Chapter 11: eNEO2050 Final Plan

Summary

The backbone of eNEO2050 is a hybrid scenario including specific projects from the discussed and evaluated four scenarios. These projects are from four categories of “Roadway”, “Transit”, “Non-Motorized Facilities” and “Emerging Technology in Transportation. The list of projects and their planned implementation decades of each project are illustrated in this Chapter. The scenario effectiveness based on the selected performance measures are evaluated by comparing 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 projects costs which produced an acceptable level of economic return indicator.

Rest of this Chapter introduces the new eNEO2050 projects with some 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.
- **Ramp Metering:** As the CMP objectives and based on the bottleneck studies, enEO2050 proposes three ramp metering locations.
- **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:** A Systemic Safety Management program as a complement to the existing NOACA safety program is introduced. This is a proactive and community-based approach to safety issue and a biennial safety community reports for each community in the NOACA region will be produced for updating the road inventory and crash data at the community level.
- **Pavement and Bridge Maintenance Management:** NOACA Pavement preservation plan based on the Maintenance & Rehabilitation (M&R) program is described and then applied to maintaining the average pavement condition rating at 75 during the period of 2020 - 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 is currently developing a new pedestrian and bicycle plan, called ACTIVATE. This plan will include 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:** Although the rail network expansion did not satisfy the fiscal constraints but Scenario 4 (TOTAL) including this expansion had the highest measure of effectiveness therefore the eNEO2050 maintain this project as a fiscally unconstraint for the future plan amendments.
- **Illustrative Project:** Hyperloop is an illustrative project of the eNEO2050 plan.

The Journey

The journey of developing eNEO2050 Long Rang Plan (LRP) began four 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

Overview

This section introduces the eNEO2050 scenario and the list of its projects and the planned implementation decades of those projects. The 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, but they fill in the details of the outlined picture of the eNEO2050 plan. Each section describes some important projects of each category.

In the 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 none of three scenarios produced an acceptable level of economic return indicator. Therefore, the following hybrid scenario as the eNEO2050 scenario was developed. 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	Decades		
		2020 - 2030	2030 - 2040	2040 - 2050
Objectives: Workforce Accessibility and Mobility				
Improve Average Auto and Transit Commute Times to Major Job Hubs	1			
Reducing Average Auto Commute time to Major Job Hubs to 30 minutes	2			
Reducing Average Transit Commute Time to Major Job Hubs to 45 minutes	3			
Roadway				
Implementing 2024 TIP Highway and Transit Projects	All Scenarios	■		
Implementing Major Highway capacity Projects	2	■	■	■
Adding Harper Road, Jackson Street, Miller Road, and Granger Road Interchanges	2	■	■	
Reducing Highway Bottlenecks	2	■	■	■
Regulating Flow of Traffic Entering Freeways by Adding Ramp Meters	2	■	■	■
Reinvigorating Arterial Network	2	■	■	■
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	Decades		
		2020 - 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 Great Lakes Hyperloop	3 & 4	■	■	
Maintain Transit Vehicles in the Good State in the end of each Decade	2	■	■	■
Maintain Transit Vehicles Serving the EJ Areas in the Good State all the times	2	■	■	■
Non-Motorized Facility				
Creating Walk and Bike Access from EJ Areas to Transit Network	3	■	■	■
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	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 were 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 eNEO2050 scenario is evaluated based on those performance measures. Table 11-2 displays the eNEO2050 performance measure values and compared them with those of the current base year of 2020 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 that highlighted in green should have higher values in order to be more effective. In contrast, the performance measures that highlighted in brown should have lower values in order to be more effective.

Table 11-2. *eNEO2050* Performance Measures

Performance Measure	2020 Base	Scenario 1	eNEO2050 Scenario
Population in 15 Minutes Walk to any Transit Stop	68%	65%	68%
EJ Workers in 15 Minutes Walk to any Transit Stop	89%	88%	88%
Number of Jobs within 15 Minutes Walk egress from any Transit Stop	78%	77%	78%
Population in 5-Mile Drive Access to Freeway System	92%	91%	91%
Annual Transit Ridership (Including Transfer Trips) – Million Person Trips	40	38	55
Non-Single Occupancy Vehicle Work Commute during a Typical Morning Peak Period	16%	16%	17.66%
Average Highway Network Pavement Condition Rating (PCR)	75.0	80	87.1
Daily Vehicular Trip Share of Autonomous, Electric Cars and Trucks	0.16%	19%	31%
Total Annual Vehicle Miles Traveled per Capita	7,345	7,946	7,902
Total Annual Freeway Delay per Capita (in Hours)	6.63	7.11	6.00
Total Annual Principal Arterial Delay per Capita (in Hours)	6.64	7.2	6.7
Annual Person Hours of Excessive Delay per Capita (in Hours)	23.04	24.89	21.06
Average Auto Work Commute Time to All Major Job Hubs (in Minutes)	38.2	37.7	37.7
Average Transit Work Commute Time from EJ neighborhoods to All Major Job Hubs (in Minutes)	60.9	60.4	56.8
Average Work Commute Time for Households with Zero Cars (in Minutes)	43.25	42.88	41.82

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

Performance Measure	2020 Base	Scenario 1	eNEO2050 Scenario
Maximum Level of Travel Time Reliability (LOTTR)*	1.48	1.52	1.52
Maximum Truck Travel Time Reliability (TTTR)*	1.83	1.83	1.90
Annual Congestion Cost per Capita (2050$)	739	821	684
Estimated Fatalities (Based on 2019 Crash Data and Annual 2% Reduction)	138	75	75
Estimated Serious Injuries (Based on 2019 Crash Data and Annual 2% Reduction)	1,307	713	713
Estimated Non-Motorized Fatalities and Serious Injuries (Based on 2019 Crash Data and Annual 2% Reduction)	167	91	91
Daily Volatile Organic Compounds (VOCs) (in Tons)	25.51	9.25	9.2
Daily Nitrogen Oxides (NO_x) (in Tons)	18.35	8.34	8.29
Annual Direct PM (in Tons)	565.09	209.65	208.49
Structurally Deficient Deck Areas of NHS Bridges	1.77%	1.77%	1.77%
Structurally Deficient Deck Areas of All Bridges	6.57%	6.57%	6.57%

Note: LOTTR values are estimated as the ratio of 80th percentile and 50th percentile of all the inter-zonal travel times.

Note: TTTR values are estimated as the ratio of 95th percentile and 50th percentile of all the inter-zonal travel times.

The Measure of Effectiveness (MOE) for the eNEO2050 scenario 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.

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

Scenario	Ratio of Estimated SMOE
1: MAINTAIN	1
eNEO2050	3.65

Table 11-4 displays the NPV (2020$) of estimated total project costs of the eNEO2050 scenario by project category.

Table 11-4. NPV (2020$) of Estimated Total Project Costs by Project Category *eNEO2050* Scenario

Project Category	Net Present Value of Project Costs (2020$) Billions	Percent of the Total NPV (2020$)	Aggregated Annual Project Costs Total Dollars for Period of 2021 – 2050 in Billion
Roadway	$9.611	72%	12.154
Transit	$2.812	21%	3.776
Non-Motorized Facility	$0.540	4%	0.694
Emerging Technology	$0.452	3%	0.716
Total	**$13.415**	**100%**	**17.340**

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

Table 11-5. Percent of the Additional eNEO2050 Scenario 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	4.54%	1
eNEO2050	14.5%	3.19

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

Scenario	SMOE Value Relative to Scenario 1 SMOE	Specific Project Cost Quotient Values	Ratio of SMOE Values and Corresponding Costs
1: MAINTAIN	1.00	1.00	1.00
eNEO2050	3.65	3.19	1.15

Chapter 9 discussed the ratio of SMOE and corresponding value as an economic return indicator. According to Table 11-6, the eNEO2050 scenario economic return is 1.15 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 4 modifications to existing interchanges and 4 new interchanges are assessed for inclusion into 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 do 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 *eNEO2050* plan to evaluate it.

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

Figure 11-1. Influence Subarea of the Proposed Interchanges

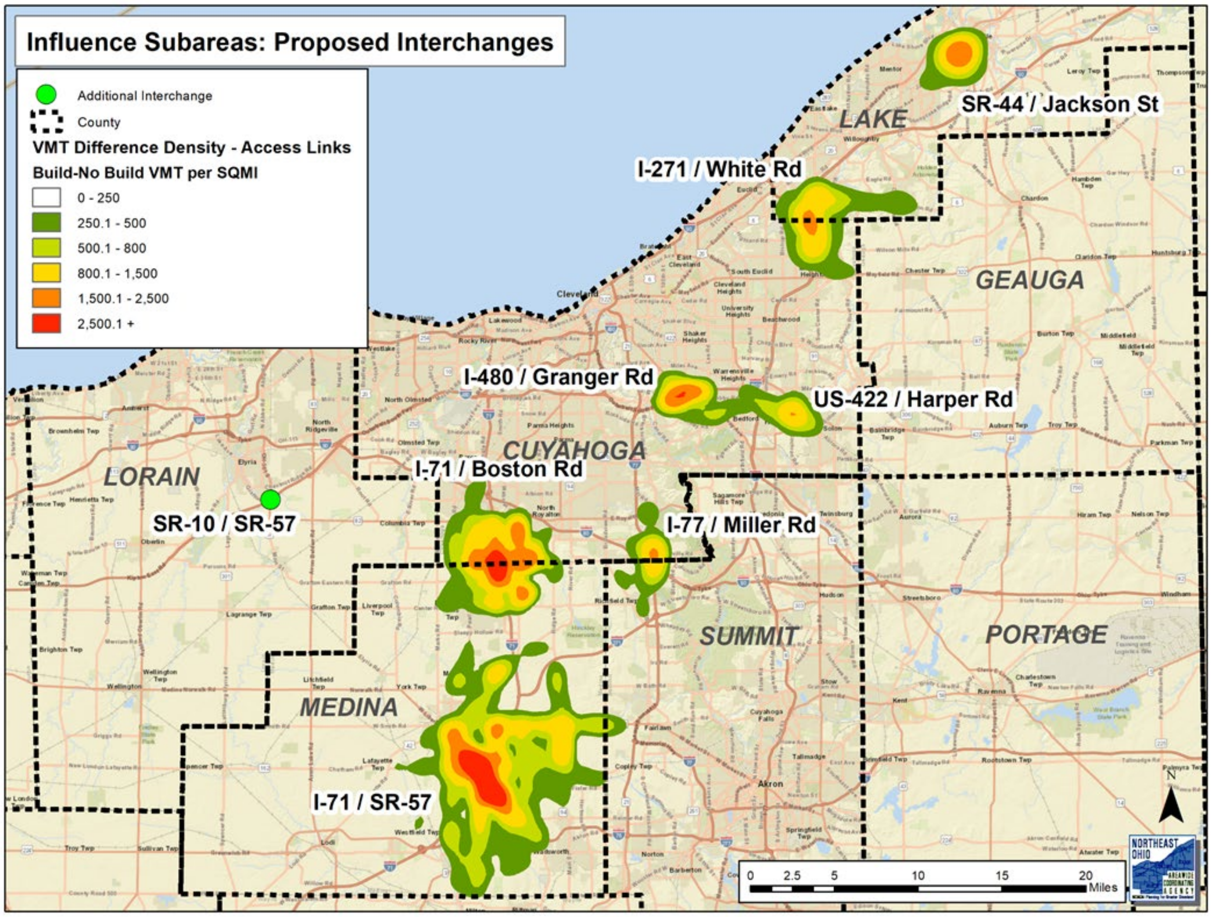


Figure 11-2 shows the cost items and procedure of the “Cost-Benefit” analysis.

