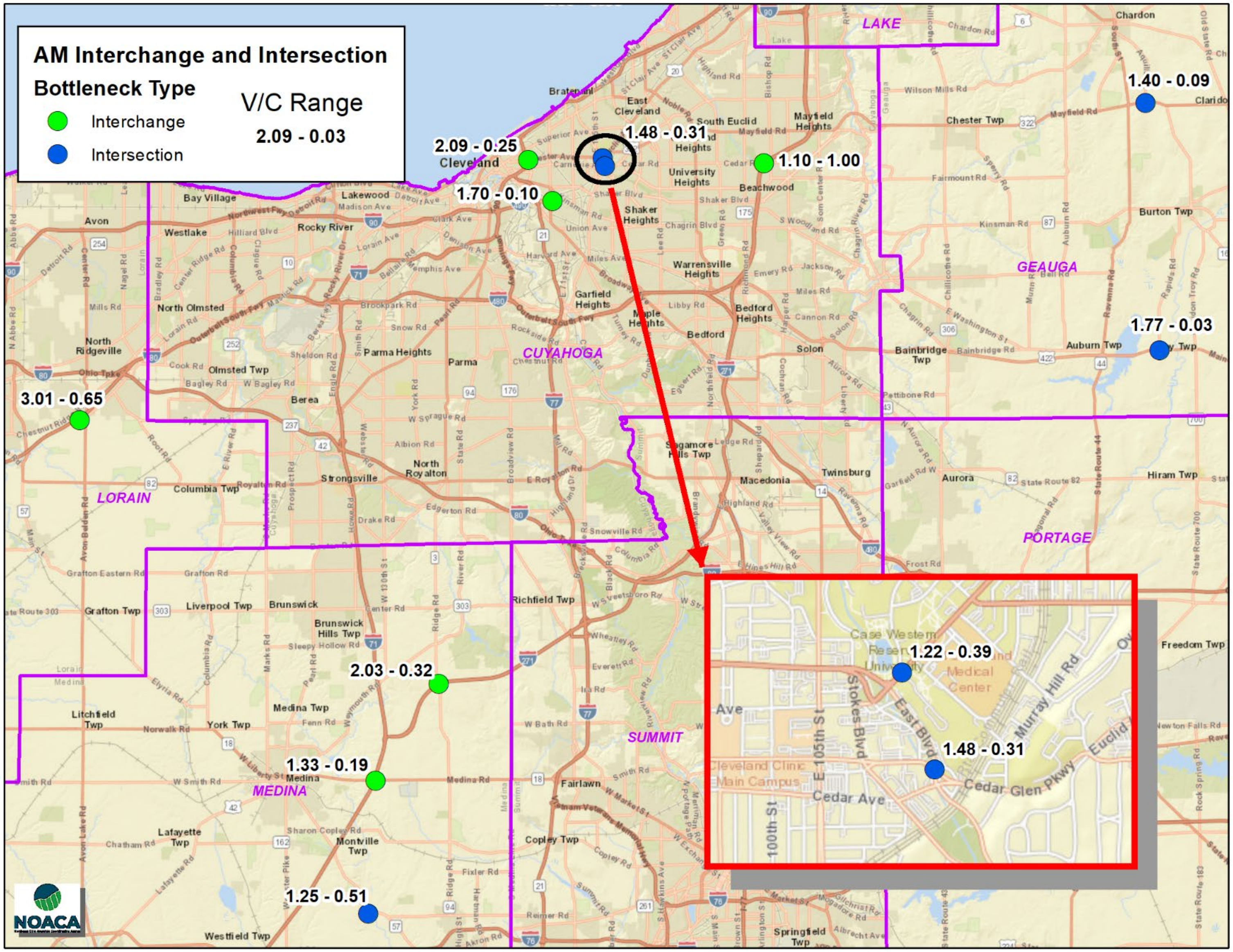
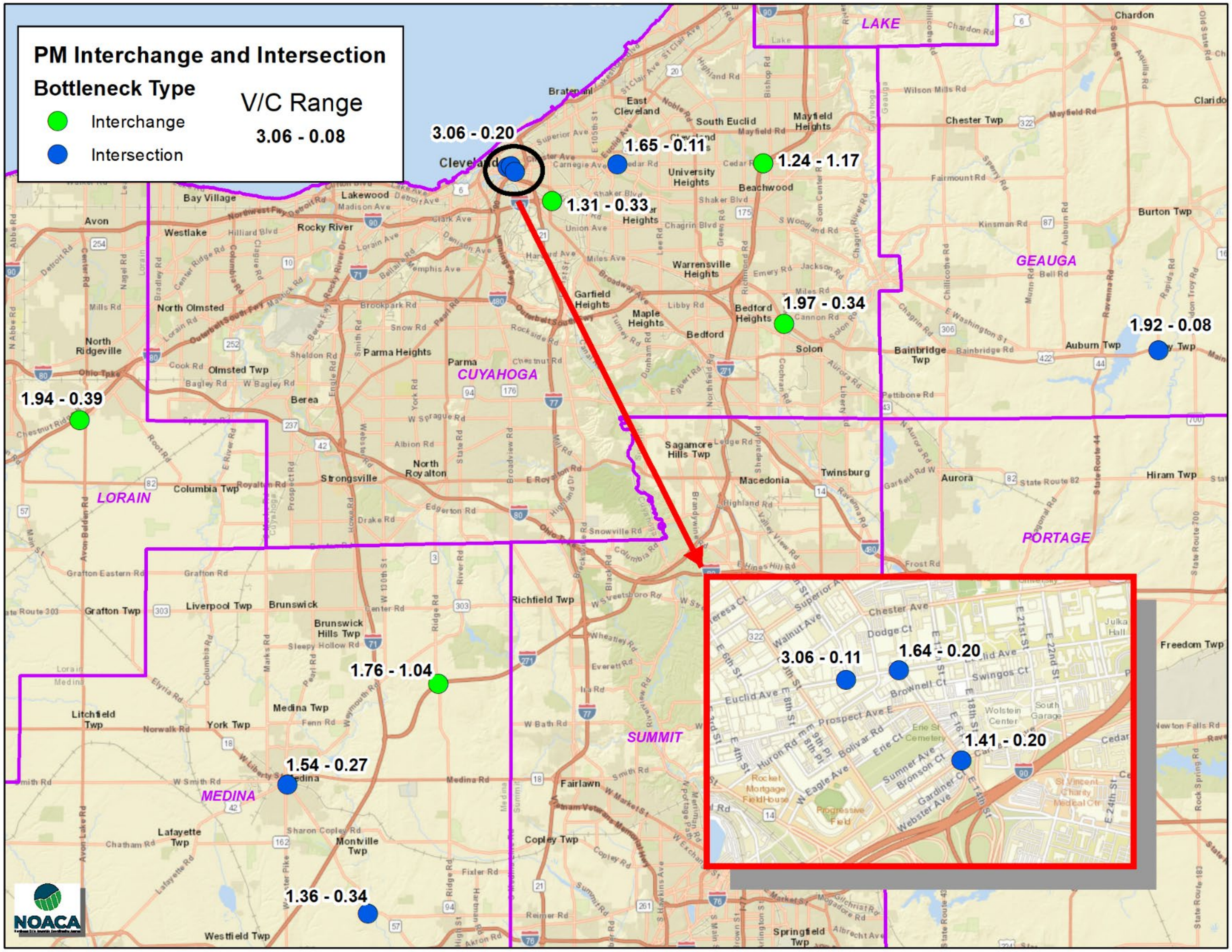


Figure 3-22. Existing Interchange/ Intersection Bottleneck Locations during the PM Peak Period



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	AM Peak Period (6AM - 9AM)		
				Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity (V/C) Ratio Range	Number of Approaches over 0.85 V/C Ratio
1	SR-10 NB Ramps / Butternut Ridge Rd / Chestnut Ridge Rd	Lorain	Interchange	1.78	3.01 - 0.65	2
2	I-90 EB Exit / Chester Ave (US-322)	Cuyahoga	Interchange	1.67	2.09 - 0.25	1
3	I-271 SB Ramps / Ridge Rd (SR-94)	Medina	Interchange	1.47	2.03 - 0.32	1
4	I-490 / Opportunity Corridor (SR-10) / E.55th St	Cuyahoga	Interchange	1.46	1.70 - 0.10	2
5	Main Market Rd (US-422) / Rapids Rd	Geauga	Intersection	1.44	1.77 - 0.03	2
6	I-71 NB Ramps / Medina Rd (SR-18)	Medina	Interchange	1.12	1.33 - 0.19	2
7	University Circle Area	Cuyahoga	Intersection	1.08 - 1.07	1.48 - 0.31	4
-	*MLK Jr Dr / Carnegie Ave*	*Cuyahoga*	*Intersection*	*1.08*	*1.48 - 0.31*	*2*
-	*Euclid Ave (US-20) / East Blvd*	*Cuyahoga*	*Intersection*	*1.07*	*1.22 - 0.39*	*2*

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

No.	Location	County	Type	AM Peak Period (6AM - 9AM)		
				Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity (V/C) Ratio Range	Number of Approaches over 0.85 V/C Ratio
8	Mayfield Rd (US-322) / Aquilla Rd	Geauga	Intersection	1.06	1.40 - 0.09	1
9	I-271 SB Ramp / Cedar Rd	Cuyahoga	Interchange	1.05	1.10 - 1.00	2
10	Wadsworth Rd (SR-57) / Styx Hill Rd / River Styx Rd	Medina	Intersection	1.03	1.25 - 0.51	3

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

No.	Location	County	Type	PM Peak Period (3PM - 7PM)		
				Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity (V/C) Ratio Range	Number of Approaches over 0.85 V/C Ratio
1	**Downtown Cleveland Area**	**Cuyahoga**	**Intersection**	**1.86 - 1.15**	**3.06 - 0.20**	**5**
-	*Euclid Ave (US-20) / E 12th St*	*Cuyahoga*	*Intersection*	*1.86*	*3.06 - 0.11*	*1*
-	*Euclid Ave (US-20) / E 14th St*	*Cuyahoga*	*Intersection*	*1.28*	*1.64 - 0.20*	*1*
-	*Carnegie Ave / E 14th St*	*Cuyahoga*	*Intersection*	*1.15*	*1.41 - 0.20*	*3*
2	**Main Market Rd (US-422) / Rapids Rd**	**Geauga**	**Intersection**	**1.58**	**1.92 - 0.08**	**2**
3	**I-271 SB Ramps / Ridge Rd (SR-94)**	**Medina**	**Interchange**	**1.37**	**1.76 - 1.04**	**3**
4	**Cedar Glen Pkwy / Cedar Rd / Euclid Heights Blvd**	**Cuyahoga**	**Intersection**	**1.28**	**1.65 - 0.11**	**1**
5	**I-271 SB Ramp / Cedar Rd**	**Cuyahoga**	**Interchange**	**1.20**	**1.24 - 1.17**	**2**
6	**US-422 / Harper Rd**	**Cuyahoga**	**Interchange**	**1.20**	**1.97 - 0.34**	**1**

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

No.	Location	County	Type	PM Peak Period (3PM - 7PM)		
				Volume Weighted Average of V/C for Intersection Approaches	Volume over Capacity (V/C) Ratio Range	Number of Approaches over 0.85 V/C Ratio
7	SR-10 NB Ramps / Butternut Ridge Rd / Chestnut Ridge Rd	Lorain	Interchange	1.19	1.94 - 0.39	2
8	Wadsworth Rd (SR-57) / S Broadway St / Lafayette Rd	Medina	Intersection	1.16	1.54 - 0.27	2
9	I-490 / Opportunity Corridor (SR-10) / E.55th St	Cuyahoga	Interchange	1.15	1.31 - 0.33	2
10	Wadsworth Rd (SR-57) / Styx Hill Rd / River Styx Rd	Medina	Intersection	1.14	1.36 - 0.34	3

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

Freeway Bottlenecks

I-90 / I-77 Interchange Area

Many trips heading to downtown Cleveland, as well as through-traffic from west to east and vice-versa, travel along I-90 through the central interchange area where I-77 and I-90 meet. These two major interstates meeting near a downtown area creates many congested segments in the immediate area, with one of the top congested segments in the AM peak period being I-90 EB from Carnegie Ave to Ontario St. This segment's AM peak period V/C ratio ranges from 1.02 to 1.26, a TTI range from 1.23 to 2.25, and an actual speed range of 22 to 41 mph. In the PM peak period, traffic wanting to exit to I-77 from I-90 WB creates a bottleneck situation at this southbound ramp. This segment's PM peak period V/C ratio is 1.48, its TTI is 5.71, and the actual speed is 6 mph.

