DISTRICT MOBILITY PROJECT

Contents

INTRODUCTION

The movement of people and goods is a fundamental aspect of a vibrant economy. In the District of Columbia (the District) and other urban areas, the high concentration of activity often results in traffic congestion. Some level of congestion is to be expected in a vibrant city, but when that congestion becomes excessive, it can reduce the attractiveness of that city. Appropriately managing congestion is therefore important to providing a high quality of life and supporting the District's economy.

While discussions of congestion often conjure up images of cars stopped on a freeway, this does not capture the reality of travel in and through the District. The District has a very diverse, multimodal transportation network. Residents, workers, and visitors are generally not dependent on a personal vehicle to move around, but instead use transit, taxis, bicycles, and their own feet to access goods and services throughout the District. These qualities make the District a very livable place. However, congested travel, unreliable travel times, and network connectivity are issues that affect District travelers no matter how they travel.

The District Department of Transportation (DDOT) is working to understand these congestion issues in order to better define a program of improvements to address them. The current national state of the practice for defining congestion problems in the transportation network focuses on vehicular congestion and does not have systematic ways of quantifying, comparing, and prioritizing solutions for congestion across modes and addressing missing links. The *District Mobility Project* presents the state of multimodal congestion in the District using measures that matter for each travel mode (e.g. walking, transit, driving, bicycling) and at geographies (e.g., Ward-level or street-level) that are comparable between modes. From this baseline, this project proposes near-term strategies to help address congestion issues and defines a more permanent monitoring program to identify and respond to ongoing or future issues. The outcomes of this project will assist policymakers and the public in understanding the factors influencing multimodal congestion and mobility in the District, along with how DDOT is working to address these concerns.

Project Vision

DDOT's mission is to enhance the quality of life for District residents and visitors by ensuring that people, goods, and information move efficiently and safely with minimal adverse impact on residents and the environment. Assessing the ability of the transportation system to provide mobility is therefore an important measure of how well both the system and DDOT itself functions. Measuring this mobility aspect of system performance is challenging, however, and conveying that information to the public and policymakers in a comprehensible fashion is not simple.

The *District Mobility Project* responds to a request from the DC Council to assess the state of congestion for all surface modes in the District and identify actions to address that congestion. The *District Mobility Project* described here is responsive both to the Council request and DDOT's own identified needs. DDOT staff broadened the focus of this effort beyond simply congestion to mobility more generally, in order to better quantify and qualify the state of its transportation system performance from a holistic multimodal perspective. The main objectives of the *District Mobility Project* are thus:

- Assess congested locations and identify means to address the congestion in the near and longer term;
- Develop a data-driven framework for monitoring multimodal congestion and system mobility in the District; and
- Identify performance measures for multimodal systems that are understandable for a broad audience, and supported by readily available, attainable, and reliable data sources.

This project builds on web-based performance dashboards and congestion reports other agencies have developed nationwide as well as the work done for *moveDC*, DDOT's long range transportation plan. This project takes advantage of a variety of data sources to describe the state of mobility across multiple modes within the system. The project team has gathered and analyzed data from many sources, then layered the results on top of each other to begin to gain a more complete view of the performance of the District's transportation system. The results of this effort are a major step forward in transportation agency performance management and represent a new best practice in the transportation industry.
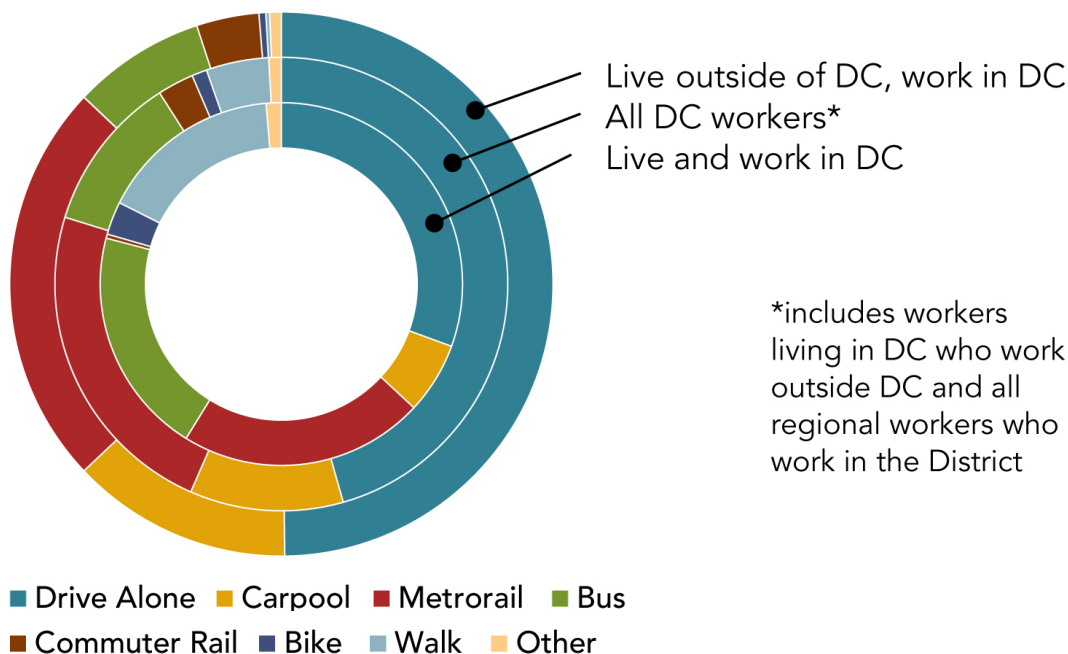
Demand on the District's Transportation System

The District is at the center of the 7th largest metropolitan area in the United States. The District has a population of over 672,000 but its daytime population doubles with an influx of over 500,000 commuters and visitors.[1]

The District's transportation system comprises over 1,100 miles of roadways, of which less than 15 miles are freeways. Therefore, the efficiency of the transportation system is largely dictated by how effectively the arterial roadways operate. The District has a very robust transit system, bikeway network, and a bikeshare program, resulting in one of the most multimodal transportation systems in the nation. According to American Community Survey (ACS) 2015 data, over one-third of District households do not own a personal vehicle and fewer than half of District residents commute by automobile.[1] Among District residents who work in the District, the non-automobile share is even higher, as shown in **Figure 1**.

The District's population has increased since 2010 and is expected to grow considerably in the coming decades. The region's population projections indicate that by 2040, approximately 150,000 more people will be living in the District, resulting in an about 0.8 percent annual growth rate. Similarly, the District's employment is projected to grow by nearly 180,000, resulting in a District employment of approximately 980,000 jobs by 2040.[2] Growth in the District and region will increase the overall number of trips made within, to, from, and through the District. Therefore, quantifying and assessing multimodal congestion in the District and understanding the transportation system's performance both today and in the future plays a critical role in sustainably accommodating this growth and maintaining the competitiveness of the District and the region at a national level.

