Policy Study 404
July 2012

Reason

Practical Strategies for Reducing Congestion and Increasing Mobility for Chicago

by Samuel R. Staley
Project Director: Adrian T. Moore

Acknowledgement

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By Samuel R. Staley, Ph.D.
Project Director: Adrian T. Moore, Ph.D.

Executive Summary

Chicago ranks among the most congested regions in the nation and current trends suggest it will become much worse. The delay per automobile commuter in the Chicago urbanized area increased from just 18 hours in 1982 to 71 hours—almost two work weeks—in 2010, representing the fastest rate of growth among 15 peer cities (in terms of size) studied by the Texas Transportation Institute (TTI). Using real-time traffic speeds and monitoring to estimate the impact of this congestion, TTI found that congestion costs commuters in Chicago more than commuters in any other city in the U.S, and put the economic cost at over $8 billion in 2010. Over one-third of these economic costs come from the impact on truck and commercial freight. If congestion continues to increase at current rates, the costs are likely to reach $11.3 billion per year by 2030 according to the Metropolitan Planning Council (MPC).

The rise in congestion is essentially a function of demand for road use increasing at a faster rate than the supply of road space, combined with inefficient traffic management. But this disparity is more significant in some parts of the system than others. For example, expressways and freeways make up 18% of the road-miles in the region, but account for 53% of vehicle miles traveled. Most of the hours of delay are concentrated on these roads. Indeed, travel demand has increased 126% on the region's expressways and freeways while supply, as measured by the number of lane-miles, has increased just 57% between 1982 and 2010. Demand on arterials and local roads increased by 40% while supply in lane-miles increased just 29%.

Fortunately, despite its magnitude, Chicago's congestion challenge is surmountable without completely rebuilding the road network. A more cost-effective solution would focus on building out the existing network, with strategic investment in new capacity creating routes that improve flow and regional access.

Chicago's transportation network suffers from three primary planning and network deficiencies:

1. A failure to provide north-south routes to supply regional access that bypasses the downtown,
2. A failure to build out road capacity in the northern parts of the region to address rising congestion and development, and
3. A failure to invest in essential road capacity for the urbanized western portions of the region.

These deficiencies can be addressed by adding incremental capacity to the existing network by putting the right roadway capacity in the right places at the right times. A missing component in the region's transportation investment strategies is an aggressive approach to re-examining the road network. Such an approach should comprehensively integrate four critical dimensions:

- The addition of new capacity in key areas of the network;
- Better management of the existing network, through Intelligent Transportation Systems (ITS) technologies, including adaptive traffic control and improved signal coordination, ramp metering and congestion pricing;
- The addition of new roadways to create critical north-south routes that more efficiently address contemporary travel needs outside the city of Chicago, thereby filling in the "missing links";
- Integrating transit into regional roadway network planning and programming.

This report develops and recommends specific projects targeting these areas, while also providing a financial framework for implementing them. Through 11 specific infrastructure projects, including three tunnels and a bus rapid transit (BRT) network, Chicago could significantly reduce congestion levels by 2040. This study details estimates of the traffic and fiscal impacts of each project derived from an enhanced regional travel demand model. These estimates suggest that in combination, the projects would require an investment of $52 billion over the next several decades. This investment would add 2,401 new lane-miles of expressways to the existing network. The model also suggests that demand is sufficient to generate $58 billion in new revenues from user fees.

The use of such fees (rather than taxes) would not only fully pay for these investments, it would also act as a form of congestion pricing and thereby ensure more continuous free-flow access throughout the region on these new roads. The use of electronic tolling would not only cut congestion, but would also be more equitable since it would be based on payments by users who choose to pay. The tolls would also provide a dedicated revenue stream to pay for ongoing construction and maintenance of the facilities. And tolled facilities are ripe for a broad range of innovative finance techniques that dovetail with approaches envisioned for the new Chicago Infrastructure Trust.

While this level of investment may seem large, it is not significantly out of line with historical rates of capacity additions. About 42 freeway lane-miles and about 100 arterial lane-miles have been added annually to the Chicago region's network over the last 25 years (and based on a smaller network than the one modeled in this study). The governors of Illinois and Indiana have also signed an agreement allowing for the use of a public-private partnership to build a major expressway along the southern edge of the Chicago metropolitan area (the Illiana Expressway).

This study estimates that adding capacity through the 11 major transportation projects outlined in this policy report, combined with variable, time-of-day tolling on new capacity set to ensure free flow travel speeds at posted maximum speed limits, should reduce regional travel delay by 10% compared to forecast levels in 2040. Chicago would reduce delay by 20% compared to projected 2040 levels, implying a significant reduction in levels of congestion over current levels.

The proposed 275-mile High Occupancy Toll (HOT) Lane project would generate nearly two-thirds of the toll revenues and handle 55% of travel demand on the proposed new roads in 2040 even though it consists of just 46% of the total lane miles built for the new system. The proposed new Outer Beltway would also experience high levels of travel, although actual use would depend on whether the land use projections are realized through the expected high jobs/housing ratio in DuPage County and low jobs/housing ratio in Will County.

Based on a typical 40-year useful life of these capital projects as well as ongoing fare collection costs, the projected revenues from the entire network are estimated to exceed costs by nearly 12% (in today's dollars). If the expensive Kennedy and Eisenhower Tunnels are deferred to a Phase II implementation (since they don't have much impact on current congestion if the other projects are built), revenues are estimated to exceed costs by almost 40%. In either case, the proposed regional road network should be financially self-supporting.

Evaluating three scenarios for a suburban BRT network suggests the most productive network would generate approximately 15,500 daily trips. Seventy percent of these trips would be generated by new riders while 30% would be diversions from other public transit modes such as bus or commuter rail. This finding suggests that transit resources may be best focused in the near and intermediate term on bringing the existing transit system up to a state of good repair, investing in improved levels of service rather than significantly expanding new capacity outside the city and along major corridors leading to downtown. Suburban BRT lines may make sense as the region continues to grow, and an emphasis should be placed on ensuring new road capacity is built to accommodate future transit demand in these corridors.

In sum, this study makes a strong case for the implementation of the 11 projects outlined in this report, either as part of a Phase I or a Phase II congestion mitigation strategy for the Chicago region. The Cross Town Tunnel and Midway Extension, the HOT Network and the Outer Beltway will have significant travel benefits for the region as well as the city of Chicago: By 2040, Chicago will benefit from about 300,000 fewer vehicle hours traveled per weekday and about 90 million vehicle hours annually. This translates into a benefit to Chicago-area businesses and residents of nearly $2 billion in the year 2040.

The Kennedy and Eisenhower tunnels are expensive and their benefits mostly occur after 2040. So these tunnels (along with new BRT lines) will likely be important for addressing future mobility needs in the Chicago area as the economy and population expand. At a minimum, these projects should be considered as part of a Phase II analysis.

Solving Chicago's congestion challenges will take leadership and a significant commitment to increasing the region's investment in core transportation infrastructure. Headway is already being made in public transit, with efforts to bring the passenger rail and bus system up to a state of good repair. Inroads are also being made to address critical logistical weaknesses in the multimodal regional freight system through the Chicago Regional Environmental and Transportation Efficiency (CREATE) program. This report addresses the critical missing component of aggressively re-examining the road network to focus on a long-term plan for alleviating congestion and outlines a financial framework to bring that plan to fruition.

Proposed Chicago Transportation Projects that Would Guarantee Free Flow Speeds and Access Throughout the Chicago Region

- **Cross Town Tunnel:** An 11-mile, $7.1 billion north-south tunnel in the alignment of Cicero Avenue and a nine-mile, $5.8 billion elevated Midway Extension running east along 63rd Street, connecting to the north endpoint of the Chicago Skyway (I-90)
- **Regional HOT Network:** An additional 275-mile (1,100 lane miles), $12.0 billion network of HOT lanes to "connect the dots," establishing a 2,401 lane-mile virtual regional HOT Lane Network that ensures free flow travel throughout the region seven days a week, 24 hours per day
- **Outer Beltway:** A 76.3-mile, $5.0 billion new outer beltway in suburban Chicago to facilitate north-south travel outside the central business district (CBD) with three lanes in each direction
- **Lake County Corridor:** A 32.3-mile, $2.1 billion expressway extension connecting the proposed Outer Beltway with I-94
- **Northbrook-Palatine Connector:** A new 25.3-mile, $1.6 billion freeway running east-west between the I-94/I-294 interchange in Northbrook and the new Outer Beltway
- **Elgin-O'Hare Extension:** A 17.3-mile, $1.1 billion extension of the Elgin O'Hare Expressway east to O'Hare International Airport and west to the new Outer Beltway
- **Illiana Corridor:** A 40.5-mile, $2.6 billion extension of the southern end of I-355, connecting Chicago with the state of Indiana
- **Arterial Queue Jumpers:** A $3.5 billion initiative to build 54 queue jumpers, primarily in Cook County, that would allow free flow travel for thru traffic at major arterial intersections
- **Bus Rapid Transit Network:** A network of new BRT services would utilize the HOT lanes to provide express bus service to key employment centers and travel destinations within the region.
- **Kennedy Tunnel:** A 9.8-mile, $6.4 billion northwest-southeast tunnel paralleling the Kennedy Expressway (I-90/I-94)
- **Eisenhower Tunnel:** A 7.3-mile, $4.8 billion east-west tunnel paralleling the Eisenhower Expressway (I-290)

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Part 1

The March Toward Gridlock

Champions of the Windy City may be surprised to learn that in 2009 drivers in the region had more time wasted in traffic and a higher economic burden from congestion than any city in America, even New York and Los Angeles. In 2010, the most recent year for available data, the effects of the recession on Chicago drove it down to second place for time wasted in traffic, but still first in costs of congestion. While estimating the burden of congestion is still more art than science, the Metropolitan Planning Council (MPC) put the figure at $7.3 billion per year in 2008, and forecast a rise to $11.3 billion per year by 2030 if trends continue.[1] The Texas Transportation Institute (TTI) used real-time traffic data to produce more precise estimates, which suggest that congestion on the Chicago region's roadways drained over $8 billion from the Chicago economy in 2010—more than eight times the combined revenues of the Cubs, White Sox, Bears, Bulls and Blackhawks.[2]

The TTI results imply that congestion costs the typical Chicago auto commuter $1,568 per year.[3] The cost to Chicago commuters is higher than the average for the other 15 "very large" urbanized areas in the U.S. Chicago's auto commuters wasted 70 hours a year—the equivalent of nearly two work weeks—on the region's clogged roads. Moreover, these costs have been marching upward, dipping just a little during the recession, despite the existence of one of the nation's most extensive rail and bus transit network. A 2006 Reason Foundation study found that unless investments are made now in its road network, Chicago travelers will waste the equivalent of two work weeks a year "stuck in traffic" by 2030.[4]

Congestion in Chicago is not just a regional problem; it's a national one. Chicago remains the economic anchor to the Midwest economy, serving as an essential transportation and distribution hub for the U.S. and a global financial services center. As home to hundreds of national and globally competitive companies, including Abbot Laboratories, AllState Insurance, Boeing, Kraft Foods, McDonald's, Molex, Motorola, Walgreens and others, moving people and goods and providing services are critical to Chicago's economic future and economic competitiveness.

As the third-largest metropolitan area in the United States, Chicago houses nearly nine million people in seven counties. The total value of goods and services produced in the Chicago area exceeded $570 billion in 2008 according to PricewaterhouseCoopers.[5] Chicago's economy trailed New York ($1.4 trillion) and Los Angeles ($792 billion) but was significantly larger than the next largest metropolitan economies of Philadelphia ($388 billion), Washington D.C. ($375 billion) and Boston ($363 billion). If Chicago were its own independent nation, its economy would rank it higher than Belgium, Sweden and Switzerland.[6] Keeping the region competitive is essential to the economic health of the Midwest as well as the nation.

High fuel prices and the onset of the recession in 2007 resulted in slightly lower total congestion levels, but this was merely a temporary lull, not a long-term trend.[7] As the economy recovers, congestion levels nationwide are resuming their relentlessly upward march. Congestion will be particularly acute in Chicago because of its pivotal role in the national transportation network as a freight and commercial truck hub. Truck traffic, in particular, is expected to rise dramatically and the Chicago region will feel these effects directly as demand increases the volume of transcontinental goods shipment. In fact, according to the TTI study, truck congestion alone represents over $2.3 billion of the total cost of congestion to the region, *more* than in Los Angeles or New York.[8] And this estimate ignores the effects on the rest of the nation due to commodities slowing to a near standstill at the Chicago transhipment point.

This report outlines a framework and specific, practical steps toward reducing and eventually eliminating traffic congestion as a meaningful hinderance to Chicago's economy and the quality of life of its residents. The next section explores in more detail the factors that influence congestion in the region and the city. Part Three examines the economic rationale for making congestion reduction a top regional (and national) priority. Part Four outlines a general framework for improving the operational efficiency of the current transportation system, while Part Five presents a general approach to adding new road capacity. Part Six discusses 11 key capacity improvement projects that would significantly reduce congestion in the city of Chicago as well as the urbanized area, while Part Seven details the expected benefits based on forecasts of travel demand and patterns. Part Eight grapples with the fiscal and economic impacts of implementing the long-range transportation plan outlined in the report. Part Nine concludes with specific recommendations and a strategy for moving forward.

Part 2

A Closer Look at Chicago's Congestion Problem

This section dissects Chicago's regional congestion problem in more detail, a crucial step toward identifying solutions. The scope of the problem, the fundamental elements contributing to congestion, and how the problem compares to other U.S. cities will be examined as well as ways to establish a meaningful framework and strategy for long-term congestion reduction and relief.

A. An Overview

The Chicago regional road network currently operates under severe traffic congestion. Many of the freeways, expressways, other arterials and collectors operate beyond their capacity during peak times and, increasingly, off peak periods. Technically, roads at their maximum engineered capacity are designated as Level of Service (LOS) E. Roads that operate beyond their capacity, where travel speeds are well below posted speed limits, are considered "severely congested" and operate at LOS F (see Table 1).

Table 1: Levels of Service (LOS) and Traffic Characteristics

LOS	Speed	Maneuverability	Incident Effects
A (free-flow conditions)	free flow speed	unimpeded	fully absorbed
B	free flow speed	largely unimpeded	easily absorbed
C	free flow speed	restricted by the presence of other vehicles	localized deterioration
D	2-8 mph below free flow speeds	noticeably limited	minor incidents create queuing
E (at capacity)	5-17 mph below free flow speeds	little freedom	extensive queuing
F	Volatile: 0-45 miles per hour	almost none	complete breakdown of traffic flow/stop-and-go traffic

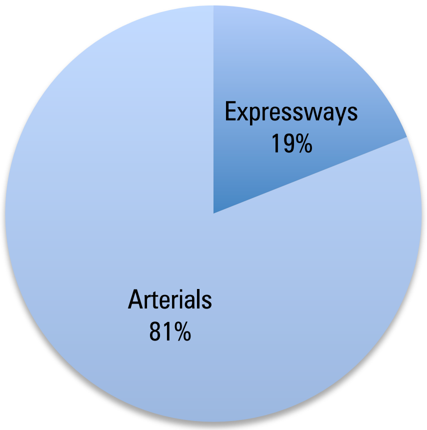
Source: Adapted by Reason Foundation from *Highway Capacity Manual* 2000, Chapter 13, "Freeway Concepts: Basic Freeway Segments," pp. 13-8 through 13-11.

Importantly, maximum capacity for a road from the transportation agency's perspective may not be the same as that for the casual traveler. Expressways, for example, are not considered congested until speeds dip below what engineers consider the threshold for maximum throughput—getting the most cars past a particular point. That speed is around 45 miles per hour. So, for transportation professionals, highway speeds that dip below the posted 55 mph (or 65 mph) because of congested traffic do not qualify as congested (no matter how irritated or frustrated drivers may be at these slower speeds). Only the points where speeds dip below the maximum throughput threshold qualify as congested, even if that speed is just a little higher than what could be achieved driving on a local road.

This policy report takes a different view, emphasizing speed over throughput. Speed is the economically relevant metric because faster travel speeds lower transportation costs, boost economic productivity and improve our quality of life.[9] Thus, roadways should routinely operate at LOS D or better because time is the standard by which users measure the value of a road's benefits. Notably, a number of express or managed lane facilities around the U.S. change their toll rates to manage the flow of traffic to ensure speeds at the posted speed limit while operating at LOS D or C.[10]

Achieving this standard of performance will not be easy. The six-county "core" Chicago region includes nearly 40,000 lane-miles of road. About one-fifth of the road network consists of expressways—principal arterials with limited access that provide for high-volume, high-speed regional travel (Figure 1). These roads typically have posted speed limits in excess of 55 mph. The remaining roads are (other principal and minor) arterials, collectors and local roads providing access within and between neighborhoods. These arterials can include a wide range of roads, from residential streets with speed limits below 25 mph to high-capacity boulevards with posted speed limits of 45 mph or higher.

Figure 1: Distribution of Road-Miles in Chicago Region



Despite their relatively small share of road-miles, the region's expressways carry a disproportionally higher burden of the region's traffic. The average weekday includes 1.7 million hours of travel by residents and visitors. Twenty-nine percent of this travel is on the limited access highway network, which represents only 19% of the lane-miles (Figure 2). The arterial network carries 71% of travel. Of course, the two road systems cannot be clearly separated or considered independently. Residents, workers and other travelers use the arterial network to reach regional expressways, and the local roads provide access to final points of destination. Nevertheless, the expressway system clearly provides an essential component of the region's road network.

Figure 2: Distribution of Travel in the Chicago Region in 2007 (Hours of Travel)

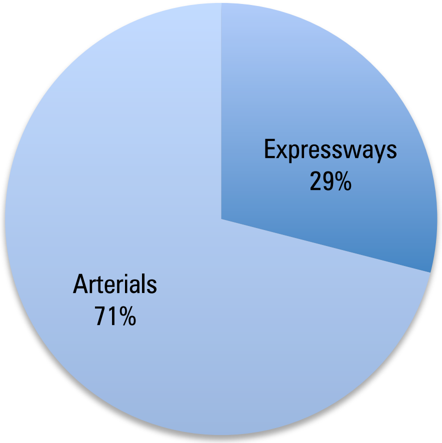
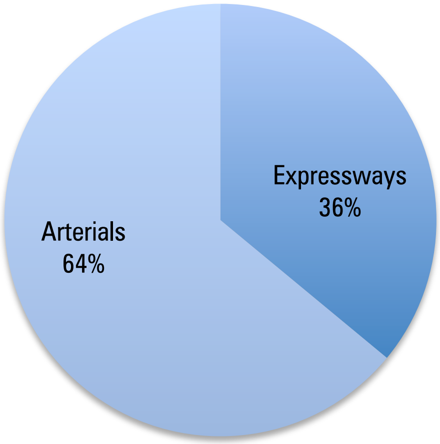


Figure 3: Distribution of Congestion for Chicago Region (Hours of Delay)



Perhaps even more importantly for this report, the expressway network shoulders a substantial burden of the region's congestion. On an average weekday, Chicago travelers rack up 521,449 hours of delay across the six-county region. More than one-third (36%) of that delay is on the region's expressways (Figure 3). Much of this delay is focused on some of the nation's worst bottlenecks near the city of Chicago's downtown, as the next section discusses. Fixing these bottlenecks, and creating more effective travel routes throughout the region, will be critical steps toward addressing congestion mitigation in the Chicago area.

B. Rising Congestion in Chicago

According to TTI, Chicago's urbanized area ranks third in the nation in terms of the total economic cost of congestion (Table 2).[11] That translates into the loss of at least $921 per peak hour traveler each year. TTI estimated the aggregate annual cost at over $8 billion in 2010, and the highest cost per driver in the nation. TTI's estimates are likely conservative, and significantly below the estimates of the MPC, in part because TTI's methods and data are more limited to ensure comparability across urbanized areas. In fact, the U.S. Department of Transportation's (DOT) chief economist estimates that the true national costs of congestion are likely double those estimated by TTI once the effects on freight traffic and travel time unreliability are factored in.[12] This report continues to rely on TTI estimates of congestion because its analysis and data cover more than two decades, providing a unique window for observing *trends* in congestion on an urban level.

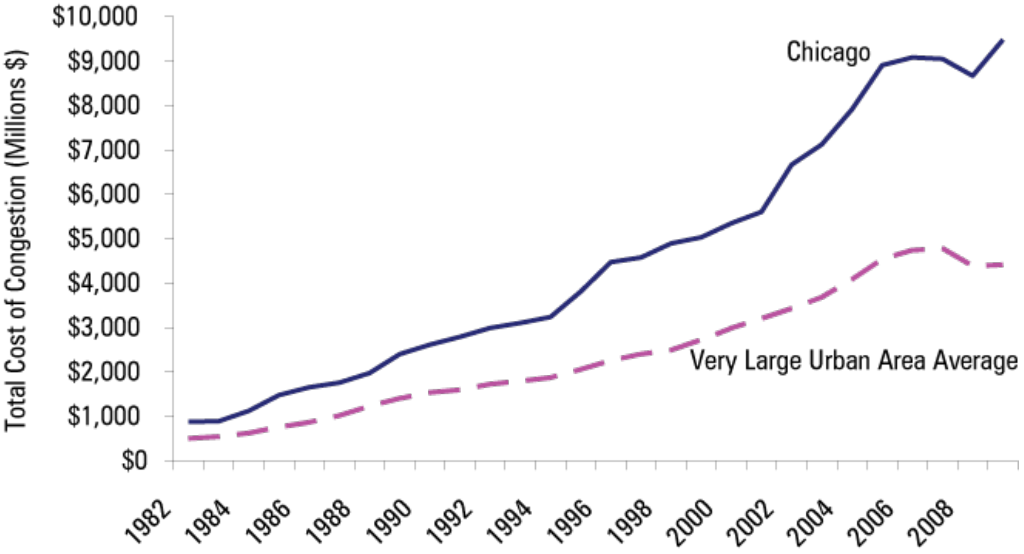
Table 2: Top 10 Most Congested Metropolitan Areas, 2010 Data

Urbanized Area (2010)	Population (thousands)	Population Rank	Total Cost of Delay (millions)	Delay Cost Rank
Los Angeles-Long Beach-Santa Ana, CA	13,124	2	$10,999	1
New York-Newark, NY-NJ-CT	18,852	1	$9,794	2
Chicago, IL-IN	**8,583**	**3**	**$8,206**	**3**
Washington DC-VA-MD	4,536	7	$3,849	4
Dallas-Fort Warth-Arlington, TX	5,158	6	$3,365	5
Houston, TX	4,056	11	$3,203	6
Miami, FL	5,391	4	$2,906	7
Philadelphia, PA	5,365	5	$2,842	8
Atlanta, GA	4,304	8	$2,489	9
San Francisco-Oakland, CA	4,058	10	$2,479	10
Avg. Ver Large Urbanized Areas (15)	6,103		$3,981	

Source: *2011 Urban Mobility Report*, Texas Transportation Institute, A&M University, Table 2, September 2011.

Not only is Chicago's congestion already costing billions of dollars every year, it is also increasing more rapidly than the 15 "very large" cities in its peer group in the TTI report (see Figure 4). In 1982, congestion cost Chicago travelers $877 million dollars annually, about 40% more than the average for this group. By 2010, congestion costs had climbed to $8.2 billion, more than double the average of $4 billion for Chicago's peer group. Average delay per automobile commuter also increased dramatically from 18 hours annually in 1982 to 71 hours in 2010.

Figure 4: Trend in Total Congestion Costs: Chicago vs. Peer Cities

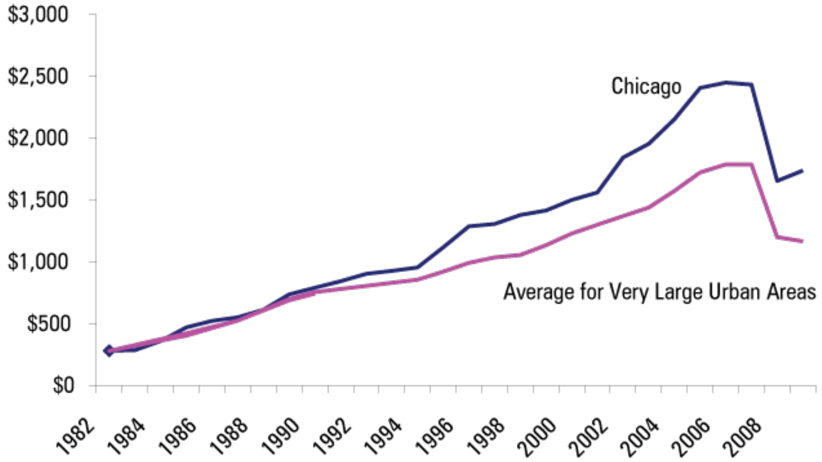


Source: 2010 Annual Urban Mobility Report, Congestion Data For Your City; Texas Transportation Institute, February 2010. Based on an average value of time of $10.73 in 1987, $15.17 in 1997, and $21.01 in 2007 including both personal vehicles and commercial vehicles.

Congestion reduces our quality of life, making it harder to predict schedules for spouses, friends and and children, complicating errands and frustrating attempts to socialize with others and partake in events and culture. But the effects of congestion are most dramatically illustrated by its estimated cost for each automobile commuter. Chicago ranked among the most severely congested urban areas in 1982 when average costs were about $877 annually per automobile commuter (Figure 5). By 2010, however, these costs had soared to nearly $1,568 per automobile commuter. The roadway congestion index rose by 42% during this period and the travel time index by 15%.

These indices, however, are regional averages and obscure intense delays that are often experienced routinely at key chokepoints. Travelers through the I-90/94 split, the Circle and the “Spaghetti Bowl” can attest through personal experience that these delays can add significant and unpredictable time to trips along particular stretches of the network. Indeed, simple congestion—too many vehicles trying to squeeze onto too few lanes—often doubles travel times along these stretches.

Figure 5: Trend in Annual Congestion Cost Per Auto Commuter

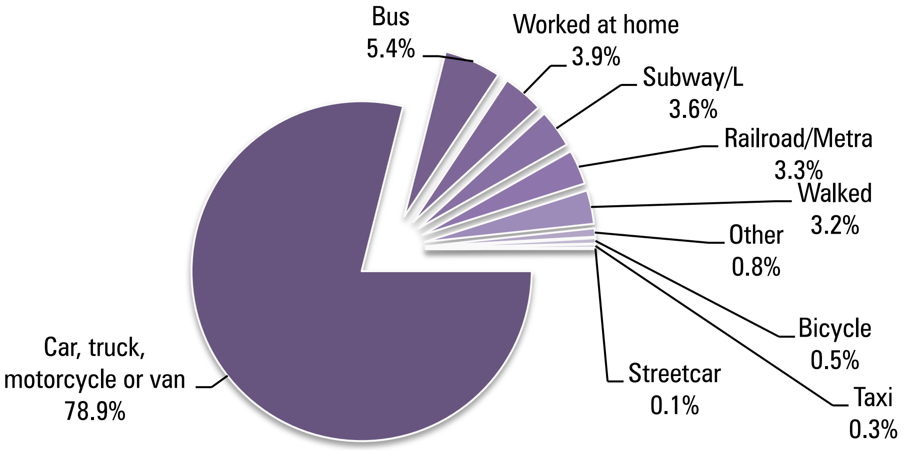


Source: 2010 Annual Urban Mobility Report, Congestion Data For Your City*; Texas Transportation Institute, January 2010*.

C. Commuting Trends and Travel Times

Complicating matters is public transit's relatively small share of overall travel. While transit's market share is large by American standards, in Chicago roughly just 6.4% of all travel and 12.4% of commuter travel is by public transit.[13] Notably, transit's commuter mode share appeared to bounce back after falling to 10.5% in 2005. Nevertheless, cars, trucks, vans and other forms of personalized travel still account for nearly 80% of commuting by Chicagoans (Figure 6). Walking and working at home make up more than 6% of commuter "travel," more than the combined contribution of the region's rail network.

Figure 6: Travel Mode Splits for Chicago Metropolitan Area: 2005-2009



Source: U.S. Census Bureau, 2005-2009 American Community Survey, Means of Transportation to Work, Table B08301.

Even though regional travel times have increased in Chicago, automobile commuters still enjoy faster commutes compared to public transit users. Based on data from the U.S. Census Bureau, the average automobile commuter's one-way travel time is about 25 minutes although these data are not adjusted for distance traveled. Public transit users reported spending 49 minutes to commute one way.[14]

In spite of the relatively long travel time compared to the automobile, commuters average about 477 miles per year on public transit in Chicago. Although that is less than half of the per capita transit utilization in New York, it is nearly double that in Los Angeles and about three times the utilization in Houston.

Another way of measuring transit usage is by the proportion of commuters regularly using transit. The recent recession, like all recessions, saw a reduction in auto use and a rise in transit use, so it makes sense to look at pre-recession figures when considering the long term. The New York urban area (which includes Northern New Jersey, Long Island, the Lower Hudson Valley and Southwest Connecticut) remains a national outlier, with 26.2% of commuters using public transit to get to work in 2005. The next highest transit usage is in Washington D.C., which is tied with Chicago, followed by San Francisco (9.1%). Los Angeles, the nation's second largest urban area, attracts just 4.5% of its commuters to public transit.

Table 3: Comparison of Commuter Mode Shares and Mean Travel Times, 2005

Travel Mode	Mode Shares						
	Chicago	Los Angeles	New York	DC	Atlanta	San Francisco	Houston
Drive Alone	72.6%	74.7%	55.3%	70.4%	79.3%	69.4%	78.3%
Carpool	9.5%	12.6%	7.9%	11.2%	10.8%	11.2%	12.8%
Transit	10.6%	4.5%	26.2%	10.6%	3.2%	9.1%	2.7%
Work at Home	3.3%	4.1%	3.5%	4.0%	4.4%	4.8%	2.9%
Other	4.0%	4.0%	7.2%	3.8%	2.3%	5.6%	3.3%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Travel Mode	Mean Travel Times						
	Chicago	Los Angeles	New York	DC	Atlanta	San Francisco	Houston
Drive Alone	28.6	27.7	27.0	29.8	29.7	24.8	27.1
Carpool	31.1	31.8	31.5	34.2	34.0	30.1	31.2
Transit	49.9	48.0	51.4	48.5	48.1	43.6	48.9
Work at Home	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Other	18.8	19.3	16.3	18.6	27.7	17.9	21.1
Average	**30.8**	**28.9**	**33.2**	**31.9**	**30.7**	**26.8**	**28.0**

Source: 2005 Transportation Profiles, U.S. Census Transportation Planning Products.

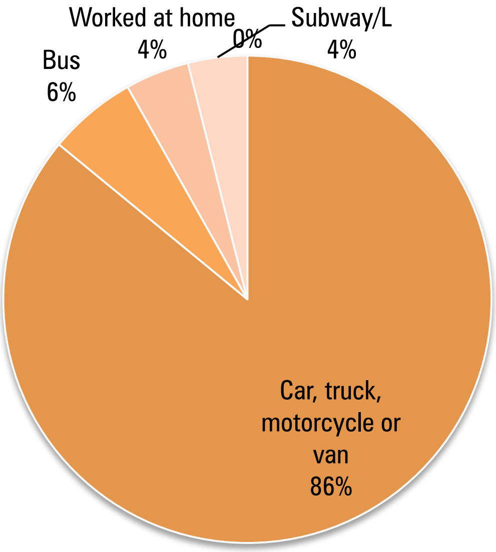
D: The Role for Transit

These observations do not diminish the importance of public transit in providing both mobility and congestion relief within the larger Chicago region. Transit provides critical access to the central business district as well as peak-hour transportation options that are important for maintaining regional competitiveness. Chicago has the second highest use of transit for commutes to the central business district (55%) among the nation's largest urbanized areas, though it is important to remember that the CBD accounts for only 15% of the Chicago urban area's employment.[15]

In addition, Chicago is rare in that rail provides a backbone to the public transit network (Figure7). While buses provide the single largest source of mobility for transit users, the regional commuter rail lines (Metra) and heavy rail system (subway and elevated "L" trains) link the region's public transit network together.

Nevertheless, most travel in large urban regions, including Chicago, is off-peak and regional in scope and nature. Transit investments will need to recognize these increasingly fragmented and decentralizing travel patterns. Not surprisingly, public transit increasingly serves a highly targeted niche market in overall regional travel with a particular emphasis on commuting (compared to general travel) into and around the central business district. Thus, as a *regional* congestion mitigation tool, transit's role likely will be limited.

Figure 7: Transit Mode Split for Chicago: 2005-2009



Source: U.S. Census Bureau, 2005-2009 American Community Survey, Means of Transportation to Work, Table B08301.

The current emphasis of the regional transportation plan on bringing the current transit system to a "state of good repair" is the appropriate one. Crucial to transit's future success and competitiveness is providing the resources to ensure the transit system functions efficiently and cost-effectively. Thus, the emphasis in the Chicago Metropolitan Agency for Planning's current long-range plan, *Go to 2040*, on shoring up existing systems and networks over new transit capacity is a strategically important objective. The recommendations in this report do not undermine this goal. Indeed, as subsequent sections point out, user demand for non-transit services should be sufficient to underwrite major new and necessary road capacity expansions without diverting resources from public transit.

E. The Full Cost of Congestion

In addition to the delays that Chicago area residents experience on a daily basis, traffic congestion also affects air quality, other aspects of the natural environment, the economy and goods movement. Ideally, these impacts would be included in estimates of the full cost of congestion. Just adding secondary economic effects, goods movement and productivity improvements led the chief economist at the U.S. DOT to double his estimates of the national economic costs from congestion compared to the figures reported by TTI.[16]

For Chicago, the Metropolitan Planning Council estimated that excess commuting time cost the Chicago region about 87,000 jobs in 2008.[17] Both the regional highway and rail networks in Chicago have become increasingly congested, reducing mobility and the reliability of freight movement as the number of rail cars per day is projected to increase to about 67,000 by the year 2020. The existing network in Chicago consists of nearly 2,800 rail-miles with about 37,500 rail cars traveling through the region each day.[18] Freight in Chicago currently accounts for about $3.2 billion in local income and the employment of over 117,000 people, adding over $8 billion to the regional economy.[19]

But these economic costs still do not include other important but difficult to quantify burdens on the region, such as lower air quality (from pollution) and other damage to the natural environment. The U.S. Environmental Protection Agency (EPA), for example, determined that the Chicago region is in non-attainment for the national ambient air quality standards for ozone as well as fine particulate matter.[20] CMAP, the Chicago Metropolitan Agency for Planning and the MPO for the region, notes that:

> *Transportation greatly affects the quality of our natural resources and environment. In both urban and rural areas of northeastern Illinois, transportation projects can improve access to natural areas, but can also degrade them with congestion and pollution.*[21]

Unfortunately, this report does not delve deeply into these additional costs of congestion. Rather, it builds on the work of others who have attempted to report on its negative effects on the region and focuses on scoping out solutions.

Congestion reduction is not a trivial or minor exercise. The geographic scale of the Chicago region as well as the complexity of regional travel patterns suggest a variety of strategies will be needed to improve mobility and economic competitiveness. An important first step is to identify specific projects that have the highest likelihood of improving mobility and reducing traffic congestion. The next sections of this report explore a range of options for the city of Chicago and the larger Chicago region, identify specific projects, and provide a preliminary assessment of the fiscal viability of these projects.

Part 3

Economic Consequences of Chronic Congestion

Growing cities typically face rising congestion when local infrastructure fails to keep pace with growing travel demand, and Chicago is no exception. Less well recognized and understood are the economic consequences of letting passenger and freight traffic bog down. Congestion increases production costs by extending the time it takes to transport resources and products to consumers, suppliers and intermediaries. This results in lower productivity, as the amount produced per unit of labor or capital falls because fewer people can get to work on time, delivery times become unreliable (requiring larger inventories to cover potential shortages of goods), and resources sit idle because of delays in the production process. Increasing travel speeds, in contrast, reduce transportation (and production) costs, boosting productivity and helping ensure cities and their regions remain economically competitive. Employment and income growth follow.[22]

A. Transportation and the Benefits of Access

Congestion burdens economic growth.[23] If a driver enters a busy road and the traffic slows, it could be said that the driver has imposed a cost on the other drivers already on the road. (Economists typically refer to such costs as “externalities.”) Since the benefits of travel arise through the movement of people and/or goods from point A to point B in the shortest time possible, any increase in the travel time resulting from slower traffic is a cost.

A city that solves the congestion problem, all other things equal, will be able to grow faster than one that doesn’t by maximizing travel speeds and minimizing transportation costs. The citizens of such a city will not only benefit from greater wealth but also from less frustration and time wasted in their daily lives.

Access to resources, goods and markets through transportation improvements has been a driving force in determining the location and growth of cities.[24] It is no coincidence that Chicago became essential to the national economy. Its role as a logistics hub was facilitated first by navigable waterways, then by railroads, and now by highways and airports. Chicago is the transportation and logistical epicenter for the nation’s interior, giving it a place and competitive advantage few other cities can rival.

More broadly, Chicago and cities like it bring people, technology, ideas and equipment together, fostering innovation and productivity. That makes them attractive places for people to live and work.[25]

While an effective, well-functioning transportation system can create the conditions for a city to emerge and thrive, an ineffective, malfunctioning transportation system can have the opposite effect. Today, Chicago is moving toward the latter situation.

B. Congestion's Impact on Economic Productivity

So, how important is congestion? Theoretically, faster travel speeds (lower congestion) should drive transportation costs down. These lower costs affect the bottom line for firms—lower costs mean higher potential for profits and lower prices for consumers. This is borne out by empirical research.

Economists Remy Prud'homme and Chang-Woo Lee conducted some of the first major contemporary studies, finding that higher travel speeds expanded the labor and employment pool in cities. For every 10% increase in travel speeds, labor markets expanded by 15% and productivity by 3%.[26] While their original study focused on cities in France, an extension to include larger cities in other countries (but not the U.S.) found similar results.[27] Other European researchers have found that slower growth in core urban areas in the Netherlands can be attributed to the "negative congestion effects caused by traffic jams."[28]

In the U.S., planner Robert Cervero extended Prud'homme and Lee's work and found that every 10% increase in commuting speed in the San Francisco Bay Area increased worker output by 1%.[29] Average speed had a bigger impact on land use and employment clustering than did factors such as employment density and racial composition of the workforce.[30]

Researchers are also finding that congestion influences economic sectors in different ways.[31] Businesses often are required to increase delivery vehicle fleets, shift delivery hours, increase inventories, manage more complex and uncertain delivery schedules at distribution centers, reduce market areas, and even move logistics and distribution centers outside urban areas to cope with congestion's impacts on the bottom line.[32] Congestion disrupts supply chains, forcing producers to increase their inventory of intermediate goods to compensate for the uncertain timing of deliveries. Such disruptions are different than those faced by retailers and wholesalers shipping goods from warehouses and distribution centers intended for direct sales to consumers at the neighborhood level. In a "just in time" economy, congestion's negative impacts loom large. This is one reason why economists Chad Shirley and Clifford Winston found that investments in highways significantly improved the profitability of businesses.

Technology and services-based industries, on the other hand, tend to be more labor-intensive. These industries are much more likely to be affected by factors that influence the ability of their employees to organize and participate in meetings, deliver intermediate products to vendors, or simply make it to work on time.

