Transportation Trends and Emerging Technologies

Final Report | October 2018

VISION FOR THE NORTHEASTERN ILLINOIS EXPRESSWAY SYSTEM

Prepared for:
Chicago Metropolitan Agency for Planning (CMAP)

ch2m

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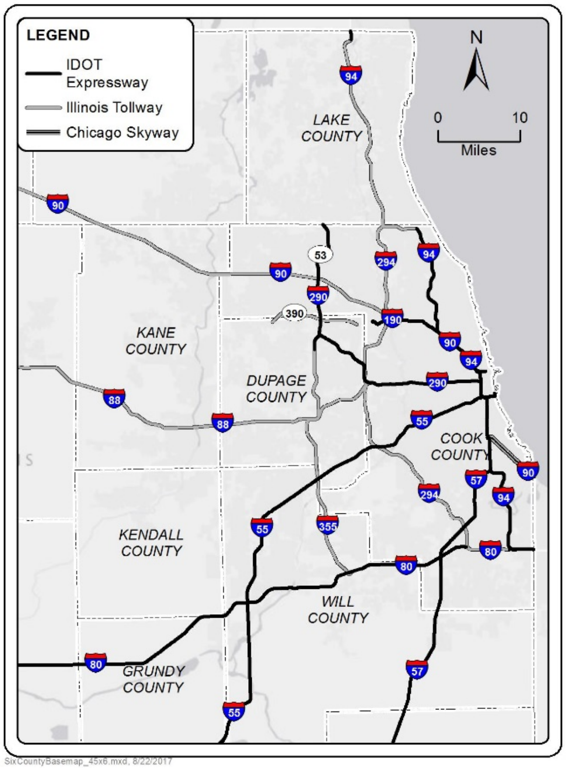
SECTION 1

Introduction

From its original construction in the 1950s and 1960s, the interstate system in the Chicago metropolitan area has served as a backbone of the region's transportation network and is vital to the area's economy and quality of life. The Illinois Department of Transportation (IDOT) and Illinois Tollway (Tollway) are responsible for planning, operation, maintenance, and construction on the region's expressway system. Figure 1 shows the project location.

IDOT District 1 oversees approximately 226 centerline miles of interstate and freeways, while the Tollway oversees approximately 210 miles of toll roads in the metropolitan area.[1] IDOT has consistently leveraged all available financial resources, from both federal and state sources, to maintain the Chicago-area expressway system in a state of good repair. Due to fiscal constraints, recent investments have generally focused on preservation and maintenance activities intended to extend the service life of aging pavements and bridges.

Figure 1. Project Location Map



SixCountyBasemap_45x6.mxd, 8/22/2017

In the most recent Fiscal Year (FY) 2019-2024 Proposed Highway Improvement Program, IDOT indicated that Illinois, like many states, does not have enough resources to maintain the existing system of roads and bridges. The FY 2019-2024 District 1 program identifies 63 centerline miles on the National Highway System (NHS)[2] for roadway maintenance, and 463,213 square feet of bridges on the NHS for maintenance, and 0 miles of safety/system modernization or system expansion on the NHS. The District 1 program identifies nearly $3 billion that will be provided during FY 2019-2024 for improvements to state highways[3] in District 1.

The Tollway system (identified in grey in Figure 1) currently consists of five toll facilities: I-90, the Jane Addams Memorial; I-94/I-294, the Tri-State; I-88, the Reagan Memorial; I-355, the Veterans Memorial; and IL-390, Elgin O'Hare Tollway. Illinois Tollway's *Move Illinois* Program, a comprehensive 15-year capital program that maps out the agency's investment plan for 2012-2026, completes the rebuilding of the 52-year-old system begun under the Congestion Relief Program (CRP) in 2004. The CRP widened several parts of the system to reduce existing congestion and accommodate future traffic growth. The majority of widening projects also included reconstruction of the existing roadway. The CRP reduced delays at toll plazas by converting all mainline toll plazas to Open Road Tolling and funded a new addition to the system, the south extension of the Veterans Memorial Tollway, which opened in

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[1] IDOT District 1 includes six counties in the metropolitan area Cook County, DuPage County, Kane County, Lake County, McHenry County, and Will County.

[2] The National Highway System consists of roadways important to the nation's economy, defense, and mobility, such as interstate facilities, other principal arterials, or intermodal connectors.

[3] State highways primary include all highways signed as interstate state and Illinois marked routes excluding the Toll System.

November 2007. The CRP was largely completed as of 2012. The *Move Illinois* Program commits nearly $12 billion in transportation funding to improve mobility, relieve congestion, reduce pollution, and link economies across northern Illinois. The program identifies the following types of major investments through 2026: reconstruction/capacity/mobility (e.g., I-90, I-294), preservation (e.g., I-88, I-355), and select priority regional mobility improvements (e.g., I-57 at I-294 interchange, construction of the missing movement; construction of the Elgin O'Hare Western Access).

In contrast to IDOT, the Illinois Tollway is a user-fee system and receives no state or federal funds for maintenance and operations. The Tollway funds the reconstruction of and improvements to the Tollway system through tolls and the issuance of revenue bonds.

This technical memorandum will explore transportation trends and emerging technologies that may be considered by IDOT and the Tollway on the region's expressway system as they prepare for the future. The memorandum is structured to discuss the following seven topics:

1. Expressway system trends
2. Passenger transportation trends
3. Freight transportation trends
4. Environmental and community trends
5. Emerging technologies and strategic approaches
6. National best management practices for integrated, multi-agency transportation operations
7. Characterization of expected policy-influence future conditions

SECTION 2

Expressway System Trends

2.1 Aging system

2.1.1 Comparison of available bridge condition, pavement condition, and pavement age of IDOT System and Tollway System[4]

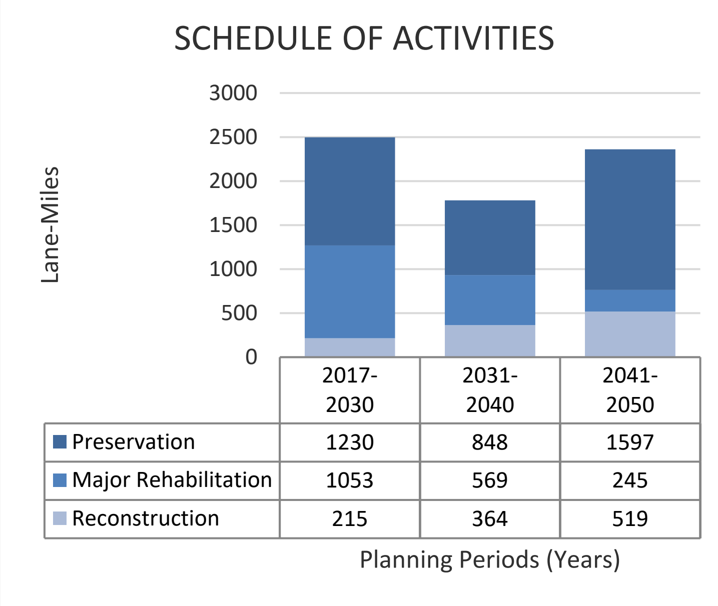
The average pavement age of IDOT's expressway system is 42 years, while the Tollway's system is 13 years. A literature review of pavement management best practices indicated that the life expectancy of pavement structures is generally accepted to be 50 years, at which point the pavement asset typically requires reconstruction or replacement (Thompson et al. 2012). IDOT's policy for the evaluation of pavement life-cycle activities is a 45-year service life expectancy. Approximately 82 percent of IDOT's expressway system will need to be reconstructed by 2050 (IDOT 2016b). Figure 2, reproduced from IDOT's *Chicago Area Expressway Long-Range Plan,* identifies in more detail the recommended number of lane-miles to be reconstructed, rehabilitated, and preserved through 2050. In summary, approximately 1,098 lane-miles of the expressway system will reach the end of their service life and need to be reconstructed by 2050. Additionally, the Long-Range Plan identified 94 mainline bridge structures for full replacement or superstructure replacement/deck replacement by 2040.

The terms "interstate," "expressway," "highway," "freeway," "tollway," and "facility" are used interchangeably throughout this document due to various contributing data sources. In the context of this document, these terms are collectively used to denote access-controlled facilities.

The average pavement age of IDOT's expressway system is 42 years, while the Tollway's system is 13 years.

Beginning in 2004 with the CRP and continuing in 2012 with the *Move Illinois* Program, the Illinois Tollway began rebuilding its facilities at the end of their service life. By 2026, the Tollway anticipates reconstructing its facilities that were built in the 1950s and 1960s. Given the differing funding positions of IDOT (major source of revenue is the federal and state motor fuel tax) and the Tollway (user-fee system from tolls and bonds), the Tollway has had more financial resources available than IDOT to invest in its system.

Figure 2. Lane-Miles of Pavement Investment Needs by Planning Period



	2017-2030	2031-2040	2041-2050
Preservation	1230	848	1597
Major Rehabilitation	1053	569	245
Reconstruction	215	364	519

Source: IDOT. 2016b. *Chicago Area Expressway Long-Range Plan.*

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[4] Pavement and bridge condition information not readily available for the Tollway's system.

2.2 Slow Growth in Expressway Capacity

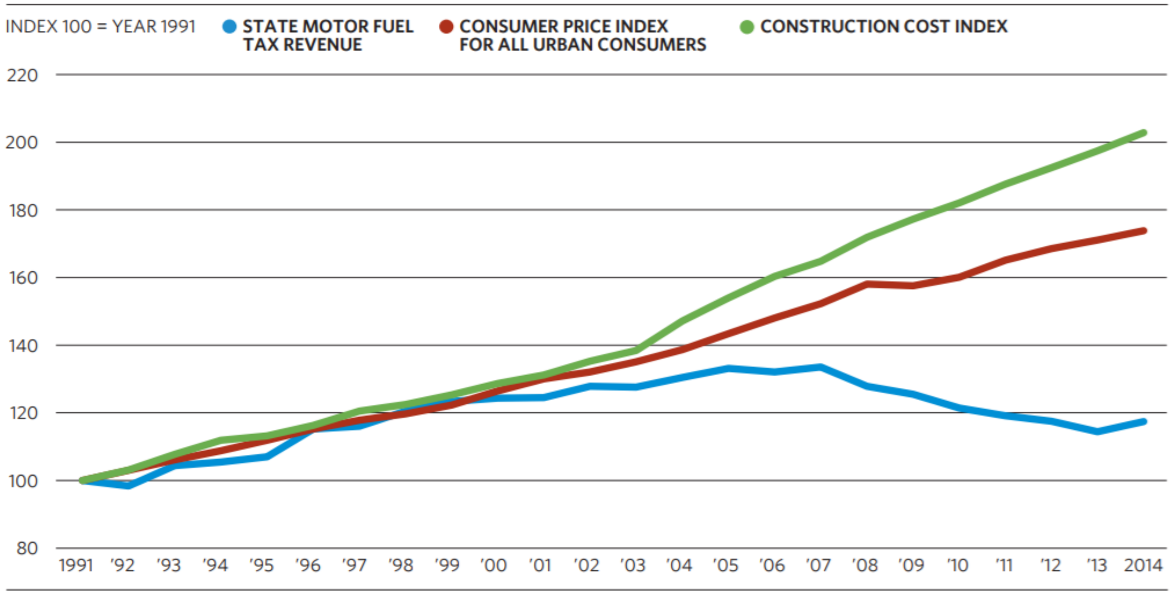
Within the Chicago region, daily VMT on the limited-access expressway system more than doubled between 1985 and 2005, growing by 136 percent. During the same period, additional lane-miles on the expressway system grew much more slowly at 36 percent (CMAP 2008).

Focusing on the IDOT system, between 1984 and 2016, the average daily VMT on the expressway system nearly doubled, increasing from 15,573,856 to 28,600,103, about 2.6 percent per year. As indicated in IDOT's *2015-2020 Proposed Multi-modal Transportation Plan*, even with the one-time infusion of federal funds and bond programs in 2009 and 2010,[5] the agency has only been able to temporarily slow the rate of deterioration of aging roads and bridges across the state. IDOT has not had the financial resources to meet the backlog of accruing needs on existing roads and bridges.

On the Illinois Tollway system within the District 1 boundaries, between 2005 and 2016, the average daily VMT increased from 8,594,929 to 9,521,338, about 1.0 percent per year. In contrast, the Tollway's Congestion Relief Program identified more than 118 miles of reconstructed expressways, modernization of tolling facilities, and capacity between 2005 to 2016 through $5.8 billion in funding (Illinois Tollway 2011).

2.3 Decline in Construction Purchasing Power of Gas Taxes and Vehicle Fees

Figure 3. State Motor Fuel Tax Revenue Compared to Consumer Price Index and National Construction Cost Index, 1991-2014



Source: CMAP (2015a)

As a per-gallon tax, MFT revenues have failed to keep pace with inflation and construction costs over time. For this analysis, the consumer price index for all urban consumers is used for inflation, while the Engineering News-Records' national construction cost index is used to measure construction costs.

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[5] American Recovery and Reinvestment Act and Jump State Capital Plan/Accelerated Construction Program in 2009 and 2010.

By 2050, the region will have more than 10.6 million residents compared with 8.5 million in 2015, and employment will be just below 5 million, growing from 4.3 million in 2015.[6] There will be a corresponding increase in travel demand. If the region is to maintain its economic vitality in the future, the expressway system needs to (1) expand and modernize to serve population and employment growth, and (2) needs to address chronic mobility and travel time reliability constraints. The motor fuel tax and vehicle fees are the primary revenue sources for funding improvements on IDOT's system; however, the Illinois motor fuel tax has not been increased in almost 30 years and has not kept pace with the consumer price index nor the construction cost index. Figure 3 illustrates the state motor fuel tax revenue compared to inflation and construction costs.

2.4 Constrained Resources Leading toward User-Fee Solutions

The cost to operate, maintain, and expand the state's transportation system increases over time; to keep up, revenues must grow. As discussed in *Adequate Transportation Funding, Reforming the Motor Fuel Tax* (CMAP 2015a) and illustrated in Figure 3, the state's revenues from motor fuel taxes have generally been declining since 2007, when revenues reached a high of $1.4 billion statewide. This can be explained by a decline in the consumption of motor fuel because of rising vehicle fuel economy and increasing use of alternative fuels. This trend is expected to continue. As part of the ON TO 2050 process, CMAP is considering several policy recommendations to increase transportation funding, building on the recommendations of the GO TO 2040 long-range plan. In the long term, CMAP recommends replacing the state motor fuel tax and further specifies that this replacement will account for growth in construction costs, as well as overall growth in the transportation system over time. CMAP analysis suggests that a mileage-based user fee, specifically a VMT fee, is the best replacement, providing sufficient, stable, and growing revenue (CMAP 2017d). A VMT fee is sustainable, equitable, and flexible, addressing the increasing fuel economy of cars and trucks to meet Corporate Average Fuel Economy (CAFE) standards and taxing travel by electric vehicles more fairly.

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[6] Chicago Metropolitan Agency for Planning (CMAP). 2017. ON TO 2050 Socioeconomic forecast.

SECTION 3

Passenger Transportation Trends

3.1 Congestion and Reliability Trends

CMAP publishes Quarterly Congestion Reports, which describe traffic congestion on the region's expressways. In comparison to 2015, each quarter in 2016 experienced an increase in congestion of 15 minutes (CMAP 2016a).[7] Congestion is heaviest entering and leaving downtown. The report also provides the regional travel time index, which measures the intensity of congestion and shows, on average, the extra travel time required during peak congestion. Compared to the same quarter in 2015, the regional travel time index in the fourth quarter of 2016 decreased from 1.44 to 1.42 in the AM peaks and increased from 1.58 to 1.60 in the PM peaks.

Travel Time Index. The travel time index is the ratio of travel time in the peak period to the travel time at free-flow conditions. For example, a value of 1.30 indicates a 20-minute free-flow trip takes 26 minutes in the peak.

Planning Time Index. This is a measure of travel time reliability. The planning time index is the ratio of the 95th percentile time (travel time on a particularly bad day) to free flow time. An index close to one indicates that on a bad day, the travel time is not much worse than free-flow travel time, and high numbers show that a bad day is much worse than free-flow travel time. For example, a value of 2.50 means that for a 30-minute trip in light traffic, 75 minutes should be planned.

Planning Time Index

Up to 1.40	Generally reliable
Up to 1.81	Moderately unreliable
Up to 2.55	Severely unreliable
Up to 3.35	Very severely unreliable
Greater than 3.35	Extremely unreliable

Source: CMAP, Travel Time Reliability, Chicago Region, 2012, December 2014

The planning time index (PTI) is a measure of travel-time reliability. It is the ratio of the total time needed to ensure a 95 percent on-time arrival to the free-flow travel time. For example, a PTI value of 3.0 means that for a 30-minute trip in light traffic, a driver should plan on 90 minutes in the peak period to be late no more than 5 percent of the time. The region's PTI improved in the fourth quarter of 2016 in comparison to the previous year. The AM index decreased by 0.14, while the PM index decreased by 0.09. Even so, travel time reliability is a large problem in the region, with the region's expressways experiencing a PTI in the PM of 3.14 (very severely unreliable) and 2.51 (severely unreliable) in the AM. Even if allowing ample time, drivers traveling during peak hours may arrive late to their destination due to unreliable travel times.

Figures 4 and 5 illustrate the planning time index on the region's expressway system for the AM and PM peak period.

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[7] Congested hours are an indication of how many hours per day a facility is congested. Technically, "congested hours" are defined as the average number of hours in which at least 20 percent of the vehicle miles traveled (VMT) on the instrumented segment is congested. For this measure, congestion is defined to occur when link speeds are less than 50 mph.

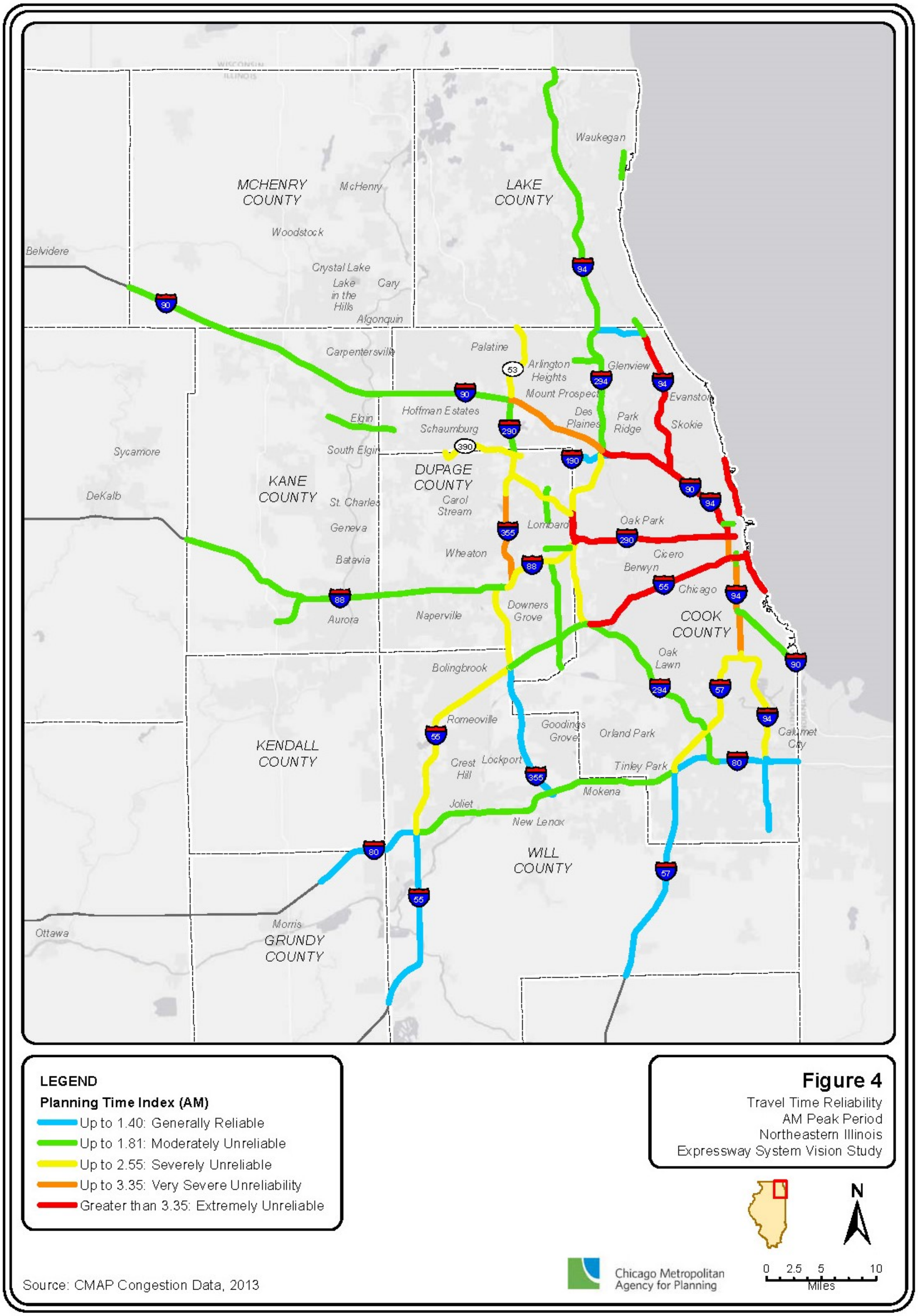
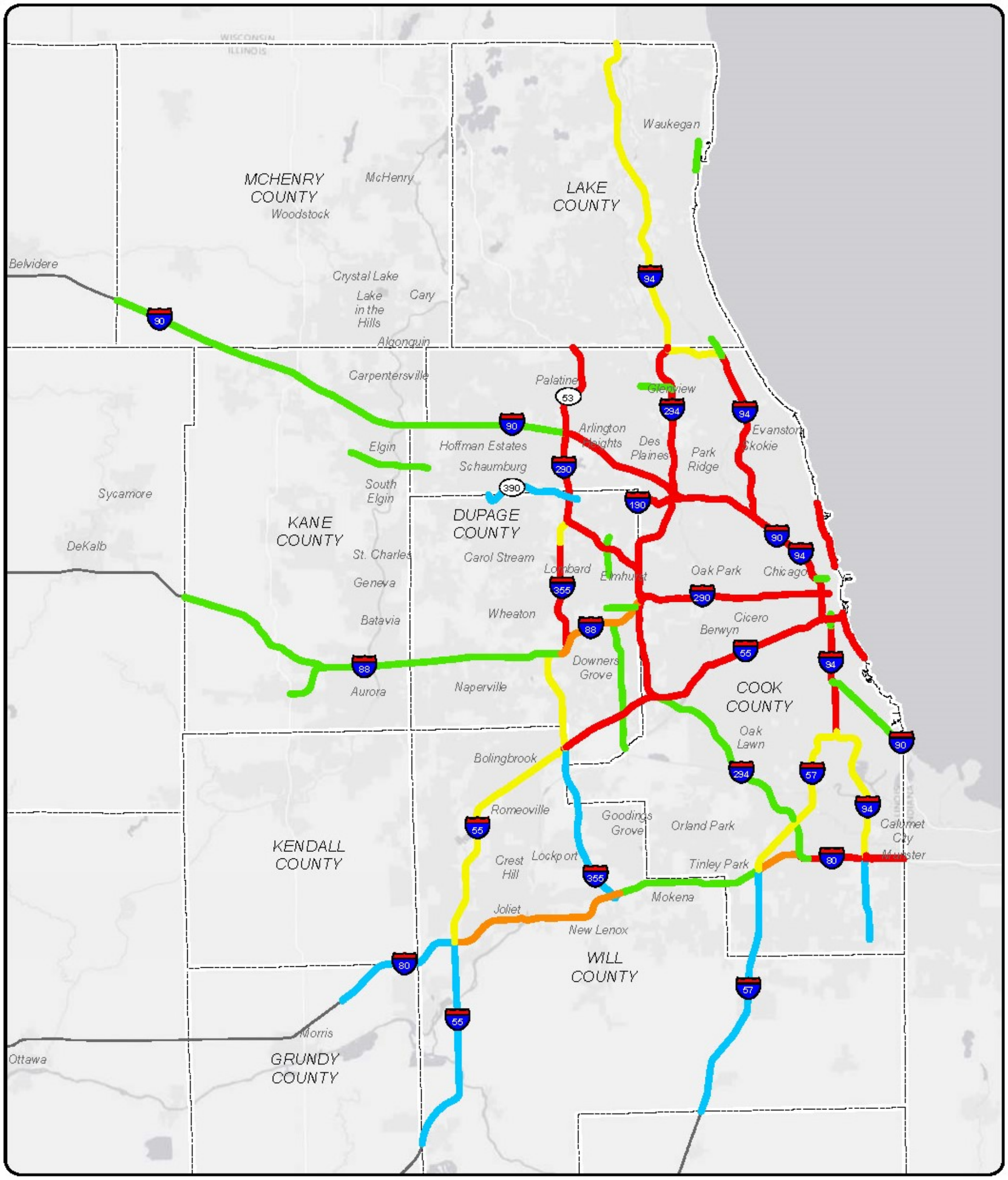


Figure 4

Travel Time Reliability
AM Peak Period
Northeastern Illinois
Expressway System Vision Study

Source: CMAP Congestion Data, 2013



LEGEND

Planning Time Index (PM)

- 🟦 Up to 1.40: Generally Reliable
- 🟩 Up to 1.81: Moderately Unreliable
- 🟨 Up to 2.55: Severely Unreliable
- 🟧 Up to 3.35: Very Severe Unreliability
- 🟥 Greater than 3.35: Extremely Unreliable

Figure 5
Travel Time Reliability
PM Peak Period
Northeastern Illinois
Expressway System Vision Study

N

0 2.5 5 10
Miles

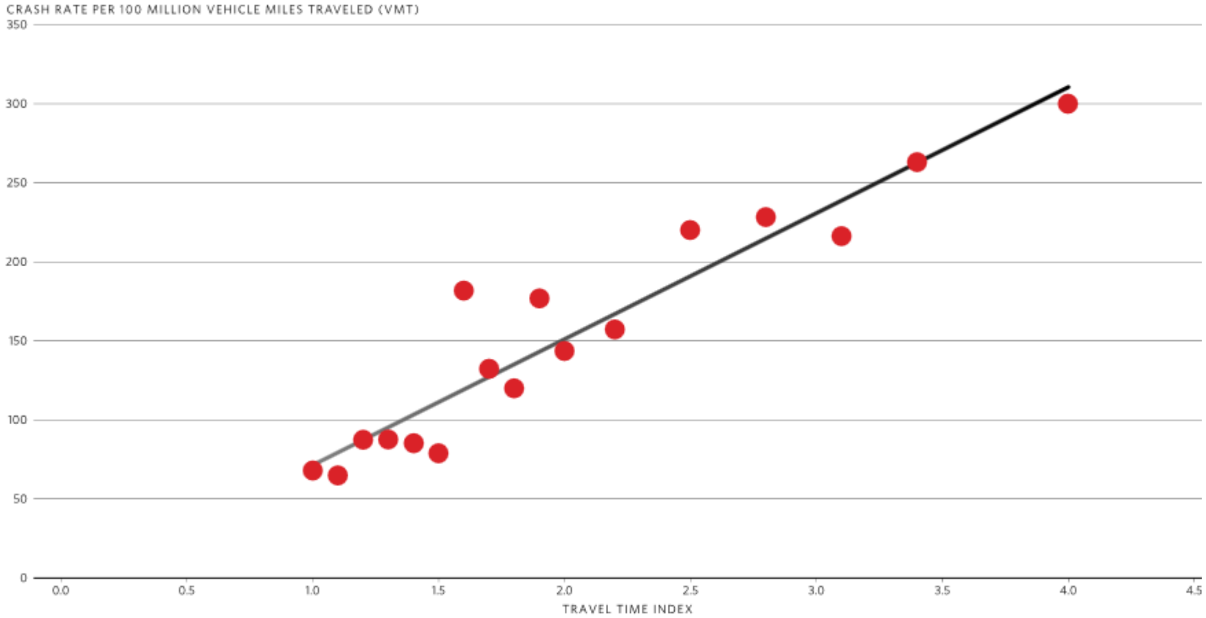
Chicago Metropolitan
Agency for Planning

Source: CMAP Congestion Data, 2013

3.2 Expressway Crash Trends

In 2016, CMAP published an analysis of expressway system crash data from 2008 to 2012. The analysis included development of crash scans that show the number of crashes occurring per 100 million VMT (CMAP 2016b). The analysis found that given the high traffic volumes on the expressway system, the Eisenhower, Stevenson, Dan Ryan, and Kennedy expressways have much higher crash rates than outlying expressways. In addition, the crash scans indicated that crashes tend to occur around interchanges and merge/diverge locations. Further, the analysis found a link between crash rates and congestion. On expressways, a one-unit increase in the travel-time index is correlated with an increase of 77 crashes per 100 million VMT (see Figure 6). However, CMAP noted that this is a correlation and that other factors are involved. For instance, CMAP indicated that crashes tend to cluster near ramps, but expressway segments with higher congestion and higher volumes also tend to have more closely spaced ramps (that is, more ramps per expressway segment). Although expressways in general have a much lower crash rate than roadways that are not access-controlled, the difference is primarily due to stopping and starting at intersections on arterial roads. Strategies to reduce congestion and improve safety will contribute to lower crash rates.