Figure 11-2. Cost-Benefit Analysis Procedure

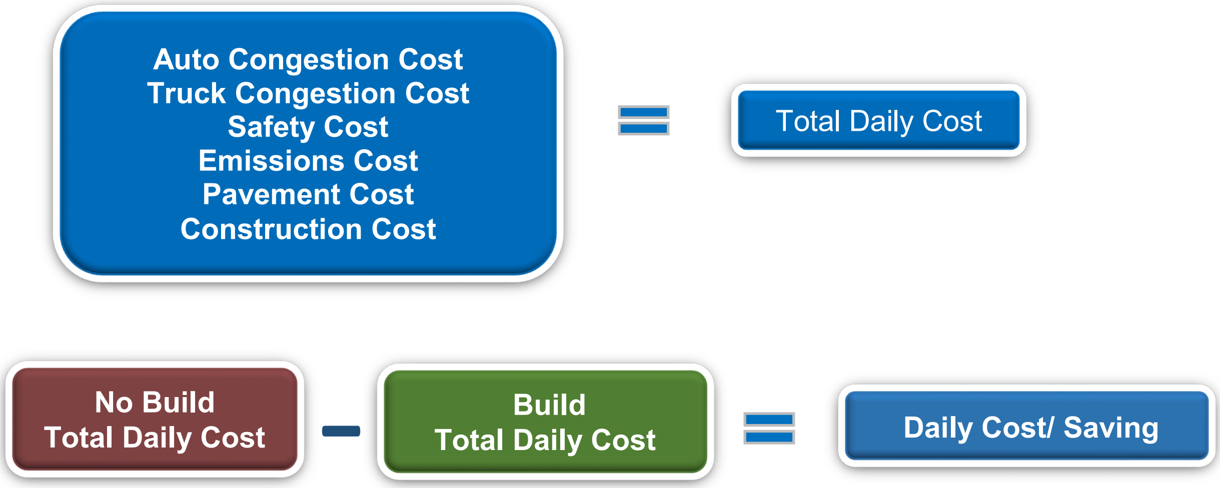


Table 11-7 shows the “Cost-Benefit Analysis” results for the influence subarea proposed interchanges.

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 as 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 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 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 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 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, but the difference is within the margin of error therefore the Miller Road interchange modification fully satisfies the “Cost-Benefit” Criteria.

Evaluation 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 and intends to integrate effective management and safe operation of the existing multimodal transportation facilities.

The CMP is intended to be an on-going process and fully integrated into the LRTP of 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 persons 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 planning decades for the NOACA congestion management are 2020 -2030, 2030-2040, and 2040-2050 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 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 also are the continuation of the prior planning decade 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 11-3 depicts the relation between the congestion management objectives and eNEO2050 goals and objectives.

Figure 11-3. Congestion Management Plan Objectives and eNEO2050 Goals and Objectives Relation

The congestion management plan objectives has been developed based on the following guidelines;

- Reduce average delay per traveler during peak periods,
- Increase the percent of non-single occupancy vehicles,
- Regulate the flow of traffic entering freeways,
- Increase 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 decade of 2020-2030, 2030-2040, and 2040-2050.

Table 11-10. Congestion Management Objectives

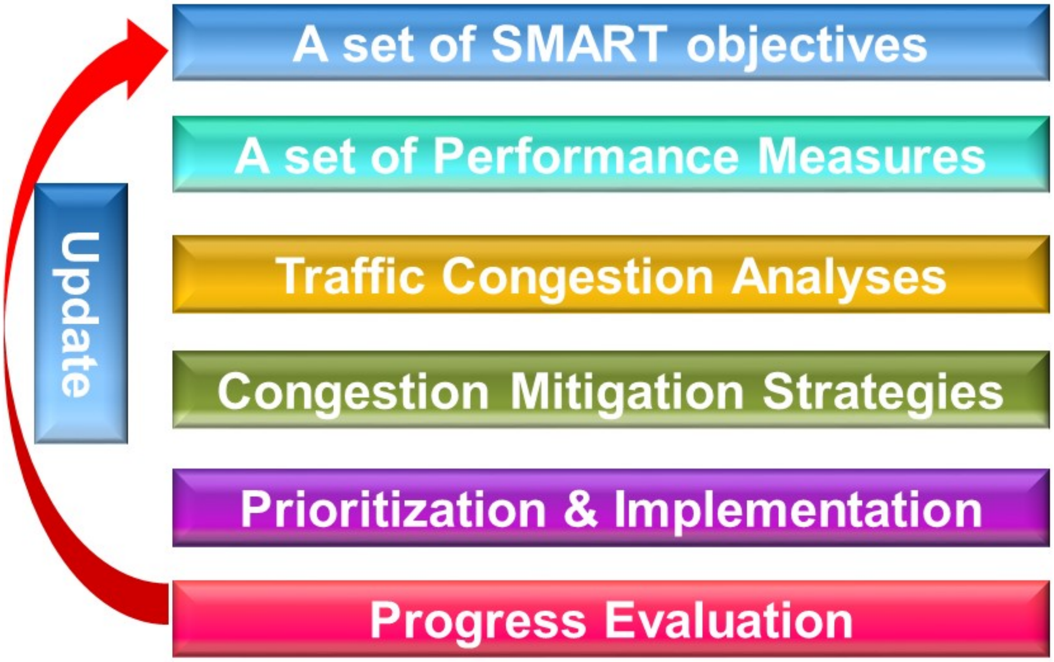
Objective/Planning Decade	2020 Base	2020 - 2030	2030 - 2040	2040 - 2050
Reduce Total vehicle delay during a typical AM and PM peak periods	**109,000 Hours**	Decrease by 2%	Decrease by 4%	Decrease by 6%
Increase the Percent of Non-Single Occupancy Vehicle Work Commute during the Morning Peak Period	**16%**	Increase by 2%	Increase by 4%	Increase by 6%
Reduce Average Auto Work Commute Time to Regional Major Job Hubs During the AM Peak Period	**38**	Reduce to 35 Minutes	Reduce to 33 Minutes	Reduce to 30 Minutes
Reduce Average Transit Work Commute Time to Regional Major Job Hubs During the AM Peak Period	**61**	Reduce to 55 Minutes	Reduce to 50 Minutes	Reduce to 45 Minutes
Implement Signal Timing Optimization Program (STOP)	**2**	At least ten Corridors in each decades		
Implement ramp metering	**None**	At least one location in each planning Decades		
Implement Diverging Diamond Interchange (DDI)	**None**	One Location in each planning Decade		
Percent of Population within 5-Mile Drive Access to a P&R Station	**70%**	Increase to 71%	Increase to 73%	Increase to 75%
Percent of population within 15 Minutes Walk Access to a transit Station	**68%**	Increase to 70%	Increase to 72%	Increase to 75%
Total of Transit & non-motorized AM Work Commute shares	**6.3%**	Increase to 7%	Increase to 9%	Increase to 11%

As discussed, the congestion management plans lay out the objectives for each decade cycle and in order 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 11-4 illustrates the cyclical nature of the congestion management process.

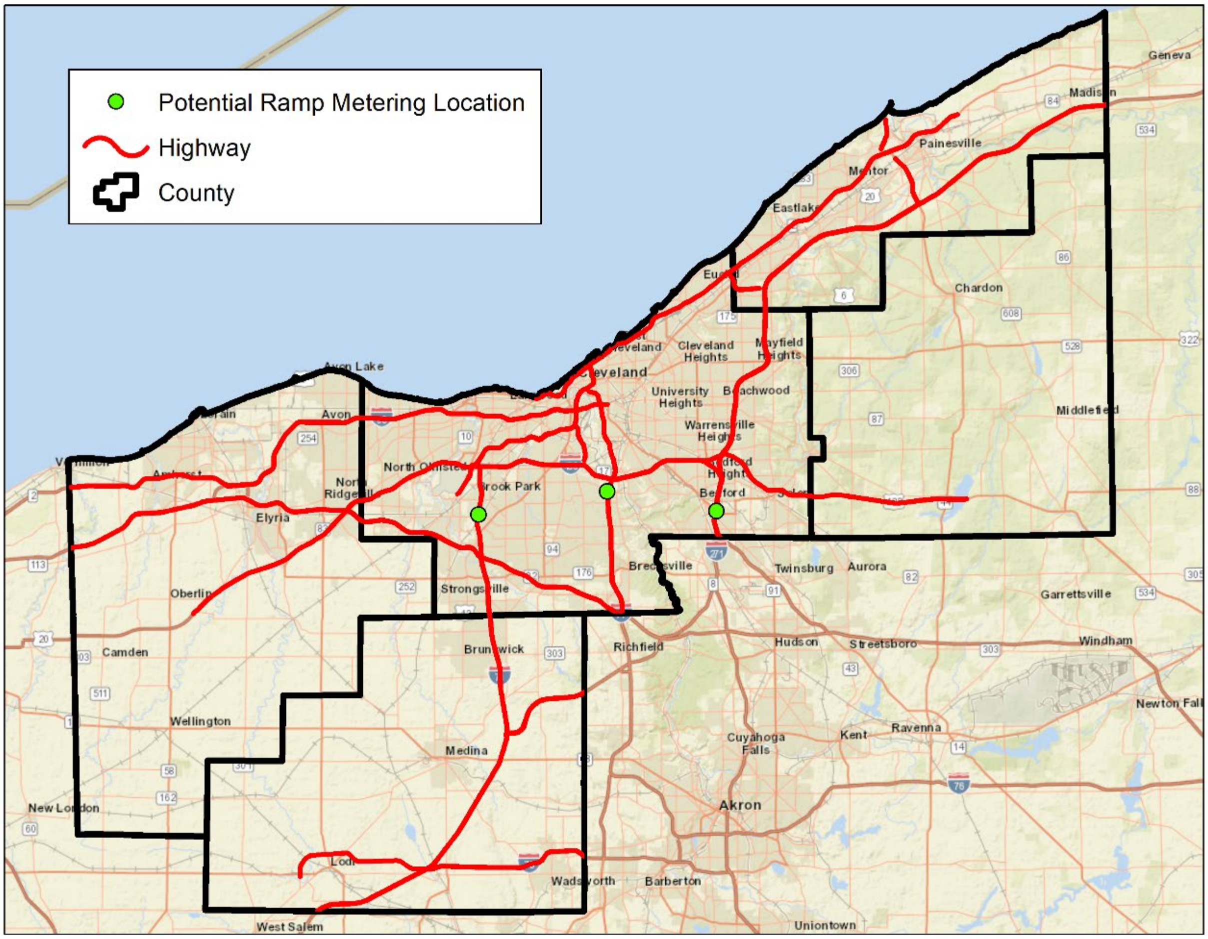
Figure 11-4. Congestion Management Process



Ramp Metering

The roadway category projects of eNEO2050 scenario included ramp metering and based on the bottleneck discussion in Chapter 3, three locations were identified and examine during the scenario simulation. Figure 11-5 displays the proposed locations of the ramp meters.