Daniel Graham, a transportation economist at Imperial College in London, England, analyzed data from neighborhoods (wards) in London to examine congestion's impacts on productivity based on two factors: how far people traveled and how much time it took them to get to their destination.[33] Based on his analysis, Graham speculated that a 5% increase in travel speed would boost productivity in London by about 1%.[34]

In the U.S., transportation researchers David Hartgen and M. Gregory Fields examined congestion's effects on eight urban areas, ranging from Salt Lake City with an urbanized area population of just 1.5 million people to the San Francisco Bay Area with an urbanized area population of 6.8 million people.[35] Their analysis looked at how travel times influenced the size of the labor market as well as access to key destinations, specifically the downtown central business district, large shopping malls, major universities, major suburbs and airports. They found that congestion reduced accessibility to these key areas because fewer people could access them within 25 minutes (the median commute time for workers in major U.S. urban areas). Perhaps more surprisingly, the magnitude of the effects was similar to that of Prud'homme and Graham. The central business districts, in particular, were most vulnerable since most growth was already going to the suburbs. Congestion simply reinforced these trends, making the downtown more isolated from the rest of the region. This result implies that, over time, rising congestion will make downtowns less productive and, ultimately, less viable. In seven of the eight urbanized areas, Hartgen and Fields found the downtown economy would be helped by eliminating congestion, which would expand its ability to tap into growing suburban markets and a decentralizing labor force. The same benefits were found for shopping malls and universities.

Hartgen and Fields's analysis uncovered several salient points about the economic impact of traffic congestion on cities. First, access by workers to jobs has a much bigger impact on economic performance than access by employers to residents. So, the key is to ensure workers have access to a large pool of employers. Second, while the most accessible place in these areas was the downtown, regional economic performance appears to hinge on other destinations, most notably growing suburbs and universities.[36]

The effects are large. If Dallas could maintain free flow conditions on its highway network, its regional economy might generate as much as $46 billion more by improving access to its universities, $23 billion by improving access to its major suburbs, $18 billion through improved access to its shopping malls, $8 billion from improved access to its airport, and $6 billion through improved access to the downtown. Denver would reap economic benefits of similar magnitudes. Atlanta would benefit, but not by quite as much: $15 billion from improved access to its growing suburbs, $24 billion by improving access to its malls and universities, and about $10 billion by improving access to its airport and downtown.

Long-term economic productivity increases further when transportation investments are more targeted. Most recently, the Chicago Metropolitan Agency for Planning (CMAP) summarized the potential economic effects of reducing congestion in its Comprehensive Regional Plan *Go To 2040* released in October 2010 (p. 250).

> *CMAP's analysis of the economic impacts of Go To 2040's recommended major capital projects estimates a **$13.3 billion** increase in long-term economic activity (as measured by Gross Regional Product) from a public-sector expenditure of $10.5 billion. This produces a benefit-to-investment **ratio of 1.26**. Reducing the various costs of traffic congestion is what drives these positive economic impacts. They include not only decreased pollution, shipping costs and time delays, but also increased productivity. Investments must be carefully targeted toward congestion reduction and other closely related performance outcomes. Building expensive new projects in inefficient locations will not make an appreciable dent in these figures. Transportation projects, especially expansion projects, must be judged against their long-term economic impacts.*

C. Balancing Supply and Demand

Given the debilitating effects of congestion, why have governments permitted congestion to continue to increase? At root, traffic congestion is the result of an imbalance between supply and demand: more vehicles are attempting to use the same limited road space. One way to think about the problem is what happens when a handful of rice is poured into a funnel. If the spout of the funnel is too narrow, the rice backs up and can even stop the flow of rice. If the spout is sufficiently wide, the rice flows through unimpeded.[37] Throughput can be maximized either by slowing the amount of rice poured into the funnel, what is known as "demand management," or by increasing the size of the funnel, i.e. "capacity expansion."

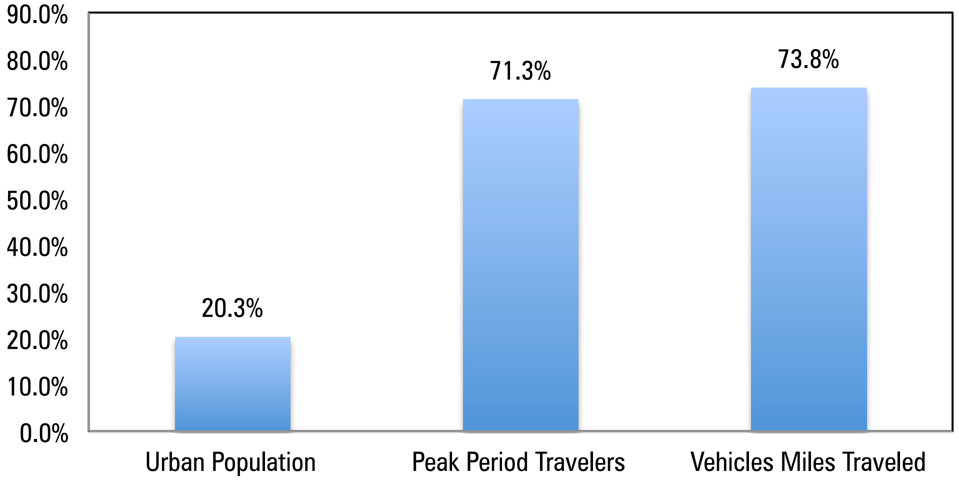
These two approaches are not mutually exclusive, particularly when the economic effects of congestion are considered. Moreover, given the constraints of current technology, limits exist on the extent to which regions can rely on one strategy to the exclusion of the other. For example, demand management strategies are crucial for optimizing a transportation network—making sure the right traffic uses the facilities at the right time—but if these strategies increase travel times and reduce mobility (and accessibility), higher transportation costs will reduce productivity and efficiency, undermining economic competitiveness. Moreover, travel demand management is effective when sufficient capacity exists in the system to optimize travel behavior and patterns.

Similarly, traffic congestion is unlikely to be solved by capacity expansion alone. The right capacity must be put in the right place at the right time. Often, policymakers and transportation planners do not have sufficient knowledge of the complexities of travel patterns and driver behaviors to make these increasingly fine-grained decisions. Nevertheless, sufficient capacity must exist in the system to allow other strategies to be effective. Thus, when these strategies are imbalanced, traffic congestion will increase.

The population of the Chicago urbanized area grew by 20%, reaching 8.5 million people, between 1982 and 2009 according to census data used by TTI (Figure 8). The actual size of the urbanized area, measured in square miles, increased by four times the region's population growth as people and jobs moved and grew in outlying counties, including DuPage, Kane, Lake and Will counties.

As the region spread out, the number of peak period travelers grew by 71% and travel demand (measured by vehicle miles traveled) rose by 74%. Thus, stress on the travel network grew as demand increased in absolute terms and travel became more decentralized with the region's population and geographic growth.

Figure 8: Change in Regional Travel Demand Indicators: 1982 to 2009



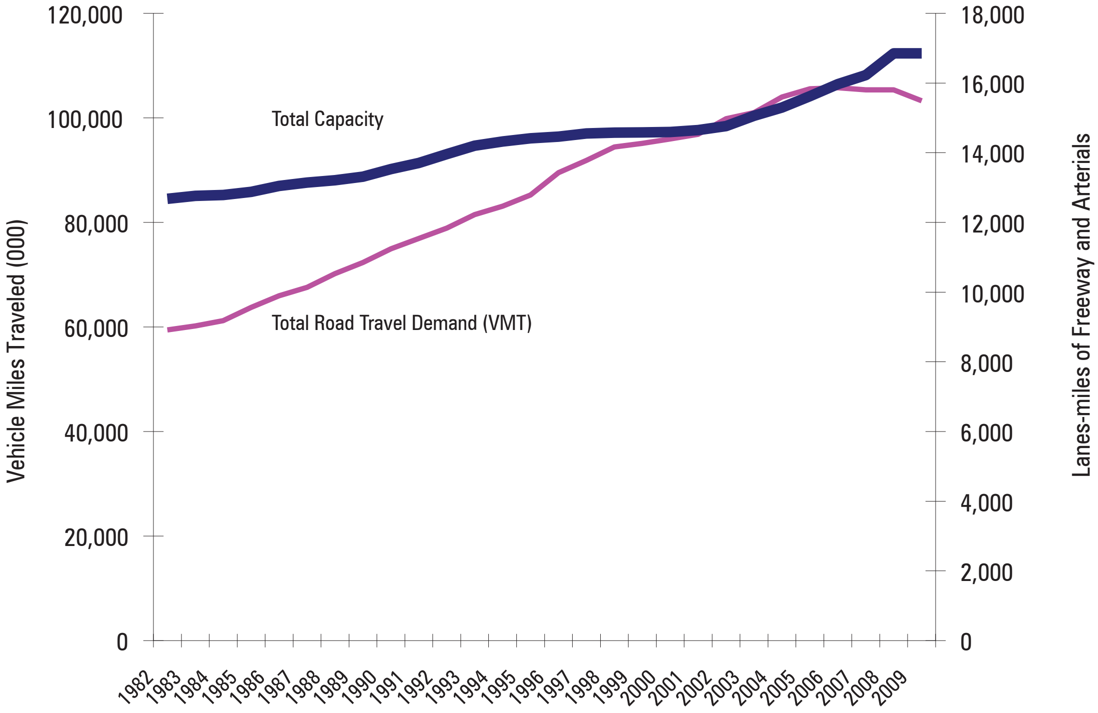
Source: *2010 Urban Mobility Report*, Texas Transportation Institute, Texas A&M University, complete data available from http://mobility.tamu.edu/ums/congestion_data/

Meanwhile, the transportation network did not keep pace with travel demand. As travel demand increased, the number of lane-miles of roadway increased by just 4,170, or 33%, over the same period.[38] Compounding matters, public transit use grew slowly and transit continued to lose market share on a regional level. This trend is confirmed by examining year-to-year changes in the number of lane-miles available to travelers (Figure 9). The rate of increase in lane-miles added to the regional road network is substantially slower than the rate of increase in the region's travel demand.

Notably, TTI found that those urban areas that have expanded road capacity more commensurate with the increase in the demand for travel make significant progress in reducing congestion. Of the 14 urban areas where road capacity increased within 10% of travel demand, congestion peaked around 2000 and steadily declined (despite the national economic boom). For those urban areas where travel demand increased 30% or faster than road capacity (such as Chicago), congestion increased more dramatically.

In fact, it took the onset of the Great Recession to blunt the upward surge of congestion, even if the effects are temporary. While congestion appeared to level off around 2005 in the national data, the trajectory of progress is not encouraging for those urban areas that failed to significantly increase road capacity. Indeed, data on travel trends by travel monitoring companies such as INRIX have found congestion increasing again after falling slightly during the economic recession. Nearly two thirds of the top 100 metropolitan areas in the U.S. began to experience increases in congestion by the middle of 2009.[39] The *2010 Urban Mobility Report* also confirms that congestion has started to increase again.

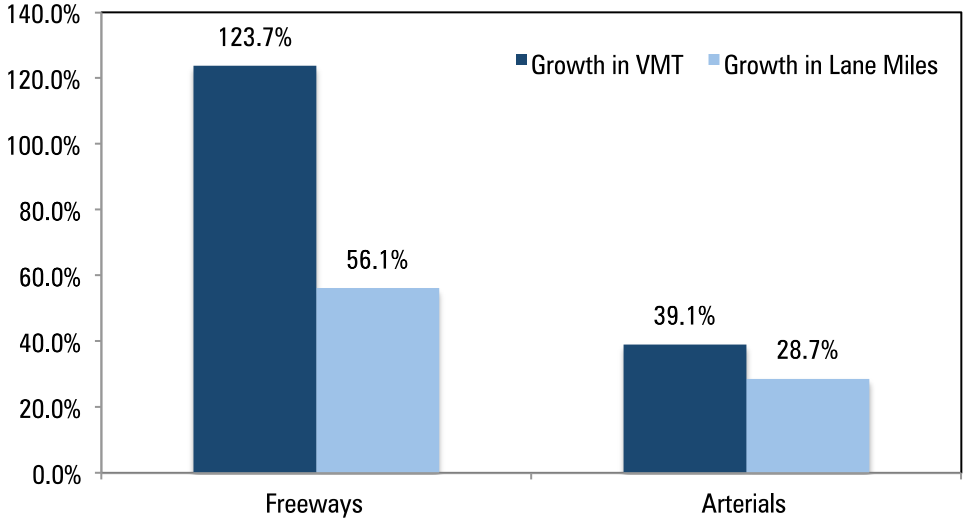
Figure 9: Trends in Travel Demand and Road Supply in Chicago



Source: *20010 Urban Mobility Report*, Texas Transportation Institute, Texas A&M University, complete data available from http://mobility.tamu.edu/ums/congestion_data/.

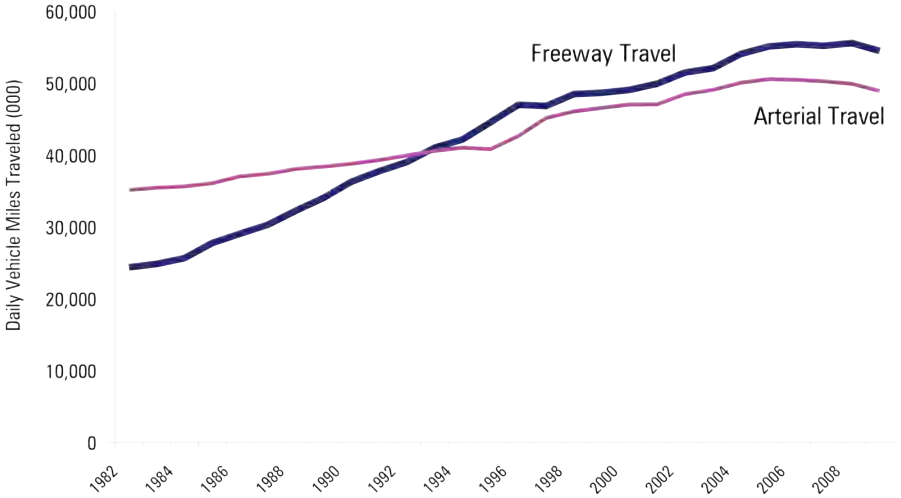
A closer look at the travel data for the Chicago region reveals an important imbalance in the development of the Chicago regional road network. As travel demand on the expressways and freeways more than doubled, the number of expressway lane-miles increased by just 56% (Figure 10). Lane-miles of arterials grew by 29%, lagging behind travel demand, which on these roads grew by 39%. The trajectory of these changes can also be seen in the year-to-year changes as the rate of increase for travel demand on Chicago's expressways has significantly and consistently outpaced demand on the arterials (Figure 11). Thus, while demand outstripped supply on the entire road network, the gap grew faster for freeways and expressways than for local roads.

Figure 10: Travel Demand vs. Growth in Capacity in Chicago: 1982 to 2009



Source: *2010 Urban Mobility Report*, Texas Transportation Institute, Texas A&M University, complete data available from http://mobility.tamu.edu/ums/congestion_data/.

Figure 11: Freeway vs. Arterial Travel Demand: 1982 to 2009



Source: *2010 Urban Mobility Report*, Texas Transportation Institute, Texas A&M University, complete data available from http://mobility.tamu.edu/ums/congestion_data/.

As the next section of this report points out, these problems are exacerbated by the poor network design of the Chicago region. The region has good east-west corridors and poor north-south connections. As a result, substantial regional traffic is funneled into the "Spaghetti Bowl" near The Circle and I-90/94 split, creating some of the nation's most severe bottlenecks. This suggests that the network of freeways and expressways should be examined more closely as policymakers search for solutions to the region's traffic congestion challenges.

Part 4

Getting Chicago Back on Track

A casual reader of Daniel Burnham's *Plan of Chicago* could be excused for wondering if today's transportation planners are serious about congestion. "Congestion," the *Plan* noted (p. 100) "is a menace to the commercial progress of the city." Yet congestion has continued to increase steadily in the Chicago region for decades.

Burnham's insights were prescient. Several studies on the Chicago region have raised both the visibility and the profile of congestion as a core challenge. Chicago Metropolis 2020 (now Metropolis Strategies) has aggressively conducted travel demand modeling to estimate the economic impacts of congestion on the region. Its two reports, *The Metropolis Plan: Choices for the Region* and *A Framework for Building a More Effective Regional Transportation System*, recognize that revamping the regional transportation network will be essential for keeping the region globally competitive and meeting its economic objectives in the 21st century.

Unfortunately, while the region has invested in important improvements in transportation infrastructure, these efforts are short of the measures necessary to change the trajectory of rising congestion, let alone reduce it. This section takes these analyses to the next level by examining, evaluating and recommending specific transportation projects and approaches that if implemented could significantly reduce traffic congestion, increase travel speeds and increase regional economic productivity.

A. A Phased Approach to Capacity Expansion

Unfortunately, building road capacity at the levels necessary to eliminate congestion doesn't happen overnight. Thus, this report assumes capacity additions will occur in phases. Phase I would include the highest priority projects that have the maximum likelihood of making a meaningful impact on traffic congestion and improving circulation in the region in the short and intermediate term (through 2040). These projects address critical deficiencies in the regional road network, including the elimination of key bottlenecks, adding more direct north-south routes, and adding capacity along critical corridors. Combined with the aggressive and judicious use of ITS technologies, also discussed later in this report, the Chicago region could go a long way toward eliminating severe regional road congestion through a strategic approach to expanding capacity at the right places.

Most of this report provides detailed analysis of Phase I expansions of the regional road network and improving the management of the existing system. Phase I projects were identified after extensive interviews with key transportation policymakers, planners, business owners, business executives and engineers, combined with an in-depth review of transportation planning documents. They also represent a down payment on a congestion-free future for the Chicago region that could help ensure economic competitiveness in the 21st century.

We build on the substantial work already completed by key groups and individuals in Chicago. Metropolis 2020, MPC and CMAP have already laid important ground work and much of the analysis in this report started from their groundbreaking efforts. In addition,

- The Chicago Department of Transportation (CDOT), in cooperation with Illinois DOT and owners and operators of off-street parking facilities, is implementing variable pricing for street parking to reduce peak-period congestion caused by vehicles entering and exiting Chicago's central area parking facilities.
- The Illinois Tollway Authority is developing plans for new lanes adjacent to its regular toll lanes on facilities that the Tollway already operates. These new lanes would be dedicated for transit vehicles and carpoolers, with single occupancy drivers paying premium rates.

Unfortunately, as the next section details more completely, these efforts have not yet yielded the levels of investment necessary to make significant inroads into reducing congestion. One of the objectives of this study is to build on these efforts to offer a more complete framework for addressing mobility and congestion challenges in the Chicago region and to investigate practical, cost-effective solutions. Our efforts identified 11 major projects that could dramatically improve circulation and mobility in the city of Chicago and the larger region while laying the groundwork for leveraging these investments for Phase II projects.

The study identified four fundamental strategies to increase travel speeds and improve the Chicago region's transportation network performance:

- Invest strategically in public transit
- Optimize road network performance
- Eliminate bottlenecks
- Add and optimize new roadway capacity

Due to network effects, all four of these strategies should be considered simultaneously, since the benefits of each one are enhanced by the proper implementation of the others. These strategies should not be considered substitutes for each other. Given Chicago's increase in transportation travel demand, rising regional population and expected growth in the traditional downtown, investments now in all four strategies will be critical for meeting future needs and keeping the region economically competitive. Yet, each of these strategies will require a different set of policies tailored to those needs and concerns.

B. Public Transit

While not a principal focus of this study, public transit is a fundamental component of an efficient transportation network for the Chicago region. Our analysis includes a scenario for expanding public transit on a regional level using BRT services. Unfortunately, as this report discusses in more detail in Part 7 Section D, adding significant new transit capacity is not estimated to significantly reduce regional traffic congestion. On the one hand, this is not surprising. Transit in the Chicago region services is just 10% of regional travel, and transit is most effective along already existing corridors serving travelers with downtown destinations.

On the other hand, these results also suggest that the design of Chicago's existing transit network is relatively efficient and that a more important public transit priority should focus on bringing the existing system up to a state of good repair rather than adding new capacity on a regional level.[40] While an expanded BRT strategy may bear more productive fruit in the future, the results suggested this should be considered as part of a Phase II strategy rather than a Phase I priority project.

Reform proposals focused on optimizing the existing public transit system and operations, however, are beyond the scope of this report. Thus, the appendices contain this study's analysis and discussion for those interested in pursuing this strategy independently. Moreover, the extensive work already in progress through the Regional Transit Authority (RTA) and Chicago Transit Authority (CTA) emphasizing investments in the current network to bring it up to a state of good repair is ongoing and far more comprehensive that what could be accomplished in this report (which focuses primarily on identifying potential network capacity additions).

C. Improving Network Efficiency

System and network efficiency focuses on improving the flow of traffic on both limited access and arterial road networks. Many, but not all, of these strategies involve the judicious application of Intelligent Transportation Systems, or ITS, including road pricing (through variable rate tolling), traffic signal optimization, highway ramp metering and incident management.

Improving system efficiency is considered the "low hanging fruit" of congestion reduction strategies, often providing significant benefits for relatively small cost. For the purposes of this report, existing system efficiency enhancements are the non-capacity expanding investments, often using the latest technologies to enhance traffic flows and increase speeds on the existing network.[41] Benefit-cost ratios for many ITS investments often exceed those of highway capacity additions because the relative investment is so small that even incremental increases in performance justify these investments. These strategies are particularly important for addressing arterial road performance, but they are also crucial to managing the interface between local roads and limited access highways.

As much as half of the congestion in large urban areas may result from incident-driven sources such as vehicle crashes, breakdowns, construction, snowstorms or other sporadic and unpredictable events. Using regional traffic management technology to change the timing of traffic signals at intersections, dispatch road clearance teams, or time traffic entering from highway ramps can signficantly improve travel speeds. Los Angeles, for example, found that traffic-signal timing optimization improved travel time by 13%, reduced delay by 21%, and elminated 30% of traffic stops.[42] London, England coordinates 3,000 traffic lights using computers to change signal times by just a few seconds to keep traffic moving in the case of accidents. Beijing, China monitors its traffic and posts alternate routes for drivers based on real-time tracking of travel speeds using more than 10,000 taxis.

Fortunately, the city of Chicago and other transportation agencies have been investing in new technologies to improve the efficiency of the system. Based on results from the Dan Ryan Expressway, for example, one study found that ramp metering—controlling access to highways using timed signals on highway ramps—could reduce travel delay by between 10% and 50% and improve travel times and speeds by up to 20%.[43] Improved signal timing and the use of traffic monitoring cameras were used to provide an alternative to the Dan Ryan during a three-year construction project along Ashland Avenue. The project covered a 13.8-mile stretch of roadway and 39 intersections while providing a foundation for the Chicago Traffic Management Center. The Chicago Transit Authority also uses GPS technology to track buses (Bus Tracker) to improve information about bus arrival and departure times for bus users as well as fleet managers. The city is also investigating the feasibility of implementing a Cooperative Vehicle-Highway Automation System to improve public transit performance and facilitate freight movement through the region.

The good news is that even more can be achieved if additional investments are made in ITS. TTI's *2011 Urban Mobility Report* summarizes operations measures for each urban area and estimates their contribution toward reducing the area's travel time index. Table 4 shows the four basic measures that are reported. The freeway and expressway measures represent the extent of ramp metering and the percentage of the system under active incident management. The arterial and local road measures reflect the extent of traffic signal coordination and arterial access management.

Table 4: Freeway and Arterials Operations Management for the Chicago Urbanized Area

	2010	2004
Freeway Ramp Metering		
▪ Percent miles of roadway	23%	23%
▪ Annual delay reduction, 1000 hrs	1,280	1,054
Freeway Incident Management		
a) Cameras		
▪ Percent miles of roadway	40%	41%
b) Service patrols		
▪ Percent miles of roadway	55%	60%
▪ Annual delay reduction, 1000 hrs	6,517	3,438
Arterial Signal Coordination		
▪ Percent miles of roadway	55%	56%

Table 4: Freeway and Arterials Operations Management for the Chicago Urbanized Area		
	2010	2004
▪ Annual delay reduction, 1000 hrs	1003	589
Arterial Access Management		
▪ Percent miles of roadway	18%	14%
▪ Annual delay reduction, 1000 hrs	15,821	3,396

Source: *2011 Urban Mobility Report*, Texas Transportation Institute, Texas A&M University, http://mobility.tamu.edu/files/2011/09/chica.pdf

1. Freeway Ramp Metering

Estimates of the impact of widespread ramp metering suggest that it can have a significant effect on recurring congestion. For example, TTI's latest report estimates that Minneapolis-St. Paul, in which ramp metering currently covers 91% of freeway miles, has significantly less travel delay than the Chicago region, where only 23% of freeway miles are covered (and these are confined largely to points within the city of Chicago). With a freeway system that is about 80% larger than that of the Twin Cities, Chicago might save over 4 million hours of delay per year with ramp metering implemented regionwide by broader use of this strategy. Since ramp metering costs a small fraction of significant lane additions, this under-used tool clearly represents "low-hanging fruit" that could build on the city's current successes.

2. Freeway Incident Management

Chicago has done better with respect to the management of incidents such as disabled vehicles, traffic crashes, spilled cargo or other debris in the road, road construction and non-emergency special events. For example, variable message signs over freeways such as the Dan Ryan and Eisenhower expressways alert travelers to delays and traffic accidents, helping them manage their routes to avoid delays.

Incident management falls within the purview of the Chicago Regional Transportation Plan, which supports the ongoing development and implementation of the region's principal ITS blueprint, the Strategic Early Deployment Plan for Northeastern Illinois (SEDP). The SEDP includes a "Regional Intelligent Transportation Systems Architecture," a 15-year guide for transportation technology integration in northeastern Illinois. The RTP's goal of improving the transportation system with ITS supports a regional and multi-state communications system that provides real-time travel conditions and emergency management information to transportation agencies, emergency response providers and the general public. Pro-active incident management in the Chicago region is intended to cover incident detection and verification, incident response and clearance, and site and area traffic management.

While considerable progress has taken place through the SEDP, there remain problems with implementing effective incident management programs due to conflicts both within and between agencies responsible for addressing incidents. In part this is due to the inherently different priorities of public safety and transportation agencies. Besides tending to the injured and dealing with fuel spills, public safety agencies are concerned with time-consuming tasks such as investigating and documenting major accidents. Transportation agencies, by contrast, are concerned with the delays imposed on motorists, buses, delivery trucks and everyone else who uses the highways. In most states, public safety agencies are either legally or de-facto in charge at incidents; minimizing delay to the traveling public is not a high priority. With certain toll roads (e.g., Florida's Turnpike and California's 91 Express Lanes) this is less true because the road managers work agressively with public safety agencies to quickly clear accident scenes and get traffic flowing again, as toll-paying customers demand timely travel.

The National Cooperative Highway Research Program (NCHRP) published a synthesis report on safe, quick clearance of traffic incidents to help transportation agencies design and implement more effective incident management programs.[44] An overall program should encompass:

- Quick clearance legislation;
- Hold harmless law for incident responders;
- Fatality certification law;
- Interagency agreements (open roads policy).

Only a few regions permit the certification of a fatality and removal of the body by anyone other than a medical examiner—which can make a major difference in accident clearance times. The city of Chicago is among the jurisdictions with such policies, as well as the states of Maryland, Tennessee and Texas. Likewise, only a few states have developed enhanced interagency agreements that make quick clearance the overarching priority, commonly termed an "open roads policy." The NCHRP study identified five such states: Connecticut, Florida, Maryland, Tennessee and Wisconsin. If congestion reduction becomes the major focus of transportation planning and programming in Chicago, priority should be given to enactment of a statewide fatality certification law and development of an open roads policy among Chicago DOT and public safety agencies.

3. Arterial Signal Coordination

The share of arterial miles with signal coordination has actually declined to 55% in 2007 from 56% in 2004 according to TTI. Not surprisingly, the benefits to traffic flow and congestion relief have also diminished. The annual delay reduction from traffic signal coordination rose from 589,000 hours to slightly over 1 million hours. This is well below the region's potential given this technology. In comparison, 92% of the Los Angeles urbanized area includes arterial road traffic signal coordination, resulting in an aggregate annual delay reduction of about 3 million hours.

Work Zone Safety and Incident Management

Highway work zones are another key source of delay, as well as a safety hot-spot. Two principal types of construction projects are of interest: routine maintenance and major rehabilitation/reconstruction. Both can be managed in ways that minimize the delay caused to motorists.

Routine maintenance must be done periodically to maintain the life of the pavement, thereby preventing major reconstruction before it is really necessary. On highly congested roadways, such resurfacing operations should not be done during peak traffic periods, because the loss of lane capacity imposes too great a cost on users. But since "peak" periods in Chicago are approaching eight hours each weekday, this means such resurfacing must be done at night and on weekends. The additional cost of night and weekend operations is far less than the delay costs that would otherwise be imposed on highway users.

Resurfacing and major reconstruction, however, inherently take lanes out of service for a considerable period of time and hence cannot be limited to nights and weekends. In this case, to minimize total delay on major freeways, the construction work should be carried out on a round-the-clock basis (24/7), with the idea of limiting the duration of construction to as short a time as possible. Design-build contracts for such projects commonly include significant financial incentives to complete the work on or before a target date, and such projects are often completed significantly ahead of the targeted completion date.

State-of-the-art traffic control in the vicinity of construction work zones can reduce delay and improve safety. The primary impact is to reduce accidents and therefore the delays associated with clearing them.

Traffic signal coordination is an on-going activity among agencies in the Chicago area, most notably as Illinois DOT works with local cities and counties. Multi-jurisdictional signal interconnect projects have been deployed on St. Charles Road, involving the towns of Elmhurst, Villa Park and Lombard. A multi-jurisdictional signal coordination agreement along 75th Street in Naperville involves Naperville, DuPage County and Illinois DOT. Pace Suburban bus is also spearheading an effort to recognize the relationship between traffic signal coordination, transit signal priority and emergency signal preemption, in order to plan efficiently for reliable emergency response and bus service and improved person-throughput on the regional arterial system.

If traffic signal coordination could be extended over the Chicago region to the same level as Los Angeles (92% coverage), annual delay reduction benefits could increase by as much as 2.5 million hours.

4. Arterial Access Management

Access management consists of a set of techniques that increase safety and improve traffic flow on major arterials. It typically includes strategies such as consolidating driveways to minimize disruptions to traffic flow, adding median turn lanes or turn restrictions, adding raised medians or adding acceleration and deceleration lanes.[45]

Because of limitations in readily available highway data, TTI uses only the extent of raised medians as its measure of access management. This may understate the extent of congestion reduction since actual programs in urban areas may include these other features. Nevertheless, data consistancy allows for comparable measures across urbanized areas for raised medians. The Chicago urbanized area has a significantly lower percentage of principal arterial roadways with raised medians (13%) compared to other "very large" urban areas, which average more than 40%. This indicates that Chicago is not leveraging the delay reduction benefits of access management as much as it could on a regional level. In Houston, which has a much smaller arterial network than Chicago, the TTI report found that 61% of arterial miles have access management and the delay reductions stemming from access management are more than 60% greater (about 4.3 million hours of delay reduction annually in Houston, compared to about 2.6 million hours of delay reduction in Chicago). This suggests that if the Chicago area increased the coverage of raised medians to a level similar to what a large city such as Houston averages, the benefits could range from an additional reduction of 6 to 11 million hours of annual delay.

In sum, the Chicago urbanized area could benefit significantly from enhanced applications of ITS technologies to improve traffic flow and optimize the efficiency of the existing network. The city of Chicago has already invested in several of these technologies, and their successes can be used as a foundation for more extensive regional applications. Moreover, these technologies will likely prove to be among the most cost-effective approaches to addressing congestion, particularly on the arterial road network.

D. Bottleneck Elimination

Eliminating bottlenecks, such as the "Spaghetti Bowl" around the Circle where the Dan Ryan and Eisenhower Expressways converge near downtown, may require both capacity additions as well as a re-design of the network. Regional population growth will increase travel demand (measured as vehicle miles traveled—VMT), and new capacity will need to be added to accommodate this growth. The key decisions for policymakers will be where the new capacity should be added and what type of capacity is necessary.

Many of the freeway interchanges in Chicago were not designed to handle the high levels of demand that they now accommodate. A national study identified the worst individual freeway bottlenecks in the Chicago region (Table 5) as of 2002.[46] The Circle Interchange—the convergence of the Eisenhower (I-290) and Dan Ryan (I-94) Expressways—ranks as the nation's third-worst bottleneck, accounting for 25 million hours of traffic delay each year and adding 17.5 minutes to the average trip during peak periods. The Dan Ryan and I-90 Skyway Split is the nation's 11th-worst bottleneck. West of downtown Chicago, the Eisenhower Expressway between US 45 and SR 50 ranks in the nation's top 20 most congested bottlenecks. Combined, Chicago's 13 most severe bottlenecks rack-up 78 million hours of delay each year, a staggering amount of time (and money) wasted because of poor design and lack of highway capacity. Worse, this waste is likely to increase significantly as peak period delays are expected to increase 6.6 minutes at the Circle Interchange, 5.4 minutes at the Skyway Split, and 4.8 minutes between US 45 and SR 50 for peak hour trips over the next 20 years. Perhaps unsurprisingly, none of these bottlenecks are among the road investments made on tollways within the last five years.

Table 5: Most Congested Freeway Bottlenecks in Chicago, 2002

Interchange	Chicago Rank	National Rank	Average Daily Traffic	Annual Hours of Delay	Peak Period Delay (minutes per vehicle per trip)	Annual Traffic Growth	Projected Average Daily Traffic 2025	Projected Peak Period Delay, 2005
I-90 at I-290 (Circle Interchange)	1	3	293,671	25,068,000	17.5	0.50%	329,367	24.1
I-94 (Dan Ryan Expressway) at I-90 Skyway Split	2	11	260,403	16,713,000	13.2	0.50%	292,056	18.6
I-290 (Eisenhower) between Exits 17b & 23a	3	19	200,441	14,009,000	14.4	0.50%	224,805	19.2
I-290 at I-355	4	42	213,906	4,301,000	–	–	–	–
Pulaski Rd at I-55	5	65	188,825	3,162,000	–	–	–	–
I-90 at I-94 (Edens Interchange)	6	93	182,054	2,652,000	–	–	–	–
I-80/I-94 Split (southside)	7	97	132,496	2,581,000	–	–	–	–
I-294 at Lake Cook Rd	8	115	109,512	2,202,000	–	–	–	–
Roosevelt Rd at I-355	9	129	125,095	2,050,000	–	–	–	–
I-355 at I-55	10	151	87,166	1,753,000	–	–	–	–
I-57 at 12th St	11	154	166,931	1,717,000	–	–	–	–
I-55 at I-294	12	160	165,903	1,706,000	–	–	–	–
I-55 from Naperville to I-80	13	227	104,537	806,000	–	–	–	–

Source: *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks*, page 3 and pages 24-57; American Highway Users Alliance, February 2004. Note that the report provided peak period delay, annual traffic growth, projected average daily traffic in 2025, and projected peak period delay in 2025 only for the top three Chicago area bottlenecks.

Bottleneck interchanges of this sort are being redesigned and rebuilt in some places. The costs of such interchange reconstruction projects vary widely, but are generally estimated to be at least $100 million per interchange and can be far higher, depending on factors such as local geology, topography, engineering and availability of financing. A review of recent projects to reconstruct bottleneck interchanges around the country found that project costs ranges from about $92 million to about $795 million.[47] But benefits of such projects from reduced delay can be hundreds of millions of dollars each year.

1. Arterial Intersections

A less well-recognized traffic choke point is a local road intersection that was either under-designed or not upgraded to meet current traffic patterns and demand. Small, low-volume two-lane roads and intersections may no longer be sufficient to carry the volumes of traffic generated through urbanization. In some cases, these choke points can be addressed by adding turn lanes or reconfiguring existing traffic flow patterns. In other cases, intersections need complete redesigns and retrofits to serve entirely new travel needs and roles. In either case, transportation planners and policymakers will need to evaluate the role the arterial system plays in creating traffic congestion.

2. Highway Network Design

A more fundamental problem appears to be a regional road network poorly matched to current day travel patterns, complexities and dynamics. All major high-volume regional highways in Chicago lead to downtown, representing a classic example of the "hub and spoke" approach to transportation planning (and dating at least as far back as the Burnham Plan in Chicago). While the hub and spoke approach was functional when city economies were dominated by large, highly concentrated CBDs, the 21st century urban areas of the U.S. are more spread out, more decentralized, and more dynamic than earlier cities.[48]

Chicago's CBD ranks as the second largest in the U.S., with nearly 550,000 jobs located within its boundaries, but its *regional* economic influence has waned.[49] Without a doubt, the enduring economic strength of the CBD helps the public transit system capture 55% of the downtown commuting market (second only to Manhattan). Yet, this high concentration of employment in one downtown (the nation's second highest with 161,000 jobs per square mile) represents just 14.3% of the urbanized area's employment. Most people work in the suburbs and the outer reaches of the city of Chicago. Thus, transit's market share of commuting outside the CBD is just 5.1%.

Addressing these bottlenecks, choke points and design issues in order to meet current and future travel will require the addition of new capacity at the right places in the existing network. As noted above, it will also require aggressive application of ITS strategies to maximize the existing (and future) network. These strategies are complementary.

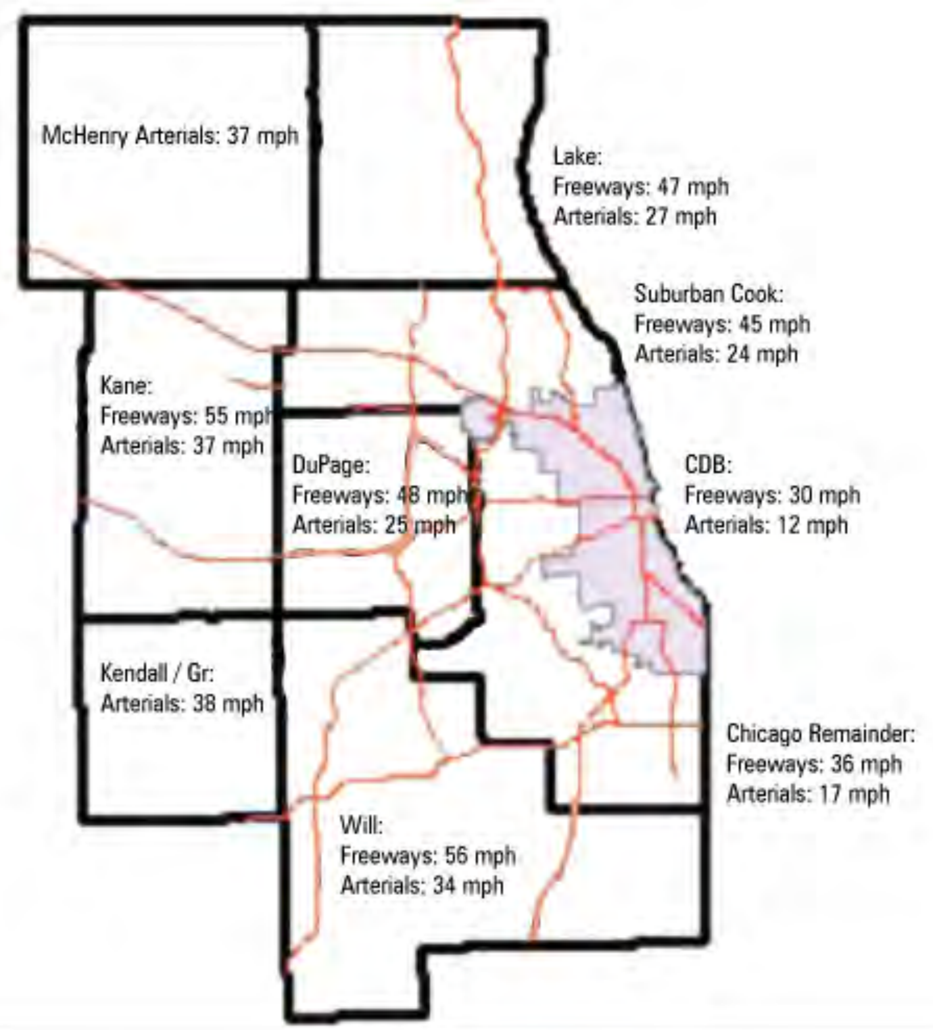
E. Expanding the Regional Road Network

The redesign of interchanges will provide little relief unless sufficient regional road capacity exists to meet rising travel demand. Chicago's inability to add the necessary capacity has significantly eroded the performance of its highway system, as average travel speeds have fallen well below free flow levels (Figure 12). Using real-time data from the traffic monitoring firm INRIX, the Texas Transportation Institute found that speeds during peak periods in Chicago averaged less than 50 mph on expressways and 25 mph on arterial streets—about 20% lower than free flow speeds.[50]

Arterial speeds during peak periods were lower in Chicago than any of the other 15 very large urban areas (including Los Angeles, Washington, D.C and New York). Expressway speeds were lower for every very large urban area except Los Angeles and Seattle. The Chicago urban area also posted among the lowest speeds on freeways and arterials even under free flow conditions.