Figure 6. Expressway Crash Rate and Travel Time Index



Source: CMAP. 2016b. http://www.cmap.illinois.gov/about/updates/policy/-/asset_publisher/U9jFxa68cnNA/content/crash-scans-show-relationship-between-congestion-and-crash-rates

3.3 Continued Dominance of Short Trips

3.3.1 All Purpose

Table 1 identifies the average mileage per trip chain[8] by trip type and area of residence in 1990 and 2008[9]. Residents of central Chicago had the shortest trip chains for all trips in both 1990 and 2008,

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[8] Trip chains are a series of individual trips linked together.

[9] The 2008 data is from the most recent CMAP Travel Tracker Survey. CMAP is currently conducting the My Daily Travel survey through May 2019, which will yield more updated information on travel patterns in the region.

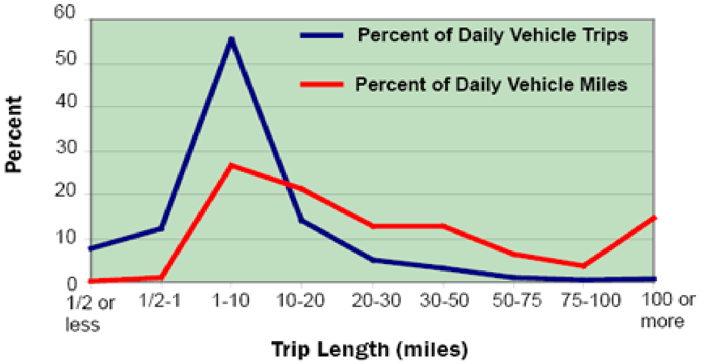
9.7 miles and 8.9 miles, respectively, experiencing an 8.2 percent reduction in trip length over this period. Residents of McHenry, Kendall, and western Kane counties had the longest trip chains for all trips in both 1990 and 2008, 19.1 miles and 19.7 miles, respectively, experiencing a 3.1 percent increase in trip length over this period. Overall, the region experienced a small (2.2 percent) increase in the average mileage per trip chain, increasing from 13.4 miles in 1990 to 13.7 miles in 2008.

Table 1. Mileage per Trip Chain by Trip Type and Area of Residence: 1990 and 2008 Household Surveys

		Work	**Percent Change (Work)**	**Shop**	**Percent Change (Shop)**	**Other**	**Percent Change (Other)**	**All**	**Percent Change (All)**
Central Chicago	2008	12.7	-3.8%	7.0	+32.1%	6.0	-10.4%	8.9	-8.2%
	1990	13.2		5.3		6.7		9.7	
North Chicago	2008	15.1	+11.8%	9.7	+59.0%	9.1	+11.0%	11.9	+17.8%
	1990	13.5		6.1		8.2		10.1	
South Chicago	2008	17.0	-11%	11.2	+27.3%	9.1	-5.2%	12.1	-8.3%
	1990	19.1		8.8		9.6		13.2	
North Cook County	2008	19.7	-6.6%	9.9	+16.5%	8.3	-10.8%	13.0	-8.5%
	1990	21.1		8.5		9.3		14.2	
West Cook County	2008	15.5	-2.6%	7.0	-19.5%	6.5	-14.5%	10.0	-9.9%
	1990	15.9		8.7		7.6		11.1	
South Cook County	2008	23.4	-4.1%	10.2	+5.2%	9.8	-1.0%	14.7	-5.2%
	1990	24.4		9.7		9.9		15.5	
Lake County	2008	23.4	-9.4%	13.1	+19.1%	10.5	-1.9%	16.4	-4.1%
	1990	25.6		11.0		10.7		17.1	
DuPage County	2008	23.8	+6.3%	11.5	+35.3%	9.9	+11.2%	15.3	+5.5%
	1990	22.4		8.5		8.9		14.5	
McHenry, Kendall and western Kane Counties	2008	27.2	-5.6%	15.6	+16.4%	13.5	+14.4%	19.7	+3.1%
	1990	28.8		13.4		11.8		19.1	
Eastern Kane County	2008	24.1	-15.7%	10.2	-9.7%	8.6	-12.2%	14.8	-16.9%
	1990	28.6		11.3		9.8		17.8	
Will County and Grundy County	2008	27.6	+40.1%	14.7	+70.9%	11.9	+33.7%	18.8	+40.3%
	1990	19.7		8.6		8.9		13.4	
Region	2008	20.3	3.0%	10.7	24.4%	9.1	2.2%	13.7	2.2%
	1990	19.7		8.6		8.9		13.4	

Source: CMAP. 2010. *Chicago Regional Household Travel Inventory: Mode Choice and Trip Purpose for the 2008 and 1990 Surveys*. June.

Figure 7. Percent of Trips and Vehicle Miles by Trip Length



Source: U.S. Department of Transportation, FHWA, Office of Highway Policy Information, National Household Travel Survey. 2008

Average mileage per trip chain in the Chicago metropolitan area continue to be dominated by short trips. This trend mirrors what is happening on our nation's roadways. In 2008, the Federal Highway Administration (FHWA) estimated that across all roadway types, approximately three-quarters of trips are 20 miles or less, with over half of all vehicle trips between 1 and 10 miles (Figure 7). FHWA data indicate that short trips of less than 20 miles account for approximately one-half of all household-based VMT (FHWA 2008a).

3.3.2 Commuting

Trip chain mileage for commuting in the region has increased slightly (3 percent) between 1990 and 2008, increasing from 19.7 to 20.3 miles. Although central Chicago experienced a 3.8 percent reduction in work trip length between 1990 and 2008, and McHenry, Kendall, and western Kane counties experienced a 5.6 percent reduction, considerable increases in other areas have contributed to an overall increase in work trip chain mileage. Will, Grundy, and DuPage counties, and north Chicago experienced an increase in the distance of work trip chains of 40.1 percent (increasing from 19.7 to 27.6 miles), 6.3 percent (increasing from 22.4 to 23.8 miles), and 11.8 percent (increasing from 13.5 to 15.1 miles), respectively. These increases may be due to new residential development, particularly in Will and Grundy counties, or in the case of north Chicago, a growing population of young people, some of whom commute to the suburbs.

3.4 Vehicle Miles Traveled Growth

3.4.1 Historic by Expressway

Vehicle miles of travel or vehicle miles traveled (VMT) is defined by FHWA as a measurement of the number of miles traveled by vehicles within a specified region for a specified time period.

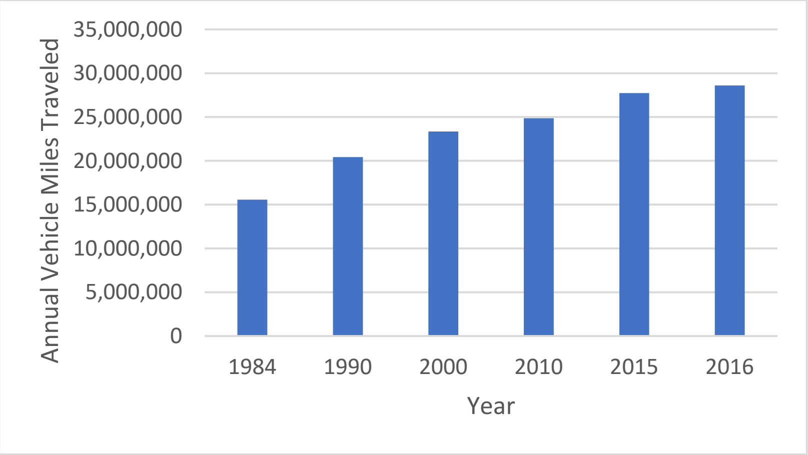
Annual VMT on the IDOT expressway system nearly doubled between 1984 and 2016, increasing from 15,573,856 to 28,600,103 (see Table 2). Between 1984 and 2000, VMT increased by 50 percent across IDOT's expressway system (from 15,573,856 to 23,337,367), and between 2000 and 2016 VMT increased by nearly 23 percent (from 23,337,367 to 28,600,103.) Between 2000-2016, while most expressways experienced an increase in VMT, several expressways experienced a decrease.

In the report, *Vehicle Miles Traveled on Expressways in the Chicago Region Recent Trends - 2011 Update,* CMAP staff explored the potential causes of the decrease in VMT growth trend between 2004 and 2009. The analysis indicated that VMT decreases may be attributed to the following:

1. Reconstruction and price increases for much of the Illinois Tollway (including the introduction of Open Road Tolling)
2. Road reconstruction projects in the region's southland
3. Regional variation in employment and residential growth
4. Changes in the cost of motor fuel
5. Changes in travel mode share
6. Higher regional unemployment

Nonetheless, since 2010, VMT has been increasing across the IDOT system (see Figures 8 and 9). It is less clear if this trend will continue. A recent CMAP analysis of trends in VMT found that VMT in Illinois has stalled over the last decade (CMAP 2016c). Regardless, it is necessary that the region's transportation system be well-equipped to handle the volume of vehicles on the road.

Figure 8. IDOT Expressway Growth in Vehicle Miles Traveled (1984 to 2016)



Source: CMAP. 2016c. *2016 Expressway Atlas: Annual Average Daily traffic on Northeastern Illinois Expressways*.

Table 2. Average Daily Expressway Vehicle Miles Traveled (VMT) on IDOT Expressways

Expressway	1984	1990	2000	Percent Change (1984-2000)	2010	2015	2016	Percent Change (2000-2016)
IL 53 Northbound	184,775	382,559	500,161	+170.7%	398,911	433,387	443,809	-11.3%
IL 53 Southbound	222,958	439,638	506,883	+127.3%	436,544	444,259	460,944	-9.1%
I-57 Northbound	449,404	600,477	766,188	+70.5%	859,724	830,271	898,489	+17.3%
I-57 Southbound	450,132	590,271	763,534	+69.6%	865,977	853,749	903,191	+18.3%
I-94 Edens Eastbound	775,174	979,936	1,107,772	+43.0%	988,640	1,002,577	1,029,766	-7.0%
I-94 Edens Westbound	842,212	1,010,654	1,153,287	+37.0%	1,061,950	1,054,459	1,080,698	-6.3%
IL 390 Elgin-O’Hare Eastbound[a]	--	--	197,453	N/A	184,398	175,910	--	-11.0%[b]
IL 390 Elgin-O’Hare Westbound[a]	--	--	201,784	N/A	179,244	168,538	--	-16.5%[b]
I-94 Bishop Ford Eastbound	531,841	606,038	874,268	+64.4%	930,082	925,466	932,219	+6.6%
I-94 Bishop Ford Westbound	504,978	643,850	849,725	+68.3%	887,430	890,105	902,241	+6.1%
I-290 Extension Eastbound	667,494	960,999	1,169,370	+75.2%	1,025,605	1,114,090	1,129,471	-3.4%
I-290 Extension Westbound	676,384	966,399	1,218,710	+80.2%	1,089,012	1,163,064	1,231,466	+1.0%
I-290 Eisenhower Eastbound	1,112,610	1,254,417	1,350,628	+21.4%	1,240,984	1,279,950	1,309,594	-3.0%
I-290 Eisenhower Westbound	1,108,271	1,245,097	1,355,959	+22.3%	1,208,316	1,276,466	1,282,440	-5.4%
I-90/94 Kennedy local Eastbound	1,323,081	1,650,155	1,493,186	+12.9%	1,521,475	1,546,999	1,564,343	+4.8%
I-90/94 Kennedy local Westbound	1,345,714	1,705,321	1,421,093	+5.6%	1,610,128	1,668,883	1,713, 157	+20.6%
I-90/94 Eastbound Reversible Lanes	99,120	143,016	131,131	+32.3%	144,043	174,385	164,077	+25.1%
I-90/94 Westbound Reversible Lanes	141,007	170,700	172,443	+22.3%	149,834	183,635	160,898	-6.7%
I-80 Eastbound	204,615	279,835	--	+36.8%[c]	679,775	830,315	987,713	+45.3%[d]
I-80 Westbound	196,909	285,918	--	+45.2%[c]	689,195	810,010	1,064,569	+54.5%[d]
I-80 Kingery Eastbound	109,178	172,931	201,138	+84.2%	230,579	260,780	281,656	+40.0%

Table 2. Average Daily Expressway Vehicle Miles Traveled (VMT) on IDOT Expressways

Expressway	1984	1990	2000	Percent Change (1984-2000)	2010	2015	2016	Percent Change (2000-2016)
I-80 Kingery Westbound	107,820	169,032	199,597	+85.1%	222,171	285,651	293,028	+46.8%
US 41 North Lake Shore Drive Northbound	--	--	496,177	N/A	463,216	483,142	494,168	-0.4%
US 41 North Lake Shore Drive Southbound	--	--	511,622	N/A	471,789	485,286	486,183	-5.0%
US 41 South Lake Shore Drive Northbound	--	207,629	246,955	+19%[e]	199,325	267,466	286,486	+16.0%
US 41 South Lake Shore Drive Southbound	--	221,149	259,697	+17.4%[e]	233,781	266,615	261,728	+0.8%
I-90/94 Dan Ryan Local Eastbound	757,120	910,099	949,004	+25.3%	1,008,842	1,042,124	1,085,408	+14.4%
I-90/94 Dan Ryan Local Westbound	758,054	1,061,048	842,611	+11.2%	906,608	1,042,032	1,090,486	+29.4%
I-90/94 Dan Ryan Express Eastbound	368,771	400,051	436,106	+18.3%	385,476	418,844	420,236	-3.6%
I-90/94 Dan Ryan Express Westbound	391,945	444,118	484,870	+23.7%	378,996	434,985	408,265	-15.8%
I-55 Stevenson Northbound[f]	1,121,651	1,485,483	1,717,359	+53.1%	2,087,048	2,946,001	3,130,842	+82.3%
I-55 Stevenson Southbound[f]	1,122,638	1,444,341	1,758,656	+56.7%	2,118,377	2,964,389	3,102,532	+76.4%
Total Regional Expressway VMT	15,573,856	20,431,161	23,337,367	+50.0%	24,857,475	27,733,833	28,600,103	+22.6%

Source: CMAP. 2016c. *2016 Expressway Atlas: Annual Average Daily traffic on Northeastern Illinois Expressways*.

[a] IL-390 Elgin-O'Hare converted to an Illinois Tollway facility in 2016

[b] Percent change calculated from 2000-2015

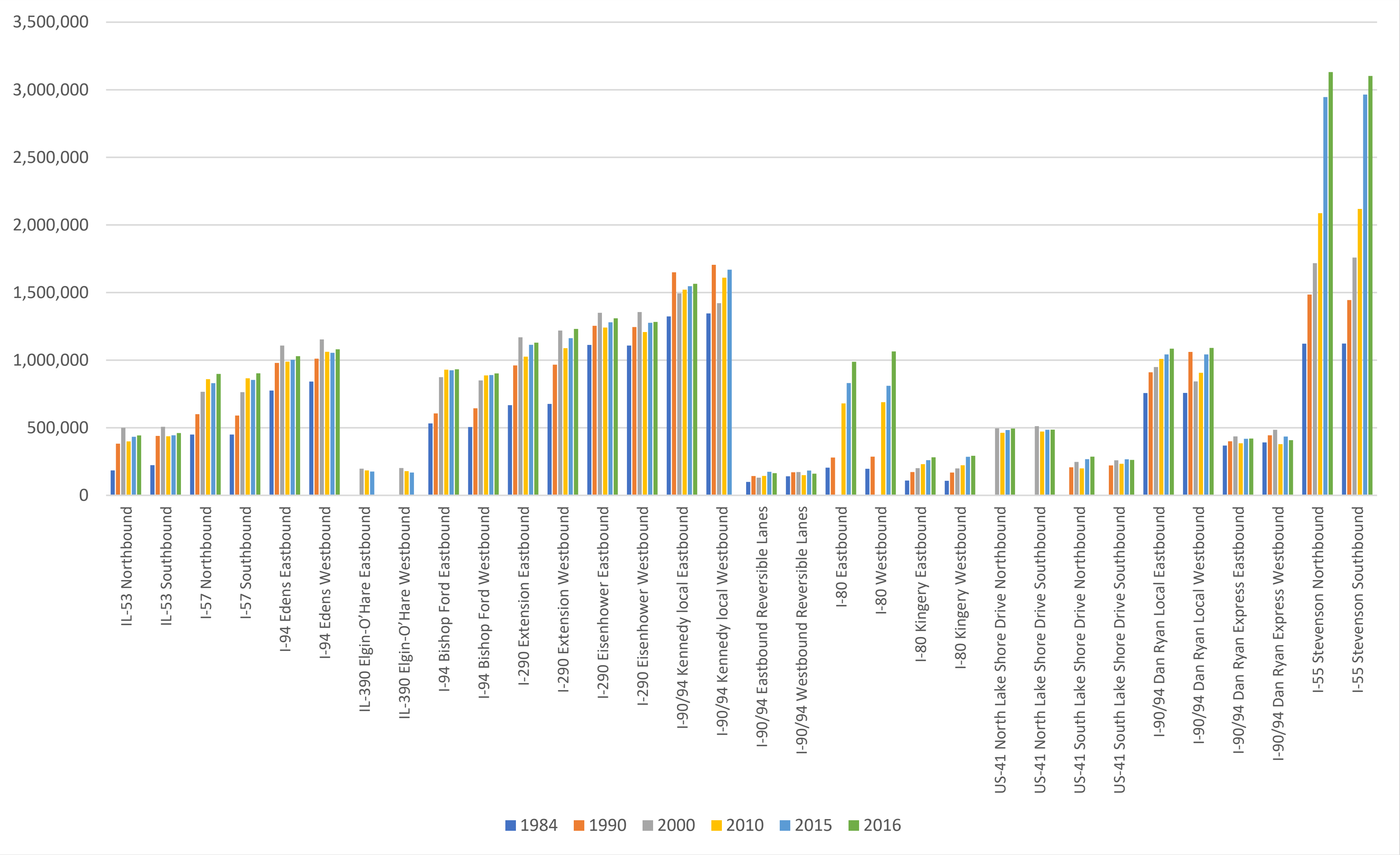
[c] Percent change calculated from 1984-1990

[d] Percent change calculated from 2010-2016

[e] Percent change calculated from 1990-2000

[f] Additional 30 centerline miles of surveillance added in 2014 on I-55 from IL 53 to IL 113/Coal City Road

Figure 9. Average Daily Expressway Vehicle Miles Traveled (VMT) – IDOT Expressways



Source: CMAP. 2016c. *2016 Expressway Atlas: Annual Average Daily traffic on Northeastern Illinois Expressways*.

3.4.2 VMT by County/City of Chicago

Table 3 illustrates the observed daily VMT values developed from the 2015 Illinois Travel Statistics published by IDOT. CMAP's GO TO 2040 model validation process compared the modeled results to observed VMT and found that overall, the distribution of modeled VMT shares corresponds very well with the observed VMT across counties and roadway types (CMAP 2017g). Suburban Cook County experiences the most VMT in the region, followed by the City of Chicago, DuPage County, and Will County.

Table 3. Daily VMT and VMT Share by County for Interstate Facilities

Interstate Location	Observed VMT	Modeled VMT
Chicago – Cook	11,093,800	14,705,279
Suburban – Cook	21,267,268	18,491,400
DuPage	7,736,630	7,960,319
Kane	2,150,019	2,826,797
Lake	3,055,395	4,483,490
McHenry	365,789	673,611
Will	5,680,707	5,985,448
Total	51,349,608	55,126,342

Source: CMAP. 2017. *Trip-Based Travel Demand Model Validation Report*. February.

3.5 Transit

3.5.1 Increased Demand for Rail and Express Bus Services, including Bus-On-Shoulder, But Lower Demand for Local Buses

Given growing expressway system congestion, rail and express bus services are increasing in demand. Travelers want to reach their destinations reliably and in as little time as possible. Table 4 illustrates the changes in transit demand between 2000 and 2016. Between 2000 and 2016, annual passenger trips on the Chicago Transit Authority (CTA) Rail and Metra increased by 35.3 and 2.7 percent, respectively. Between 2000 and 2016, passenger trips on CTA Bus and Pace decreased by 14.6 and 18.9 percent, respectively. Although percent change in passenger trips varies for all modes, overall percent change from 2000 to 2016 demonstrates the increased demand for rail (i.e., CTA Rail and Metra) and decreased demand for local buses (i.e., CTA Bus and Pace). Increased demand for rail transit is also evident by the rapid growth of transit-oriented development in the City of Chicago and surrounding suburbs.

Table 4. Rail and Bus Transit Annual Passenger Trips, 2000-2016

Year	CTA Bus	Percent Change	CTA Rail	Percent Change	Metra	Percent Change	Pace	Percent Change
2016	259,100,000	-5.5%	238,600,000	-1.3%	80,100,000	-1.8%	31,300,000	-5.4%
2015	274,300,000	-0.7%	241,700,000	+1.5%	81,600,000	-2.2%	33,100,000	-4.9%
2014	276,100,000	-8.0%	238,100,000	+3.9%	83,400,000	+1.3%	34,800,000	-3.1%
2013	300,100,000	-4.5%	229,100,000	-0.9%	82,300,000	+1.2%	35,900,000	+1.4%
2012	314,400,000	+1.3%	231,200,000	+4.3%	81,300,000	-1.7%	35,400,000	+5.0%
2011	310,400,000	+1.4%	221,600,000	+5.1%	82,700,000	+1.6%	33,700,000	+4.3%
2010	306,000,000	-4.0%	210,900,000	+4.1%	81,400,000	-1.1%	32,300,000	0%
2009	318,700,000	-3.0%	202,600,000	+2.3%	82,300,000	-5.2%	32,300,000	-14.6%
2008	328,200,000	+6.1%	198,100,000	+4.1%	86,800,000	+4.2%	37,800,000	+3.3%
2007	309,300,000	+3.2%	190,300,000	-2.5%	83,300,000	+4.3%	36,600,000	-3.7%
2006	299,600,000	-1.9%	195,200,000	+4.5%	79,900,000	+5.0%	38,000,000	+3.0%
2005	305,500,000	+3.2%	186,800,000	+4.5%	76,100,000	+3.1%	36,900,000	+8.2%
2004	296,000,000	+0.8	178,700,000	-1.3%	73,800,000	-0.3%	34,100,000	+1.2%
2003	293,600,000	-3.7%	181,100,000	+0.4%	74,000,000	-2.0%	33,700,000	-3.2%
2002	304,800,000	+0.6%	180,400,000	-0.7%	75,500,000	-3.7%	34,800,000	-5.9%
2001	303,100,000	-0.1%	181,700,000	+3.1%	78,400,000	+0.5%	37,000,000	-4.1%
2000	303,300,000	--	176,300,000	--	78,000,000	--	38,600,000	--
2000-2016	**-44,200,000**	**-14.6%**	**+62,300,000**	**+35.3%**	**+2,100,100**	**+2.7%**	**-7,300,000**	**-18.9%**

Source: Regional Transportation Authority Mapping and Statistics (RTAMS). 2017. System Ridership.

A variety of technological improvements, including real-time traveler information, transit signal priority, use of Arterial Rapid Transit (ART) and Bus Rapid Transit (BRT), and flexible scheduling of demand-responsive service, can make transit easier to use and more efficient to operate in the future. Innovative technologies have the potential to offer cost savings, reduce congestion, and improve safety. See Section 6, *Emerging Technologies and Strategic Approaches*, for more information on these strategic approaches.

BRT is one promising solution to address the region's transit needs and provide an alternative in heavily congested areas. Currently, BRT is being evaluated on the region's expressways in the form of "express" bus service running on the expressway system shoulder to bypass congestion, but it has the potential in the long-term to provide BRT-like service. At present, Pace Bus is operating "express" bus service on the I-55 Stevenson Expressway during the weekday rush hour using the shoulder to sidestep congestion (see Table 5). IDOT plans to upgrade the I-55 Stevenson Expressway with a managed lane to improve operations and travel times. Express bus service may be able to operate in the managed lane providing BRT-like service. Additionally, Pace operates "express" bus service on the I-90 Jane Addams/Kennedy Expressway between Elgin and Rosemont. The flex lane allows buses to travel on an inside lane during traffic congestion to

A **managed lane** is a highway facility or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions. (FHWA) bypass traffic. Additionally, construction is currently underway to implement bus-on-shoulder on the I-94 Edens Expressway, allowing Pace to operate "express" bus service along the corridor.

Table 5. Express Bus Service on I-55 Stevenson Expressway

Pace Express Bus Route	Locations
Route 755	Operates on I-55, service between Plainfield and the Illinois Medical District and West Loop
Route 855	Operates on I-55, service between North Bolingbrook and the East Loop
Route 851	Operates on I-55, service between South Bolingbrook and the East Loop
Route 855	Operates on I-55, service between Plainfield and the East Loop
Route 856	Operates on I-55, service between Toyota Park Transit Center to the East Loop

CMAP staff modeled forecast boardings for Pace Express Bus services along various expressways. Table 6 illustrates the changes in incremental boardings from 2015 to 2050 over No-Build Scenarios. All routes, except one, I-55, Pattern 3, are projected to increase in boardings. These projections highlight the increasing demand for express bus service. In fact, boardings on four routes are projected to increase by over 100 percent.

Table 6. Pace Express Bus Incremental Boardings over No-Build Scenarios

Route Description	2015	2050	Percent Change (2015-2050)
I-355, Pattern 1	1,284	1,587	+23.6%
I-290, Pattern 1	3,038	4,108	+35.2%
I-290, Pattern 2	325	350	+7.7%
I-94 I-394, Pattern 1	2,864	7,166	+150.2%
Edens, Pattern 1	2,718	3,623	+33.3%
Edens, Pattern 2	542	939	+73.2%
Edens, Pattern 3	312	453	+45.2%
Edens, Pattern 4	1,582	1,852	+17.1%
I-80, Pattern 1	397	722	+81.9%
I-80, Pattern 2	51	249	+388.2%
I-80, Pattern 3	8	10	+25.0%
I-88 I-290, Pattern 1	2,970	6,129	+106.4%
I-90 Randall, Pattern 1	3,408	5,022	+47.4%
I-90 Randall, Pattern 2	1,549	3,004	+94.0%
I-90 Randall, Pattern 3	71	99	+39.4%
I-57, Pattern 1	2,180	4,548	+108.6%
Elgin O'Hare, Pattern 1	2,803	3,705	+32.2%
I-294 North WI, Pattern 1	3,441	4,335	+26.0%
I-294 Central, Pattern 1	1,265	2,042	+61.4%

Table 6. Pace Express Bus Incremental Boardings over No-Build Scenarios

Route Description	2015	2050	Percent Change (2015-2050)
I-294 Central, Pattern 2	1,342	2,086	+55.4%
I-294 Central, Pattern 3	514	646	+25.7%
I-294 South, Pattern 1	680	1,203	+76.9%
I-294 South, Pattern 2	298	398	+33.6%
I-294 South, Pattern 3	1,008	1,697	+68.45
I-55, Pattern 1	2,927	4,711	+60.9%
I-55, Pattern 2	1,828	3,363	+84.0%
I-55, Pattern 3	5,756	4,641	-19.4%
I-55, Pattern 4	3,264	3,756	+15.1%
I-55 West Loop, Pattern 1	1,975	2,559	+29.6%
I-55 West Loop, Pattern 2	982	1,298	+32.2%

Source: CMAP, Pace Express Bus Network Model, 2017

In the report *Bus Rapid Transit: Chicago's New Route to Opportunity*, the Metropolitan Planning Council identified 10 BRT corridors in the City of Chicago and adjoining suburbs based on feasibility, locations that support existing community assets, and accessibility gaps in the current transit network. CMAP modeled the demand for these services based on the travel behaviors of people collected through surveys over the past 40 years. The model indicates that transit mode shares for trips beginning and ending in the BRT corridors increases from 12 to 13.5 percent; for trips with one end in the BRT corridors, it increases from 14.7 to 15.8 percent. There is growing demand for transit service that provides a fast, reliable travel alternative to driving.