I-90 / I-71 / SR-176 Interchange Area

The I-90 / I-71 / SR-176 interchange area is a highly traveled corridor leading to and from downtown Cleveland. In particular, I-71 and SR-176 heading northbound feed into I-90 heading towards downtown Cleveland, creating a bottleneck situation in the AM peak period. Conversely, in the PM peak period, traffic heading towards these two freeways creates a lot of congestion upstream before splitting into their separate directions. In the AM peak period, the I-71 NB segment between W 14th St and I-90 EB has a V/C ratio range of 0.99 to 1.14, a TTI range of 1.37 to 1.89, and an actual speed range of 23 to 45 mph. Also in the AM peak period, the opposite direction along I-71 SB from I-90 EB to SR-176 SB has a V/C range of 0.97 to 1.17, a TTI range from 1.16 to 1.68, and an actual speed range of 23 to 36 mph. In the PM peak period, this southbound section of I-71 is also congested and actually begins upstream along I-90 WB starting at the I-77 interchange. This segment has a V/C ratio range of 0.93 to 1.42, a TTI range of 1.11 to 4.21, and an actual speed range of 11 to 47 mph.

I-480 / SR-176 Interchange Area

The ramps between I-480 and SR-176 are used by many commuters during both the AM and PM peak periods to travel to downtown Cleveland, as well as the job hubs along I-480, such as the Hopkins Airport area and Independence. More specifically, the ramps from I-480 WB to SR-176 NB and SR-176 SB to I-480 EB are the most congested during both peak periods. In the AM peak period, the I-480 WB Ramp to SR-176 NB has a V/C ratio that ranges from 0.99 to 1.29, a TTI range from 1.18 to 2.57, and an actual speed range from 18 to 39 mph. In the PM peak period, this same segment is also congested with a V/C ratio range of 1.01 to 1.30, a TTI range of 1.21 to 2.68, and an actual speed range of 17 to 38 mph. The ramp in the opposite direction, from SR-176 SB to I-480 EB, is congested in both the AM and PM peak periods. In the AM peak period, the V/C ratio is 1.21, the TTI is 1.93, and the actual speed is 24 mph. In the PM peak period, the V/C ratio is 1.24, the TTI is 2.12, and the actual speed is 22 mph.

I-71 / I-480 Interchange Area

Many trips destined for downtown Cleveland travel along I-71, and many of these trips also transfer from I-480 or SR-237, creating a lot of congestion where these three highways meet. In particular, the segment along I-71 NB just north of I-480 to W 150th St is quite congested due to this being the segment where all traffic from I-71, I-480, and SR-237 converge on a northbound path to downtown Cleveland. In the AM peak period, this segment has a V/C ratio of 1.08, a TTI of 2.23, and an actual speed of 28 mph.

I-77 between I-480 and I-80

I-77 between I-480 and I-80 is a busy portion of the interstate system with many trips traveling NB to job hubs such as Independence and downtown Cleveland or heading SB to the I-80 turnpike and points outside the NOACA region. In particular, the SB segment of I-77 between Pleasant Valley Rd and Wallings Rd is quite congested in the PM peak period. It has a V/C ratio range of 1.00 to 1.11, a TTI range of 1.39 to 2.00, and an actual speed range of 31 to 45 mph.

I-480 between I-77 and I-271

I-480 between I-77 and I-271 is a highly traveled east-west highway corridor connecting eastern and western suburbs to nearby job hubs, such as Independence, Chagrin Highlands, and Solon. In the AM peak period, the ramp from I-77 NB to I-480 EB is congested with a V/C ratio of 1.17, a TTI of 1.69, and an actual speed of 28 mph. Not far to the east, there is another highly congested segment in the AM peak period along I-480 EB, specifically between Transportation Blvd and Granger Rd. This segment has a VC ratio range of 0.96 to 1.20, a TTI range of 1.43 to 4.00, and an actual speed range of 16 to 45 mph. This same segment is also congested in the PM peak period with a V/C ratio range of 1.00 to 1.25, a TTI range of 1.60 to 5.47, and an actual speed range of 12 to 41 mph. Traveling back westward to the I-480 / I-77 interchange, the ramp from I-480 WB to I-77 SB is congested, with a V/C ratio of 1.35, a TTI of 3.23, and an actual speed range of 18 mph.

I-480 / I-271 Corridor Area

I-480 and I-271 merge in southeastern Cuyahoga County to form one combined highway corridor for about a 4-mile stretch. Due to the convergence of these two major and highly-traveled highways, this area has many congested segments in both the AM and PM peak periods. In the AM peak period, the NB/WB segment between the I-480/I-271 merge and Broadway Ave has a V/C range ratio of 0.95 to 1.10, a TTI range of 1.27 to 1.92, and an actual speed range of 32 to 49 mph. A few miles to the north, I-480 WB between the I-271 split and Rockside Rd is also congested. This segment has a V/C ratio of 1.19, a TTI of 1.8, and an actual speed of 26 mph. In the PM peak periods, the SB/EB sections of this corridor become more congested. In particular, I-271 SB between the express lanes and the ramp from I-480 WB has a V/C ratio of 1.12, a TTI of 2.06, and an actual speed of 29. A short distance to the south, the I-480 EB segment between Rockside Rd and the I-271 merge is congested, with a V/C ratio of 1.14, a TTI of 1.56, and an actual speed of 30 mph.

I-77 / I-490 Area

The I-77 / I-490 interchange area is just south of the I-90 / I-77 interchange area near downtown Cleveland. As a result, this area has many trips heading to and from the downtown interchanges to the north. There are other trips that are seeking destinations to the east and west, such as points along the Opportunity Corridor to the east or I-490 to the west. In the PM peak period, the ramp from I-77 NB to the I-490 EB and WB ramps is quite congested. This segment has a VC ratio of 1.25, a TTI of 2.23, and an actual speed of 16 mph.

Interchange/Intersection Bottlenecks

Downtown Cleveland Area

Downtown Cleveland is the largest job hub in the NOACA region. With many workers traveling to and from the area in the AM and PM, as well as a growing residential population, traffic congestion at peak travel times is common. One such area of downtown Cleveland that has higher levels of congestion during peak times is the area near Playhouse Square and Cleveland State University, on the eastern side of downtown Cleveland. In particular, four signalized intersections have high levels of congestion: two located on the city's traffic grid and two at the innerbelt freeway. The intersection of E 12th St and Euclid Ave is congested in the PM peak period, with one approach, southbound E 12th St, having a V/C ratio value of above 3. In the AM peak period, none of the approaches are congested at this intersection. Just to the east, the intersection at E 14th and Euclid Ave is also congested in the PM peak period, with the eastbound approach having a V/C ratio of above 1.5. In the AM peak period, none of the approaches are congested at this intersection. Just to the south and adjacent to ramps leading to/from the innerbelt freeway, the intersection at E 14th St and Carnegie Ave is congested in the AM and PM peak periods. In the AM peak period, the northbound approach along E 14th St has a V/C ratio value of above 1.25. In the PM peak period, three approaches at this intersection have V/C ratio values above 1: northbound on E 14th St, southbound on E 14th St, and westbound on Carnegie Ave. On the eastern edge of downtown, the intersection of the eastbound I-90 exit ramp and Chester Ave is also congested in both the AM and PM peak periods. In the AM peak period, the eastbound exit ramp has a V/C ratio above 2. In the PM peak period, this same ramp has a V/C ratio above 1.

University Circle Area

Like Downtown Cleveland, the University Circle area is one of the region's largest job hubs, and with that distinction comes traffic congestion during peak travel times. In particular, two signalized intersections are quite congested in the AM peak period: MLK Jr Dr / Carnegie Ave and Euclid Ave / East Blvd. At the MLK Jr. Dr / Carnegie Ave intersection, two approaches are congested with V/C ratios above 1, specifically westbound Carnegie Ave and northbound MLK Jr Dr. At the Euclid Ave / East Blvd intersection, two approaches are congested with V/C ratios above 0.85, specifically westbound Euclid Ave and eastbound Euclid Ave. In the PM peak period, one of the main entry points into the University Circle area, the Cedar Glen Pkwy / Cedar Rd / Euclid Heights Blvd intersection, is congested. This signalized intersection has one approach with a V/C ratio above 0.85, specifically Cedar Glen Pkwy eastbound. In the AM peak period at this intersection, Euclid Heights Blvd westbound is congested, with a V/C value of 0.88.

I-271 / Cedar Rd Interchange

The I-271 / Cedar Interchange is located along the border of the cities of Lyndhurst and Beachwood in eastern Cuyahoga County. This interchange is near large retail areas to the west, such as Beachwood Place and Legacy Village, as well as large office parks to the east. In the AM and PM peak periods, the signalized intersection at Cedar and the southbound ramp to I-271 is congested. In both time periods, both the eastbound and westbound approaches on Cedar Rd have V/C values above 0.85.

I-490 / Opportunity Corridor / E 55th St Interchange

I-490 terminates at E 55th in the City of Cleveland. At this location east-west highway turns into the Opportunity Corridor that leads to and from the University Circle job hub. In both the AM and PM peak periods, the signalized intersection of I-490 / Opportunity Corridor / ramp to E 55th St is congested. Specifically, both the eastbound and westbound approaches along I-490 and Opportunity Corridor have V/C values above 0.85.

US-422 / Harper Rd Interchange

The US-422 / Harper Rd interchange, located in the City of Solon, southeastern Cuyahoga County, is the main entry point from the highway system to the Solon job hub along the Harper Rd / Cochran Rd corridor. Large employers, such as Nestle, are located in close proximity to the interchange, which creates traffic congestion conditions. The signalized intersection where Harper Rd meets the eastbound ramps is particularly congested in the PM peak period. Specifically, the northbound approach on Harper Rd has a V/C value of 1.97, indicating high levels of congestion. In the AM peak period, one approach has a V/C value above 0.85, specifically the eastbound exit ramp, and one approach has a V/C value close to 0.85, specifically northbound Harper Rd at 0.81.

US-422 / Rapids Rd Intersection

The US-422 / Rapids Rd intersection is located in Troy Township in southern Geauga County. This intersection is near where US-422 changes from a 4-lane divided highway to a 2-lane roadway. In both the AM and PM peak periods, this intersection is congested, with 2 approaches having high levels of congestion. Specifically, in both time periods, the eastbound and westbound approaches on US-422 have V/C values above 0.85.

US-322 / Aquilla Rd Intersection

The US-422 / Rapids Rd intersection is located in Claridon Township in northern Geauga County. This is a signalized intersection where two one-lane roads meet in a rural area. In the AM peak period, this intersection has 1 congested approach, which is US-322 westbound. None of the approaches are congested in the PM peak period.

I-271 / Ridge Rd Interchange

The I-271 / Ridge Rd Interchange is located in northeastern Medina County in Granger Township. This interchange mostly serves rural areas of the county, being located a few miles away from the largest urban areas in the county, such as the cities of Brunswick and Medina. In both the AM and PM peak periods, the intersection at the southbound exit ramp has congestion issues. In the AM peak period, the southbound approach on Ridge Rd has a V/C ratio value above 2, which indicates an extremely congested situation during that time frame. In the PM peak period, all three approaches have V/C ratios above 1 (southbound and northbound on Ridge Rd and the southbound exit ramp from I-271).

I-71 / SR-18 Interchange

The I-71 / SR-18 interchange is located in central Medina County along the Medina Township and Montville Township border, just east of the City of Medina. This interchange is one of the main access points to and from the City of Medina, and thus has high traffic volumes along its ramps and along SR-18. In particular, the intersection at the northbound exit ramp is congested in both the AM and PM peak periods. In the AM peak period, this signalized intersection has two approaches with V/C ratios above 0.95, both on SR-18. The same two approaches are also congested in the PM peak period, with V/C ratio values above 1.

SR-10 / Butternut Ridge Rd / Chestnut Ridge Rd Interchange

The SR-10 / Butternut Ridge Rd / Chestnut Ridge Rd interchange is located in southeastern Lorain County near the border of North Ridgeville and Eaton Township. Butternut Ridge Rd and Chestnut Ridge Rd run parallel to SR-10 with an access road connecting the interchange ramps to the two roadways. The unsignalized intersection of the eastbound ramps and the access road is congested in both the AM and PM peak periods. In the AM peak period, two approaches (the eastbound exit ramp and northbound access road) have V/C values above 0.85. The same two approaches have V/C values above 0.85 in the PM peak period as well.

SR-57 / Styx Hill Rd / River Styx Rd Intersection

The SR-57 / Styx Hill Rd / River Styx Rd Intersection is located in Guilford Township in southern Medina County, just northwest of the City of Wadsworth. This location is a 4-way intersection with multiple congested approaches in both the AM and PM peak periods. In the AM peak period, three out of four approaches have V/C values above 0.85 (SR-57 westbound, River Styx southbound, and River Styx northbound). In the PM peak period, traffic congestion is worse, with the same three approaches having V/C values above 1.

SR-57 / S Broadway St / Lafayette Rd
The SR-57 / S Broadway St / Lafayette Rd intersection is a 4-way stop located in the City of Medina, just south of Medina's historic square. In the PM peak period, two approaches have V/C values above 0.85, and 1 approach is just below at 0.78. The two congested approaches are Lafayette Rd eastbound and Broadway St southbound, and the approach at near-congested levels is SR-57 westbound. In the AM peak period, the situation is somewhat improved but still congested, with only one approach, SR-57 westbound, having a V/C value of over 0.85.