The most congested facilities in the region are those closest to the city of Chicago and its major bottlenecks as well as the sections of I-90, I-94, I-55, and I-290 inside the city limits. Average freeway speeds are about 30 miles per hour within the CBD (LOS F conditions), reflecting the high volume of traffic that is destined for downtown as well as points beyond the CBD without sufficient alternate routes (see Figure 12).

Figure 12: Estimated Average Speed of Freeways/Arterials by County/District, 2005



Source: *Chicago Metropolitan Urban Partnership: Proposal to Reduce Traffic System Congestion in Northeastern Illinois*, page 5; Illinois Department of Transportation, April 2007.

During morning and afternoon peak periods, most of Chicago's regional transportation network operates either at capacity or in severely congested conditions. Average freeway speeds farther away from downtown Chicago range from 36 to 56 miles per hour. Arterial roads in the CBD average speeds of 12 miles per hour and arterials in the remainder of the Chicago region have speeds averaging between 17 and 38 miles per hour. As the population of greater Chicago continues to grow, it is likely that higher congestion will be observed throughout the region over time without upgrades to the regional road network.

Eliminating all severe regional road congestion (purging LOS F conditions) could be accomplished by 2040 if the Chicago region increased the number of road network lane-miles by 18%, from 39,431 to 46,662. The lane-miles for expressways, tollways and ramps would have to increase 22% region-wide to purge severe congestion, increasing the size of the network from 7,283 to 8,884 lane-miles. Thus, arterial lane miles would need to increase 18%, from 31,960 to 35,591, and 1,601 lane-miles would need to be added to achieve an expressway network operating at its engineered capacity (LOS E). Using typical costs for these new lane-miles, an additional $16 billion would be necessary to construct these roads. This new capacity should also be tolled to both manage the roads more efficiently and provide a dedicated revenue stream for ongoing construction and maintenance.

Achieving LOS E (if possible) would benefit regional traffic flow considerably, reducing total travel times by 12.6% and reducing vehicle delay by 37.5% by 2040. Importantly, these travel time savings would be achieved in conjunction with a small 0.9% *reduction* in vehicle miles traveled. The reduced congestion, in effect, is allowing more direct routing.[51]

These improvements, however, would have to be achieved in the face of decades of congestion neglect in the Chicago region. Indeed, congestion has been increasing relentlessly at least since the 1980s.

Fortunately, local policymakers have recognized the need for capacity additions, even if the additions have been modest. Over the last five years, the Illinois Tollway Authority has added 263 new lane-miles to its existing network (Table 6).[52] While the new segments are welcome additions to the Chicago regional road network, they fall well below what is necessary to significantly address rising congestion in the region or alleviate congestion in the city of Chicago. Also, all these recent capacity additions were made on toll roads and were likely only possible because of the ability to tap into a dedicated revenue stream supported by users. This is an important lesson for developing a meaningful and practical congestion relief strategy for the region and will be discussed in more detail in later sections.

Table 6: Recent Road Capacity Additions in the Chicago Region

Illinois Tollway Projects	Lane-Miles Added
A 12.5 mile extension of the I-355 Veterans Memorial Tollway (the I-355 South Extension) between I-55 and I-80.	84.3
Widening of the I-294/I-80 South Tri-State Tollway between I-90 and Wisconsin border, and between I-55 and SR 394.	96.4
Widening of the I-88 Reagan Memorial Tollway between SR 56 and I-294.	37.2
Widening of the I-90 Jane Addams Memorial Tollway between US 51 interchange and Wisconsin border.	45.3
Total Lane-Mile Addition	**263.2**

Part 5

The Right Roads in the Right Place at the Right Time

In order for Chicago to significantly improve mobility, reduce congestion and improve economic competitiveness, the region will have to invest in a wide range of transportation improvements, including improved freight movement, public transit and roads. Currently, the region has identified a menu of projects essential to removing nationally debilitating freight bottlenecks through the Chicago Region Environmental and Transportation Efficiency Program. The Chicago RTA is helping to coordinate resources to bring public transit up to a state of good repair. However, necessary investments in major roadway improvements are not being made. The remainder of this report outlines a series of proposed investments in the regional road network and provides estimates of the benefits and costs of these projects, which will be essential to mobility in the 21st century.

The Chicago region's approach to transportation planning and investment must have both tactical and strategic dimensions. Tactically, investments must be made in projects and programs that allow the network to operate most efficiently and to meet existing travel demand. Strategically, the right infrastructure must be built in the right place at the right time. At present, Chicago is failing both tactically and strategically, with congestion rising and mobility declining.

We explore the costs and benefits of these roadway projects using a regional transportation planning model first developed by the Chicago-based business group Metropolis 2020. The Metropolis 2020 model included a number of important features, including land-use impacts on transportation choices, increasing travel demand and the potential impacts of road pricing during peak and off-peak periods. Reason Foundation enhanced this model with the assistance of the transportation consulting firm Smart Mobility to include the effects of household income on transportation decisions, a more sophisticated approach to the use of road pricing to ensure free flow conditions on key segments of the regional network, and estimates of potential road-pricing revenue (based on travel demand forecasts) to finance new investments. The Metropolis/Reason Transportation Model of the Chicago region, or MRTM, is described more fully later in this report and in more detail in Appendix D.

Removing severe congestion by the year 2040, based on the results of the MRTM model, will require the expansion of expressway capacity in the Chicago region by about 1,600 lane-miles, or about 22% over the next 30 years and arterial capacity by about 5,600 lane-miles, or 18%. These investments comprise about 53 freeway/tollway additions and about 188 arterial lane-mile additions per year.[53]

The city of Chicago, nearby cities, regional transportation agencies and state agencies have committed to major improvements in the region's infrastructure. While a more complete discussion of these projects and the planning process is contained in Appendix A, most of the committed transportation investments appear focused on bringing the region's transit system up to a state of "good repair" and expanding transit options for residents working and living in the city of Chicago. Given the decades of deferred maintenance on the public transit system, the emphasis on operations and maintenance is an understandable goal.

Yet, the Chicago region is faced with significant transportation challenges that require moving beyond simply bringing the *current* transportation network up to speed. In order to keep the transportation network functioning effectively, the region and city of Chicago will need to add new capacity at key points in the region's infrastructure based on existing and expected travel patterns. These enhancements must also be linked to sustainable revenue sources to ensure these facilities remain in a state of good repair and funds are generated to address future travel needs.

The projects outlined in this report are ambitious, many achieving the status of billion-dollar "mega-projects," and their successful implementation will take outside-the-box thinking and policymaking. Fortunately, three current transportation projects provide important policy experience and foundations for what will be necessary to develop and manage a 21st century transportation network in the Chicago area.

First is the city of Chicago's controversial experiment with variable pricing for parking in the downtown area (inside the Loop). This is laying important technical and practical groundwork for recognizing the role market prices will play in managing transportation systems more efficiently as well as developing sustainable funding sources and the technology needed to implement this approach.[54] The Chicago Department of Transportation (DOT) is working with the Illinois DOT, the private partner for the on-street parking meter system, and off-street parking owners/operators to study more comprehensive variable parking pricing for the Chicago CBD to reduce congestion during peak periods.[55] The plan involves higher peak-period parking prices for off-street facilities within the Chicago and would be coupled with peak-period on-street parking restrictions.[56]

Second, the Illinois Tollway Authority is investigating the potential of adding 80 more miles of tollroads to its existing toll facilities: I-90 (Jane Addams Memorial Tollway), I-294/I-94 (Tri-State Tollway), I-88 (Reagan Memorial Tollway) and I-355 (Veterans Memorial Tollway). Currently, automobile drivers using Illinois Tollway facilities pay distance-based tolls but they do not vary by lane, by time of day or by actual congestion levels. Thus, the tolls raise revenues to pay for the facilities, but they are not effective in managing system performance.

The lanes potentially added by the tollway would convert the far left lanes of its existing tollways to premium service lanes in which single occupant vehicles (SOVs) are tolled at higher rates that change based on time of day. High-occupancy vehicles (HOVs) in those lanes and all vehicles in other lanes would pay standard, non-variable toll rates.

Most recently, a study by the Tollway, the MPC, and Wilbur Smith Associates examined the feasibily of applying this type of toll technology to 27 segments of the tollways and Illinois DOT expressways to determine which parts of the network would benefit from adding new lanes through variable, time-of-day congestion pricing. A detailed examination of segments along the I-55 Stevenson Expressway, I-90 Janes Addams Tollway and I-90/94 Kennedy reversible lanes found substantial time savings and benefits.[57] Adding one lane in each direction to the Jane Addams Tollway between IL-31 and I-294 could generate revenues of nearly $30 million a year in 2020 and drop morning rush-hour travel times on one 12-mile segment from 59 minutes (averaging 12 mph in 2020 without the new lanes) to 12 minutes in the priced lane (averaging 59 mph).[58] Morning travel times on the Stevenson Expressway along a 5.7-mile stretch between Cicero Avenue and I-90/94 could cut travel times from 23 minutes (averaging 15 mph in 2020 without the new lanes) to six minutes if a High Occupancy Toll (HOT) lane were added in each direction.[59] These new lanes would generate nearly $25 million in new revenue from users. The Kennedy Expressway had the smallest impact, but travelers would still expect to reap substantial time savings with the priced lanes while generating another $23 million in revenue. Thus, these preliminary studies suggest congestion pricing can create substantial benefits for travelers during critical times of the day, and these benefits are implied in the willingness of drivers to pay tolls to use them (and they offset the costs of building the new lanes). Indeed, the report concludes: "The data suggest that by better managing new highway capacity, the region may be able to curb its congestion problem and generate additional revenue that can be re-invested into the transportation network."[60]

The highway management innovations examined in the Wilbur Smith report are part of a national trend toward using road pricing to create sustainable revenue streams to finance new road capacity based on direct user fees. By optimizing travel time and speed, and thus road network efficiency, the newest off-the-shelf technology is used to maximize the road's benefits to users. Important precedents for this approach to managing roadways exist in the SR-91 Express Lanes in Southern California, the I-15 managed lanes in San Diego, the I-394 managed lanes in Minneapolis, the Katy Freeway managed lanes in Houston, and the I-25 managed lanes in Denver.

A third major Chicago transportation initiative, the CREATE Program, was developed as a multi-agency initiative to identify opportunities for investing in critically needed capital improvements to increase the efficiency of the region's rail infrastructure.[61] A feasibility plan developed in 2005 lists potential projects intended to improve the efficiency and reliability of freight rail service; reduce motorist, passenger rail and freight rail delays; reduce highway and rail traffic congestion; improve rail-highway grade crossing safety in the Chicago region; provide economic benefits; provide environmental benefits; and provide energy benefits.[62] In November 2009, the Illinois DOT submitted a $300-million grant application to fund 16 projects in the CREATE program through the federal government's Transportation Investment Generating Economic Recovery (TIGER) grant program. In February 2010, the U.S. Department of Transportation earmarked $100 million toward a $162-million package of projects that will help relieve freight rail congestion in the Chicago area. These projects will improve traffic control systems, construct a new rail bridge and improve switches, roadways, sidewalks and other aspects of the CREATE program.

While upgrading freight rail operations is important to improve the system's performance, Chicago's lack of adequate road infrastructure (and north-south routes in particular) contributes significantly to rising traffic congestion and lower national economic productivity. TIGER grants were not given to Chicago to build road capacity for passenger cars despite Chicago's high levels of congestion.

Part 6

A Regional Investment Plan for Congestion Relief

Beginning in the fall of 2007, Reason Foundation and its consultant, Booz Allen Hamilton, began a review and assessment of transportation projects that could significantly improve flow and reduce congestion in the Chicago region. The goal was to identify key bottlenecks and inefficiencies in the region's road network, and to propose projects that would significantly reduce congestion and improve productivity for the Chicago area.

This investigation revealed that Chicago's primary obstacle to mobility, and the principal source of regional traffic congestion, was a roadway network poorly suited for the needs of a 21st century economy and metropolis. Fortunately, the region does not have to rebuild its road network from scratch. The essential elements of the road network are in place. Instead, the key challenge is the installation of critical new capacity in the right place at the right time to complete the network, with an emphasis on expressways.

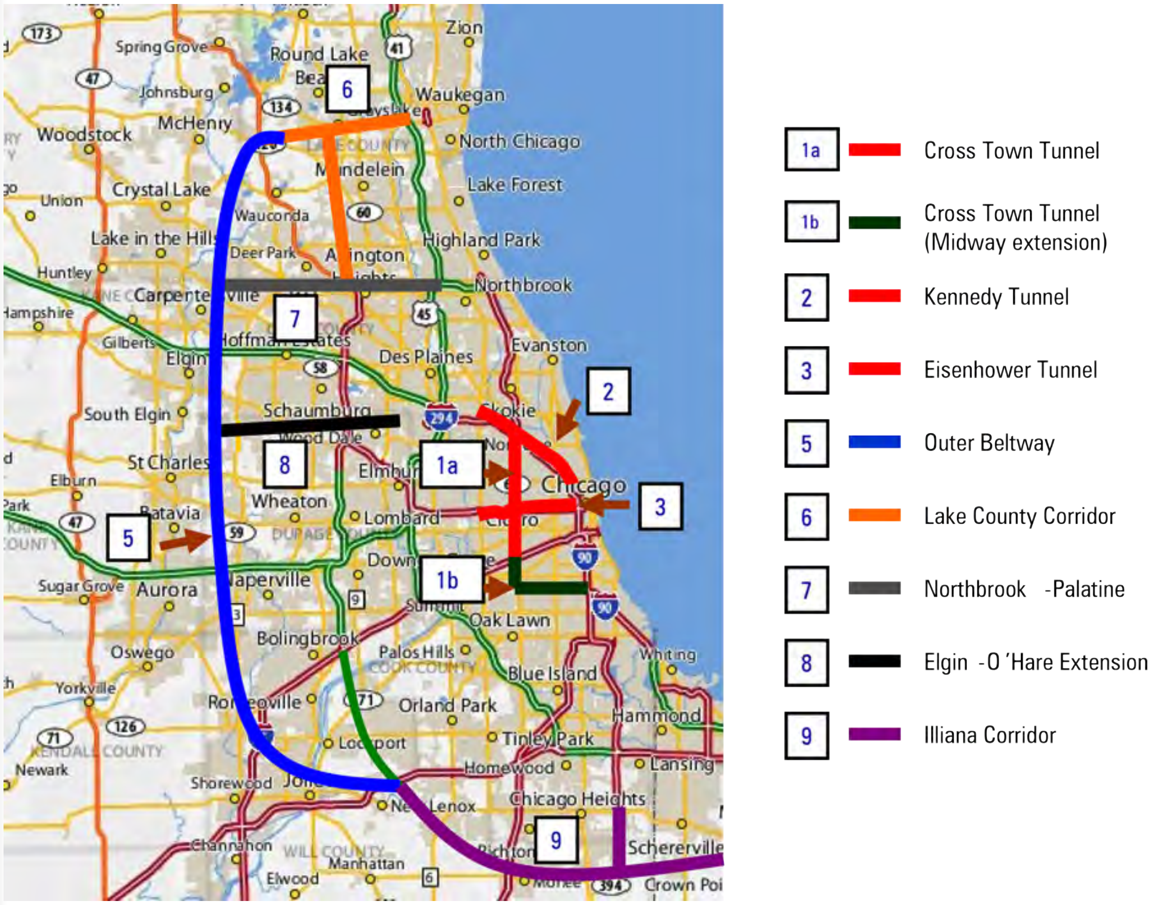
In Chicago, the road network suffers from three significant limitations. First, the region lacks important north-south links that can channel commercial and passenger traffic efficiently. Without these links, congestion is created by concentrating traffic around the downtown. Second, the region has failed to build new road capacity to provide efficient point-to-point access for residents and businesses located in the urbanized western portions of the region. Third, the region has failed incrementally to expand capacity in existing corridors, particularly in northern areas. The result is congestion that ranks among the most severe in the nation.

A. Rationale and Benefits of Key Transportation Projects

Among the key projects the Reason Foundation study team examined were several tunnels. For example, a tunnel paralleling I-90/I-94 to the west of downtown would provide a critical alternate route for regional north-south traffic along the Eisenhower, Kennedy and Stephenson Expressways as well as a more direct link to Midway Airport. Smaller expressway segments connecting to O'Hare Airport, an extension of an existing highway in Lake County north of the city, and a new expressway running east-west along a corridor connecting Palatine and Northbrook (also north of the city) would provide essential relief along this congested corridor. A completely new outer beltway would address travel needs in the western portions of the already urbanized areas. All these projects could be linked through incremental expansion of other roads through a regional network of express tollways.

A review of existing transportation plans and commitments, discussions with transportation experts, and feedback from key stakeholders in the Chicago region identified 11 potential projects (summarized below) that could immediately reduce travel delay and improve the regional road network.[63] Nine of these projects involve the addition of new road capacity (see Figure 13). The estimated cost for building all of these projects approaches $52 billion (in 2010 dollars).

Figure 13: Proposed Chicago Regional Mobility Study Projects 1-3 & 5-9



Source: Reason Foundation and Booz Allen Hamilton. Project 4 : Regional HOT Lane Network, Project 10 : Arterial Queue Jumpers, and Project 11 : Bus Rapid Transit Network are shown as separate exhibits.

Project 1. Cross Town Tunnel

Project #1: Cross Town (Cicero Avenue) Tunnel			
Overview	An 11-mile north-south tunnel (Project 1a) in the alignment of Cicero Avenue between the Kennedy Expressway (I-90/I-94), the Eisenhower Expressway (I-290), and the Stevenson Expressway (I-55). Also, a 9-mile elevated Midway Extension (Project 1b) of the Cross Town Tunnel would run south of I-55 along Cicero Avenue then east along 63rd Street until it connects with the north endpoint of the Chicago Skyway. The tunnel and elevated extension would have two travel lanes in each direction. By diverting north-south regional traffic around the CBD, this project would help alleviate the traffic problems around some of the nation's most debilitating bottlenecks (the Circle and the I-90 Skyway Split). In large part, these projects allow the Chicago region to "connect the dots" to create a network of 2,401 lane-miles of integrated roadway to enable free flow travel throughout the region.		
Rationale	Section 1a of the Cross Town Tunnel will allow through-traffic to bypass the downtown area and provide a North-South connection between I-90/I-94, I-290 and I-55 outside the existing interchanges of I-55 with I-90/I-94 and I-290 with I-90/I-94. The tunnel will also give residents west of downtown Chicago, within the I-294 Loop, easier access to the expressways. Section 1b of the Cross Town Tunnel, or the Midway Extension, will provide a direct connection between the new North-South connection, the Chicago Midway Airport, I-90, and the Chicago Skyway.		
Status	This is a new project, not included in the CMAP RTP.		
Crosstown		**Midway Extension**	
Route Length	11 miles	Route Length	9 miles
Capacity	44 miles	Lane Miles	36 miles
Total Cost	$6.6 billion	Total Cost	$5.4 billion
Cost Per Mile	$150 million	Cost Per Mile	$150 million
Min Toll	$0.19	Min Toll	$0.19
Avg Toll (2040)	$0.47 per mile (am peak)	Avg Toll (2040)	$0.23 (am peak)
Peak Toll (2040)	$0.71 per mile	Peak Toll (2040)	$0.38
Annual Rev (2040)	$134.8 million	Annual Rev (2040)	$35.3 million
Cost Covered by Users	18.9%	Cost Covered by Users	6.0%
Avg Speed	54.9 mph	Avg Speed	55.0 mph

Project 2. Kennedy Tunnel

Project #1: Kennedy Tunnel	
Overview	The Kennedy Tunnel adds two travel lanes in each direction paralleling the current Kennedy Expressway (I-90/I-94) along a northwest-southeast alignment, similar to Elston Ave. The tunnel will have a north terminal point at Nagle Avenue, near Bryn Mawr Avenue, and connect with the Kennedy Expressway. On the south-end terminal point, the tunnel will connect with Chicago Avenue. Intermediate entry/exit points include I-94 and Fullerton Avenue.
Rationale	The Kennedy Tunnel will serve as an express alternative to I-90/I-94. The tunnel will provide a limited-access bypass for traffic to/from the near-north neighborhoods, such as River North, Lincoln Park, Bucktown and Logan Square. The Kennedy Tunnel will also relieve congestion on the Kennedy Expressway.

Project #1: Kennedy Tunnel			
Status	This is a new project identified by the Reason Foundation Mobility Project and not currently included in the CMAP RTP.		
Route Miles	9.8	Minimum Toll	$0.17
Lane Miles	39	Average Toll	$0.27
Total Cost	$5.9 billion	Peak Toll	$0.39
Cost Per Mile	$151.3 million	Avg Travel Speed	54.9 mph
Yr Toll Rev (2040)	$134.8 million		
Cost Covered by Users	9.7%		

Project 3. Eisenhower Tunnel

Project #3: Eisenhower Tunnel			
Overview	The Eisenhower Tunnel would be an east-west link paralleling the current Eisenhower Expressway (I-290). The endpoints of the tunnel would be at Austin Avenue on the west side and at the interchange with the Kennedy/Dan Ryan Expressway (I-90/I-94). Intermediate entry/exit points include Cicero Avenue and Western Avenue. Two travel lanes in each direction are considered.		
Rationale	The Eisenhower Tunnel would serve as an express alternative to the Eisenhower Expressway by adding capacity and reducing the number of ramps, thus relieving congestion off this expressway by diverting through-traffic. The tunnel will provide limited-access bypass for traffic to/from the western suburbs (e.g. Oak Park). This tunnel would also alleviate one of the nation's biggest bottlenecks between exits 13 and 17.		
Status	This is a new project, not included in the CMAP RTP.		
Route Miles	7.3	Min Toll (2040)	$0.0
Lane Miles	29	Avg Toll (2040)	$0.21
Total Cost	$4.4 billion	Peak Toll (2040)	$0.26
Cost Per Mile	$151.7 million	Avg Travel Speed	55.0 mph
Yr Toll Rev (2040)	$29.7 million		
Cost Covered by Users	7.0%		

Project 4: Regional HOT Network

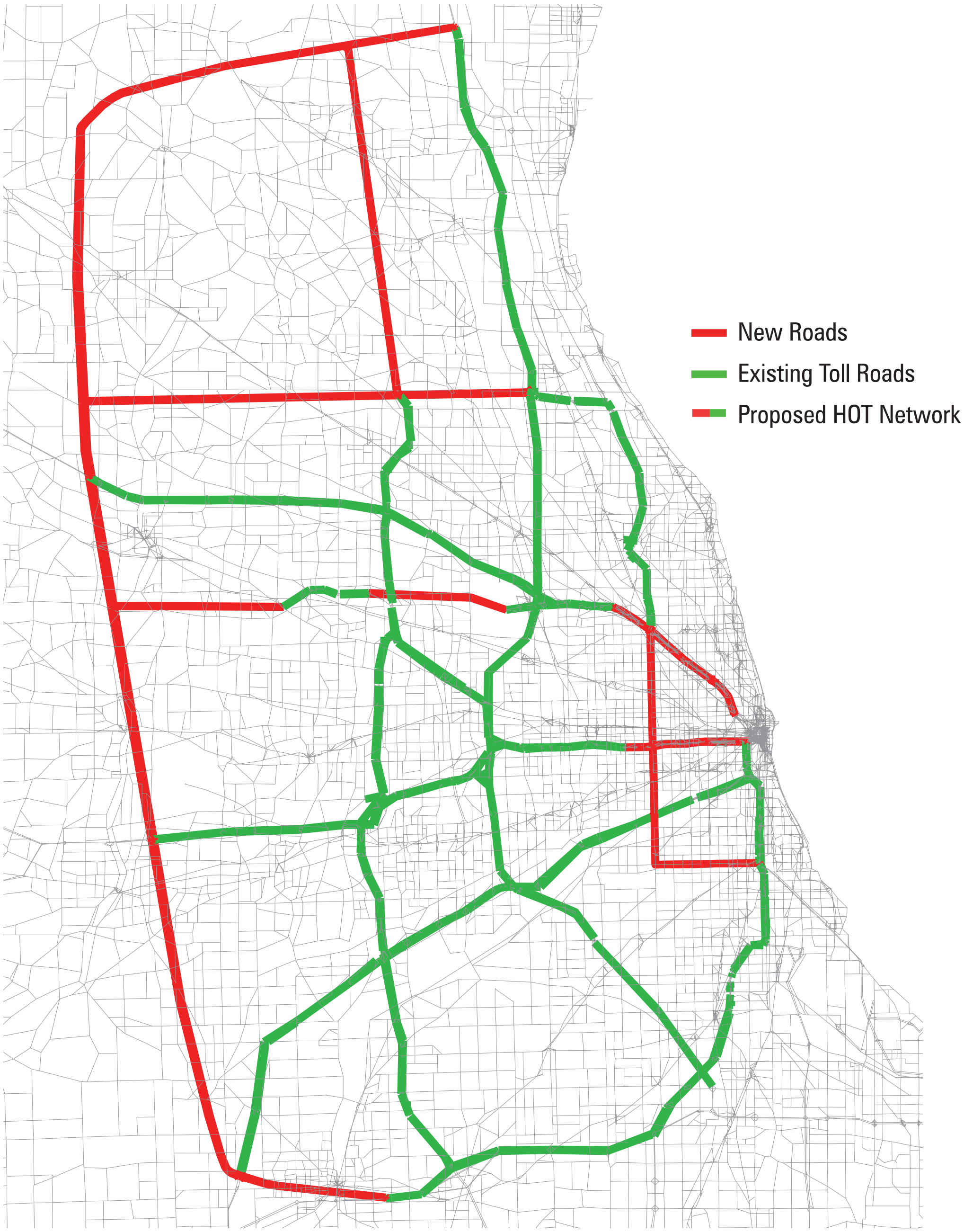
Project #4: Regional HOT Network (Figure 14)	
Overview	This project consists of a network of high-occupancy toll (HOT) lanes throughout the Chicago region, on the following facilities and built within existing rights of way: two lanes added in each direction on I-294 (Tri-State Tollway), I-90 (Northwest Tollway), I-88 (East-West Tollway), and I-355 South of I-88. Toll rates would vary by time of day to ensure HOT lanes would be free-flowing at all times. This project would also add 275 route-miles of roadway capacity in addition to other projects identified in this plan to create a regional managed lane network.
Rationale	The Chicago region is expected to grow from about 8.1 million in the year 2000 to about 10.1 million in the year 2030, resulting in substantial additional travel demand on what is already a highly congested transportation network. A HOT lane network will give Chicago travelers the option to use free-flowing traffic lanes throughout the region at all times of the day, improve overall system efficiency by increasing total vehicle throughput, generate much-needed transportation revenue, and facilitate the provision of BRT service by allowing buses to operate at free-flow speeds. CMAP and other transportation stakeholders in the Chicago region recognize the need to add lanes to existing freeways in order to relieve existing and projected congestion levels. Depending on

Project #4: Regional HOT Network (Figure 14)			
	the magnitude of congestion on a particular facility, the HOT lane would either be a conversion of an existing lane or construction of a new lane. On Illinois DOT facilities within and near Chicago's central business district, it is possible that the construction of two new HOT lanes in each direction would be required in order to clear recurring LOS E/LOS F conditions in the year 2040. Toll rates would vary by time of day to ensure HOT lanes would be free-flowing at all times. Another important component of this project is the introduction of a regional network of Bus Rapid Transit (BRT) services that will use the HOT lane network for higher speed travel. The BRT project is described to follow as Project 11.		
Status	The regional HOT network proposed in this memo would build on existing expansion plans for the Illinois Tollway, possibly including additional Tollway facility segments while extending the concept to include existing freeways currently maintained by the Illinois DOT. For Illinois DOT facilities, the primary difference from Tollway facilities is that the general purpose lanes adjacent to the HOT lane would be free, as opposed to having a flat-rate toll.		
Route Miles	275	Min Toll (2040)	$0.64
Lane Miles	1100	Avg Toll (2040)	$0.98
Total Cost	$11.1 billion	Peak Toll (2040)	$1.19
Cost Per Mile	$10.1 million	Avg Travel Speed	55.0 mph
Yr Toll Rev	$3.4 billion		
Cost Covered by Users	320%		

Project 5: Outer Beltway

Project #5: Outer Beltway			
Overview	This project consists of a new limited access highway that provides an outer expressway through Cook, DuPage and Will Counties. There would be three value-priced toll lanes in each direction using right-of-way adjacent to existing railroad lines.		
Rationale	Suburb-to-suburb travel in the Chicago region will increase significantly going forward. This project provides a much-needed alternate north-south route that avoids key regional traffic bottlenecks at or near downtown, including the Circle, the Skyway Split, the Eisenhower Expressway and at the I-355 interchange. The Outer Beltway will greatly facilitate travel by providing a non-radial expressway in suburban Chicago already experiencing growth, connecting numerous communities and enhancing access to many current and emerging employment centers.		
Status	The CMAP RTP contains the Suburban Transit Access Route (STAR Line) commuter rail service in the same alignment as the proposed Outer Beltway. While rail service is successful in bringing travelers radially between suburbs and downtown areas, including in Chicago, its effectiveness in handling circumferential suburb-to-suburb travel is less likely given the more dispersed nature of trip ends. An Outer Beltway as a roadway project is more likely to provide travelers with the flexibility to go directly between their origin and destination, without the need to make transfers between transit vehicles.		
Route Miles	76.3	Min Toll (2040)	$0.19
Lane Miles	458	Avg Toll (2040)	$0.82
Total Cost	$4.6 billion	Peak Toll (2040)	$1.02
Cost Per Mile	$10.0 million	Avg Travel Speed	65.0 mph
Yr Toll Rev (2040)	$737.4 million		
Cost Covered by Users	166.7%		

Figure 14: Proposed Project 4: Regional HOT Network



Note: Red lines represent new roads; Green lines represent existing roads.
Red + Green lines represent the proposed HOT Network.

Project 6: Lake County Corridor

Project #6: Lake County Corridor			
Overview	The Lake County Corridor is an expressway connecting the proposed Outer Beltway with I-94. An expressway extension of SR 53 from its current north terminus at Lake-Cook Road in Palatine would continue northwest through Lake County connecting to the corridor. There would be three value-priced toll lanes in each direction.		
Rationale	Lake County and eastern McHenry County are experiencing rapid population and employment growth. The SR 53 extension will serve these areas effectively. The SR 53 extension would also have an eastern spur that connects with I-94 near Waukegan.		
Status	This project is similar to the McHenry-Lake Corridor (also referred to as the Richmond-Waukegan Corridor) and the Central Lake County Corridor projects as described in the CMAP RTP. The alignment and endpoints are different, with the SR 53 extension connecting with a proposed Outer Beltway.		
Route Miles	32.3	Minimum Toll (2040)	$0.20
Lane Miles	194	Avg Toll (2040)	$0.77
Total Cost	$1.9 billion	Peak Toll (2040)	$0.78
Cost Per Mile	$9.8 million	Avg Travel Speed (current)	65.0 mph
Annual Toll Rev	$199.7 million		
Cost Covered by Users	109.3%		

Project 7: Northwest-Palatine Connector

Project #7: Northwest-Palatine Connector			
Overview	The Northwest-Palatine Connector is an expressway running east-west between the I-94/I-294 interchange in Northbrook and the proposed Outer Beltway in Barrington. There would be three value-priced toll lanes in each direction.		
Rationale	The Northwest-Palatine Connector will serve rapidly growing communities in the northern Chicago region, including Northbrook, Wheeling, Palatine and Barrington. The project is also expected to relieve congestion at the I-94/I-294 interchange, one of the most congested in the country.		
Status	This is a new project identified through the Reason Mobility Project and not included in the CMAP RTP.		
Route Miles	25.3	Min Toll	$0.18
Lane Miles	152	Avg Toll (2040)	$0.75
Total Cost	$1.5 billion	Peak Toll (2040)	$0.76
Cost Per Mile	$9.9 million	Avg Travel Speed (current)	65 mph
Annual Toll Rev (2040)	$118.8 million		
Cost Covered by Users	82.3%		

Project 8: Elgin-O’Hare Extension

Project #8: Elgin-O’Hare Extension	
Overview	The Elgin-O’Hare Extension is an extension of the existing Elgin-O’Hare Expressway in two directions. The eastern portion of the project would be a tunnel in Elk Grove Village between the current eastern terminus at I-290 and O’Hare International Airport. The western portion of the project would extend the expressway from its current western terminus at US 20 in Hanover Park to the proposed Outer Beltway in Bartlett. There would be three value-priced toll lanes in each direction.

Project #8: Elgin-O'Hare Extension			
Rationale	The O'Hare International Airport is a major employer and regional destination, with accessibility issues from west of the airport. Northwest Cook County and northern DuPage County are among the most rapidly growing employment areas in the region. The Elgin O'Hare Expressway Extension will provide much-needed expressway capacity in this region.		
Status	This project is similar to the Elgin-O'Hare Expressway Expansion as described in the CMAP RTP. The alignment and endpoints are different, with this project connecting directly with the O'Hare International Airport and with a proposed Outer Beltway.		
Route Miles	17.3	Min Toll	$0.58 per mile
Lane Miles	104	Avg Toll	$0.77 per mile
Total Cost	$1.0 billion	Peak Toll	$0.85 per mile
Cost Per Mile	$9.6 million	Avg Travel Speed	61.9 mph
Annual Toll Rev	$312.4 million		
Cost Covered by Users	324.8%		

Project 9: Illiana Corridor

Project #9: Illiana Corridor			
Overview	The Illiana Corridor is an extension of I-355 from its current south terminus at I-57 to the Indiana State Line. There would be three value-priced toll lanes in each direction, possibly with one lane per direction as a truck-only toll lane. This project also includes an extension of IL 394 south to the new corridor.		
Rationale	The Illiana Corridor provides a logical continuation of the I-355 expressway to the state of Indiana. The Illiana will facilitate travel in northern Will County, and provide trucks going between factories/warehouses in the Chicago area and regions east of Chicago an alternate route to I-90 and I-94.		
Status	This project has broad support from regional organizations. It is included in the CMAP RTP as two separate projects: the I-57/IL394 Connector and the Illiana Corridor. In 2010, the governors of Illinois and Indiana agreed to an overall framework for funding this project using a public-private partnership and tolling if the financial commitments to build the highway could be secured.		
Route Miles	40.8	Min Toll (2040)	$0.18 per mile
Lane Miles	245	Avg Toll (2040)	$0.72 per mile
Total Cost	$2.4 billion	Peak Toll (2040)	$0.72 per mile
Cost Per Mile	$9.8 million	Avg Travel Speed	64.4 mph
Annual Toll Rev (2040)	$124.6 million		
Cost Covered by Users	54.0%		

Project 10: Arterial Queue Jumpers

Project #10: Arterial Queue Jumpers (Figures 15 & 16)	
Overview	This project consists of 54 queue jumpers at selected major arterial intersections throughout the Chicago region shown in Figure 16. Each queue jumper consists of grade separations that involve "jumping" one lane of travel for each roadway in each direction over the intersection, bypassing the need for vehicles to stop at the intersection (Figure 15). One arterial uses an overpass for the queue jumper; the other arterial uses an underpass for the queue jumper. Unpriced queue jumpers are common in U.S. cities and elswhere, and examples include Dupont Circle in Washington, D.C. and the Allen Expressway in Houston. Queue jumpers with road pricing have been implemented in Lee County (Fort Meyers/Sarasota), Florida and are a significant part of a recent proposal to eliminate congestion in that region.[64]
Rationale	The Chicago region has significant congestion on its arterials. Queue jumpers will reduce much of this congestion by separating north-south traffic from east-west traffic at select major intersections, effectively acting as a grade separation.
Status	This is a new project, not included in the CMAP RTP.

Figure 15: Typical Arterial Queue Jumper Concept

Figure 16: Proposed Project 10: Arterial Queue Jumpers

Source: Reason Foundation and Illinois Institute of Technology.

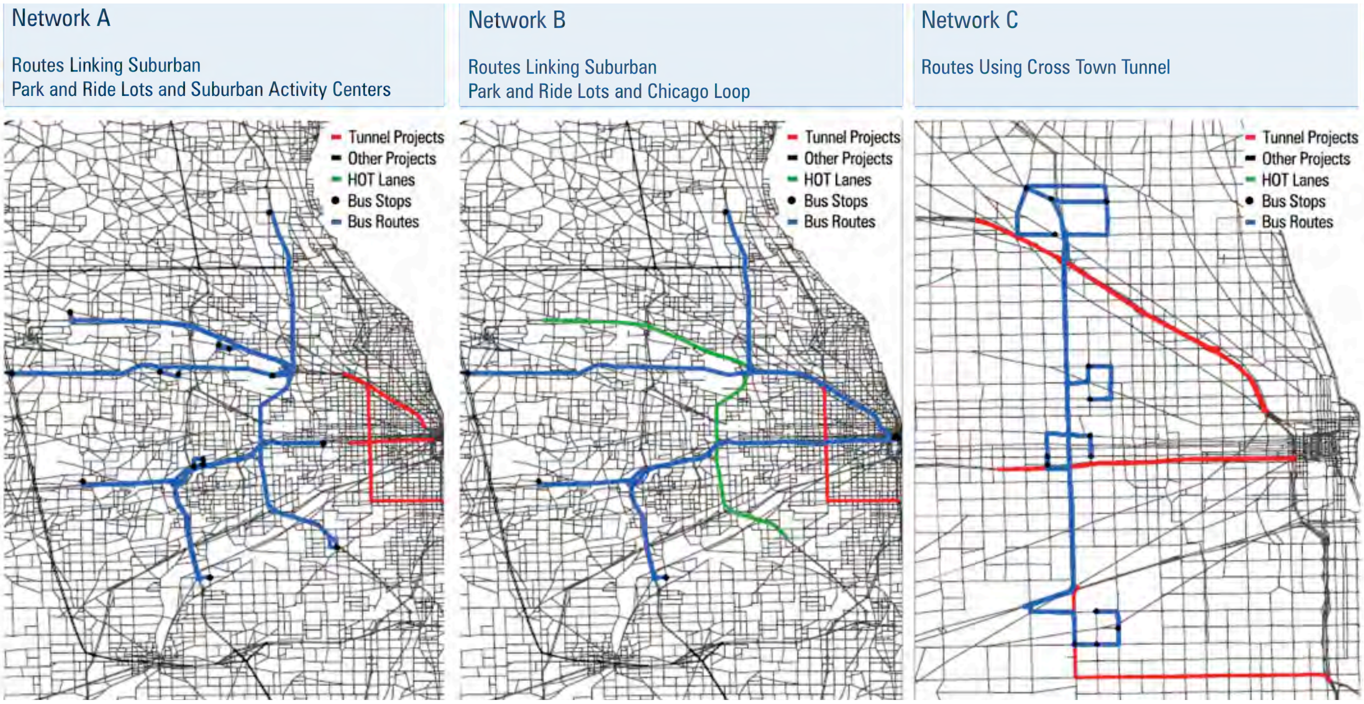
Project 11: Bus Rapid Transit Network

Project #11: Bus Rapid Transit Network	
Overview	This project consists of a Bus Rapid Transit (BRT) system for the Chicago region. A network of new BRT services would utilize the HOT lanes contained in Project 4 to provide express bus alternatives to automobile travel. The report examines potential ridership using three different BRT networks: one linking park-and-ride lots with major suburban activity centers (A), a second linking park-and-ride lots to the downtown Loop (B), and a third paralleling the Cross Town Tunnel. This BRT network consists of three types of services: 1. Category 1: Routes linking suburban park-and-ride lots to suburban activity centers and outer CTA rail stations. 2. Category 2: Routes linking suburban park-and-ride lots to suburban activity centers and to the Chicago Loop. 3. Category 3: Routes using the Cross Town Tunnel. These BRT routes are intended to minimize travel time and the number of transfers required between key origins and destinations. For the first two BRT route categories, each route includes a suburban park-and-ride lot location at the outer edge of the Regional HOT lane network so that travelers can park at the lot and use the BRT service. Each route would then traverse the regional HOT network. For Category 1, routes would exit and re-enter the network at select locations to serve local activity centers, then continue and provide feeder service to/from an outer CTA rail station. For Category 2, routes would continue non-stop until reaching the Chicago Loop. For Category 3, routes are designed specifically to serve activity centers near the Cross Town Tunnel and utilize the tunnel to achieve free flow speeds. Service parameters for each route are as follows: ▪ Fifteen-minute peak-period headways. ▪ Travel times similar to the automobile, plus four minutes per stop. ▪ Distance-based fare structure similar to Metro commuter rail fares.
Rationale	BRT services work well in conjunction with a managed lane network, as the BRT services can leverage the managed lanes to allow for free flow travel speeds to riders over long distances. BRT services can be implemented at a lower capital cost than rail services and also provide flexibility: new BRT services can be added and route alignments can be adjusted on an as-needed basis.
Status	This is a new project, not included in the CMAP RTP. The CMAP RTP does include several BRT projects, but they have different route alignments from those described in this report.