3.5.2 Lack of Funding for Operations

Chronic underfunding threatens the future of the region's transit system, which is aging and in need of improvement. The RTA's 2007 *Moving Beyond Congestion* initiative highlighted the transit system's considerable capital and operating funding needs, caused by years of underinvestment. As identified in GO TO 2040 Plan Update, the RTA's 2007 initiatives, which underscored the systems funding challenges, resulted in new operating funding from increases in the sales tax and Chicago's Real Estate Transfer Tax. Although this averted the immediate operating funding crisis, it did not fully solve the problem of sustainable funding, especially for the backlog of capital maintenance needs as capital funding continues to be diverted to pay for operations. Transit's funding challenges have arisen from cost increases such as the following:

- Operating costs that have risen at an average rate of 4.5 percent per year over the past decade, considerably above the rate of inflation, and
- Other elements outside the direct control of the operators of the transit system, including material and fuel price inflation, liability claims, rising demand for federally mandated Americans with Disabilities Act paratransit services, and costs of health insurance and pension obligations.

These problems are not unique to this region; transit agencies in many other U.S. metropolitan areas face similar increasing costs (CMAP 2014a). Today, the RTA's operating revenue and funding comes from several sources including passenger fares, the RTA sales tax, state funding, and the real estate transfer tax.

SECTION 4

Freight Transportation Trends

4.1 Continued Dominance of Truck Traffic, but with Growing Intermodal Volumes

The Chicago metro area is a major freight hub. The area's urban interstate highways experience heavy truck traffic daily. In Illinois, one in seven vehicles is a truck, and some highways in the Chicago area carry more than 30,000 trucks daily. Further, intermodal volumes are growing in the Chicago area due to the low cost of rail transportation and nationwide access provided by trucks. The Chicago area is the largest point of origin and termination for intermodal shipments in the U.S., and it accounts for about half of the nation's intermodal traffic. In 2014, more than 15 million freight containers originated or terminated in the Chicago area. In some cases, intermodal volumes grew by 30 percent between 2009 and 2014.

Chicago's existing freight infrastructure allows it to play a central role in the national freight network and intermodalism with its extensive freight network, including seven interstate highways, six of the seven Class I railroads, O'Hare International Airport, water terminals serving the Great Lakes and Illinois Waterways, and 18 active intermodal facilities. In the early 20th century, the railroads that once dominated freight movement lost a major portion of its market share to trucking with the completion of the federal aid network. The rail industry's share of freight movement has increased since the 1970s, with advent of intermodal container facilities, but truck traffic continues to dominate due to its flexibility in providing universal access using the highway network.

4.2 Freight as an Increasing Proportion of VMT

Annual truck VMT on Illinois urban interstates and freeways follows a similar trend to average daily expressway VMT. Although the percentage of truck traffic decreased from 2009-2011 as illustrated in Table 7, truck VMT increased again in 2012 and thereafter. The decrease experienced between 2009 and 2011 was likely the result of the economic recession. In the years surrounding the economic recession, the truck percentage of total VMT was relatively stable overall, ranging from 12 to 15 percent. CMAP forecasts the percentage of truck VMT to increase to 20 percent by 2040 (CMAP 2017g).

Table 7. Total Annual VMT and Truck VMT on Urban Interstates and Freeways in Illinois, 2005-2016

Year	Truck VMT	Total VMT	Percent Truck	Percent Change
2005	3,128,000	22,429,000	13.9%	-
2006	3,191,000	22,871,000	14.0%	0.04%
2007	3,457,000	23,248,000	14.9%	6.6%
2008	3,526,000	23,419,000	15.1%	1.3%
2009	2,927,000	23,866,000	12.3%	-18.5%
2010	2,976,000	24,266,000	12.3%	-0.002%
2011	2,285,000	23,240,000	9.8%	-19.8%
2012	2,935,000	22,989,000	12.8%	29.8%
2013	3,132,000	24,151,000	13.0%	1.6%
2014	3,317,000	24,194,000	13.7%	5.7%
2015	3,456,000	24,897,000	13.9%	1.2%
2016	3,506,000	25,899,000	13.5%	-2.5%

Source: IDOT Illinois Travel Statistics, 2016

4.3 Suburbanization and Ex-Urbanization of Freight Facilities

Historically, industrial development occurred near the core of the region, in the City of Chicago and Cook County, and close to existing transportation facilities. More recently, industrial development has moved from the core of the region to suburban areas, where land is less expensive, and larger sites are available. Modern industry requires increasingly large buildings; therefore, there is demand for large sites, which tend to be located on the periphery of the region. The suburbanization of industrial development will impact the movement of freight traffic within the region, and necessary changes must be made to accommodate for these trends. For example, new types of distribution building and goods movements strategies are taking place in response to the shift to online ordering. The square footage of existing distribution buildings grew by 30 percent between 2000 and 2015 (CMAP 2017f). Table 8 shows rentable building area by industrial type for 2016. Suburban Cook County has the greatest amount of rentable building area in the region, followed by City of Chicago, DuPage County, and Will County.

Table 8. Rentable Building Area by Industrial Type, 2016 (in millions)

	Chicago	Suburban Cook	DuPage	Kane	Kendall	Lake	McHenry	Will	Region
Warehouse	70.4	141.7	95.9	35.4	1.6	30.6	9.9	75.1	460.6
Manufacturing and Food Processing	70.2	101.5	32.5	20.8	6.9	25.6	12.6	20.5	290.5
General Industrial	30.7	36.2	17.3	12.7	0.2	11.1	4.0	5.5	117.7
Distribution	10.0	29.2	21.5	10.5	3.1	6.8	2.3	46.5	129.8
Flex	14.3	29.4	17.0	5.4	0.4	7.3	3.3	4.3	81.5
Total	195.6	338.0	184.1	84.9	12.2	81.4	32.0	152.0	1080.1

Source: CMAP. 2016d. Freight Land Use Topics. Memorandum to the CMAP Freight Committee and Economic Development Committee. May.

4.4 Urban Freight Issues

4.4.1 Access Issues for First and Last Miles

Although trucking has proved to be an efficient method for a product's first and last mile of movement, there are challenges. These challenges include the following:

- Bottlenecks
- Local regulations on truck operations, such as routing restrictions, permitting requirements, parking restrictions, and time of day delivery restrictions
- Inadequate geometrics for trucks and/or inadequate connections between industrial and freight facilities and the expressway system

For example, trucks may have to drive on local roads for a longer time or in a circuitous manner due to local truck restrictions that designate where trucks cannot go based on truck type, weight, and dimensions. Trucks may encounter stricter restrictions where activity and noise from freight is less welcome. Additionally, truck restrictions often differ by municipality, township, or county. These restrictions add complexity to truck routes, and drivers may have to make turns or diversions to alternate routes to complete first and last miles.

4.5 Truck Parking

4.5.1 ATRI Survey of Truck Parking

The American Transportation Research Institute (ATRI) conducted an online survey of truck drivers to identify truck parking issues in Mid America Association of State Transportation (MAASTO) states. Over 2,600 responses were received. Most drivers require truck parking two to four times per week and spend 30 minutes to 1 hour looking for parking each time. Thirty-five percent of drivers indicated that Illinois is the state most difficult to find parking in—the highest percentage of all 10 MAASTO states. It is difficult to find parking at both public and private truck stops. While drivers did not disclose their specific parking locations, the survey results indicate that they most often park at private truck stops. However, if parking is unavailable, drivers may park on ramps, shoulders, or other locations that present both a safety and operational issue for the expressway system.

Table 9 identifies the location of public and private truck parking near the expressway system. Figure 10 illustrates these parking places, including the location of intermodal facilities.

Table 9. Location of Truck Parking Facilities near the Expressway System

Type	Name	Direction	Expressway	Number of Parking Spaces
Truck Parking	Truck parking lot	--	I-290	50-100
Truck Parking	AF Truck Center	--	I-294	50-100
Truck Parking	Pilot Travel Center - Alsip	--	I-294	50-100
Truck Parking	Pilot Travel Center - Bridgeview	--	I-294	0-50
Truck Parking	Truck parking lot	--	I-294	50-100
Toll Plaza	Touhy Avenue	NB Only	I-294	0-50
Toll Plaza	Irving Park Road (Illinois 19)	SB Only	I-294	0-50
Toll Plaza	Cermak Road (22nd Street)	NB and SB	I-294	0-50
Toll Plaza	82nd Street	SB Only	I-294	0-50
Toll Plaza	83rd Street	NB Only	I-294	0-50
Toll Plaza	163rd Street	NB and SB	I-294	0-50
Oasis	O'Hare Oasis	NB and SB	I-294	0-50
Oasis	Hinsdale Oasis	NB and SB	I-294	0-50
Truck Parking	Pilot Travel Center - Carol Stream	--	I-355	50-100
Truck Parking	Truck parking lot	--	I-355	50-100
Toll Plaza	Army Trail Road	NB and SB	I-355	0-50
Toll Plaza	Boughton Road	NB and SB	I-355	0-50
Toll Plaza	Spring Creek	NB and SB	I-355	0-50
Truck Parking	Greater Chicago Truck Plaza	--	I-55	100+
Truck Parking	PETRO Stopping Center	--	I-55	100+
Truck Parking	Pilot Fuel	--	I-55	0-50
Truck Parking	Pilot Travel Center - Channahon	--	I-55	0-50

Table 9. Location of Truck Parking Facilities near the Expressway System

Type	Name	Direction	Expressway	Number of Parking Spaces
Truck Parking	Truck parking lot	--	I-55	100+
Truck Parking	Pilot Travel Center - Bridgeview	--	I-55	50-100
Truck Parking	McCormick Place - Lot B	--	I-55	100+
Truck Parking	Pilot Travel Center - Monee	--	I-57	50-100
Truck Parking	Pilot Travel Center - Alsip	--	I-57	50-100
Truck Parking	Pilot Travel Center - Joliet	--	I-80	0-50
Truck Parking	Pilot Travel Center - Minooka	--	I-80	100+
Oasis	Chicago Southland Lincoln Oasis	NB and SB	I-80	50-100
Toll Plaza	York Road	WB Only	I-88	0-50
Toll Plaza	Meyers Road	EB Only	I-88	0-50
Toll Plaza	Aurora	EB and WB	I-88	0-50
Truck Parking	Arrowhead Travel Plaza	--	I-90	50-100
Truck Parking	Truck parking lot	--	I-90	50-100
Truck Parking	Truck parking lot	--	I-90	100+
Toll Plaza	Marengo-Hampshire	EB and WB	I-90	0-50
Toll Plaza	Elgin	EB and WB	I-90	0-50
Toll Plaza	Devon Avenue	WB Only	I-90	0-50
Toll Plaza	River Road	EB Only	I-90	0-50
Oasis	Des Plaines Oasis	EB and WB	I-90	0-50
Truck Parking	Gurnee Truck Stop	--	I-94	0-50
Truck Parking	Love's Travel Stop	--	I-94	0-50
Truck Parking	Truck parking lot	--	I-94	100+
Toll Plaza	Waukegan	EB and WB	I-94	0-50
Toll Plaza	Edens Spur	EB and WB	I-94	0-50
Oasis	Lake Forest Oasis	NB and SB	I-94	0-50

Source: ATRI. 2017. MAASTO Driver Survey Presentation.

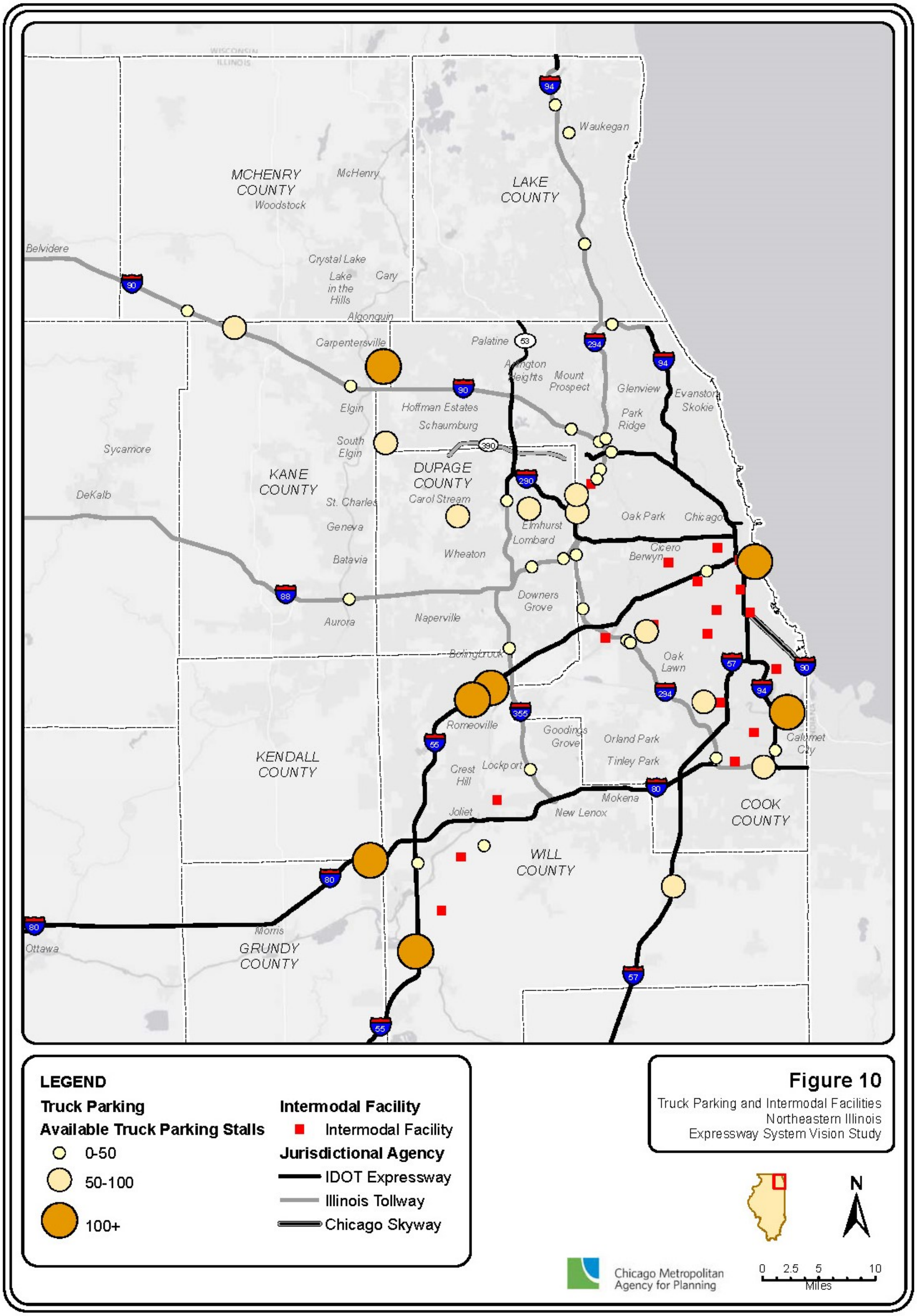


Figure 10
Truck Parking and Intermodal Facilities
Northeastern Illinois
Expressway System Vision Study

4.5.2 Time of Day of Pickups, Deliveries, and Truck Travel

The trucking industry faces many challenges when making deliveries, including peak-hour congestion and local restrictions on delivery time. Traveling during peak traffic hours is inefficient and may interfere with pickup and delivery schedules. Monday through Thursday, urban interstate traffic is higher than average between 7:00 AM and 8:00 PM. In addition, traffic is above average during the weekdays and in the spring, summer, and fall months.

Many truckers face time-of-day delivery challenges. For example, one municipality may impose time-of-day restrictions on truck deliveries, while its neighbors may impose different restrictions or no restrictions at all. Truck movements typically cross multiple jurisdictions, requiring truckers to be aware of multiple regulations.

Of all trucks stopping in the Chicago metro area, more than 50 percent of the stops were in Cook County, 22 percent were in Will County, and 9 percent were in DuPage County. Travel paths of complete truck trips show that 33 percent of trips were intra-county, 17 percent were between 2 metropolitan area counties, and 37 percent were between the Chicago region and the external area; 13 percent of trucks traveled through the region but did not stop. Given the large number of trucks stopping in Cook County and associated freight traffic, truck parking is limited, and travel times are slow.

Other travel patterns include truck traffic to Chicago’s south and west sides, as these areas house the region’s major industrial and transportation centers. Not surprisingly, these areas generate the most heavy-truck trips—over 500 heavy-truck trips per square mile. Some industrial and transportation centers generated more than 1,000 or 10,000 heavy-truck trips per square mile.

Potential solutions to these travel patterns and challenges include better advance traveler information, coordinated local regulations, more parking, and policies to encourage night deliveries.

4.6 Residential and Business Delivery and Pickup, Larger Numbers of Smaller Trucks

Due to growing intermodal volumes in the Chicago area and the use of rail transport for long-haul portions of many trips, there is a corresponding increase in the number of smaller trucks for the first and last mile of a product’s movement. That is, there is a greater number of smaller trucks transferring goods from transportation facilities to residences and businesses. Companies offering 1- to 2-day shipping (e.g., Amazon Prime), which involves frequent deliveries and a more expansive, although smaller, vehicle fleet, are contributing to increased traffic volumes on the region’s roadways. Additionally, there has been an increase in the use of smaller trucks due to local truck restrictions on truck type, weight, and dimensions.

4.7 Bigger Loads for Over-The-Road Operations

Given heavy-truck traffic and larger modern industrial development, loads are increasing for over-the-road truck operations. While the region’s freight flows mostly come or go from Midwestern neighbors, California is also a top origin and destination. Trucks are transporting larger, heavier loads over long distances. Inbound and outbound growth in tonnage by freight truck is projected to increase by 58 and 38 percent, respectively by 2040. Trucks will be carrying heavier loads, causing potential implications associated with wear on roads.

4.8 Projected Changes in Truck Flows

2040 truck volume estimates by truck tons, destined for or originating in the CMAP seven-county region for inbound, outbound, intra, and through traffic are projected to increase from 2007 truck volume estimates by 88, 35, 53, and 106 percent, respectively (see Table 10). Projected increases in truck volumes are substantial. As a result, the region's expressways will see increases in congestion and bottlenecks, impacting overall regional mobility. In particular, local roads will experience higher volumes of freight traffic due to industrial development on the periphery of the region. In addition, expressways will require more frequent maintenance from wear and tear.

Table 10. 2007 Truck Volume Estimates and 2040 Forecasts for the CMAP 7-County Region

		Truck Tons	**Percent Change**	**Truck Loads**	**Percent Change**
Inbound	2007	101,863,000	88%	6,637,000	75%
	2040	191,603,000		11,624,000	
Outbound	2007	91,028,000	35%	7,296,000	53%
	2040	122,588,000		11,130,000	
Intra-region	2007	172,628,000	53%	21,454,206	37%
	2040	264,491,000		29,408,000	
Through Traffic	2007	232,756,000	71%	12,907,000	109%
	2040	480,328,000		27,019,000	

Source: CMAP, Freight Volumes for the Trucking System

SECTION 5

Environmental and Community Trends

The interstate system has served as a core component of the region's transportation network and is vital to the region and state economy and quality of life. Additionally, the interstate system has increased travel safety, provided improved personal mobility, and enhanced security by providing for rapid military movements in response to national or world events. However, there have been some less desirable effects from development and use of the interstate system. This section explores some of the environmental and community impacts stemming from the development and use of the region's expressway system, as well as some potential impacts from global climate change, and introduces strategies to lessen the effect on the environment and communities. These strategies are further examined in Section 6.10, *Technologies and Strategies to Address Environmental and Community Needs*.

5.1 Increased Flooding Potential

One of the most significant water resource problems in the region is flooding. The Chicago region has been experiencing more frequent and intense flooding events due to a combination of factors, including changing precipitation patterns and urban development.

The effects of a changing climate include increased temperatures, longer periods of drought, and increased heavy storm events. Chronic flooding events cumulatively affect residents, businesses, and the region's economy and infrastructure. Storm and flooding events can also interrupt operation of the transportation network, leading to congestion, accidents, and road closures.

Development leads to increased impervious cover, which prevents the infiltration of rainwater into the ground and generates additional stormwater runoff. Urbanization has increased the prevalence of flooding, since more rainfall is converted to runoff rather than absorbed into the ground. In addition, stormwater and sewer infrastructure is often not built to accommodate heavy precipitation events. The typical standard rainfall amount used to size drainage systems in northeastern Illinois is the 24-hour, 10-year storm of 4.47 inches (based on rainfall frequencies from Bulletin 70, State Climatologist Office for Illinois). However, the 24-hour, 100-year storm has been met or exceeded three times since the 1980s (CMAP 2013).

The region should continue to identify best management practices and approaches within transportation right of way to adapt infrastructure to the potential impacts of increased flooding.

5.2 Air Quality

Motor vehicles emit harmful chemicals, including nitrogen oxides (NOx) and volatile organic compounds, which are sources of ground-level ozone. Ground-level ozone can trigger a variety of health problems including aggravated asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses. In addition to health effects, ground-level ozone can impact the environment, including damaging plants, trees, and crops. Motor vehicles also produce emissions of fine particulate matter (PM2.5). Many scientific studies have linked breathing particulate matter to significant health problems. The seven-county metropolitan Chicago region is in "nonattainment" with federal standards established by the Clean Air Act for ozone and particulate matter. Transportation and land use decisions play a part in affecting air quality, as automobile traffic and construction of transportation facilities are both significant sources of air pollution.

Greenhouse gases from human activities are the most significant driver of observed climate change. Greenhouse gases trap the sun's energy and thereby heat the earth's atmosphere. They include carbon dioxide, a byproduct of burning fossil fuels, methane from agricultural sources, and nitrous oxide from industrial sources. The transportation sector is the second-largest contributor of greenhouse gas emissions in the region, after energy use in buildings, accounting for nearly a quarter of the region's emissions (CMAP 2017k). Most of the transportation emissions are from on-road sources, predominantly passenger vehicles or light-duty trucks. Policies that promote investments in low-carbon transportation alternatives that reduce emissions, including alternative fuel vehicles, electric vehicles (see Section 6.7, *Electric Vehicle Technologies*), transit, bicycling, and walking, help to reduce emissions. Continued investments in low-carbon transportation options are needed to mitigate climate change.

5.3 Noise

Transportation facilities, including roadways and freight, create noise concerns. Noise, defined as unwanted or excessive sound, can be annoying, can interfere with sleep, work, or recreation, and in extremes, may cause physical and psychological damage. Transportation noise is perhaps the most pervasive and difficult source to avoid. Effective control of the undesirable effects of highway traffic noise requires that land use near highways be controlled, that vehicles themselves be quieted, and that mitigation of noise be undertaken on individual highway projects. Approaches such as cleaner or quieter trucks and locomotives, noise walls, and landscaping may go a long way toward mitigating local concerns.

5.4 Barrier Aspect of Expressway System

While some of the Chicago area's original expressways were laid out and built next to railroad corridors, others ran straight through urban cores, disrupting communities and displacing neighborhoods and families whose homes stood in the way (e.g., the Eisenhower, and Dan Ryan expressways). Today, these expressways present a large physical barrier for pedestrians and bicycles. These can be physical, social, or symbolic barriers that bisect neighborhoods and business districts. The presence of an expressway often restricts access between the two sides, whether because of a real lack of crossing points for various modes of transportation, or because of a perceived separation and distance. Future improvements should attempt to mitigate this barrier effect and improve access.

5.5 Congestion Pricing - Traffic Spillover onto Surface Streets during Congestion

Congestion pricing is a strategy to address the demand side of highway travel. CMAP's GO TO 2040 Plan includes policies that support highway congestion pricing, which involves varying the price to travel on designated travel lanes on a road based on the amount of traffic on that road. The intent of congestion pricing is that higher prices would reduce traffic by encouraging travelers to carpool, take transit, or consider alternative routes and times for their trips. At the same time, those who choose to pay a premium price would experience travel time savings and improved trip reliability.

One concern about congestion pricing is that traffic spillover to other roadways would result. Spillover could occur in the general-purpose lanes, which would then become more congested as they absorb the drivers not be willing to pay the premium to use the priced lanes. Spillover could occur on local roads, as some drivers would exit the highway all together, thereby shifting congestion onto those streets.

For existing highways where new capacity is not added, congestion pricing can be a significant challenge from public perception point of view. However, when congestion pricing is established as part of adding capacity (adding travel lanes), CMAP's analysis indicates that spillover should not occur. It is possible that other measures to minimize spillover may be required, such as making improvements to surface streets to handle increased traffic. Traffic spillover onto surface streets during periods of congestion is something that would have to be closely monitored if congestion pricing were implemented.

5.6 Greenfield/Low-Density Development Trends

Land use and development patterns, which shape the built and natural environments, directly affect a community's exposure to climate effects, as well as its emissions. For instance, compact developments and mixed-use communities encourage walking and bicycling, which reduces transportation emissions. Redevelopment of previously developed land—known as infill—is one of the best ways to create vibrant downtowns and neighborhoods, while also minimizing the impacts of the built environment on farmland and natural resources. Infill development makes efficient use of existing infrastructure and creating more walkable communities.

Greenfield, low-density development pressure is a significant challenge for some parts of the region—particularly at the edges of the metropolitan area. Growing communities often end up bearing the burden of costs to expand services and infrastructure as new development occurs, significantly decreasing the fiscal benefits they receive from new development. They then find themselves needing additional revenue sources to replace road, water, and other infrastructure over the long term.

For development that does occur on agricultural and natural lands, more compact and conservation-oriented designs can minimize the size of the development and reduce the long-term maintenance costs. Slightly more compact and conservation-oriented development standards, such as lot size, minimum block length, and street design standards, can reduce the expansion of infrastructure and reduce long-term infrastructure costs for municipal service providers.

SECTION 6

Emerging Technologies and Strategic Approaches

Emerging technologies and strategic approaches to managing traveler demand have the potential to reduce congestion in the future and shift how people in the Chicago metropolitan area get around. This section discusses several emerging technologies and strategic approaches for considerations in northeastern Illinois, including the following:

- Tunnel technologies
- Cantilevered facilities
- Pavement technologies
- Bridge and roadway designs to mitigate increased flood risk
- Transportation system management technologies
- Automated and connected vehicle technologies
- Electric vehicle technologies
- Traffic management technologies for passenger vehicles
- Traffic management technologies for truck vehicles
- Technologies and strategies to address environmental and community needs

Each topic area begins with a brief explanation of the technology, a discussion of current and future trends, followed by a discussion of recommended next steps for the region.

6.1 Tunnel Technologies

6.1.1 What It Is

Road tunnels use underground space for the transportation of goods and people. Tunnel boring, however, is costly and may present engineering challenges, but in locations where feasible and where aboveground options are expensive, too, it may offer significant operational and air quality benefits. In Chicagoland, road tunnels may be appropriate in the highly developed urban core, where expansion of the roadway to provide 2-3 lanes in each direction to address congestion and provide additional capacity is untenable.