FIGURE 1 COMMUTE MODE SHARE FOR WORKERS IN THE DISTRICT BY PLACE OF RESIDENCE.

Live outside of DC, work in DC
All DC workers*
Live and work in DC

*includes workers living in DC who work outside DC and all regional workers who work in the District

■ Drive Alone ■ Carpool ■ Metrorail ■ Bus
■ Commuter Rail ■ Bike ■ Walk ■ Other

1   American Community Survey. 2015. https://www.census.gov/programs-surveys/acs/about.html

2   Metropolitan Washington Council of Governments, "Growth Trends to 2040: Cooperative Forecasting in the Washington Region, Round 8.0", Fall 2010. https://www.mwcog.org/documents/2010/12/17/growth-trends-cooperative-forecasting-in-the-metropolitan-washington-region-cooperative-forecast-growth/

DEFINING SYSTEM PERFORMANCE

Traditionally, multimodal system performance in urban environments has been challenging to characterize and quantify. Additionally, many of the most widely used performance measures for congestion focus on a single mode. These performance measures are valuable for improving a single mode but provide limited value when seeking to understand and balance the needs of all modes in the urban environment. To address this limitation, this project characterized system performance into mobility categories with similar objectives, allowing different modes to be compared spatially and temporally. Three (3) general categories of system mobility identified in this project are *congestion*, *reliability*, and *accessibility*.

- **Congestion:** measures system capacity and the volume of usage. Discussions of congestion often focus on the intensity of travel during peak periods as more users in a system with limited space or resources degrade system performance. Congestion increases travel times and makes traveling more uncomfortable, particularly when it means less personal space (such as on the bus or the sidewalk). Mitigating congestion improves the quality of life for residents and travelers by keeping the system moving overall.

- **Reliability:** captures the variability in travel times and the resulting uncertainty experienced by travelers. While congestion might exist at some level, it becomes much more frustrating when it varies from day to day or even hour to hour, and thus reliability of travel times by mode is another important way of understanding system performance. Unreliability in travel time forces people to leave extra early to arrive at a destination (e.g., job, day-care, etc.) on-time. Reducing travel time variability improves travelers' experience and makes the overall system function more efficiently.

- **Accessibility:** measures the ability to reach valued destinations and opportunities (e.g., jobs, hospitals, shopping, etc.) in a given time period. When the network is congested, it typically takes longer to get around and therefore hinders an individual's accessibility. However, if trips are typically relatively short, even with congestion most destinations may be accessible. Accessibility provides a way to make comparisons between modes and, more importantly, factors in the role of land use in transportation. An additional formulation of this category measures the ability of a traveler to use a particular mode. Greater modal access also improves system resilience by increasing the range of travel options available.

Measuring Multimodal System Mobility

Congestion performance measures for automobiles are well-established within transportation agencies, and interviews with peer agencies indicated that congestion measures are consistently popular with the public and policymakers. However, multimodal measures have been applied in more limited contexts. Further, many agencies do not dynamically communicate the results of measures they have to the public and do not internally assess how they perform in terms of improving mobility.

The three mobility categories – congestion, reliability, and accessibility – each provide a valuable perspective on multimodal system mobility in the District. There are a wide range of performance measures that can represent system performance across the categories. This project focuses on performance measures that can be calculated for the entire District on an annual basis.
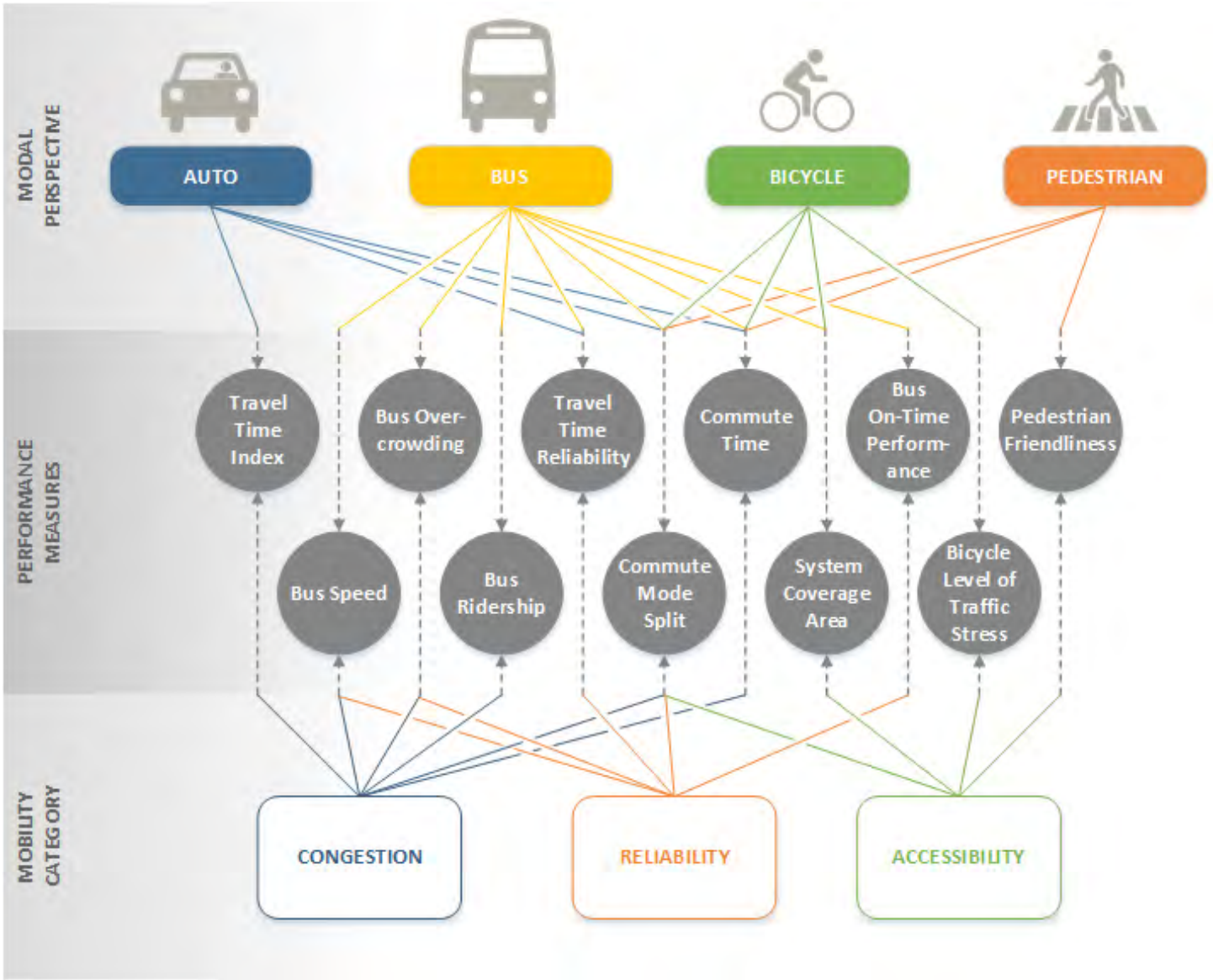
The project team selected the final list by comparing the desired types of measures to the available data and iteratively narrowing the list based on whether the measures were meaningful. This project focuses on metrics across the mobility categories that are applicable for all types of modes and on certain mode-specific measures that can address the multimodal needs of the District's transportation system. The final list of measures prioritized those that can be supported by readily available, attainable, and reliable data sources. Due to some limitations of availability and spatial coverage, certain performance measures were not selected even though there was high interest.