Combined, the new road capacity projects would provide 504 route-miles of new limited access highways and 2,401 lane miles of new capacity by 2040 (Table 7). These projects would go a long way toward moving the region out of severely congested conditions and adding the strategically critical capacity needed to ensure free flow travel (as part of a Phase II). (Of course, as mentioned earlier, capacity improvements are necessary, but not a sufficient condition for attaining free flow travel. Significant investments in ITS technologies will be essential for attaining the free flow travel conditions that will optimize system performance in terms of speed and increased productivity.)

The HOT Network understandably accounts for the largest share of lane-miles in the new project because of its comprehensiveness on a regional scale (Figure 18). Two new lanes of capacity in each direction would be added on each major highway, knitting the entire six-county Chicago region together with roadways that guarantee a free flow travel option. The Outer Beltway captures the next largest share of lane-miles, reflecting its arcing north-south design that links growing outer suburbs while providing a free flow link around the city of Chicago, bypassing some of the nation's most crippling traffic bottlenecks. All the other projects are significantly smaller in scope in terms of physical capacity, although they provide strategically important investments.

Figure 17: Proposed Bus Rapid Transit Network



Network A

Routes Linking Suburban
Park and Ride Lots and Suburban Activity Centers

Network B

Routes Linking Suburban
Park and Ride Lots and Chicago Loop

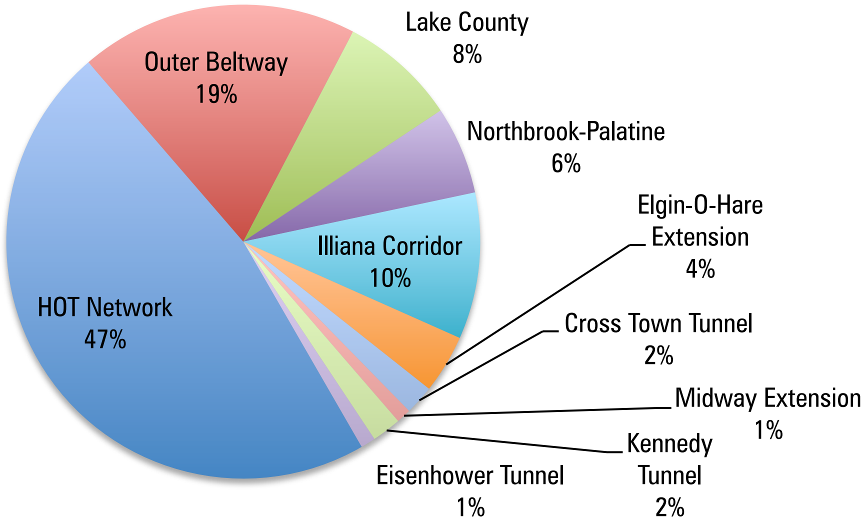
Network C

Routes Using Cross Town Tunnel

Table 7: Summary of Proposed New Capacity

	Project	Miles	Lanes in Each Direction	Lane Miles
1a	Cross Town Tunnel	11.0	2	44
1b	Midway Extension	9.0	2	36
2	Kennedy Tunnel	9.8	2	39
3	Eisenhower Tunnel	7.3	2	29
4	HOT Lanes	275.0	2	1,100
5	Outer Beltway	76.3	3	458
6	Lake County Corridor	32.3	3	194
7	Northbrook-Palatine	25.3	3	152
8	Elgin-O'Hare Extension	17.3	3	104
9	Illiana Corridor	40.8	3	245
	Total	504.1		2,401

Figure 18: Distribution of Lane-Miles on Proposed Projects: Total Lane-Miles Added by Major Project



Potential Benefits of Tunnels as Alternatives to Surface Roads

When assessing tunnel project costs relative to tunnel project benefits (including mobility, reliability, air quality and economic productivity), additional hard-to-quantify benefits specific to tunnels include:

- *Reduced need to relocate existing homes, businesses and other land uses.* In downtown areas such as Chicago, the costs and impacts associated with relocation for an at-grade or elevated construction project could be prohibitive.
- *Less disruption during construction to surface street traffic conditions and area businesses.* The construction of at-grade or elevated projects may result in traffic flow disruption and loss of economic activity that is valued in the billions, depending on the project's scope. By contrast, tunnel projects may avoid much of this disruption since most construction activities take place underground.
- *Less noise and pollution.* With tunnel projects, the noise and pollution impacts to residents and businesses in the local community can be mitigated relative to an at-grade or elevated project.
- *Aesthetic and property value considerations.* Tunnel projects are not as visible to residents, employees and visitors of a community as at-grade or elevated projects. This has aesthetic benefits, as well as property value benefits (an at-grade or elevated project is likely to negatively impact property values in the surrounding area).
- *Potentially lower ongoing operations and maintenance expenses*, due to tunnels having less weather exposure.

These additional factors should be taken into account when conducting a cost-benefit analysis of tunnel projects relative to other transportation options. A full life-cycle evaluation of costs and benefits, based on the project construction phase through project opening and continuing through project operations and maintenance in future years, will likely yield different conclusions than an evaluation based only on a single phase.

B. The Role of Congestion Pricing

All newly constructed lanes on these new facilities would be tolled using off-the-shelf technology to ensure free flow travel at all times of the day. Tolls would be calibrated based on rates necessary to maximize travel speed and reliability (not revenue). Combined with queue jumpers at key intersections and ITS improvements on arterials, these capacity additions would achieve the goal of eliminating LOS F and LOS E conditions in the Chicago region by 2040, even with anticipated population growth and real (inflation-adjusted) increases in income. Implementing these projects would represent a huge, one-time catch-up to better match the system's capacity to the growth in population and travel over the past several decades. More modest additions to the network would be required after 2040 to move on to a more aggressive congestion-reduction goal.

Moreover, congestion pricing *reduces* the need for future investments in the road network. An analysis of Chicago's roadway capacity in 2006 found that the urbanized area would need to add 3,800 new lane-miles by 2030 to eliminate severe congestion (LOS F) on the region's road network.[65] The transportation modeling used to generate this estimate did not include road pricing and assumed congestion reduction policies would follow less sophisticated approaches such as simply laying more asphalt and pavement that would literally build the region out of congestion.

Congestion pricing, in contrast, optimizes the use of existing and new capacity, implicitly encourages alternate travel options (e.g., walking and public transit) and otherwise influences travel behavior by making the costs of using roads more transparent. An important experiment undertaken in Oregon found that simply providing automobile users with real-time information about the costs of travel reduced travel by more than 10%.[66] Based on estimates with the MRTM, road pricing reduces the financial investment necessary to eliminate severely congested conditions, in this case by 1,400 lane-miles (or 36.8%).

The next section provides a more complete explanation of the potential travel benefits of these projects based on estimates and forecasts from the MRTM model.

Part 7

Travel Benefits of Roadway Congestion Relief

If the Chicago region is to accommodate the addition of well over one million more people by 2030, including over 350,000 in the city itself, it is essential that sufficient and appropriate infrastructure is built.[67] With a population of 10 million, the six-county Northeast Illinois region will be a global megacity in just 20 years. The key question is whether the 11 projects identified in the previous section would significantly improve traffic flow and reduce congestion in a meaningful way. This section evaluates that question based on computer models and simulations of the regional economy.

A. Methodology for Estimating Travel Benefits

The Metropolis/Reason Transportation Model of the Chicago region (MRTM) represents an enhancement to the original Metropolitan Transportation Model (MTM) developed in the 1990s by the transportation consulting firm Smart Mobilty for Chicago Metropolis 2020. The innovative features of this transportation model include methods for capturing the impacts of changing demographics, land use, transit and roadway projects on travel demand (VMT), hours of delay and hours of travel. The model also has the advantage of allowing for analyzing the effects of road pricing on regional mobility, congestion and revenue generation for financing projects. A more detailed description of Smart Mobility's model is contained in Appendix D.

The original MTM was developed by Metropolis 2020, a nonprofit organization focused on the business competitiveness of the Chicago area, to evaluate different transportation scenarios for its report: *The Metropolis Plan*: *Choices for the Chicago Region.*[68] The MTM is noteworthy because it includes features that are more sensitive to urban form than traditional transportation models. For example, in MTM, auto ownership depends in part on residential density and transit service. MTM also included a walk trip model that responds to residential density, employment density and the balance between jobs and housing. These features are particularly important for the Chicago region because of the unusual (for the U.S.) economic strength of the Chicago CBD and projections that the city of Chicago is expected to capture an even larger share of population and household growth (although not employment growth) for Cook County through 2030. Land uses inside and close to the city typically have higher densities and a greater mix of uses supporting both walking and transit than do outlying cities and urbanizing areas. Thus, MTM's ability to capture mode choice (auto versus transit) based on urban form variables is particularly helpful.

In addition to urban form, MTM was enhanced by freight modeling capability when Metropolis 2020 developed the *Metropolis Freight Plan*.[69] The key enhancements added at this stage included splitting weekday travel into four periods and modeling car travel and truck travel separately using a multi-class assignment process. A transit analysis for the Regional Transit Authority added capabilities for income stratification for work trips, improved transit travel times and new mode choice coefficients (estimates) for improved sensitivity to transit service variables such as transit travel time and fares.

For the current analysis, Reason Foundation added three additional features to MTM to create what is now referred to as the Metropolis/Reason Transportation Model (MRTM):

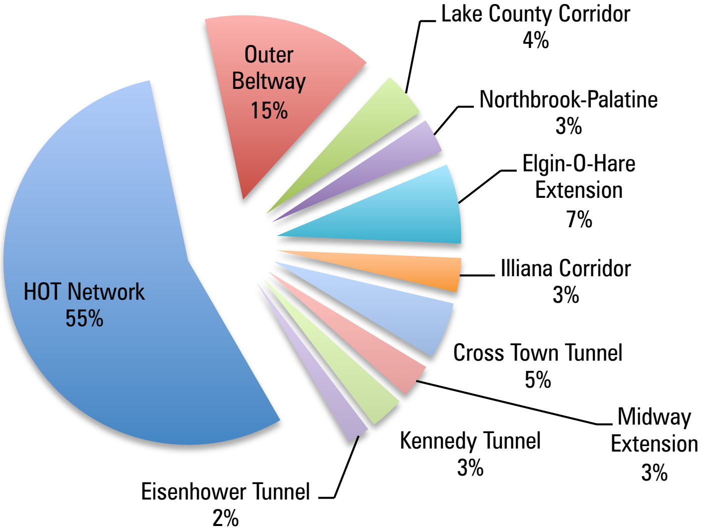
- *Dynamic pricing internal to model*. MRTM now dynamically calculates tolls for each directed link for each time period with the goal of achieving free flow travel at posted highway speeds. In the case of these projects, the tunnels (Cross Town, Midway Extension, Eisenhower and Kennedy) were posted at 55 miles per hour while the HOT Network, Outer Beltway and other expressways were posted at 65 miles per hour.
- *Addition of time periods for dynamic tolling*. While the initial transportation model included four time periods—off peak, morning rush, mid-day off peak, and afternoon rush—the new model expands to include "shoulder" periods. Shoulder periods are times of the day where travel is heavier than off peak periods, such as early morning or late evening, but not heavy enough to qualify as peak. The new time periods were:
  - Early: midnight to 5 a.m. (5 hours).
  - Morning shoulder: 5 a.m. to 6 a.m. and 9 a.m. to 10 a.m. (2 hours).
  - Morning peak: 6 a.m. to 9 a.m. (3 hours).
  - Mid-day: 10 a.m. to 2 p.m. (4 hours).
  - Afternoon shoulder: 2 p.m. to 3 p.m. and 6 p.m. to 8 p.m. (3 hours).
  - Afternoon peak: 3 p.m. to 6 p.m. (3 hours).
  - Late evening: 8 p.m. to midnight (4 hours).
- *Multi-class assignment by income group*. In the prior model version, the different income groups exhibited different behavior when deciding what to do (trip distribution) and what mode to use (mode choice). In this version, the income groups also behave differently when choosing routes on the road network (assignment). Higher income workers have higher values of time and are more likely in the model to choose tolled roadways.

MRTM was applied to develop estimated travel benefits and costs for the projects described below. Detailed tables for traffic volume and toll revenue for each time period for the six-county region, Cook County and the city of Chicago are in Appendix B. Importantly, the numbers show totals for each time period, recognizing that the time periods are of different lengths. As such, in some cases, traffic volumes are higher for the mid-day period, which includes four hours, than for the morning or afternoon peak periods, which each include three hours.

B. Impacts of New Capacity on Travel Delay and Congestion

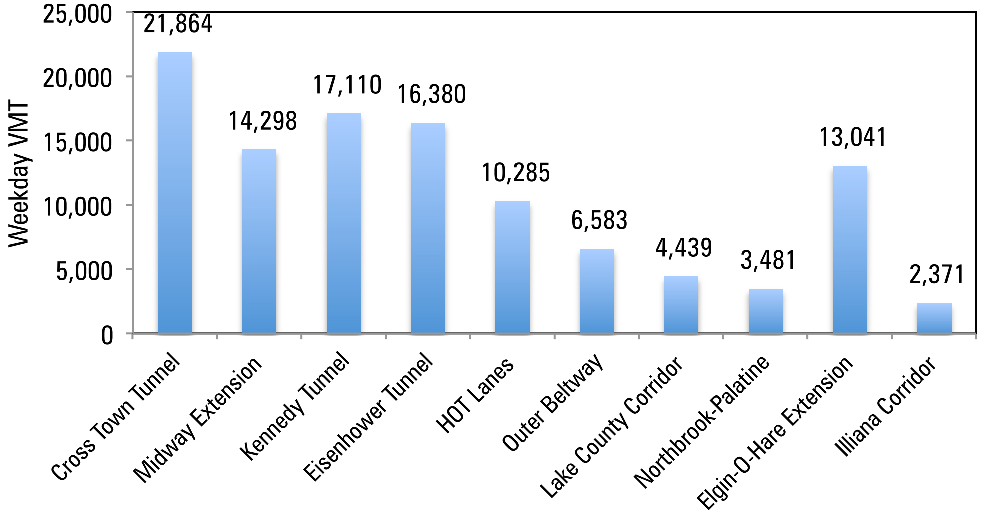
If all nine expressway road projects are built, the new network will accomodate 20.6 million vehicle miles traveled in 2040. This represents 8.6% of the total travel demand for the six-county core region that includes Cook, DuPage, Kane, Lake, McHenry and Will Counties in 2040. More than half, 55%, of the future network's travel demand will be on the HOT Lanes even though they provide only 47% of the new road capacity (Figure 19). The Outer Beltway is expected to accommodate 15% of the travel demand on the system although it accounts for 19% of the new capacity. Notably, the Cross Town Tunnel and the Midway Extension provide just 3% of the new capacity but are expected to accommodate 8% of the travel demand on the new system.

Figure 19: Distribution of Travel Demand in 2040



Perhaps not surprisingly, the Cross Town Tunnel is expected to experience the greatest traffic intensity by 2040 (Figure 20) of all the projects recommended. An average weekday is projected to handle 21,864 vehicle miles traveled per lane-mile in this tunnel. The proposed Kennedy and Eisenhower tunnels have similarly high levels of use, although the volume of travel demand more closely corresponds to their share of the new capacity to the system. The elevated Midway Extension is expected to accommodate 14,298 vehicle miles traveled per lane-mile, a level of traffic intensity similar to the relatively short but apparently heavily used Elgin-O'Hare Extension.

Figure 20: Traffic Volume Per Lane-Mile by Project in 2040

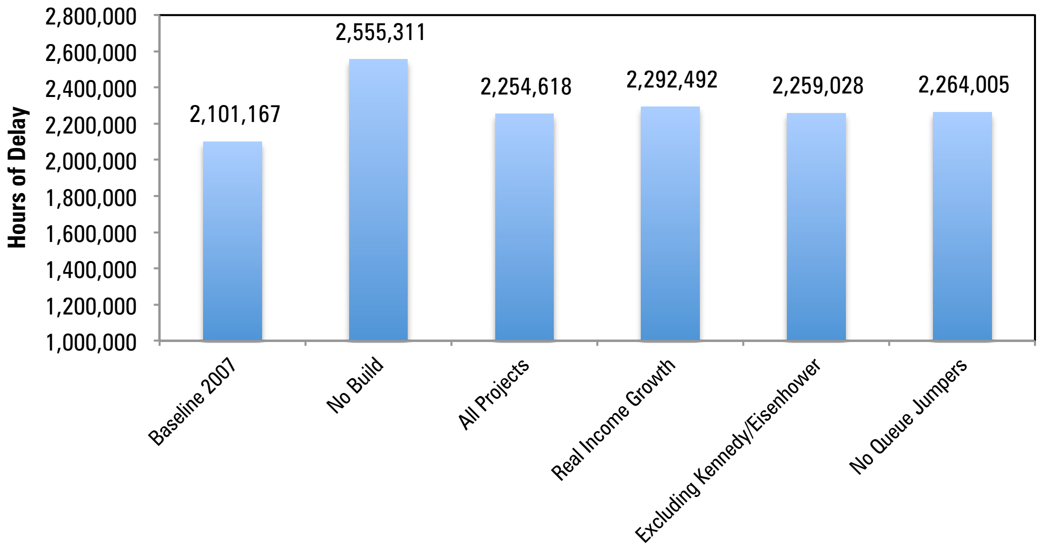


If the Chicago region does nothing to accommodate projected population and employment growth, the amount of travel delay experienced by residents and workers in their cars, trucks and other vehicles is projected to reach 2.56 million hours each weekday by 2040—450,000 more hours of delay than currently experienced by the region (Figure 21). Building all 11 projects (including bus rapid transit and queue jumpers) is expected to reduce average weekday travel time by 11% to 2.25 million hours (Figure 21). Even with these projects, travel delay increases through the region by about 7% as population increases by 24% and the addition of 728,907 new households. While the rate of growth has slowed, congestion does not fall in absolute levels (more on this in the following section of this report).

Nevertheless, *these projects ensure free flow access throughout the Chicago region* at posted speed limts (or more) by creating a virtual HOT network of managed lanes priced to maintain posted speed limits. Most of the improved travel time will be on the expressways. The delay, similar to current conditions, will be felt largely on the unpriced portions of the road network (an inevitable consequence of providing unrestricted and free access to roads). Nevertheless, arterial travel times should improve since the improved expressway capacity will divert or absorb some trips that otherwise would have added to local road congestion.

To evaluate the robustness of this outcome, this study evaluated the effects of alternate scenarios on travel delay (a measure of congestion) and total amount of time spent traveling. The most basic comparison was between the "no build" scenario where nothing is done to improve the network and a scenario where all projects were built. Since the MRTM allows for travel behavior to vary based on changes in income, we also examined the effects of higher average household incomes on trip choice and behavior. Generally, rising income increases the demand for travel. This effect is evident in our results since the vehicle hours of delay increase somewhat when incomes rose. Figure 21 shows the difference the projects make. Compared to baseline 2007 congestion, the no build scenario results in considerably worse congestion. Excluding some of the projects results in more congestion than if all are built.

Figure 21: Effects of New Capacity on Travel Delay in 2040: Chicago Region

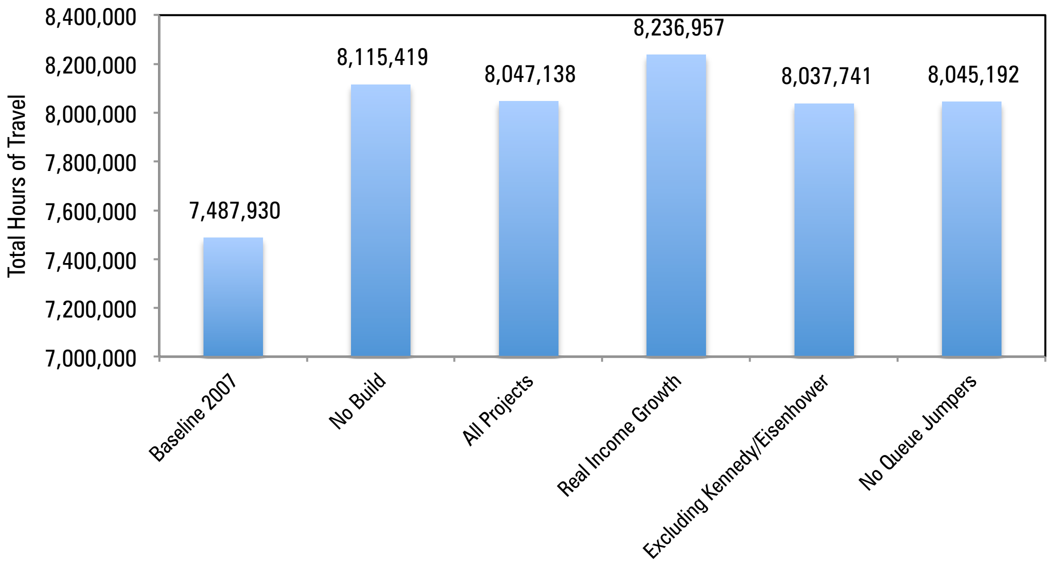


Another scenario excluded the Eisenhower and Kennedy tunnels. Although traffic intensity in these tunnels is relatively high compared to the other projects (see Figure 20), they are expensive and carry just 3% of the region's travel. While delay is higher, the effect on regional delay is minor.

A third alternative excluded the arterial queue jumpers. Delay increased somewhat, but the effect was small. This is not altogether unsurprising since the queue jumpers by nature are very localized in their impacts. They represent improvements in intersections for major roads. Moreover, Chicago's most serious congestion appears to be concentrated on its expressways in major corridors without significant north-south connectivity. Thus, any positive impacts from queue jumpers may be overwhelmed by other factors such as population and income growth making any improvements in circulation among specific intersections difficult to estimate or detect. We believe queue jumpers warrant further analysis to more fully understand their impacts on local traffic flow as well as regional patterns.

When the effects of the projects are evaluated according to the total number of hours spent on the road by Chicago residents, the results vary more significantly. Building all nine projects and the HOT network reduces the amount of time traveling overall compared the "no build" scenario (Figure 22). This results from both an increase in the speed of traveling to destinations as well as the reduction in the number of trips (or overall travel). Rising real incomes, however, are likely to increase travel times (although the speed of travel can be maintained). Excluding the tunnels or queue jumpers from the transportation plan appears to have little impact on the amount of time Chicago area residents spend traveling. Total time traveling is about 10% higher than current levels, a result of the continued existence of delay as well as more vehicle miles traveled enabled by higher incomes and the mobility provided in a more extensive road network.

Figure 22: Effects of New Capacity on Average Weekday Travel in 2040: Chicago Region



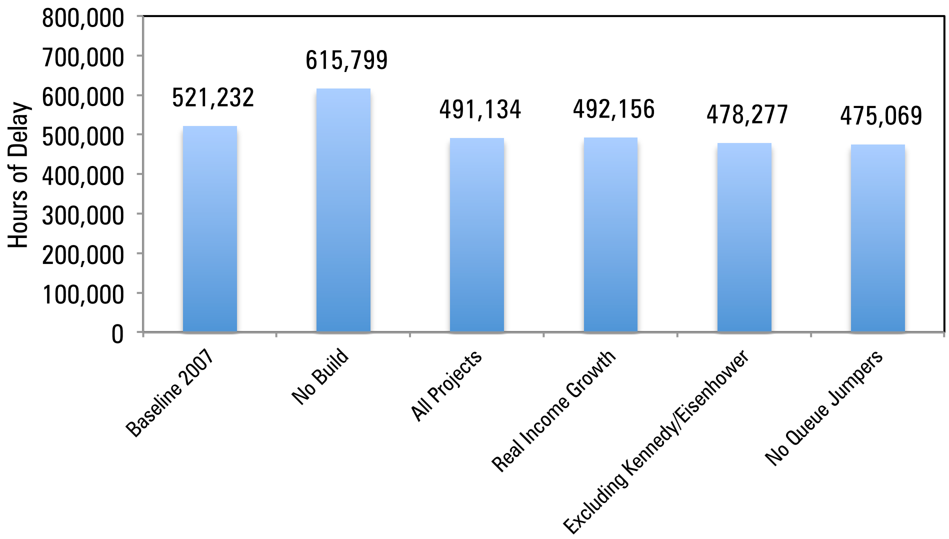
C. Effects on the City of Chicago

Notably, the *city* of Chicago benefits significantly from regional investments in road capacity even though many of the proposed projects are physically located outside its boundaries. City travelers can expect to experience a surprising 20.2% reduction in the hours of travel delay in 2040 if the network is built out as this study proposes compared to the “no build” scenario (Figure 23). Moreover, *delay is reduced in absolute levels* as congestion is relieved around the CBD and Loop. In effect, the new Outer Beltway, HOT lanes and tunnels inside the city redirect passenger and commercial through-traffic onto north-south routes away from the city center, relieving pressure on key bottlenecks and dramatically improving travel speeds and flow.

The benefits to the city are robust even as regional income rises. The effect of excluding the Kennedy and Eisenhower tunnels is noteworthy since this appears to reinforce the critical role of the Cross Town Tunnel, the Midway Extension, and maintaining a network of free flowing managed lanes throughout the region to improve circulation and traffic flow.

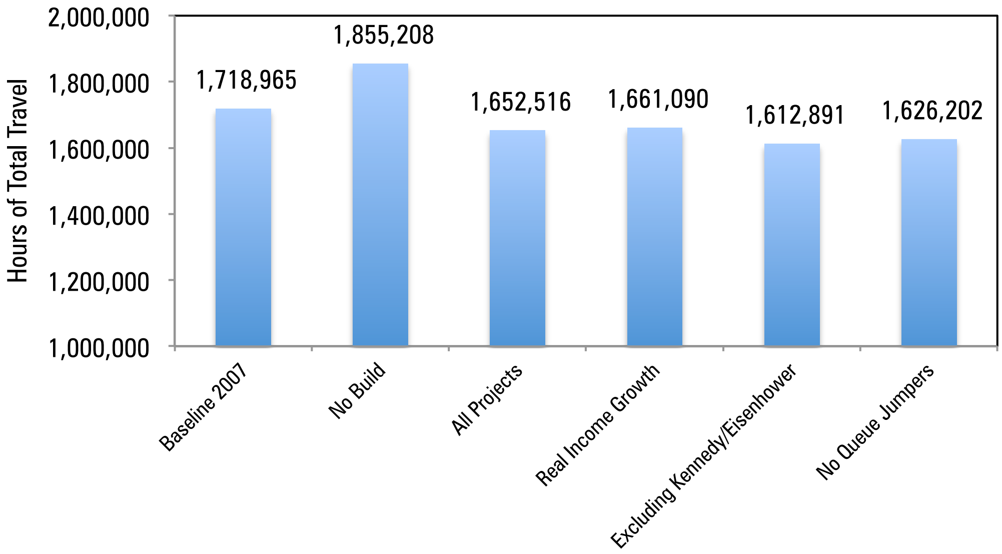
Excluding the queue jumpers appears to slightly increase delay for the city. Without queue jumpers, the amount of delay experienced by city travelers increases by an additional 16,000 vehicle hours. Delay falls from 491,134 hours with all projects to 475,069 when the queue jumpers are excluded. Again, we believe this result is most likely an artifact of the highly localized nature of the impacts by queue jumpers on arterial intersections.

Figure 23: Effects of New Capacity on Weekday Travel Delay in 2040: City of Chicago



The effects on total hours traveling by city residents are more uniform. Average weekday travel for residents and workers in the city of Chicago is expected to fall by 200,000 hours by 2040 if the projects are built compared to the No Build scenario (Figure 24). This reduction is strikingly consistent regardless of whether incomes increase, the Eisenhower and Kennedy tunnels are excluded from the project, or queue jumpers are excluded.

Figure 24: Effects of New Capacity on Weekday Traveling in 2040: City of Chicago



D. Bus Rapid Transit

A robust network of HOT lanes ensuring free flow speeds through the region provides an opportunity to enhance public transit services on a regional level. Earlier work by Reason Foundation found that the high-speed corridors create "virtual exclusive busways" (VEB) and opportunities for high-speed or express bus services that could effectively compete with the automobile on speed and reliability.[70]

The MRTM travel demand model has enhanced features well suited for evaluating public transit ridership and impacts based on travel patterns, demographics, income and land use. Thus, Reason Foundation's transportation plan includes a Bus Rapid Transit (BRT) project (described in Project No. 11 and with the networks outlined in Figure 17) to create VEB as part of its regional transportation enhancements. More complete details of the modeling and results are delineated in Appendix C for the interested reader.

Unfortunately, the research shows the effects on regional travel to be relatively small. Fixed-routed public transit generates the highest ridership when linking residents and workers to dense employment centers. It is likely that the relatively low ridership reflects the low density of development in outlying suburban areas and the distances between major employment centers. Forecasted ridership per weekday for the entire network of routes is expected to average 15,446 unlinked trips by 2040. About 70% of these trips are forecasted to be "new" transit trips while the remainder represent diversions from other transit alternatives (bus or rail).

The single route with the highest projected ridership (more than 3,000 unlinked trips) is on the Elgin-O'Hare Extension, connecting a park-and-ride lot near the Outer Beltway to O'Hare Airport. The BRT lines that services suburban activity centers and CTA rail stations (Network A in Figure 17) have higher projected ridership than those that link suburban park-and ride-lots to the Chicago Loop directly (Network B in Figure 17). Ridership for the Loop routes is likely low because of its relatively small market for such long transit trips and its overlap with Metra commuter rail service.

Ridership for the Cross Town Tunnel (Network C in Figure 17) BRT routes is higher than for the Loop routes but lower than for the suburban routes. Ridership for these routes may be limited by an assumption made in the modeling that park-and-ride lots are not feasible at these locations (which are within the city of Chicago). Thus, access to BRT is limited to those transferring from other transit services or walking. Importantly, these ridership estimates assume that the implementation of BRT has no significant impact on regional land-use patterns.

By comparison, CTA currently has an average weekday ridership of 1.68 million unlinked trips (1.04 million on bus, 0.64 million on rail) and Metra has an average weekday ridership of about 317,000 unlinked trips.[71] These ridership numbers would be expected to increase through the year 2040 as a result of the region's natural economic and population growth. The ridership projections of the new BRT services clearly are modest in comparison to ridership on existing transit services in the Chicago region. This is not necessarily surprising given the robustness of the existing transit network in Chicago, but the results raise concerns about the timing of BRT investments not tied into downtown transit corridors.

Part 8

Funding Congestion Relief

Travel benefits are only one side of the transportation planning and investment equation. Equally important are the costs of building the new capacity and, perhaps even more importantly, to the way in which the projects are funded. Given the importance of these issues to the final policy decision on whether to consider and implement the transportation plan proposed in this report, this section more fully explains the sources and estimates for arriving at the costs for implementing these projects. While the projects outlined in the report will cost over $50 billion, revenues generated directly from users through tolls should be sufficient to fund the capital and operating costs. This is a particularly important issue given CMAP projections indicating that likely revenues from federal, state and local sources will barely cover maintenance of the existing network.[72]

A. Tunnel Costs

A number of site-specific factors greatly influence the construction cost of any individual tunnel project, including right-of-way restrictions, terrain, groundwater levels, soil and rock conditions, surrounding land use and local labor agreements. These factors need to be assessed in a thorough, site-specific engineering feasibility study before construction or a final decision is made to commit public funds to the project. Our estimates represent a conceptual, sketch-level estimate of construction costs for the tunnels proposed in this report based on an evaluation of costs associated with actual tunnel projects undertaken in other areas.

Given the difficulties in estimating the cost of tunneling, it is worth contemplating actual costs for existing tunnels. Table 8 features a set of examples of tunnel costs produced by consulting firm Arup. These data consider eight actual roadway tunnels constructed in Paris, Zurich, Dublin, Madrid, Hamburg, Wuhan (China), Nanjing (China) and Shanghai.

Table 8: Overview of Selected Completed Tunnel Projects

	Paris A86 Highway	Zurich Uetliberg	Dublin[2] Sea Port	Madrid M30 South Bypass	Hamburg Elbe River	Wuhan Yangtze River	Nanjing[2] Chang-jiang	Shanghai[2] Yangtze
Length (miles)	5.25	2.73	3.5	2.2	1.9	2.24	3.7	15.8
Total Cost[1]	3,050	1,080	1,150	570	768	239	422	1,600
Cost /Mile[1]	580	396	328	259	404	106	114	290
Total Lanes	6	4	4	6	3	4	6	6
TBM Type	All Terrain	Boring Extender	Hard-Rock	EPB Shield	Mixshield	Slurry	Slurry	Slurry

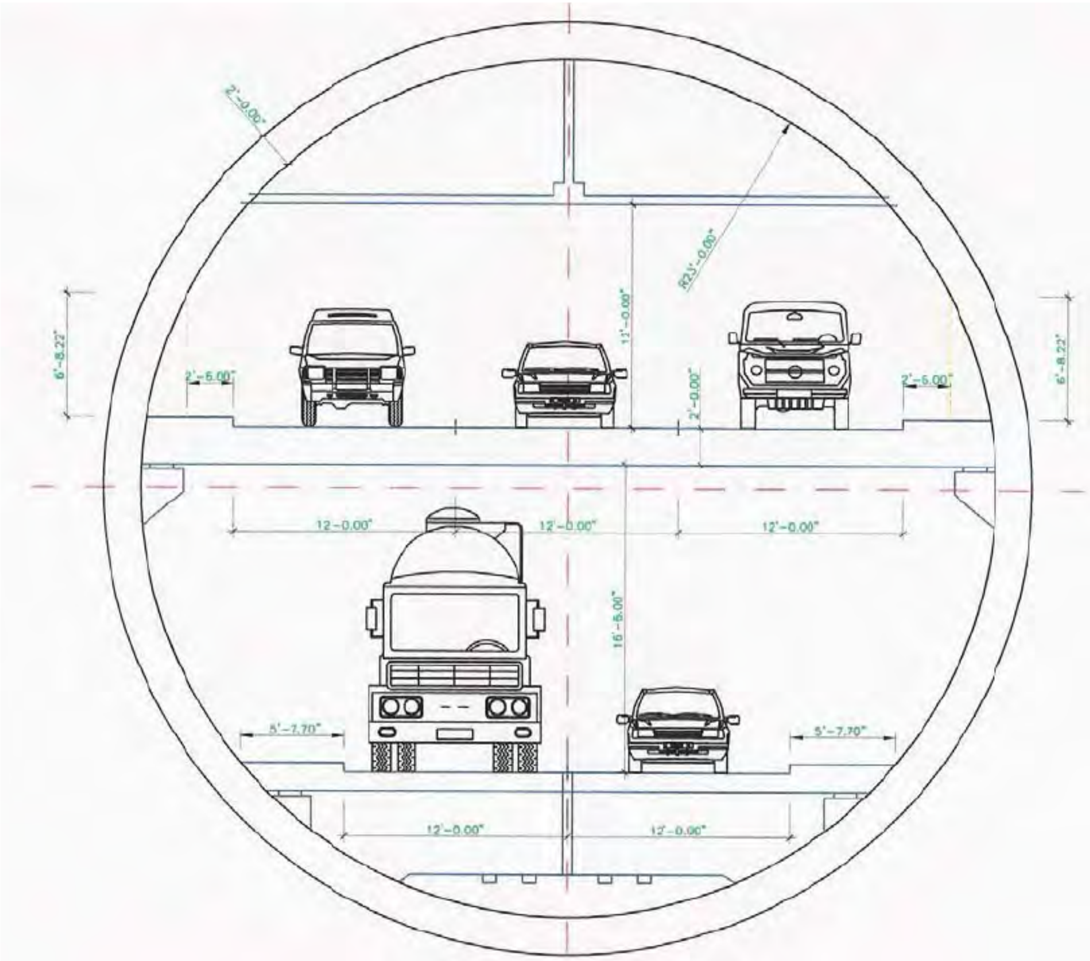
[1] All cost in millions of USD, using current costs. [2] Dublin, Nanjing and Shanghai each included cut and cover tunnel sections that could not be analyzed separately. Source: The Deep Bore Tunnel: A Practical Solution for the Post-Viaduct Era, Supplemental Tunnel Project Data Examples, page 9; Cascadia Center Discovery Institute, February 2008

When converted to U.S. dollars using current costs, the tunnel construction costs cover a very large range. Wuhan in Hubei Province of China built its tunnel for the lowest amount on a cost per route-mile basis ($106 million per mile) while Paris paid the most ($580 million per mile). On a per *lane-mile* basis (cost adjusted for the number of lanes), Nanjing in Jiangsu Province of China reported the lowest cost (at $19 million per lane-mile) while Hamburg paid the most ($135 million). The range in tunnel construction costs is greater yet when considering recent experience and cost estimates in the United States.

- *Central Artery/Tunnel in Boston, Massachusetts.* The Central Artery/Tunnel, or the "Big Dig," was a project consisting of two tunnels: a 3.5-mile long roadway tunnel (4 lanes per direction, or 8 lanes total) completed in 2006 that goes underneath downtown Boston, and the 1.6-mile (2 lanes in each direction, 4 lanes total) Ted Williams Tunnel connecting Logal International Airport to South Boston. The total project comprised 34.4 lane-miles of roadway and tunnel. In 1985, based on preliminary environmental impact studies, the project cost was estimated at $2.8 billion, or $5.67 billion when converted to year 2010 dollars.[73] When the Big Dig was completed, the actual project cost was $14.6 billion ($2.8 billion per mile, or $424 million per lane-mile). The Ted Williams Tunnel alone cost $1.9 billion, or $296.9 million per lane-mile. The reasons for project cost escalation can be summarized as follows: errors and omissions during the design process; costs added for environmental mitigation; scope growth, such as new interchanges; and inflation due to delays in construction.[74]

- *I-710 Gap Closure in Los Angeles, California.* The proposed I-710 Gap Closure, a 4.5-mile tunnel between the I-10 and I-210 freeways northeast of downtown Los Angeles, had an estimated construction cost of $3.197 billion based on a technical feasibility assessment initially completed in 2006 and further refined in 2007.[75] The project concept called for two tunnels with two levels of lanes each for a total of 5 lanes per direction (10 lanes total), as depicted in Figure 25. The more recent projected estimated cost for this tunnel, available from year 2008 long-range planning work, is $6.343 billion to construct 4 lanes in each direction, or 8 lanes total ($1,410 million per mile or $176 million per lane-mile).[76] This includes both construction costs and associated debt service.