Principal Arterial Network

As discussed in Chapter 3, the principal arterial network plays an alternative role in reducing traffic congestion in the existing freeway system. The eNEO2050 plan attempts to restore the mobility function of the principal arterial network by implementing capacity-improving strategies such as Signal Timing Optimization Programs (STOP). Map 3.8 in Chapter 3 illustrates the principal arterial network in the NOACA region. This section describes the prioritization process for implementing STOP and major transit corridors. Also, as a part of the eNEO2050 plan, the resulting top 10 priority lists for STOP and transit corridors are displayed.

The corridors in the principal Arterial Network were evaluated and ranked into "Top 10" priority lists for different purposes. During the prioritization process, the attributes of the corridors were weighted, normalized, and then added together for one composite corridor value. For the STOP priority list, the all-user delay attribute was given the highest weighting factor so that corridors with very high user delay would rise to the top of the list. For the transit priority list, the bus-miles traveled attribute was given the highest weighting factor so that corridors with high amounts of bus travel would be highly ranked. The rest of the attributes were given lower weighting values based on their level of importance to each purpose. Tables 11-6 and 11-7 show the attribute weighting values for the corridor prioritization in STOP and major transit corridors.

Table 11-6: Attribute Weighting Values for the Corridor Prioritization in STOP

All User Delay	Person-Miles Traveled by All Modes	Emissions Reduction	Signal Density	Crash Density	Bus-Miles Traveled	Freight-Miles Traveled	**Total**
25	20	20	15	8	7	5	**100**

Table 11-7: Attribute Weighting Values for Prioritization of Transit Corridors

Signal Density	Crash Density	Freight-Miles Traveled	Person-Miles Traveled	All User Delay	**Bus-Miles Traveled**	**Total**
5	5	0	5	5	**80**	**100**

After these coefficients were applied to each program accordingly, two lists were created for each program:

1. A “General” list, in which composite scores for both directions and time periods were summed to result in one score for each corridor, and
2. An “Extremity” list, in which each direction and time period for every corridor was evaluated separately.

The final “Top 10” priority lists resulted from merging these two lists based on which corridors appeared highly on both the “General” and “Extremity” lists. The “General” list was created so that the overall conditions on each corridor could be summarized regardless of direction and time, and the “Extremity” list was created so that any one direction or time period with particularly severe conditions could be identified and prioritized, if necessary. Therefore, the combination of these two lists accounts for both the extreme situations and the entire corridor in general.

Both “Top 10” priority lists can be used to identify which corridors of the region are highly traveled by different modes and should be highly considered for transportation investments.

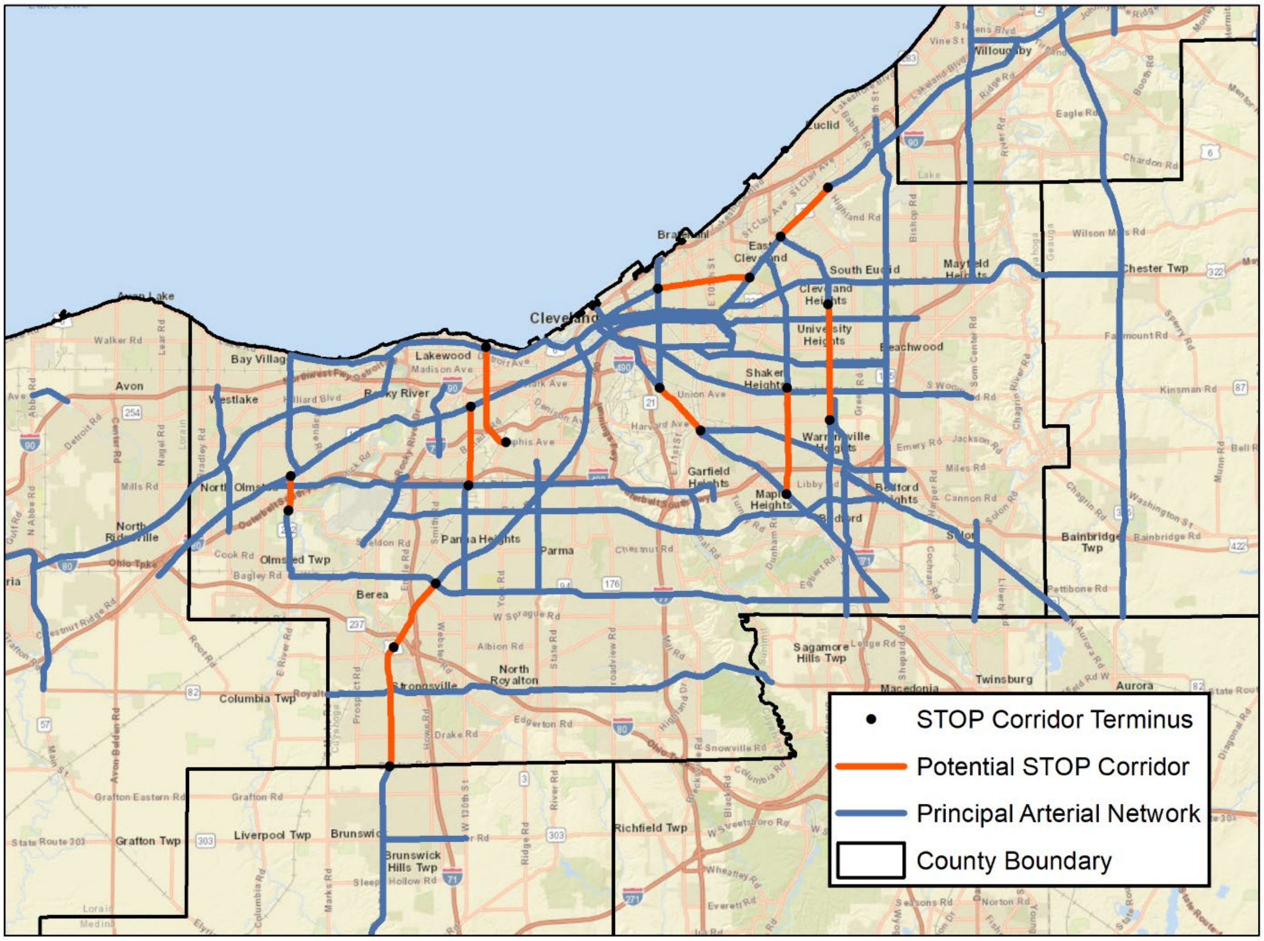
Signal Timing Optimization Program (STOP)

As discussed in the previous section, Table 11-8 shows the “Top 10” priority list for implementing STOP projects. Also, Map 11-3 displays the locations of these corridors in the principal arterial network.

Table 11-8: “Top 10” Priority Corridors for STOP Projects

Street Name	From	To
Pearl Rd (US-42)	Valley Pkwy	E Bagley Rd
Superior Ave (US-6)	E 55th St	Euclid Ave
Euclid Ave (US-20)	Noble Rd	Chardon Rd
Great Northern Blvd (SR-252)	Butternut Ridge	Lorain Rd
West 117th St/Memphis Ave	Tiedeman Rd	Lake Ave
Pearl Rd (US-42)	Boston Rd	Valley Pkwy
Warrensville Center Rd	Harvard Ave	Stonehaven Rd
West 130th St	Brookpark Rd	Lorain Ave
Broadway Ave (SR-14)	E 55th St	Miles Ave
Lee Rd	Broadway Ave	Van Aken Blvd

Map 11-3: Locations of the “Top 10” Priority Corridors for STOP Projects



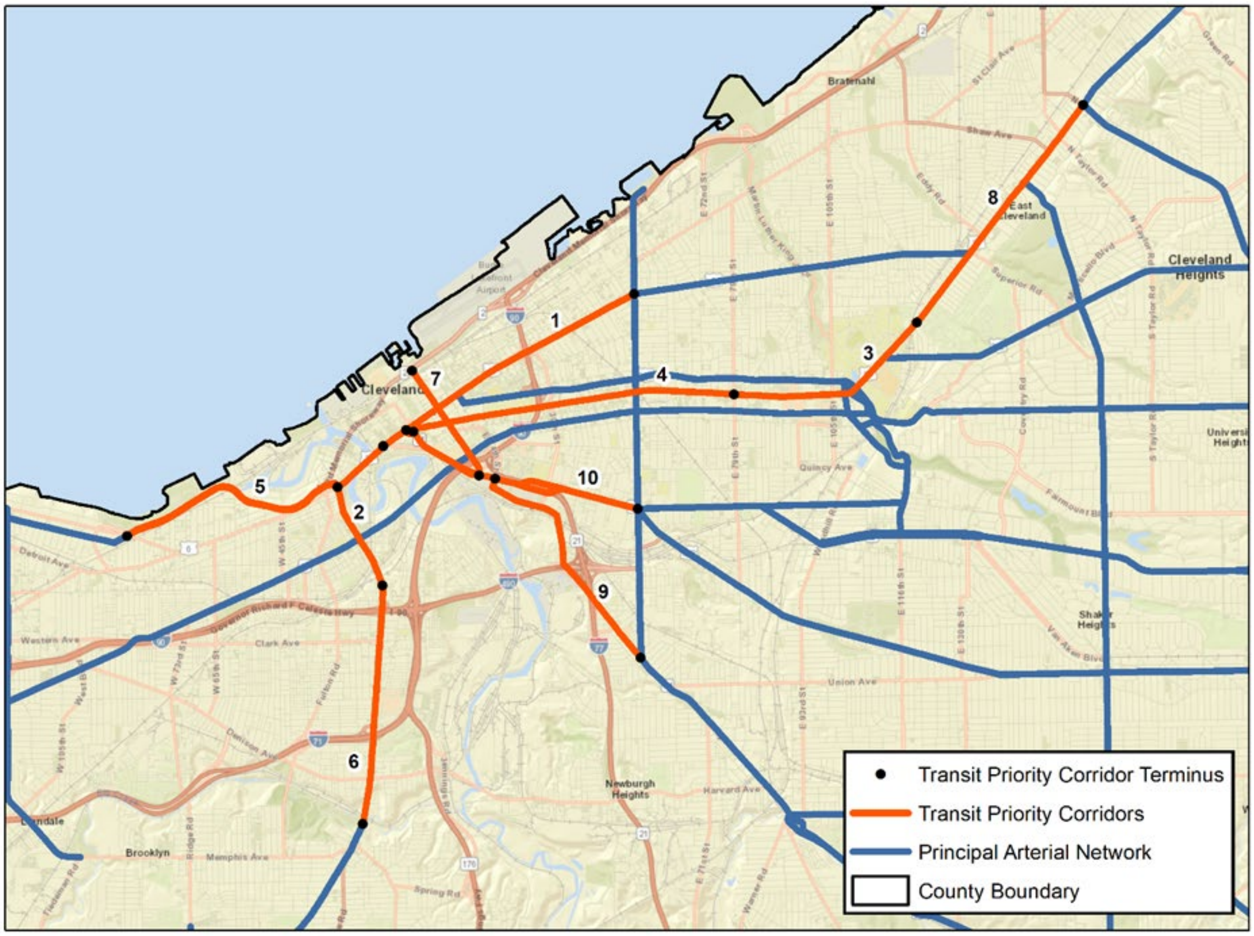
Main Transit Corridors

Similar to STOP corridors, Table 11-9 shows the "Top 10" priority list of Transit corridors. Also Map 11-4 displays the locations of these corridors in the principal arterial network.

Table 11-9: "Top 10" Priority Corridors for Transit

Street Name	From	To
Superior Avenue (US 6)	West 9th Street	East 55th Street
West 25th Street (US 42)	I-90 (Potter Ct)	Detroit Avenue
Euclid Avenue	East 79th Street	East 123rd Street
Euclid Avenue	Superior Avenue	East 79th Street
Clifton Road /W. Shoreway / Superior Avenue	Lake Avenue	West 9th Street
Pearl Road / West 25th Street (US 42)	Broadview Avenue (Brookside Park Dr.)	I-90 (Potter Ct)
East 9th Street	State Route 2	Ontario Street
Euclid Avenue	East 123rd Street	Noble Road
Broadway Road (State Route 14)	Orange Avenue	East 55th Street
Ontario Road/ Orange Avenue / Woodland Road (US 42)	Euclid Avenue	East 55th Street

Map 11-3: Locations of the "Top 10" Priority Corridors for Transit



Traffic Safety

Current Safety Improvement Programs

The international Vision Zero initiative envisages having a transportation network with zero deaths or injuries. One of NOACA's transportation planning goals is to achieve this vision in its five-county region in the future. NOACA has several safety programs, such as the Transportation Safety Action Plan (TSAP), Regional Safety Program (RSP), Safe Route to School (SRTS), SAVE Plan, etc., to improve the efficiency and safety of the transportation system. However, the cornerstone of NOACA's safety implementation comes from biannual Community Safety Reports.