Figure 11-5. The Locations of the Proposed Ramp Meters



Principal Arterial Network

As discussed in Chapter 3, the principal arterial network plays an alternative role to the existing freeway system in reducing traffic congestion. 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). Chapter 3 illustrated 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, signal density attribute was given the highest weighting factor so that corridors with very high signal density 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 shows the attribute weighting values for the corridor prioritization in STOP and major transit corridors.

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

Signal Density	Crash Density	Freight-Miles Traveled	Person-Miles Traveled	All User Delay	Bus-Miles Traveled	**Total**
50	5	5	10	20	10	**100**

Table 11-12. 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.

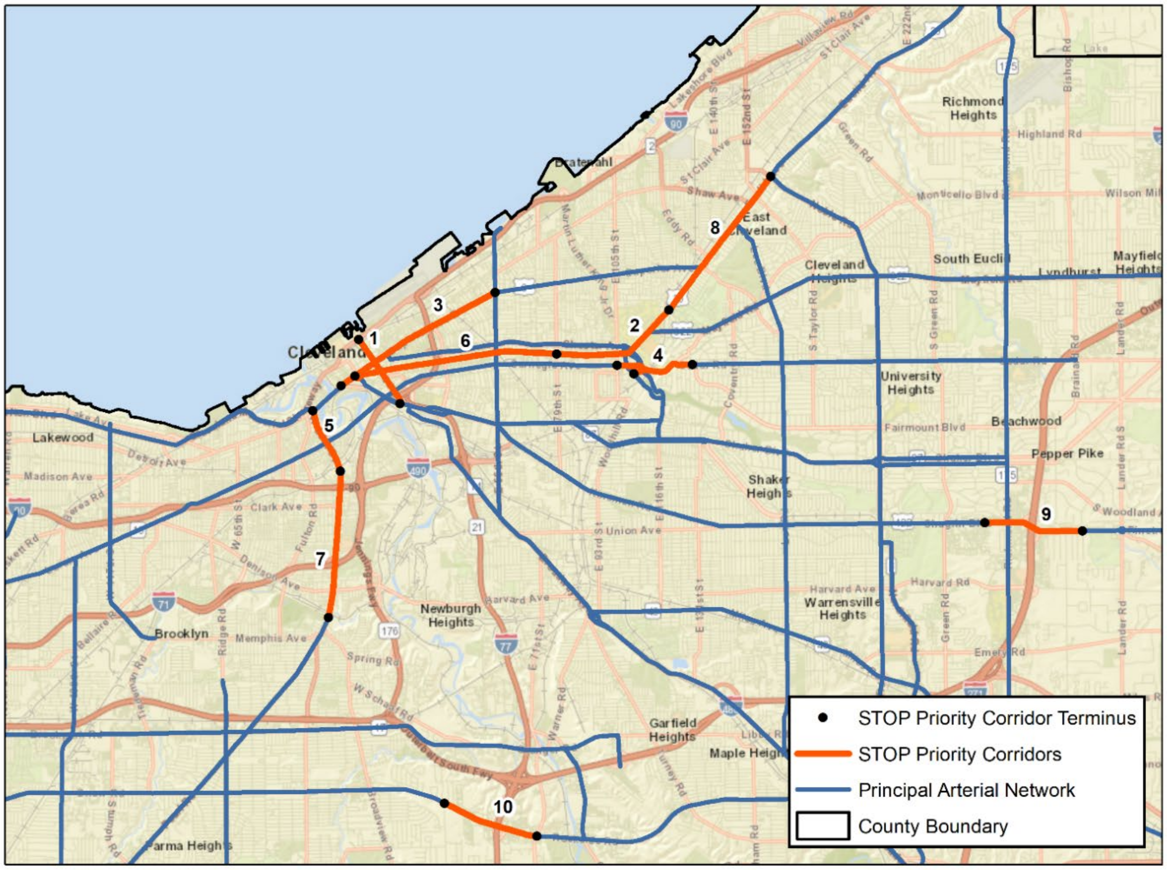
Signal Timing Optimization Program (STOP)

As discussed, Table 11-8 shows the “Top 10” priority list for implementaing STOP projects. Also Figure 11-6 displays the locations of these corridors in the principal arterial network.

Table 11-13. “Top 10” Priority Corridors for STOP Projects

Street Name	From	To	Rank
East 9th Street	State Route 2	Ontario Street	1
Euclid Avenue	East 79th Street	East 123rd Street	2
Superior Avenue (US 6)	West 9th Street	East 55th Street	3
Carnegie Avenue / Cedar Road	East 105th Street	Fairmount Blvd	4
West 25th Road (US 42)	I-90 (Potter Ct)	Detroit Avenue	5
Euclid Avenue	Superior Avenue	East 79th Street	6
Pearl Road / West 25th Street (US 42)	Broadview Avenue (Brookside Park Dr.)	I-90 (Potter Ct)	7
Euclid Avenue	East 123rd Street	Noble Road	8
Chagrin Blvd.	West of Richmond Road (Commerce Park)	Belmont Road	9
Rockside Road	Crossview Road	Brecksville Road	10

Figure 11-6. Locations of the "Top 10" Priority Corridors for STOP Projects



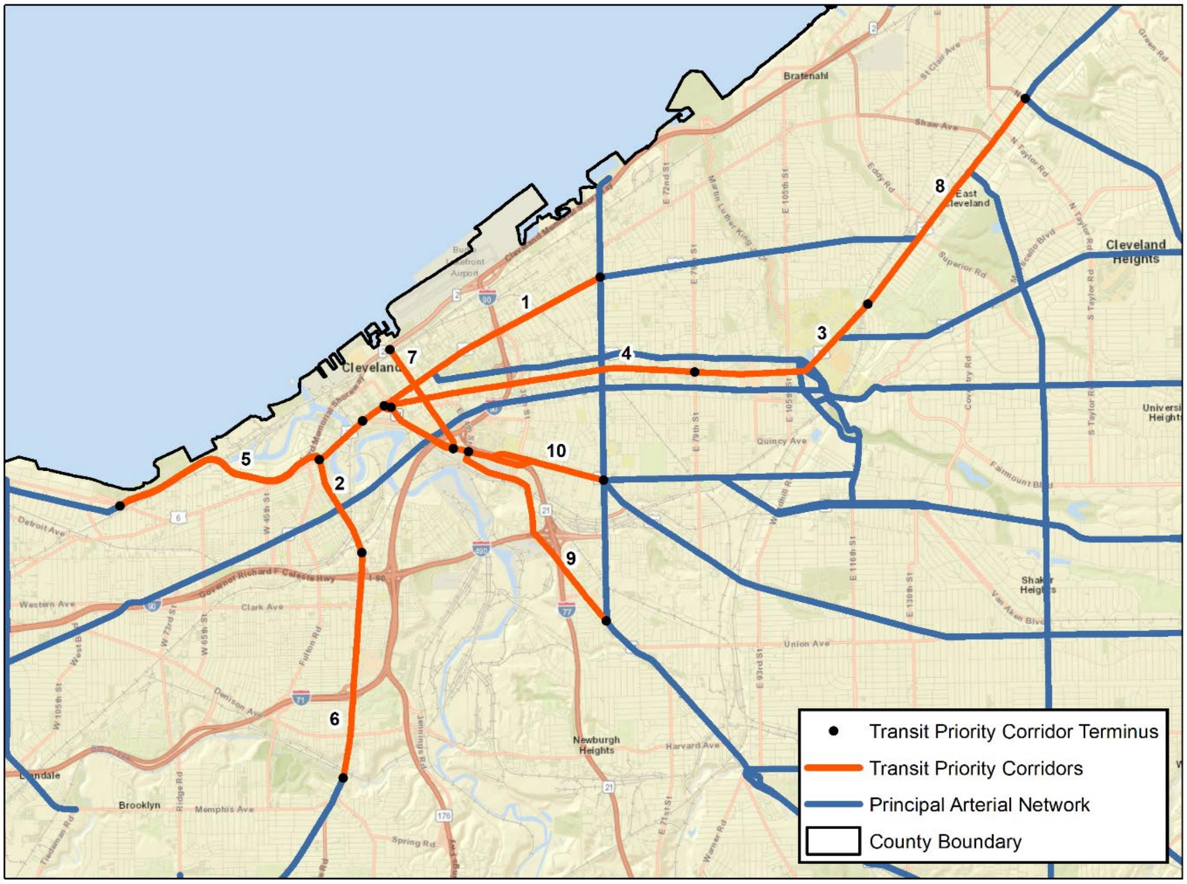
Main Transit Corridors

Similar to STOP corridors, Table 11-9 shows the "Top 10" priority list of Transit corridors. Also Figure 11-7 displays the locations of these corridors in the principal arterial network.