Summary of Performance Measures

Figure 2 displays the eleven (11) measures identified for the project, the mobility category each metric falls under, and shows their applicable mode of transportation. Each mode has a variety of associated performance measures. The performance measures, in turn, are tied to the mobility categories. As the diagram illustrates, several measures address multiple modes, as much as possible, the three mobility categories are addressed for each mode.

The next section focuses on each performance measure described in **Figure 2** and provides key results and findings.

MODAL PERSPECTIVE

AUTO   BUS   BICYCLE   PEDESTRIAN

PERFORMANCE MEASURES

Travel Time Index

Bus Over-crowding

Travel Time Reliability

Commute Time

Bus On-Time Performance

Pedestrian Friendliness

Bus Speed

Bus Ridership

Commute Mode Split

System Coverage Area

Bicycle Level of Traffic Stress

MOBILITY CATEGORY

CONGESTION   RELIABILITY   ACCESSIBILITY

Commuting

Congestion is perhaps most commonly associated with commuting. How workers in the District experience congestion, however, varies by the mode(s) people choose. This section highlights how the District residents get to and from their place of work and reports the average time DC residents spend to commute to work by mode. The results are presented based on the 2010 US Census tract boundaries.

Mode Split

Figure 3 displays the percentage of District residents using a particular mode to travel to work by Census tracts. Commute mode split categories typically include a full range of travel options, including drive-alone, carpool, public transportation, bicycle, walking, and working from home. The results shown below represent a sample of these modes.

Results show that Census tracts with close proximity to downtown DC generally have lower shares of drive alone commuters. This can be explained by two factors: (1) these Census tracts are typically well served by high frequency transit, resulting in higher transit mode share; and (2) walk and bicycle trips are usually shorter than those by car or public transportation, thus it is easier to commute by bicycle or on foot in Census tracts that are within close proximity to the large concentration of jobs downtown. Census tracts further from the center tend to have higher shares of commuters driving alone to work. Transit usage, however, is fairly consistent across the District, reflecting the generally good coverage of bus and rail service in DC.

FIGURE 3 PERCENTAGE OF DISTRICT RESIDENTS COMMUTING BY A PARTICULAR MODE BY 2010 US CENSUS TRACT BOUNDARIES

Drive Alone

Public Transportation

Walk

Bicycle, Taxi, Other

Percent of Commuters

0% - 10%

11% - 20%

21% - 50%

51% - 100%
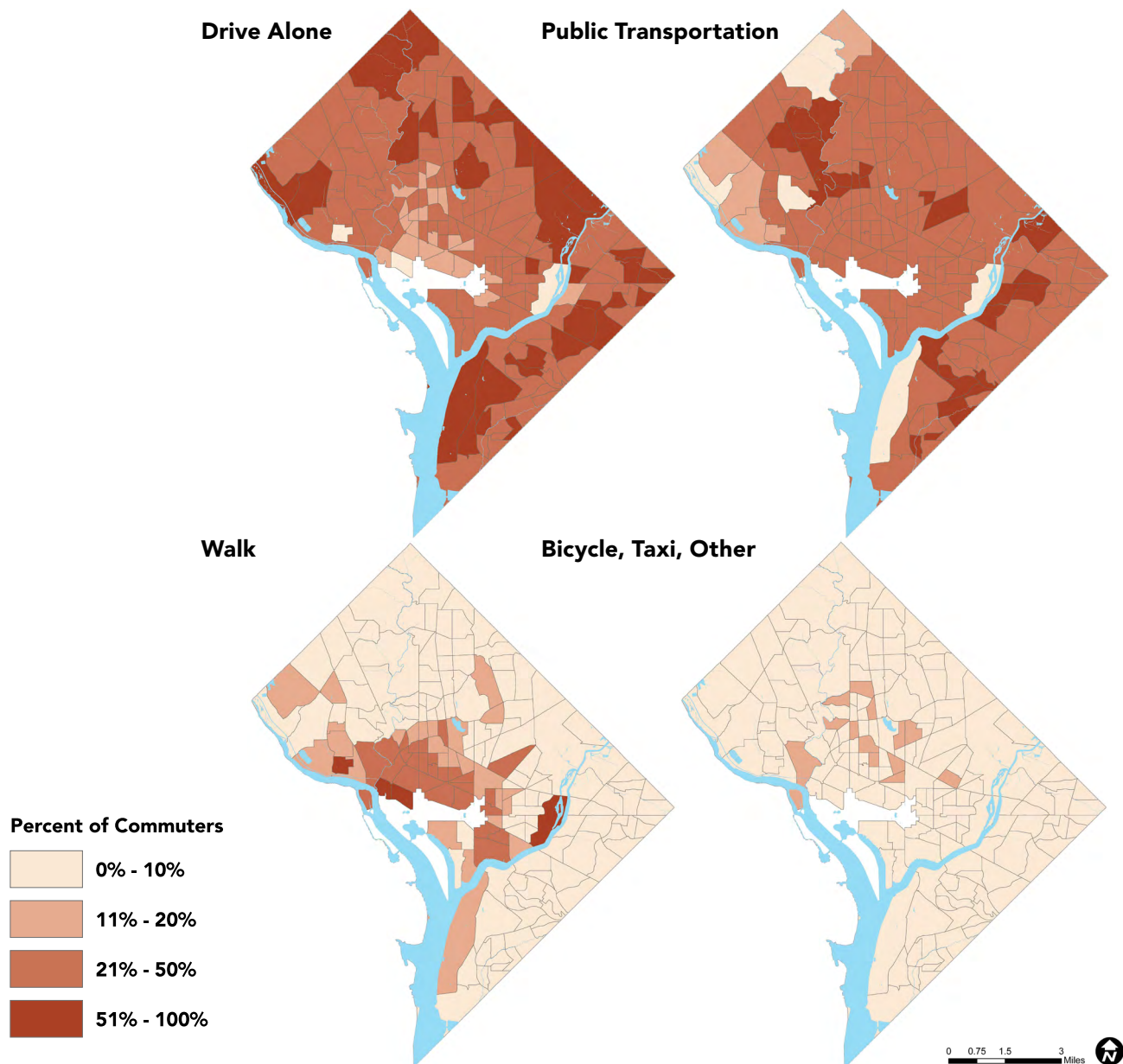
Average Commute Time

Figure 4 shows the average amount of time District residents spend commuting when using any of the available modes of transportation in each of the Census tracts (i.e., commute time is averaged over all modes). Results show that the average commute time to work for the majority of Census tracts is within 25 to 35 minutes. In general, residents of southeast Washington DC spend relatively longer commuting to work.