6.1.2 Current Technology and Future Trends

A deep tunnel may be appropriate through the urban core, where expansion of the existing roadway footprint would have significant effects on adjacent land uses. For deep tunnels, tunnel boring machines (TBMs) are used as an alternative to traditional drilling and blasting methods, as they minimize disturbances to surrounding infrastructure. TBMs have been used successfully in urban areas as demonstrated recently in Los Angeles, where a tunnel was bore 110 feet below ground to extend approximately 1,440 feet of the Metro Rail system, connecting multiple rail lines. The project’s chief mechanical engineer, Richard Lane, told the *Los Angeles Times* on June 1, 2017, “With the old equipment, the ground might move as much as an inch and a half…On this project, sensors have picked up movement of no more than 0.16 inch.”

TBMs produce a smooth tunnel wall that reduces some of the cost associated with lining the tunnel and makes the tunnel suitable for heavily urbanized areas. Major disadvantages to TBMs are the upfront costs, difficulty transporting the machine, energy requirements for operation, and the tons of earth that must be removed from the construction site. Therefore, they are most applicable for longer tunnels, where the relative cost of TBMs versus drill and blast methods is less. This is because tunneling with TBMs is much more efficient and results in shortened completion times.

There are several examples of tolled tunnels in highly developed and congested urban areas including:

- Alaskan Way Viaduct tunnel, which is currently under construction, is a four-lane 2-mile long bored underground tunnel beneath an industrial corridor and the central business district of Seattle. The tunnel will replace the Alaskan Way Viaduct which is a double-decked elevated section of SR-99 that runs along the waterfront in the Seattle. Characteristics of the project include two fewer travel lanes than the current viaduct, and transit improvements to offset the loss of capacity. Notably, the tunnel allows the reconnection of a community with waterfront.
- Addison Airport Tunnel in north Dallas which connects the Dallas North Tollway and I-35E under the Addison Airport runway, allowing motorist to bypass the notorious congestion of north Dallas and Addison. The tunnel opened in 1999.

6.1.3 Recommendations

Along the northeastern Illinois expressway system tunnels could be considered at locations with intractable congestion where expanding the roadway facility to improve mobility is unreasonable, such as:

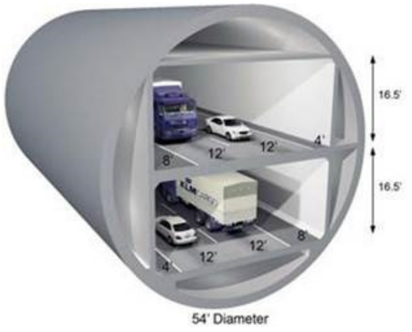
- I-90/I-94 Kennedy and Dan Ryan Expressways through downtown Chicago (approximately Ohio St. to 31st St.)
- I-90/I-94 Kennedy Ohio Street ramps to Michigan Avenue
- I-290 Eisenhower Expressway through Maywood and Forest Park, near the Des Plaines River and Forest Home Cemetery
- For transit use (CTA Blue Line), between Rosemont and Montrose Avenue where the Blue Line is co-located with I-190/I-90/I-94, which would free up space to expand I-90

For example, to provide supplemental capacity to I-90/I-94 Kennedy and Dan Ryan expressways through downtown Chicago, a tunnel could be constructed using a combination of methods, including the traditional cut-and-cover methods at the portals, as well as a tunnel boring machine (TBM) along the length of the tunnel. There are several important considerations, including:

- Real estate/corridor siting complexities, such as identifying each property owner the tunnel would pass beneath and securing an easement.
- Other underground structures such as the CTA blue line, underground service tunnels, underground utilities such as the Chicago Deep Tunnel, and proposed O'Hare express rail service.

Establishing the location of the tunnel would require a detailed concept study that includes investigations into both a proposed tunnel alignment and profile. Based on preliminary investigations of a bypass to the Kennedy/Dan Ryan Expressway through the urban core, the invert (bottom) of the tunnel would likely need to be about 200 feet below ground surface (bgs) to avoid the CTA subway system and the diameter of the tunnel would need to be about 60 feet to accommodate 2-3 lanes in each direction (stacked). If additional lanes are needed, a two-hole bored tunnel system would need to be considered. A detailed evaluation of the tunnel alignment and profile would include analyses of geology, ground water conditions, location of underground

Figure 11. Tunnel Cross Section



utilities, underground intersections (subways), surface and subsurface obstructions, and hazardous materials. In addition, a cost-benefit analysis that includes the expected rate of return on investment would need to be conducted. Further, potential community impacts and how fill material will be removed from the site would need to be considered.

6.2 Cantilevered Facilities

6.2.1 What It Is

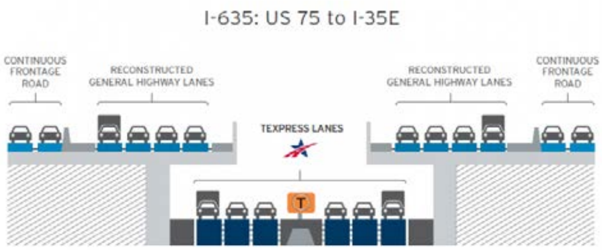
Cantilevered highway facilities, also referred to as elevated expressways or “double-decking,” involve the construction of highway travel lanes above other travel lanes to improve highway operations.

6.2.2 Current and Future Trends

This innovative design allows the capacity of the facility to be increased while maintaining the same footprint of the current facility. Examples of cantilevered facilities include the I-635 LBJ Freeway Managed Lanes in Dallas-Fort Worth, Texas, and the Lee Roy Selmon Tollroad in Hillsbourgh County, Florida.

The LBJ Express corridor involved the creation of managed lanes on nearly 6 miles of I-35E. A 10.7-mile stretch of I-635 from I-35E east to U.S. 75 (which included 8 general-use lanes and 4 to 6 frontage road lanes) was completely rebuilt with 6 new managed lanes sunk below the cantilevered general-purpose lanes. See Figure 12.

Figure 12. Cantilevered Highway Facility



Source: http://www.lbjtexpress.com/maps/I-635-I-35E-cross-section-maps

The Selmon Tollroad is a 15-mile all-electronic toll roadway that links west Hillsborough County through downtown Tampa to Brandon. The cantilevered portion of the facility includes three Reversible Express Lanes, which provides additional capacity westbound during the morning commute, and eastbound during the evening commute and on weekends.

The Kennedy Expressway (I-90 and I-90/94) Managed Lanes Study, prepared by AECOM in 2012, considered as one option a cantilevered facility (referred to as a two-level structure) from Roosevelt Road to 31st Street (at the location of the High Bridge, built as part of the original construction of I-90/94 and the Dan Ryan Expressway). The second level would allow for two managed lanes in each direction. The lanes would be managed 24/7 and could allow connectivity to managed lanes along I-290, I-55, and direct access to downtown entrance and exit ramps. The facility would allow access to and from the general purpose and managed lanes, along with the Franklin (Chinatown) feeder, to the express and local lanes of the Dan Ryan Expressway. This improvement would have minor need for right of way or air rights.

6.2.3 Recommendations

There are several challenges to constructing cantilevered facilities in the Chicago area, including the following:

- General maintenance/operations (e.g., snow removal)
- Negative effect on adjacent communities, including visual and physical impacts, as well as increased and magnified noise generated by traffic

- Termini treatments
- Costs

Nonetheless, cantilevered facilities may be appropriate in the Chicago area where right-of-way restricts capacity improvements. IDOT and Tollway should continue to monitor this strategy to address mobility issues as appropriate across the northeastern Illinois expressway system.

6.3 Pavement Technologies

6.3.1 What It Is

State DOTs and the federal government are changing the way they prioritize maintenance activities and design and construct roads and bridges. Asphalt and concrete pavements have continued to evolve since their origins in the 1800s. They have become stronger, more economical, and more sustainable, as well as safer, quieter, and smoother for drivers. Some research efforts to improve asphalt and concrete pavements have focused on specialty mixes for specific applications, while others have focused more broadly on best practices, enhanced durability, and increased use of recycled materials. Today, innovative pavement technologies are emerging, largely due to the present and expected impacts of climate change. Warmer temperatures, wet conditions, and extreme weather events can damage roads, bridges, and other transportation facilities and cost large sums to repair. In addition, the process to create asphalt and concrete pavements releases high concentrations of greenhouse gases. Further, pavements need to be designed to endure increasing volumes of passenger vehicles, freight traffic, and bus transit.

6.3.2 Current Technology

Since the 1800s, applying heat and pressure to a mixture of aggregates and asphalt binder has been a common, cost-effective method for creating long-lasting pavements. Asphalt pavements can be divided into three categories, each designed for different uses, locations, and traffic volumes, as follows.

- ***Dense-Graded Asphalt:*** An impervious pavement that can provide a smooth, high performance surface that is easy to maintain. Most asphalt pavements are dense-graded and are used effectively in all pavement layers and for all traffic conditions (APA Undated).
- ***Open-Graded Asphalt:*** This pavement type is specifically designed to allow water to drain through the pavement. It can be constructed as an open-graded friction course (OGFC), which facilitates water movement to the side of a pavement, improving friction while reducing road spray and noise; or it can be constructed as full-depth porous pavement, where water drains through the pavement to the soil. Full-depth porous pavements are a U.S. Environmental Protection Agency stormwater management best practice and can help reduce pollutant concentrations. OGFCs have also been demonstrated to help filter possible pollutants from highway runoff (APA Undated). Open-graded asphalt is used as a surface mixture only; it should only be used on high- or medium-traffic-volume roadways (interstates and highways) with posted high speeds, which helps to keep the pores from clogging.
- ***Stone-Matrix Asphalt (SMA):*** A gap-graded pavement designed to improve durability and rut resistance by using a stable stone-on-stone skeleton held together by a mixture of asphalt cement and stabilizing agents such as fibers and/or asphalt modifiers. SMA has good friction characteristics and is effective in reducing spray and traffic noise. SMA is primarily used to pave high-volume interstates and highways (APA Undated).

  The Illinois Tollway has researched various SMA mixes. Future mix designs may yield longer life with little to no extra cost. A field study conducted in the late fall of 2008 tested a warm-mix asphalt additive on a project at no additional construction cost. The results showed similar performance characteristics and improved fatigue performance to traditional SMA. In addition, SMA mixtures may have several benefits, as follows:

  - Reduced asphalt plant emissions
  - Reduced fuel and energy use
  - Paving benefits
  - Reduced worker exposure

Concrete pavement has also been commonly used since the late 1800s for highways, airports, and many streets and roads. The following are types of concrete pavements:

- ***Jointed Concrete Pavements:*** The most commonly used concrete pavements, which are designed and constructed with controlled cracks. Concrete pavements will crack naturally, and jointed pavements have enough joints to control the location of all expected natural cracks (ACPA Undated).
- ***Continuously Reinforced Concrete Pavements:*** Constructed with reinforcing steel to hold cracks together tightly, this type of pavement does not require any transverse contraction joints. Transverse cracks are expected in the concrete, so the reinforcing steel is placed prior to the placement of concrete (ACPA Undated). Continuously reinforced concrete pavement was used in reconstructing the Dan Ryan Expressway. The pavement is 0.7 percent steel and has a 40-year design life.
- ***Concrete Overlays (Bonded and Unbonded):*** Bonded concrete overlays are thin (2 in. to 6 in. thick) and may be placed directly on an underlying asphalt, concrete, or composite pavement that is still structurally sound. These overlays can be used to extend pavement life by 15 to 25 years. Bonded concrete overlays are typically 4 to 11 inches thick and are placed on a stable base to serve as a new full-depth pavement section. They can extend pavement life by 15 to 30+ years (ACPA Undated).
- ***Precast Pavements:*** A highly durable finished pavement typically used for constructing or repairing a concrete pavement surface, where casing and curing of panels are done in advance. They are a repair option for jointed concrete pavements and may be a reconstruction option for either jointed plain concrete pavements or asphalt pavements. Also, they have a high load-carrying capacity and are relatively fast to construct (ACPA Undated).
- ***Next-Generation Concrete Surface:*** A surface that can be used for either new or existing concrete pavements that is proving to be as quiet or quieter than any alternative (ACPA Undated).
- ***Roller-Compacted Concrete:*** A stiff, zero-slump, strong concrete mixture that is typically placed with high-density paving equipment. It may be used as monolithic surface pavement or as a support layer for both low-speed or industrial applications and roads with high load-carrying capacity.
- ***Cement-Treated Base:*** A mixture of aggregate material and/or granular soils combined with engineered amounts of Portland cement and water. It is used as a concrete pavement subbase or flexible pavement base material. It allows for the use of marginal aggregates, including recycled materials (ACPA Undated).
- ***Recycled Concrete Aggregates:*** Aggregates produced from recycling existing concrete and reused in various pavement applications. The Illinois Tollway has tested pavement mixtures with recycled concrete aggregate (RCA) and fractionated reclaimed asphalt pavement (FRAP).

  In widening and rebuilding the Jane Addams Memorial Tollway (I-90), the Illinois Tollway recycled and reused the existing concrete and asphalt as base material for the new road bed. In addition to reducing the cost of this work, reuse of these materials reduced the need for virgin materials and reduced the volume of material that would otherwise be sent to landfills.

6.3.3 Future Trends

There are numerous pavement innovations being developed and tested, including the following:

- ***Inductive Charging Pavements:*** This “inductive power transfer” technology integrates electrical supply cables in a prefabricated concrete slab implemented in the roadway. These cables create an electromagnetic induction field, used for charging an electric vehicle while driving. Highways England is currently conducting off-road trials to test Dynamic Wireless Power Transfer technology. The trials involve fitting vehicles with wireless technology and testing the equipment, installed underneath the road, to duplicate highway conditions. The off-road trials are expected to last for approximately 18 months and could be following by road trials.
- ***Intelligent Networked Highways:*** Fiber optics and sensors embedded in roadway pavement, in addition to roadside “listening stations,” will link up with global positioning system (GPS) receivers in cars to monitor traffic patterns and accidents. Information is then passed back to the navigation system in vehicles to help drivers avoid congested areas and accidents. This technology is different from loop sensors used in Chicago area expressway pavements, which measure vehicle speed and obtain travel time information, as information is passed back to vehicles.
- ***Solar Roadways:*** A structurally engineered solar panel that can be driven upon. The roadway surface layer contains solar collector cells, LED lights, and heating element, covered with a translucent high-strength glass that still provides traction for cars. A middle layer contains a microprocessor board that can sense vehicle and pedestrian loads, control the heating element for snow and ice removal, control variable lighting, and provide communications. The bottom layer distributes solar power among other things. In December 2016, a 540-square-plot section of drive-over solar panel roadway was installed at the I-85 Visitor Center in West Point, Georgia. The clean energy generated by the site will help to power the Georgia Visitor Information Center. Drive-over solar panels have the potential to generate electricity for multiple uses, including remote areas where the cost of connecting to the grid is expensive. Missouri DOT is planning to install energy-generating photovoltaic pavers along a segment of sidewalk at the Route 66 Welcome Center in Missouri.
- ***Solar Power Pavement Markings/Signs:*** Illuminated roadway markings and signage powered by solar energy are emerging technologies. Solar-powered raised pavement markings (SRPM) contain a small photovoltaic cell that stores energy during daylight hours. The SRPM then automatically turns on at night. SRPMs have multiple uses, including crosswalks, lane delineation, curves, shoulders, guard rails and jersey barriers, temporary traffic pattern changes, and speed bumps. This technology is still being evaluated to ensure that the products meet standards for retro reflectivity and chromaticity standards. The Colorado DOT has installed solar-powered LED pavement markings along sections of I-70, which are intended to improve delineation along dark stretches of the roadway, and ultimately improve safety on the corridor. Additionally, IDOT and Tollway have implemented some solar powered signs in the region.
- ***Solar, Wind-Power Generators Jersey Barriers:*** Jersey barriers embedded with miniature wind turbines that harness wind energy generated from passing traffic along a highway.
- ***Dynamic Paint:*** Symbols that appear on the road surface that can indicate whether the temperature is hot enough or cold enough to affect driving conditions. It provides early warning when roads start to become dangerous because of freezing weather conditions.
- ***Glass Material in Highways:*** Recycled broken glass, a renewable material (also referred to as cullet or pulverized glass aggregate), can be used as roadway aggregate material. Cullet has been found to

be a suitable supplement for gravel in many construction applications; it does not have harmful environmental side effects and can be cost-competitive with other aggregate materials.

- ***Green Cement:*** This is an alternative process to create cement in a way that releases less greenhouse gases than the typical process. The Illinois Tollway has conducted research on recycled concrete aggregates and additives to traditional pavement, which reduce asphalt plant emissions, fuel, and energy use.
- ***Hydrogen Highways:*** For hydrogen-powered vehicles to become a viable option, investment in the underlying infrastructure is required (i.e., hydrogen stations). A hydrogen highway would be a chain of hydrogen fuel stations and infrastructure along a common highway or route to enable hydrogen-powered cars to travel. California has developed a blueprint for Hydrogen Highway infrastructure and plans to have as many as 100 hydrogen stations open by 2017. An East Coast Hydrogen Highway from Maine to Florida is also being planned.
- ***Pavement Heat Exchangers:*** There is research underway on evaluating the thermal energy potential of “asphalt collector” systems to take advantage of the heating or cooling effects that pavements can provide. This technology could potentially provide heating, cooling, or energy to associated/surrounding structures or facilities, reduce the heat island effect, and provide additional safety in the form of deicing.
- ***Photocatalytic Concrete:*** Photocatalytic concrete contains a type of cement mix coated with highly reactive titanium dioxide particles that react to break down harmful air pollutants. This process cleans the concrete by deflecting and degrading dirty air particles. In addition to cleaning the air, titanium dioxide helps keep the concrete cool by reflecting sunlight. This technology has been tested and proven successful in several European locations. In addition, the I-35W replacement bridge in Minneapolis includes two 30-foot sculptures made of photocatalytic concrete.
- ***Resin Based Pavement:*** Resin-based pavements use clear tree resin and pitch from pine trees in place of petroleum-based elements to bind aggregate. Because the resin is transparent, the pavement takes on the lighter color of aggregate, which gives the pavement a higher surface reflectivity and lower surface temperature than blacktop asphalt. Because the mixture does not need to be heated like conventional asphalt, less energy and fossil fuels are expended in the construction process. Resin pavements are more commonly used on lower-volume public roads, highway and airport shoulders, private access roads, parking lots, sidewalks and walkways, and trails.
- ***Solar Highway Energy Generation:*** The concept of “Solar Highways” involves the installation of photovoltaic panels along undeveloped highway right-of-way. The energy created by the solar panels can be used to power different elements of the highway, such as night time illumination, road signs, emergency telephones, and even ventilation systems for tunnels. The first “Solar Highway” project in the U.S. was completed at the I-5/I-205 Interchange near Tualatin, Oregon, in December 2008. The project consists of 504 ground-mounted solar panels that produce 128,000 kilowatt hours annually, or about one-third of all electricity needed to run the illumination at the interchange. Another successful project is Nevada’s State Highway 447, referred to as “America’s Solar Highway.” It includes 10 solar arrays that produce 451 kilowatts of energy along 75 miles, equating to 6 kilowatts per mile, believed to be the largest amount of distributed solar power per mile of any highway in the U.S.
- ***Glow-in-the-Dark Road Markings:*** Road markings with “glow-in-the-dark” paint so that they can be seen without the need for lights.
- ***Anti-Icing Roads:*** Road surfaces creating naturally reactive de-icer (such as the patented, epoxy-aggregate pavement surface, SafeLane surface overlay) that prevent ice from forming on the roadway.

- ***Interactive Wind-Powered Lights:*** Road lights that only turn on when a car is present and are powered by the wind.
- ***Piezoelectric Energy Roads:*** Piezoelectric crystals generating energy from the vibrations that vehicles generate as they drive along the roadway.

Table 11. Summary Assessment for Planning Consideration – Future Pavement Technologies

Criteria	**Inductive Charging Pavement**	**Intelligent Networked Highways**	**Solar Roadways**	**Solar Power Pavement Markings/Signs**	**Solar, Wind-Power Generators Jersey Barriers**	**Dynamic Paint**	**Glass Material in Highways**	**Green Cement**	**Hydrogen Highways**	**Pavement Heat Exchangers**	**Photocatalytic Concrete**	**Resin Based Pavement**	**Solar Highway Energy Generation**	**Glow in the Dark Road Markings**	**Interactive Wind-Powered Lights**	**Piezoelectric Energy Roads**
Likelihood of Technology Readiness	🟩	🟩	🟩	🟩	🟨	🟨	🟨	🟨	🟥	🟥	🟥	🟨	🟩	🟨	🟥	🟥
Ease of Implementation	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟨	🟥
Effect on Demand and Revenue	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥	🟥
Relevance for Chicago Area	🟨	🟨	🟨	🟩	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
Environmental Sustainability	🟩	🟩	🟩	🟩	🟩	🟨	🟨	🟩	🟩	🟩	🟩	🟨	🟩	🟨	🟩	🟩
Potential Ranking for Further Consideration	1	1	2	3	3	3	-	-	-	-	-	-	-	-	-	-

1 = High, 2 = Medium/High, 3 = Medium

Green = High, Yellow = Medium, Red = Low

Note: The rankings in this table are based on CH2M staff engineering judgement.

6.3.4 Recommendations

The following pavement technologies are recommended for further consideration and evaluation in the **near-term**:

- Tollway could continue to research and field test advancements in current pavement technologies (e.g., stone matrix asphalt mixtures, recycled concrete aggregates, continuously reinforced concrete pavements)

Inductive Charging Pavement

IDOT and/or Tollway could conduct a pilot project for the implementation of inductive charging pavements, to include the following types of activities:

- Develop a focus group (possibly of 6 to 12 participants) including agency personnel to identify potential corridors for pilot studies.
  - Corridors that provide for long-haul trips are prime for testing inductive charging pavement technology, for example I-80
- Establish an additional toll for the electric vehicle lane as it provides users with a service; simulate back-office systems in order to test its functionality and necessary data exchange prior to making actual financial transactions.
- Consider the effects of potential increases in truck weight in the future; inclusion of the technology in the pavement will increase pavement thickness.
- To support the roll-out of inductive charging pavement and encourage adoption of electric vehicles, continue to build out the necessary electric vehicle infrastructure to stimulate the demand for compatible vehicles (see Section 6.7, Electric Vehicle Technologies); focus on commercial operators as early adopters. Conduct a set of controlled trials and follow-on public demonstrators to generate evidence of the system functionality and share outputs with potential users and other key stakeholders.
- Engage in FHWA's Alternative Fuels Corridors program (see Section 6.7, *Electric Vehicle Technologies*).
- Gain support of vehicle manufacturers for installing vehicle inductive charging components; non-vehicle manufacturer supported retrofits should not be attempted.
- Identify and trial all construction methods to gather evidence on complexity and cost of construction, as well as long-term impact on degradation of the interfaces and the road structure.
  - Once a preferred construction method is identified, carry out additional investigations to develop a concept for required machinery to optimize the construction method and minimize construction time.
- Investigate different coil lengths to understand the variability and implications on safety (systems with shorter coil lengths are likely to be safer and cope with higher utilization).

Intelligent Networked Highways

IDOT and/or Tollway could conduct a pilot project for the implementation of intelligent networked highways to include the following types of activities:

- Consider embedding fiber optics or sensors in the pavement. For example, IDOT and/or Tollway could employ detection and cloud-based software that understands and can report available parking spots to truckers or monitor traffic patterns and accidents to alert drivers to incidents.

- An alternative or complementary strategy is installing various forms of intelligent systems, such as cameras and wireless infrastructure on light poles or other overhead infrastructure. Maintenance or replacement may be easier and less costly than devices installed within or under pavements.

Solar Roadways

When reconstructing or restriping its expressways, IDOT and/or Tollway could conduct a pilot project for implementation of solar roadways.

The following pavement technologies are recommended for further consideration and evaluation in the **long-term**:

Solar Power Pavement Markings/Signs

IDOT, Tollway, and/or CMAP could conduct a research project on solar power pavement markings/signs to include the following types of activities:

- International best practice scan
- Cost-benefit analysis
- Replacing existing electronic roadway signs with solar-powered signs

Solar, Wind-Power Generators Jersey Barriers

IDOT, Tollway, and/or CMAP could conduct a research project on solar, wind-power generators in jersey barriers to include the following types of activities:

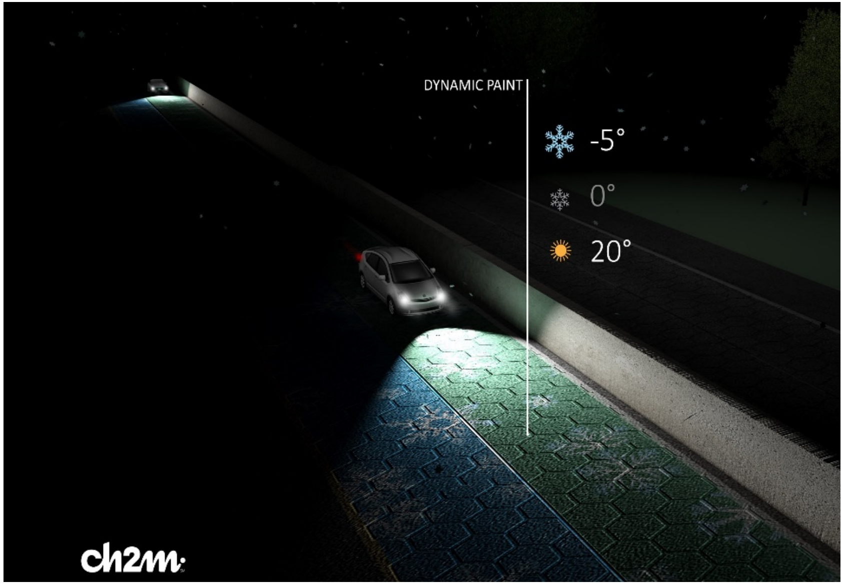
- International best practice scan
- Embedding expressway barriers with miniature wind turbines; the wind energy generated from passing traffic can be used to illuminate lighting, electronic signage, etc.

Dynamic Paint

IDOT, Tollway, and/or CMAP could conduct a research project on dynamic paint to include the following types of activities:

- Painting symbols on the expressways that appear when freezing temperatures may create potentially dangerous roadway conditions, providing early warning to users.

Figure 13. Dynamic Pavement Paint



6.4 Bridge and Roadway Designs to Mitigate Increased Flood Risks

6.4.1 What It Is

Bridges and roads that parallel or intersect rivers and floodplains are subject to flooding, and as a result of climate change, increased flood risks pose a concern (refer to Section 5.1, *Increased Flooding Potential*). In the past 30 years, flooding has cost billions in damages per year, including damages to bridges and roads.

Areas in Metropolitan Chicago experience severe flooding due to several unique factors:

- The city was constructed on low-lying swamp land adjacent to Lake Michigan
- There is very little topographic relief, as the city sits on a flat plain that was once the bottom of Lake Chicago
- The storm sewer systems within the city and many surrounding suburbs are combined with sanitary sewers; this presents unique challenges since the combined flow must be treated before being discharged to rivers.

A massive deep tunnel system, known as the Tunnel and Reservoir Plan (TARP) was initiated in the 1970s to reduce flooding and improve water quality. Since construction began in 1975, 109 miles of tunnels and two reservoirs have been completed. Local combined sewer systems discharge into the large-diameter tunnels, which capture and convey combined stormwater and sewerage in three huge reservoirs. Stored water is then pumped to water reclamation plants for treatment prior to being discharged to waterways.

While local roads contribute to the TARP system, most expressways and tollways have separate stormwater systems that convey runoff directly to rivers. Many of the older systems discharge directly to rivers with no storage or flow attenuation, contributing to the flooding of the waterways. Some of the systems rely on pump stations due to the flat topography of the region. These pump systems can lack capacity to keep up with heavy rainfall events, causing dangerous ponding conditions and damage to embankments and retaining walls. In addition, these systems are very expensive to construct and maintain, and provide no water quality benefits.

6.4.2 Current Technology

Historically and still in many places, flood management involves redirecting flood runoff using floodgates, artificial levees, dams, and reservoirs, rather than creating more resilient infrastructure.