Table 11-14. "Top 10" Priority Corridors for Transit

Street Name	From	To	Rank
Superior Avenue (US 6)	West 9th Street	East 55th Street	1
West 25th Street (US 42)	I-90 (Potter Ct)	Detroit Avenue	2
Euclid Avenue	East 79th Street	East 123rd Street	3
Euclid Avenue	Superior Avenue	East 79th Street	4
Clifton Road /W. Shoreway / Superior Avenue	Lake Avenue	West 9th Street	5
Pearl Road / West 25th Street (US 42)	Broadview Avenue (Brookside Park Dr.)	I-90 (Potter Ct)	6
East 9th Street	State Route 2	Ontario Street	7
Euclid Avenue	East 123rd Street	Noble Road	8
Broadway Road (State Route 14)	Orange Avenue	East 55th Street	9
Ontario Road/ Orange Avenue / Woodland Road (US 42)	Euclid Avenue	East 55th Street	10

Figure 11-7. Locations of the "Top 10" Priority Corridors for Transit



Traffic Safety

Current Safety Improvement Programs

The nationally Vision Zero initiative envisages to have a transportation network with zero deaths or injuries. One of the NOACA's transportation planning goals is to achieve this vision in its five-county region in the future. During the last few years, NOACA has initiated several safety programs such as Transportation Safety Action Plan (TSAP), Regional Safety Program (RSP), Safe Route to School (SRTS), SAVE Plan, etc. to improve the efficiency and safety of transportation system.

Similar to other traditional program, SAVE plan intends to save lives by identifying the high-crash locations and implementing safety treatments at those sites. The SAVE Plan was developed with the vision that traffic deaths and injuries can be prevented with appropriate planning, policies and programs, with a long-term goal of reducing the number of fatalities and serious injuries by 50% by the year 2040.

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.

Systemic Safety Management Approach

Recently, to complement the current safety programs such as SAVE plan, NOACA have incorporated a Systemic Safety Management approach within its safety improvement programs. The Systemic Safety Management approach is used to program implementation of safety treatments at sites that reduce the potential for crashes using Crash Prediction Models. The Systemic Safety Management approach is intended to address 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 identifying where to make safety improvements.

The Systemic Safety Management approach identifies safety projects further into future based on highway, street and intersection characteristics in the absence of high-quality historical site-level crash data.

The NOACA Systemic Safety Management approach is a 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 modification in design or traffic control. CMF is the ratio between the numbers 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) which is a publication of the American Association of State Highway Transportation Officials (AASHTO).

Finally, NOACA is planning to produce biennial safety community reports for each community in the NOACA region.

Pavement, Bridge and Transit Asset Management

Current and Future Pavement Conditions

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 narrative 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.

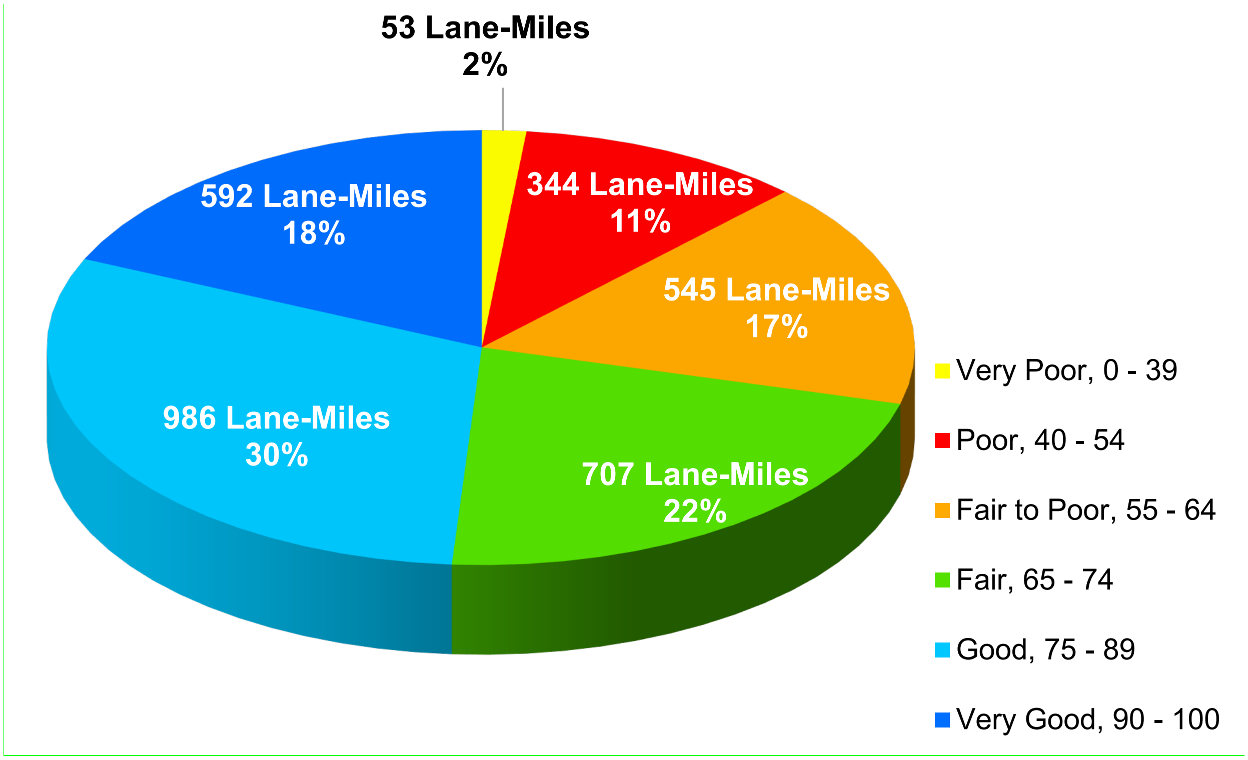
The NOACA region has a total of 3,347 centerline miles of roadways including freeway and federal –aid highways which is equivalent to 8,249 lane-miles. The2020 all road types network weighted lane-mile average PCR weighted lane-mile average is about 75. The similar PCR average for the NOACA Federal Aid Eligible roads is about 73. Although this average indicates a general fair to good pavement condition for the region, but 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.

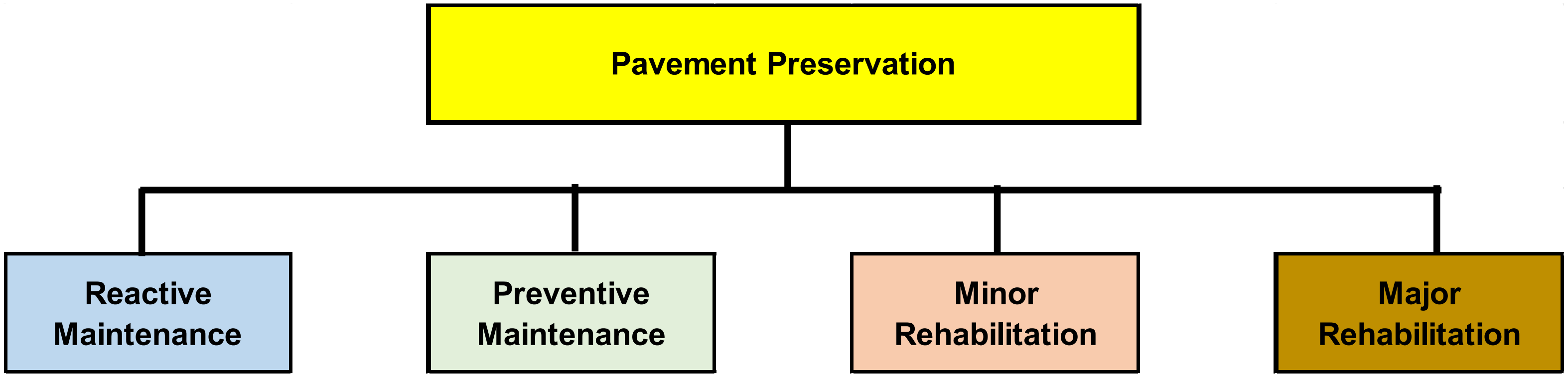
Figure 11-8 displays the 2020 lane miles of PCR categories for the NOACA Federal Aid eligible road system.

Figure 11-8. 2020 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 is 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.

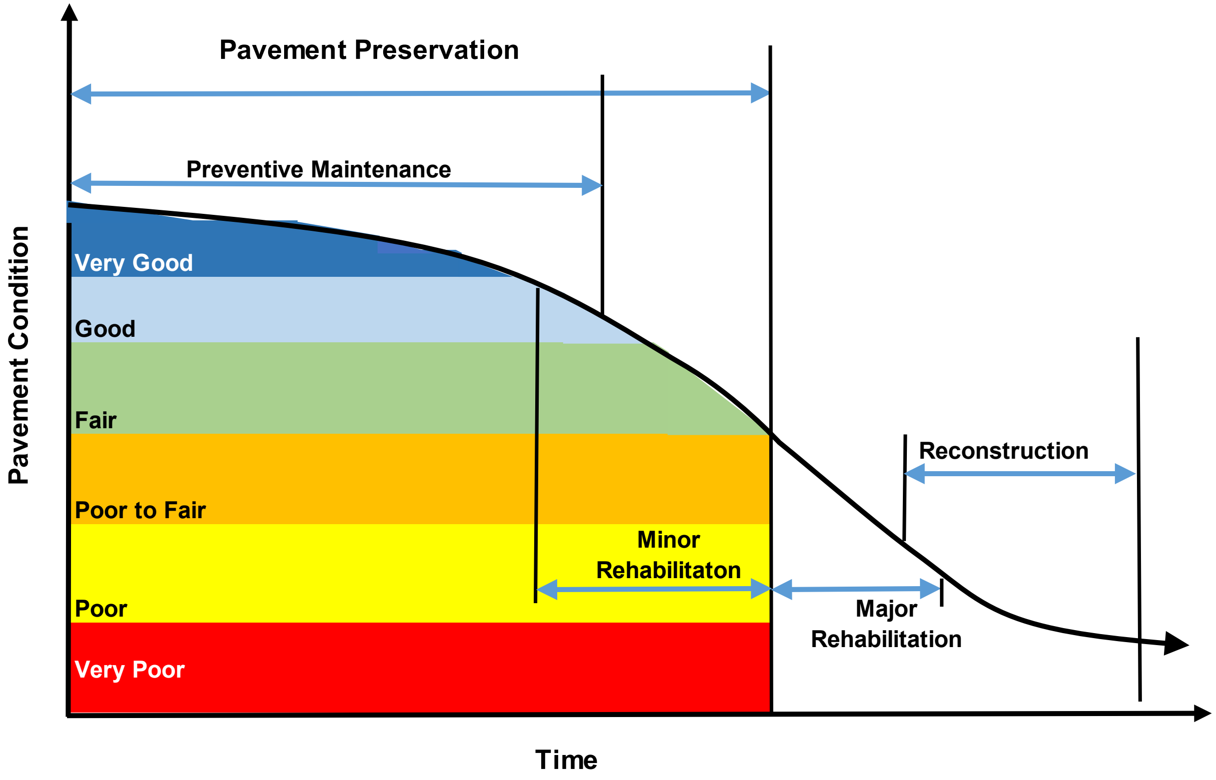
Minor Rehabilitation consists of non-structural enhancements made to the existing pavement sections to eliminate age-related, top-down surface cracking that develop in flexible pavements due to environmental exposure. Because of the non-structural nature of minor rehabilitation techniques, these types 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 recycle materials for the reconstruction of the complete pavement structure.