Figure 25: I-710 Gap Closure Tunnel Schematic



Source: I-710 Tunnel Financial Feasibility Assessment, page 3; Los Angeles County Metropolitan Transportation Authority, California Department of Transportation, and Parsons Brinckerhoff, January 2008

- *Riverside-Orange County Tunnel in Southern California.* Transportation planners in Riverside and Orange counties in Southern California have estimated the cost of an 11.5-mile tunnel (2 lanes in each direction, or 4 lanes total) between the two counties underneath the Santa Ana Mountains at approximately \$8.5 billion (about \$739 million per mile, or \$185 million per lane-mile).[77]

- *Alaskan Way Viaduct in Seattle, Washington.* A 2.5-mile tunnel (3 lanes in each direction, or 6 lanes total) is currently replacing the Alaskan Way Viaduct, an existing elevated freeway structure in the downtown Seattle area with seismic risks. The initial estimate for the total cost for this project was \$3.63 billion in the year 2005 and was revised to \$4.63 billion in 2006, based on further research and the increased cost of key materials and labor.[78] The tunnel alone, including approach roads, is expected to be \$1.9 billion, translating into a tunnel construction cost of \$190 million per lane-mile. The remainder of the project's expenses include the cost of tearing down the elevated freeway and other infrastructure improvements not directly related to the tunnel.

While cost estimation of the proposed tunnel projects in Chicago must be based on a thorough evaluation of site-specific factors including right-of-way restrictions, terrain, groundwater levels, soil and rock conditions, surrounding land use and local labor agreements, this report used a range from about $80 million to $300 million per lane-mile for the proposed projects based on peer research. An average construction cost of about $162 million per lane-mile in year 2010 dollars is used as a mid-range estimate.[79]

B. Cost Estimation for Surface Road Projects

As with the tunnel projects, cost estimates for lane additions and new roadways can vary significantly depending on a number of site-specific factors, including right-of-way requirements, structure and interchange requirements, environmental impacts, soil and site conditions and local labor agreements. The presence and impact of such factors would need to be assessed in a thorough, site-specific engineering feasibility study. For example:

- A study prepared by Robert W. Poole, Jr. on behalf of the Florida DOT reviewed costs from the Federal Highway Administration (FHWA) used in the Highway Economic Requirements System and derived an average construction cost of new expressway lanes of $10.87 million per lane-mile in year 2008 dollars, excluding right-of-way needs.[80]
- A review of 11 highway projects conducted by the Chicago Area Transportation Study (CATS; the predecessor agency to CMAP) in 2002 found that construction or reconstruction costs per lane-mile varied from about $1.5 million to about $15 million per lane-mile.[81] An approximate unit capital cost of $7.3 million per lane-mile was selected for highway construction or reconstruction projects.
- A separate review of 12 highway projects conducted by the Washington State Department of Transportation in 2004 found that construction costs per lane-mile (excluding tunnels and bridges) varied significantly, from about $1.9 million to about $21 million per lane-mile.[82] A review of 19 highway projects in Washington State found that construction costs per lane-mile (excluding tunnels and bridges) varied from about $1 million per lane-mile to nearly $70 million per lane-mile.

For this report, a construction cost estimate of $10.9 million per lane-mile for new lane capacity is assumed in year 2010 dollars. This is based on the $10.87 million per lane-mile estimate from the FDOT report in year 2008 dollars, adjusted for inflation based on the Consumer Price Index reported by the U.S. Bureau of Labor Statistics.

C. Costs for Arterial Queue Jumpers

A report prepared by Reason Foundation in February 2009 for the Lee County, Florida area estimated the cost of queue jumper development at $44 million for a six-lane facility per linear mile.[83] A report prepared for the Florida Department of Transportation in January 2009 estimated the cost of a queue jump overpass or queue jump underpass at $39.5 million each.[84] These numbers would again depend on site-specific factors.

The queue jumper concept for this report involves jumping one lane of traffic per direction instead of two lanes per direction, and involves both an overpass and an underpass at each interchange. For this report, we assume a cost of $32.5 million per overpass or underpass that involves jumping one lane, or a total cost of $65 million per interchange in year 2010 dollars.

D. Summary of Cost Estimates for Proposed Projects

Table 9 shows the cost estimates per project, and total overall, based on the discussion above in year 2010 dollars. The total construction cost estimate, excluding the Bus Rapid Transit network, is about $52 billion. Forty-six percent of the total plan construction costs would be dedicated to tunnels even though they represent 6% of the total lane-miles added (Figure 26). The HOT lanes are expected to account for 23% of the total construction costs.

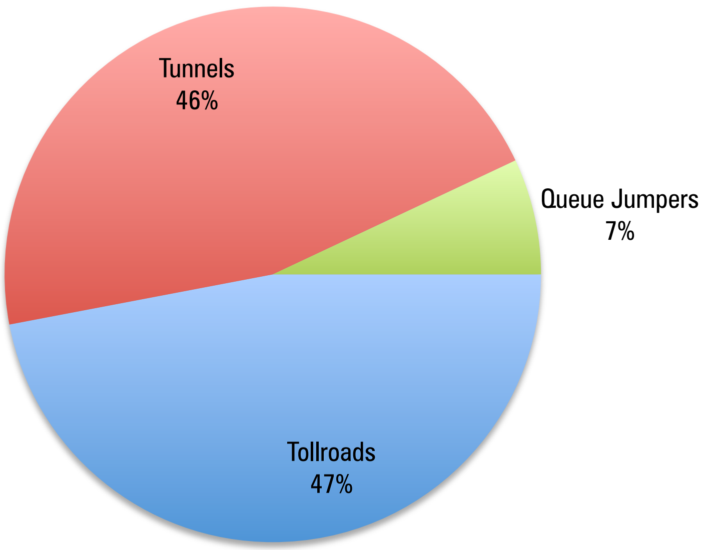
Table 9: Project Cost Estimates: (Costs in 2010 dollars)

Project	Project Name	Miles	Lanes ea. Direction	Lane-Miles	Cost Per Lane-Mile	Est Cost (billions)
1a	Cross Town Tunnel	11.0	2	44	$162 mil.	$7.1 B
1b	Midway Extension	9.0	2	36	$162 mil.	$5.8 B
2	Kennedy Tunnel	9.8	2	39	$164 mil.	$6.4 B
3	Eisenhower Tunnel	7.3	2	29	$164 mil.	$4.8 B
4	HOT Lanes	275.0	2	1100	$10.9 mil.	$12.0 B
5	Outer Beltway	76.3	3	458	$10.9 mil.	$5.0 B
6	Lake County Corridor	32.3	3	194	$10.6 mil.	$2.1 B
7	Northwest-Palatine	25.3	3	152	$10.7 mil.	$1.6 B
8	Elgin-O'Hare Ext.	17.3	3	104	$10.4 mil.	$1.1 B
9	Illiana Corridor	40.8	3	245	$10.6 mil.	$2.6 B
10	Queue Jumpers				$64 mil.*	$3.5 B
11	BRT				**	
	Total	504		2,401		$52.0 B

*Arterial queue jumper costs estimate based on 54 queue jumpers at $64 million per facility. **Costs for Bus Rapid Transit System were not estimated for this report since most of the cost would be operating expenses.

Source: Booz Allen Hamilton and Smart Mobility.

Figure 26: Distribution of Capital Costs for Regional Transportation Plan ($52 Billion)



E. Revenue Potential from Proposed Projects

A crucial element of the proposed transportation plan in this report is using road pricing both to manage the road network to maximize travel speed and to generate revenue to fund the projects. Indeed, this principle has been endorsed by CMAP as well. In *Go To 2040*, CMAP notes the shortfall between revenues and system needs, and encourages the exploration of "innovative financing," particularly user fees. "Among the many options for raising revenues," CMAP writes, "the [Chicago] region should prioritize ones that require users to pay an amount closer to their actual cost of using the system, particularly on the highway system, where each additional user imposes congestion costs on others. These types of strategies would both help raise more revenue and also enable the system to operate more efficiently." [85] Fortunately, the MRTM provides a sophisticated procedure for estimating revenues based on changes in travel behavior prompted by road pricing.

Importantly, all projects proposed in this study incorporate road pricing as a fundamental feature of both the management and funding for the network although only *new* capacity is priced. (Existing roadways and capacity that are not priced will remain unpriced.) Thus, all 2,401 lane-miles of new capacity are expected to generate revenue from users that can be used to offset the capital, maintainance and operating costs of the projects.

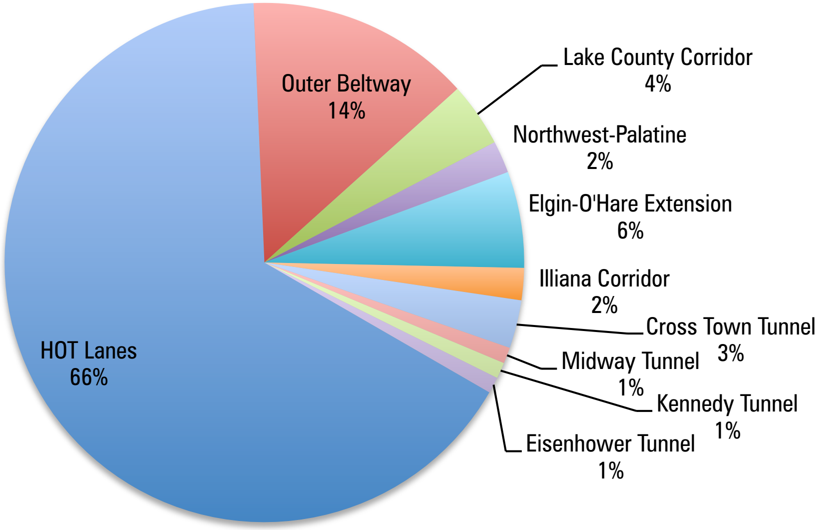
Based on projected travel behavior, demographic, land use and employment trends through 2040, the proposed road network is expected to generate $5.6 billion annually by 2040 (using 2010 dollars and assuming the facilities begin earning revenues in 2016). More than two-thirds of this revenue will be generated from the 275 route-miles (1,100 lane-miles) of managed lanes added to the existing network to establish a regional HOT network that guarantees free flow travel at posted speed limits throughout the Chicago region (Figure 27). Another 14% of the revenue from the proposed system will be generated by the Outer Beltway. While 13% of the travel is expected to be handled by the tunnels, these projects are expected to generate just 6% of the revenue.

Revenue Forecasting Assumptions

Forty-year revenue projections for the projects were generated for the Chicago regional toll network assuming a five-year construction phase and operations in year six (or in the year 2016). These projections were based on the following assumptions:

- Annual growth in gross revenue of 3.4% based on the historical average of traffic growth in the Chicago region.
- A conversion factor of 300 for weekday revenue to annual revenue.
- A net revenue factor (accounting for the cost of revenue collection) of 90%.
- A net present value (NPV) factor of 6% annually for converting revenue projections to a year 2016 base year (although using 2006 dollars as the baseline).
- Approximate useful life of the facilities of 40 years.

Figure 27: Toll Revenues Generated in 2040 ($18.7 billion)



The net-revenue NPV of the projects is estimated at about $58.1 billion (Table 10). Thus, the estimated project revenues are expected to cover estimated construction costs, including the ongoing cost of revenue collection, plus generate an additional $6.1 billion over the 40-year period (revenue-to-cost ratio of 111.7%).

Projects 2 (Kennedy Tunnel) and 3 (Eisenhower Tunnel) are relatively expensive to construct as tunnel projects and generate less revenue than Project 1. Excluding these projects (while keeping them on the drawing board for future consideration as Phase II) would significantly alter projected revenues and costs, changing the estimates of the overall feasibility of these projects. The year 2040 average weekday revenue of the proposed road infrastructure without Projects 2 and 3 is projected at $18.3 million in year 2010 dollars, or 1.9% lower.[86]

Yet, as Table 11 shows, the net-revenue NPV of these projects is estimated at about $57.0 billion. This is compared to a total capital cost estimate of about $40.8 billion without Projects 2 and 3 included. Thus, without the Eisenhower and Kennedy tunnels, the estimated project revenues are expected to cover the estimated project costs, including the ongoing cost of revenue collection, plus generate an additional $16.2 billion over the 40-year period (revenue-to-cost ratio of 139.7%).

In short, under either scenario, the proposed projects cover their construction, operating and debt service costs. The additional revenues could be used to upgrade other parts of the transportation network or begin funding Phase II projects to effectively eliminate all congestion throughout the region.

Table 10: Forty-Year Project Revenue Estimates, All Projects (2010 dollars)

Year	Revenue/Weekday	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2016	$8,445,736	$2,533,720,796	$2,280,348,717	1.0000	$2,280,348,717
2017	$8,728,668	$2,618,600,443	$2,356,740,399	0.9434	$2,223,348,892
2018	$9,021,079	$2,706,323,558	$2,435,691,202	0.8900	$2,167,773,841
2019	$9,323,285	$2,796,985,397	$2,517,286,857	0.8396	$2,113,587,949
2020	$9,635,615	$2,890,684,408	$2,601,615,967	0.7921	$2,060,756,493
2021	$9,958,408	$2,987,522,335	$2,688,770,102	0.7473	$2,009,245,618
2022	$10,292,014	$3,087,604,334	$2,778,843,900	0.7050	$1,959,022,314
2023	$10,636,797	$3,191,039,079	$2,871,935,171	0.6651	$1,910,054,396
2024	$10,993,130	$3,297,938,888	$2,968,144,999	0.6274	$1,862,310,485
2025	$11,361,399	$3,408,419,841	$3,067,577,857	0.5919	$1,815,759,986
2026	$11,742,006	$3,522,601,905	$3,170,341,715	0.5584	$1,770,373,068
2027	$12,135,364	$3,640,609,069	$3,276,548,162	0.5268	$1,726,120,646
2028	$12,541,898	$3,762,569,473	$3,386,312,526	0.4970	$1,682,974,361
2029	$12,962,052	$3,888,615,550	$3,499,753,995	0.4689	$1,640,906,566
2030	$13,396,281	$4,018,884,171	$3,616,995,754	0.4423	$1,599,890,301
2031	$13,845,056	$4,153,516,791	$3,738,165,112	0.4173	$1,559,899,283
2032	$14,308,865	$4,292,659,604	$3,863,393,643	0.3937	$1,520,907,885
2033	$14,788,212	$4,436,463,700	$3,992,817,330	0.3714	$1,482,891,119
2034	$15,283,617	$4,585,085,234	$4,126,576,711	0.3504	$1,445,824,625
2035	$15,795,619	$4,738,685,590	$4,264,817,031	0.3305	$1,409,684,648
2036	$16,324,772	$4,897,431,557	$4,407,688,401	0.3118	$1,374,448,029
2037	$16,871,652	$5,061,495,514	$4,555,345,963	0.2942	$1,340,092,189
2038	$17,436,852	$5,231,055,614	$4,707,950,052	0.2775	$1,306,595,111
2039	$18,020,987	$5,406,295,977	$4,865,666,379	0.2618	$1,273,935,329

Table 10: Forty-Year Project Revenue Estimates, All Projects (2010 dollars)

Year	Revenue/Weekday	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2040	$18,624,690	$5,587,406,892	$5,028,666,203	0.2470	$1,242,091,914
2041	$19,248,617	$5,774,585,023	$5,197,126,521	0.2330	$1,211,044,460
2042	$19,893,445	$5,968,033,621	$5,371,230,259	0.2198	$1,180,773,072
2043	$20,559,876	$6,167,962,747	$5,551,166,473	0.2074	$1,151,258,350
2044	$21,248,632	$6,374,589,499	$5,737,130,550	0.1957	$1,122,481,381
2045	$21,960,461	$6,588,138,248	$5,929,324,423	0.1846	$1,094,423,724
2046	$22,696,136	$6,808,840,879	$6,127,956,791	0.1741	$1,067,067,399
2047	$23,456,457	$7,036,937,048	$6,333,243,344	0.1643	$1,040,394,876
2048	$24,242,248	$7,272,674,440	$6,545,406,996	0.1550	$1,014,389,061
2049	$25,054,363	$7,516,309,033	$6,764,678,130	0.1462	$989,033,291
2050	$25,893,685	$7,768,105,386	$6,991,294,847	0.1379	$964,311,316
2051	$26,761,123	$8,028,336,916	$7,225,503,225	0.1301	$940,207,294
2052	$27,657,621	$8,297,286,203	$7,467,557,583	0.1228	$916,705,778
2053	$28,584,151	$8,575,245,291	$7,717,720,762	0.1158	$893,791,709
2054	$29,541,720	$8,862,516,008	$7,976,264,407	0.1093	$871,450,402
2055	$30,531,368	$9,159,410,294	$8,243,469,265	0.1031	$849,667,541
					$58,085,843,420

Year 2040 per weekday total, minus BRT: $18,624,690
Source: Smart Mobility.

Table 11: Forty-Year Project Revenue Estimates, Without Projects 2 (Kennedy Tunnel) and 3 (Eisenhower Tunnel) (2010 dollars)

Year	Revenue/Weekday	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2016	$8,289,059	$2,486,717,673	$2,238,045,906	1.0000	$2,238,045,906
2017	$8,566,742	$2,570,022,715	$2,313,020,444	0.9434	$2,182,103,487
2018	$8,853,728	$2,656,118,476	$2,390,506,629	0.8900	$2,127,559,410
2019	$9,150,328	$2,745,098,445	$2,470,588,601	0.8396	$2,074,378,722
2020	$9,456,864	$2,837,059,243	$2,553,353,319	0.7921	$2,022,527,344
2021	$9,773,669	$2,932,100,728	$2,638,890,655	0.7473	$1,971,972,048
2022	$10,101,087	$3,030,326,102	$2,727,293,492	0.7050	$1,922,680,438
2023	$10,439,473	$3,131,842,027	$2,818,657,824	0.6651	$1,874,620,925
2024	$10,789,196	$3,236,758,735	$2,913,082,861	0.6274	$1,827,762,713
2025	$11,150,634	$3,345,190,152	$3,010,671,137	0.5919	$1,782,075,774
2026	$11,524,180	$3,457,254,022	$3,111,528,620	0.5584	$1,737,530,829
2027	$11,910,240	$3,573,072,032	$3,215,764,829	0.5268	$1,694,099,335
2028	$12,309,233	$3,692,769,945	$3,323,492,951	0.4970	$1,651,753,459
2029	$12,721,592	$3,816,477,738	$3,434,829,965	0.4689	$1,610,466,064
2030	$13,147,766	$3,944,329,743	$3,549,896,768	0.4423	$1,570,210,693
2031	$13,588,216	$4,076,464,789	$3,668,818,310	0.4173	$1,530,961,550
2032	$14,043,421	$4,213,026,359	$3,791,723,724	0.3937	$1,492,693,482
2033	$14,513,876	$4,354,162,742	$3,918,746,468	0.3714	$1,455,381,966
2034	$15,000,091	$4,500,027,194	$4,050,024,475	0.3504	$1,419,003,093
2035	$15,502,594	$4,650,778,105	$4,185,700,295	0.3305	$1,383,533,550

Table 11: Forty-Year Project Revenue Estimates, Without Projects 2 (Kennedy Tunnel) and 3 (Eisenhower Tunnel) (2010 dollars)

Year	Revenue/Weekday	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2036	$16,021,931	$4,806,579,172	$4,325,921,255	0.3118	$1,348,950,607
2037	$16,558,665	$4,967,599,574	$4,470,839,617	0.2942	$1,315,232,103
2038	$17,113,381	$5,134,014,160	$4,620,612,744	0.2775	$1,282,356,429
2039	$17,686,679	$5,306,003,634	$4,775,403,271	0.2618	$1,250,302,520
2040	$18,279,183	$5,483,754,756	$4,935,379,280	0.2470	$1,219,049,833
2041	$18,891,535	$5,667,460,540	$5,100,714,486	0.2330	$1,188,578,342
2042	$19,524,402	$5,857,320,468	$5,271,588,422	0.2198	$1,158,868,518
2043	$20,178,469	$6,053,540,704	$5,448,186,634	0.2074	$1,129,901,325
2044	$20,854,448	$6,256,334,318	$5,630,700,886	0.1957	$1,101,658,199
2045	$21,553,072	$6,465,921,517	$5,819,329,366	0.1846	$1,074,121,040
2046	$22,275,100	$6,682,529,888	$6,014,276,899	0.1741	$1,047,272,203
2047	$23,021,315	$6,906,394,639	$6,215,755,175	0.1643	$1,021,094,482
2048	$23,792,530	$7,137,758,860	$6,423,982,974	0.1550	$995,571,103
2049	$24,589,579	$7,376,873,782	$6,639,186,403	0.1462	$970,685,708
2050	$25,413,330	$7,623,999,053	$6,861,599,148	0.1379	$946,422,351
2051	$26,264,677	$7,879,403,022	$7,091,462,719	0.1301	$922,765,483
2052	$27,144,543	$8,143,363,023	$7,329,026,721	0.1228	$899,699,945
2053	$28,053,886	$8,416,165,684	$7,574,549,116	0.1158	$877,210,955
2054	$28,993,691	$8,698,107,235	$7,828,296,511	0.1093	$855,284,102
2055	$29,964,979	$8,989,493,827	$8,090,544,444	0.1031	$833,905,335
					$57,008,291,371

Year 2040 per weekday total, minus BRT: $18,279,183 (also excludes Kennedy and Eisenhower Tunnels)

Source: Smart Mobility.

Part 9

Policy Recommendations

Chicago is the economic hub of the central United States, but rising traffic congestion is threatening the region's economic competitiveness and $500 billion economy. Congestion already costs travelers at least $8 billion per year, and might rise to over $11 billion by 2030 if appropriate action is not taken. If, as expected, the region grows over one million residents over the next 20 years, even $11 billion could be on the low side. The region already has worse congestion than Los Angeles and New York (measured by hours wasted per auto commuter) and the long-term trend is for traffic congestion to worsen significantly.

The regional transportation network overwhelmingly depends on road-based travel to move goods and people. While the region's public transit systems serve vital roles in providing access to the downtown and other activity centers, the dispersed nature of future development and relatively low density of land-use patterns imply road-based transportation will continue to be essential to meeting the region's future mobility needs.

Chicago's road network suffers from three primary limitations. First, new road capacity has not kept pace with development. Travel demand has increased 74% since 1982, but the lane-miles of roadway have increased by just 28%. Meanwhile, public transit's market share declined during the same period. Second, travel demand has increased fastest on the region's expressways but this has not been matched by an increase in supply. While vehicle miles traveled on freeways increased by 124% from 1982 to 2009, freeway lane-miles increased by just 39%. Arterials and local roads, in contrast, experienced more modest increases in demand compared to supply (56% versus 29%). Third, Chicago's road network is designed in a manner that creates congestion in a dispersed metropolis. Travelers have few north-south routes for traversing the seven-county urbanized area, resulting in choke points and bottlenecks at key points such as The Circle.

Chicago's path out of congestion will require a multi-pronged strategy, including keeping its public transit network in a "state of good repair," increasing the efficiency of the existing road system by applying Intelligent Transportation Systems technologies such as traffic signal coordination and ramp metering, and strategically targeting bottlenecks. A fourth crucial strategy that has yet to receive substantial public attention is bolstering the road network through major capacity expansions.

This policy study has attempted to identify specific projects that could significantly alleviate congestion by 2040 as well as outline more far-reaching improvements in the transportation network to effectively eliminate the negative economic consequences of traffic congestion. The 10 projects outlined in this project involve investments in public infrastructure of $52 billion over the next several decades. These projects would build 2,401 new lane-miles of road capacity, including three major tunnels that parallel Cicero Avenue, the Kennedy expressway and the Eisenhower expressway. The application of efficiency-enhancing congestion pricing strategies suggests that users on the new capacity would more than offset the costs of building the system. The productivity benefits would be significant as the Chicago region becomes more competitive within the U.S. as well as globally. Indeed, significant improvements in personal and commercial mobility within the region should reinforce Chicago's role as an emerging world megacity and a growth center for the U.S.

A. Phased Approach

Given the scale of the capacity additions needed to address severe traffic congestion, we recommend a phased approach. Phase I includes capital projects that are critical to meeting the city of Chicago's and the Chicago region's transportation needs in the short and intermediate run (at least through 2030). Phase II projects will need to be identified as part of a subsequent study of the region's travel needs and focus on travel needs in 2040 and beyond. The analysis in this report has helped identify and analyze the fiscal and mobility impacts many of the key projects would have on the region.

Using one of the most sophisticated regional transportation models yet developed to evaluate congestion pricing on road networks, the 11 major transportation projects outlined in this policy report should reduce travel delay by 10% over current trends by 2040 if implemented. The projects, if tolled, would reduce vehicle hours of delay by about 300,000 hours per weekday as compared to a No Build alternative, even with increased regional travel demand (measured by vehicle miles traveled) that might result from increased mobility. Annual total revenues estimated from the network are $57.0 billion in 2010 dollars.

A proposed 275-mile managed lanes (HOT lane) project would generate nearly two-thirds of the toll revenues and handle 55% of travel demand in 2040 even though it consists of just 46% of the total lane-miles built for the new system. A new Outer Beltway also experienced very high demand, although actual levels of use will depend on whether the land-use projections are realized through the expected high jobs/housing ratio in DuPage County and low jobs/housing ratio in Will County.

Based on a 40-year useful life of the capital projects as well as ongoing fare collection costs, the revenues from the entire network should exceed costs by 11.7%. If the expensive Kennedy and Eisenhower Tunnels (Projects 2 and 3) are excluded, revenues should exceed costs by 39.7%. In either case, the proposed regional road network should be financially self-supporting. Notably, these estimates exclude the ongoing operating expenses of the Bus Rapid Transit network, which could presumably be covered through other transit funding sources. Any revenues in excess of construction and operating costs for the capital facilities analyzed in this study could be used to leverage Phase II projects.

B. Shifting Risk and Optimizing the Network

Undertaking the infrastructure improvements necessary to significantly affect congestion in the Chicago region will require a substantial investment. Eight of the 10 road-based projects examined in this report meet the definition of "mega-projects"—multi-billion-dollar infrastructure projects. The remaining two projects are still expected to exceed $1 billion. Successfully managing costs and revenues will be crucial to their success, and regional policymakers will need to consider innovative financing and management strategies to handle these risks and develop the system.

The two major risks frequently seen with such projects are cost overruns and traffic/revenue shortfalls.[87] The private sector can play a critical role in mitigating these risks if contracts and long-term agreements are structured properly through public-private partnerships (PPPs). In the U.S., the most common type of public-private partnership is a design-build contract. The private sector bids for a specific project, and the winning bidder designs and builds the facility based on specifications established by the government agency managing the bidding process. These design-build contracts shift much of the cost-overrun risk to the private partner.

Design-build contracts do not shift traffic and revenue risk, nor do they ensure that the initial design is optimized for lowest life-cycle cost. Long-term concession agreements with the private sector address both concerns. Traffic and revenue risk is a serious issue for new toll roads. Recent reports by two of the leading bond rating agencies, Fitch and Standard & Poor's, point to a tendency of such forecasts to be overly optimistic, which puts the bondholders at risk. Several recent PPP projects of the type noted above, in which the private sector develops the project but does not take on ownership-type risks, have experienced serious shortfalls in early-years traffic and revenue: Colorado's Northwest Parkway, South Carolina's Southern Connector and Virginia's Pocahontas Parkway. Both the Pocahontas Parkway and the Northwest Parkway have been rescued by means of long-term concession agreements, under which a global toll road company refinanced the project and took on full ownership-type risks for 99 years. The Southern Connector declared bankruptcy in 2010.

Unlike these cases, the revenue-generating potential for the Chicago projects taken together suggests a substantial role for a PPP to manage project costs and ensure the facilities operate at peak performance. *Long-term concessions*, in particular, allow the private partner to take on the major responsibility for financing the project by investing private equity for perhaps one-quarter to one-third of the project cost and securing the long-term debt needed to fill the gap in the construction budget. Long-term concessions by their nature shift ownership responsibility for facilities over a defined period, often 50 or more years, during which the private firm (or consortium) must build, operate, manage and maintain the toll road or toll lanes at its own risk.

In addition to shifting revenue and cost-overrun risk, long-term concessions have two other advantages over more traditional design-build contracts. Long-term concessions facilitate minimizing life-cycle costs for new facilities. If the same enterprise that is designing and building the toll road also must operate it profitably for 50 years, it has every incentive to build it right in the first place, rather than cutting corners to get the initial cost down. Spending an extra 10 to 15% on a more durable pavement in the first instance generally pays for itself several times over in lower ongoing maintenance costs over the roadway's lifetime. But neither traditional public-sector project development nor the design-build PPP model is able to internalize this incentive effect, since operating and maintenance costs are not the responsibility of the entity designing and building the roadway.

Long-term concessions also provide more opportunities for cost-sharing for those projects that cannot be fully supported by toll revenue financing. In such cases, the public sector (e.g., IDOT, CDOT or even the Illinois Tollway) would have to make an "equity" investment for, say, 30% of the project cost, with the balance being financed out of toll revenues, and the responsibility to collect and manage these toll revenues falling to the concessionaire. In most cases, with this type of mixed funding, the concession company agrees to share toll revenue above a certain level with the state agency. This type of mixed financing is being done currently under the expansive PPP/tolling regime in Texas.

For these and other reasons, PPPs and long-term concessions are a widely used tool in Europe and Asia; they are used extensively for transit, road, tunnel and bridge projects. Indeed, the entire limited access highway network in France is currently under long-term concessions with several private companies. China tapped into private capital to finance almost all of its recent investments in an intercity highway network that now rivals the size of the U.S. Interstate Highway System.

The city of Chicago has used long-term concession agreements to shift management responsibilities for the Chicago Skyway to a private consortium and, more controversially, upgrade the city's parking meter system. The city has also explored a long-term concession for upgrading and managing Midway Airport.

More importantly, the prospect for long-term concession agreements with private firms appears to be improving dramatically as the U.S. economy emerges from the recession. The Florida Department of Transportation (FDOT) closed on a public private partnership to improve the I-595 corridor in Broward County (Miami) in March 2009. The $1.8 billion project would create a 10.5-mile stretch of reversible managed lanes in the median of I-595, with a private consortium led by Florida-based ACS Infrastructure Development under a 35-year concession agreement.

In October 2009, FDOT closed on a $900-million public private partnership agreement to build a tunnel connecting the Port of Miami with the mainland, also using a 35-year concession agreement.[88] By using the long-term concession process, the state of Florida was able to secure significant savings (half of the state DOT's internal estimates) while adopting cutting-edge technologies that will significantly enhance the project's ability to meet growing travel needs while controlling costs. Large diameter tunnel-boring machines, for example, will be used to construct the tunnels. As one observer noted: “These benefits have long been realized in European and Asian transport construction, and now the U.S. is poised to start catching up.”[89]

C. Moving Forward

In sum, the comprehensive approach outlined in this report would result in significant travel benefits to the Chicago region and the city of Chicago in particular. Congestion will fall in absolute terms for the city of Chicago as new routes divert regional through-traffic away from the city center and Loop. Travel times will fall with congestion as residents, workers and commercial trucks outside the city center find more efficient and quicker routes to their destinations.

More specifically, this report recommends pursuing a two-phase approach that puts the projects with the most potential for relieving congestion and improving circulation at the top of the priority project list. These projects include the Cross Town Tunnel in the city of Chicago, a new Outer Beltway, and establishment of an integrated regional network of priced lanes in a HOT network to ensure continous free flow travel at posted speed limits throughout the region.

The Phase I projects outlined in this report will provide Chicago-area travelers with substantial mobility benefits:

- In the year 2040, the delay reduction in the Chicago region of about 300,000 vehicle hours per weekday is about 90 million vehicle hours annually. Using an average value of time of $20.90 per hour (year 2006 dollars) based on TTI data, this translates into a benefit of about $1.88 billion dollars in the year 2040.
- Without Projects 2 and 3, the effects in 2040 are very similar, so these projects would deliver their benefits mainly after 2040 as the Chicago region continues to grow.

While the Kennedy and Eisenhower tunnels are expensive, they still might be important to address the future mobility needs of the Chicago region and, at a minimum, should be retained as part of a Phase II analysis. Similarly, the proposed Bus Rapid Transit network should be planned and included as a Phase II project that matures with the growth of the regions oustide the city center.

About the Author

Samuel R. Staley, Ph.D. is a senior research fellow at Reason Foundation and managing director of the DeVoe L. Moore Center at Florida State University in Tallahassee where he teaches graduate and undergraduate courses. Staley is the author of several books, in 2008 co-authoring *Mobility First: A New Vision for Transportation in a Globally Competitive 21st Century* and in 2006 co-authoring *The Road More Traveled: Why The Congestion Crisis Matters More Than You Think, and What We Can Do About It.* His more than 100 professional articles, studies and reports have appeared in publications such as *The Wall Street Journal*, *The New York Times*, *Washington Post*, *Los Angeles Times*, *Investor's Business Daily*, *Journal of the American Planning Association*, *Planning* magazine, *Reason* magazine, *National Review* and many others. Staley is a former chair for his local planning board in his hometown of Bellbrook, Ohio. He is also a former member of its Board of Zoning Appeals and Property Review Commission, vice chair of his local park district's open space master plan committee, and chair of its Charter Review Commission. Staley received his B.A. in Economics and Public Policy from Colby College, M.S. in Social and Applied Economics from Wright State University, and Ph.D. in Public Administration, with concentrations in urban planning and public finance from Ohio State University.

Related Reason Foundation Studies

Gaining Public Support for Congestion Pricing on Highways: Delivering value and offering multiple options for drivers and truckers, by Robert Poole, 2012, http://reason.org/news/show/public-support-congestion-pricing

Increasing Mobility in Southeast Florida: A new approach based on road pricing and bus rapid transit, by Robert Poole, Thomas A. Rubin and Chris Swenson, 2012, http://reason.org/news/show/mobility-in-southeast-florida

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Why Mobility Matters to Personal Life, by Ted Balaker, 2007, http://reason.org/news/show/why-mobility-matters-to-person

Appendix A

Appendix A: Projects Currently Being Planned in the Chicago Region

In 2005, the Chicago Metropolitan Agency for Planning (CMAP) was created by state legislation, merging the staffs of the Chicago Area Transportation Study (CATS) and the Northeastern Illinois Planning Commission (NIPC) into a single agency. CMAP serves as the MPO for seven counties that collectively encompass the greater Chicago region: Cook, DuPage, Kane, Kendall, Lake, McHenry and Will.

In addition to CMAP, the Illinois DOT operates and maintains most of the primary expressways near the city of Chicago, while the Illinois Tollway operates and maintains four of the expressways in outlying areas: the Jane Addams Memorial Tollway (I-90), the Tri-State Tollway (I-294/I-94), the Ronald Reagan Memorial Tollway (I-88), and the Veterans Memorial Tollway (I-355). The Chicago Skyway between the Dan Ryan Expressway and the Indiana Toll Road is also a tolled facility. Individual cities operate and maintain arterials and local roads within their respective jurisdictions, the largest being the city of Chicago. Regional transit service is provided primarily by CTA (rail and bus service in the city of Chicago), Pace (bus service suburban Chicago), and Metra (regional commuter rail service).

A. CMAP Year 2030 Regional Transportation Plan

This report used the *Updated 2030 Regional Transportation Plan* (RTP) for Northeastern Illinois, developed by CMAP in September 2007 and updated in 2008 as a building block for developing the comprehensive network of improvements to the region. The 2030 RTP serves as the long-range planning document to guide future transportation investments in the Chicago metropolitan area and has three overall goal statements: [90]

- Maintain the integrity of the existing transportation system;
- Improve transportation system performance; and
- Employ transportation to sustain the region's vision and values.

CMAP indicates these are broad vision goals intended to focus decision-makers on the important features of their transportation investment choices. Each goal statement is supported by a set of objectives. These objectives focus on areas including maintenance, reconstruction and replacement; congestion management; transportation system efficiency; transportation and land use interaction; mobility and accessibility; commercial goods movement; natural environment; economic development; social equity; community development; public health and safety, and security. Congestion management is an objective associated with improving system performance, but is not a primary goal and is not a specific criterion used for selecting individual projects.

The 2030 RTP estimated that about $65.0 billion in funding would be available to maintain and improve the transportation system in the Chicago region between 2004 to 2030: [91]

- About $47.0 billion will be needed for "Management Recommendations," to maintain the existing transportation system in a state of good repair.
- About $3.6 billion is proposed for "Committed Recommendations," or for major capital projects that are already funded.
- About $5.0 billion is proposed for "Strategic Recommendations," or strategic improvements to the region's "shared-use" system composed primarily of arterial, bus, truck, bicycle and pedestrian facilities.
- The remaining $9.4 billion is recommended for other "Major Capital Recommendations," consisting of projects in various stages of planning and design.

By comparison, the total of unconstrained project needs identified during the Shared Path 2030 public outreach process conducted from June 2001 to October 2003 was about $85 billion.[92] As such, the gap between the unconstrained needs and the fiscally constrained plan is about $20 billion during the 2004–2030 planning timeframe. An overview of the projects contained in the RTP encompasses: [93]

Management Recommendations

Management recommendations include the following projects: Circle Line Phase I (Pink Line), Blue Line Douglas Branch Rehabilitation, Green Line Enhancements, SouthWest Service to Manhattan, North Central Service Upgrades, Union Pacific West to Elburn, I-355 Extension, I-90/94 (Dan Ryan) Improvements and I-80/94 (Kingery) Improvements.

Committed Recommendations

Committed recommendations include project improvements to the following routes: the Brown Line, I-88 Ronald Reagan Memorial Tollway, I-294/I-94 Tri-State Tollway, I-55 Interim and the I-355.

Strategic Recommendations

Strategic recommendations include the following projects: Chicago Bus Rapid Transit Network, Central Area Bus Rapid Transit, DuPage "J" Bus Rapid Transit, Cermak Road Bus Rapid Transit, Golf Road Bus Rapid Transit, Ogden Avenue Transitway, Pace Arterial Rapid Transit Systems, CTA Neighborhood Express, Pace Express Bus Transit Systems, CREATE Corridors and NHS Intermodal Connectors.

Other Major Capital Recommendations: Other major capital recommendations are further divided into three categories: "System Recommendations" (relatively short turnaround projects to upgrade and enhance existing major facilities), "Project Recommendations" (projects that have been studied previously with respect to preferred mode, alignment and service pattern, and that may proceed with specific project design and engineering), and "Corridor Recommendations" (project proposals for which a general travel need and initial transportation concepts have been identified, and that require further study pertaining to cost effectiveness).