- Floodgates are adjustable gates used to control water flow in flood barriers, reservoir, river, stream, or levee systems.
- Artificial levees, or floodwalls, parallel the course of a river and prevent flooding of adjacent areas.
- Dams retain water when needed and release water into spillways when levels become too high. Prior to rainy or wet seasons, the water level can be lowered to make room for anticipated precipitation.
- Storm sewer systems direct runoff into reservoirs and detention basins to attenuate flow before discharging to rivers and streams. These basins can significantly reduce runoff volume discharged to downstream waterbodies during peak storm events by limiting outflow with restrictors and encouraging infiltration.

These systems, however, may fail due to structural, mechanical, or hydraulic issues, inadequate maintenance, and age. Artificial levees can fail in a number of ways, including overtopping, erosion, structural failure, levee saturation, and levee breach. Also, artificial levees constrict the flow of the river, causing increased water levels and higher velocity flow, which puts more pressure on levees downstream and makes the water more difficult to control. In addition, dams can fail due to malfunctioning dam components, inadequate design, seepage issues, spillway damage, embankment and stability problems, and improper operation or maintenance. Dams also disrupt the ecosystem's interconnectedness, particularly in terms of aquatic species migration, habitat, and the surrounding environment. In fact, there is a growing movement to remove or modify dams that have damaged local ecosystems, outlived their usefulness, or become a safety hazard. Alternative, environmentally-friendly and resilient strategies should be explored in future flood management efforts.

6.4.3 Future Trends

As storm events become more intense as a result of climate change, strategies that promote resilient infrastructure, rather than redirect floodwater, should be a priority. To mitigate increased flood risks, transportation agencies have begun to implement changes in how they address maintenance, rehabilitation, and the construction of new bridges and roads.

6.4.3.1 Iowa DOT

In Iowa, which experienced major flooding in summer 2008, the Iowa DOT incorporated a grade rise of about 2 feet for future work on I-35 bridges, which was the most cost-effective resilient design that would prevent the Interstate from overtopping during a 200-year flood. In concert with proposed grade raising for another major Iowa Interstate, I-80, the Iowa DOT detailed that an analysis of bridge scour severity would be needed since a grade rise would increase the amount of water that would pass through the bridge opening.

6.4.3.2 Minnesota DOT

During their pilot project, the Minnesota DOT (MnDOT) noted that some of the most effective ways to increase resilience in major rainfall events would be to increase the width and height of drainage culverts, add a floodplain enhancement upstream of culverts to give waterways room to spread out and to lower the elevation of peak flows, and to replace culverts with bridges. In addition to these improvements, new construction by MnDOT was designed to handle 50-year storm events.

6.4.3.3 New York State DOT

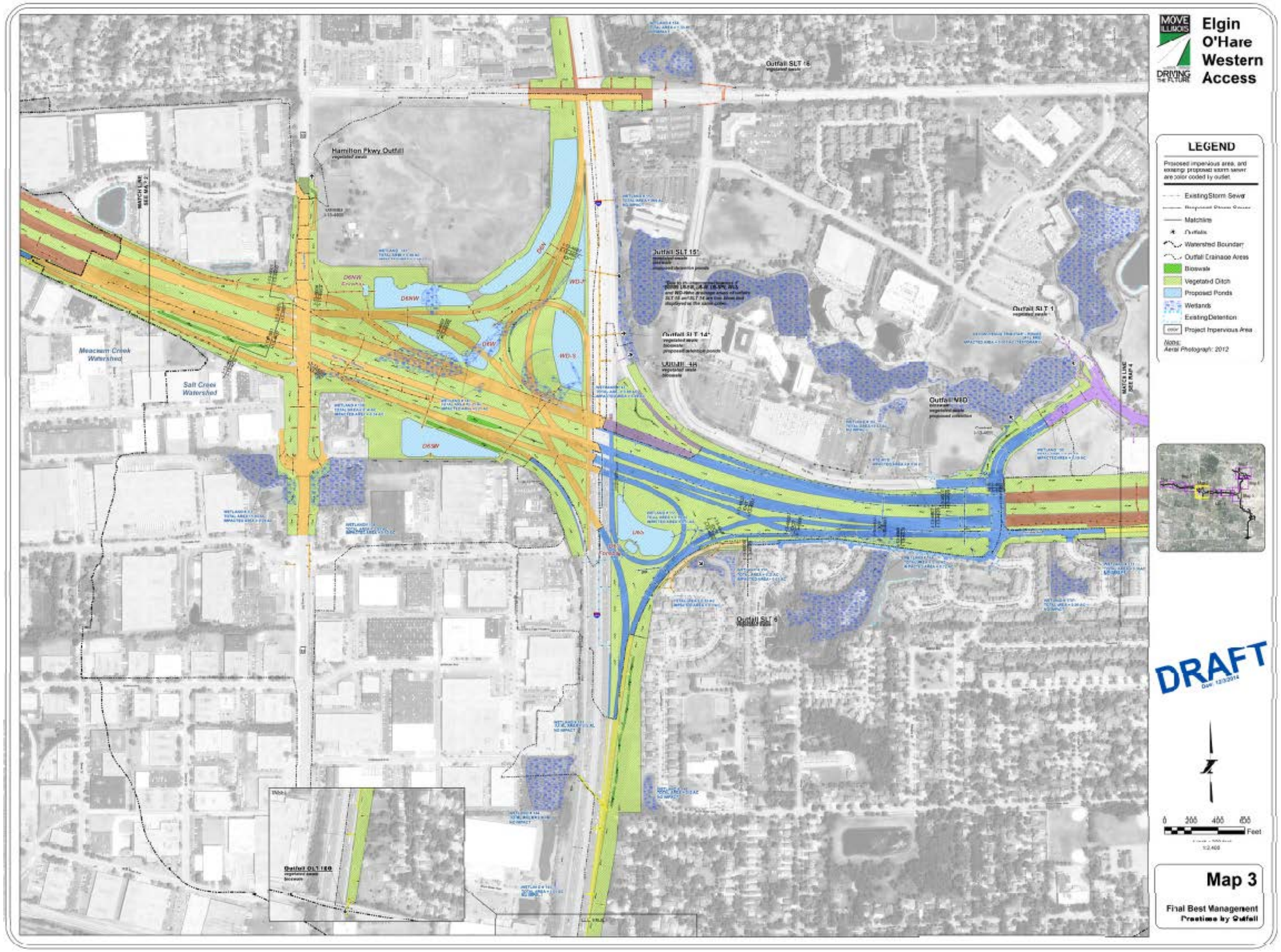
As part of a statewide study to determine effective climate change adaptation strategies, the New York State DOT (NYSDOT) determined that infrastructure designs should be tailored to handle the climate variables and impacts expected at the date of implementation and beyond, and that a flexible adaptation pathway would allow agencies to change the adaptation strategy over time. NYSDOT also recommended that climate adaptation strategies be included in regular maintenance and rehabilitation efforts and that new heat thresholds be considered for bridge and road surfacing projects. It also identified a number of adaptation strategies that could be used to mitigate the effects of increased precipitation, including the following:

- Increasing the carrying capacity of culverts, detention basins, and other drainage systems
- Ensuring adequate maintenance of roadway infrastructure
- Raising road embankments and increasing slopes
- Raising or relocating roadways out of flood zones
- Monitoring scour action at inland bridges

6.4.3.4 Illinois DOT and Illinois Tollway

In the Chicago area, the Elgin-O'Hare Western Access Project IL 390/I-290 system interchange features stormwater best management practices, including seven basins, three bioswales, and expansive vegetated areas (see Figure 14). The Elmhurst Road interchange at I-90 will also include these features as part of the Elgin-O'Hare Western Access project.

Figure 14. IL 390/I-290 System Interchange Stormwater Management



In 2010, the Illinois Tollway partnered with the Forest Preserve District of Cook County to implement a stormwater demonstration project along the North Tri-State Tollway (I-294) in northern Cook County. The demonstration project includes approximately 16 acres of Forest Preserve property from Touhy Avenue near O'Hare Airport to Lake Cook Road. The Tollway constructed wet and dry bioswales along 30,000 linear feet of roadway to facilitate the widening and reconstruction of I-294 while at the same time managing the stormwater runoff from the roadway (see Figure 15) (Illinois Tollway Undated). Bioswales are vegetated drainage courses that manage stormwater by slowing, filtering, and reducing runoff through infiltration and evapotranspiration. This is accomplished by using specialized plants that absorb pollutants and runoff, along with engineering soil layers that increase retention and infiltration. They provide an alternative to traditional ditches and sewers and are designed to treat and infiltrate a specified amount of runoff from a large impervious area, such as a roadway (Soil Science Society of America 2018).

In addition to bridge and roadway design to mitigate increased flood risks, state DOTs are conducting efforts (i.e., vulnerability assessments) to better understand the potential for flooding in certain locations. In conducting vulnerability assessments, Connecticut, Iowa, and Minnesota used hydraulic analyses for bridges and culverts to evaluate the hydraulic performance of the structures over a range of flow conditions. These efforts will help to plan for and mitigate future events before they occur.

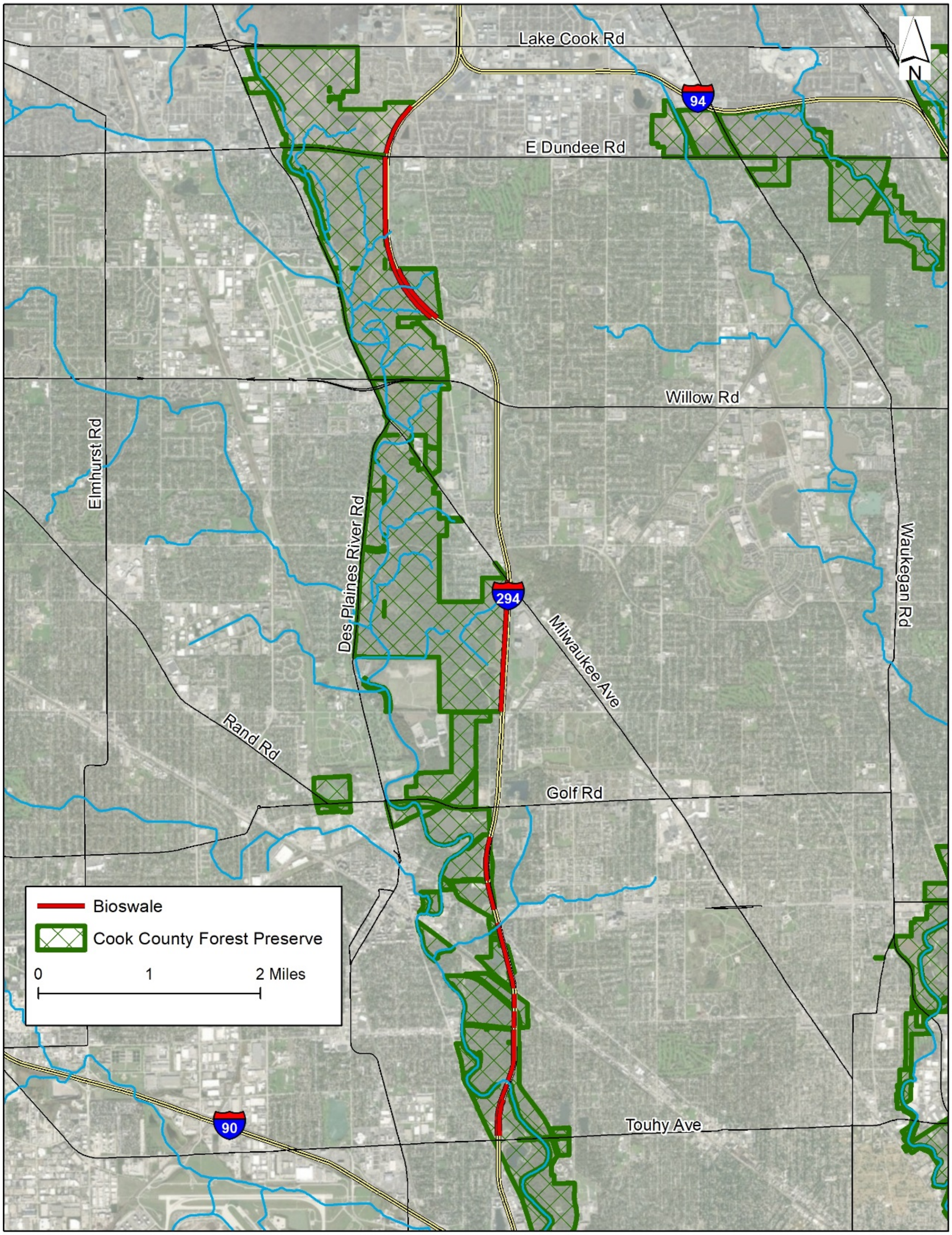
6.4.4 Recommendations

As flooding in the region is expected to become more frequent in the future, associated damages could increase if climate change isn’t considered. The following strategies are recommended for consideration to mitigate increased flood risks to bridges and roadways:

6.4.4.1 Design Considerations

- Establish the minimum freeboard between the 50-year flood elevation and the proposed low edge of pavement to be 3 feet.
- Design roadways to prevent a 500-year storm from encroaching on the low edge of pavement.
- Perform a hydrologic analysis on each regionally delineated drainage basin contributing to the proposed contract outfalls.
- Perform a hydrologic analysis to support water quality volume standards.
- Require flow attenuation using detention basins with restricted outfalls. Flow attenuation should match the pre-development conditions release rate for the 100-year design storm.
- Construct detention basins with capacity to route the 100-year critical duration storm event and with 3 feet of freeboard.
- Design culverts to pass the 50-year peak flow with 3 feet of freeboard below the edge of pavement. In addition, the headwater elevation should not exceed the inner crown elevation (no ponding upstream of the culvert during the 50-year storm). 100-year and 500-year storms are checked to ensure no encroachment at low the edge of pavement.
- Analyze potential future precipitation patterns in hydrologic models to determine future flooding potential.
- The rainfall intensity-duration-frequency curves used by many agencies (IDOT, Tollway) is based on Bulletin 70 – Frequency Distributions of Heavy Rainstorms in Illinois (1989). This data is almost 30 years old and does not reflect climate change trends. A statistical precipitation evaluation tool should be used to develop intensity-duration-frequency curves from projected precipitation data.

Figure 15. Location of Bioswales along I-294 Tri-State Tollway (Touhy Ave to Lake Cook Road)



Source: Adapted from Miner et al. 2016, Illinois State Geological Survey

6.4.4.2 Planning Considerations

- Develop a list of bridges/structures at risk if flooding occurs (comparing floodplain elevations to known bridge elevations).
- Work with communities to conduct vulnerability assessments as part of transportation planning; address local flooding as part of roadway improvements when feasible.
- Develop and enhance operational strategies to maintain performance.
- Identify roadway design opportunities that provide space for stormwater management. This includes ramp reconstruction to provide space for detention basins, or underground storage facilities constructed beneath the roads.
- Develop design principles for stormwater best management practices.

6.4.4.3 Application

The following locations are highly susceptible to flooding and would benefit from the recommendations above:

- I-290/I-294/I-88 System Interchange
- I-290 Mannheim Road and 25th Avenue interchanges. On Addison Creek, there is significant flooding resulting in flood damage both upstream and downstream of I-290. The Mannheim Road and 25th Avenue loop ramps lie within the Addison Creek floodplain.

The I-390/I-290 system interchange design may serve as an example to guide reconstruction.

6.5 Transportation System Management Technologies

6.5.1 What It Is

Improved highway management and operations techniques address the recurring and non-recurring sources of congestion to move toward a system that operates more efficiently, reliably, and safely, while also costing less than capacity expansion. Highway management and operations strategies include active traffic management (ATM), managed lanes (controlled by pricing, occupancy, or other means), ramp metering, incident management (detection and response), traveler information, access management, and integrated corridor management (ICM). Supporting strategies can include roadway weather detection and response, traffic signal coordination, work zone management, and transportation demand management.

6.5.2 Current and Future Trends

6.5.2.1 Active Traffic Management

ATM is the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions (FHWA 2012). ATM provides real-time information to drivers including travel times, traffic incident advisories, lane closures, and traffic pattern changes. ATM approaches include dynamic lane use/shoulder control, dynamic speed limits, queue warning, adaptive ramp metering, dynamic rerouting, dynamic junction control, adaptive traffic signal control, and automated enforcement.

The Tollway has implemented ATM on the Jane Addams Memorial Tollway (I-90) between the Kennedy Expressway and Barrington Road. Operational features include optional hard shoulder running (which can be used by Pace bus services when congestion conditions arise, for supplementary general-purpose capacity for serious incidents, or for maintenance or responder use), variable speeds, dynamic junction control, queue warnings, and merge control.

The Tollway's Traffic and Incident Management Center collects data and video to provide information to drivers, as well as for Pace buses to drive in the shoulder lanes. The data is also shared with navigation apps such as Waze, MapQuest and Google Maps, allowing motorists to better plan their travel. SmartRoad high-tech gantries are located every half-mile between Barrington Road and the Kennedy Expressway to communicate with drivers.

Best Practices in Managed Lanes

- ➢ Planning and Project Development
  - Agency Collaboration
  - Selecting a Managed Lane Strategy
  - Identifying a Hierarchy of Users
  - Establishing Threshold Values
  - Communicating the Managed Lane Strategy
- ➢ Facility Operations with Continual Monitoring
  - Project Flexibility
  - Monitoring and Evaluation
- ➢ Life-Cycle Considerations

Source: FHWA 2008

6.5.2.2 Managed Lanes

"Managed lanes" are defined as a limited number of lanes set aside where operational strategies are used and actively adjusted as needed for the purpose of achieving pre-defined performance objectives. Managed lanes can be single lanes up to the whole facility. Managed lanes are controlled to optimize travel flow and reduce congestion. The following are the most commonly applied managed lane strategies:

- Dedicated lanes (express and reversible lanes)
- Congestion pricing (allocating capacity through a traveler's willingness to pay) (see Section 5.5, Congestion Pricing – Traffic Spillover onto Surface Streets during Congestion)
- Vehicle preferences (managing lanes by restricting or encouraging certain vehicle characteristics, such as truck only, bus only, passenger vehicle only, or high-occupancy vehicle [HOVs])

Other supporting technologies and strategies are often used to support managed lanes, including variable message signage, overhead lane usage signal systems, and electronic toll collection.

Managed-lane facilities can encourage ridesharing or transit ridership through occupancy discounts (high-occupancy toll lanes [HOT]) and through placement and seamless integration (e.g., direct ramp access) of adjacent park-and-ride facilities. If transit services are provided along with managed lanes, increases in transit use may occur. Benefits are higher where managed lane facilities connect dense residential areas to job-rich economic corridors and centers.

Some successful examples of managed lanes are as follows:

- I-35W in Minneapolis includes a dynamic shoulder lane in the left-most lane from 42nd Street to downtown, which operates as a:
  - Priced dynamic shoulder lane at times when the adjacent stretch of I-35W is operated as a HOT lane
  - Priced dynamic shoulder lane at times when the capacity is needed
  - Shoulder when needed
- The New Jersey Turnpike Dual-Dual Section is a 31-mile dual-dual section of the turnpike, each with its own ingress and egress points. Trucks are required to travel on outer lanes, while passenger vehicles may travel on inner or outer lanes. There is an HOV lane on the outer section, which operates during peak periods. Drivers receive discounts for traveling in the HOV lane or for having an EZ-pass. Lastly, the Turnpike Authority varies pricing to shift travelers out of peak. The project has enhanced safety and improved operations through increased flexibility.
- The SR 91 Express Lanes in Orange County, California, includes 10 miles of toll express lanes in the center median of SR 91, with two lanes in each direction. The tolls are fully automated, and drivers must have a registered account. The toll rates vary by the time of day. The project has provided

motorists with a congestion-free alternative and maintained financial viability of the lanes. The Inland Empire-Orange County Line operated by Metrolink provides commuter rail service adjacent to the SR 91 Expressway.

The Orange County Transportation Authority (OCTA) uses congestion management pricing to optimize traffic at free-flowing speeds. To accomplish this, hourly traffic volumes are continually monitored; tolls are adjusted with increases and decreases in traffic demand. OCTA's policy is to adjust an hourly toll to manage demand. Once an hourly toll is adjusted, it is maintained at this price for several months. Signs at each entry point to the express lanes display the toll rates for travel at the time of entry.

OCTA provides discounts to vehicles with three or more persons (HOV3+), zero-emission vehicles, motorcycles, disabled plates and disabled veterans. The vehicles ride for free except Monday – Friday from 4 p.m. to 6 p.m. in the eastbound direction, when these vehicles pay 50 percent of the toll. To receive the discount, motorists must have a valid FasTrak® account with a properly mounted transponder.

6.5.2.3 Ramp Metering

Ramp metering is the use of traffic signals at on-ramps to manage the rate of vehicles entering the freeway. Ramp metering systems have been used since the 1960s and have proven to be successful in reducing traffic congestion and improving driver safety. Transportation management technologies allow service providers to actively control ramp metering rates on mainline and ramp traffic. Ramp metering operations continue to advance. Innovative ramp metering operations include the following:

- Extended hours of operations
  - Policies that extend ramp meter operations outside peak hours and for special events and construction activities offer further flexibility and control
- Special ramp treatments
  - Strategies that can improve traffic conditions, improve safety at the merge point, and provide driver incentives for specific modes of travel. For example, an agency could designate a bypass lane accessible only to HOVs or transit vehicles.
- Adaptive ramp metering
  - Uses algorithms that can optimize either local or systemwide conditions. Adaptive ramp metering can also use advanced metering technologies such as dynamic bottleneck identification, automated incident detection, and integration with adjacent arterial traffic signal operations.
- Integrated freeway and arterial corridor
  - When operating independently of the ramp meter signals, the arterial signals may release too many cars onto the ramp, causing backup onto the arterial. If the two systems are integrated, backup could be reduced leading to safer and more efficient conditions.

6.5.2.4 Incident Management

FHWA's Office of Operations estimates that 25 percent of congestion is caused by incidents, such as crashes, disabled vehicles, or debris. Bottlenecks, traffic volumes exceeding the capacity of the road, bad weather, work zones, poor signal timing, and special events cause the remaining 75 percent. Improving incident management is a priority because reducing an incident's duration lessens the effect on highway operations and reduces the potential for additional or secondary incidents. FHWA estimates that approximately 20 percent of all incidents are secondary incidents (FHWA 2004).

The following are incident management recommendations useful for promoting improved operations in the region (CMAP 2016f):

- Automated expressway incident detection.
- Closed-circuit television units to monitor critical arterial locations.
- Public Safety Answering Point data exchange with traffic management centers as a standard feature.
- Traffic management centers are integrated, and arterial traveler information is available regionwide.
- Emergency lane patrols are expanded to include the entire expressway system and operate 24/7.
- Local governments require incident management training for law enforcement and fire/rescue organizations.
- Local system operators are authorized to remove disabled vehicles on or near travel lanes and protected from liability for damage under Illinois law.
- Informational materials about quick clearance laws and procedures are distributed to local incident responders, including departments of transportation.
- The region, working with system operators and municipal, county, and state police, establish a goal to reduce the amount of time roads are closed due to crash investigations and develops a plan for achieving the goal.
- A regionwide communication system is developed that supports field equipment, including vehicle to infrastructure technologies.

6.5.2.5 Traveler Information

The highway system is most effectively managed when communication extends coordination beyond an individual operating agency by establishing communication between highway agencies, emergency management services, transit operators, and real-time traveler information services. The long-term goal for the region’s highway operators is a connected management system where individual agencies can monitor and manage their own equipment in the field such as cameras, message signs, and traffic signals. Highway and emergency response agencies exchange information and share camera images. Highway agencies actively adjust traffic control equipment and inform the public of road conditions. Information is passed to other highway and transit agencies who can also respond by making changes in their own systems. The continuous and automatic flow of data and communications facilitates a more modern, performance-driven operations environment for the highway system. This requires coordination between agencies and agreements on how to share data and what to do in response to shared information.

Beyond transportation agencies communicating and transmitting data to each other, ways for the traveling public to receive information are equally as important. Many state and local transportation departments transmit information through 511 mobile applications; transit agencies publish real-time information through their own applications; and private application companies serve as an additional resource for travelers. Mobile applications can incentivize travelers to change their behavior. If designed well, a smartphone application can have a profound impact on how travelers choose to transport themselves.

6.5.2.6 Access Management

Access management is used to restrict entry to a facility based on congestion levels or operational conditions, such as maintenance needs or an incident. Access management does not necessarily restrict the type of user, but in some situations direct connect ramps may be provided exclusively for bus, trucks or carpool use. In addition, it can control demand by using grade-separated ramps as opposed to at-grade ramps, limiting access to fewer entry and exit points, or use of actual barriers at ramp locations to control access. Drivers face fewer decision points and traffic conflicts, which simplifies driving and increases driver safety. As a result, access management reduces traffic congestion, extends facility life, increases public safety, and preserves the transportation functions of a highway.

6.5.2.7 Integrated Corridor Management

ICM focuses on improving the transportation network by encouraging the efficient movement of people and goods through institutional collaboration, proactive communication, and integration of operations along major corridors (including interstates, arterials, and transit services). Through an ICM approach, transportation agencies manage the corridor as a multimodal system and make operational decisions using real-time data to optimize performance across the corridor. Dallas and San Diego were selected by U.S. Department of Transportation (USDOT) to be “Pioneer Demonstration Sites,” and deployment of ICM began in 2013. Separate efforts in San Francisco on the “I-80 Integrated Corridor Mobility Project” and Virginia “I-95/I-395 Integrated Corridor Management Initiative” are also underway to apply ICM concepts to improve corridor performance. The integration of operations of transportation networks within a corridor maximizes the effectiveness of operations, mitigates the effects of incidents, and reduces congestion.

A related concept being advanced is called Active Transportation Demand Management (ATDM), which focuses on the active management, control, and influence of travel demand, traffic demand, and travel flow of transportation facilities. ATDM can include multiple approaches spanning active demand management (e.g., dynamic pricing, on-demand transit, predictive traveler information), traffic management (e.g., adaptive traffic signal control, dynamic lane reversal, dynamic shoulder use, adaptive ramp metering, see ATM above), and parking management (variably priced parking, dynamic parking reservation systems).

6.5.2.8 Smart Cities

Similar to ICM—which operates and manages individual transportation systems as a unified network—“Smart Cities” is defined as “a system of interconnected systems, including employment, health care, retail/entertainment, public services, residences, energy distribution, and transportation, tied together by information and communication technologies that transmit and process data about all sorts of activities within the city” (FHWA 2016c). Smart cities can use their technological infrastructure in conjunction with mobile applications to improve safety, enhance mobility, enhance ladders of opportunity, and address climate change.

In 2015, USDOT launched the Smart City Challenge, asking mid-sized cities across America to develop ideas for an integrated, first-of-its-kind smart transportation system that would use data, applications, and technology to help people and goods move more quickly, cheaply, and efficiently. USDOT identified a high-level vision and goals for the Smart City Challenge, including (USDOT 2017a):

- Technology Elements
  - Urban automation
  - Connected vehicles
  - Intelligent, sensor-based infrastructure
- Innovative Approaches to Urban Transportation Elements
  - User-focused mobility services and choices
  - Urban analytics
  - Urban delivery and logistics
  - Strategic business models and partnering
  - Smart grid, roadway electrification, and electric vehicles
  - Connected, involved citizens

- Smart City Elements
  - Architecture and standards
  - Low-cost, efficient, secure, and resilient ICT
  - Smart land use

Over the past year, the USDOT has leveraged nearly $350 million in public and private funds for smart city and advanced transportation technologies (USDOT 2017b).

6.5.2.9 Summary

Table 12 evaluates transportation system management technologies against several criteria to assist with planning and implementation decisions. In general, criteria identified in green have a greater effect on a technology's overall potential than blue and yellow.

Table 12. Summary Assessment for Planning Consideration – Transportation System Management Technologies

Criteria	**Active Traffic Management**	**Managed Lanes**	**Ramp Metering**	**Incident Management**	**Traveler Information**	**Access Management**	**Integrated Corridor Management**
Time Frame	*Now*	*Now*	*Now*	*Now*	*Now*	*Now*	*Ongoing*
Technology Readiness	*Mature*	*Mature*	*Mature*	*Maturing*	*Maturing*	*Mature*	*Maturing*
Policy Considerations	*None*	*Can be contentious*	*None*	*None*	*None*	*Local issues*	*None*
Ease of Implementation	*Moderate*	*Moderate*	*Moderate*	*High*[a]	*Moderate*	*High*	*Low*[b]
Effect on Demand and Revenue	*High*	*High*	*Minimal*	*Moderate*	*Minimal*	*Minimal*	*Moderate*
Importance for Planning	*High*	*High*	*Low*	*Low*	*Moderate*	*Moderate*	*High*
Potential Ranking for Further Consideration	High	High	Moderate	High	High	Moderate	High

[a] High implies the technology is fairly easy to implement.