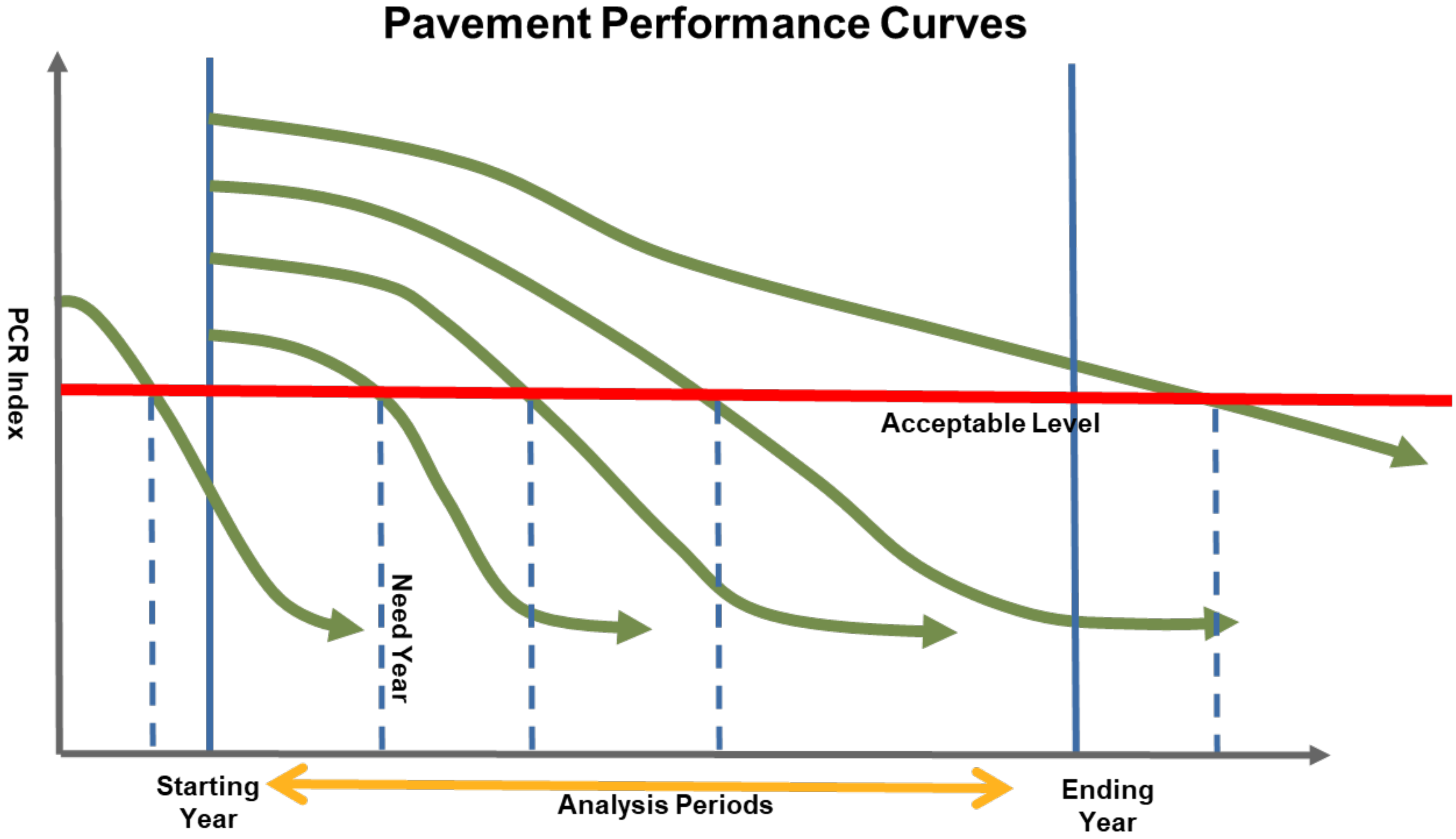
Figure 11-10 illustrates a general schematic for the timing of the pavement preservation Components.

Figure 11-10. A General Schematic for 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. Pavement condition of a road segment deteriorates under 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.

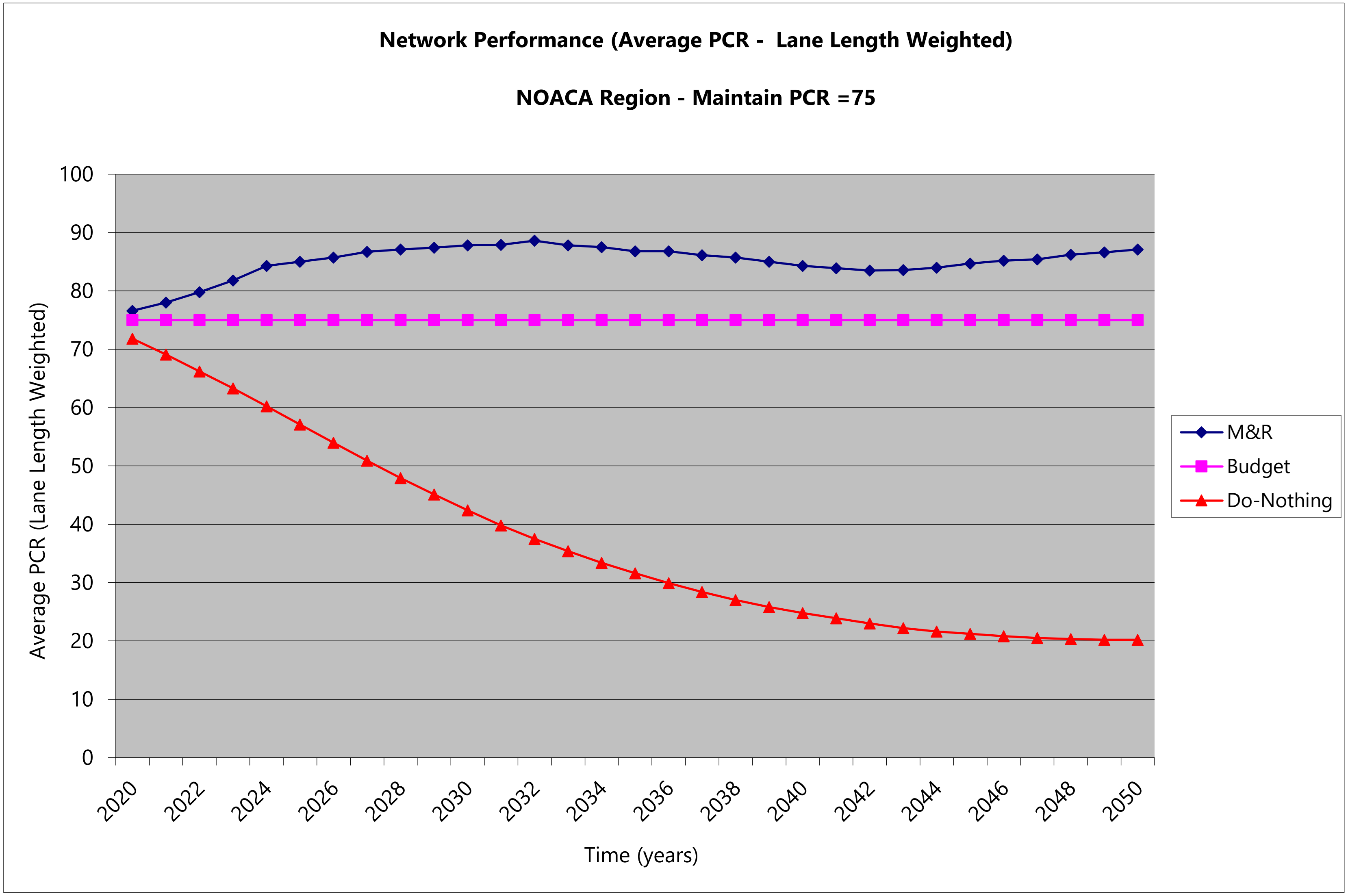
As shown in Table 11-1, eNEO2050 includes maintaining pavement conditions with average PCR of 75. The following paragraphs compare three scenarios of "Budget", "M&R" and "Do-Nothing".

The "M&R" program is applied to the Federal-Aid network including highways and the treatments are applied in their recommended years. The lane-length weighted average PCR would be 85 and at the end of the program, the network PCR would be 87.1 with 0.4% falling below the minimum acceptable PCR. The total required budget is $5.9 billion.

If no rehabilitation is implemented (Do- Nothing), the network is expected to have an average of 37. At the end of the program, the network PCR would drop to 20 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 2020 to 2050. The total required budget is over $14 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; Fair: 6-5; 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. 2020 Bridge Condition Ratings for Bridges in the NOACA Region

Condition Ratings	Condition Description	General Condition	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)	Poor (Structurally Deficient)	6%
5	Fair	Fair	12%
6	Satisfactory		27%
7	Good	Good	31%
8	Very Good		17%
9	As Built		7%

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 service, and the level of traffic demand on these bridges expressed in average daily traffic.

The current total deck areas of all the highway bridges in the NOACA region is over 22.8 million Sq. Ft. 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% (405,152 Sq. FT). The percent of the NHS bridges and bridges on other type of roads is less than 6.6% (1.5 million Sq. Ft).