Figure 5 shows average commute times for the District residents by travel mode and overall. This analysis does not take into account where District residents work, and whether transit service or biking/walking options are available. Particularly for low- and moderate-income workers who do not work in the downtown area, transit service often does not align well with travel needs.

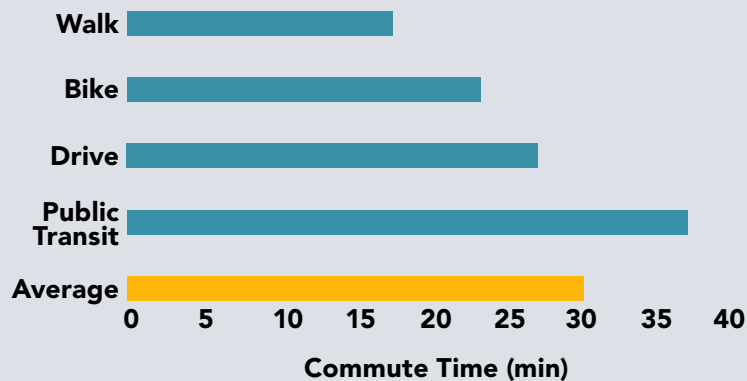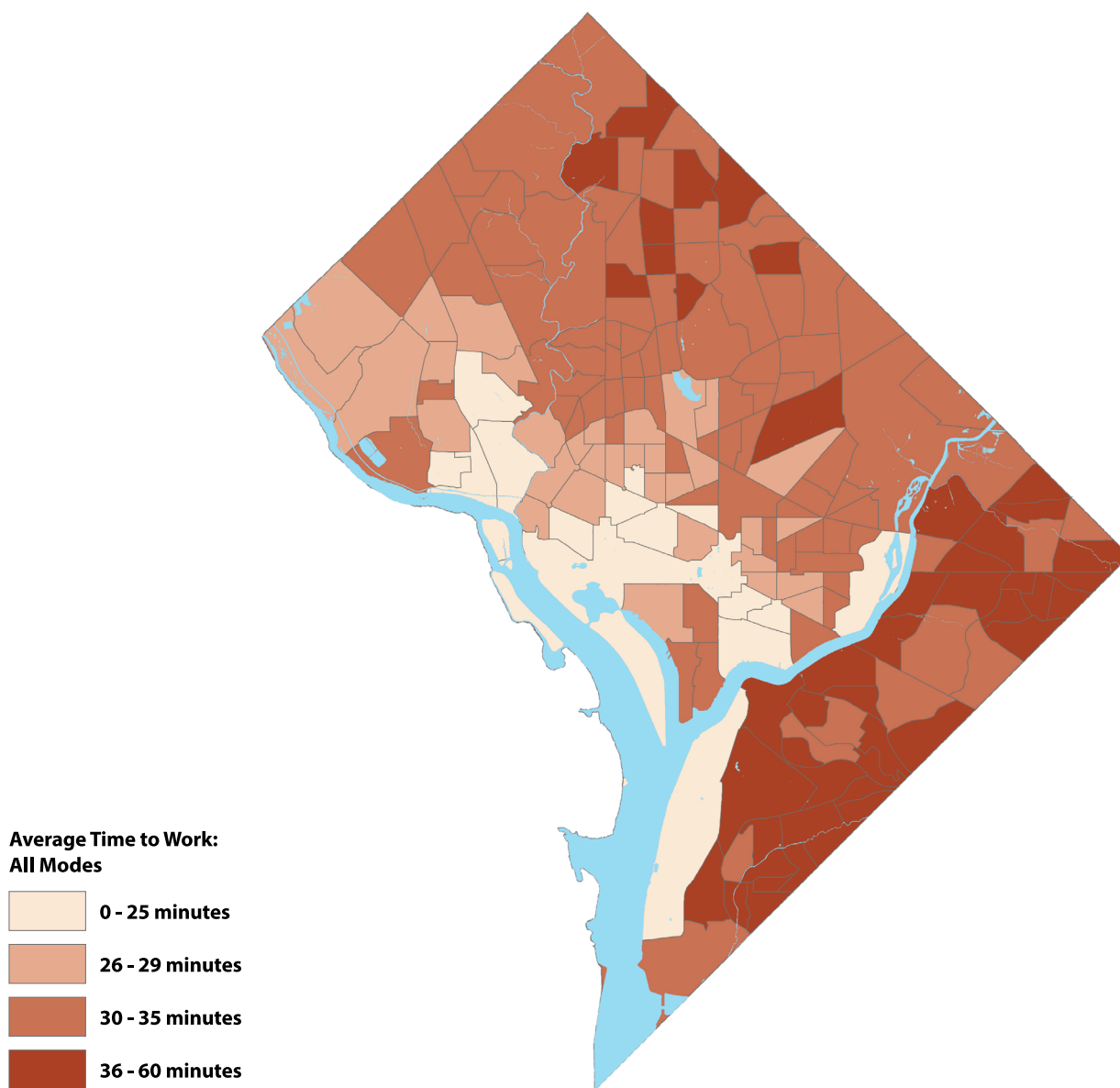**FIGURE 5** AVERAGE COMMUTE TIME FOR DISTRICT RESIDENTS BY TRAVEL MODE

FIGURE 4 AVERAGE TIME RESIDENTS SPEND COMMUTING TO WORK BY 2010 US CENSUS TRACT BOUNDARIES

Average Time to Work: All Modes

- 0 - 25 minutes
- 26 - 29 minutes
- 30 - 35 minutes
- 36 - 60 minutes

Congestion

Congestion results from large numbers of people or vehicles using limited space, resulting in more crowded and slower moving roadways and buses. This section discusses the results for the congestion-related measures for automobiles and buses.

Auto Congestion – Travel Time Index

Travel time index (TTI) is measured as an indicator of auto congestion in the District. TTI is defined as the ratio of peak period (congested) travel time to travel time under "light" or "free-flow" conditions. For example, a TTI of 1.5 indicates that a trip that would normally take 20 minutes under free-flow conditions takes 30 minutes (or 50 percent longer) as a result of traffic congestion. The project team calculated TTI for autos in the District using INRIX traffic data, which collects roadway speeds and travel times anonymously from mobile phones and connected vehicles. The analysis was based on the 2015 INRIX data and includes most major roadways in the District.

Figure 6 displays weekday morning and evening peak periods travel time index in the District based on the 2015 INRIX data. The District's roadway system primarily consists of non-highway facilities. Therefore, it is important to understand the performance of non-highway roadways (i.e., excluding Interstate-295, DC-295, etc.) as the efficiency of the transportation system is largely dependent on the performance of these roadways. **Figure 7** provides percent of roadway miles operating under variable TTI thresholds for non-highway (i.e., excluding Interstate-295, DC-295, etc.) roadway facilities in the District.