[b] Low implies the technology is difficult to implement.

Source: CH2M staff engineering judgement

6.5.3 Recommendations

The following transportation system management technologies are recommended for further consideration by IDOT and/or Tollway.

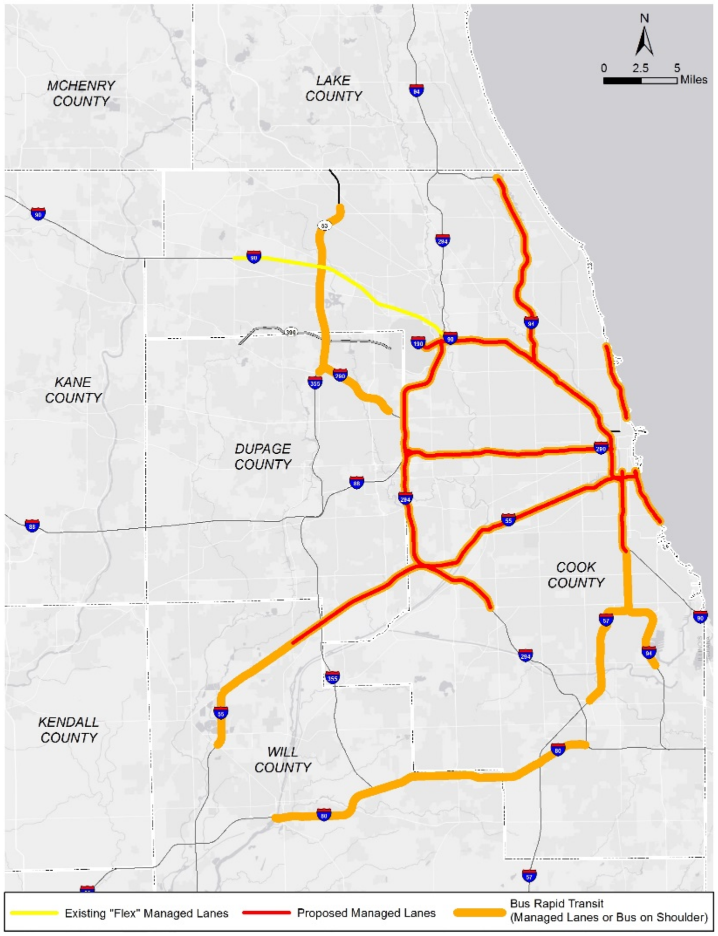
Active Traffic Management

- Develop a concept of operations for ATM in each expressway corridor. As appropriate, this may be part of the ICM concept of operation.

Managed Lanes

- Evaluate a network on managed lanes across the northeastern Illinois expressway system, including I-94 Edens Expressway (US 41 Skokie Highway to I-90 Kennedy Expressway), I-90/I-94 Kennedy Expressway (Jane Addams Memorial Tollway to 31st S.t), I-290 Eisenhower Expressway (I-88 to Jane Byrne Interchange), I-55 Stevenson Expressway (I-355 to Lake Shore Drive), I-90/I-94 Dan Ryan Expressway - Express Lanes (69th St. to 31st St), North Lake Shore Drive (Hollywood Ave to Division St), South Lake Shore Drive (57th St. to I-55), I-294 (Balmoral Ave to 95th St.), and I-80 (Ridge Road to I-94/IL 394).

Figure 16. Managed Lane, Express Bus, and Bus on Shoulder - Corridors for Evaluation



- Evaluate running express bus service/bus rapid transit in managed lanes network. See Figure 16.

Ramp Metering

- Assess the suitability and feasibility of innovative ramp metering operations

Incident Management

- Identify opportunities for improved incident management operations in the region. See Section 7.1, *Invest in Traffic Management Centers to Coordinate Responses*.

Traveler Information

- Develop a connected management system that establishes communication between highway agencies, emergency management services, transit operators, and real-time traveler information services
- Implement a regional 511 system

Access Management

- Identify conditions under which to restrict entry to expressway facilities

Integrated Corridor Management

- See Section 7.5, *Implement Integrated Corridor Management*. Develop a concept of operations for integrated corridor management system including IDOT, Tollway, emergency management services, transit operators, and real-time traveler information services.

Smart Cities

- Coordinate with USDOT on implementing Smart City technologies
- Conduct a study of best practices and lessons learned from other U.S. cities

6.6 Automated and Connected Vehicle Technologies

6.6.1 What It Is

In recent years, few emerging transportation technologies have captured as much public and policymaker attention as automated or “driverless” vehicles.

The term Connected and Autonomous Vehicles (CAV) refers to vehicles that can partially or completely drive on their own, providing for safety, convenience, accessibility, and quality of life benefits. Automated vehicles (AVs) use information from radar, LIDAR, laser light, GPS, odometry, and computer vision to detect their surroundings. Advanced control systems interpret sensory data to identify appropriate navigation paths, as well as obstacles and relevant signage. Connected vehicles (CVs) communicate and share vital transportation information to other vehicles, roads and other infrastructure. There is general agreement that the technology will be most effective if both AV and CV elements are implemented and can work together.

Implementation of CAVs will bring disruptive changes – both positive and negative. CAVs have the potential to dramatically change the transportation network and system performance. Smart communications technology would enable vehicles to send and receive real-time information about road conditions and enable transportation agencies to quickly re-route vehicles, respond to accidents, and adjust signal timing, speed limits, and tolls to reduce congestion and improve the speed and reliability of transportation. In addition, CAVs could provide critical mobility to the elderly and disabled, enhance effective road capacity, and reduce fatal crashes, injuries, traffic congestion, and fuel consumption. AVs might be able to travel with more compact spacing (laterally and longitudinally), increasing the capacity of roadways while maintaining safety. With the reduced need for parking, particularly in urban centers, there may be opportunities for best uses of shared public spaces.

At the same time, CAVs are likely to result in an increase in demand. As mobility improves, so does the number of vehicle miles traveled (VMT). VMT increases will be related to the demand for more trips, for trips serving populations that currently don’t drive (children, disabled, elderly), and empty vehicles. There may also be shifts from transit usage (with high occupancies) to lower-occupancy CAV use. Also, the transition period between human driving and fully-automated driving is likely to be marked by focused decreases in capacity, safety conflicts, and policy issues.

Given the disruptive nature of CAV technology, it is important to start to plan strategies and look at new possibilities and opportunities to transform transportation to accommodate this emerging technology.

6.6.2 Current and Future Trends

The range of predictions for mass adoption of fully autonomous vehicles is wide, with most predictions in the 10 to 20-year timeframe. The rate of technology adoption will depend on a number of factors, including the price of remote sensing technology, the adoption of CV technologies, and customer preferences (CMAP 2017m). Auto manufacturers are beginning to introduce CAVs. By the end of 2018, all major auto manufacturers will have cars in service that make use of some CAV technology. The CAV market is forecasted to be a $7 trillion business by 2050 (Galeon and Houser 2017).

Level 1 automated technologies are already widely available in 2017 vehicle models, such as adaptive cruise control and parking assist (see Figure 17 for the standard description of the levels of automation in vehicles). Level 2 technologies are available in a few vehicles (e.g., Tesla) and Level 3 technologies are being tested on public roads in the U.S.

> CMAP's *Emerging Transportation Technology Strategy Paper* (2017) indicated that over 30 automobile manufacturers are currently trying to develop a fully autonomous (Level 5) passenger vehicle. Several industry leaders are designing autonomous commercial vehicles, such as driverless shuttles, buses, and trucks. Driverless transit initiatives have been implemented, with small- and large-scale demonstrations in Europe, Asia, and the U.S. In particular, autonomous trucks hold promise for achieving new efficiencies in the productivity of goods distribution. Connected autonomous trucks traveling in platoons can travel farther with lower fueling and labor costs, meaning more consumers can be serviced within a one-day range of a distribution center, critical in dense urban areas where demand for distribution space outpaces supply (CMAP 2017m). Other potential technologies to reduce surface trips include aerial transportation like delivery drones or even aerial taxi service, and in-pavement charging. Figure 18 is an illustration of the application of these technologies in a future corridor.

The freight industry is a leader in CAV technology, and the mass adoption of autonomous trucks is expected to be much faster than for personal vehicles. Trucking companies can retrofit or purchase entire fleets, whereas the turnover of personal vehicles will likely be slower due to individual ownership.

Most commercial trucks are already fitted with electronic logging devices to log driving time, and most have the capabilities for additional CV features. Truck platooning is being tested in the U.S. and Europe. This technology connects trucks using Wi-Fi, sensors, GPS, and cameras. The leading vehicle dictates speed and direction, while the following vehicles automatically steer, speed up, and slowdown in close convoy. With CAVs, the potential savings to the freight industry are huge; savings from labor, fuel efficiency, productivity, and accidents are estimated to be $168 billion annually. Retrofitting or purchasing trucks with driverless capabilities is an attractive option for trucking companies.

6.6.2.1 State Initiatives

As part of its statewide I-80 Planning Study, Iowa DOT developed an assessment of automated corridors to leverage existing AV knowledge, understand AVs and other transformative shifts in transportation, prepare for AV impacts on safety, mobility, and reliability in Iowa, and consider the impact of AVs on the future I-80 design criteria. The study's findings allowed for consideration of "future proof" design strategies for I-80, including provisions for expandability (i.e., future AV-only lanes), communication and continuous power along the corridor, enhancements to pavement structures to accommodate increased traffic demand due to AVs, and detection and data processing of AV information.

Michigan, Ohio, and Pennsylvania have formed a "Smart Belt Coalition" of state transportation agencies, academic, and research affiliates to collaborate on research and testing for automated and connected vehicle initiatives. The coalition's mission is to create a mechanism for transportation agencies, academic institutions, and others to collaborate on connected and automated vehicle initiatives. In a recent presentation to the International Bridge, Tunnel, and Turnpike Association, the coalition identified the following near-term priorities:

- Work zones: reservation and traveler information system
- Freight: truck platooning
- Traffic incident management: CV applications
- Work zones: intelligent/connected work zone detection
- Freight: truck parking (see Section 6.3.1.3, *Recommendations, Intelligent Networked Highways*)

Figure 17. Levels of Automated Vehicles (adopted from Society of Automotive Engineers)

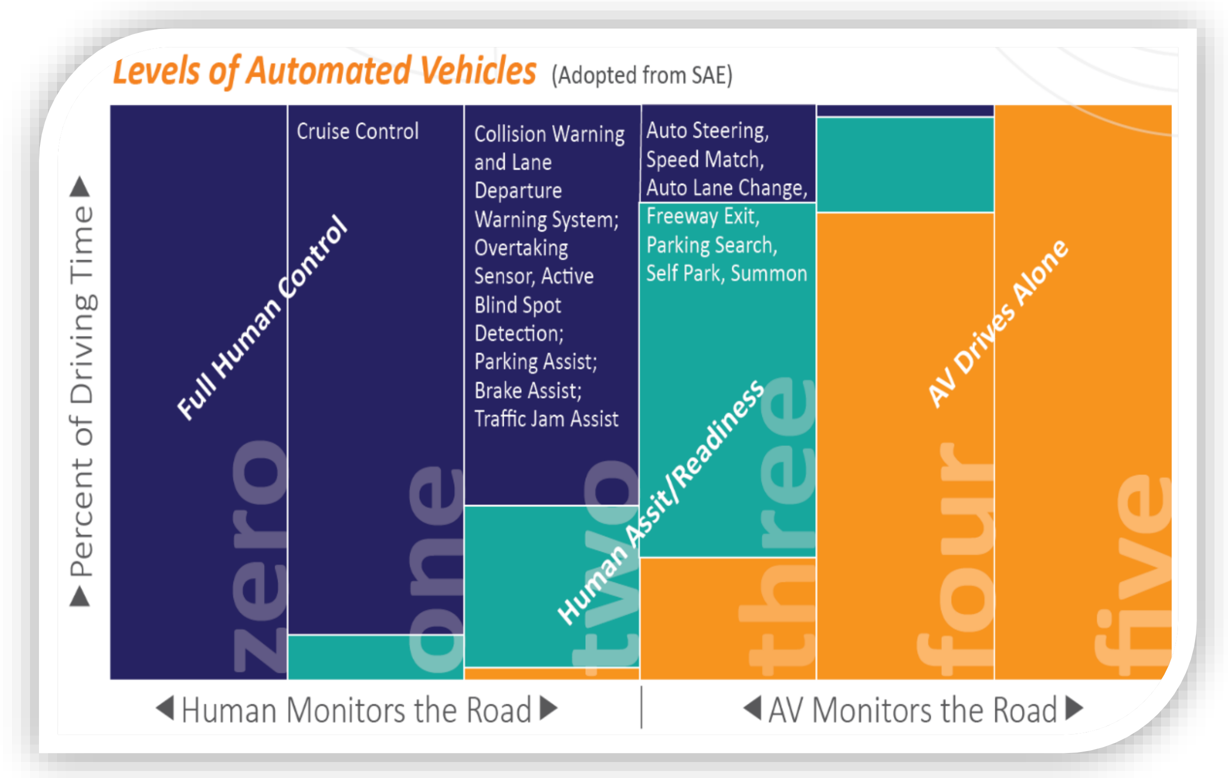
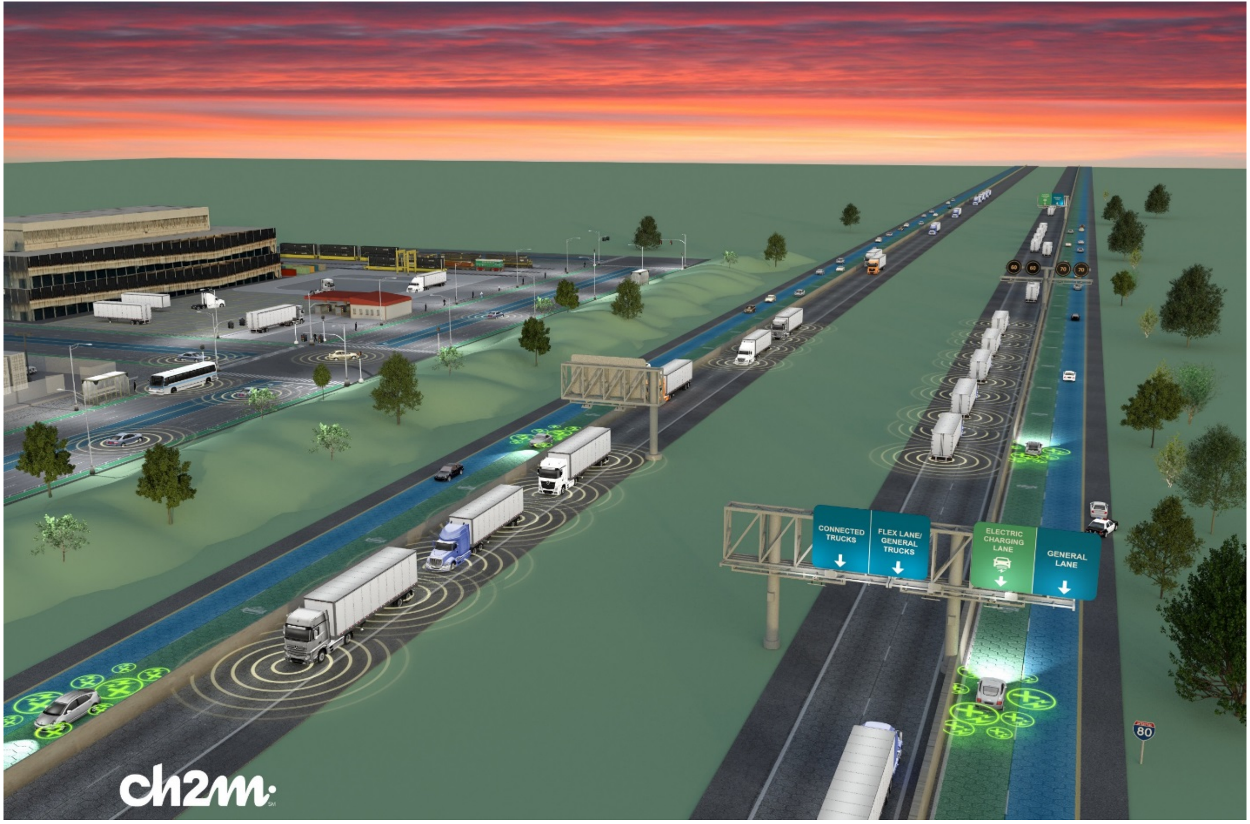


Figure 18. Connected Highway: AV Technologies for Truck Platooning, Inductive Charging Pavements



The USDOT designated 10 proving-ground pilot sites to encourage testing and information sharing of automated vehicle technologies. These proving ground designations will foster innovations that can safely transform personal and commercial mobility, expand capacity, and open new doors to disadvantaged people and communities. Although the Chicago region is not part of the proving ground pilot sites, the region can benefit from information sharing. In 2017, the State of Illinois passed legislation that would preempt local authorities from enacting or enforcing ordinances that prohibit the use of vehicles equipped with Automated Driving Systems. The next step for the State is to consider enabling legislation to allow autonomous vehicle testing.

6.6.2.2 Connected Vehicle Technologies

6.6.2.2.1 V2V Technology

Vehicle-to-vehicle (V2V) technology can transmit information between vehicles to aid in accident avoidance. V2V technology is expected to drive market penetration of AV/CV. All the major automakers are sharing data on V2V to help standardize communications between cars of different brands. In 2012, the University of Michigan Transportation Research Institute and USDOT, in partnership with Toyota, conducted a pilot test of nearly 3,000 V2V-equipped cars in Ann Arbor, Michigan. In spring 2016, University of Michigan Transportation Research Institute and USDOT announced a plan to increase the fleet size to 5,000 for further testing.

6.6.2.2.2. V2I Technology

Vehicle-to-infrastructure (V2I) technology is complementary to V2V technology. The communication flows for V2V and V2I technology are based on current and future networking technologies, including dedicated short-range communications (DSRC), GPS, cellular, Bluetooth, and other communications systems, for 360-degree awareness of nearby vehicles. V2I technology will support the transportation system by transmitting information to aid in monitoring roadway conditions. These systems will “talk” to equipment installed in the road and other infrastructure, such as traffic signals, stop signs, toll booths, work or school zones, and railroad crossings. Roadside equipment will “listen” or monitor for vehicle information and transmit it back to a traffic management center for use—such as detecting the deployment of antilock braking systems that may indicate roadway icing. However, by adding V2I connectivity, there are issues with security, privacy, data, analytics, and aggregation due to the abundance of data associated with vehicles.

The region is already deploying V2I in the form of transit signal priority, a partnership project between IDOT, county DOTs, the City of Chicago, RTA, Pace, and CTA, using a radio on the bus to communicate specific messages to a radio at the traffic signal. Any transmission of dynamic information from the traffic management center to a field device will require supporting communication infrastructure, as will any collection of intelligence from vehicles for use in managing the system. In addition, traffic management center hardware, software, and staffing will be needed to support the system (see Section 6.5.2.1, *Active Traffic Management* and Section 7.1, *Invest in Traffic Management Centers to Coordinate Responses*). The advance of this technology will likely require roadside devices to exchange information with vehicles and transmit information between the device and a center—another reason for operating agencies in the region to expand or regionalize traffic management centers (see Section 7.1, *Invest in Traffic Management Centers to Coordinate Responses*).

6.6.2.3 Planning Considerations

Connected infrastructure to facilitate exchanges of operational and safety data between vehicles and transportation infrastructure, will likely have mixed effects on **highway maintenance costs**. Connected technologies might improve the use of the existing infrastructure (the same or more volume in less space) and lower maintenance needs and costs by reducing the need for treatment materials (e.g., salt). At the same time, it will likely require more capital to maintain the communications infrastructure. The benefits to IDOT and Tollway from deploying CV technologies might include reduced dependence on IDOT/Tollway traffic monitoring infrastructure, reduced resources needed for system maintenance, improved transportation asset condition monitoring, and increased availability of information for performance measurement.

Other design factors in planning expressway corridors for future AV deployment include **dedicated right-of-way**. CAVs – notably trucks traveling long distances – can travel in platoons or more closely together due to wireless communication, and at faster average speeds. Also, many vehicles are likely to be smaller with better lateral control, allowing narrower lanes, and they may not require shoulders or even medians. Given these characteristics, dedicated managed lanes prohibiting human-operated vehicles may prove to be an interim solution for mixed traffic. Dedicated AV lanes on expressways will produce the greatest efficiencies because they can provide for high travel speeds at long distances. Expressways also have the physical space for reconfiguration in comparison to arterial roads. In addition, since CAVs might accommodate the same or more volume in less space, newly available road might be reallocated to other road users.

There are also potential negative impacts. CAVs have the potential to increase VMT and congestion. Several research studies have been conducted that use modeling to determine the impact of AV/CVs on travel behavior (see Section 6.6.4 CAV Research Studies.) Broadly, the studies conclude that CAVs will increase VMT, while congestion will decrease in the long-term. However, the magnitude of these impacts will depend largely on market penetration. Mid-term operations may be worse, when there are a mix of CAV and human-driven vehicles. These variable changes in travel behavior should inform and influence planning decisions.

Table 13 evaluates CAV technologies against several criteria to assist with planning decisions. In general, the criteria identified in green have a greater effect on a technology's overall potential than blue and yellow.

Table 13. Summary Assessment for Planning Consideration - Automated and Connected Vehicle Technologies

Criteria	**CV Systems**	**CAV Testing (Pilot Projects)**	**CAV Infrastructure**	**Full Automation**
Time Frame	Emerging	Emerging	5-10 years	10-20 years
Technology Readiness	Emerging	Emerging	Early	Distant
Policy Considerations	None	Can be Contentious	None	Contentious and Unknown
Ease of Implementation	Moderate	Moderate	High[a]	Low[b]
Effect on Operations and Safety	Low	Low	Moderate	High
Importance for Planning	Moderate	Moderate	High	High
Potential Ranking for Further Consideration	**High**	**High**	**Moderate**	**Low**

[a] High implies the technology is fairly easy to implement.

[b] Low implies the technology is difficult to implement.

6.6.3 Recommendations

The following strategies are recommended for further consideration:

- IDOT and/or Tollway should develop a concept of operations for implementing technology to support CAVs.
  - The concept of operations should consider CAV-supportive infrastructure based on market penetration (i.e., communications infrastructure [advanced cellular and fiber], detection [cameras, sensors, and processed data from CAVs], dedicated right-of-way).
  - The concept of operations should consider both an interim and an ultimate configuration (i.e., dedicated CAV lanes in the interim and converting all lanes long term). It should also consider the very near term, before there are enough CAVs to justify dedicated lanes.
- IDOT should develop a communication protocol/policy for V2I communication
- IDOT should implement managed lanes on the region’s expressways and explore other pricing policies that could manage increased travel caused by autonomous vehicles.
- CMAP should support legislation allowing CAV testing in Illinois. Build upon the legislation passed in 2017 (effective June 1, 2018), that “preempts local authorities from enacting or enforcing ordinances that prohibit the use of vehicles equipped with Automated Driving Systems.”
- CMAP should convene and coordinate regional stakeholders to engage in national and state-level conversations about autonomous and connected vehicle policy and industry standards.
- CMAP should support pilot testing of CAV infrastructure, which might provide opportunities to promote adoption of these technologies.
- IDOT should develop a comprehensive plan to help manage its efforts to oversee and advance the safe development, testing, and deployment of AV technology challenges as they arise.
- IDOT, Tollway, and CMAP should standardize the practice of including AV scenario analysis in long-range plans and alternatives analyses for specific corridor/site improvements.
- IDOT, Tollway, and CMAP should consider how previous design practices might change to accommodate AVs. IDOT, Tollway, and CMAP should consider AVs at all levels of the design process. Design considerations/recommendations include the following:
  - Design pavement considering AVs (potential impact on pavement thickness)
  - Design the pavement base and geogrid to extend the full width of the pavement
  - 12-foot-wide left shoulder and right shoulder with full depth shoulder pavement
  - Construct continuous fiber optic and power lines along the corridor
  - Design AV-supportive infrastructure
  - Improve lane markings and signage
- IDOT and Tollway should consider the advances in how bridge and pavement infrastructure are maintained and replaced with the introduction of CAVs, and the potential for many more vehicles on the roadway. Opportunity for additional study includes the pavement effects of truck only facilities and vehicles with little lateral movement within lanes due to lane centering.
- To prioritize roadways with the highest potential CAV benefits, IDOT and Tollway should conduct a safety analysis method that provides for a location-specific estimate of crashes that could be prevented using AV technology and considers how speed-limit AVs interact with fast-moving vehicles on the expressway system.

- IDOT and/or Tollway should identify CAV initiatives that will best serve the region. For example, I-80 may be suitable for CAV testing/pilot program, specifically for truck platooning and truck parking. Market penetration of automated trucks is anticipated to be sooner than passenger vehicle, and the corridor supports long-haul freight trips.
- IDOT and/or Tollway should monitor the progress of ongoing CAV pilot programs for best practices and lessons learned, including provisions for expandability (i.e., future AV-only lanes), communication and continuous power along the expressway corridors, enhancements to pavement structures to accommodate increased traffic demand due to CAVs, and detection and data processing of AV information.
- IDOT and/or Tollway should monitor research being conducted on the impacts of CAVs on VMT and congestion to support planning decisions

6.6.4 CAV Research Studies

Motamedidehkordi, N., Benz, T., & Margreiter, M. 2015. Effects of Connected Highly Autonomous Vehicles on the Propagation of Congested Patterns on Freeways. Conference Paper.

Atkins Ltd., prepared for the UK Department for Transport. 2016. Research on the Impacts of Connected and Autonomous Vehicles (CAVs) on Traffic Flow.

Public Transport Research Group (PTRG). 2016. Autonomous Vehicles: Potential Impacts on Travel Behavior and Our Industry. BusVic Maintenance Conference.

Truong, L.T., De Gruyter, C., Currie, G., & Delbosc, A. 2017. Estimating the Trip Generation Impacts of Autonomous Vehicles on Car Travel in Victoria, Australia. Transportation, 44 (6), pp. 1279-1292.

Bierstedt, J., Gooze, A., Gray, C., Peterman, J., Raykin, L., & Walters, J. 2014. Effects of Next-Generation Vehicles on Travel Demand and Highway Capacity. Fehr & Peers: FP Think Working Group.

Childress, S., Nichols, B., Charlton, B., & Coe, S. 2014. Using an Activity-Based Model to Explore the Possible Impacts of Automated Vehicles. TRB 2015 Annual Meeting, Washington D.C.

Harper, C.D., Hendrickson, C.T., Mangones, S., & Samaras, C. 2016. Estimating Potential Increases in Travel with Autonomous Vehicles for the Non-Driving, Elderly and People with Travel-Restrictive Medical Conditions. Transportation Research Part C: Emerging Technologies, Volume 72. November 2016, Pages 1-9.

6.7 Electric Vehicle Technologies

6.7.1 What It Is

Electric vehicles use a battery to store the electrical energy that powers a vehicles' motor. Electric vehicles offer many benefits; they help reduce petroleum consumption and address concerns from carbon dioxide emissions, an important factor in global warming, and improve air quality. The Chicago region was identified at one of the top 10 urban areas in the nation for plug-in electric vehicle stock in 2016, with approximately 9,100 registered plug-in hybrid electric vehicles (PHEV) and plug-in electric vehicles (PEV) (Wood et al. 2017).