Bridge Priority Index. There are 196 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 will pass over these bridges expressed in a typical daily Passenger Car Equivalent (PCE) volumes, 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 which 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

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

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 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. Bridge Replacement and Rehabilitation Costs

Bridge Road Type	Replacement Cost (\$/ft^2) (2020\$)	Rehabilitation Cost (\$/ft^2) (2020\$)
NHS	**\$172**	**\$117**
Non-NHS	**\$196**	**\$133**

The required annual budget range is about \$100 to \$150 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 \$20 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

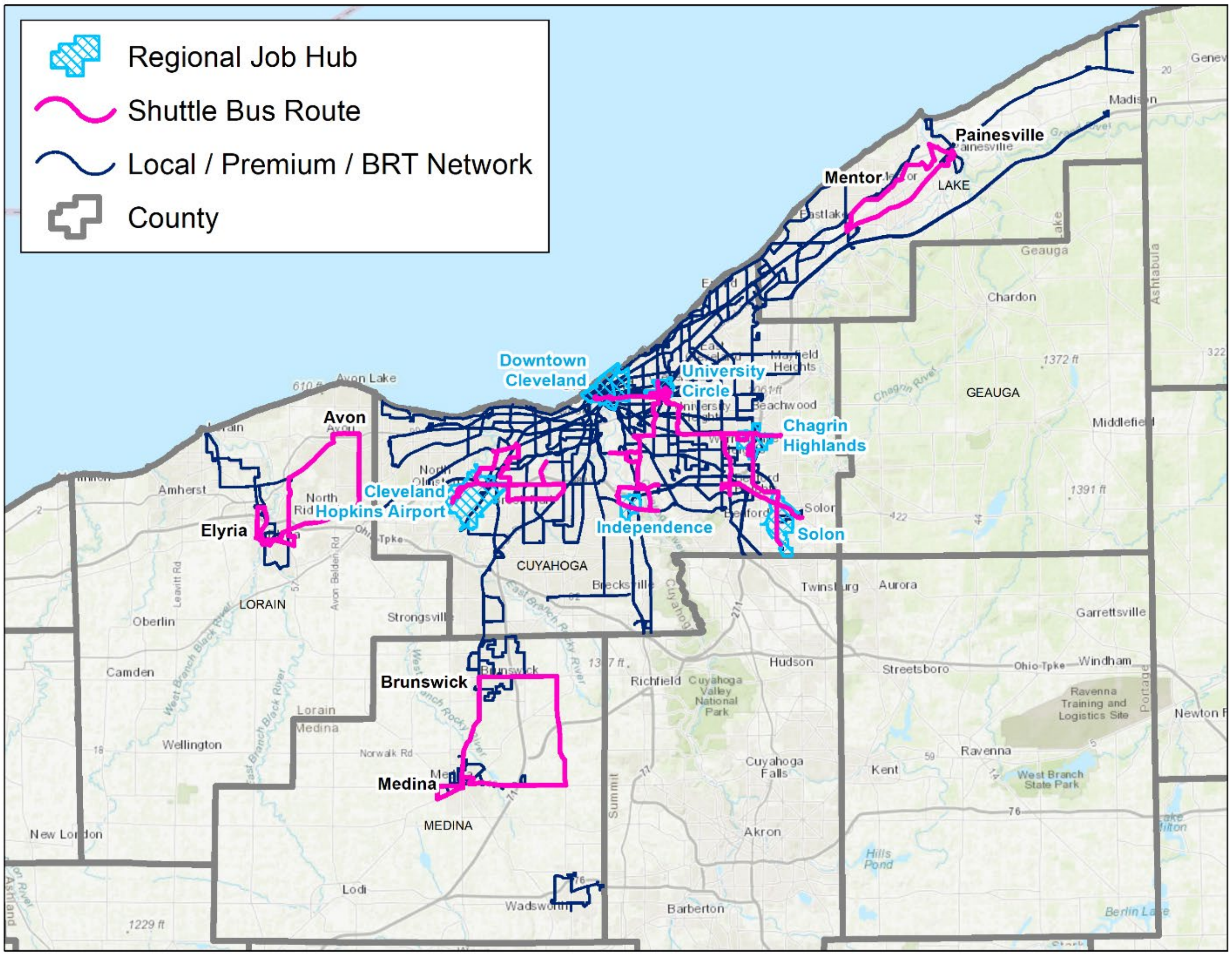
Corridors with higher residential and employment densities are the backbone of the transit network. Rapid transit is most viable at densities of at least 30 units per acre or 50 to 75 employees per acre. To compare, the minimum density for on-street bus service is about 6 to 8 units per acre. Interested 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 make it more apparent. Shortening work travel time not only will benefit commuters, but will also mitigate traffic congestion severity, reduce VMT in the region, lessen stress and load on road pavements and lowers the overall burden on the transportation system. Therefore, success of any future transportation plan depends significantly on reducing travel time and improving safety of the work journeys.

The NOACA Workforce Accessibility and Mobility study indicated that a small portion of EJ area workers live in the reasonable transit commute sheds of the regional major job hubs. The majority of EJ area workers should currently spend more than an hour traveling from home to reach their employment location during the AM peak period.

In order to

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

The eNEO2050 plan recommendations include the following transportation solutions:

<u>Transit Solutions</u>

- 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 densities 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 the northeast Ohio

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

1. Utilitarian trips,
2. Access to transit services, and
3. Recreational pursuits

Trip distance is a well-established determinant of non-motorized travel: 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 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" –"last mile" trips, and those short trips create a complete connection from commuters' 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 11-2 as typical non-motorized facilities and riders should be able to safely and conveniently reach to transit stops via a well-connected system of pedestrian and bicycle infrastructure. Table 11-13 displays the eNEO2050 plan proposal for the non-motorized modes by facility type and implementation decades.

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

Non-Motorized Mode	**2020 - 2030**	**2030 - 2040**	**2040 - 2050**	**Total**
Bike Facility Projects	Miles	Miles	Miles	Miles
Conventional Bike Lanes	17	206	45	**269**
Buffered Bike Lanes	76	7	1	**84**
Separate Bike Lanes / Cycle Track	15	16	0	**31**
All Purpose Trail	205	252	85	**542**
Total Miles	**313**	**481**	**132**	**926**
Bike Storage Lockers (Number)	0	240	0	**240**
	2020 - 2030	**2030 - 2040**	**2040 - 2050**	**Total**
Pedestrian Projects (Number)	Number	Number	Number	Number
Smart Pedestrian Crossing	50	50	0	**100**
ADA Curb Ramp	540	42	0	**582**
High Visibility Crosswalk	5,858	301	0	**6,159**
Pedestrian Signal	4,058	166	0	**4,224**
Midblock Enhancements	89	15	0	**104**
Total Number	**10,595**	**574**	**0**	**11,169**

NOACA is currently developing a new pedestrian and bicycle plan, called ACTIVATE. This plan will provide a vision for increasing the use of bikeways and walkways for transportation and commuting and also serving as a guide for future bicycle and pedestrian improvements. This plan will also include a prioritization model based on a Connectivity Scoring Quantitative System (CSQS) for investing in non-motorized facility for accessing to the transit network.

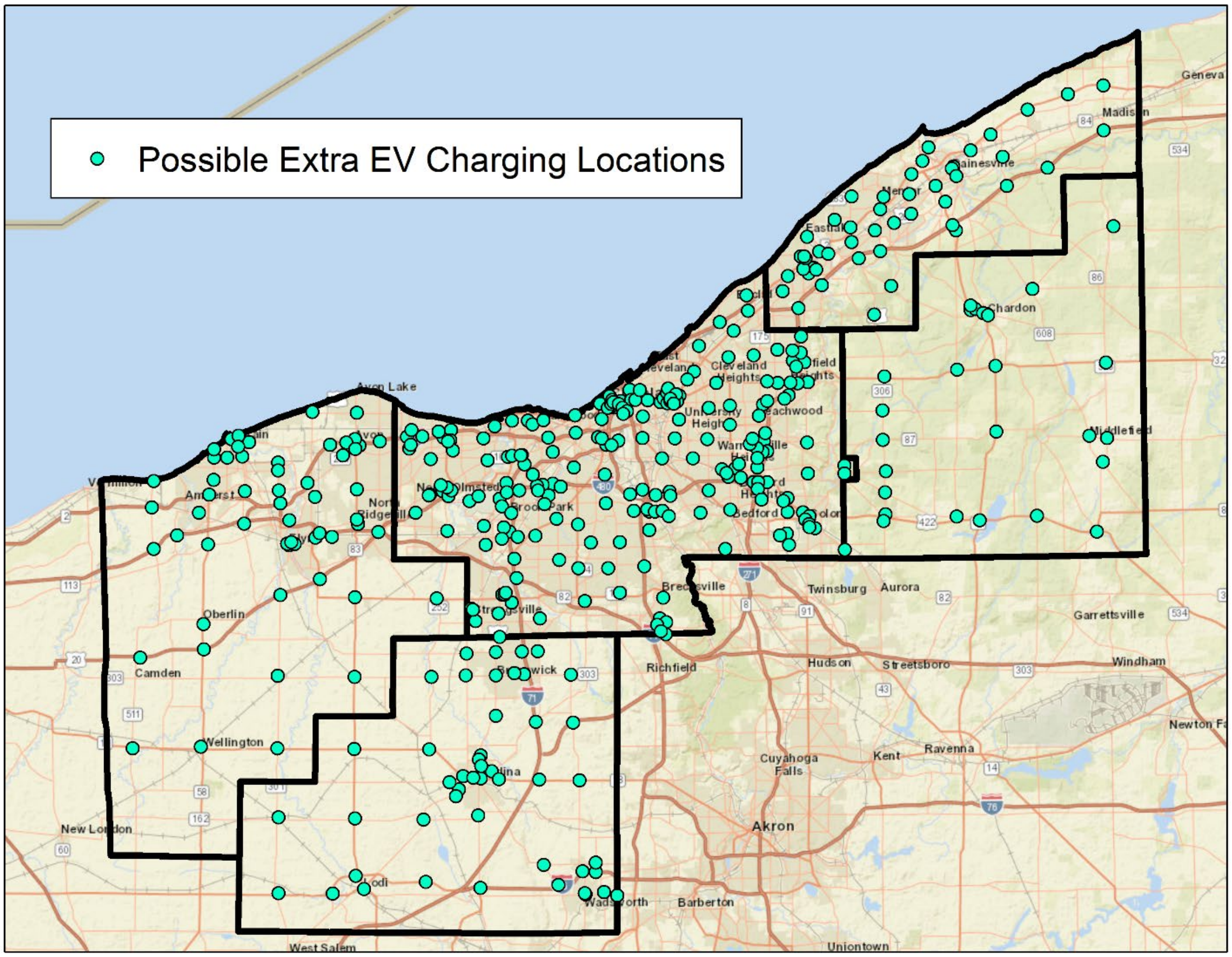
Emerging Technology in Transportation

Electric Vehicles

Future of Charging Stations

The charging station sites for Electric Vehicles (EV) is 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 be neither adequate nor a strong reinforcement for the expected EV growth in the next three decades. Similar to location distribution of fuel stations for the conventional Internal Combustion Engine Vehicles (ICEV), the EV charging port location 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



Air Quality and Climate Benefits of Electric Vehicles (EVs)

As projected in Chapter 9, there will be about 144,000 Electric vehicles in the NOACA region by 2050. Evaluating a future with 144,000 electric vehicles (EVs) on the roads in the NOACA region by 2050, includes estimating the potential benefits for air quality. As noted in Chapter 8, EVs have no tailpipes and therefore do not emit any exhaust emissions into the environment. While the lifecycle emissions of EVs are contingent upon how the electricity they utilize is generated, even an EV that uses electricity from a grid powered by fossil fuels results in a net benefit for local air quality and overall climate health, when compared to a conventional ICEV. In addition, shifting emissions from the tailpipe to a power plant's smokestack provides immediate benefits from a public health perspective, as vehicle exhaust tends to occur in closer proximity to where people live and breathe.