FIGURE 6 WEEKDAY TRAVEL TIME INDEX IN THE DISTRICT DURING THE MORNING AND EVENING PEAK PERIODS

Morning Peak Travel Time Index   Evening Peak Travel Time Index

1.2   1.5   2.0   2.5   3.0
Travel Time Index
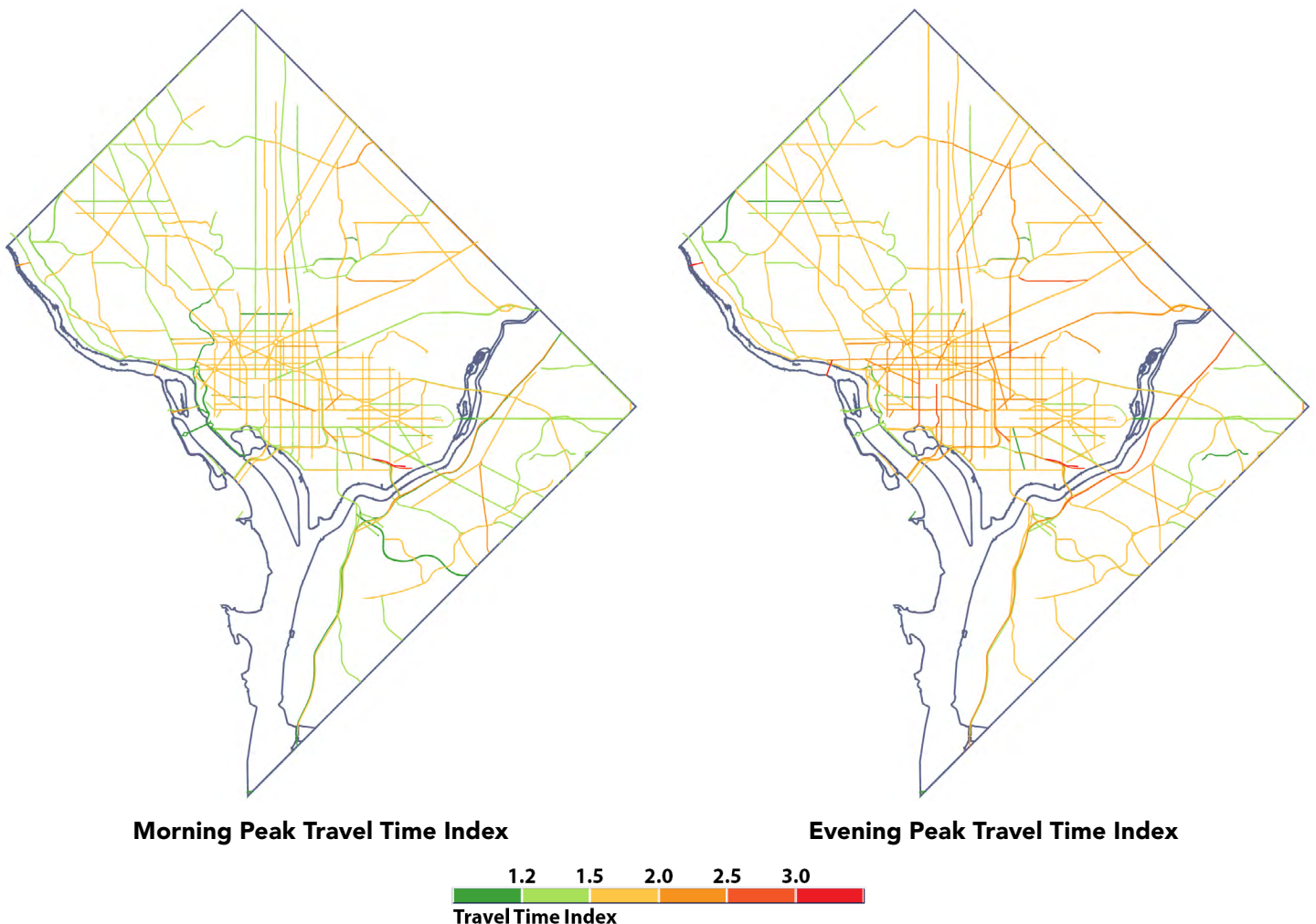
Key TTI findings for the District are:

- Traffic congestion is the worst during the evening peak on weekdays.

- For all the roadways considered in the District (generally all larger roads, including interstates and arterials), congestion is worst during the weekday evening peak when 15 percent of the roadways experience TTI higher than 2.0. This number is around three percent for the weekday morning peak, and two percent for the weekend morning peak.

- When only non-highways are considered (i.e., excluding Interstate-295, DC-295, etc.), TTI results show a very similar pattern of when congestion occurs. This is not surprising as highways comprise only a very small portion of the District's transportation system. So while highways do carry a lot of vehicles, overall congestion on the roadway system is largely dictated by how effectively the arterial roadways operate.

- Key Bridge in the inbound direction has the highest TTI during the evening peak period. Average inbound evening peak speed is only 8 mph, less than one-third of its speed of 26 mph under light traffic conditions. However, it is important to emphasize that there are other segments in downtown Washington, DC with speeds slower than 8 mph, but their associated TTI is substantially lower than Key Bridge as these roadways generally have lower base speeds, even under light traffic conditions, due to delays from traffic signals. The lower base speeds lower their TTI, even though the travel speeds are similar or worse during peak periods.

- Southeast Freeway has the highest TTI at all other times. Among non-highways, heavy commuter routes such as Chain Bridge or New York Avenue NE (U.S. Route 50) experience high TTI.