6.7.2 Current and Future Trends

6.7.2.1 Charging Infrastructure

CMAP's E*merging Transportation Technology Strategy Paper* (2017) projected that by 2050, more than a quarter of cars and light-duty trucks will be powered by electricity and other alternative fuels. Battery cost reduction and improved charging infrastructure are needed in order to increase adoption rates of electric vehicles. On a single charge, most electric vehicles have a range of 60 to 120 miles (FHWA 2016a), which covers most trips in the trips in the Chicago metropolitan area (see Section 3.3, *Continued Dominance of Short Trips*). A tightly knit network of home, public, and workplace charging stations, which tops off the battery quickly, is critical to increase adoption rates.

In September 2017, the U.S. Department of Energy released a report addressing the fundamental question of how much PEV charging infrastructure is needed in the U.S. to support both PHEVs and battery electric vehicles (BEVs). To dispel range-anxiety concerns – that is, driver concern of not being able to recharge their car's battery – researchers identified BEV drivers be no more than 3 miles from a non-residential direct current fast charging (DCFC) station in cities and every 70 miles on average along the nations interstate corridors. For BEV drivers to be no more than 3 linear miles from a DCFC station in a given city, 56 stations per 1,000 square miles would be required (for reference, there are currently 960 gasoline stations per 1,000 square miles in U.S. cities). At present public DCFC station density is 17 per 1,000 square miles in the Chicago region (Wood et al. 2017).

Incentivizing the installation of fast chargers at workplaces, multi-unit housing developments, and public spaces such as parking lots is needed in Chicago, as well as policies to support PEV incentives such as state rebates in addition to federal rebates to reduce the cost of purchasing a PEV. Several programs in the metropolitan area are laying groundwork for increasing electric vehicle infrastructure:

- Drive Clean Chicago, a partnership between the Chicago Department of Transportation and CALSTART, and funded with resources from the federal Congestion Mitigation Air Quality program, provides incentives for alternative fuel vehicles and charging stations. Drive Clean Chicago is providing $835,000 in incentives to cover 30 percent of the capital cost for station development, with a target goal of 17 new DCFC stations.
- Chicago was one of 11 metropolitan areas to be identified for high-speed charging stations with funding from Electrify America, a subsidiary of Volkswagen created to implement the settlement over clean diesel vehicles. Electrify America infrastructure improvements will put charging in five different types of developments, ranging from multifamily homes to public parking lots, as well as implement a long-distance highway network of fast chargers spaced about 66 miles apart on interstates I-75, I-94, I-80, and possibly others intersecting with the Chicagoland metropolis (Fox 2017).
- In October 2017, CMAP awarded the City of Chicago a $15.5 million federal grant for electric vehicle infrastructure. The grant will fund 182 electric fleet vehicles including six airport buses, nine fast-charging stations, and 182 lower level charging stations. The City estimates the additions to its electric fleet will reduce greenhouse gas emissions overall by more than 10,000 tons. In addition, the City fleet programs could kick-start the widespread adoption of electric vehicles throughout Chicago.

Signage is a critical element of electric vehicle infrastructure. FHWA's Alternative Fuel Corridors Program is establishing a national network of alternative fueling and charging infrastructure along national highway system corridors. FHWA invites nominations from states to assist is designating corridors on an annual basis; 2016 and 2017 designations totaled 71 corridors in 44 states. In 2016, FHWA designated four corridors through the Chicago metro area as electric vehicle signage-ready, meaning they have a minimum of 2 to 3 public DC fast-charging stations no greater than 50 miles apart, and are at least 150 miles in length. These corridors are eligible to feature new signs alerting drivers where they can find fuel for their alternative fuel vehicles. These signs are similar to existing signage that alerts drivers to gas stations, food, and lodging. The following are the four designated corridors in the Chicago metro area are:

- I-80 from South Bend, IN to Joliet, IL
- I-94 from Sun Prairie, WI to IL/IN border
- I-55 from Chicago, IL to Bloomington, IL
- I-90: from IN border to Sun Prairie, WI

CMAP is also involved with the expansion of Chicago's electric transit fleet (i.e., city buses). The CTA has an open request for proposals for a company to manufacture between 20 and 45 all-electric buses and up to 13 en-route charging stations. CTA has been operating two electric buses since 2014. Executing plans for more widespread electric vehicle use has its challenges; for example, charging infrastructure is a challenge. Charging stations need to be strategically placed throughout the street network, and people living in apartment don't have many options unless their building has electric vehicle charging stations. Nonetheless, CMAP anticipates increased adoption of electric vehicles and continues to plan for these changes.

Other strategies being explored elsewhere include the concept of dynamic wireless power transfer equipment installed under the road surface to extend the charging infrastructures. This would enable car batteries to be recharged as the vehicle is traveling along the expressway, removing the need for drivers to pull off the road and stop to recharge their car's battery. See Figure 19.

The world's first electrified road opened in Sweden, which recharges the batteries of cars and trucks driving on it. About 1.2 miles of electric rail is embedded in a public road near Stockholm. Energy is transferred from the two rail tracks via a movable arm attached to the bottom of a vehicle. The road is divided into 50-meter sections, with an individual section powered only when a vehicle is above it. When the vehicle stops, the current is disconnected. The system is able to calculate the vehicle's energy consumption, which enables electricity costs to be debited per vehicle and user. The cost is approximately $1.2 million per 0.6 mile (Boffey 2018).

6.7.3 Recommendations

The following strategies are recommended for further consideration by IDOT and/or Tollway:

- Monitor the progress of Electrify America's electric vehicle infrastructure improvements, and identify additional opportunities to support electric charging stations (fast-charging stations are currently available at 7 Tollway Oases)
- Conduct a feasibility study for implementing inductive charging pavement along I-80, including activities such as survey of consumers, surveys, and discussions with freight and coach operators and other interested parties, to identify their views on electric vehicles and the concept of wireless power transfer, evaluation of wireless power transfer technologies, and a benefit cost analysis of wireless power transfer. See Section 6.3.1.3, *Recommendations – Inductive Charging Pavements* for more information.

Figure 19. Electric Recharging Lane

Source: Highways England 2015

6.8 Traffic Management Technologies for Passenger Vehicles

6.8.1 What It Is

There are several technologies that serve to improve the overall movement of passenger vehicles, improve safety, and reduce congestion. This section discusses shared mobility options. See Section 6.5, *Transportation System Management Technologies*, for systemwide traffic management technologies.

6.8.2 Current and Future Trends

6.8.2.1 Integrating Transportation Network Companies into Base Transit System

A transportation network company (TNC) connects passengers with drivers who provide transportation on the driver's non-commercial vehicle (e.g., their personal vehicle) via websites and mobile apps. These services allow riders to arrange rides in real-time with drivers who provide a ride in exchange for payment. Uber and Lyft are examples of well-known (and growing) TNCs. These services have sometimes been called "ride sourcing" services, rather than "ridesharing," since they are not designed to reduce vehicle trips, as is the goal for ridesharing approaches (e.g., carpooling and (HOV Lanes). However, these companies are increasingly pursuing ridesharing functions, which involve the sharing of one vehicle by multiple riders. Some services have gone further, creating smartphone-enabled transit services. The service optimizes pick-ups, drop-offs, and routing based on demand, at a cost typically higher than a public transit fare but lower than a taxi. These services can provide a level of flexibility less available in more traditional public transit systems.

Several cities are piloting partnerships with TNCs in an effort to provide more responsive, cost effective, and higher quality service to people with disabilities and people in less dense areas. In December 2016, Metra selected Uber as its "Official Rideshare Partner" to market last-mile services to customers while also generating non-fare revenue. In addition, the City of Chicago passed an ordinance (effective January 1, 2017), that regulates TNCs by establishing registration procedures for drivers and regulating operation at major destinations like O'Hare International Airport, Midway International Airport, and Navy Pier.

Further, the Pinellas Suncoast Transit Authority's DirectConnect program subsidizes Uber, Lyft, and taxi rides to designated bus stops from surrounding areas without public transit service. Also, the Alameda-Contra Costa Transit District is developing its own ride-sourcing service using similar mobile ride requesting technologies. The agency operates a shuttle service between bus stops within specified service zones that can be booked as little as 30 minutes in advance.

Supporters view ride sourcing as part of a suite of transport options that serve a previously unmet demand for fast, flexible, and convenient mobility in urban areas. By providing an appealing alternative to driving, it can potentially reduce auto use when effectively coupled with transit. However, it has been argued that these privatized transit companies have the potential to undermine local transit routes and fare revenues. Further, while some of the services might provide a dramatic improvement in underserved areas, these benefits may not equally apply to all income ranges. Lower income travelers that do not have access to a smartphone or cannot afford the new services might be left worse off as the traditional transit services they rely upon lose market share.

Another potential issue with ride-sourcing services is their projected reliance on CAVs. For example, Uber recently agreed with Volvo to purchase up to 24,000 AVs, with the goal of using AVs to pick up passengers in 2019. Similarly, the CEO of Lyft recently announced that half of its vehicles will be autonomous by 2021. There is much uncertainty if AVs will increase or decrease VMT – in a ride-sourcing scenario, these AVs might continue to drive around empty until a call for ride comes in. As discussed below, the use of these vehicles as shared resources could conceivably reduce VMT.

6.8.2.2 Applications to Automated and Connected Vehicle Technologies

There may be opportunities for passenger vehicles to operate as shared autonomous vehicles (SAVs). SAVs could operate as fleets of self-driving cars for which customers pay an initial subscription fee and then pay per use. A study conducted by researchers at the University of Texas at Austin demonstrated that one SAV would take 11 conventional vehicles off the road (University of Texas at Austin 2014). SAVs have the potential to dramatically decrease motor vehicle crashes and fatalities and increase the capacity of roadways. However, many uncertainties remain with autonomous passenger vehicles.

6.8.3 Recommendations

- Identify opportunities to integrate ride sharing and transit across the expressway system (see Section 7.5, *Implement Integrated Corridor Management*)
    - Incorporate ride sharing options in the ChicaGO app (see Section 7.5, *Implement Integrated Corridor Management*)
- Monitor the effects of Metra’s partnership with Uber
- IDOT and Tollway should monitor the emergence of SAV technologies and be prepared to adapt them (see Section 6.6, *Automated and Connected Vehicle Technologies*).

6.9 Traffic Management Technologies for Truck Vehicles

6.9.1 What It Is

There are several technologies that serve to improve the overall movement of trucks, improve safety, and reduce congestion.

6.9.2 Current and Future Trends

Lack of information about availability of safe truck parking is a significant issue for truckers and motorists. Truck parking overflows onto the shoulders of rest area ramps, freeway ramps, and adjacent roads, creating safety concerns for commercial vehicle operators and motorists. Deployment of Truck Parking Information Management System (TPIMS) is a critical to improving truck safety, efficiency and way-finding, as well as to better align with the needs of truck drivers to meet Federal Motor Carrier Safety Administration’s Hours of Service requirements. The MAASTO TPIMS Partnership proposes to deploy the system throughout its eight-state region on high-volume freight corridors, including: I-35, I-64, I-65, I-70, I-71, I-75, I-80, I-94, and I-135. The proposed project is a system that uses existing ITS infrastructure and capabilities, along with emerging vehicle detection and data collection technologies to address these needs. This project will monitor the availability of truck parking and will provide real-time information to commercial vehicle operators using multiple information dissemination methods, including dynamic truck parking signs, smart phone applications, and traveler information websites (MAASTO 2015).

Figure 20. Dynamic Message Sign: Truck Parking

Other potential truck parking studies have looked at the possibility of allowing truckers to make reservations – for a fee – for parking spots at rest areas.

CMAP's *Emerging Transportation Technology Strategy Paper* (2017) indicated that a specialized but crucial application of increased transportation data is in the area of goods movement, partly fueled by a shift to online ordering of goods and increasing consumer expectation of short delivery timelines. Drastic improvements in freight supply-chain information across modes and across industries are also expected in the coming decades. Large companies such as FedEx, UPS and Wal-Mart, have sophisticated software systems that optimize their truck movements, both for long-haul and local trips. Software companies are developing freight movement optimization software, which allows for sophisticated optimization of routing and order processing of pickups and deliveries. Optimization areas can include route, forecasted traffic, real-time traffic, incident avoidance, freight/warehouse facility loading dock hours, driver schedule, driver hours of services, and more. FHWA is also developing a freight-centric traveler information system (FRATIS) with the goal of improving intermodal freight operation, reducing freight congestion, and improving air quality near intermodal facilities. The Supply-Chain Innovation Network of Chicago is working to encourage off-peak delivery coordination and streamline permitting for oversize and overweight vehicles (CMAP 2017m).

In addition, automated and connected vehicle technologies have the potential to improve truck movement throughout the region (see Section 6.6, *Automated and Connected Vehicle Technologies*). In particular, truck platooning has the potential to dramatically decrease a company's labor costs, fuel costs, motor-vehicle crashes and fatalities, and increase the capacity of roadways. In-vehicle technologies are available on the market for trucking companies to satisfy the electronic logging device rule to electronically record a driver's Record of Duty Status, which replaces the paper logbook some drivers previously[10] used to record their compliance with Hours of Service requirements. These on-board devices also provide information on miles driven by location (in support of the International Fuel Tax Agreement), fuel efficiency and utilization, and driver safety (e.g., excessive speeds, hard braking), thereby improving fleet efficiency and safety.

These innovations may have a particularly profound impact on the Chicago region, as trucks account for about one in seven vehicles on the urban Interstate highways in Illinois, and some facilities in metropolitan Chicago carry over 30,000 trucks each day (CMAP 2017f). CMAP's *Emerging Transportation Technology Strategy Paper* (2017) indicated that the number of intermodal containers moved through Chicago terminals has risen every year between 2009 and 2015, and volumes of freight movement are anticipated to increase. Changes in freight supply-chain management strategies also have significant land use and congestion management implications, as many goods movement companies first invested in large distribution facilities near interstates on the region's periphery, and then began to establish neighborhood distribution centers within urban areas to facilitate more rapid "on demand" delivery. Shifting freight patterns often leaves communities and transportation agencies planning for yesterday's freight system and struggling to anticipate future freight traffic (CMAP 2017m). The region will need to develop strategies to track these shifts, plan for major transportation investments, and assist local communities in addressing the challenges these facilities may pose.

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[10] ELD was part of MAP-21. Fleets had until December 2017 to implement certified ELDs to record HOS.

6.9.3 Recommendations

The following strategies are recommended for further consideration:

- IDOT and/or Tollway should identify corridors for piloting truck platooning (see Section 6.6, *Automated and Connected Vehicle Technologies*)
    - The I-80 corridor is fit for testing because it accommodates long-haul trips
- IDOT and/or Tollway should identify corridors for piloting TPIMS
- IDOT and/or Tollway should identify opportunities for dedicated freight facilities, such as truck parking in expressway right-of-way or direct access ramps to freight areas
- CMAP's Freight Committee should work with public stakeholders to develop continuous data feeds for use by trucking-industry apps that coordinate freight issues such as parking, routing, and weight restrictions.
- CMAP's Freight Committee should collaborate with municipalities and counties to protect existing and future freight corridors.

6.10 Technologies and Strategies to Address Environmental and Community Needs

6.10.1 What It Is

The expressway system is the transportation backbone of our regional economy; it facilitates movement of products and goods, connects workers to their jobs, creates opportunities for communities, and protects the area from increasingly unpredictable natural hazards. At the same time, the expressway system has negatively influenced our communities and the environment by contributing to air and noise pollution, severing communities and neighborhoods, and reducing developable land. Technologies and strategies to address environmental and community effects resulting from the presence of expressways and associated passenger and truck vehicle traffic includes the following:

- Reducing vehicle emissions
- Reducing vehicle noise
- Connecting communities
- Using highway right-of-way for renewable energy production

6.10.2 Current and Future Trends

6.10.2.1 Reducing Vehicle Emissions

See Section 5.2, *Air Quality*, for background information.

The U.S. Department of Energy Vehicle Technologies Office supports research to improve fuel efficiency and reduce emissions produced by both light and heavy-duty vehicles.

The following research is currently under development:

- New combustion strategies that can minimize emissions formation in the engine itself and improve fuel efficiency.
- Improving the efficiency and reducing the cost of after-treatment technologies that reduce exhaust emissions.

- Improving technology that converts wasted engine heat into electricity that can power auxiliary loads and vehicle accessories.
- Better understanding how fuels from new sources can affect advanced combustion systems.
- Improving lubricants that can improve fuel efficiency.
- Minimizing unnecessary idling from vehicles through behavioral strategies and Idling Reduction Technologies.
- Lowering the cost and improving the performance of lightweight materials like carbon fiber, aluminum, high-strength steel, and magnesium.
- Reducing the energy lost to non-engine sources such as braking, drag, rolling resistance, and auxiliary loads like air conditioning.

In addition to research, the U.S. Department of Energy also supports FuelEconomy.gov, which provides tips on how to reduce the amount of gas used. These strategies include driving more efficiently, performing scheduled car maintenance, carpooling, purchasing a more efficient vehicle, and taking appropriate measures in cold and hot weather.

Other strategies to reduce vehicle emissions include incentivizing the replacement of motorized vehicles with exhaust emissions reduction such as for vehicle fleets, incentivizing the availability of alternative fueling stations and electric vehicle charging stations along the expressway, and incentivizing freight industries to increase to more fuel-efficient vehicles and reducing idling.

6.10.2.2 Reducing Vehicle Noise

Vehicles – trucks in particular – can create unpleasant, unwanted noises (see Section 5.3*, Noise*). Sound or noise barriers are a common method to addressing vehicle noise from expressways. However, sound barriers may be costly and unsightly, and traditional concrete sound barriers reflect noise back towards the noise source and beyond. A more effective alternative is absorptive sound barriers, which are made of porous surface material and absorb sound, preventing it from reflecting back off the barrier (Sound Fighter Systems 2018).

Additionally, asphalt pavement mixes are a more recent strategy to help reduce traffic noise at the point where the tire meets the road. Different pavement designs can reduce noise in different ways. A porous or open-graded pavement can dissipate sound energy generated by contact between the tire and the surface; an even smoother surface, such as a fine-graded mix, has less macrotexture, reducing contact forces, and thus noise, between the pavement and the tire. Research shows that developments like stone-matrix asphalt, open-graded friction courses, fine-graded surfaces and rubberized asphalt can help reduce highway noise by as much as 7 decibels. Reducing noise by just 3 decibels is equivalent to doubling the distance from the source of noise to the listener (Asphalt Pavement Alliance Undated-b).

In addition, policies that regulate land use planning and control through legislative statutes that control the building of noise sensitive receptors (e.g., homes, offices, and churches) adjacent to existing highways is another strategy to prevent traffic noise problems (Maryland DOT undated).

6.10.2.3 Connecting Communities

Transportation and land-use decisions play a key role in linking Economically Disadvantaged Areas (EDAs) to jobs. EDAs are parts of the region with concentrated low incomes, limited English proficiency residents, and/or minority residents. Expressways have historically divided communities, and in some cases, have created a physical barrier between low-income and higher-income neighborhoods.
In addition, for residents of EDAs, daily commutes can be particularly long due to lacking transportation infrastructure in these areas. By better connecting all residents to the economy and civic life, the region

will achieve broader economic success. The strategies described in the following subsections serve to connect communities.

Strategic Replacement of Expressways with Thoroughfares

Cities in the U.S. and abroad have had positive experiences with decommissioning urban highways completely and replacing them with at-grade thoroughfares. Although the potential of decommissioning highways has been a source of fear for some urban residents, particularly business owners, with adequate provision of transit lines and facilities for alternative modes of transportation, expressway decommissioning has been shown to generate economic investment, and environmental and community benefits. This has been a successful option in numerous locations, including San Francisco and Milwaukee.

There are also opportunities to construct new facilities as “modern thoroughfares.” Modern thoroughfares are grade-separated, limited-access highways. This type of facility has a smaller footprint to minimize potential negative impacts while protecting the natural environment and preserving community character. Several examples exist, including the Paris Pike (Kentucky), US-285 (Colorado), and the Keystone Parkway (Indiana).

Expressway Caps (partial and full)

Expressway capping (also known as decking) involves construction of a usable structure on top of a new or existing highway, rail line, water body, or other form of transportation infrastructure. Typically, expressway decks are composed of concrete slabs overlain with soil to create a park or vegetative cover, or support other uses such as buildings, bicycle lanes, or parking. Expressway caps can often serve to reconnect areas previously divided by the roadway. Expressway caps can provide environmental benefits, including minimizing air quality impacts, noise pollution, and diesel emissions, to name a few. They can also serve to capture stormwater runoff that would otherwise flow across impervious surfaces. The Brooklyn Heights Promenade, completed in 1950, is an example of an expressway cap. The 1/3-mile-long platform and pedestrian walkway, cantilevered over I-278, is lined with flower beds, trees, and benches and offers unobstructed views of New York City’s skyline. Other representative projects include the Markaret T. Hance Deck Park (Phoenix, Arizona), Riverfront Plaza/Founders Bridge and Hartford Public Library (Hartford, Connecticut), Central Artery/Tunnel (Boston, Massachusetts), and I-71 and Lytle Park (Cincinnati, Ohio). In the Chicago area, IDOT is exploring decking concepts adjacent to overhead bridge structures to provide an extra-wide deck that could accommodate a retail development area alongside a sidewalk or park-space.

Complete Streets

Complete Streets is a transportation and policy approach that encourages streets to be planned, designed, and operated to enable safe access and travel for all users of all ages and abilities. Complete Streets policies are intended to formalize a community’s intent to plan, design, and maintain streets so they are safe for pedestrians, bicyclists, transit users, motorists, and freight vehicles alike. The Complete Streets design treatments may include: sidewalks, bike lanes (or wide paved shoulders), special bus lanes, comfortable and accessible public transportation stops, frequent and safe crossing opportunities, median islands, accessible pedestrian signals, curb extensions, narrower travel lanes, roundabouts, and more. Complete Streets policies may be appropriate and should be considered when planning changes to roadways parallel to, or crossing (under or over), expressway facilities. Expressway construction and reconstruction can also include parallel multi-use paths, such as the Veterans Memorial Trail developed parallel to portions of I-355. In addition, Complete Streets tools should be considered when planning off-system connections to in-line bus stations, transportation centers, and park and ride facilities for travelers using express bus services on the expressway system.

6.10.2.4 Using Highway Right-of-Way for Renewable Energy Production

Utility/energy-generation corridors use the highway right-of-way for decentralized renewable energy production. Examples of technologies include solar energy production, wind energy production, special roads (solar roads/piezoelectric energy) (see Section 6.3, *Pavement Technologies*), geothermal energy, carbon sequestration, or biomass production. See Section 7.6, *Leverage Shared Right-of-Way,* for more detail on sharing highway right-of-way for non-highway uses).

6.10.3 Recommendations

The following strategies are recommended for further consideration:

6.10.3.1 Reducing Vehicle Emissions

- IDOT, Tollway, and/or the State of Illinois could incentivize cleaner trucks to reduce air emissions. Potential ways to do this could include reducing truck tolls, reducing annual vehicle registration fees, or giving gift cards for toll fees.
- IDOT, Tollway, and/or the State of Illinois could incentivize the replacement of motorized vehicles with exhaust emissions reduction such as for vehicle fleets.
- IDOT and Tollway could increase the availability of alternative fueling stations and DC fast charging stations along the expressway.

6.10.3.2 Reducing Vehicle Noise

- IDOT and Tollway could reconstruct its roadways using pavement designs that reduce noise.
- IDOT and Tollway could construct absorptive sound barriers along its expressways

6.10.3.3 Connecting Communities

Expressway Caps / Replacement of Expressways with Boulevards

The following recommendations are suggested for further consideration by IDOT and/or Tollway:

- Expressway caps should be considered, where feasible, in areas where communities or business areas are bisected, or cut off from important resources/amenities. Examples of connections that should be considered include:
  - I-90/I-94 from Fulton to Jackson, connecting downtown Chicago with the West Loop Area
  - I-290 between Austin and Harlem, reconnecting the north and south areas of Oak Park bisected by construction of the Eisenhower Expressway
- Allow expressway caps to be a stand-alone project for consideration of study, funding, and construction – rather than being tied to roadway improvement projects.
- Further evaluation of locations throughout the interstate system where expressway caps could be appropriate should be undertaken.
- Evaluate selling air rights to developers to recoup a portion of the cost of capping the highway.
- Consider locations where expressway can be replaced with a boulevard-type facility, or where a boulevard could be appropriate for a new facility in order to fit the community character in which it is located or to reduce environmental impacts. The following examples should be considered:
  - A “modern boulevard” should be considered for the proposed IL 53 corridor into Lake County.
  - Convert the Ohio Street feeder ramp that connects the Kennedy Expressway to River North and points beyond with a similar boulevard so that traffic is calmer (Grid Chicago 2012).

- Undertake further evaluation of locations throughout the expressway system where converting expressways (particularly feeder, secondary, or “junior expressways” developed in the 1960s) to thoroughfares could be appropriate.

Complete Streets

- IDOT, the Tollway, and/or CDOT could strengthen pedestrian/bicyclist connections across expressways to better connect bisected communities; for example, across Lake Shore Drive to better connect community areas with the lakefront.
- IDOT and Tollway could modify its project standards to include multi-modal enhancements along the roads that the expressway crosses over or under.
- IDOT, Tollway, and Pace Bus could work with local communities to provide first and last mile arterial enhancements to accommodate pedestrians and bicyclists traveling to express bus stations along the expressway.

6.10.3.4 Using Highway Right-of-Way for Renewable Energy Production

The following recommendations are suggested for further consideration by IDOT and/or Tollway:

- Evaluate the viability of using the highway right-of-way for decentralized renewable energy production, focused on highway uses.
- Review state and federal legislation to ensure that IDOT and/or Tollway is permitted to implement non-highway uses in roadway right-of-way
- Assess opportunities for utility/energy generation at reconstructed interchanges where there is available land, for example when a cloverleaf interchange is removed/redesigned
- Engage in FHWA’s Alternative Fuels Corridors program (see Section 6.7, *Electric Vehicle Technologies*).

SECTION 7

National Best Management Practices for Integrated, Multi-Agency Transportation Operations

Integrated, multi-agency transportation operations support a connected and efficient transportation system. As the region's expressways experience increasing passenger vehicle and freight traffic, a multi-jurisdictional multi-modal approach that provides commuters and freight forwarders with reliable transportation options is essential. The following are best management practices to achieve an integrated, multi-agency transportation system:

- Invest in traffic management centers to coordinate responses
- Support revenue sharing
- Pursue joint planning for terminal areas
- Form operating partnerships
- Implement integrated corridor management
- Leverage shared right-of-way

7.1 Invest in Traffic Management Centers to Coordinate Responses

7.1.1 What It Is

Coordination between highway agencies, emergency management services, transit operators, and real-time traveler information services is essential to effective highway management, improving overall mobility and safety. Traffic Management Centers (TMCs) are communication hubs, housing the staff, hardware, and software to support higher-level highway operations, such as the following:

- Traffic flow monitoring – collecting real-time information on traffic flow and operating conditions. This may come from agency infrastructure (detectors, CCTV), data from private companies (e.g., INRIX) provided for a fee, or some combination.
- Environmental and Roadway Weather Information Systems data collection and monitoring (e.g., visibility, winds, pavement conditions such as dry, wet, icy, etc.).
- Providing travel information (reporting highway and roadway conditions, delays, accidents, scheduled construction or other events). This can be accomplished via dynamic message signs, and traveler information sites (e.g., 511, wireless apps, etc.).
- Active traffic and congestion management (management of ramp metering and associated rates, dynamic speed limits / advisories, dynamic lane assignment (including reversible lanes), shoulder running, adjusting signal timing).
- Failure management of transportation system-related field equipment.
- Incident management (detection, verification, response, and clearance of events, including accidents, vehicle breakdowns, roadway debris). This also includes coordinating service patrols.

- Special-event traffic management using the strategies noted above, for events that are expected to have a significant impact on the transportation system, such as sporting events.
- Emergency management (coordinating the response of emergency service providers).
- Traffic signal system management, including transit signal priority for buses and preemption for emergency vehicles.
- Transit vehicle monitoring, including schedule adherence and “next bus” information at bus stops.
- APTS system management (monitoring and evaluating the performance of public transit vehicles).