The SAVE plan intends to save lives by identifying high-crash locations and implementing safety treatments at those sites. The plan was developed with the vision that traffic deaths and injuries can be prevented with appropriate planning, policies, and programs. The long-term goal is to reduce the number of fatalities and serious injuries to zero by 2050.

The SAVE Plan is a localized companion document that supports the Ohio Department of Transportation's (ODOT) Strategic Highway Safety Plan (SHSP), which is the cornerstone of the federal Highway Safety Improvement Program (HSIP) in Ohio. The 10 emphasis areas identified for specific action in the SAVE Plan are:

1. Intersection,
2. Roadway Departure,
3. Young Driver,
4. Speed,
5. Impaired Driving,
6. Older Driver,
7. Distracted Driving,
8. Pedestrian,
9. Motorcycle, and
10. Bicycle

Since creating the SAVE Plan, NOACA has added a localized approach through its community safety reports, identifying predictive high-crash locations in cities and villages throughout the NOACA region. We also now use an equal annual reduction to reach zero fatal or serious injury crashes by 2050, which leads to a decrease of 26% by 2030 and 63% by 2040, thereby being more aggressive than SAVE.

Systemic Safety Management Approach

NOACA has incorporated a Systemic Safety Management approach within its safety improvement programs. This approach is used to program the implementation of safety treatments at sites that reduce the potential for crashes using Crash Prediction Models. The Systemic Safety Management approach addresses crash types that occur with high frequency across the roadway network but are not concentrated at individual locations, which tend to be overlooked when ranking sites using a crash-history-based safety management approach.

As a proactive approach, the Systemic Safety Management programs countermeasures for implementation at locations that may not have a history of crashes. In particular, even sites with zero crash history can be identified for potential safety improvement. By applying this approach, NOACA will consider the potential for future crashes and crash history when determining where to make safety improvements.

The NOACA Systemic Safety Management approach is community-based, and specific Safety Performance Functions (SPFs) are being developed for each community based on road inventory, traffic volume, and crash data. This approach also uses the FHWA Crash Modification Factors (CMF) that indicate how much crash experience is expected to change following a design or traffic control modification. CMF is the ratio between the number of crashes per unit of time expected after a modification or measure is implemented and the number of crashes per unit of time estimated if the change does not take place.

This approach is mainly based on the Highway Safety Manual (HSM), a publication of the American Association of State Highway Transportation Officials (AASHTO).
Finally, NOACA produces biennial safety community reports for communities in the NOACA region.

Pavement, Bridge, and Transit Asset Management

Current and Future Pavement Conditions

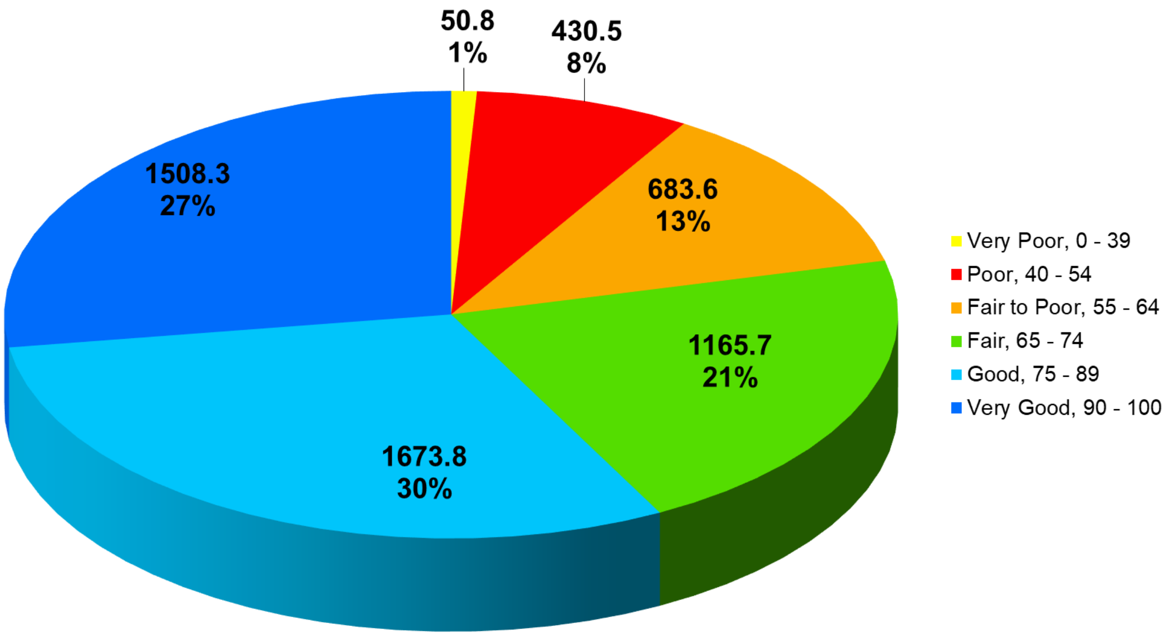
The majority of vehicular trips take place through the highways and street network. This network is an important asset item of the transportation infrastructure and its expansion, maintenance and operation very much depend on the available funds in any period of planning. The overall pavement and bridge condition of the highways and streets is an indicator of the quality of service provided to traffic through the system.

In order to provide an accurate assessment of the current status and further pavement analyses, the pavement network is required to be divided into homogeneous discrete sections in terms of surface distress, traffic volumes, pavement structure, etc. The Pavement Condition Ratings (PCR) measure is a qualitative description of the structural state of the pavement. The PCR values span a spectrum of descriptive narratives ranging from "Very Good" to "Very Poor". Each roadway segment is scored from 0 to 100, with 0 representing completely distressed pavement and 100 indicating perfect pavement condition.

The NOACA region has a total of 3,342 centerline miles of roadways, including freeway and federal–aid highways, which is equivalent to 8,682 lane-miles. In 2022, the all road types network weighted lane-mile average PCR is about 78. The PCR average for the NOACA Federal Aid Eligible roads is similar, at about 77. Although this average indicates a generally fair to good pavement condition for the region, it obfuscates the fluctuating condition observed by traffic.
NOACA prepares to produce biennial pavement maintenance management community reports for each community in the NOACA region for each community in the NOACA region.
This section describes the eNEO2050+ pavement maintenance management plan succinctly.

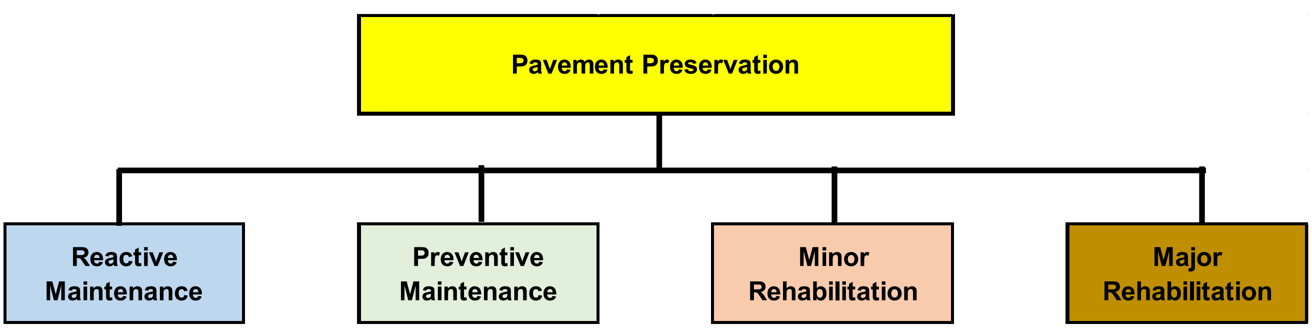
Figure 11-8 displays the 2022 lane miles of PCR categories for the NOACA Federal Aid eligible road system.

Figure 11-8. 2022 Lane-Miles of the PCR Categories for NOACA Federal-Aid Eligible Roads



Pavement Preservation is a program employing a network-level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet motorist expectations. A pavement preservation program consists primarily of four components: Reactive Maintenance, Preventive Maintenance, Minor Rehabilitation, and Major Rehabilitation/ Reconstruction, as shown in Figure 11-9.

Figure 11-9. Components of Pavement Preservation



Reactive Maintenance, also known as routine or corrective maintenance, consists of work that is performed to respond to specific conditions and deficiencies on pavements that are distressed and possibly unsafe. These activities are not planned in advance and seldom improve the pavement system performance in a long term.

Preventive Maintenance is considered as cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, delays future deterioration, and maintains or improves the functionality condition of the system without increasing structural capacity.

Pavement Rehabilitation is defined as resurfacing, restoration, and rehabilitation (3R) work consisting of structural enhancements that extend the service life of an existing pavement and/or improve its structural capacity. Rehabilitation techniques include restoration treatments and/or structural overlays. This may include partial recycling of the existing pavement, placement of additional surface materials, and/or other work necessary to return an existing pavement to a condition of structural or functional adequacy.

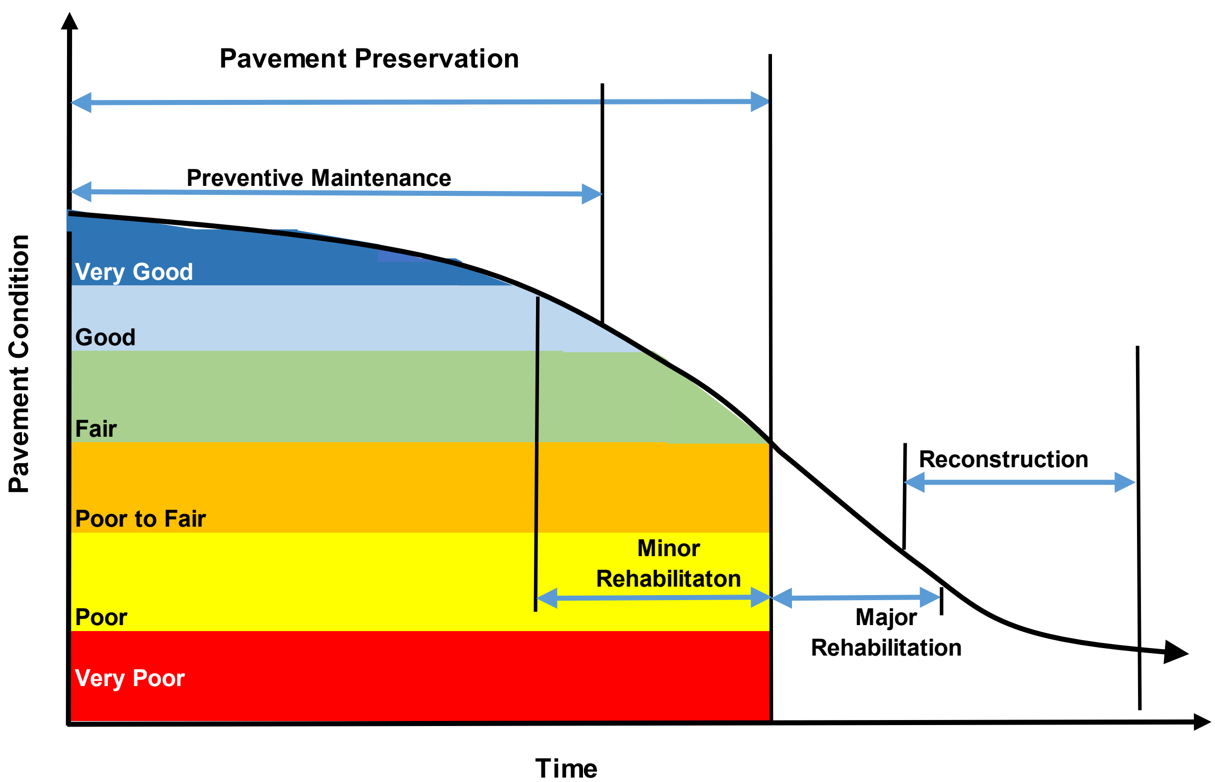
Minor Rehabilitation consists of non-structural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develops in flexible pavements due to environmental exposure. Because of the non-structural nature of minor rehabilitation techniques, these types of rehabilitation techniques are placed in the category of pavement preservation.

Major Rehabilitation consists of structural enhancements that both extend the service life of an existing pavement and/or improve its load-carrying capability.

Pavement Reconstruction is defined as the replacement or reestablishment of the original pavement structural capacity by the placement of the equivalent or increased pavement structure. Reconstruction may utilize either new or recycled materials for the reconstruction of the complete pavement structure.