FIGURE 7 NON-HIGHWAY TRAVEL TIME INDEX DISTRIBUTION IN THE DISTRICT DURING THE MORNING AND EVENING PEAK HOURS ON WEEKDAYS AND WEEKENDS
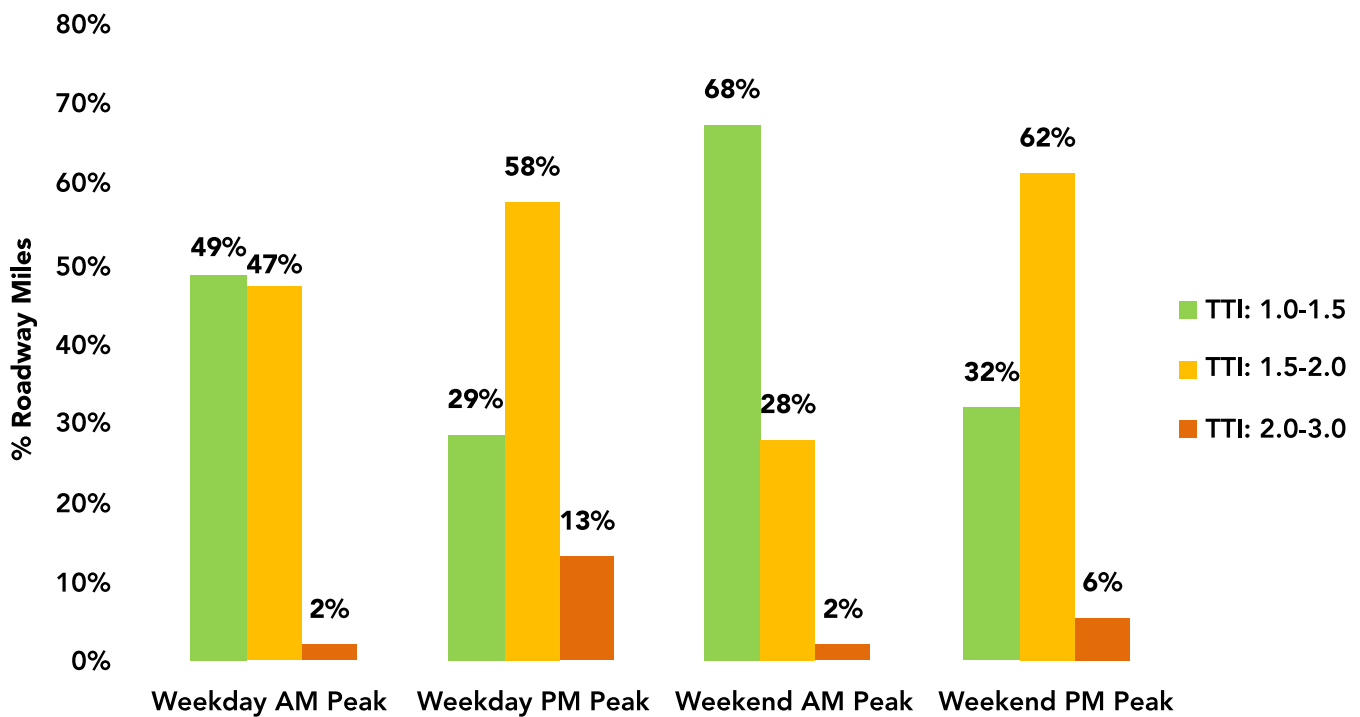
Bus Congestion

Three performance measures were identified for this project as an indicator of system congestion for buses: (1) bus ridership, (2) bus overcrowding, and (3) bus speed. The measures are selected such that they reflect the effect of overall congestion both from a customer's perspective (e.g., overcrowding) and from the perspective of the transit agencies (e.g., ridership).

Ridership

While ridership is not a direct outcome of congestion, it is an indicator of intensity of use for transit. In addition, ridership is used as a measure of success for most transit systems.[3] This project examined two measures for ridership: (1) stop ridership based on the boarding at each stop by time period, and (2) line ridership in terms of the average weekday boarding for all routes within a Metrobus Line. Results are summarized based on WMATA's automatic passenger counter (APC) data from October 2015.

FIGURE 8   TOTAL WEEKDAY BOARDINGS BY STOP IN THE DISTRICT
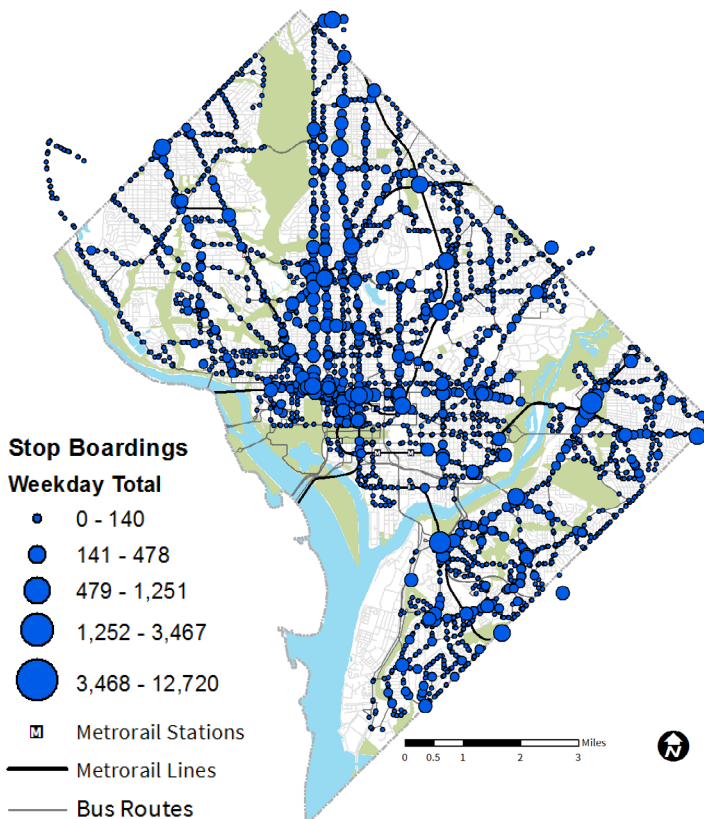
Stop Ridership

Figure 8 displays total weekday boarding by stop in the District. **Table 1** lists the stops with the highest boarding as well as the routes served by each stop.

TABLE 1   STOPS WITH HIGHEST WEEKDAY TOTAL BOARDINGS

Bus Stop	Routes Served by Stop	Weekday Total Boardings
Anacostia Metrorail Station	90; 94; A2, 4, 6, 7, 8, 9, 42, 46, 48; B2; P6; V2; W2, 3, 4, 6, 8	12,720
Minnesota Avenue Station	U4, 5, 6, 7, 8; V2, 4; X1, 2, 3, 9	6,574
Brookland-CUA Metrorail Station	80; G8; H1, 2, 3, 4, 6, 8, 9; R4	3,467
Silver Spring Metrorail Station	70; 79; S2,4,9	2,594
Rhode Island Ave Metrorail Station	B8,9; D8; H8,9; P6; T18; 81, 82, 83, 84, 86	2,518
Georgia Avenue-Petworth Metrorail Station	60, 62, 63, 64; 70; 79; H8	2,485
H Street NW at 7th Street NW	X2 East, 80 North, P6 North	2,391
Fort Totten Metrorail Station	60, 64; 80; E2,4	2,156
Friendship Heights Metrorail Station	31, 33; 30S, 30N; E6; N2, 3, 4, 6	2,093
14th Street NW at Irving Street NW	52, 53, 54 North; H8 West	1,849

Key stop level ridership findings are summarized as follows:

- Highest boarding bus stops are all located at or adjacent to Metrorail stations. This can be attributed to multiple bus routes serving those stops and high volumes of passenger activity to/from Metrorail stations or between buses.

- The stop located at H Street NW and 7th Street NW is the only very high boarding stop located in the downtown. Downtown stops are generally not among the highest ridership stops since the downtown has a high density of bus stops, resulting in a more even distribution of passengers across these stops, thereby diminishing stop level ridership.