- **System Recommendations**: Union Pacific North Upgrades, Rock Island Upgrades, SouthWest Service Upgrades, Metra Electric Upgrades, Union Pacific West Upgrades, I-190 (O'Hare) Improvements, IL 394 Improvements, I-57 Improvements, I-80 Improvements, I-90 Jane Addams Memorial Tollway Improvements, I-55 Improvements (South) and the Elgin-O'Hare Expansion.
- **Project Recommendations**: Circle Line Completion, Orange Line Extension, Yellow Line Upgrade and Extension, Red Line Extension, Union Pacific Northwest Upgrades and Extension, BNSF Railway to Oswego, SouthEast Service Commuter Rail, O'Hare Bypass South and STAR Line Phase I.
- **Corridor Recommendations**: West Loop Transportation Center, Express Airport Train Service, Blue Line West Extension, Heritage Corridor Upgrades, Rock Island Extension, SouthWest Service Extension, Metra Electric Extension, Milwaukee District West and North Extensions, BNSF Railway to Plano, I-290 High Occupancy Vehicle Lanes, Elgin-O'Hare Extensions, O'Hare Bypass North, STAR Line Completion, Mid-City Transitway, McHenry-Lake Corridor, Central Lake County Corridor, South Suburban Corridor, I-57/IL 394 Corridor, Illiana and Prairie Parkway.

Taken together, the major capital improvements contained in the RTP call for a wide range of new capital projects throughout the Chicago region, covering highways, transit and freight rail. Many of these projects are located outside of the city of Chicago in anticipation of future population and employment growth patterns. These projects maintain the overall radial nature of the Chicago region, while adding in select outer beltways designed to facilitate suburb-to-suburb travel.

Among the more significant roadway-related major capital projects not already committed (i.e., "Project Recommendations" and "Corridor Recommendations") are as follows:

- **I-290 High Occupancy Vehicle Lanes:** I-290 (Eisenhower Expressway) serves Chicago's CBD and western suburbs. This project consists of a high-occupancy vehicle (HOV) lane on I-290 from I-88 to Austin Boulevard. The expressway serves a corridor with complementary transit service and high transit ridership. The new facility would provide increased through person-travel capacity in a congested travel corridor by providing capacity for transit and other high-occupancy vehicles.
- **Elgin-O'Hare Extensions**: The Elgin-O'Hare Expressway is proposed to link the western suburbs in Cook and DuPage Counties with Chicago O'Hare International Airport at the proposed western terminal. This project would provide new multimodal highway segments to complete west and east segments of the existing Elgin-O'Hare Expressway and provide new access to and a western bypass of O'Hare Airport.
- **O'Hare Bypass South**: On the southern end of the existing Elgin-O'Hare Facility, a new spur freeway will connect from the Tri-State to the extended Elgin-O'Hare expressway and the planned O'Hare western terminal.
- **O'Hare Bypass North**: On the northern end of the existing Elgin-O'Hare Facility, a new connection will link the proposed western terminal with the Northwest Tollway.
- **McHenry-Lake Corridor**: This project would provide a fully access-controlled highway from the terminus of the US12 freeway at the Wisconsin border to the IL120 north extension near Wilson/Fairfield Road. This project would provide increased highway accessibility to western Lake and eastern McHenry Counties, as recent development in this corridor has been rapid.
- **Central Lake County Corridor**: This project would extend IL53 from its current terminus at Lake-Cook Road to central Lake County. The proposal includes a dual terminus with I-94 to the east and IL120 at Wilson Road to the west. Rapid development in the Central Lake County Corridor has been occurring for decades.
- **South Suburban Corridor**: This project would extend from the proposed I-355 south extension to I-80 east to I-57 in order to connect to the proposed I-57/IL394 Connector. This project would improve highway accessibility in an arc from I-80 to I-57 in a rapidly developing part of Will County.
- **I-57/IL 394 Corridor**: This project would extend the proposed South Suburban extension from its proposed terminus at I-57 east to IL394 in the vicinity of the proposed South Suburban Airport (SSA). This project connects to the proposed Illiana Corridor. The I-57/IL394 Connector would provide access between these two south suburban highways north of the SSA site. The proposed highway would provide a link between the highways to facilitate travel between the east and west sides of the airport; connections to the airport itself are also planned. This project would also improve highway accessibility for northern Will County, and support community and economic development through its support of the South Suburban Airport.
- **Illiana**: This project would extend the proposed I-57/IL394 Connector from its proposed terminus at IL394 east to I-65 in Indiana. The project would provide improved highway accessibility for northern Will County and provide a suitable freight route in the area. The

project would provide better access between the two states and distribute through-traffic to freeway facilities, relieving arterials primarily in Indiana. The project may also strengthen the proposed South Suburban Airport in Illinois by improving highway access to the site, thereby supporting community and economic development.

- **Prairie Parkway**: This project would introduce a new highway facility connecting I-80 to I-88 in Kane and Kendall Counties. Evaluation of an I–80 to I–88 North-South Connector in Illinois is included in the current federal authorization. Rapid residential and commercial growth are developing in the area. The project would provide improved access between Grundy, Kendall and Southern Kane Counties.

B. *Go to 2040* Long-Range Transportation Plan

In September 2010, CMAP released an updated long-range transportation plan titled *Go to 2040* (www.goto2040.org). Like the previous 30-year RTP, the plan includes recommendations under "constrained" (likely revenues) and "unconstrained" (new revenue) scenarios. The revised RTD reflects many of the same projects recommended in the 2030 plan.

While the 2040 plan emphasizes bringing public transit up to a "state of good repair," about $15 billion in new capacity projects have been identified. Several of these projects (such as the lane widenings for managed lanes) are also included in the Reason Foundation plan (Table A1). Only one major project, the Western O'Hare Bypass, is not included among the recommendations in the Reason Foundation plan. Thus, the effects of these improvements to the road system are included in the transportation modeling.

On the other hand, substantial portions of the proposed Reason Foundation network are excluded from the CMAP 2040 plan. The Cross Town Tunnel, for example, is not included. In several cases only portions of projects recommended by Reason Foundation (e.g., the Prairie Parkway) are included in the unconstrained plan. Thus, specific segments do not map well onto the Reason Foundation plan.

Several factors likely explain the inconsistency between the CMAP plan and Reason Foundation plan. First, Reason Foundation, unlike CMAP, is not bound or constrained by identifying projects based on current revenue streams. All of Reason Foundation's transportation modeling and simulations are built on a system that includes *new revenue* through user fees. Indeed, a primary goal of the project was to test the degree to which users value the improvements sufficiently to fully fund needed improvements. Second, Reason Foundation's project selection was based on a comprehensive, regional approach to improving network efficiency. This principle resulted in identifying projects that added crucial north-south alternatives to the current network. Third, a primary goal of the Reason Foundation project was to reduce congestion and improve travel times in absolute terms throughout the region. Fourth, Reason Foundation's planning horizon is longer than CMAPs; revenue and cost projections extend to 50 years rather than 30 years. Thus, the Reason Foundation project team's mandate was to present an aggressive strategy for addressing traffic congestion in the city of Chicago as well as the larger region. Moreover, Reason Foundation was able to think "outside the box" to examine the effects of major projects (e.g., tunnels) that would be off the table in the current political environment that necessarily excludes user fees and other user-based revenues streams to fund major, core transportation projects.

In conclusion, Reason Foundation's plan benefits from fewer legal and practical political constraints than planners working through the formal long-range planning process for the Chicago region. The selection of projects, and their fiscal implications, reflect the differences in these perspectives and planning frameworks.

Table A1: Comparison of CMAP Roadway Projects with Projects Recommended by Reason Foundation

	Type	Description	In Reason Proposal?
Fiscally Constrained Projects			
Elgin O'Hare Expressway Add Lanes	Existing	I-290 to Gary Avenue	
I-190 Access Improvements	Existing	Cumberland Ave (at I-90) to O'Hare Terminals	NO
I-290 Managed Lanes	Existing	I-88 to Austin Blvd	YES
I-55 Managed Lanes	Existing	From Weber Rd to I-90/94	YES
I-80 Add Lanes	Existing	US 30 to US 45	YES
I-88 Add Lanes	Existing	Orchard Road to IL-56	YES
I-90 Managed Lanes	Existing	I-294 to Elgin Toll Plaza	YES
Central Lake County Corridor	New	IL-53 North and IL-120 Limited Access	YES
Elgin O'Hare Expressway East Extension	New	I-290 to West O'Hare Bypass	YES
Western O'Hare Bypass	New	I-294 to I-90	NO
I-294 at I-57 Interchange	Existing	I-294 at I-57	NO
I-94 Add Lanes North	Existing	From IL-173 to Wisconsin border	NO
Fiscally Unconstrained Projects			
I-55 Add Lanes and Reconstruction	Existing	Naperville Rd to Coal City Rd	NO
I-57 Add Lanes	Existing	I-80 to Wilmington-Peotone Road	YES
I-80 Add / Managed Lanes	Existing	Grundy County Line to US 45	YES
IL 394	Existing	I-80 to IL 1/Goodenow Road	NO
Elgin O'Hare Expwy Far West Extension	New	Shales Pkwy to E Bartlett Rd, as high-level arterial	NO
Elgin O'Hare Expwy West Extension	New	Gary Ave to US 20	YES
Illiana Corridor	New	I-55 to I-65	YES
I-80 to I-55 Connector	New	Prairie Pkwy to Illiana Corridor	YES
McHenry-Lake Corridor	New	IL 120 @ Wilson Rd to Richmond	NO
Prairie Parkway	New	I-88 to I-80	YES

Source: CMAP, *Go to 2040*, List of Major Capital Projects, http://www.goto2040.org/projectlist/, accessed August 12, 2010.

Appendix B

Appendix B: Detailed Average Weekday Metrics for Chicago, Cook County and the Six-County Chicago Region

This technical appendix includes more extensive and detailed metrics for the travel effects of building the major new road capacity projects discussed in this report. These estimates and forecasts were prepared by Smart Mobility using the Metropolis 2020/Reason Transportation Model, or MRTM, incorporating the enhancements described in Appendix D.

A. Year 2040 Model Results: All Projects

Table B1 shows estimated vehicle miles traveled (VMT) per weekday per facility in the year 2040.

Interestingly, VMT is higher for the mid period than for the morning or afternoon peaks. While this may seem counterintuitive, the mid-day period covers a longer period of time (4 hours) than the peak period (three hours). These numbers may also reflect higher volumes of truck traffic which typically occur during mid-day periods. Regardless, the data reinforce the common-sense observation that Chicago's regional road network is heavily traveled and in need of capacity expansion.

Table B1: Scenario 1 – Weekday Vehicle Miles Traveled (VMT)

Project	Early	AMsh	AMpk	Mid	PMpk	PMsh	Late	Grand Total
1a	26,473	98,897	158,133	222,896	168,122	166,977	120,501	961,999
1b	658	36,377	95,064	147,814	116,832	99,630	18,340	514,714
2	51	49,441	133,320	191,334	141,992	135,670	15,471	667,278
3	793	33,069	86,614	134,439	107,269	91,384	21,454	475,021
4	75,296	547,795	2,483,998	3,323,119	2,703,057	1,920,113	562,701	11,616,079
5	18,278	182,196	691,391	770,213	691,666	520,798	140,270	3,014,811
6	1,906	50,092	249,809	195,838	189,739	135,248	38,485	861,117
7	649	25,323	137,383	125,617	131,919	91,841	16,361	529,094
8	15,894	96,684	287,115	332,132	291,178	242,365	90,884	1,356,252
9	4,492	40,636	155,546	130,195	127,552	93,229	29,357	581,007
Total	144,491	1,160,510	4,478,372	5,573,597	4,669,326	3,497,254	1,053,823	20,577,371

Source: MRTM

The projects collectively are modeled as carrying about 20.6 million vehicle miles traveled (VMT) per weekday in 2040. Project #4, the regional HOT lane system, carries over half the total at 11.6 million VMT per weekday (this is for the HOT lanes only, not including the general purpose lanes on the same roadways).

The next most significant project is #5, the Outer Beltway, carrying about 3.0 million VMT per weekday. The high VMT on the Outer Beltway is partially due to the long length of this project, but also indicates heavy demand. Usage of the Outer Beltway in the model is heaviest in the southwest quadrant. The 2030 CMAP land use projections assume that DuPage County continues to attract a large fraction of future jobs and that Will County continues to attract a large fraction of future housing. The 2040 projections are based on the 2030 CMAP projections and include the same pattern. This sets up strong travel demand between Will County and DuPage County, and the Outer Beltway is carrying much of this traffic in the model. The Outer Beltway was modeled as four lanes.

Regionally, the 20.6 million VMT per day on the projects represents about 8.2% of the daily VMT in the core six-county region.

Table B2 shows estimated vehicle hours traveled (VHT) per weekday per facility in the year 2040 for Scenario 1.

Table B2: Scenario 1 – Weekday Vehicle Hours Traveled (VHT)

Project	Early	AMsh	AMpk	Mid	PMpk	PMsh	Late	Grand Total
1a	481	1,800	2,879	4,058	3,061	3,040	2,191	17,510
1b	12	661	1,730	2,689	2,126	1,812	333	9,365
2	1	899	2,426	3,483	2,585	2,469	281	12,144
3	14	601	1,577	2,447	1,953	1,663	390	8,644
4	1,369	9,965	45,204	60,469	49,186	34,935	10,236	211,365
5	281	2,800	10,635	11,841	10,638	8,007	2,156	46,357
6	29	771	3,845	3,013	2,919	2,081	592	13,250
7	10	390	2,114	1,933	2,030	1,413	252	8,141
8	252	1,559	2,632	5,379	4,703	3,916	1,461	21,902
9	70	631	2,412	2,021	1,979	1,447	455	9,015
Total	2,520	20,077	77,453	97,332	81,178	60,784	18,349	357,692

Source: MRTM

VHT was calculated primarily to assess year 2040 weekday average speeds per facility. Average speed results are shown in Table B3.[94]

Table B3: Scenario 1 – Weekday Average Speed (miles per hour)

Project	Early	AMsh	AMpk	Mid	PMpk	PMsh	Late	Grand Total
1a	55.0	54.9	54.9	54.9	54.9	54.9	55.0	54.9
1b	55.0	55.0	54.9	55.0	55.0	55.0	55.0	55.0
2	55.0	55.0	54.9	54.9	54.9	54.9	55.0	54.9
3	55.0	55.0	54.9	54.9	54.9	55.0	55.0	54.9
4	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
5	65.1	65.1	65.0	65.0	65.0	65.0	65.1	65.0
6	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
7	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
8	63.0	62.0	62.0	61.7	61.9	61.9	62.2	61.9
9	64.6	64.4	64.5	64.4	64.4	64.4	64.5	64.4
Total	57.3	57.8	57.8	57.3	57.5	57.5	57.4	57.5

Source: MRTM

The average speeds modeled are consistent with the coding in the model. The new toll roads are operating at close to the coded speeds, as traffic flows in the model are adjusted with dynamic tolls to maintain a maximum flow of 1,600 vehicles per lane per hour. The tunnels are coded at 55 miles per hour. The HOT lanes are also coded at 55 miles per hour, which reflects the model speed coded by CMAP for the existing general purpose lanes. It also reflects the constraints under which most of these projects probably would operate, which include narrow buffers between HOT lanes and general purpose lanes, and slip lanes between the general purpose lanes and the HOT lanes. The completely new roadways are coded at 65 miles per hour.

Table B4 shows estimated toll revenue per weekday per facility in the year 2040 for Scenario 1, provided in year 2006 dollars.

Table B4: Scenario 1 – Weekday Toll Revenue ($)

Project	Early	AMsh	AMpk	Mid	PMpk	PMsh	Late	Grand Total
1a	4,976	23,217	112,878	116,225	98,094	71,363	22,625	449,379
1b	127	6,977	35,846	28,353	23,613	19,112	3,529	117,557
2	9	9,293	52,506	43,007	45,576	29,404	2,890	182,685
3	<1	6,254	22,908	25,755	22,780	17,519	3,876	99,092
4	48,116	459,864	2,947,371	3,074,704	2,807,366	1,717,245	364,844	11,419,509
5	3,564	138,106	703,370	581,076	529,911	399,001	103,023	2,458,051
6	376	38,992	194,692	149,602	146,926	105,175	29,969	665,732
7	120	19,018	104,683	94,028	100,206	69,684	8,180	395,918
8	9,170	72,313	244,421	247,430	218,896	182,022	67,331	1,041,583
9	819	29,004	112,746	92,433	91,968	67,543	21,063	415,576
Total	67,277	803,038	4,531,420	4,452,613	4,085,337	2,678,069	627,330	17,245,083

Source: MRTM

With dynamic tolling, the 2040 system generates about $17.2 million per weekday in 2006 dollars. Using the same 300 weekday-to-year multiplier applied for earlier MTM projects, this equals about $5.2 billion per year in 2006 dollars.[95] Project 4: Regional HOT Lane Network generates about 66% of the total revenue at about $11.4 million per weekday. Project 5: Outer Beltway generates about 14% of the total revenue at $2.5 million per weekday.

Table B5 shows the dynamic average toll rates per facility per time period in the year 2040 for Scenario 1, in year 2006 dollars.

Table B5: Scenario 1 – Dynamic Toll Rates ($/mile)

Project	Early	AMsh	AMpk	Mid	PMpk	PMsh	Late	Grand Total
1a	0.19	0.23	0.71	0.52	0.58	0.43	0.19	0.47
1b	0.19	0.19	0.38	0.19	0.20	0.19	0.19	0.23
2	0.17	0.19	0.39	0.22	0.32	0.22	0.19	0.27
3	--	0.19	0.26	0.19	0.21	0.19	0.18	0.21
4	0.64	0.84	1.19	0.93	1.04	0.89	0.65	0.98
5	0.19	0.76	1.02	0.75	0.77	0.77	0.73	0.82
6	0.20	0.78	0.78	0.76	0.77	0.78	0.78	0.77
7	0.18	0.75	0.76	0.75	0.76	0.76	0.50	0.75
8	0.58	0.75	0.85	0.74	0.75	0.75	.074	0.77
9	0.18	0.71	0.72	0.17	0.72	0.72	0.72	0.72
Total	0.47	0.69	1.01	0.80	0.87	0.77	0.60	0.84

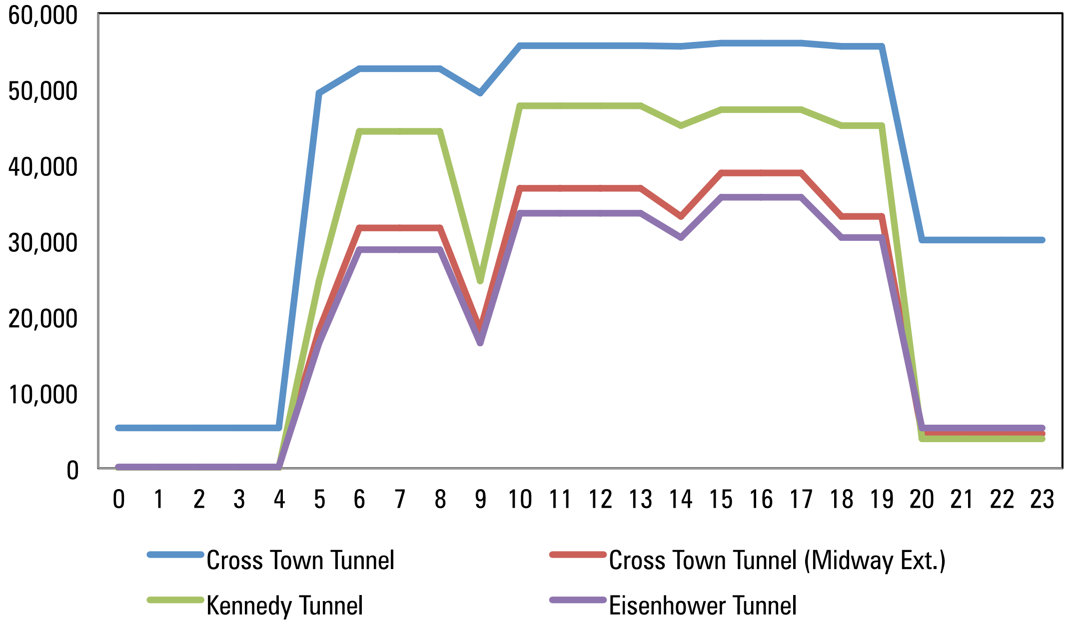
Source: MRTM

As shown in Table B5, the highest toll rates are in the 2-hour morning peak period. The highest average tolls, $1.19 per mile (2006 $), are for the HOT lanes in the morning peak period. The next highest average tolls, $1.02 per mile, are for the Outer Beltway in the morning peak period. As discussed above, the Outer Beltway traffic demand is strongly linked to the 2040 housing and employment projections. Without the projected jobs/housing imbalances in DuPage and Will Counties, the modeled traffic demand for this roadway would be less. If demand were less, the dynamic toll rates also would be lower, so revenues could be significantly lower.

These toll rates are significantly higher than the current rates charged by the Illinois Toll Authority. Importantly, however, the toll rates in this study are based on forecasts of traffic volumes and travel demand in 2040. Steadily rising levels of congestion will require higher toll rates to guarantee free flow travel on the priced lanes. Thus, given severe congestion on the much larger unpriced road system, these higher toll rates are demand-driven estimates, not cost-driven (e.g., debt payment).

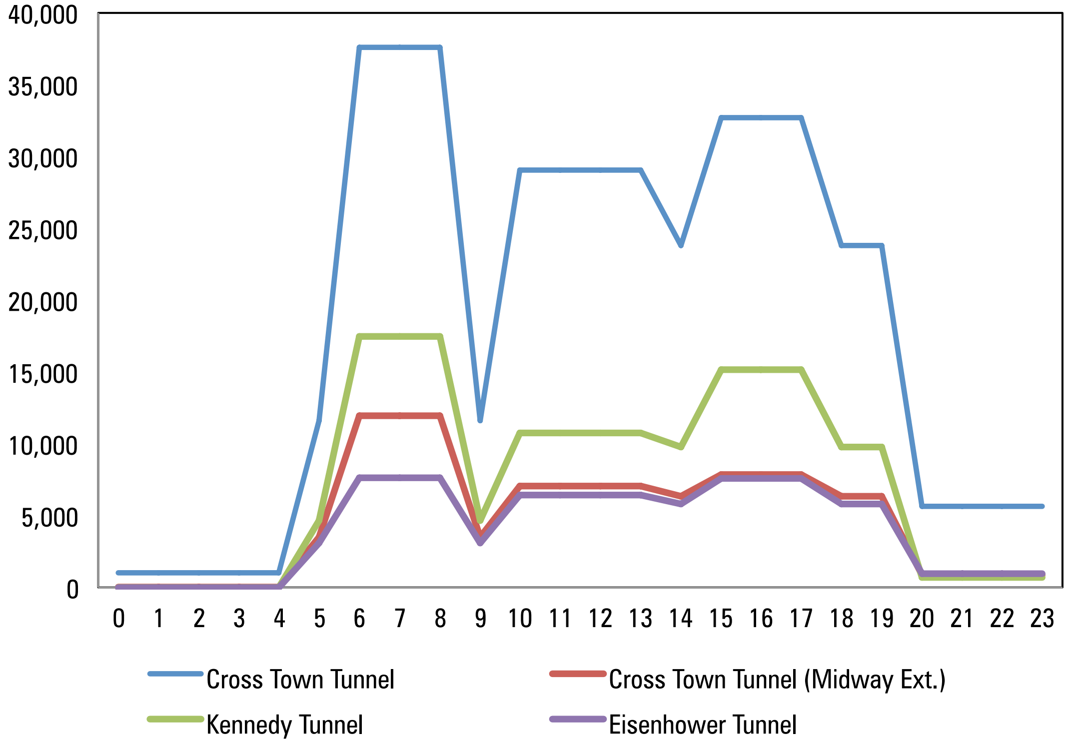
The following figures restate the VMT and revenue results to illustrate the patterns over the course of a 24-hour day.

Figure B1: 2040 Build–Vehicle Miles Traveled (VMT) by Hour for Tunnel Projects



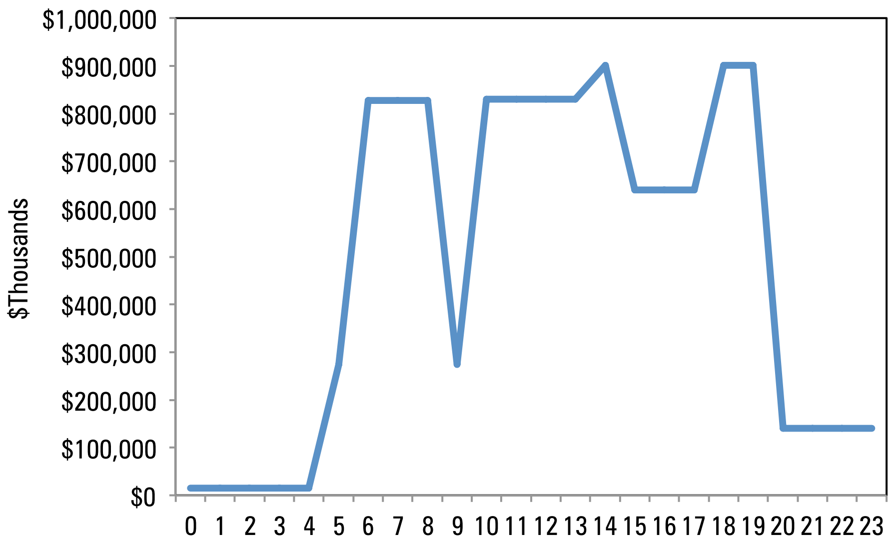
Source: MRTM

Figure B2: 2040 Build–Toll Revenue by Hour for Tunnel Projects (2006 $)



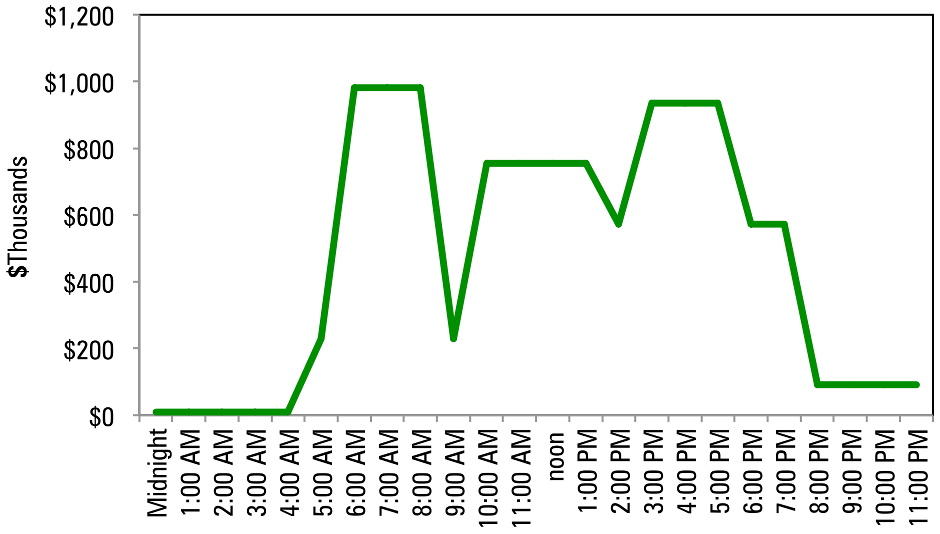
Source: MRTM

Figure B3: 2040 Build–Vehicle Miles Traveled (VMT) by Hour for Regional HOT Lane Network



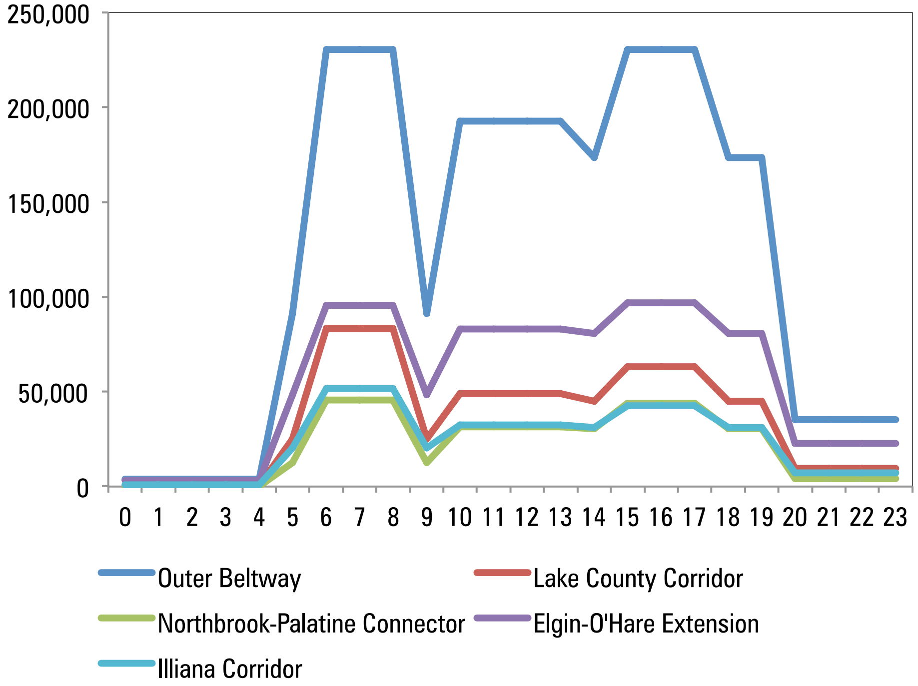
Source: MRTM

Figure B4: 2040 Build–Toll Revenue by Hour for Regional HOT Lane Network (Year 2006 $)



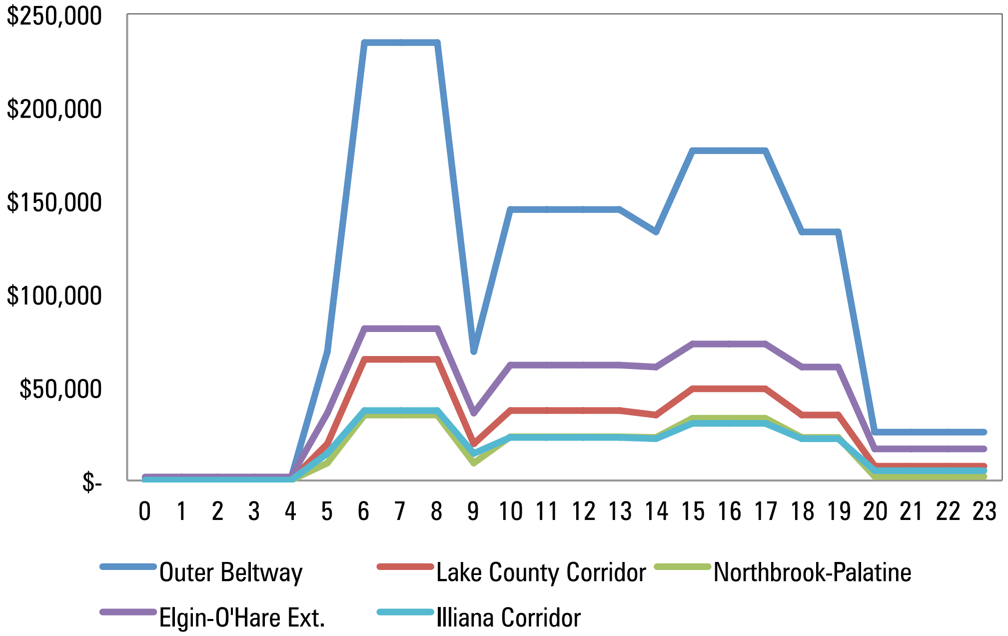
Source: MRTM

Figure B5: 2040 Build–Vehicle Miles Traveled (VMT) by Hour for New Roadways



Source: MRTM

Figure B6: 2040 Build–Toll Revenue by Hour for New Roadways (2006 $)



Source: MRTM

B. Regional Metrics by Scenario

This section provides year 2040 comparative metrics by time period from the MRTM model for the following five scenarios:

- 2040 No Build: No projects.
- 2040 Build Base: Implementation of all 11 projects. This scenario matches the one on which the results provided in Part 4.2 are based.
- 2040 Build Inc: The 2040 Build Base assumes no change in real (inflation-adjusted) income between 2007 and 2040. This scenario assumes a 2% per year growth in real income between 2007 and 2040—or 92% total growth in real income during this timeframe.
- 2040 Build without Projects 2 & 3: Same as 2040 Build Base, but without Project 2: Kennedy Tunnel and Project 3: Eisenhower Tunnel, which did not produce as much revenue as Projects 1a and 1b.
- 2040 Build No Queue Jumpers: Implementation of all projects except for Project 10: Arterial Queue Jumpers.

Results are provided for the following three geographies:

- Table B6: City of Chicago only.
- Table B7: Cook County only.
- Table B8: Six-County Chicago Region.

For each scenario, the following metrics are provided by time period: Average Speed, VHD (vehicle hours of delay), VHT (vehicle hours of travel) and VMT (vehicle miles of travel). The right column shows the percentage difference of each scenario compared to the no-build scenario, using the sum across time periods.

Table B6: City of Chicago Year 2040 Metrics

	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total	% Change from NB
2040 No Build									
Speed	37.4	28.6	20.1	22.2	22.1	24.7	31.5	23.8	
VHD	1,641	26,807	161,665	173,463	138,530	90,673	23,020	615,799	
VHT	52,559	126,846	373,048	474,527	371,168	296,983	160,077	1,855,208	
VMT	1,967,804	3,633,865	7,488,232	10,541,000	8,198,688	7,334,938	5,038,862	44,203,389	
2040 Build Base									
Speed	37.6	30.2	22.2	24.4	24.3	26.9	32.4	25.8	8.5%
VHD	1,537	22,216	129,188	136,745	109,532	71,870	20,046	491,134	-20.2%
VHT	48,549	116,180	328,093	418,444	327,550	265,877	147,823	1,652,516	-10.9%
VMT	1,826,223	3,512,463	7,284,482	10,207,363	7,957,568	7,141,601	4,784,244	42,713,944	-3.4%

Table B6: City of Chicago Year 2040 Metrics

	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total	% Change from NB
2040 Inc Test									
Speed	37.9	30.8	22.1	24.7	24.4	27.1	33.2	26.0	9.3%
VHD	1,335	21,243	134,577	135,482	110,073	70,994	18,452	492,156	-20.1%
VHT	47,796	115,606	336,221	418,529	330,281	266,210	146,448	1,661,090	-10.5%
VMT	1,812,702	3,558,979	7,427,301	10,321,499	8,061,255	7,217,324	4,865,833	43,264,893	-2.1%
2040 w/o 2&3									
Speed	37.5	30.2	22.2	24.3	24.2	26.7	32.4	25.8	8.2%
VHD	1,521	21,650	124,926	133,873	105,780	70,777	19,749	478,277	-22.3%
VHT	47,760	113,429	318,603	409,054	318,776	260,302	144,966	1,612,891	-13.1%
VMT	1,792,020	3,422,921	7,084,628	9,926,667	7,730,280	6,942,735	4,695,043	41,594,295	-5.9%
2040 Build No. OJ									
Speed	37.5	30.3	22.5	24.5	24.6	27.0	32.3	26.0	9.2%
VHD	1,558	21,681	124,430	133,371	104,752	69,405	19,872	475,069	-22.9%
VHT	48,198	114,822	321,453	412,888	320,655	261,586	146,599	1,626,202	-12.3%
VMT	1,808,436	3,478,671	7,223,580	10,114,419	7,882,930	7,068,041	4,739,434	42,315,512	-4.3%

Source: MRTM

Findings from Table B6 are as follows:

- *Speed:* The Build scenarios improve average regional speeds in the city of Chicago by 8.2% to 9.3% over the No Build scenario, from 23.8 miles per hour to 25.8 to 26.0 miles per hour. Average speed increases were fairly similar between the AM peak, mid-day, PM peak and PM shoulder time periods.
- *Vehicle Hours of Delay:* The Build scenarios reduce vehicle hours of delay in the city of Chicago by from 20.1% to 22.9% over the No Build scenario, from about 616,000 hours of delay to about 475,000 to 492,000 hours of delay. Most of the delay reductions occur in the AM peak, mid-day and PM peak time periods.
- *Vehicle Hours Traveled:* The Build scenarios decrease vehicle hours traveled in the city of Chicago by from 10.9% to 13.1% over the No Build scenario, from about 1.86 million vehicle hours to about 1.61 to 1.66 million vehicle hours.
- *Vehicle Miles Traveled:* The Build scenarios decrease vehicle miles traveled in the city of Chicago by from 2.1% to 5.9% over the No Build scenario, from about 44.2 million vehicle miles to about 41.6 to 43.3 million vehicle miles.

Table B7: Cook County Year 2040 Metrics

	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total	% Change from NB
2040 No Build									
Speed	40.9	31.8	22.9	25.0	24.6	27.4	35.0	26.7	
VHD	2,590	60,888	358,217	384,674	317,599	208,213	51,004	1,383,185	
VHT	128,766	299,750	866,308	1,091,010	871,126	698,201	384,262	4,339,424	
VMT	5,265,370	9,522,768	19,827,399	27,245,995	21,436,126	19,141,248	13,436,485	115,875,391	
2040 Build Base									

Table B7: Cook County Year 2040 Metrics

	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total	% Change from NB
Speed	41.2	33.2	25.9	27.5	27.3	29.7	35.8	29.1	9.0%
VHD	2,642	57,213	298,365	328,452	270,522	182,826	50,144	1,190,165	-14.0%
VHT	132,478	305,782	829,609	1,061,121	847,300	693,362	395,215	4,264,867	-1.7%
VMT	5,463,720	10,143,035	21,464,565	29,204,648	23,121,049	20,568,726	14,134,507	124,100,250	7.1%
2040 Inc Test									
Speed	41.6	34.0	25.9	27.9	27.5	30.2	36.6	29.4	10.2%
VHD	2,457	53,610	310,448	329,595	275,165	180,142	46,039	1,197,457	-13.4%
VHT	133,265	306,071	853,572	1,075,281	864,108	701,034	394,119	4,327,451	-0.3%
VMT	5,538,942	10,411,908	22,071,368	29,970,324	23,748,007	21,158,092	14,424,271	127,322,911	9.9%
2040 w/o 2&3									
Speed	41.2	33.0	25.8	27.3	27.1	29.5	35.7	28.9	8.4%
VHD	2,675	57,716	295,289	332,965	271,141	184,891	50,144	1,194,820	-13.6%
VHT	132,136	305,257	823,391	1,061,823	844,987	692,936	393,818	4,254,347	-2.0%
VMT	5,439,236	10,075,277	21,281,251	28,968,368	22,933,333	20,409,515	14,056,254	123,163,236	6.3%
2040 Build No. QJ									
Speed	41.2	33.1	25.8	27.5	27.3	29.6	35.7	29.1	8.8%
VHD	2,702	57,619	297,822	328,912	268,659	182,869	50,752	1,189,334	-14.0%
VHT	132,167	304,991	826,345	1,057,784	842,243	690,619	394,442	4,248,589	-2.1%
VMT	5,446,227	10,094,288	21,358,182	29,042,249	23,004,609	20,454,432	14,077,880	123,477,867	6.6%

Source: MRTM

Findings from Table B7 are as follows:

- *Speed:* The Build scenarios improve average regional speeds in Cook County by from 6.6% to 9.9% over the No Build scenario, from 26.7 miles per hour to 28.9 to 29.4 miles per hour.
- *Vehicle Hours of Delay:* The Build scenarios reduce vehicle hours of delay in Cook County by from 13.4% to 14.0% over the No Build scenario, from about 1.38 million hours of delay to about 1.19 to 1.20 million hours of delay. Most of the reductions occur in the AM peak, mid-day, PM peak and PM shoulder.
- *Vehicle Hours Traveled:* The Build scenarios decrease vehicle hours traveled in Cook County by from 0.3% to 2.1% over the No Build scenario, from about 4.34 million vehicle hours to about 4.25 to 4.33 million vehicle hours.
- *Vehicle Miles Traveled:* The Build scenarios increase vehicle miles traveled in Cook County by from 6.3% to 9.9% over the No Build scenario, from about 115.9 million vehicle miles to about 123.2 to 127.3 million vehicle miles.