TMCs can be managed by individual transportation agencies; multijurisdictional and centralized, where staffing, hardware, and software cost are shared; multi-modal, where roadways and transit can be operated as a unit and information is shared so agencies can make changes in their own systems; involve multiple agencies with different charges like transportation, emergency service, or media agencies; and/or virtual through the use of computers and computer networks, but no physical “nerve” center.

7.1.2 Current Practices

The Chicago area was a pioneer for traffic management on expressways. The Tollway and IDOT operate the largest TMCs in the region. Kane and Lake counties have TMCs, while DuPage County has a Virtual TMC. Cook County does not maintain a TMC, but the Chicago DOT operates a small-scale TMC out of its Traffic Control Room.

Recently, the leadership of Cook, DuPage, Lake, Kane, Kendall, and McHenry counties endorsed efforts to regionalize traffic management and invited IDOT to play a key role in this collaborative effort as many major routes in the areas covered by TMCs are under the state’s jurisdiction. A region-wide, multi-jurisdictional center is a more cost-effective approach than individual agency facilities. The collaboration between IDOT and the Lake County DOT in the PASSAGE system is a good example of how surveillance and traffic signals on state roads can tie into a central system.

New Jersey operates a single statewide TMC that includes NJ DOT, the NJ Turnpike, and the State Police in the same facility (although the DOT and Turnpike use different central software), thereby providing improved coordination through face-to-face interaction. New York and Pennsylvania both operate multiple regional TMCs throughout their respective states; and both are currently implementing a single statewide software package to improve interoperability between regions and their TMCs. Also, Washington operates six regional TMCs. In comparison to having numerous TMCs operated by individual transportation agencies, regional and statewide TMCs support a more coordinated, efficient transportation system.

7.1.3 Recommendations

The following strategies are recommended for further consideration:

- Expressway redevelopment should include power and communications access to facilitate communications to and from traffic management centers.
- IDOT should lead a study of the feasibility of implementing a regional, multi-jurisdictional, multi-modal TMC, either virtual or traditional, including an assessment of the following:
  - Combining existing TMCs into a central system and extending coverage to unserved areas
  - Establishing memoranda of understanding and data interoperability agreements between RTA, CTA, Pace, IDOT, Illinois Tollway, and ride-share entities (Taxi, Uber/Lyft)
  - Establishing memoranda of understanding and data interoperability agreements with UPS, FedEx, Amazon, and other shipping companies

  - Implementing a robust ATM network, in concert with back-office systems
  - Enhancing incident management support to public safety agencies, and dispatching of service patrols from TMC
  - Supporting ICM strategies throughout the region. (Refer to discussion below on ICM)

7.2 Support Revenue Sharing

7.2.1 What It Is

A shared revenue program invests the net revenues from congestion pricing (i.e., tolls) in transit. Transit operations on facilities with HOT lanes and/or express lanes can be improved along with improving congestion. Shared revenue between transportation networks may make more efficient use of funds.

7.2.2 Current Practices

The Move NY Fair Plan, released in February 2015, aims to reduce congestion and fund transit by reforming New York City's toll system. The Plan proposes that tolls are highest where congestion is worst, in an effort to reduce traffic by aligning road prices with demand for road space. The Plan designates three-quarters of the net revenue from tolls to transit and one-quarter to roads and bridges. Along with the Plan's obvious benefits to reduce congestion and improve transit, there are several additional benefits, including safer streets, time savings, job creation, and economic productivity. The complete Move NY Fair Plan can be accessed at: http://iheartmoveny.org/wp-content/uploads/2015/02/Move-NY-Fair-Plan-150217v1.pdf.

Several other states, including Virginia, California, Georgia, Florida and Minnesota, have implemented HOT lanes or tolled Express Lanes, from which revenue is allocated for transit along the tolled facilities. For example, in 2009, San Diego's I-15 HOT lanes generated $2.5 million in revenue with 79 percent going to cover operations on the facility, including tolling itself and contribution to the California Department of Transportation to help maintain the facility (i.e., signage, sweeping, etc.). Twenty-one percent of the revenue was used to fund the Inland Breeze bus service in the HOT lane corridor. Improved transit service along tolled expressway corridors provides an alternative transportation option for users unwilling to pay the toll or for low-income users.

7.2.3 Recommendations

The following strategies are recommended for further consideration by IDOT and/or Tollway:

- Explore the Federal Highway Administration's Value Pricing Pilot Program to implement congestion pricing on the existing toll-free expressways to reduce congestion and manage demand. If the Value Pricing Pilot Program is the mechanism to implement congestion pricing IDOT and/or Tollway will execute an agreement with FHWA.
- If congestion pricing or tolling is implemented on the non-tolled expressway system, some portion of these revenues could fund a portion of transit operations in these corridors or on adjacent arterial corridors.
  - Projects would be funded with net toll revenues after financing construction, repayment of debt-service, and costs and expenses of tolling operation and tolling maintenance, including reasonable reserves for major maintenance of expressway and toll system infrastructure.
  - Transit services could include local and commuter bus service, express bus service, rail system improvements, vanpools, park and ride lots, or transit centers.
  - Establish a revenue account for the net toll revenues/to fund the expressway transit services.

  - Develop a policy to address equity due to tolling (e.g., a low-income assistance plan such as discounted toll rates or toll caps for qualifying users).

- If the Tollway is responsible for implementing congestion pricing on existing non-tolled expressways, legislative action will be needed to revise the Tollway Trust Indenture to allow future new revenue use for transit and off-system investments while protecting investors and existing bonds.

7.3 Pursue Joint Planning for Terminal Areas

7.3.1 What It Is

Joint planning for terminal areas is the collaborative efforts of multiple jurisdictions in developing passenger transfer facilities. Terminal areas, which house multiple transportation networks and support transportation connections, enhance the movement of the transportation system overall.

7.3.2 Current Practices

Transportation centers provide an opportunity to better access other public transportation or improve distribution to the central business district. The proposed West Loop Transportation Center is a good example of joint planning for terminal areas. The West Loop Transportation Center would connect Union and Ogilvie stations with new underground rail infrastructure beneath Clinton Street. It would allow Metra and Amtrak to travel directly through downtown to serve destinations within and outside the region. Under consideration as part of this plan is a new Blue Line Station to serve Union and Ogilvie stations, and a light rail or bus rapid transit from the transportation center. For more detailed information, visit http://www.ctaa.org/webmodules/webarticles/articlefiles/rail/rail18/Connecting-the-Loop.pdf.

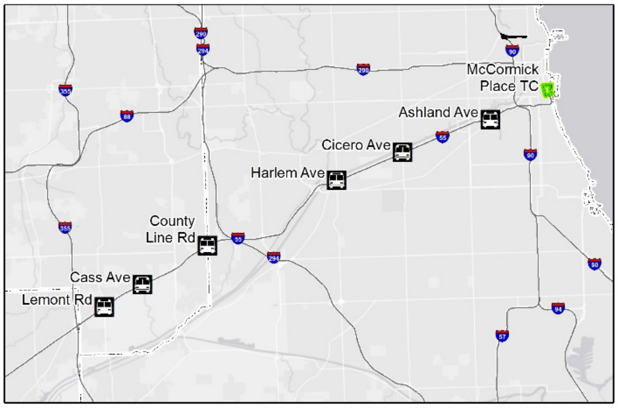
7.3.3 Recommendations

The following strategies are recommended for further consideration:

- Develop a network of transportation centers in the central business district to distribute passengers to their final destinations. Identify locations that have good access to other transit services and/or the potential for new transit service (e.g., new stations, or new busway service). These facilities could operate as ride-share locations with mobility as a service option. The following locations are recommended for consideration (see Figure 21):
  - West Loop Transportation Center
  - United Center
  - McCormick Place
  - North Branch Industrial Corridor
- Additionally, identify potential transportation centers further from the central business district to complement existing park and ride facilities and Pace transportation centers. For example, the Cumberland and Rosemont park and ride lots, or new park and ride facilities, such as I-94 at Lake Cook Road, and I-57 near the I-94/I-57 junction.

Figure 21
CBD Distribution
Northeastern Illinois
Expressway System Vision Study

Figure 22. I-55 Corridor: Potential In-line Transit Stations



- Development of a system of In-line transit stations along the I-55 Stevenson Expressway similar to the I-90 Market Expansion Program in Barrington and Elgin. Potential locations for in-line transfer stations along I-55 include: Lemont Road, Cass Avenue, County Line Road, Harlem Avenue, Cicero Avenue, and Ashland Avenue. Additionally, identify opportunities for in-line transfer stations along other expressway corridors. Desirable locations for in-line transit stations include:
  - Potential to reclaim land for parking
  - Proximity to employment centers, commercial, and residential
  - Sufficient spacing between adjacent structures/interchanges to accommodate acceleration distance for median station
  - Potential to accommodate intersecting Pace routes or other transit services (CTA bus or “L”)
  - Located on toll zone boundary in full-scale tolling scenario

7.4 Form Operating Partnerships

7.4.1 What It Is

Operating partnerships are relationships involving a wide range of agencies and organizations that may play a role in implementation. Partnerships are crucial to an effectively managed and efficient transportation system.

7.4.2 Current Practices

The project team conducted a survey of partner transportation agencies across the nation on their experiences with alliance/coalition formation in the transportation industry. Staff at partner agencies were asked to identify some of the benefits of forming operating alliances/coalitions. Respondents indicated the following:

- Multimodal inter-regionally significant projects have been advanced and delivered
- Ability to secure discretionary grant funding due to the strength of the coalition
- Ability to designate an interstate route a corridor of national significance due to the strength of the coalition
- Integrated corridor management—coordination of TMCs across four states
- Development of a strategic plan
- Shared research findings
- Funding efficiencies
- Economic development opportunities
- Lobbying

These benefits align with the initial impetus respondents identified for forming an alliance/coalition, including economic development, improved mobility, integrated corridor management, and lobbying for federal funds. In all cases, these alliance/coalitions were organized by a formal, signed charter, and staff time was funded by the state, agency, or grants.

When asked about the decision-making process, respondents indicated that the alliance/coalition was developed and organized commonly through collaborative discussion between decision leaders. Additionally, respondents indicated they involved stakeholders in their efforts through steering committees, stakeholder groups, accepting external proposals, and targeting local governments and policies.

The survey results show that communication, structure, and focus are important elements for a successful alliance/coalition. The tangible benefits gained through participating in multi-agency operations, mirror the findings of FHWA in Integrated Corridor Management, Managed Lanes, and Congestion Pricing: A Primer (FHWA 2016b) including better management of congestion, enhanced traffic incident management, enhance transit options, and opportunity for revenue sharing towards multimodal infrastructure operations.

In addition, many partner agencies are preparing to incorporate smart/emerging technologies on projects, with most agencies indicating they are ready now or within the next 5 years to implement these technologies on projects. In preparing for technological innovations that make travel and goods movement faster and more convenient, respondents identified the following emerging technologies:

- Automated Vehicles/Connected Vehicles (AV/CV)
  - DRSC roadside unit deployment
- Truck platooning
- Truck parking/sustainable rest areas/smart truck stops
- Active traffic management
  - Managed lanes/congestion pricing
  - Speed harmonization
  - Dynamic lane management/ramp metering/shoulder use
- Integrated corridor management
  - Incident management
  - Emergency response

Related to preparing for technological innovations that improve road safety, respondents identified the following:

- Automated enforcement
- Wrong-way driving controls
- Virtual guardrails/edge of pavement detection
- Automated detection of pavement issues (potholes, faulting)
- Automated detection of incident management
- Smart construction zones

With respect to preparing for technological innovations that lessen environmental effects, respondents identified the following:

- Energy
  - Solar highways
  - Alternative fuel corridors
  - Inductive charging pavements
- Other freight and transit/rail
  - Provide reduced tolls or truck only lanes
  - Hyperloop (passenger and freight)
  - Drone deliveries

7.4.3 Options to Consider

The following operating partnerships are options for further consideration:

- **Development of operating agreements and policies to operate the existing non-tolled interstate facilities as tolled facilities.** Develop operating agreements to optimize operations and maintenance of the existing non-tolled expressway system (i.e., the existing IDOT facilities), implementation and operation of systemwide toll collection, and implementation of the overall Vision. **Benefits –** 1. Creates a firewall between the existing Tollway bonds and future financing, and 2. Opportunity to create new tolling without the constraints of Toll Highway Act and the Tollway Trust Indenture (i.e., ability to use revenues for transit investments, and off-system investments such as traffic signal interconnect on parallel facilities that may be necessary to address traffic diversions).

- **Explore opportunities for private sector partnerships in ITS, communications, media, and automations.** Such partners are valuable, as they provide and distribute the information required to operate managed lanes simultaneously based on congestion levels and traffic incidents. Further, actively engaging law enforcement and emergency services personnel in overall corridor management is critical as they are the front line for dealing with incidents and emergencies along the corridor and planning for special events which may impact corridor operations.

7.5 Implement Integrated Corridor Management

7.5.1 What It Is

A "corridor" is defined as a largely linear geographic band characterized by existing and forecasted travel patterns involving both people and goods. ICM is the integrated management of freeway, transit, arterial and roadway facilities, and parking systems within a corridor using ITS technologies and innovative practices. It is the management of a corridor as a system rather than the management of the individual transportation networks (e.g., rail lines, bus routes, arterials, and freeways) within a corridor, which is the current practice in the U.S. (FTA 2017). The goal of ICM is to coordinate multiple transportation networks and cross-network connections within a corridor. Operating multiple transportation networks as a unit will smooth traffic in corridors, improve mobility, and support a connected management system. One of the core tenets of the ICM is that travelers will utilize pre-trip and en-route corridor-level information to better inform and optimize their personal travel decisions (Transportation Research Circular 2016). A successful implementation of ICM requires a real-time system of the entire network of all mode operations and interconnectivity between the individual systems. A successful ICM would also promote cross network shifts, modal shifts, change in time of departures, and real-time capacity/demand management.

7.5.2 Current Practices

In spring 2013, USDOT selected two corridors, in Dallas and San Diego, as demonstration sites to implement ICM. While the programs are too new to provide data on the impacts, study modeling demonstrates several expected benefits, including savings in person hours, fuel, mobile emissions, and reduced travel time (see Table 14). Additionally, simulation of ICM at these two Pioneer Sites indicated Benefit / Cost ratios for combined strategies of 7.1:1 to 25.1:1.

Table 14. Expected Annual Benefits of ICM in USDOT Demonstration Sites

	San Diego	**Dallas**
Person Hours Saved	246,000	740,000
Reduction in Travel Time Variance	10.6%	3%
Gallons of Fuel Saved	323,000	981,000
Tons of Mobile Emissions Saved	3,100	9,400

Source: CMAP. 2016e. *MO Report.* May.

An implementation guide has been developed based on the successes and lessons learned thus far in Dallas and San Diego. The guide can be found on the USDOT National Transportation Library website at: https://ntl.bts.gov/lib/59000/59600/59604/FHWA-JPO-16-280.pdf.

As part of the Circle Interchange Project, the I-290 Eisenhower Environmental Impact Statement (EIS), and Blue Line EIS, IDOT worked in partnership with CTA to address regional mobility issues. As part of this collaborative approach, the agencies identified and implemented the following:

- New approach for revamping parallel roads to handle construction phase/post construction traffic flow
- New traffic management systems/technology for corridor operations
- Treatments for reconnecting bisected communities
- Transit service enhancements
- Identification of funding sources and future collaboration opportunities

7.5.3 Recommendations

Integrated corridor management recommendations are considered in a separate document (Jacobs 2018).

7.6 Leverage Shared Right-of-Way

7.6.1 What It Is

There are opportunities to leverage shared right-of-way to improve the region's transportation system. Expressway corridors play a key role in rapid transit, with several heavy rail lines sharing right-of-way with expressways, and bus-on-shoulder service emerging as a strategy to provide fast, reliable bus transportation. Including transit components as part of major highway projects is cost effective and would serve to improve the region's transportation system. Bus-on-shoulder service is an affordable option for rapid bus service on expressways because it is less expensive to modify shoulders than to construct new roadways.

Value capture is an emerging tool in transportation infrastructure funding and finance. Property values directly or indirectly benefit from better access to new or improved facilities. The revenue from increased property values attributable to better accessibility provided by a facility can be at least partially captured by the public entity to fund and maintain that facility. Value capture mechanisms include air rights, development exactions, joint development, land value taxation, special assessments, and tax increment financing. Without these mechanisms, the value is instead transferred to nearby private property owners. More value can be captured through shared right-of-way. For example, the communications network is one of the most important features of a TMC, which requires a variety of wireline and wireless media for performing communication responsibilities. In particular, fiber-optics systems provide high bandwidth and high data-transmission rates. The private sector uses fiber optics systems for a variety of purposes, and other public agencies also have a need for high-speed, high bandwidth communications. As a result, there are opportunities for large cities to enter into multi-agency sharing arrangements for installation and use of fiber optic systems. More revenues can be generated and invested into infrastructure through interagency fiber optic sharing.

Further, there are opportunities for stormwater management and energy production in highway right-of-way. Stormwater management practices (e.g., bioswales, detention basins) in highway right-of-way promote infiltration and reduce flooding, ultimately increasing water quality and reducing the costs of flood damage. Similarly, highway right-of-way can accommodate alternative energy production, such as solar panels or wind turbines. Energy generated can be used to power roadway lighting or electronic signs.

7.6.2 Current Practices

Pace Bus, in collaboration with IDOT and RTA, currently operates bus-on-shoulder service along I-55 (see Section 3.5, *Transit* for more information). Since implementation, bus ridership on I-55 has more than quadrupled, and on-time performance is over 90 percent, in comparison to 70 percent prior to shoulder service.

The CTA Blue Line to Forest Park, which runs along I-290, is another example of shared right-of-way. The CTA Blue Line Vision Study concluded that up to 15 feet of CTA right-of-way could be available for expressway improvements. Also, the CTA and IDOT have explored opportunities to extend the Blue Line along I-290 to Mannheim Road. Using existing right-of-way is less expensive than obtaining additional right-of-way. As a result, more funds can be allocated towards other projects.

7.6.3 Recommendations

The region’s transportation agencies should continue to explore opportunities for shared right-of-way to maximize the use of transportation infrastructure. The following are the types of activities that support shared right-of-way:

- Truck parking
  - CMAP should identify opportunities for truck parking in expressway right-of-way based on areas where truck parking is limited
- Stormwater management
  - CMAP should identify available right-of-way for stormwater management (e.g., detention, porous pavement, native buffers) along expressways. For example, the CTA Blue Line Vision Study identifies 15 feet of available CTA right-of-way along I-290. This space could be used for stormwater management.
  - Identify opportunities for roadway reconstruction and design (e.g., ramp reconstruction, or the elimination of loop ramps) that provide space for stormwater management.
  - The following locations are highly susceptible to flooding and the region’s transportation agencies should study the potential for stormwater management in available right-of-way:
    - I-290/I-294/I-88 System Interchange
    - I-290 near Addison Creek. Right-of-way is available at the Mannheim Rd (IL-45) and 25th Ave interchanges, which consist of several large loop ramps within the Addison Creek floodplain.

Stormwater Best Management Practices

- ➢ Bioretention/detention
- ➢ Bioslope
- ➢ Catch Basins with sumps or open bottoms
- ➢ Water Quality Manholes
- ➢ Inlet Filters
- ➢ Infiltration Trenches/Strips
- ➢ Permeable Pavement
- ➢ Pollution Prevention/Street Sweeping
- ➢ Surface Sand Filter
- ➢ Soil Amendments
- ➢ Bioswales
- ➢ Vegetation/Landscaping

Source: NCHRP Report 565

- Wildlife corridor management
  - Construct fencing and deer reflectors at high-risk areas to reduce the risk of collision.
  - Construct wildlife overpasses, bridges, and culverts to facilitate wildlife movement across expressways.
- Value capture
  - Identify appropriate value capture mechanisms as part of transportation planning.
- Transit (i.e., bus on shoulder and express bus in managed lanes)
- Communications (e.g., fiber options)
- Energy production (e.g., solar panels, wind turbines)
- Utilities

SECTION 8

Characterization of Expected Policy-Influenced Future Conditions

The emerging technologies, strategic approaches, and best management practices described in Sections 6 and 7 have the potential to transform the region's transportation system and alter how Chicagoans get around. This section describes the expected outcomes by 2050 as a result of implementing the policies and recommendations outlined in the previous sections.

8.1 Tolling and Revenue Collection

The cost to operate, maintain, and expand the state's transportation system increases over time; to keep up, revenues must grow. Illinois, like many states, does not have enough resources to maintain the existing system of roads and bridges. Federal and state funds, including revenues from the motor fuel tax, are insufficient. Several states and local agencies have turned to tolling to fund infrastructure improvements.

Front-ended revenue collection is a user-pay strategy that would generate revenue to reconstruct the expressway facilities at the end of their service life. Front-ended revenue collection involves implementing tolling infrastructure now to pay for the reconstruction of the facility at a later time. It would minimize or eliminate the need for federal and state revenues. The strategy involves the installation of tolling infrastructure on the expressway system to collect user fees from drivers using the system. The expressways would be improved with the tolling revenues generated from front-ended revenue collection.

Another funding strategy is to implement tolling corridor-by-corridor as the expressways are reconstructed or improved. Although revenues would not be as robust initially under this scenario, it may be more acceptable to the public than front-ended revenue collection and allow for improvements to be made on subsequent corridors based on lessons learned. In addition, this strategy would accommodate for new tolling technologies as they emerge; whereas the tolling system under the front-ended revenue collection strategy will become outdated en masse and need to be replaced, costing the region a considerable sum.

FHWA has two programs that IDOT/Tollway could apply for to assist with implementing tolling. First, the Value Pricing Pilot Program supports implementation and evaluation of congestion pricing pilot projects on highways through tolling or other mechanisms. The Value Pricing Pilot Program is limited to situations that cannot be accommodated under the mainstream tolling programs, such as the pricing of existing toll-free facilities without substantial reconstruction of those facilities. Similarly, the Interstate System Reconstruction and Rehabilitation Pilot Program allows conversion of toll-free Interstate highways into toll facilities "for the purpose of reconstructing or rehabilitating Interstate corridors that could not otherwise be adequately maintained or functionally improved without the collection of tolls."

In 2050, the region's expressway system is equipped with tolling infrastructure, such as roadside vehicle sensors, tolling gantries, and communications systems. The region has experienced 30 years of sustained revenue as a result of the monies collected from the implementation of tolling. The toll rate has been adjusted to address diversions from the tolled expressway to parallel arterials or transit, and strategies have been implemented to lessen any impacts on neighborhoods and parallel arterials.

8.1.1 Tolling Improvements to Address Asset Condition and Existing Congestion

By 2050, the region has implemented robust transportation improvements in conjunction with the implementation of tolling (e.g., express bus, bus-on-shoulder riding, in-line stations, rail investments, park and ride lots) to ensure motorists have alternative options. The region has implemented a state of the art multi-modal system by dedicating a portion of the toll revenue to transit services. As a result of improved and expanded transit service, the region has witnessed a behavior change; more people are choosing transit over driving.

The tolling revenue enabled the issuance of bonds, and the funding was used to advance the backlog of improvement projects on the expressway system in a staged and coordinated manner. The transportation agencies have been able to implement strategies to address congestion, improve mobility and improve safety. The issuance of bonds that are purchased by investors is the most common method of borrowing. The bond issuance yields an immediate influx of cash in the form of bond proceeds. The borrower then retires the debt obligation by making principle and interest payments to the investors over time. This is the technique the Illinois Tollway implemented to fund a portion of its Congestion Relief Project *Open Roads for a Faster Future*. Although bond financing imposes interest and other debt-related costs, bringing a project to construction more quickly than otherwise possible can sometimes offset these costs. Delaying projects can impose costs from inflation, lost driver time, freight delays, wasted fuel, and forgone or deferred economic development. Analysis of the financial costs and benefits of debt financing weighs the costs of borrowing against the economic, safety, and mobility benefits of completing the project sooner than would be possible with pay-as-you-go funding (USDOT, Federal Highway Administration 2010).

8.1.2 Managed Lanes, Managed Expressways, and Express Bus Service Operated in Managed Lanes

In 2050, the managed lanes and managed expressways have proved to be a viable travel option in congested expressway corridors, improving mobility and travel time reliability. Express bus services running in a managed lane network operate on small headways, providing passengers with a flexible, less expensive and less polluting travel option. Further, passengers riding in the express buses have access to the latest technologies enabling them to work or enjoy entertainment. The transit investments have solved the first and last mile problem for commuters with shared autonomous electric vehicles.

8.1.3 Increased Market Penetration by Electric Vehicles

By 2050, due to battery cost declines, strong policy support from federal and state governments, and a robust network of electric vehicle infrastructure, BEVs are on track to surpass gasoline-powered vehicles in the region. Seldom does the region experience ozone action days during the summer, and neighborhoods and communities are benefitting from quieter trucks and fewer health complications from particulate matter.

The low cost of electric vehicles has led to development of a network of small shared autonomous electric vehicles. People can pick up a vehicle at charging stations throughout the city and at transfer stations and drop them off at another charging station at their destination using an app on their phone.

8.1.4 Increased Market Penetration by Connected and Automated Vehicles

In 2050, connected and automated vehicles are common and affordable. There is less congestion on the expressway and arterial network as vehicles are traveling in a connected and coordinated manner (i.e., platooning). People of all abilities are experiencing independent mobility and increased safety throughout our communities. Further people have new-found time for work or relaxation, as they no longer have to drive a car.

8.1.5 Dedicated Freight Facilities

The trucking industry was an early adopter of autonomous vehicles, and the industry has experienced efficiency gains and lower operating costs in 2050. Truck platooning has provided fuel economy benefits, eased congestion on the regions expressways, and improved overall safety. Dedicated freight facilities, such as truck parking in expressway right of way or direct access ramps to industrial/freight distribution/warehousing areas, have further improved freight operations, and these savings have been passed on to consumers.

8.1.6 Reduced Impact on the Environment and Communities

By 2050, strategies to lessen the environmental and community effects from passenger and truck vehicles are at work. The region has experienced a reduction in vehicle emissions and improved air quality with the move to alternative and electric vehicles. In addition, the region has experienced a reduction in vehicle noise due to quieter passenger cars (i.e., from the increased penetration of electric vehicles) and quieter truck vehicles as the freight industry leveraged market incentives to purchase quieter vehicles. There is a better connection between areas that had previously been divided by expressway with new infrastructure such as expressway caps, and safer streets for users of all ages and abilities (i.e., from Complete Streets initiatives and the increased penetration of autonomous vehicles).

8.1.7 Less Congested, More Accessible System Facilitating Economic Development

The estimated annual cost of congestion in 2010 was $7,300,000,000.[11] Congestion was expensive for residents, businesses, and governments. It limited people's ability to get around and restricted their choices of where to live and work. It limited businesses' access to skilled labor and deterred new business. In addition, congestion wasted fuel, caused air pollution, and reduced safety and security by delaying rapid response to emergencies.

The region's freight system is key to economic prosperity. However, congestion reduced reliability of train and truck shipments. According to the Texas Transportation Institute's *Urban Mobility Report* (2012), metropolitan Chicago has the nation's third-worst truck congestion as measured by hours of delay. In 2011, 22.8 million trucking hours were lost at an estimated economic cost of $1.7 billion.

However, in 2050, the region has implemented a suite of strategies that reduce congestion and sustain the economic vitality of our region:

- Large-scale tolling (revenue package assessment)
- Integrated system of managed-lanes network
  - Staged implementation from all vehicles to AV/CV only options
  - Integration of managed lanes and transit service
- Truck only lanes and truck only corridors
- Location-specific interchange and access treatments at bottlenecks and intermodal areas
- Tunneling consideration at some locations to add supplemental capacity
- Off-system options for supporting transit improvements to offset tolling impacts

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[11] Metropolitan Planning Council

The region has witnessed numerous benefits:

- Time savings; time savings are spent in the labor force or on more productive tasks rather than sitting in traffic
- Fuel savings
- Decreased vehicle emissions, which has reduced costs associated with pollution
- Increased travel options
- Improved reliability and speed of commercial shipments, which has decreased lost trucking hours
- Improved safety and security, which has resulted is less injuries and fatalities and reduced healthcare costs
- A transportation system in a state of good repair
- New business, which has helped to diversify and expand the tax base

SECTION 9

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