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3   Transit-Oriented Development: Developing a Strategy to Measure Success. National Cooperative Highway Research Program (NCHRP) Research Results Digest 294, Transportation Research Board.

Line Ridership

Line ridership is calculated based on the average weekday boarding along all routes within a Metrobus line using WMATA's 2015 October APC data. Line ridership is an important measure to help agencies evaluate and prioritize investments in certain routes with high ridership.
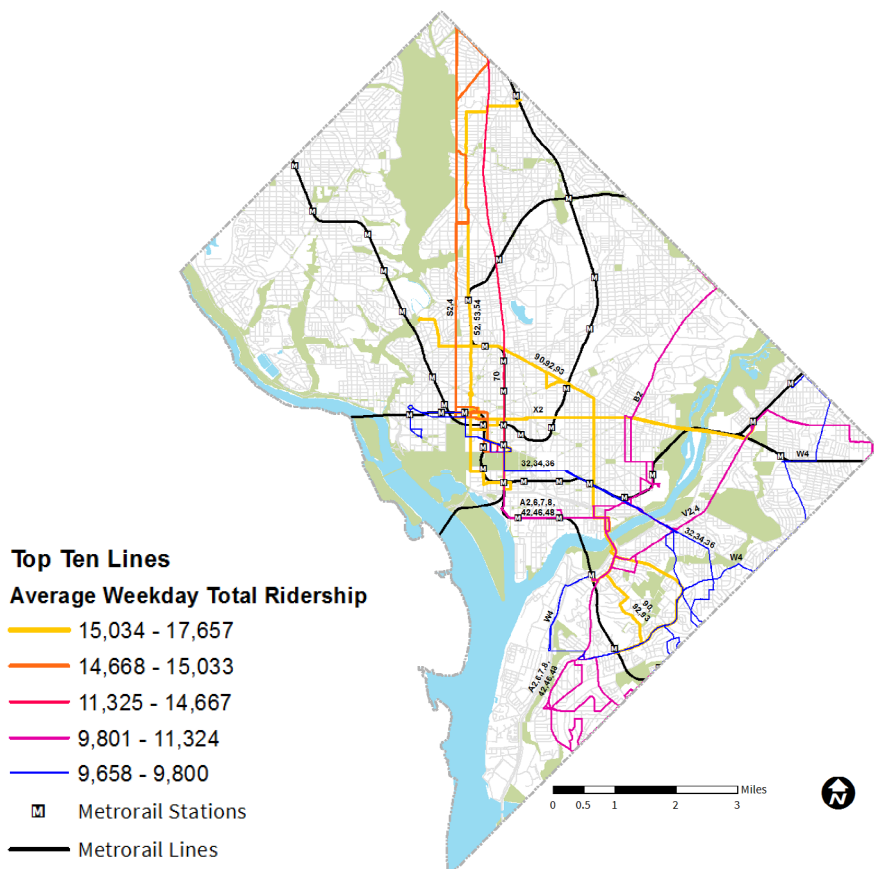
Figure 9 shows the highest ridership lines within the District. **Table 2** provides line names as well as specific routes for those high ridership lines. Key line ridership findings are:

- The Georgia Avenue – 7th Street Metrobus Line (70/79 buses) has the highest average weekday total ridership with 23,516 riders.

- Three of the top four lines - 14th Street (52/53/54 buses), 16th Street (S1/S2/S4/S9 buses), and Georgia Avenue – 7th Street (70/79 buses) - provide north-south connections between northwest and downtown.

- One line, Benning Road – H Street (X2/X9 buses), provides east to west connections between northeast and northwest, and has the third highest ridership with 19,145 daily riders.

- One line, Bladensburg Road – Anacostia (B2 buses), provides connections between southeast, southwest, and northeast, and has more than 11,000 daily riders.

TABLE 2 TOP TEN LINES AVERAGE WEEKDAY RIDERSHIP

Line Name	Routes	Average Weekday Total Ridership
Georgia Avenue – 7th Street Line	70, 79	23,516
16th Street Line	S1, S2, S4, S9	21,744
Benning Road – H Street Line	X2, X9	19,145
14th Street Line	52, 53, 54	17,657
U Street – Garfield Line	90, 92, 93	16,926
Anacostia - Congress Heights Line	A2, A6, A7, A8, A9, A42, A46, A48	12,256
Bladensburg Road – Anacostia Line	B2	11,324
Capitol Heights – Minnesota Avenue Line	V2, V4	11,261
Pennsylvania Avenue Line	32, 34, 36, 39	11,222
Deanwood – Alabama Avenue Line	W4	9,658

FIGURE 9 TOP TEN LINES AVERAGE WEEKDAY RIDERSHIP IN THE DISTRICT

Top Ten Lines
Average Weekday Total Ridership
- 15,034 - 17,657
- 14,668 - 15,033
- 11,325 - 14,667
- 9,801 - 11,324
- 9,658 - 9,800
- Ⓜ Metrorail Stations
- — Metrorail Lines

Bus Overcrowding

Overcrowding on buses degrades the travel experience for passengers and reduces the attractiveness of transit, which in turn affects ridership. Overcrowding is generally as a result of lack of available service/capacity combined with unreliable service (bus bunching, for example, leads to some full buses and some empty buses).

Overcrowding is calculated based on the maximum number of passengers on the bus relative to the seated vehicle capacity to establish the load to seat ratio by each time period. That ratio is calculated for each day and then averaged over the whole analysis period. This report uses October 2015 APC data to calculate the average maximum vehicle load by time period. Overcrowding is defined based on WMATA's load standard, which uses 120% of the seated capacity as the overcrowding threshold. For a bus rider, this would mean all the seats are full and standing passengers would experience uncomfortable conditions.
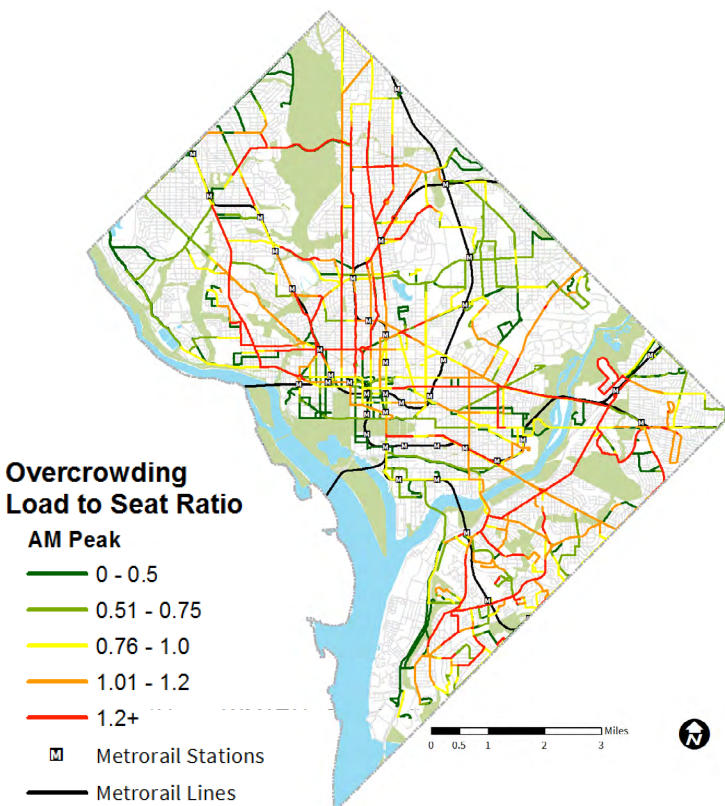
Table 3 lists the routes that exceeded the load standards in each time period. **Figure 10** displays overcrowding levels for WMATA buses in the District during the morning peak period, when the most severe overcrowding is experienced. The time periods used for the analysis are