According to an analysis from NOACA staff, including 144,000 EVs in the passenger vehicle fleet for Northeast Ohio will reduce emissions of GHGs, NO_x, VOCs, and SO_2 by roughly 8.4% in 2050.[1] Though some of these reductions may be offset by emissions from electricity generation, the benefits will remain. Unfortunately, the region cannot expect to see this same level of reduction in emissions from $PM_{2.5}$. A significant and growing share of $PM_{2.5}$ from passenger vehicles is coming from non-exhaust emissions (i.e. brake and tire wear, resuspension of road dust), hence eliminating a vehicle's tailpipe cannot address this issue.

Moreover, the rate of non-exhaust $PM_{2.5}$ emissions is heavily influenced by the mass of the vehicle. On average, EVs weigh 24% more than comparable ICEV models, due largely to the weight of the battery pack.[2] As a result, non-exhaust emissions from EVs will be virtually identical to those from ICEVs in 2050, on a per mile basis. Consumer choices will also influence this trend. Over the past 20 years, the average weight of a passenger vehicle in the U.S. has increased by 334 pounds (8.7%).[3] This trend has been driven entirely by the market shift away from passenger cars and towards light trucks, which grew by 777 pounds (17.6%). In model year 2000 (MY2000), passenger cars made up 55.1% of the light-duty vehicles produced in the U.S.; by MY2019, that share had fallen to just 32.7%.[4] If this market trend continues as consumers begin replacing their ICEVs with EVs, the associated increase in vehicle mass will likely further erode the $PM_{2.5}$ emissions benefits of EVs in Northeast Ohio.

Furthermore, because it is less expensive to drive a vehicle for one mile on electricity than on gasoline, the cost to operate an EV is lower than for ICEVs. Due to a phenomenon known as the rebound effect, as the marginal cost of driving falls, people will tend to drive more, offsetting some of the savings in both costs and emissions. U.S. EPA estimates that EV drivers will accrue roughly 10-20% more VMT than ICEV drivers as a result of this effect. This increase in VMT further erodes the potential $PM_{2.5}$ emissions reductions from EVs in the NOACA region. After accounting for

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[1] NOACA estimates using U.S. EPA's Motor Vehicle Emissions Simulator, version 2014a (MOVES2014a).

[2] Timmers, Victor RJH, and Peter AJ Achten. "Non-exhaust PM emissions from electric vehicles." *Atmospheric Environment* 134 (2016): 10-17.

[3] U.S. EPA, *2019 Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975* (Washington, DC: U.S. EPA, 2020), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100YVFS.pdf (accessed April 8, 2021).

[4] Ibid.

these two effects, NOACA staff estimates that adding 144,000 EVs to the region's vehicle fleet may reduce mobile $PM_{2.5}$ emissions by approximately 1.9% in 2050.

Ultimately, the air quality and climate benefits of EVs in the NOACA region will depend on a number of factors, including how many consumers switch from ICEVs, how quickly they make the switch, the availability of EV charging infrastructure, the energy sources used for electricity generation, the type of EVs they purchase; e.g. PHEVs (Plug-in Hybrid Electric Vehicle) vs. BEVs (Battery Electric Vehicle); sedans vs. SUVs, and their travel behavior. If Northeast Ohio residents rapidly shift towards EVs in larger numbers, charge the EVs with clean energy sources, and incorporate EV use into a more sustainable, multimodal lifestyle, the potential benefits may increase significantly beyond those estimated here.

EVs also present a complex environmental justice issue. As discussed in Chapter 8, racial minorities tend to live closer to heavily-traveled roads and, as a result, are exposed to higher levels of mobile emissions. As such, shifting away from ICEVs and towards EVs should benefit these communities. Nevertheless, the relationship between EVs and environmental justice is not clear-cut. According to a recent study, higher-income neighborhoods benefit from EVs, while lower-income neighborhoods actually see their air quality deteriorate. Asian-American and Latino communities also experience improved air quality, while Black communities suffer from higher levels of pollution.[5] These discrepancies may stem from differing levels of access to EVs by race and income level. Whereas households earning less than $100,000 per year account for 72% of ICEV purchases, those same households only purchase 44% of EVs. And while Black and Latino consumers make up 41% of ICEV buyers, their share is just 12% of EV purchases.[6] These same disparities exist for EV charging infrastructure. Neighborhoods with more multiunit dwellings are less likely to have public EV charging stations, and majority Black and Latino areas are half as likely to have access to a public EV charger.[7]

One reason for these discrepancies may be the types of vehicles that EVs tend to replace. On average, emissions are higher for older vehicles and among vehicles with lower fuel economy.[8] Average vehicle emissions also tend to be higher in low-income communities, even when controlling for average vehicle age.[9] These trends suggest that targeting EV subsidies and charging infrastructure in low-income communities would tend to have the greatest emissions saving and public health benefits. Higher-income households are more likely to purchase EVs and these EVs tend to replace newer vehicles with better fuel economy. For instance, more than 10% of the vehicles that EV buyers replace are Hybrid Electric Vehicles (HEVs).[10] Policies that

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[5] Holland, S. P., Mansur, E. T., Muller, N. Z., & Yates, A. J. (2019). Distributional effects of air pollution from electric vehicle adoption. *Journal of the Association of Environmental and Resource Economists*, *6*(S1), S65-S94.

[6] Muehlegger, E., & Rapson, D. *Understanding the Distributional Impacts of Vehicle Policy: Who Buys New and Used Electric Vehicles?* (Davis, CA: UC Davis, National Center for Sustainable Transportation, 2018), https://escholarship.org/uc/item/0tn4m2tx (accessed April 8, 2021).

[7] Hsu, Chih-Wei, and Kevin Fingerman. "Public electric vehicle charger access disparities across race and income in California." *Transport Policy* 100 (2021): 59-67.

[8] Harrington, W. (1997). Fuel economy and motor vehicle emissions. *Journal of environmental Economics and Management*, *33*(3), 240-252.

[9] Wenzel, T., Brett, C. S., & Robert, S. (2001). Some issues in the statistical analysis of vehicle emissions. *J Transp Stat*, *3*, 1-14.

[10] Xing, J., Leard, B., & Li, S. (2021). What does an electric vehicle replace? *Journal of Environmental Economics and Management*, 102432.

target EV subsidies and charging infrastructure to low-income communities of color may go a long way towards enhancing the environmental justice benefits from EVs in Northeast Ohio.

Fiscally Unconstrained and Illustrative Projects

The four evaluated scenarios in Chapter 9 included a few major projects which did not meet the estimated available annual budget discussed in Chapter 10 and they were considered as fiscally unconstraint projects. This section describes one of these projects: The Expansion of the Transit Network.

Visionary Rail Network Phasing Study

Scenarios 3 and 4 included the “Modified Intermediate” phase of the expansion of the rail network to provide an alternative mode transportation for inter-County connectivity. The “Intermediate” phase of the visionary future rail network will extended the current 34 miles of rail to 135 miles and the number of stations will increase from 49 to 111. The length of the “Final” phase of the visionary rail network will be 205 miles including 186 stations.

Expanding rail services can occur in multiple phases. At this point, no rail expansion projects can be included in the fiscally constrained portion of the long-range plan. However, the fiscally constrained part of the plan does include a feasibility study to phase future rail extension based on different alignment and technology options. The Visionary Rail Network Phasing Study will develop a 30-year phased plan to prioritize the proposed corridors based on an assessment of alternative route alignments and technologies for each corridor. For instance, job hubs could initially be served by bus rapid transit that operate along the highways in HOV lanes. As demand grows for these routes, investment in rapid transit rail becomes increasingly necessary. Multiple technologies (light rail, heavy rail, or fully-automated light rail system) should be explored for the feasibility study. Each alternative for each corridor should be evaluated along multiple accounts to determine a preferred alternative. Evaluation accounts include considerations of land redevelopment potentials along the corridors, impact on travel times in the transportation network, cost effectiveness, a positive effect on travel choices in existing neighborhoods, support for economic development, benefits to disadvantaged groups, and flexibility in phasing. Figures 11-15 and 11-16 show the “Intermediate” and “Final” phases of the visionary rail network. Table 11-14 details costs by phase.