Table B8: Six-County Chicago Region Year 2040 Metrics

	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total	% Change from NB
2040 No Build									
Speed	44.1	34.5	25.0	27.3	26.8	29.8	38.1	29.1	
VHD	4,294	111,953	665,649	706,031	590,023	386,879	90,483	2,555,311	
VHT	240,081	560,195	1,629,932	2,030,165	1,633,654	1,308,257	713,136	8,115,419	
VMT	10,580,625	19,333,548	40,765,451	55,452,106	43,846,289	39,010,801	27,148,656	236,137,476	
2040 Build Base									
Speed	44.3	35.6	28.1	29.6	29.3	31.8	38.7	31.3	7.6%
VHD	4,335	108,575	557,572	621,550	518,672	353,043	90,871	2,254,618	-11.8%
VHT	246,744	575,929	1,566,441	1,998,900	1,608,184	1,315,265	735,674	8,047,138	-0.8%
VMT	10,940,560	20,517,041	43,960,420	59,254,106	47,106,003	41,762,222	28,434,664	251,975,017	6.7%
2040 Inc Test									
Speed	44.8	36.5	28.1	30.0	29.5	32.3	39.5	31.7	8.8%
VHD	3,937	102,991	585,333	630,247	533,011	351,655	85,318	2,292,492	-10.3%
VHT	249,599	581,864	1,624,616	2,044,217	1,654,498	1,341,104	741,059	8,236,957	1.5%
VMT	11,178,507	21,259,758	45,584,684	61,393,710	48,850,361	43,341,760	29,249,034	260,857,814	10.5%
2040 w/o 2&3									
Speed	44.3	36.5	28.1	29.5	29.2	31.7	38.6	31.2	7.4%
VHD	4,343	108,915	555,204	626,710	518,220	354,698	90,938	2,259,028	-11.6%
VHT	256,458	575,429	1,561,195	2,000,314	1,605,242	1,314,683	734,419	8,037,741	-1.0%
VMT	10,920,811	20,457,241	43,795,201	59,029,716	46,940,587	41,614,989	28,364,844	251,123,389	6.3%
2040 Build No. OJ									
Speed	44.3	35.6	28.0	29.6	29.3	31.7	38.6	31.3	7.4%
VHD	4,401	109,520	560,511	624,493	518,304	354,698	92,079	2,264,005	-11.4%
VHT	246,500	575,979	1,567,487	1,999,101	1,605,461,	1,314,833	735,831	8,045,192	-0.9%
VMT	10,926,236	20,480,876	43,887,989	59,136,986	47,023,009	41,680,152	28,393,725	251,528,972	6.5%

Source: MRTM

Findings from Table B8 are as follows:

- *Speed:* The Build scenarios improve average regional speeds in the Chicago region by from 7.4% to 8.8% over the No Build scenario, from 29.1 miles per hour to 31.2 to 31.7 miles per hour.
- *Vehicle Hours of Delay:* The Build scenarios reduce vehicle hours of delay in the Chicago region by from 10.3% to 11.8% over the No Build scenario, from about 2.56 million hours of delay to about 2.25 to 2.29 million hours of delay. Most of the reductions occur in the AM peak, mid-day and PM peak time periods.
- *Vehicle Hours Traveled:* Most of the Build scenarios decrease vehicle hours traveled in the Chicago region by from 0.8% to 1.0% over the No Build scenario, from about 8.12 million vehicle hours to about 8.04 to 8.05 million vehicle hours. The exception is the 2040 Build with income growth scenario, for which vehicle hours traveled increases by 1.5% to 8.24 million vehicle hours.
- *Vehicle Miles Traveled:* The Build scenarios increase vehicle miles traveled in the Chicago region by from 6.3% to 10.5% over the No Build scenario, from about 236.1 million vehicle miles to about 251.1 to 260.9 million vehicle miles.

Table B9: City of Chicago 2007 Metrics

2007 Base	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total
Speed	37.6	29.0	21.3	23.5	23.2	25.6	31.6	24.9
VHD	1,711	23,716	138,160	141,912	116,407	76,741	22,585	521,232
VHT	52,480	120,488	344,335	428,530	340,425	274,903	157,805	1,718,965
VMT	1,972,893	3,499,986	7,324,423	10,067,190	7,894,708	7,042,125	4,982,189	42,783,514

Source: Booz Allen Hamilton and Smart Mobility, in year 2006 dollars.

Table B10: Cook County 2007 Metrics

2007 Base	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total
Speed	41.1	32.5	24.4	26.3	25.9	28.5	35.3	28.0
VHD	2,670	54,249	305,717	325,794	272,752	179,172	50,190	1,190,544
VHT	129,200	288,467	805,925	1,009,591	812,748	656,398	383,845	4,086,175
VMT	5,311,986	9,361,723	19,662,070	25,560,857	21,032,078	18,737,582	13,546,366	114,212,661

Source: Booz Allen Hamilton and Smart Mobility, in year 2006 dollars.

Table B11: 6-County Core Region 2007 Metrics

2007 Base	Early	AMsh	AMpk	mid	PMpk	PMsh	Late	Total
Speed	44.2	35.4	26.9	29.1	28.5	31.3	38.4	30.7
VHD	4,430	95,407	547,045	562,958	485,743	317,689	87,895	2,101,167
VHT	240,314	529,483	1,488,277	1,825,284	1,492,089	1,203,710	708,773	7,487,930
VMT	10,633,126	18,761,934	40,018,082	53,192,206	42,482,517	37,677,323	27,216,584	229,981,771

Source: Booz Allen Hamilton and Smart Mobility, in year 2006 dollars.

Appendix C: Detailed Estimates for Bus Rapid Transit System

Given the important role transit plays in the Chicago region, the potential for expanding public transit service to meet increasing travel needs was explored as part of this report using the MRTM. Using models of the public transit service Bus Rapid Transit, the routing was developed to mirror missing links in the road investments identified as crucial to meeting regional travel needs.

This appendix provides a more detailed explanation of the rationale for BRT and the particular route configurations used for this report. The next section provides a thumbnail sketch of routes and results. The second section provides extensive background information on BRT concepts, designs and programs. This appendix concludes with a detailed explanation of the routes chosen for modeling in this report.

A. Brief Summary of BRT Ridership Forecast and Results

The service design includes three types of express point-to-point services that use the managed toll lane system:

1) Routes linking suburban park-and-ride lots to suburban activity centers and outer CTA rail stations;
2) Routes linking suburban park-and-ride lots to suburban activity centers and to the Chicago Loop, and
3) Routes using the Cross Town Tunnel.

These routes were intended to minimize travel time and the number of transfers required between key origins and destinations.

BRT average weekday ridership estimates based on forecasts from the MRTM for 2040 are:

1) 15,446 daily unlinked trips with 6,303 of these accessing by walk and the other 9,143 accessing by driving;
2) An increase of 10,734 daily unlinked trips (i.e. 70% of riders new to transit and 30% taken from other transit services), and
3) An increase of 3,998 linked trips per day.

These ridership numbers were disappointing in the face of expected rising population, income and economic growth that would bolster transit usage as land uses densify and urbanize in the future (a feature of the MRTM). The problem in attracting high BRT ridership is largely due to land use. With the exception of the O'Hare Airport, the 2040 demographic forecasts (derived from regional planning agency estimates) do not include very dense suburban activity centers near the BRT routes. BRT has the potential to attract higher density, transit-supportive land use, but this modeling assumes that there would be no such independent effect. The model also does not assume any improvements in the walkability of the suburban activity centers. Such improvements also could increase ridership considerably.

A major advantage of BRT over rail is that it can be developed incrementally. Express point-to-point services using the managed toll lanes could be implemented one at a time at any date when and if higher density, walkable activity centers develop. As more routes develop, there would be beneficial system effects, but any route could also stand alone.

B. BRT System Design Background Information

The core of the Chicago region has one of the most comprehensive public transit systems in the U.S. This system includes the three general levels of service that are characteristic of successful transit systems in European cities and cities in other parts of the world including: 1) slow speed/frequent stop local bus services, 2) higher speed urban rail with less frequent stops, and 3) high-speed commuter rail with few stops.

In the Chicago region, these services are provided by different entities. The CTA provides local bus service in the city of Chicago, and Pace provides bus service in the rest of the core six-county region. CTA also provides the heavy urban rail service in the city of Chicago. Metra provides regional commuter rail service, supplemented by some Pace suburban express bus routes. These providers are coordinated by the RTA. However, it has been a continuing challenge to integrate these different services into a seamless system.

In a traditional dense urban area with highly concentrated development in walkable centers like the Chicago Loop, this type of system that the Chicago region has today works very well. A large fraction of households and workplaces are within walking distance of a transit stop. Short trips are accommodated on the slow mode. Longer trips can step up to the higher speed trunk lines.

Yet, this type of transit system has been incapable of responding to the great land use changes that have occurred over the past several decades, including a major shift of the population into low-density suburbs, and the shift of jobs to low- and medium-density suburban areas. It is not feasible to provide walk-access transit to all of these areas, even if the areas were walkable, and many are not. It is prohibitively expensive to extend rail services across these great distances even if it could be justified by ridership forecasts, which it cannot.

A combination of increased auto availability, higher real incomes, and land use changes has caused a decline in the regional transit mode share. Between 1980 and 2000, the transit work trip mode share for the greater Chicago-Gary-Kenosha Consolidated Metropolitan Statistical Area declined from 16.2% to 11.5%,[96] continuing a post-World War II trend.

Expensive new urban rail systems in the United States have met a very polarized response. Proponents argue that they attract new transit riders, encourage economic development and revitalize cities. Opponents respond that they make little difference in changing the regional transportation mode split, and cannot be justified economically.

Bus Rapid Transit (BRT) is an umbrella term for a set of different types of services that are intended to provide some or all of the attractive aspects of rail systems at much lower cost. The federally sponsored National BRT Institute's homepage states:

> *BRT is an innovative, high-capacity, lower-cost public transit solution that can achieve the performance and benefits of more expensive rail modes. This integrated system uses buses or specialized vehicles on roadways or dedicated lanes to quickly and efficiently transport passengers to their destinations, while offering the flexibility to meet a variety of local conditions. BRT system elements can easily be customized to community needs and incorporate state-of-the-art, low-cost technologies that attract more passengers and ultimately help reduce overall traffic congestion.*[97]

The wide range of services called BRT is illustrated in this excerpt from a Federal Transit Administration report:

> *BRT systems in the U.S. have incorporated all types of running ways —mixed flow arterial (Los Angeles, Oakland, Kansas City), mixed flow freeway (Phoenix), dedicated arterial lanes (Boston, Orlando), at-grade transitways (Miami, Eugene), and fully grade-separated surface transit-ways (Pittsburgh), and subways (Seattle, Boston).*[98]

In the U.S. today, these projects represent isolated projects rather than a reworking of the entire system. In many cases, the projects involve upgrading individual bus routes. For example, the Franklin Corridor EmX in Eugene and Springfield, Oregon operates in its own travel lanes, replacing a conventional bus route. With increased visibility and higher frequency, the new EmX has increased ridership, but the travel time has been reduced by only an average of 1 minute in each direction.[99] Similarly, the $200 million investment in the Euclid Avenue corridor in Cleveland, including upgrading a conventional bus route to the HealthLine BRT, has initially increased ridership by only 12% over the former conventional bus route.[100]

This project focuses on how the proposed system of managed toll lanes for the Chicago region might be integrated with BRT. This is a very different type of BRT than the Eugene and Cleveland examples discussed above. As of now, no U.S. region has implemented a comparable system, but some regions in the U.S. are planning BRT systems using managed freeway lanes. For example, the San Diego region is integrating freeway BRT as part of a managed lane system. An example is the Interstate 15 Express Lanes project currently under construction, with BRT operation scheduled to begin in 2012.

An integral part of the express lanes is the BRT system, a new high frequency express bus system that will connect residential areas with major employment centers. Buses will run more often, providing reliable and convenient service that is similar to the services of a light rail system. Five BRT Centers will be available along the I-15 at the Mira Mesa Transit Station, Sabre Springs/Peñasquitos Transit Station, Rancho Bernardo Transit Station, Del Lago Transit Station and Escondido Transit Station.

The Transit Stations will connect to the I-15 Express Lanes by Direct Access Ramps (DARs). DARs allow buses and HOVs to directly access the express lanes without yielding to traffic in the general purpose lanes.[101]

The San Diego plans call for transit stations to be located alongside the highway with direct access ramps to the managed lanes.

Figure C1: Direct Access Ramp at Sabre Springs/Peñasquitos Transit Station

Source: Booz Allen Hamilton and Smart Mobility, in year 2006 dollars.

In contrast, Minnesota DOT is planning for transfers from freeway BRT to local bus services with inline stations in its I-35W Bus Rapid Transit project.[102] These are stations in the median of the highway with elevators to move passengers to local grade-separated bus routes.

These are two contrasting strategies for dealing with a fundamental issue with managed freeway lane BRT—how to utilize the high-speed potential of the managed lanes without losing too much time in travel onto and off the roadway. It also is critical to provide as high a quality of service as possible to the customers.

From the customer's perspective, the ideal transit trip is a "one-seat ride" beginning at his origin and ending at his destination. This is the great advantage of private cars; they usually provide a one-seat ride. In the suburbs, a one-seat transit ride generally is infeasible. The closest approximation is likely to be driving from home to a park-and-ride lot, and then taking a transit trip to the final destination. In some cases, a feeder bus route may be available from home to the transit station. Either case requires two seats—the car/feeder bus plus the BRT. And this is a best case scenario. The majority of suburban transit trips will be likely to require more than two seats. Whenever an additional transfer is required, the mode share drops. While the time traveling on a transit vehicle can be productive for work, reading, socializing or rest, transfers are disruptive and undesirable.

In either the San Diego design or the Minneapolis design, reaching the final destination will likely require transferring to a local bus at a highway transit station. This is a third seat, and additional transfers could be required.

Neither San Diego nor Minneapolis has published full transit system designs that show how the non-BRT services will be integrated. Given the lack of U.S. experience, it is helpful to look outside the U.S. for examples of how BRT can change an entire transit system. One success story is the "Quickway" model described in a 2008 report published by the Federal Transit Administration.[103]

The Quickway model focuses on the creation of grade-separated running ways, or Quickways, with passing facilities at stations, in order to permit a range of services, many of which will branch off from the originating corridor. The investment in grade-separation permits much higher operating speeds (especially at high bus volumes) than would be possible with at-grade busways, reducing the travel time needed to produce any given service, changing in fundamental ways the cost basis of operating such services: as operating costs go down (due to shorter round-trip times) and revenues increase (due to the increase in ridership associated with reduced travel time), a virtuous circle is created.[104]

In the Quickway regions highlighted—Ottawa, Bogota and Brisbane—the grade-separated running ways are primarily exclusive busways. While managed shared freeway lanes could similarly provide high-speed and reliable service, there can be tradeoffs as described in the Quickway report as part of the Brisbane case study.

Brisbane's Quickways avoid running in the center of arterials or freeways—at least, in the central urbanized area. This is a major distinction between the two systems, and one that represented a deliberate choice for Brisbane planners. Freeway-based operations posed a number of strategic hazards:

- They would create pressure to open up the facilities to automobiles (for example, the El Monte Busway in Los Angeles was eventually opened to carpools), which would then create safety concerns at stations and reduce the reliability of the system (maintaining exceptionally high reliability was seen as key for attracting and retaining transit riders);

- They would locate stations farther away from actual land uses, forcing potential users to walk longer distances on isolated bridges over freeways, reducing the attractiveness of the system;
- Additional noise and isolation would make stations less attractive, and tighter spaces would preclude full stations (with passing lanes and generous passenger platforms); and
- In the end, it would impose greater costs and engineering challenges to get transit vehicles in and out of the facility without getting caught in intervening traffic.

The southern segment of the Southeast Busway was therefore built adjacent to the Southeast Motorway in mostly unused right-of-way; at key points, it deviates slightly to permit better station integration into major trip generators.[105]

This discussion highlights a significant challenge in designing the BRT system—how to use the managed lanes for BRT while minimizing the negative aspects that the Brisbane planners avoided. The first issue raised in Brisbane, reliability, should not be a problem for the managed toll lanes because a high level of service will be maintained with dynamic pricing. (However, it will be important to design access and egress so that congestion is avoided at these points as well.)

The other issues involve the aesthetics and locations of transit stations, especially the issue discussed above of forcing bus transfers (which are undesirable in any case) either in medians (as in the Minneapolis design) or adjacent to a major highway (as in the San Diego design). Instead of either of these options, this report favors a set of overlapping point-to-point express routes where the endpoints are not necessarily on the major highway.

This concept borrows from Quickway case studies where higher speed service without transfers is provided between popular origins and destinations. For example, in Bogota:

> *An extensive origin/destination survey along the key corridors was conducted, and the result of this exercise was the identification not of a single set of parallel express routes, but of a network of express routes, each linking a group of stations that the origin/destination analysis had identified as generating sufficient demand for such services.*

The power of this express network becomes apparent when one considers that both all-stops and express services were devised that “turn the corner” from one corridor to another, permitting travel along different corridors without the need for transfer.[106]

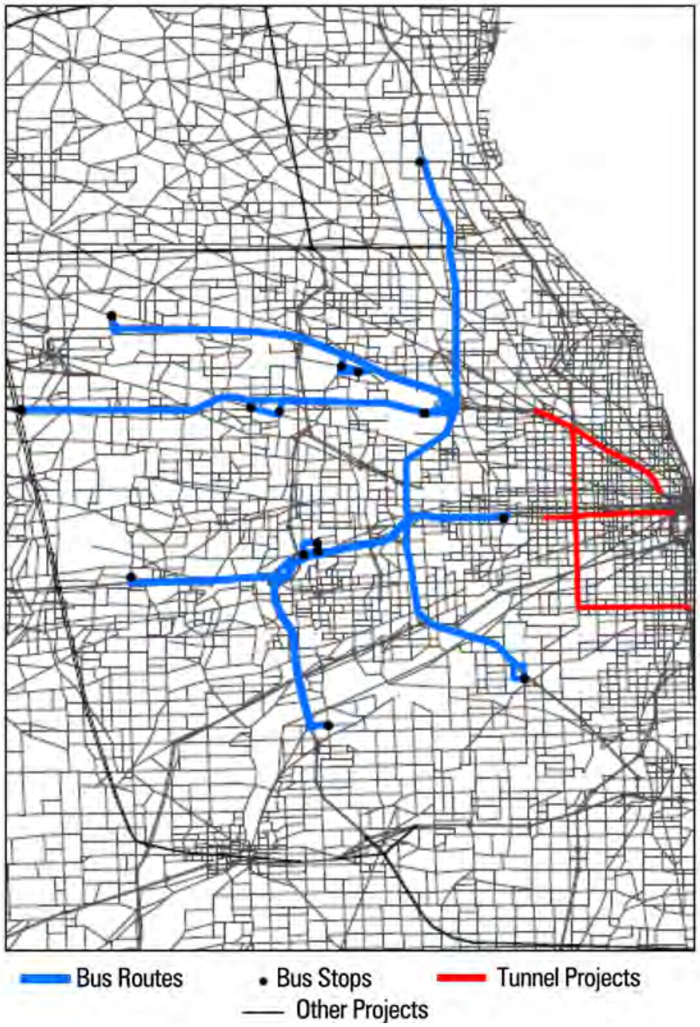
C. BRT System Design for the Chicago Region

BRT services for the Chicago region emphasized point-to-point express routes that use the managed lane system in this report. In this way, public transit could piggyback on the investments in the roadways to leverage costs. This approach also addresses concerns over the cost-effectiveness of adding new capacity to the regional public transit system during a period of tight budgets and the strategic importance of bringing the existing network up to a state of good repair.

Three general groups of BRT service were included in the design of the regional BRT system as illustrated in the following three graphics.

- Routes linking suburban park-and-ride lots to suburban activity centers and outer CTA rail stations;
- Routes linking suburban park-and-ride lots to suburban activity centers and to the Chicago Loop, and
- Routes using the Cross Town Tunnel.

Figure C2: Routes Linking Suburban Park-and-Ride Lots and Suburban Activity Centers

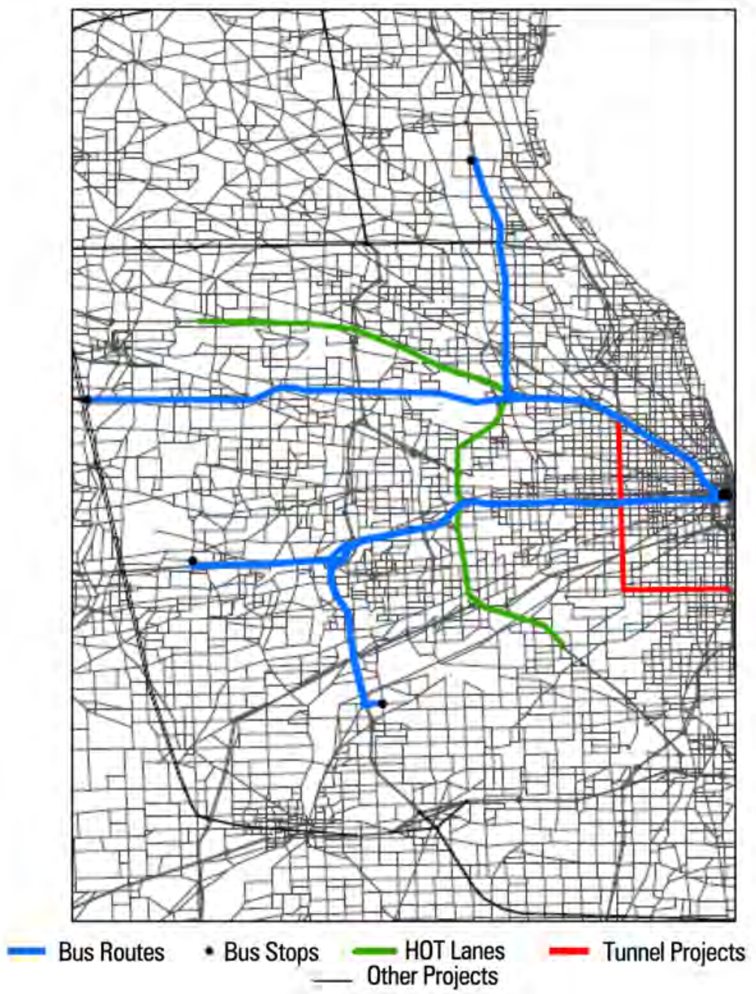


Source: Booz Allen Hamilton and Smart Mobility, in year 2006 dollars.

Figure C2 shows BRT routes (in blue) and station locations (black dots) for the first group. Each route includes a suburban park-and-ride location (which also could be an activity center) at the outer edge of the radial managed toll lanes system. The BRT would travel without stops and then exit and serve a set of local activity centers. It would then return to the managed toll lanes and continue on to an outer CTA rail station. This can also be an activity center, as in the case of the O'Hare station, which also is located at a major activity center. In this way, the BRT routes provide both drive-access transit trips to the suburban activity centers and reverse commute transit service to the suburban activity centers (through the CTA bus/rail system).

Figure C3 shows routes on many of the same alignments that would provide direct express service to the Chicago Loop from suburban park-and-ride lots.

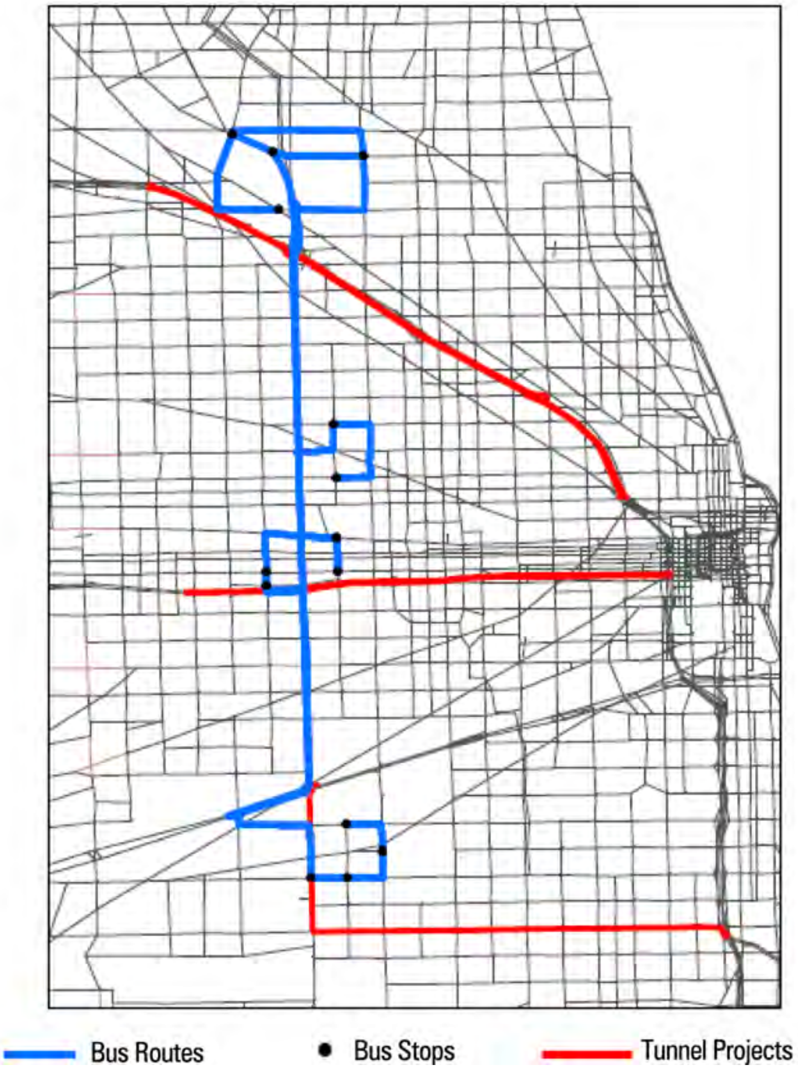
Figure C3: Routes Linking Suburban Park-and-Ride Lots and Chicago Loop



Source: Booz Allen Hamilton and Smart Mobility, in year 2006 dollars.

The third group of BRT routes uses the Cross Town Tunnel to provide express services between activity centers.

Figure C4: Routes Using Cross Town Tunnel



Source: Booz Allen Hamilton and Smart Mobility, in year 2006 dollars.

In all three groups the locations for the stops were selected based on the number of trip ends estimated by Traffic Analysis Zone (TAZ) based on the 2040 household and employment projections. Service assumptions include:

- 15 minute headways;
- Travel times peak period auto travel time plus 4 minutes per stop (acceleration time, deceleration time, stop time, and any extra time for getting to stations);
- Distance-based fares similar to Metra commuter rail fares.

D. BRT Modeling Results

The ridership results are somewhat disappointing. The routes are forecast to collectively attract a total of 15,446 daily unlinked trips in 2040, with 6,303 of these accessing by walking and the other 9,143 accessing by driving. Some of the unlinked BRT trips are attracted from other transit service (all existing transit service was maintained in the 2040 modeling). Comparing the 2040 model with BRT vs. the 2040 model without BRT (both with all of the road projects), the number of unlinked trips in the BRT model is 10,734 higher than for the model without BRT. Therefore, about 70% of the BRT ridership is new to transit, and the other 30% is drawn away from existing transit services. Many one-way transit trips involve more than a single unlinked trip. The BRT model increases daily linked transit trips by only 5,850.

The route with the strongest ridership (more than 3,000 unlinked trips) is the route along the Elgin-O'Hare Extension connecting a park-and-ride lot near the Outer Beltway to O'Hare Airport. In general, the group 1 suburban services show higher ridership than the routes that go all the way to the Chicago Loop. Ridership for the Loop routes is held down by a combination of a relatively small market for such long transit trips and competition with Metra service that serves these trips relatively well. The ridership for the Cross Town Tunnel routes generally is higher than for the Loop routes but lower than for the suburban routes. Ridership for these routes is held down somewhat by a conservative assumption that it will not be feasible to provide park-and-ride lots at these locations, which are within the city of Chicago.

E. Potential for Increasing Ridership

The problem in attracting high BRT ridership in the model is largely due to land use. In suburban areas with free parking and high mobility, even the best transit service can achieve only a low mode share, perhaps 5%. Therefore, a successful transit service will need to draw this 5% from a large number of trips going from the same origins to the same destinations. With the exception of the O'Hare Airport, the 2040 forecasts do not include any very dense suburban activity centers that are served by the BRT routes. The Reason model included stops at the places with the highest trip generation numbers, and would have included more stops if there were more activity centers with high trip generation.

BRT does have potential for attracting higher density, transit-supportive land use, but this modeling assumes that there would be no such effect. This research also did not assume any improvements in the walkability of the suburban activity centers. Such improvements also could increase ridership considerably.

A major advantage of BRT over rail is that it can be developed incrementally. Express point-to-point services using the managed toll lanes could be implemented one at a time at any date when and if higher density, walkable activity centers develop. As more routes develop, there would be beneficial system effects, but any route could also stand alone.

Appendix D

Appendix D: The Metropolis 2020/Reason Foundation Transportation Model

The Metropolis/Reason Transportation Model of the Chicago region (MRTM) has many advanced features that support more accurate transportation modeling that is sensitive to roadway and transit capacity, land use and pricing.

The original Metropolis Transportation Model was developed for modeling scenarios for the *Metropolis Plan*: *Choices for the Chicago Region*.[107] Compared to most other regional transportation models, the MTM is noteworthy because it includes features that make the model more sensitive to urban form. In the MTM, auto ownership depends, in part, on residential density and transit service. The MTM includes a walk trip model that is sensitive to residential density, employment density and the balance between jobs and housing. The MTM's mode choice model (auto versus transit) is sensitive to urban form variables.[108]

Enhanced freight modeling capability was added when the MTM was used in developing the *Metropolis Freight Plan*.[109] Enhancements in this stage included:

- splitting weekday travel into four modeling periods, and
- modeling cars and trucks separately using a multi-class assignment process.

The separate model time periods provide better estimates of traffic conditions under congested morning and afternoon peak period conditions. This model structure also supports pricing analyses.

Modeling cars and trucks separately supports modeling roadways where trucks are prohibited and also truck-only roadways. It also supports different toll structures for trucks and cars.

Further model improvements were made for transit analyses for the RTA in 2007. These enhancements include:

- income stratification in work trips;
- improved transit travel times, and
- new mode choice coefficients for improved sensitivity to transit service variables.

The MTM models several trip types. Trips between home and work are particularly important for weekday transit trips and peak congestion. This version of the MTM improves the accuracy of modeling work trips by dividing workers and jobs into four income segments. This accounts for areas where there are mismatches, e.g. an excess of high-income jobs in the Loop that may not be available to a large share of inner city residents, or an excess of low-income service jobs in high-income suburbs.

In the earlier MTM, it was assumed that there was a single speed for each rail and bus line, and that this speed would not change between the present and the future. In the enhanced MTM, transit travel times are calculated based on a running speed and a "dwell time" for each stop. Appropriately, this enables express services with fewer stops to have shorter travel times than local services. The travel speed for buses is based on the congested travel speed for cars, so that bus travel times may be longer in the future than they are today.

The earlier versions of the MTM were estimated from the CATS household travel survey data collected in the early 1990s. The mode choice model coefficients for work trips in this enhanced MTM have been estimated from 2000 Census data. (CMAP is now doing a new household travel survey—the first in the region since 1990–1992.) The estimated model incorporates the urban form variables used in earlier MTM versions, but places equal emphasis on sensitivity to transit service, particularly transit travel times and fares.

The Reason Foundation dynamic pricing project adds three enhancements to the model:

1) Additional time periods;
2) Dynamic pricing internal to model;
3) Multi-class assignment by income group.

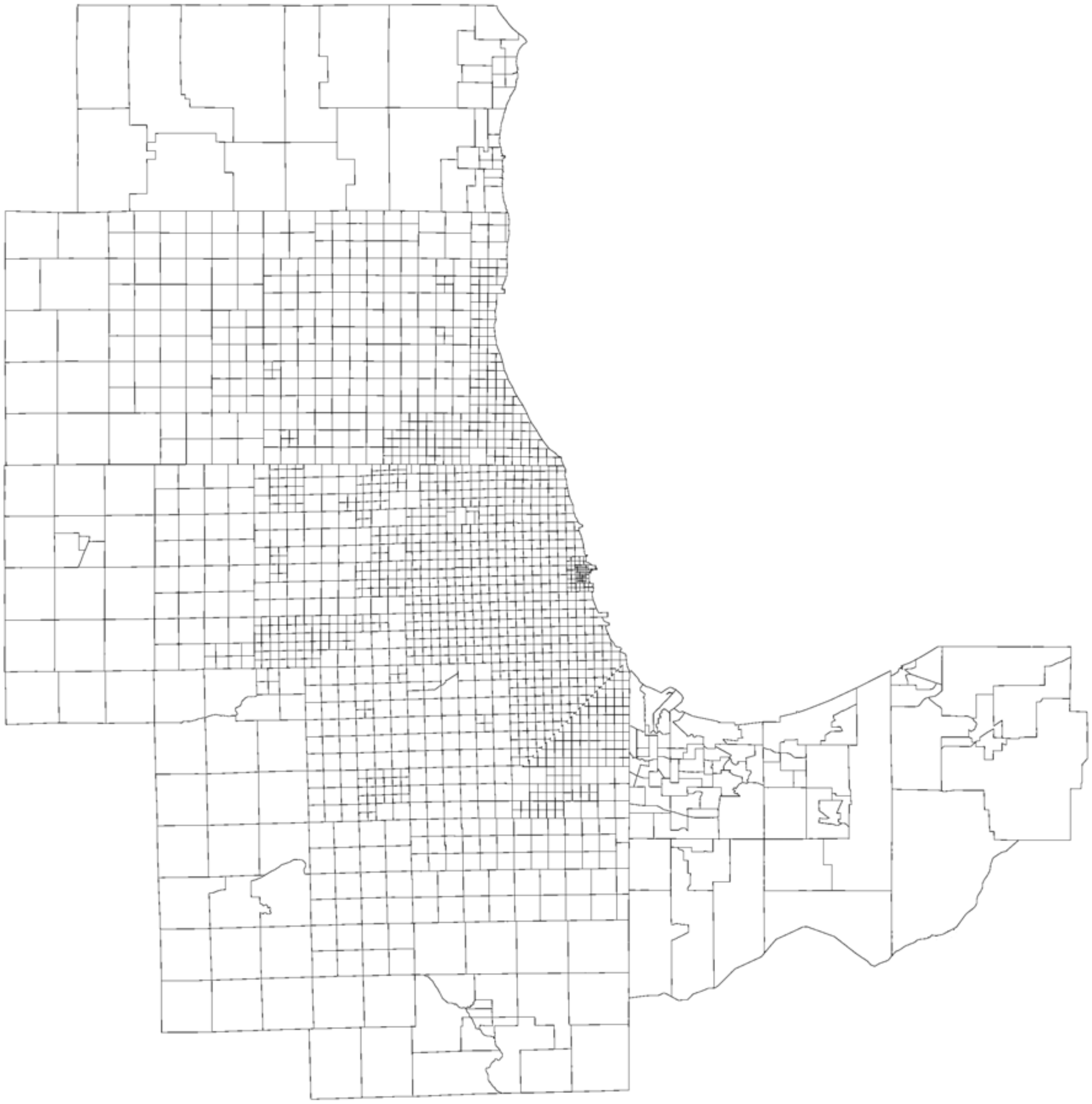
Additionally, it increases the number of time periods from four to seven. As discussed above, the model now dynamically calculates tolls for each directed link for each time period.

In the prior model version, the various income groups exhibited different behavior when deciding where to go (trip distribution) and what mode to use (mode choice). In this version, the income groups also behave differently when choosing roadways (assignment), for example higher income workers have higher values of time and are more likely in the model to choose tolled roadways.

A. Transportation Analysis Zones

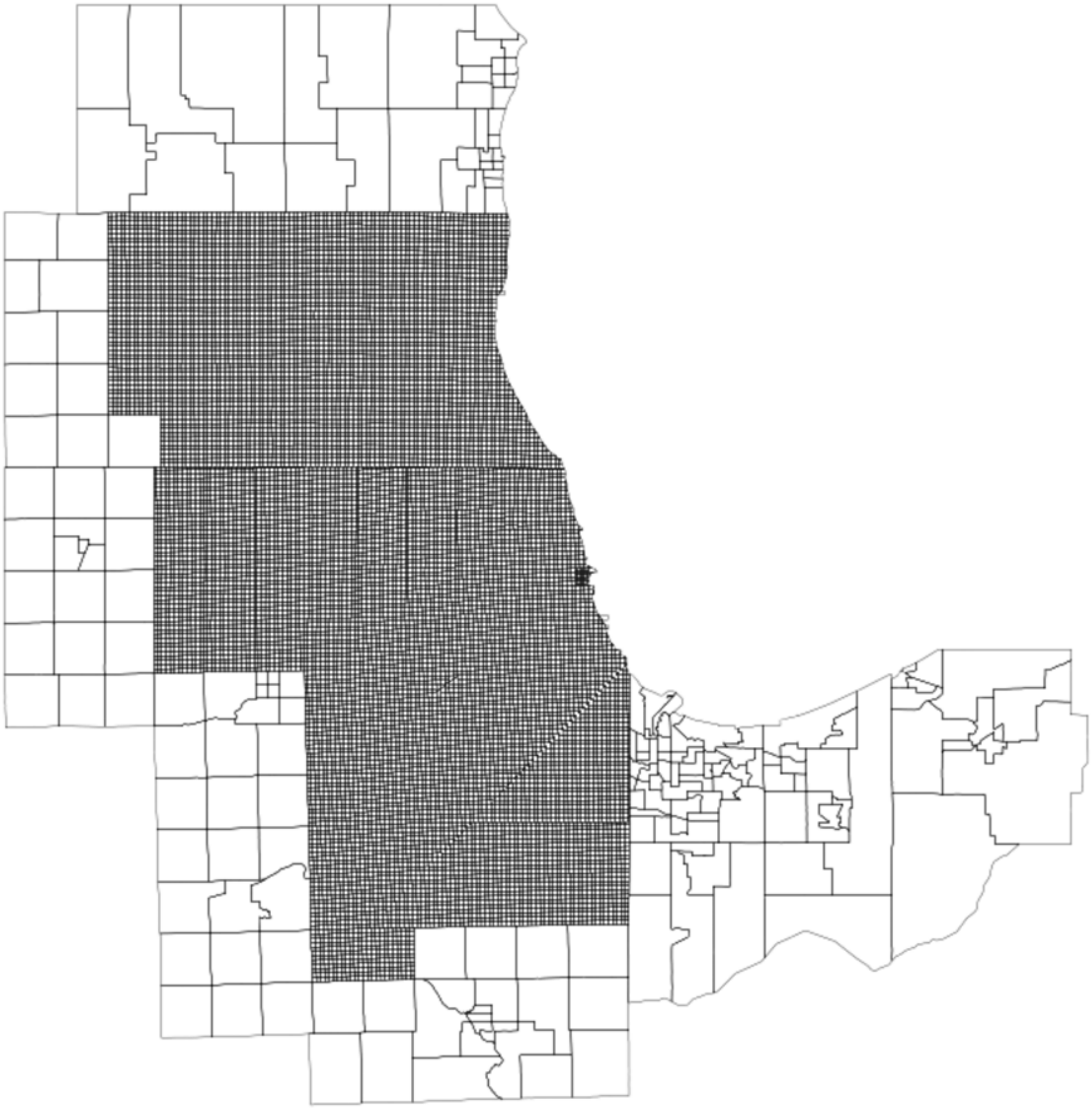
The MRTM uses the same Traffic Analysis Zones (TAZs) used by CMAP. This includes 1,877 internal TAZs and 14 external TAZs for a total of 1,891 TAZs. The TAZs are smallest in the Loop and become increasingly large as the distance from the core increases. The model area includes 15 counties, including counties in Wisconsin and Indiana. The TAZs are shown in Figure D1.