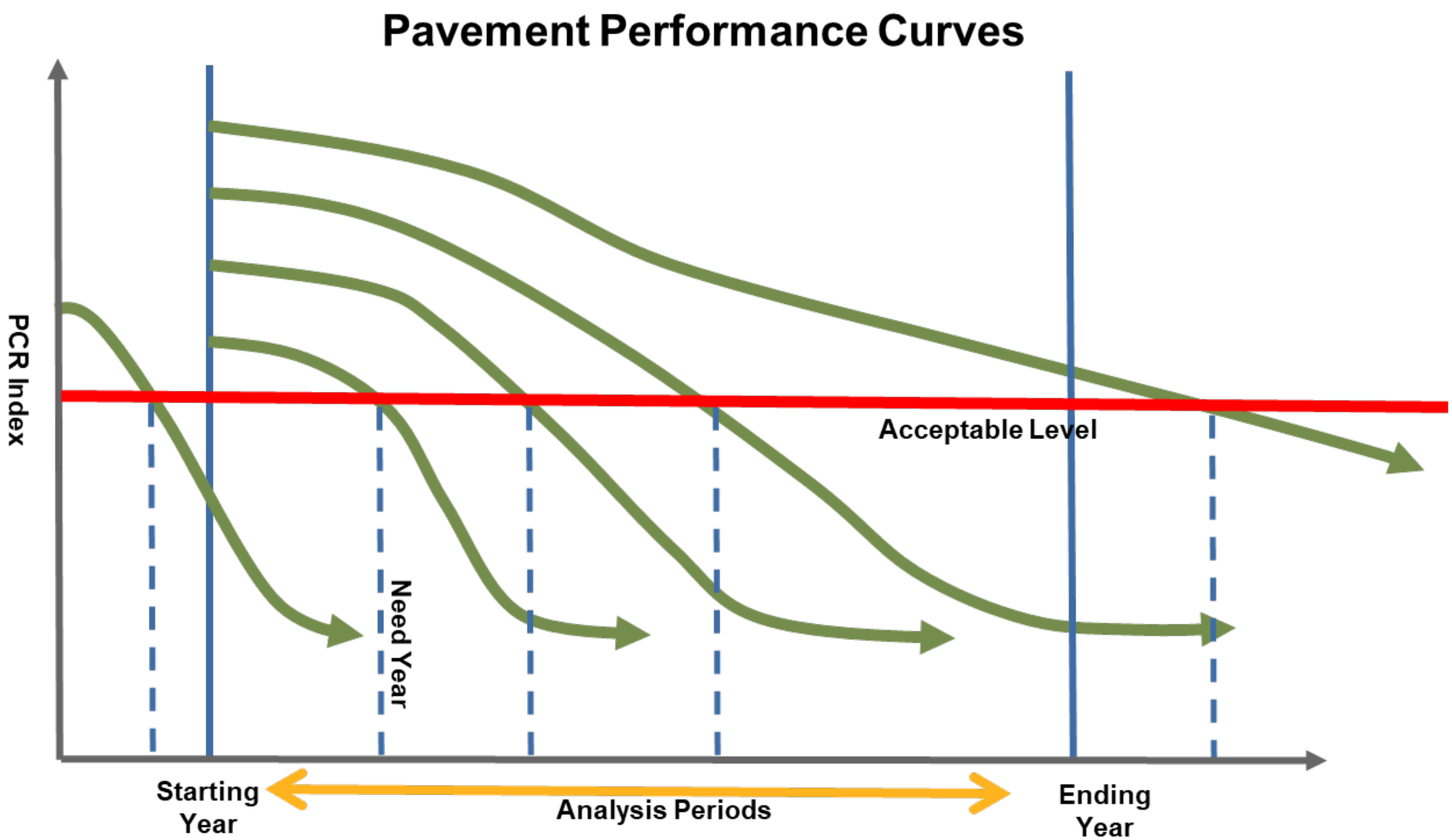
Figure 11-10 illustrates a general schematic for the timing of the pavement preservation Components.

Figure 11-10. A General Schematic for the Timing of Pavement Preservation Components



Maintenance and Rehabilitation (M&R) Program. In order to estimate the preventive maintenance and rehabilitation requirements of a pavement network over a period of time, the first step is to determine the "Need Year," or when a pavement segment requires rehabilitation. The "Need Year" of a pavement is defined as the year in which the pavement condition falls below a critical level. The pavement condition of a road segment deteriorates due to traffic, climate, etc., and consequently, its PCR value is reduced. Without any treatments and depending on the deteriorating factors, pavements perform differently, and Figure 11-11 depicts the typical acceptable level and "Need Year" relation for several road segments. As shown, the definition of the acceptable level is a critical factor in determining the "Need Year" for any road segment.

Figure 11-11. The PCR Acceptable Level and "Need Year" Relationship



The critical level is set by the minimum acceptable PCR. In the NOACA region, the minimum acceptable PCR for the arterial roadway function class is 55 and for the major and minor collector is 50.

The second step is to determine any feasible preventive maintenance and/or rehabilitation strategies based on a decision tree approach. The “M&R” program determines the optimal preventive maintenance and rehabilitation strategy for each segment and its recommended implementation year based on the considered decision tree.

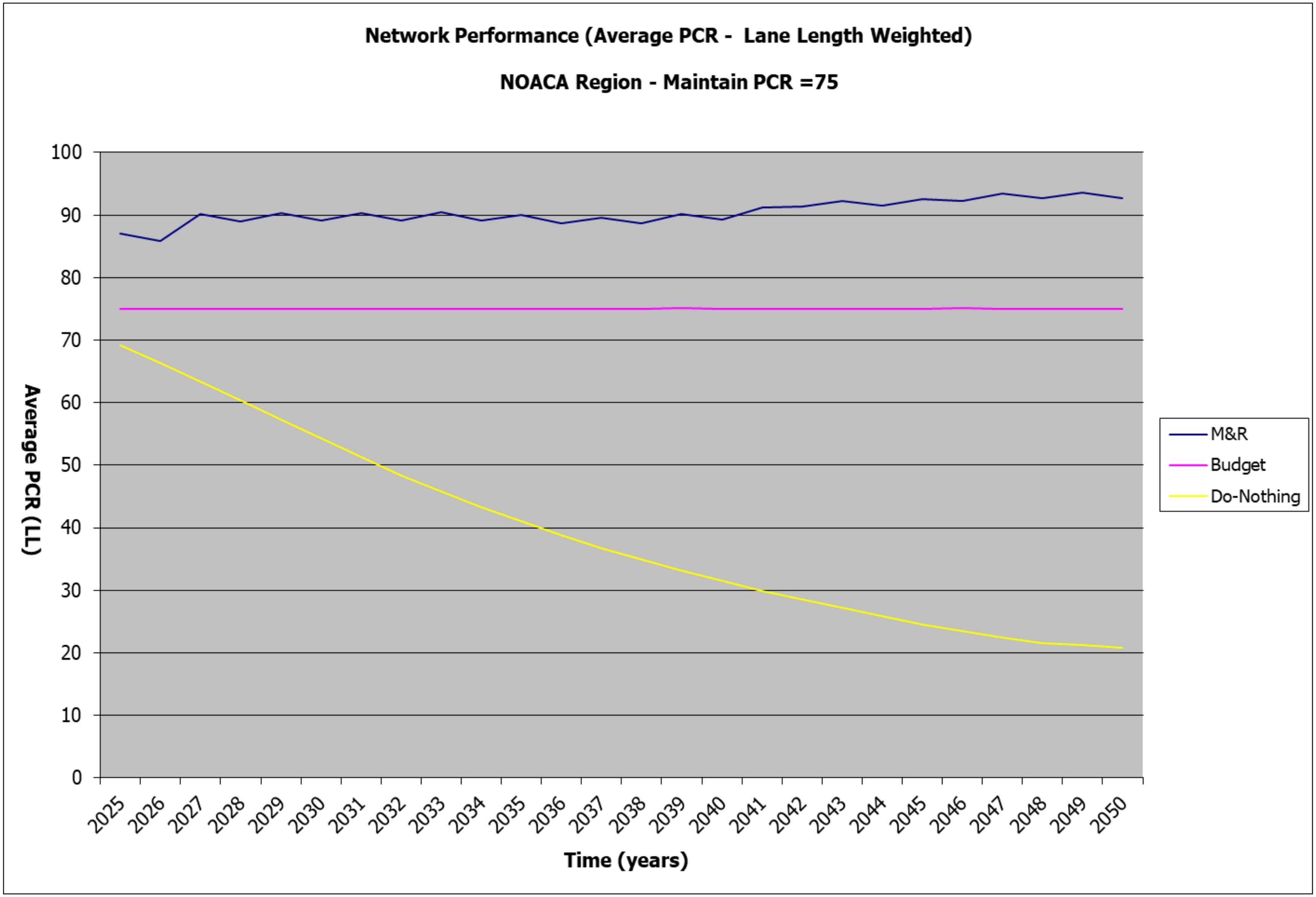
As shown in Table 11-1, eNEO2050+ includes maintaining pavement conditions with average PCR of 75. The following paragraphs compare three scenarios of “Budget”, “M&R” and “Do-Nothing”.

The “M&R” program is applied to the Federal-Aid network, and the treatments are applied in their recommended years. The lane-length weighted average PCR would be 90.4, and at the end of the program, the network PCR would be 92.7, with 0% falling below the minimum acceptable PCR. The total required budget is $2.6 billion.

If no rehabilitation is implemented (Do-Nothing), the network is expected to have an average of 39.3. At the end of the program, the network PCR would drop to 20.8, with 100% falling below the minimum acceptable PCR.

Finally the strategy of maintaining average PCR of 75 applies a set of maintenance treatments in order to keep the roadway network average PCR equal to 75 each year from 2025 to 2050. The total required budget is over $3.7 billion. Figure 11-12 shows the annual network average PCR for the discussed maintenance and rehabilitation strategies and the advantage of the “M&R” program.

Figure 11-12. PCR Acceptable Level and "Need Year" Relationship



Current and Future Bridge Conditions
Northeast Ohio has several major river drainage basins flowing into Lake Erie, including the Black River, Rocky River, Cuyahoga River, Chagrin River, and the Grand River. As a result, the area contains a significant number of bridges.

ASCE Policy Statement 208- Bridge Safety reports the average age of the nation's bridges is 42 years, which leaves just eight years until a typical 50-year design life is exceeded. In general, it can be said that additional repairs and rehabilitation investment is likely required as bridge structures continue to age.

The Northeast Ohio Report Card Committee discovered a similar trend. The inventory of existing bridges indicates that the average age of bridge assets continues to rise. Agencies are stretching available funds to maintain the inventory at an acceptable operating level. Local transportation agencies are doing a commendable job of inspecting, load rating, prioritizing, rehabilitating, and in some cases replacing the bridges, most often well beyond a 50-year life cycle.

The National Bridge Inspection Standards (NBIS) defines Bridge Condition Ratings that apply across the United States as: Good: 9-7; Satisfactory; 6 Fair:5; Poor: 4-0. Brief descriptors of condition ratings are provided in Table 11-10, and this table also presents consolidated bridge ratings for all the bridges in the NOACA region.

Table 11-15. 2025 Bridge Condition Ratings for Bridges in the NOACA Region

General Appraisal Ratings	Condition Description	Percentage of each Category
Less than or Equal to 4	Poor (Rating Value = 4) Serious (Rating Value = 3) Critical (Rating Value = 2) Imminent Failure (Rating Value = 1) Failure (Rating Value =0)	5%
5	Fair	14%
6	Satisfactory	28%
7	Good	31%
8	Very Good	17%
9	As Built	5%

ODOT has established a Statewide System Goal of 6.8 for their structures, which is just slightly below the condition rating of “Good”. This goal considers a constrained funding stream and balancing of ODOT resources between other high priority assets such as interstate and freeway pavement, interchanges, traffic signing, safety features, and operations and maintenance commitments.

It is always possible to rank bridges or prioritize the attention they need based on their Bridge Condition Ratings or General Appraisal Values (GAV) and /or Sufficiency Rating Values (SR), based on their condition only. Other factors, however, should be taken into consideration when assessing the immediacy of attention needed for infrastructure improvements. These factors include the importance of the various functional classes of the roadways that the bridges serve, and the level of traffic demand on these bridges expressed in average daily traffic.

The current total deck area of all the highway bridges in the NOACA region is over 22.8 million square feet. The FHWA has presently set the target as maintaining NHS bridges at less than 10.0% of deck area as structurally deficient. The total structurally deficient on NHS bridges in the NOACA region is less 2% (419,155 Sq. FT). The percent of the NHS bridges and bridges on other type of roads is less than 3.5% (786,600 Sq. Ft).

Bridge Priority Index.

There are 168 bridges in the NOACA region that have bridge appraisal values of 4 or less. Appraisal values range between 0 and 9 (failure condition to excellent condition). Bridges with general appraisal values of 4 or less require urgent or expeditious attention as they demonstrate a condition of poor, very poor, near failure (must be closed), or failure (closed). Bridge conditions are also evaluated using numerical “sufficiency rating” values ranging from zero to 100.

While bridges may be ranked solely based on their conditions described by their general appraisal values, and or by their sufficiency rating values, it is possible and perhaps preferable to rank them or prioritize them according to the attention they deserve based on an index that takes into consideration the functional class of the roadways they carry, and the traffic demand in addition to the general appraisal and sufficiency rating values. All these factors, therefore, should be taken into account when assessing the immediacy or urgency of attention needed for infrastructure improvements. These factors, hence, are weighted according to the relative importance of the various functional classes of the roadways, the bridges' service, the level of future traffic volumes that will pass over these bridges, expressed in a typical daily Passenger Car Equivalent (PCE) volume, the general appraisal, and sufficiency rating.