Figure 11-15. Intermediate Phase of the Visionary Rail Network

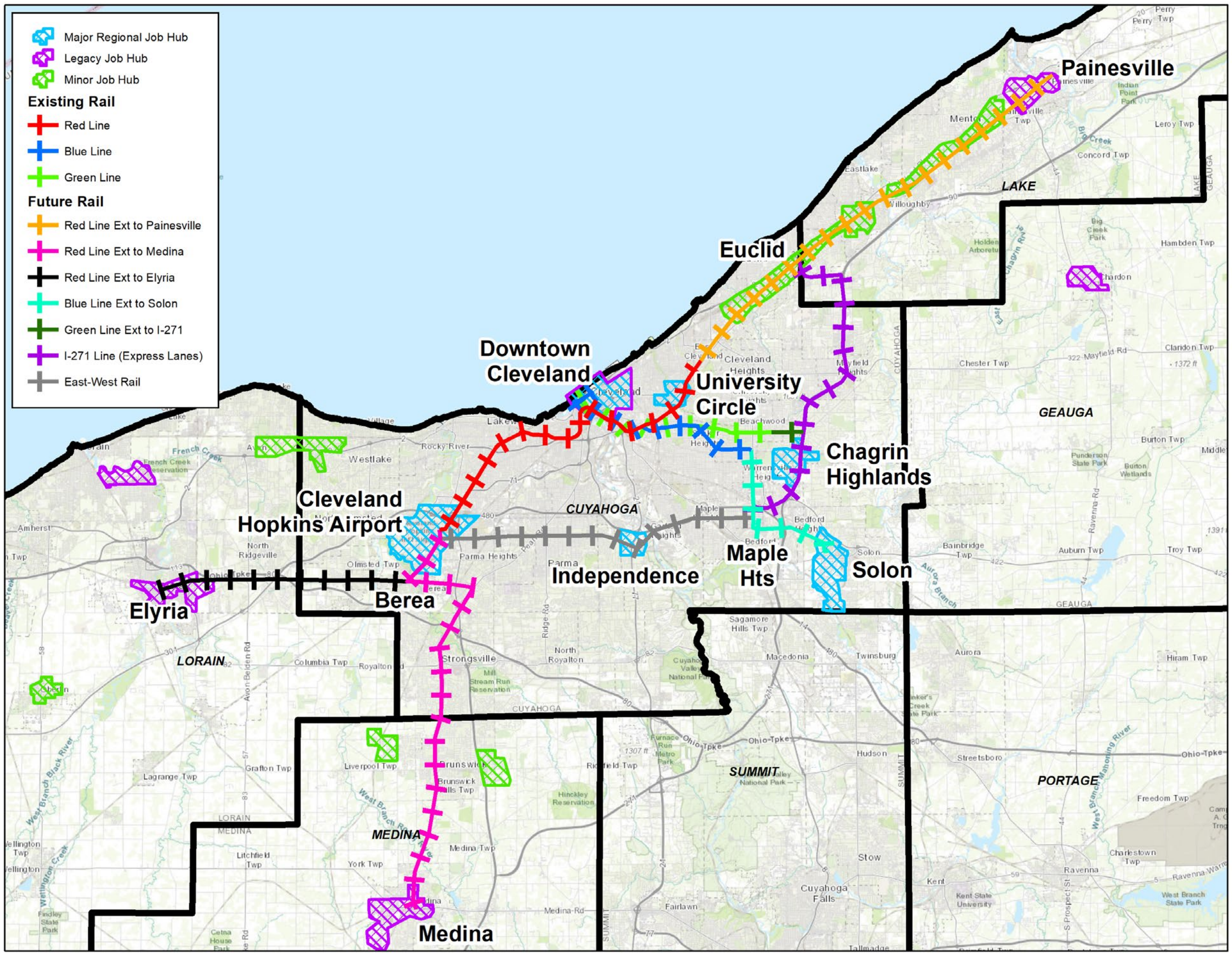
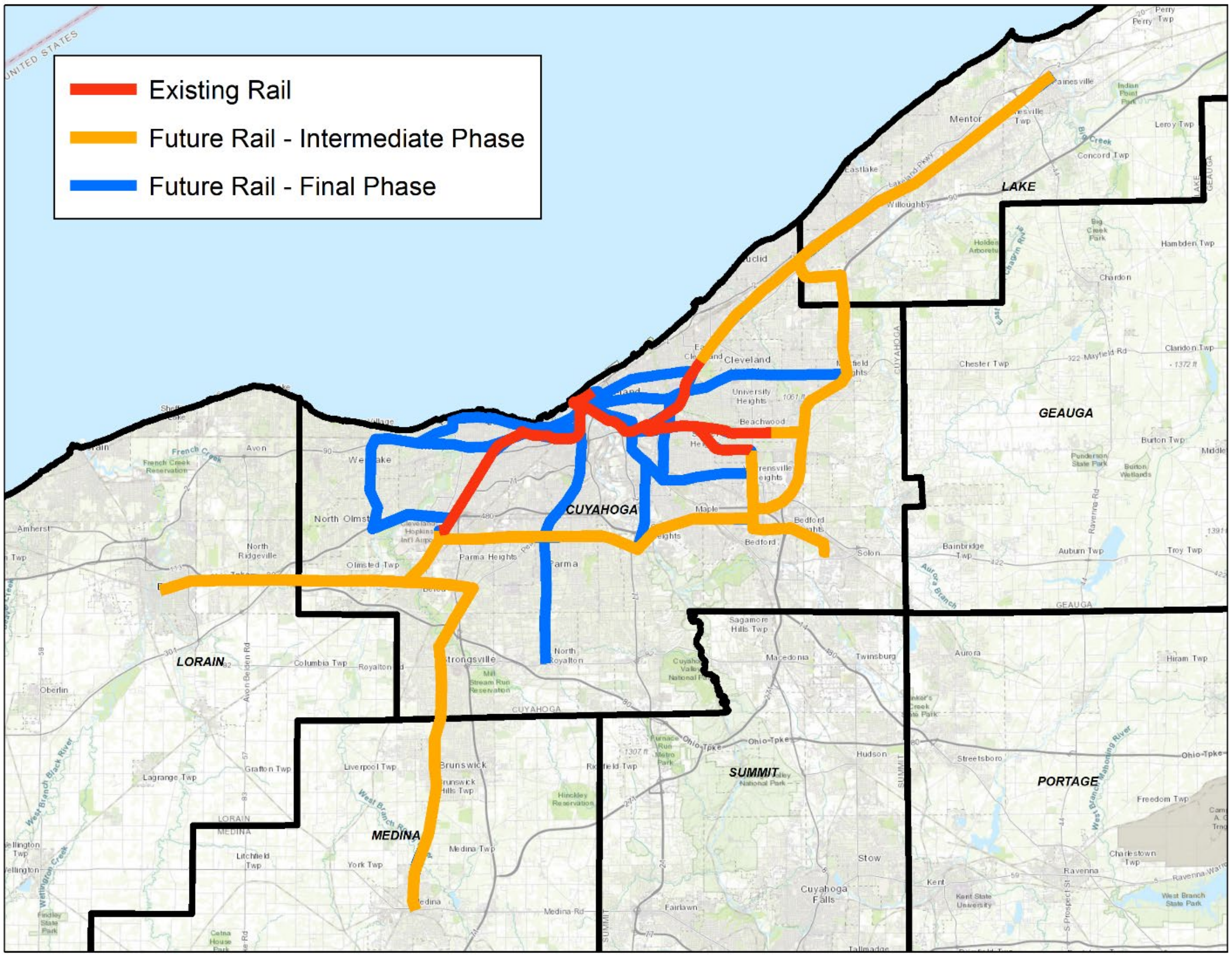


Figure 11-16. Final Phase of the Visionary Rail Network



Assuming total construction cost of $55 million (2020$) for each miles of rail extension and 11 million (2020$) construction cost for each extra station, Table 11-12 displays the total cost of the visionary rail network by phase.

Table 11-19. Net Present Value (NPV) of Visionary Rail Network Cost by Phase

Rail Network Extension Phase	Existing Rail Length (Miles)	Additional Rail Length (Miles)	Additional Number of Stations	Cost Per Mile (2020$)	Cost Per Station (2020$)	Total Construction Cost (2020$)
Existing	34	0	49	N/A	N/A	N/A
Intermediate	0	101 Miles	62	$55 Million	$11 Million	$6.24 Billion
Final	0	70 Miles	137			$5.36 Billion

Rail Network Phase	Total Rail Network Length (Miles)	Number of Stations	Grand Total Construction Costs (2020$)
Existing	**34**	**49**	**0**
Intermediate	**135**	**111**	**$6.24 Billion**
Final	**205**	**186**	**$11.6 Billion**

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 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: 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 for 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

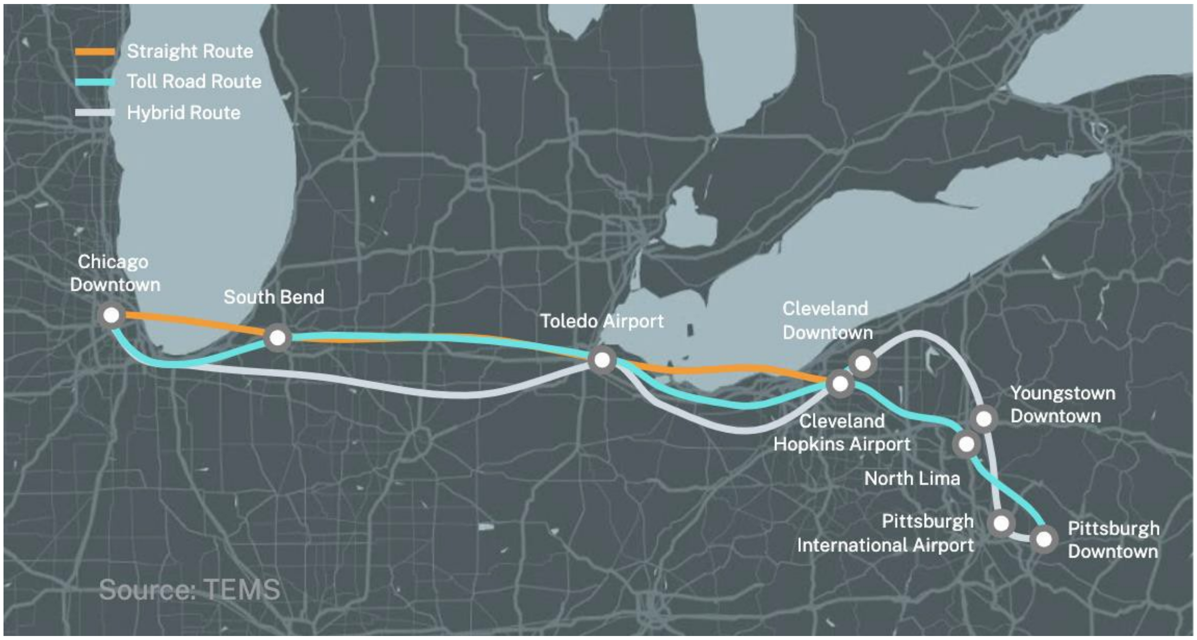
The Hyperloop is an entirely new mode of transportation based on early theoretical and experimental work in reduced pressure transport in the early 20th century. Hyperloop consists of an evacuated guideway tube within which a magnetic levitation system is used to propel self-contained capsules carrying 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 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 including 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



Source: TEMS

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 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, and investment and tax revenues for communities; and will also improve accessibility and reduce transportation costs allowing for individuals to have improved access to education, employment and services. Unlike other transportation projects, the Hyperloop will have transformational impacts to 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 per year
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 trade, laborers)
- Manufacturing labor (equipment, vehicles)
- Financial labor (financial, bankers)

The Hyperloop, with speed up to 760 mph, will have a significant property development potential. Table 11-16 provides detail 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.

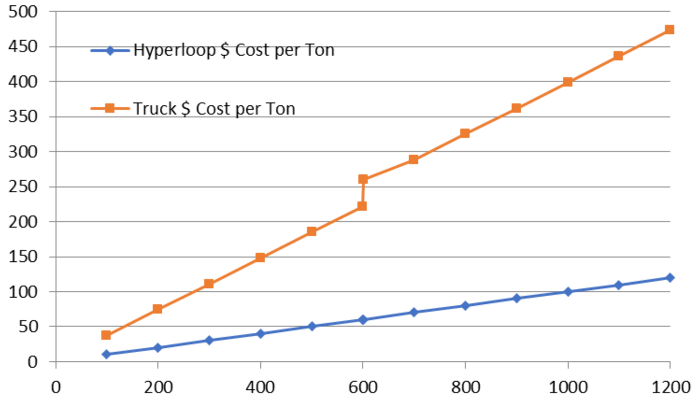
Table 11-22. 2030 Hyperloop Station Forecasted Volume (On and Offs)

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 which is faster than truck and cheaper than air, which would undoubtedly position it as a premium freight service. With Hyperloop cheaper than truck 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 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 Hyperloop over truck.

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 a 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[11], 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 is 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 speed. 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.

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.

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