Figure D1: MRTM Transportation Analysis Zones



Households and employment data and projections from CMAP are tabulated at a finer "subzone" level within the core six-county area. As discussed below, some MRTM calculations are done at this finer subzone level. The 15,334 subzones are illustrated in Figure D2 (although individual subzones are too small to see in the figure).

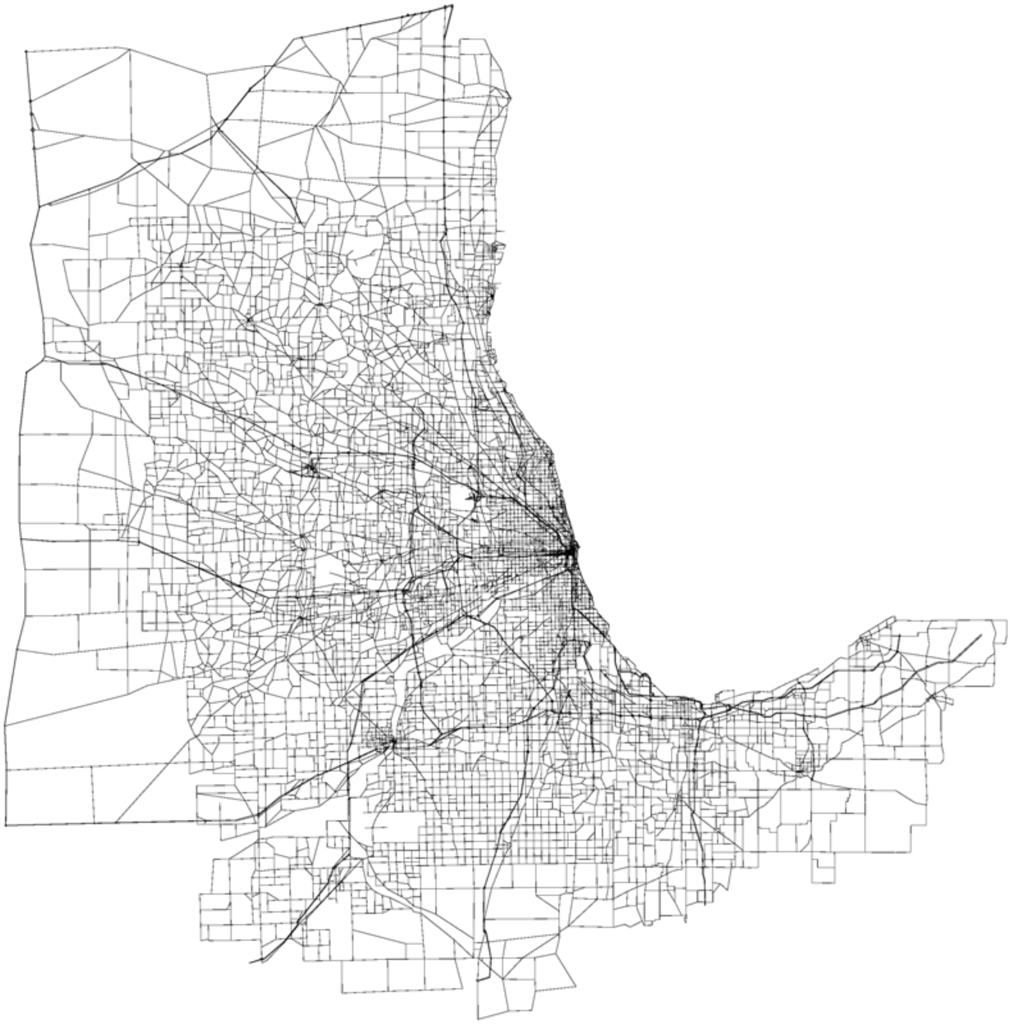
Figure D2: MRTM Subzones



B. Road Network

The road networks were received from CMAP in emme/2 format and converted to TransCAD format for use in the MRTM. The 2007 base network includes 23,807 links (including both one-way and two-way links) plus centroid connectors that connect the road network to the 1,891 TAZs.

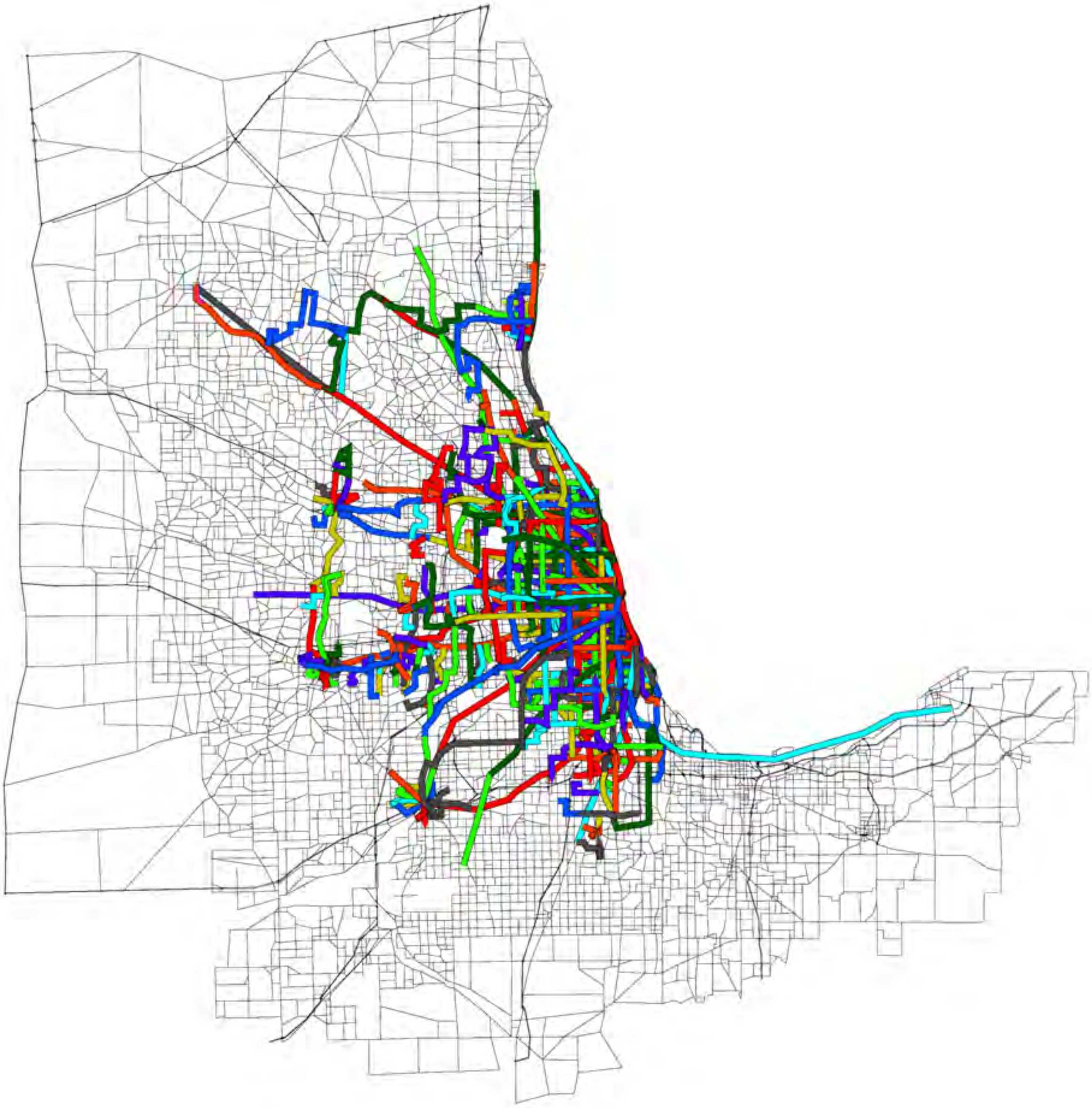
Figure D3: 2007 Roadway Network



C. Transit Network

The transit networks were received from CMAP in emme/2 format and converted to TransCAD format for use in the MRTM. The transit network includes METRA rail, CTA rail, CTA bus and Pace bus fixed-route and schedule services.

Figure D4: 2007 Transit Network



D. Households and Employment

Households and employment data and projections for 2007, 2020 and 2030 at the subzone level were received from CMAP and used in this project.

E. Four-Step Model

The MRTM generally follows the standard four-step modeling process with some extensions. The basic four steps are:

1) *Trip Generation* – calculating the number of origins and destinations by trip type for each land use type;
2) *Trip Distribution* – matching the origins and destinations to form complete trips;
3) *Mode Choice* – determining the mode for each trip (auto, transit or walking);
4) *Traffic Assignment* – assigning autos to the auto network.

In addition to these trips, the MTRM includes two other steps: an "Auto Availability" step prior to Trip Generation, and a "Walk Model" step between Trip Generation and Trip Distribution. The MTRM includes "feedback" between the Trip Distribution, Mode Choice and Assignment steps. All of these choices are dependent on automobile and transit travel times. If routes are highly congested in the peak travel hour, some travelers may choose alternate destinations. Others may choose alternate modes. The method of successive averages (MSA) is used to accomplish this feedback process.

F. Auto Availability

Trip Generation includes both auto trips and non-auto walk and transit trips. Nevertheless, the number of total trips made has been found to be related to the number of available autos. Those households with more autos make more trips, on average, than those with fewer autos. Therefore, predicting the number of autos in each scenario is important. The phrase "Auto Availability" is used interchangeably with "auto ownership" among transportation modelers, although "Auto Availability" is more precise because many vehicles are leased.

The MTM estimates Auto Availability using a statistical model developed by the Center for Neighborhood Technologies (CNT) from Chicago data.[110] In this model, Auto Availability is calculated as an average value that is influenced by four multiplicative factors. These are:

- *income* – Auto Availability is lower with low incomes;
- *household size* – Auto Availability increases with household size;
- *residential housing density* – Auto Availability decreases with increased density, and
- *transit accessibility* – Auto Availability decreases with increased transit service.

G. Trip Generation

The MRTM segments travel information into seven trip types, including:

- home-based work trips for income group I (lowest income)
- home-based work trips for income group II
- home-based work trips for income group III
- home-based work trips for income group IV (highest income)
- home-based non-work trips
- work-based non-home trips
- non-home/non-work trips

Trip generation rates in the original MTM were estimated from 2000 Census Journey to Work data and the 2001–2002 National Household Travel Survey (NHTS).

1. Walk Model

The TAZs in the model typically are too large to treat walk trips realistically within the Trip Distribution and Mode Choice steps. Therefore a separate Walk Model step has been added between the Trip Generation and Trip Distribution steps. In this step, non-motorized (walk and bicycle) trips are estimated. This is done with a statistical model estimated from the CATS household survey data with the “3 Ds”—“Density,” “Distribution” and “Design,” – as independent variables. The 3 Ds have been used extensively in studies of land use/transportation interactions throughout the United States. “Density” includes separate measures of housing density (units per square mile) and employment (employees per square mile). “Diversity: is the absolute value of the difference between the two density numbers, and is a measure of jobs/housing balance. “Design” approximates the walkability of a neighborhood by counting the number of intersections per square mile.

2. Trip Distribution

Trip distribution functions represent the relative attractiveness of possible destinations with differing travel times. These functions also were estimated using 2000 Census and 2001–2002 NHTS data. Origins and destinations are computed for internal-to-internal trips and also for external-to-internal and internal-to-external trips.

3. Mode Choice

The mode choice between auto and transit depends on the service characteristics of each mode, including travel time and out-of-pocket cost. The modeling of transit travel times is realistic for both rail and bus transit. Rail transit is modeled with running speeds and dwell times for each stop. In cases where there are both express and local trains, TransCAD is able to calculate the probability of getting either an express or local train, and estimates an average travel time. Bus travel time is estimated based on the congested travel times on the streets and an additional time for each stop. The functional form is a nested binomial logit model.

4. Trucks and Through Trips

Base year and future truck trip tables were estimated during the freight project. These truck trips are added to the trip tables prior to assignment. Estimated through-trips also are added in at this stage.

5. Traffic Assignment

The MRTM uses a multi-class assignment process with six classes:

- Income group I work trips
- Income group II work trips
- Income group III work trips
- Income group IV work trips
- Non-work trips
- Trucks

Some roadway links, including the tunnels, prohibit trucks. Truck tolls on the Illinois State Tollway system are higher than car tolls. Values of time ($ per hour) vary for the different trip types. For example, higher income workers and truckers are willing to pay higher tolls for the same amount of time savings.

The MRTM uses equilibrium assignment with 50 assignment iterations in the final assignment for each time period.

6. Model Feedback

The four-step model represents a complex decision made all at once—where to go, what mode to take, and what route to take—as a set of sequential steps. If only one pass through the steps is made, the assumptions during the different steps may be inconsistent. For example, during the first pass it will appear that the roadways are uncongested. Therefore, travel demand in the first pass will be overestimated. This problem is corrected through model feedback, i.e. feeding back the congested travel times to the Trip Distribution and Mode Choice steps. The results from the different steps are averaged using the Method of Successive Averages (MSA). Four passes through the four-step process are done.

7. Time of Day Modeling

The four MSA passes are done for the morning peak hour period only. This establishes the daily transit and auto trip tables. The daily auto trip table is then segmented into trip tables for each of the other time periods and assigned.

8. Modeling Dynamic Tolls

The addition of dynamic tolls to the model required another set of MSA iterations within the assignment step. At the end of each dynamic toll MSA iteration, the assigned volume for a dynamic toll link is checked against the target (1,600 vehicles per lane per hour). If the volume is too high, the toll is increased. If the volume is below the target, the toll is decreased—but not below $1 per segment. Eight dynamic toll MSA iterations are done.

9. TransCAD Implementation

The auto availability, trip generation, and walk model steps have been implemented in Microsoft Excel. All of the other steps are implemented in TransCAD using the built-in GISDK scripting language.

10. Model Validation

The model validation builds on all previous model development work and model experience. In the current project, model validation has been limited to three areas:

- Checking the model traffic volumes for major roadways;
- Checking whether traffic loading is realistic for toll roads, and
- Checking volumes by time period.

The Illinois State Department of Transportation posts traffic flow maps on its website with average daily traffic volumes for major roadways, including both free roads and toll roads. Modeled daily traffic volumes were checked against a representative sample of major roadway links.

Table D1: Model Fit with Illinois DOT Daily Traffic Flow Maps

	Number of Roadways	Total Error	RMSE[111]
Toll	66	-2.9%	18.1
Non-Toll	38	-3.2%	26.7
Total	106	-3.7%	22.8

Hourly data from Illinois DOT for 49 locations in the Chicago region was used—all for non-toll locations. Before delivering the data, the data were accepted "as is" and possibly less than completely accurate. In general, the volumes appear to be somewhat higher than the traffic volumes on the traffic flow maps for the same roadway links, and the numbers may be inflated. Therefore, we focused more on the proper distribution of traffic during the day rather than on the exact numbers. The calculated RMSE numbers for the seven periods are: early 26.2, a.m. shoulder 19.8, a.m. peak 20.5, mid-day 20.6, p.m. peak 24.8, p.m. shoulder 20.9, and late 19.1

Endnotes

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[1] *Moving at the Speed of Congestion*, p. 2; Metropolitan Planning Council, August 2008. Also based on follow up information from MPC provided by e-mail, August 2009. These estimates were made before the recession. While congestion levels eased somewhat during the economic decline, most accounts indicate congestion is increasing again due to the modest economic recovery.

[2] Congestion data from David Shrank & Tim Lomax, *2010 Urban Mobility Report*, Texas Transportation Institute, Texas A&M University. Revenues of Chicago sports teams based on annual revenues estimates calculated by *Forbes* magazine and reported at *Forbes.com*.

[3] David Shrank, Tim Lomax and *2011 Urban Mobility Report* (Texas Transportation Institute, Texas A & M University, December, 2012), http://mobility.tamu.edu/files/2011/09/chica.pdf

[4] David T. Hartgen and M. Gregory Fields, *Building Roads to Reduce Congestion in America's Cities: How Much and at What Cost?* Policy Study No. 246 (Los Angeles: Reason Foundation, 2006), http://reason.org/news/show/127670.html, accessed March 16, 2011; see also Sam Staley and Adrian Moore, *Mobility First: A New Vision for Transportation in a Globally Competitive 21st Century* (Lanham, MD: Rowman & Littlefield, 2006), pp. 11-17.

[5] PricewaterhouseCoopers UK Economic Outlook, November 2009, Table 3.3, p. 22, https://www.ukmediacentre.pwc.com/imagelibrary/downloadMedia.ashx?MediaDetailsID=1562, retrieved March 16, 2011.

[6] Ibid., Table 3.4, p. 23.

[7] *Economic Factors Tap the Brakes on Traffic Congestion*; 2009 Annual Urban Mobility Report Press Release, July 2009, http://mobility.tamu.edu/ums/media_information/press_release.stm

[8] Shrank and Lomax, *2010 Urban Mobility Report*, Table 2, p. 26.

[9] See the discussion in Sam Staley and Adrian Moore, *Mobility First: A New Vision for Transportation in a Globally Competitive 21st Century* (Lanham, MD: Rowman & Littlefield 2009), Chapter 3, pp. 37-45.

[10] See Staley and Moore, *Mobility First*, pp. 140-42.

[11] An urbanized area is different from a metropolitan area. Metropolitan areas consist of counties with both rural and urban characteristics. The metropolitan area is configured by the U.S. Bureau of the Census primarily based on commuting patterns between counties. An urbanized area, on the other hand, describes a region primarily based on the contiguity and degree of urbanized land based on measures of density. Thus, an urbanized area is typically geographically smaller, but represents a more cohesive economic region than a metropolitan area (which often includes significant rural area components that may or may not be connected to the regional urban economy).

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[12] Jack Wells, Chief Economist, U.S. Department of Transportation, "The Role of Transportation in the U.S. Economy," presentation to the National Surface Transportation Policy and Revenue Study Commission, June 26, 2006.

[13] Overall travel is calculated by the authors based on estimates from the complete dataset provided by the Texas Transportation Institute for their *2010 Urban Mobility Report* and assuming Chicago average vehicle occupancy is equal to the national average (1.59 people per car). Market share for commuter travel is based on data from the 2006-2009 American Community Survey for Chicago.

[14] There is not an apparent direct correlation between the Travel Time Index (for which Chicago was relatively high among the regions) and annual hours of delay per peak traveler (for which Chicago was relatively low). This is because the Travel Time Index only represents the ratio of peak period travel times to free flow conditions. Other factors, including average commute lengths and automobile mode shares, impact annual hours of delay per peak traveler.

[15] Alan Pisarski, *Commuting in America III*, NCHRP Report 550 (Washington, D.C.: Transportation Research Board, 2006) Table 3-34, p. 94. See also Wendell Cox, "Demographia, United States, Central Business Districts," Table 3, Ranking: CBD Transit Market Share, June 2006, www.demographia.com/db-cbd2000.pdf.

[16] *"The Role of Transportation in the U.S. Economy,"* Jack Wells, Chief Economist, U.S. Department of Transportation, presentation to the National Surface Transportation Policy and Revenue Study Commission, June 2006.

[17] *Updated 2030 Regional Transportation Plan for Northeastern Illinois*, Chicago Metropolitan Agency for Planning, October 2008, p.14.

[18] *Chicago Region Environmental and Transportation Efficiency Program; Final Feasibility Plan*, Federal Highway Administration Illinois Division Office, August 2005, p.37.

[19] *The Metropolis Plan: Choices for the Chicago Region, Section I: The Metropolis Plan*, Chicago Metropolis 2020, February 2003, p.22.

[20] *Updated 2030 Regional Transportation Plan for Northeastern Illinois*, p.8.

[21] *Moving at the Speed of Congestion*, p.6.

[22] During the short run, perhaps even a decade or two, it might seem that rising congestion and economic growth go hand in hand as more jobs and cars are added to a largely stagnant road system. This perception is deceptive. Congestion has a distinctly negative impact on the economy, even if its effects are overshadowed on the surface by stronger forces such as non-transportation-related increases in productivity or innovations that create the illusion of long-term growth. Silicon Valley is perhaps the classic example of a urban region that rode the coattails of high-tech innovation for decades but is now struggling with maintaining its competitive advantage in no small measure because of high congestion and low mobility, and its accompanying high transportation costs (for workers, freight and families).

[23] Arthur O'Sullivan, *Urban Economics*, 6th edition (New York: McGraw Hill, 2007), pp. 207-224.

[24] See the brief overview and description in Arthur O'Sullivan, *Urban Economics*, 6th ed. (New York: McGraw-Hill, 2007), pp. 20-23; Ted Balaker and Sam Staley, *The Road More Traveled: Why the Congestion Crisis Matters More Than You Think, and What We Can Do About It* (Lanham, MD: Rowman & Littlefield, 2006); Joel Kotkin, *City: A Global History* (New York: Modern Library, 2005).

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[25] See, for example, Vernon Henderson, "How Urban Concentration Affects Economic Growth," Policy Research Working Paper, The World Bank, Development Research Group, April 2000. In some nations, urbanization is promoted as a matter of policy to reduce reliance on the agricultural sector. This is particularly evident in many African countries. Nevertheless, even in these cases, an economy's wealth is primarily generated by cities.

[26] Remy Prud'homme and Chang-Woo Lee, "Size, Sprawl, Speed and the Efficiency of Cities," *Urban Studies* Vol. 36, no. 11 (October 1999), pp. 1849-1858.

[27] Remy Prud'Homme, "Transportation and Economic Development," paper prepared for ECMT 199th Round Table, March 2000.

[28] Lourens Broersma and Jouke van Dijk, "The Effect of Congestion and Agglomeration on Multifactor Productivity Growth in Dutch Regions," *Journal of Economic Geography*, Vol. 8, no. 2 (2007), pp. 181-209.

[29] Robert Cervero, "Efficient Urbanization: Economic Performance and the Shape of the Metropolis," *Urban Studies*, Vol. 38, no. 10 (2001), pp. 1651-1671.

[30] Cervero also found that as the labor market was expanded to include the number of workers within a 60-minute distance, labor productivity increased by 25%.

[31] For an interesting examination of how agglomeration economies influence the productivity of firms in different industries, see David L. Rigby and Jurgen Essletzbichler, "Agglomeration Economies and Productivity Differences in US Cities," *Journal of Economic Geography,* Vol. 2 (2002): 207-432.

[32] A more complete discussion of the business impacts can be found in Glen Weisbrod and Stephen Fitzroy, "Defining the Range of Urban Congestion Impacts on Freight and Their Consequences for Business Activity," Working Paper August 2007, Economic Development Research Group, Boston, Massachusetts, http://www.edrgroup.com.

[33] Graham used data from 10,780 wards in London. Daniel J. Graham, "Variable Returns to Agglomeration and the Effect of Road Traffic Congestion," *Journal of Urban Economics*, (2007)

[34] These results are consistent with other empirical studies of the relationship between transport investments and economic productivity. See Daniel J. Graham, "Agglomeration Economies and Transport Investment," Discussion Paper No. 2007-11, Joint Transport Research Centre, Organization for Economic Development and Cooperation (OECD) & International Transport Forum, December 2007, available at http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DiscussionPaper11.pdf, accessed 21 July 2010.

[35] David T. Hartgen and M. Gregory Fields, *Gridlock and Growth: The Effect of Traffic Congestion on Regional Economic Performance*, Policy Study No. 371 (Los Angeles: Reason Foundation, August 2009), http://reason.org/files/ps371_growth_gridlock_cities_full_study.pdf. The other urbanized areas were Charlotte (1.7 million), Seattle (3.3 million), Denver (2.6 million), Atlanta (4.3 million), Detroit (4.9 million), and Dallas (4.8 million).

[36] Notably, airport access does not appear to have significant impact on regional economic performance.

[37] The concept was developed by Seattle-based science writer Paul Haase, winner of a competition sponsored by Washington State Department of Transportation Secretary Doug

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MacDonald and the Transportation Research Board of the National Academy of Sciences to find the best way to "communicate to the public the concept of through-put maximization." See http://www.wsdot.wa.gov/traffic/congestion/rice.htm and Susan Gilmore, "Rice is Nice When Trying To Visualize Highway Traffic," *Seattle Times*, 29 December 2006, http://seattletimes.nwsource.com/html/localnews/2003500083_macdonald29m0.html.

[38] Importantly, these figures likely *underestimate* the actual increase in road capacity. As the urbanized area expands, roads formerly outside the area will then be counted. Thus, new roads or lane-miles may not have been added to the network and some of the increase may be a statistical artifact of the way the data are collected. Unfortunately, there is no reliable methodology for differentiating old lane-miles from newly added lane-miles in the Texas Transportation Institute's database.

[39] "Gridlock in the U.S. Hits Bottom According to INRIX National Traffic Scorecard," 1 August 2009, INRIX, http://www.inrix.com/pressrelease.asp?ID=76, accessed July 22, 2010.

[40] Speech by Peter Rogoff, Administrator, Federal Transit Administration, U.S. Department of Transportation at the Federal Reserve Bank of Boston conference "Next Stop: A National Summit on the Future of Transit," May 18, 2010, http://www.fta.dot.gov/news/speeches/news_events_11682.html

[41] For an overview of these strategies and their cost effectiveness, see Staley and Moore, *Mobility First*, chapter 9, pp. 129-154; Balaker and Staley, *The Road More Traveled*, pp. 155-165.

[42] These examples are drawn from Staley and Moore, *Mobility First*, p. 131.

[43] Kouros Mohammadian and Saurav Chakrabarti, "Optimizing Ramp Metering Strategies," presentation given at ITS Midwest Annual Meeting, University of Illinois at Chicago, Chicago, Illinois, February 7, 2006.

[44] *Measuring and Communicating the Effects of Traffic Incident Management Effects,* National Transportation Cooperative Highway Research Program Research Results Digest No. 289, Transportation Research Board, http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_289.pdf

[45] Although raised medians are often a principal element in access management, under heavy traffic conditions they can increase recurring congestion due to the limits on storage capacity of left-turn bays. Once these turn bays become full, additional left-turning traffic spills into the through-lanes adding to delays. But because raised medians also increase safety by reducing the number of conflict points (thereby reducing accidents), they reduce incident-related congestion. When analysts crunch the numbers, they find a net decrease in congestion from the addition of raised medians, as the latter effect outweighs the former. David Shrank and Tim Lomax, *2009 Urban Mobility Report: Six Congestion Strategies and Their Effects on Mobility*, Texas Transportation Institute, Texas A&M University, tti.tamu.edu/document/TTI-2008-10.pdf, last accessed June 20, 2012.

[46] American Highway Users Alliance, *Unclogging America's Arteries: Effective Relief for Highway Bottleneck,* (Washington, D.C., February 2007) p. 3 and pp. 24-57.

[47] Robert Poole, *Reducing Congestion in Atlanta: A Bold New Approach to Increasing Mobility* (Los Angeles: Reason Foundation, November 2006) pp. 15-16.

[48] This approach to transportation network design is discussed extensively in Sam Staley and Adrian Moore, *Mobility First: A New Vision for Transportation in a Globally Competitive Twenty-First Century* (Lanham, MD: Rowman & Littlefield, 2006), pp. 69-90.

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[49] Based on 2000 census data reported by Wendell Cox, "United States Central Business Districts," June 2006, http://www.demographia.com/db-cbd2000.pdf, last accessed10 November 2009.

[50] Shrank and Lomax, *2010 Urban Mobility Report* (with appendices), Exhibit A-8, p. A-16.

[51] Achieving LOS D, which would allow free flow travel throughout the entire region *on all roads,* would reduce travel time (18.2%) and eliminate almost all (85.8%) vehicle delay. However, this requires increasing road-miles of capacity by 91%, from 39,431 to 75,412. The increase for freeways, tollways and ramps was 66%, from 7,283 to 12,125. The increase for arterials was 97%, from 31,960 to 63,099. The additional capacity causes additional travel, increasing in VMT (15.5%), which is one reason why so much additional capacity is needed.

[52] Notably, only the 12.5-mile extension of I-355 is included as a recommendation in the Reason Foundation report.

[53] To remove LOS E conditions in the year 2040, freeway/tollway capacity would need to increase by about 4,800 lane-miles or about 66%. Arterial capacity would need to increase by about 31,000 lane-miles or about 97%. This is about 161 freeway/tollway lane-mile additions and about 1,038 arterial lane-mile additions per year. In contrast, about 42 freeway lane-miles and about 100 arterial lane-miles have been added annually to the Chicago region's network over the last 25 years (although based on a smaller network than the one modeled for this report)

[54] A review of the controversy can be found in Leonard C. Gilroy, "Setting the Record Straight on Chicago Parking Meter Privatization," Out of Control Policy Blog, Reason Foundation, 7 August 2009, http://reason.org/news/show/setting-the-record-straight-on-1

[55] *Chicago Metropolitan Urban Partnership: Proposal to Reduce Transportation System Congestion in Northeastern Illinois*, page 16; Illinois Department of Transportation, April 2007.

[56] Pricing may be based on expressway and arterial congestion, time of day (peak/off-peak), and/or parking occupancy levels. Drivers would be informed of parking availability and rates through variable message signs and the internet. Different rates are likely to apply to long-term, regular parkers versus short-term parkers.

[57] *The Road Less Traveled: Exploring Congestion Pricing in Chicagoland*, Illinois Tollway, Metropolitan Planning Council, Wilbur Smith Associates, July 2010.

[58] Ibid., p. 15.

[59] Ibid., p. 16.

[60] Ibid., p. 17.

[61] CREATE partners include the U.S. Department of Transportation, the Illinois Department of Transportation, the city of Chicago Department of Transportation, and the Association of American Railroads (which includes BNSF Railway, Canadian Pacific Railway, CN, CSX Transportation, Norfolk Southern, Union Pacific Railroad, Metra, and Amtrak.)

[62] *Chicago Region Environmental and Transportation Efficiency Program; Final Feasibility Plan*, pp. 37 to 39 and 43 to 46; Federal Highway Administration Illinois Division Office, August 2005.

[63] Agencies interviewed include the Chicago Metropolitan Agency for Planning, Illinois Department of Transportation, the city of Chicago, Illinois Tollway, Regional Transportation

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Authority, Chicago Transit Authority, Metropolitan Planning Council, Chicagoland Chamber of Commerce, Chicago Federal Reserve Board, Illinois Institute of Technology, University of Illinois-Chicago, Northwestern University and Roosevelt University

[64] Staley and Moore, *Mobility First*, pp. 106-107; Robert W. Poole and Chris Swenson, *Reducing Congestion in Lee County, Florida*, Policy Study No. 374 (Los Angeles: Reason Foundation, February 2009), http://reason.org/files/14d2460502c35b0b036cbd528fc114d7.pdf

[65] David T. Hartgen and M. Gregory Fields, *Building Roads to Reduce Traffic Congestion in America's Cities: How Much and At What Cost?* Policy Study No. 346 (Los Angeles: Reason Foundation 2006), http://reason.org/news/show/building-roads-to-reduce-traff-1. The summary for Illinois can be found at http://reason.org/news/show/126820.html. Last accessed 11 November 2009.

[66] *Oregon's Mileage Fee Concept and Road User Fee Pilot Program: Final Report*, Oregon Department of Transportation, Salem, Oregon, November 2007, pp. 43-44, http://www.oregon.gov/ODOT/HWY/RUFPP/docs/RUFPP_finalreport.pdf

[67] Chicago Metropolitan Agency for Planning, forecasts to 2030, available http://www.cmap.illinois.gov/2030_forecasts.aspx, last accessed 16 December 2009.

[68] See http://www.metropolisplan.org for *Metropolis Plan* report and technical modeling appendix

[69] See http://www.chicagometropolis2020.org/10_40.htm for *Metropolis Freight Plan* and technical report.

[70] Robert W. Poole, Jr. and Ted Balaker, *Virtual Exclusive Busways: Improving Urban Transit While Relieving Congestion*, Policy Study No. 337 (Los Angeles: Reason Foundation, September 2005), http://reason.org/files/f74f4436cd5e98624899baf1c02c384f.pdf

[71] CTA and Metra websites; www.transitchicago.com and www.metrarail.com

[72] CMAP, *Go to 2040 Comprehensive Regional Plan*, DRAFT, August 2010, pp. 155-159.

[73] Big Dig (Boston, MA); Wikipedia, http://en.wikipedia.org/wiki/Big_Dig_(Boston,_Massachusetts)

[74] *Cost-Benefit Analysis of Boston's Central Artery/Tunnel*, slides 12-24; Joanlin Hsu, Shannon McKay, and Markques McKnight, April 2003. See also, Staley and Moore, *Mobility First*, pp. 99-100.

[75] *I-710 Tunnel Financial Feasibility Assessment*, p. 3; Los Angeles County Metropolitan Transportation Authority, California Department of Transportation, and Parsons Brinckerhoff, January 2008.

[76] *2008 Regional Transportation Plan: Project List*, page 194; Southern California Association of Governments, May 2008.

[77] "Drillers probe mountain to find route for tunnel to ease Riverside Freeway traffic," *Los Angeles Times*, June 2008.

[78] *Alaskan Way Viaduct Projects & SR 520 Bridge Projects—Updated Cost Estimates*; Washington State Department of Transportation, September 2006, http://www.wsdot.wa.gov/Projects/Viaduct/ CostEstimates/Default.htm

[79] The "low" tunnel construction cost of $80 million per lane-mile is based roughly on the actual per lane-mile tunnel construction cost in Dublin, Ireland (tunnel costs reported in China and

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Madrid, Spain of between $19 million and $48 million per lane-mile were deemed too low to be representative of construction costs in the United States). The "high" tunnel construction cost of $300 million per lane-mile is based roughly on the construction cost estimate of the Alaskan Way Viaduct tunnel option in Seattle, Washington (the construction cost of the Big Dig in Boston, Massachusetts of $521 million per lane-mile is not used as a basis for the cost range due to exceptional conditions associated with that project).

[80] *A Managed Lanes Vision for Southeast Florida*, p. 26; Prepared for the Florida Department of Transportation by Robert W. Poole Jr, January 2009.

[81] *Inflation-Adjusted Cost per Lane Mile for Major Chicago Area Highway Engineering and Construction Projects* and *Highway Working Group: Unit Capital Cost Information*; Chicago Area Transportation Study, November 2002.

[82] *Highway Construction Costs: Are WSDOT's Highway Construction Costs in Line with National Experience?*, slides 1 to 5; Washington State Department of Transportation, July 2004.

[83] Robert Poole, *Reducing Congestion in Lee County, Florida*, policy study (Los Angeles: Reason Foundation, February 2009) pp. 30-31.

[84] Poole, *A Managed Lanes Vision for Southeast Florida*, p. 28.

[85] CMAP, *Go to 2040*, p. 166.

[86] In addition, a study conducted by the Illinois Tollway, Metropolitan Planning Council, and Wilbur Smith Associates recommends tolling the reversible lanes on the Kennedy expressway. This option was not modeled as part of this project. Nevertheless, if these reversible lanes are added, travel demand for the Kennedy tunnel would likely fall. Policymakers should consider examining the effects of congestion-priced reversible lanes on the demand for the tunnel. Importantly, the likely impact on the Cross Town Tunnel will be small. See *The Road less Traveled: Exploring Congestion Pricing in Chicagoland*, report released July 2010 by the Illinois Tollway, Metropolitan Planning Council and Wilbur Smith Associates.

[87] Bent Flyvbjerg, et al, *Megaprojects and Risk*, Cambridge (U.K.): Cambridge University Press, 2003.

[88] Jeffrey A. Parker, "The Port of Miami Tunnel Breaks New Ground for Greenfield P3 Projects in the U.S.," *Public Works Financing* (November 2009), pp. 16-22.

[89] Ibid., p. 16.

[90] *Updated 2030 Regional Transportation Plan for Northeastern Illinois*, p. 19; Chicago Metropolitan Agency for Planning, October 2008. Also based on follow up information from CMAP provided by e-mail, August 2009.

[91] *Updated 2030 Regional Transportation Plan for Northeastern Illinois*, p. 93.

[92] Ibid., p. 4.

[93] Ibid., Chapters 6 and 7.

[94] Some transportation planners may consider these numbers are too high. They appear to imply that there is still reserved link capacity not fully used. While beyond the scope of this preliminary report, one way this problem could be addressed is by differentiating auto and truck speeds, acceleration and deceleration rates, and capping on the maximum allowable link-

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specific operating speeds by facility type (IS, Freeways, Expressways, Major Arterials, Minor Arterials, Collectors, and toll plazas, etc.) in the microsimulation model.

[95] There are 365 days in a year. The multiplier of 300 reflects generally lower traffic volumes on weekends and holidays, less peaking on weekends and holidays, and lower values of time for non-work travel.

[96] Nancy A. McGuckin and Nanda Srinivasan, *Journey to Work in the United States and its Major Metropolitan Areas—1960-2000*. Exhibit 4.13, Transit and Walk Commutes: 1980 - 2000, pp. 4-9.

[97] http://www.nbrti.org/learn.html (accessed 5-14-09).

[98] Helen M. Tan and Dennis Hinebaugh, *Characteristics of Bus Rapid Transit for Decision-Making*, p. E-2. Federal Transit Administration, February 2009. http://www.nbrti.org/docs/pdf/High%20Res%20CBRT%202009%20Update.pdf

[99] Cheryl Thole, Alasdair Cain, and Jennifer Flynn, "The EmX Franklin Corridor: BRT Project Evaluation: Final Report," National Bus Rapid Transit Institute, Center For Urban Transportation Research, University of South Florida, Tampa, Florida, April 2009, last accessed June 20, 2012.

[100] "HealthLine Ridership Up; Other RTA Route Numbers Unchanged," Cleveland: NewsNet5, December 9, 2008. http://www.newsnet5.com/investigations/18238882/detail.html

[101] Keep San Diego Moving – TransNet: *Interstate 15 Express Lanes: Fact Sheet*, April 2009. http://www.keepsandiegomoving.com/CW_Images/CW_T_I15_So_FS_AllSegsvFINAL_apr.pdf

[102] http://www.stride-mn.org/BRT/main.htm

[103] Alan Hoffman, "Advanced Network Planning for Bus Rapid Transit: the Quickway Model as a Modal Alternative to "Light Rail Lite," Federal Transit Administration, February 2008. http://www.nbrti.org/docs/pdf/BRT%20Network%20Planning%20Study%20-%20Final%20Report.pdf

[104] Ibid., p. xii.

[105] Ibid., pp. 43-44.

[106] Ibid., p. 25.

[107] See http://www.metropolisplan.org for *Metropolis Plan* report and technical modeling appendix.

[108] For a discussion of the land use variables in the MTM and similar models for the Baltimore and Austin regions, see Norm Marshall and Brian Grady, "Travel Demand Modeling for Regional Visioning and Scenario Analysis." *Transportation Research Record*, No. 1921, *Travel Demand 2005*, (Washington, DC: Transportation Research Board, 2005) pp. 44-52.

[109] See http://www.chicagometropolis2020.org/10_40.htm for *Metropolis Freight Plan* and technical report.

[110] Center for Neighborhood Technologies*, The Location Efficient Mortgage Project: Summary of Results of Location and Auto Cost Correlation Study,* Chicago, IL.

[111] The Root Mean Square Error (RMSE) is a commonly used statistic for checking travel demand model fit.

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