The concept of Bridge Priority Index (BPI) was developed in order to rank all bridges, or at least those that are in poor condition, in a manner to help present them for repair or reconstruction in priority order based on a combination of categorical elements, namely condition, functional class, and future traffic volume. Each categorical element consists of factors that were given weighted values to reflect the level of their relative importance.

Bridge Priority Index (BPI) =
Average Daily Traffic Weighted Value × A Significance Factor of 3 +
General Appraisal Weighted Value × A Significance Factor of 4.5 +
Sufficiency Rating Weighted Value × A Significance Factor of 4.5 +
Functional Class Weighted Value × A Significance Factor of 1.5 +
Functionality Obsolete Value × A Significance Factor of 1.5 +
Structurally Deficient Value × A significance Factor of 1.5

$$\boldsymbol{BPI} = \mathbf{3} \times \boldsymbol{ADT_{wv}} + \mathbf{4.5} \times (\boldsymbol{GA_{wv}} + \boldsymbol{SR_{wv}}) + \mathbf{1.5} \times \boldsymbol{FC_{wv}} + \mathbf{1.5} \times (\boldsymbol{FO_{wv}} + \boldsymbol{SD_{wv}})$$

Where:

- *BPI*: Bridge Priority Index
- ADT_{wv}: Typical Future Daily Traffic Volume in PCE Weighted Value
- GA_{wv}: Bridge Condition General Appraisal Weighted Value

- SR_{wv}: Bridge Condition Sufficiency Rating Weighted Value
- FC_{wv}: Functional Class Weighted Value
- FO_{wv}: Functionality Obsolete Weighting Value
- SD_{wv}: Structurally Significant Weighting Value

The higher the Bridge Priority Index, the more urgent or compelling the need is for prioritizing addressing the condition of the bridge. Weighted Values and Significance Factors associated with the Bridge Priority Index parameters in the above captioned equation are shown below, as well as a description for the various general appraisal values:

FORECAST TRAFFIC DEMAND	Weighting Value	Category Significance Factor: 3
0001-2,000 Vehicles per Day per lane	1	
2,001-4,000	2	
4,001-8,000	3	
8,001-12,000	4	
12,001-16,000	5	
16,001-20,000	6	
20,001-40,000	7	
40,001-50,000	8	
50,001-70,000	9	
70,001-100,000	10	
100,001 or more	11	

GENERAL APPRAISAL VALUE	Weighting Value	Category Significance Factor: 4.5
0	9	
1	8	
2	7	
3	6	
4	5	
5	4	
6	3	
7	2	
8	1	
9	0	

SUFFICIENCY RATING	Weighting Value	Category Significance Factor: 4.5
00-20	4	
21-40	3	
41-60	2	
61-80	1	
81-100	0	

FUNCTIONAL CLASS	Weighting Value	Category Significance Factor: 1.5
Interstate / Other Freeway	6	
Principal Arterial	5	
Minor Arterial	4	
Major Collector	3	

Minor Collector	**2**
Local	**1**

STRUCTURALLY DEFICIENT	**Weighting Value**	**Category Significance Factor: 1.5**
On NHS Bridge	**2**	
On Non-NHS Bridge	1	

FUNCTIONALITY OBSOLETE	**Weighting Value**	**Category Significance Factor: 1.5**
Obsolete	1	

Table 11-16. Future Rehabilitation Costs

	Rehabilitation and Maintenance Cost for Each Decade in Millions (2025$)			
Bridge Road Type	2025 - 2030	2031 - 2040	2041 - 2050	Total
NHS	$40	$68	$97	$205
Non-NHS	$81	$135	$193	$409

The required annual budget range is about $20 to $30 million for maintaining the deck area of the structurally deficient bridges less than 10 percent in the next three decades. In addition, the required budget for immediate bridge replacement is about $11 million.

Transit Asset Management

In 2019, NOACA developed a group Transit Asset Management Plan, which covers the three tier II transit agencies in Lake, Lorain, and Medina Counties (see Table 11-12). Together, the three counties cover a population area of about 703,729 people (US Census, 2010), making up approximately 6% of the state population. Laketran is Lake County's public transportation system, providing the following services: six in-county local routes, four commuter park-and-ride routes to Cleveland, and door-to-door dial-a-ride. Laketran maintains a total of 123 revenue vehicles and reported a 2017 ridership of over 750,000. The second plan participant, Medina County Public Transit, serves Medina County residents, providing 84,672 demand response trips, 22,048 Medina loop trips, and 654,897 total vehicle miles in 2012. Medina County Transit maintains a total of 23 revenue vehicles. Finally, Lorain County Transit serves Lorain County residents. The agency maintains a revenue fleet of 13 vehicles serving an average of 120 passengers per day. In 2016, Lorain County Transit recorded a fixed-route ridership of 30,271.

The plan covers the four year period between 2019 and 2022, and contains the following elements: (i) an asset inventory, (ii) a condition assessment of assets for which the group plan participants have direct capital responsibility, (iii) an investment prioritization list, and (iv) documentation of the analytical processes and decision support tools used in the plan development.

Table 11-17. Transit Asset Management Plan Elements

Asset Category/ Class	Count	Avg. Age	Avg. Mileage	Avg. TERM Condition	Avg. Value	% At or Past ULB	FY19 Performance Target
Revenue Vehicles	159	3.8	101,547	-	$164,043.07	4.4%	
BR - Over-the-road Bus	20	1.0	20,040	-	$632,500.00	0.0%	0%
BU - Bus	16	8.5	255,888	-	$475,000.00	0.0%	0%
CU - Cutaway Bus	115	3.7	100,457	-	$103,048.00	5.2%	6%
MV - Mini-van	2	1.0	35,212	-	$36,600.00	0.0%	0%
VN – Van	6	7.0	110,331	-	$80,000.00	16.7%	17%
Equipment	28	9.5	47,899	-	$86,212.00	17.9%	
Non-Revenue/Service Automobile	6	7.3	72,539	-	$26,000.00	16.7%	17%
Trucks and other Rubber Tire Vehicles	9	4.3	35,579	-	$44,600.00	22.2%	23%
Facilities	9	12.8	N/A	4.4	$3,838,889.00	-	
Administration	2	16.0	N/A	4.0	$13,875,000.00	-	0%
Maintenance	2	9.0	N/A	4.0	$1,000,000.00	-	0%
Passenger Facilities	5	13.0	N/A	4.6	$960,000.00	-	0%

Transit

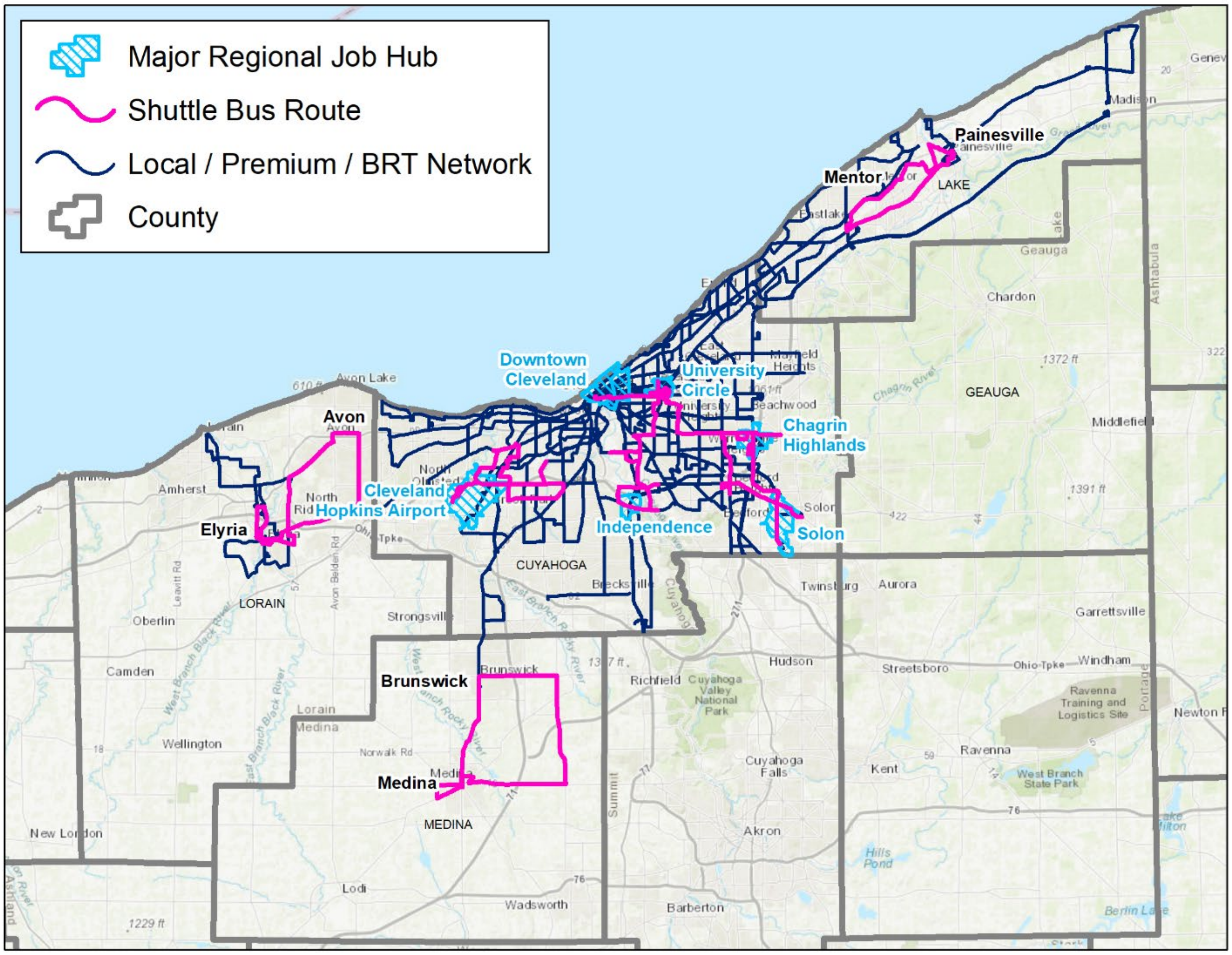
Complete Transit Connectivity

Corridors with higher residential and employment densities are the backbone of the transit network. Rapid transit is most viable at densities of at least 30 units per acre or 50 to 75 employees per acre. To compare, the minimum density for on-street bus service is about 6 to 8 units per acre. Interested municipalities can support the transit system by ensuring sufficient densities that permit the operation of transit services. NOACA will support communities that are interested in rezoning for higher densities within ¼ mile of locally-proposed and regionally coordinated rapid transit stops. Rezoning in these locations will also help diversify the housing stock of the region.
The other important factor in increasing transit ridership is connectivity. As discussed in Chapter 9, the “first mile” and “last mile” bus services connected to the main transit corridors are the missing links in providing a complete transit connectivity from riders’ actual origins to their destinations. Autonomous shuttle buses contribute not only the local demand but also complete the connectivity of transit services running through the main corridors. With new technology, some companies offer automated on-demand bus shuttle services that operate similar to taxi services. Exploring these technologies for Northeast Ohio can be a viable option to connect residents to nearby rapid transit stops and job hubs.

Furthermore, investment in bike sharing infrastructure as well as separate bike lanes within a 2 mile radius of job hubs and rapid transit stops will enable additional mobility of residents in the region.

Figure 11-13 displays a set of suggested autonomous shuttle feeder bus services in four counties in the NOACA region. These services circulate transit riders between transit hubs, job hubs, and neighboring urbanized areas.

Figure 11-13. *eNEO2050+* Transit Network and Shuttle Bus Routes



Workforce Accessibility and Mobility

Work trips are the most crucial mandatory trips in an urbanized area. Previous NOACA studies indicated that the available workers in the commute sheds of any major job hub is higher than the number of workers currently living in that commute shed. These discrepancies illustrate the mismatch between where workers live and work, and the lack of transit services makes it more apparent. Shortening work travel time will not only benefit commuters but also mitigate traffic congestion severity, reduce VMT in the region, lessen stress and load on road pavements, and lower the overall burden on the transportation system. Therefore, the success of any future transportation plan depends significantly on reducing travel time and improving the safety of work journeys.

In order to:

- Reduce the mismatch between workers and employers' locations.,
- Reduce the work commute times and
- Fulfill the workforce objectives stated in Table 11-1,

The eNEO2050+ plan recommendations include the following transportation solutions:

Transit Solutions

- More frequent express and local buses to regional job hubs
- Implement low-cost traffic engineering solutions at identified arterial bottleneck locations on transit routes
- Extend the transit network to/from major regional job hubs and inter-county transit services
- Adding more park-and-ride locations throughout the region
- Dedicate highway lanes to express buses and car pooling
- Develop more bike lanes and sidewalks to access major transit stations

For these transportation solutions to be successful, NOACA relies on coordination with local governments on land uses that are adjacent to major transit stops and within job hubs. A transit system can be supported by looking at the use of land and densities:

- Rapid transit is most viable at densities of at least 30 units per acre or 50 to 75 employees per acre
- On-street bus service needs at least a density of about 6 to 8 units per acre
- Mixed-use development at major transit stops and in job hubs can support the viability of the station
- Some businesses value close proximity to existing rapid transit services as it is an element of attracting and retaining high-skilled workers. Ensure that developable lots (e.g., cleaned-up brownfields) are available in locations with rapid transit access.

NOACA Policies

Regarding the above recommended solutions, the potential planning policies currently under discussion at NOACA's policy committee are:

- Support and prioritize transportation funding, especially transit expansion and enhancements around major job hubs
- Support and prioritize funding for multimodal accessibility to job hubs and connections to transit services
- Support regionalized transit system – inter-county transit routes and expansion of park-and-ride system
- Encourage efficient mixed-use development
- Implement mobility-accessibility study for any current and potential employment centers

Non-Motorized Transportation

Non-Motorized modes of travel (also known as Active transportation and human powered transportation) are not used extensively as a means of transportation in the NOACA region today. According to the NOACA travel forecasting model, walking and bicycling total shares are less than 0.5 percent of the total daily person trips. This is especially the case for utilitarian trips, which are trips undertaken with the purpose of reaching a particular destination for accomplishing an activity. The low usage of walk and bicycle modes of transportation is due to many reasons such as:

- The concomitant increasing usage of motorized vehicles for transportation,
- The relatively low cost of operating motorized automobiles,
- The sprawling land use patterns.
- The adverse climatic conditions in Northeast Ohio

The usage of non-motorized modes may be categorized as:

1. Utilitarian trips,

2. Access to transit services, and
3. Recreational pursuits (including exercise)

Trip distance is a well-established determinant of non-motorized mode choice: all else being equal, the farther away one is from a destination, the less likely one is to use bicycling or walking. Although distance is objectively measurable, its effect may vary for individuals depending on their physical condition, attitudes, perception of distance, and trip purpose. A reasonable distance to walk for utilitarian trips is about ¾ miles. That is estimated based on a travel time of 15 minutes with a walking speed of three miles per hour. Similarly, an average distance for utilitarian biking trips is about three miles. Compared to other trip purposes, bicycling is used the most for recreational pursuits.

Considering the acceptable walking and biking distances for land use and transportation planning purposes, access to transit by non-motorized modes is an important aspect of a cohesive, multimodal transportation system. As discussed previously, these connections to the transit network are often referred to "first mile" and "last mile" trips, and those short trips, combined with a transit trip, create a complete connection from travelers' origins to their destinations.

The eNEO2050+ plan recommends to invest in non-motorized facilities for accessing the transit network for the purpose of creating a true multimodal transportation system for the NOACA region. These connecting projects were highlighted in Table 11-1 as typical non-motorized facilities and riders should be able to safely and conveniently reach transit stops via a well-connected system of pedestrian and bicycle infrastructure. Table 11-18 displays the eNEO2050+ plan proposal for non-motorized modes by facility type and implementation decades.

Table 11-18. Miles of Non-Motorized Mode Facilities in eNEO2050 Plan

Non-Motorized Mode	2025 - 2030	2030 - 2040	2040 - 2050	Total
Sidewalk	40	80	80	**200**
All Purpose Trail	23	46	46	**115**
Low-Stress, In-Street Bike Facility	76	152	152	**380**

Further information regarding non-motorized investment is available in NOACA's ACTIVATE plan, which provides a vision for increasing the use of bikeways and walkways for transportation and commuting and also serves as a guide for future bicycle and pedestrian improvements. The plan includes a prioritization model based on a Connectivity Quantitative Score Index (CQSI) for investing in non-motorized facilities for accessing the transit network.

Emerging Technology in Transportation

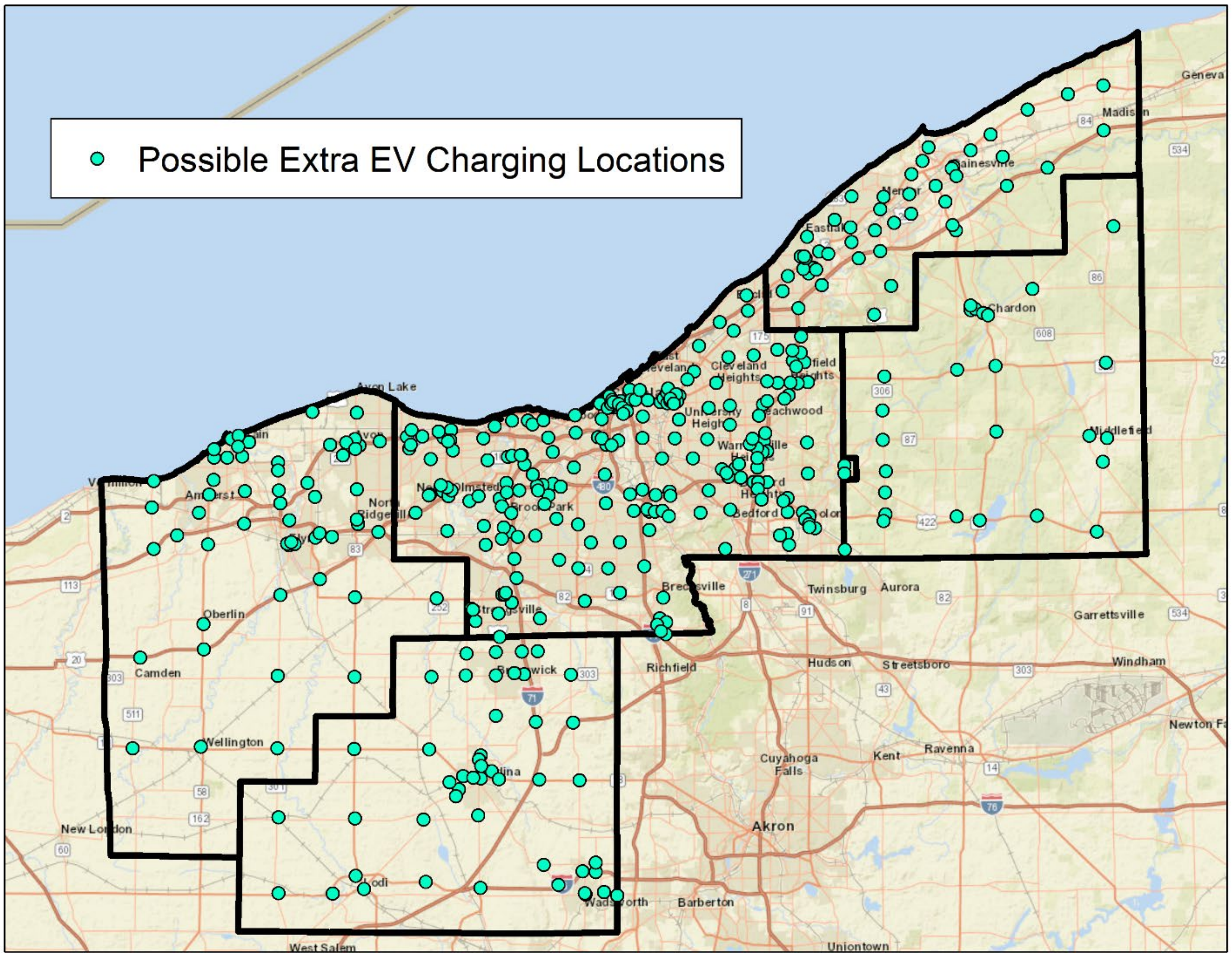
Electric Vehicles

Future of Charging Stations

The charging station sites for Electric Vehicles (EVs) are a necessary part of the required Electric Vehicle Supply Equipment (EVSE). EV owners currently charge their vehicles overnight at home using residential charging ports. However, residential charging will neither be adequate nor a strong reinforcement for the expected EV growth in the next three decades. Similar to the location distribution of fuel stations for the conventional Internal Combustion Engine Vehicles (ICEV), the

EV charging port locations' ultimate coverage area should be in such a way that drivers can reach one of these facilities by driving a few miles. Figure 11-14 shows the proposed EV charging ports to support the projected number of EVs by 2050.

Figure 11-14. *eNEO2050+* EV Charging Locations



Fiscally Unconstrained and Illustrative Projects

Illustrative Project: Hyperloop

Background

On February 26, 2018, the Northeast Ohio Areawide Coordinating Agency (NOACA) and Hyperloop Transportation Technologies (HTT) entered into a public private partnership to complete a feasibility study for the technical analysis and evaluation of a Cleveland, Ohio to Chicago, Illinois and Pittsburgh, Pennsylvania corridor; known as the Great Lakes Hyperloop Feasibility Study. The project launched on July 1, 2018, with the feasibility study being completed in December 2019. NOACA also conducted a peer review of the feasibility study with participants from Cleveland State University, Carnegie Mellon, the University of Illinois, Chicago, and Northwestern University to provide an independent review of the project framework, assumptions, and analysis approach. The project had many collaborating partners, such as the Illinois Department of Transportation, Indiana Toll Road, Federal Highway Administration, NASA, Eastgate Regional Council of Governments, Erie Regional Planning Commission, Southwestern Pennsylvania Commission, Team NEO, and Toledo Metropolitan Area Council of Governments. The feasibility study assessed the technical and financial feasibility of the environmental, financial, operational, and structural requirements to create a Hyperloop Transportation System. The feasibility study also addressed the requirements for building and achieving optimal alignment of the system, siting requirements for location of major structures, assessing the constraints on alignment of the system, integrating the Hyperloop transportation system with existing transportation infrastructure, and identifying issues with construction of the optimized system.

The Feasibility Study for the Great Lakes Hyperloop revealed positive financial and cost benefit results creating a strong case for developing the corridor connecting Chicago, Cleveland and Pittsburgh as a passenger and freight system. As a result of these positive findings the Preliminary Development phase becomes the next necessary step forward in the project development process.

Why Cleveland to Chicago and Pittsburgh?

Cleveland to Chicago represents a natural convergence of major interstate travel routes: I-80 from New York City, NY, and I-90 from Boston, MA, both come together at Cleveland and share the corridor to Chicago. I-76 feeds directly into I-80 from the east, adding direct connections from Pittsburgh, Philadelphia, Baltimore, and Washington, D.C. This geography naturally funnels traffic from the entire East Coast via Cleveland towards Chicago and beyond. As such, it is clear that a Cleveland to Chicago Hyperloop will develop into a critical component of a national Hyperloop network. Since a Cleveland to Chicago link is essential for making so many connections, this would be an excellent place to begin developing a national Hyperloop network.

Technology

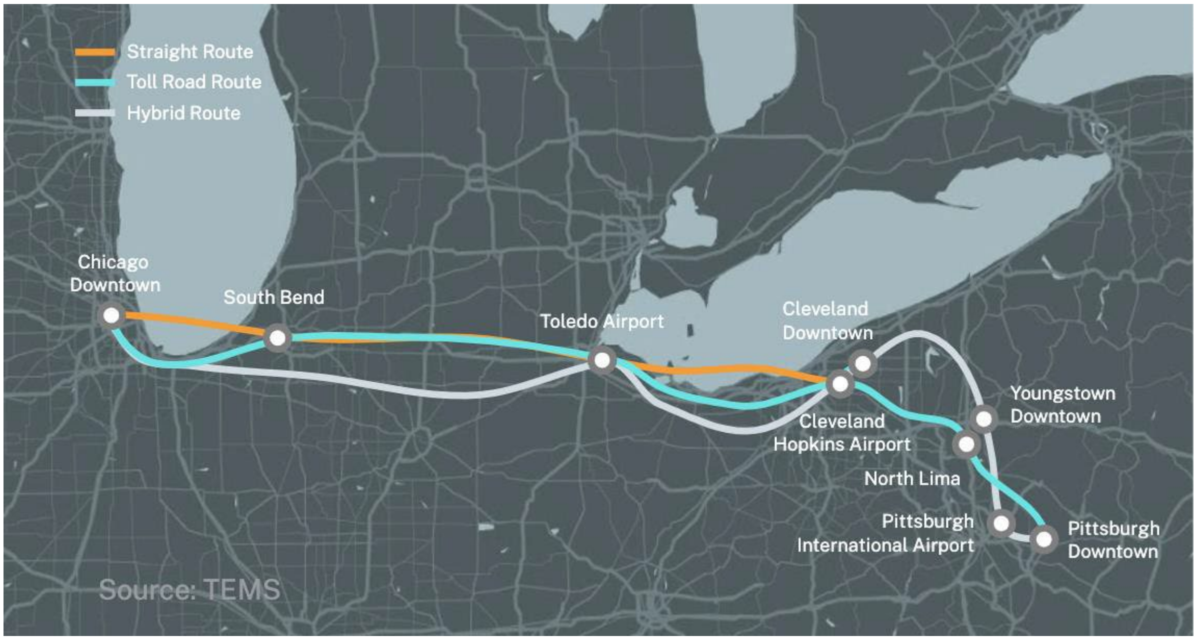
The Hyperloop is an entirely new mode of transportation based on early theoretical and experimental work in reduced-pressure transport in the early 20^{th} century. Hyperloop consists of an evacuated guideway tube within which a magnetic levitation system is used to propel self-contained capsules carrying either passengers or cargo. Since maglev is used and most of the air has been removed from the tubes, friction is very low. This makes it possible for vehicles to reach very high speeds with minimal resistance. Since very little energy will be dissipated by air resistance, and magnetic drag actually reduces as speeds go up, much of the energy imparted to vehicles upon acceleration can be electrically recovered when the vehicles slow down. In addition, because of the lack of friction, vehicles will be able to accelerate on straight sections of guideway to very high speeds (700 mph+), exceeding even those of commercial jetliners. Capsules are powered by passive magnetic levitation, powered by solar power. Magnets are arranged in a Halbach array configuration, enabling capsule levitation over an unpowered but conductive track.

Feasibility Study Results

Representative Routes
Three representative routes between Cleveland and Chicago were studied, as well as two representative routes between Cleveland and Pittsburgh. The first route (Straight Route) connects Cleveland to Chicago on as close to a straight line as possible. The original concept for the second route (Toll Road Route) was to utilize existing right-of-way, but the existing highway alignment proved to be too curvy for the Hyperloop's use. As a result, a new approach generally following the corridor of the toll road was adopted. The proposed Toll Road alignment crosses the tollway on numerous occasions as it follows the general course of the highway. The Toll Road Route was extended to Pittsburgh via Cranberry Township. The third route (Hybrid Route) is primarily based

on the use of some very straight Midwestern rail lines from Cleveland to Chicago, but also includes a number of short interconnecting greenfield links. Some straight sections of highway right-of-way have also been included. The Hybrid Route was extended to Pittsburgh via Youngstown to Pittsburgh (see Figure 11-17).

Figure 11-17. Representative Hyperloop Routes: Chicago-Cleveland-Pittsburgh



Economic Competitiveness

Creating a corridor, and eventually a network, for ultra high-speed transportation between remote regional hubs will enhance opportunity and economic mobility throughout the region. Unlike other forms of transportation, the low-cost and efficient operation of the Hyperloop system enables a return on investment for system operators. Reducing the travel times between cities will allow residents to access jobs across the connected corridor, which will expand local job markets and add entirely new industries relying on the network.

Through operational efficiencies, reduced variable costs, sustainable net-positive energy production, and dynamic uses of space and system infrastructure, the Hyperloop system enables an affordable travel experience throughout the connected region.

The Hyperloop, similar to other transportation projects, will have various economic impacts such as employment, productivity, business activity, property values, investment, and tax revenues for communities; and will also improve accessibility and reduce transportation costs, allowing individuals to have improved access to education, employment, and services. Unlike other transportation projects, the Hyperloop will have transformational impacts on the communities it serves. Table 11-15 demonstrates how transformational the Hyperloop is forecasted to be.

Table 11-20. Potential Socioeconomic and Tax Benefits of Hyperloop

Time Frame	Socioeconomic Benefit	Tax Benefit	Impact (Increase)*
2025 - 2050	Employment		931,745 persons/yr
2025 - 2050	Income		$47,577 M
2025 - 2050	Property Value		$74,842 M

2025 - 2050		Local Income Tax	$2,021 M
2025 - 2050		Federal Income Tax	$9,401 M
2025 - 2050		Property Tax	$1,273 M

*Great Lakes Feasibility Study

Increase in income equals twice the capital cost of the project, property value increase equals three times the capital cost of the project and expanded tax base equals 50 – 55 percent of project capital costs.

The construction of a Hyperloop system will also create significant temporary construction employment while the project is built. This will include the following jobs:

- Construction labor (civil engineers, skilled trades, laborers)
- Manufacturing labor (equipment, vehicles)
- Financial labor (financial, bankers)

The Hyperloop, with speeds up to 760 mph, will have a significant property development potential. Table 11-16 provides details for the property value improvement that is forecasted to be realized from the Hyperloop.

Table 11-21. Property Value Improvement at Hyperloop Stations

Station Name	Property Value Improvement 2020~2050 (million $)*
Chicago-Downtown, IL	27,112
Chicago-Airport, IL	6,933
South Bend, IN	5,457
Toledo, OH	5,169
Hopkins Airport, OH	3,037
Cleveland, OH	12,257
Youngstown, OH	2,994
Pittsburgh, PA	11,882
Total	**74,842**

*Great Lakes Feasibility Study

The Hyperloop is forecasted to obtain 25 to 30 percent of the transportation market, and has approximately 30 percent induced demand with 50 percent being diverted from auto. This results in millions of people using the Hyperloop for commuting, business and special occasions. Table 11-17 demonstrates the volume of individuals utilizing the Hyperloop.

Table 11-22. 2030 Hyperloop Station Forecasted Volume (On and Offs)

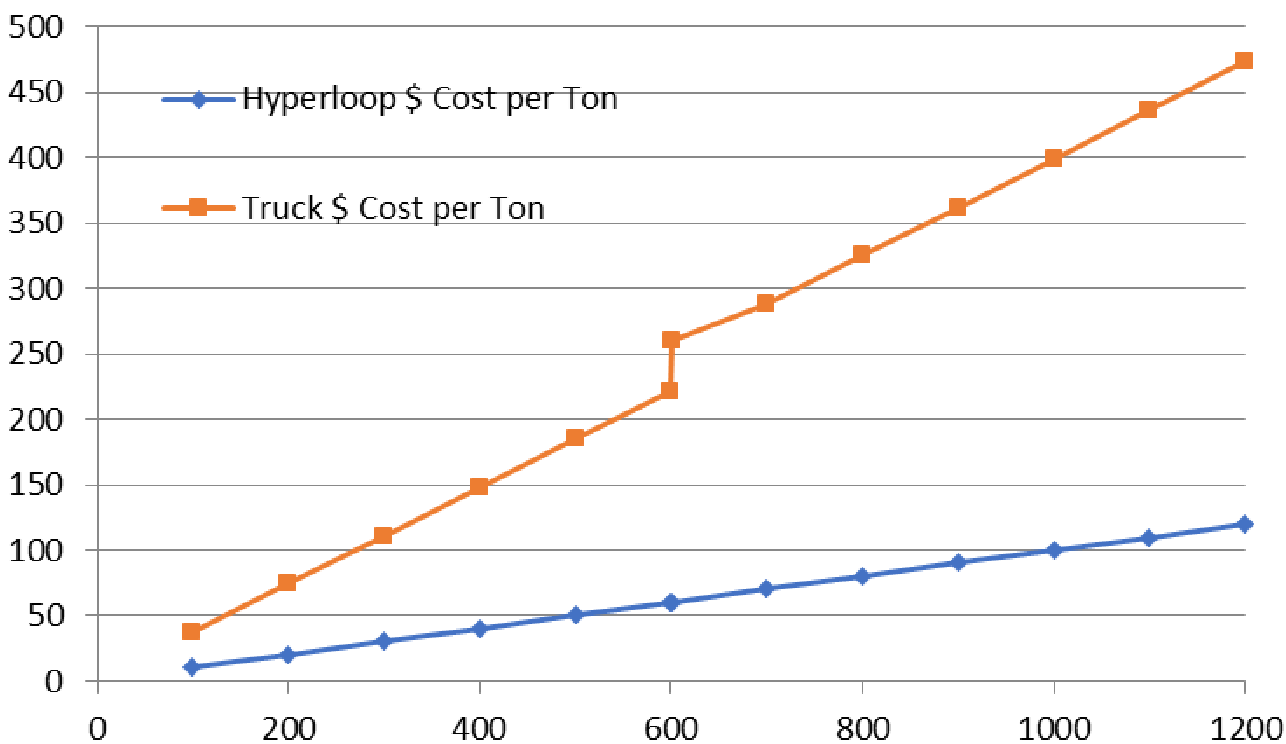
Station Location	Volume (Millions)*
Chicago, IL	6.81
South Bend, IN	3.11
Toledo, OH	2.80

Hopkins Airport, OH	2.11
Cleveland, OH	5.14
Youngstown, OH	1.25
Pittsburgh, PA	6.25

*Great Lakes Feasibility Study

Hyperloop promises to develop a freight service that is faster than truck and cheaper than air, which would undoubtedly position it as a premium freight service. With Hyperloop being cheaper than trucks and faster than air, it would likely become a dominant mode for intercity freight transport rather than just a niche provider of transportation services. Once the Hyperloop becomes a reality, existing logistics patterns will adjust to take advantage of the capabilities of this new mode of transportation. Figure 11-18 depicts the freight cost savings for the Hyperloop over trucks.

Figure 11-18. Hyperloop vs Truck Freight Cost



According to FAF-4 there are 80,000 tons of air cargo moving annually within the corridor, most of that from Cleveland to Chicago. Hyperloop service will be both faster and much cheaper than the existing air service, so a 76% market share has been projected.

The LTL ground express market is much larger, consisting of 2.09 million tons of express cargo in 2022. Of this, Hyperloop is forecasted to capture a 52% share, which results in 1.08 million tons of freight captured by the Hyperloop system in 2022, which is the first year of operations in the feasibility study analysis.

The overall freight tonnage therefore is 1.14 million per year which is 52% of the overall express freight that will be available in the Chicago-Cleveland-Pittsburgh corridor by 2022. It is clear that most of this volume would be attracted from ground LTL freight. If the corridor were longer than it is, then the Air Cargo share of freight might be expected to increase.

This forecast grows by 4% for LTL traffic and by 5% for Air Cargo tonnage every year.

Environmental Sustainability

Air pollution is the fourth leading risk factor for premature deaths worldwide. Motor vehicle air pollution (whose pollutants include ozone, particulate matter and total suspended particulate, sulfates, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead) contributes to various health problems including cancer, cardiovascular and respiratory diseases, chronic diseases like diabetes, preterm birth, diseases of the central nervous system, dementia, decreased cognitive function, and perinatal mortality.

The Hyperloop system accelerates the shift toward renewable electrification of transportation while preserving local ecosystems and utilizing low impact processes and structures. Surface-level or subsurface iterations of the Hyperloop system disturbs fewer habitats and requires less natural space to operate than road or air facilities.

The Hyperloop system reduces CO2 emissions by 143 million tons[1], while facilitating shifts away from key emitters of carbon dioxide like electricity-generating plants and petroleum-powered vehicles. Creation of ultra high-speed travel along the corridor could lead to a shift among consumers from current modes of transportation between connected cities and toward faster and cheaper alternatives. Likewise, as passengers and goods travel through the system, congestion in surface-level facilities, and therefore pollution, will decrease from the displacement of trucks, trains, and people moving along the corridor.

Safety

Transportation systems are most effective when safety is engineered at the earliest stages, and not as an afterthought in the design process. The Hyperloop system is designed around creating the safest mode of transportation possible. During the early phases of designing the Hyperloop systems, redundant safety measures were designed to ensure additional layers of protection. In addition, longer headways are planned for initial rollouts of the system, which will be reduced over time along with increased capacity as operational experience and service data are available.

The vast majority of transportation-related accidents are related to human error; as the Hyperloop system operates autonomously, the system is substantially safer. The enclosed tube system isolates the capsule from obstacles and outside conditions including weather, traffic, pedestrians, and wildlife. The low-pressure tube environment provides a natural fire-resistive separation that is superior to other forms of transportation. Removing obstacles from the guideway reduces risk factors from collisions at high speeds. Likewise, operating in all weather conditions provides reliable and consistent connections during inclement weather and peak traffic conditions.

The elevated tube or subterranean design eliminates travel conflicts with other modes of transportation. Subsurface operations provide additional isolation from transportation systems operating on the surface level. Public transit and transit oriented development create safer communities by implementing human design elements into the framework of the community. As these developments reduce reliance on single occupancy vehicles, creation of Hyperloop facilities could bolster safety by enabling less interactions with other transportation systems.

[1] https://www.glhyperloopoutreach.com/feasibility-study

The Hyperloop will integrate engineering, operations, and safety concepts from aviation and highway, as well as from rail. This is why the Hyperloop has been called a “fifth mode” of transportation, since it doesn’t fit neatly into any of the pre-established models, but rather it integrates design and operational concepts from a number of different pre-existing modes. So many of Hyperloop’s concepts are not really new, but rather integrate already proven technologies in a new way.

Next Steps/Implementation Strategies

The Feasibility Study for the Great Lakes Hyperloop revealed positive financial and cost benefit results creating a strong case for developing the corridor connecting Chicago, Cleveland and Pittsburgh as a passenger and freight system. As a result of these positive findings the Preliminary Development phase becomes the next necessary step forward in the project development process.