- AM Early: 4:00 AM – 5:59 AM,
- AM Peak: 6:00 AM – 8:59 AM,
- Midday: 9:00 AM – 2:59 PM,
- PM Peak: 3:00 PM – 6:59 PM,
- Early Night: 7:00 PM – 10:59 PM, and
- Late Night: 11:00 PM – 3:59 AM

TABLE 3 BUS ROUTES ABOVE THE WMATA LOAD STANDARD BY TIME PERIOD

Time Period	Routes	Number of Routes
Early AM	30N, S2	2
AM Peak	E4, 42, L1, 33, 30N, 90, 32, W2, L2, G2, 31, 53, B2, 30S, W1, D2, 63, H3, V2, A2, S4, 52, U6, M4, 79, H4, W8, W4, X2, A4, H8, 64, 43, 54, 39, S2, X9, G8, V4, S9	40
Midday	S2, V2, 30S, 79, S4, 53, W4, L2, 70, 92	10
PM Peak	W4, 30S, V2, 79, 52, M4, 64, 42, S9, 30N, 33, E4, 31, 53, 63, U6, A8, 32, W1, L2, S4, X9, 70, X2, H8	25
Evening	30S, S2, S4	3
Late Night	S2	1

FIGURE 10 AM PEAK BUS OVERCROWDING

Overcrowding Load to Seat Ratio

AM Peak
- 0 - 0.5
- 0.51 - 0.75
- 0.76 - 1.0
- 1.01 - 1.2
- 1.2+
- Ⓜ Metrorail Stations
- ▬ Metrorail Lines

Key findings are summarized below:

- Overcrowding is highest in the AM peak where 40 routes have segments with overcrowding above WMATA's standard. High levels of overcrowding also occur during the PM peak with 25 routes experiencing overcrowding.
- Route S2 on 16th Street NW experiences overcrowding during all time periods, with the exception of PM Peak. However, other S series bus routes (S4 and S9) running on the same corridor also experience overcrowding during the PM Peak.

Table 4 lists the route segments as well as the associated routes with the highest load/seat ratio for each time period. The highest level of overcrowding was S9 in the southbound direction during the AM peak period with a load/seat ratio of 1.57. Similar to the previous findings S buses series experience the highest overcrowding during the AM Peak Midday and Late Night periods.

TABLE 4 HIGHEST BUS ROUTES ABOVE THE LOAD STANDARD BY TIME PERIOD

Time Period	Route	Direction	On Street	Overcrowding Load/ Seats
Early AM	30N	West	15th Street NW between F Street NW and I Street NW	1.29
AM Peak	S9	South	16th Street NW between Argonne Place NW and Caroline Street NW	1.57
Midday	S2	South	16th Street NW between Argonne Place NW and S Street NW	1.48
PM Peak	W4	North	Alabama Avenue SE between 12th Street SE and Congress Heights Metrorail Station	1.55
Evening	30S	West	Wisconsin Avenue NW between 34th Street NW and R Street NW	1.29
Late Night	S2	North	16th Street NW between Harvard Street NW and Newton Street NW	1.24

Bus Speeds

Speed is one of the key performance measures for bus operations as it is an indicator of quality of service for passengers. From a passenger's point of view, low speeds increase travel times and make the trip less pleasant. Average bus speed is also important to transit operators. Lower bus speeds cause longer running times and increased operating cost for transit agencies. Furthermore, if bus speeds increase sufficiently along a high frequency bus route, the number of buses required to operate the route can decrease.

This project analyzed the average bus speed between time points on all routes within the District using October 2015 data to assess bus performance. For each time point, the speeds are calculated for each individual route/ direction and in aggregate for all buses that drove the route between time points. The data is presented by time periods throughout the day, as defined above.

Figure 11 displays average PM peak period bus speeds in the District. The AM peak period has similar results. Bus speeds during late night are also shown in **Figure 12** to provide a speed reference under light traffic conditions.
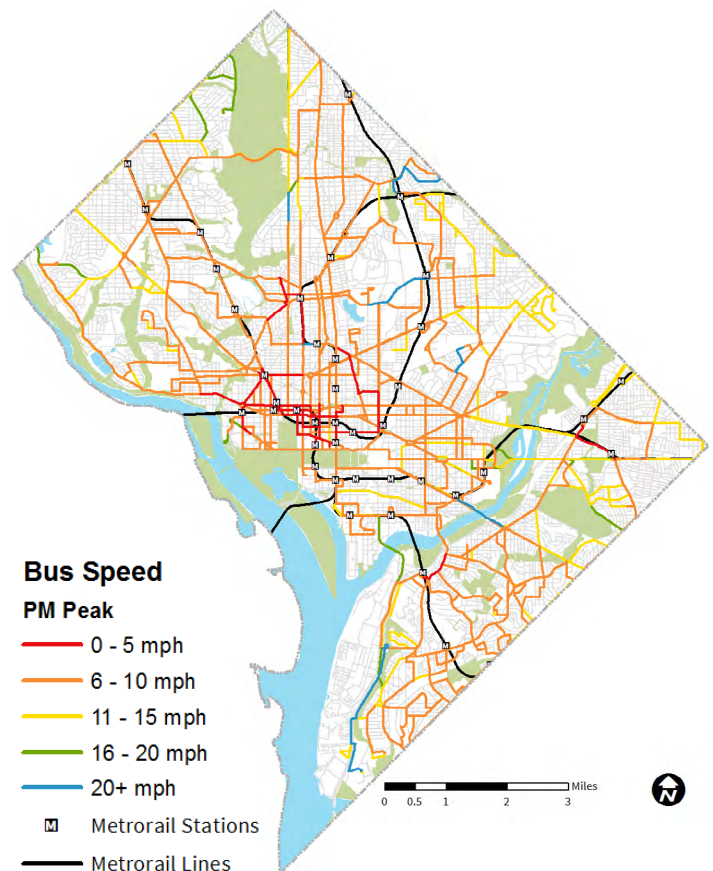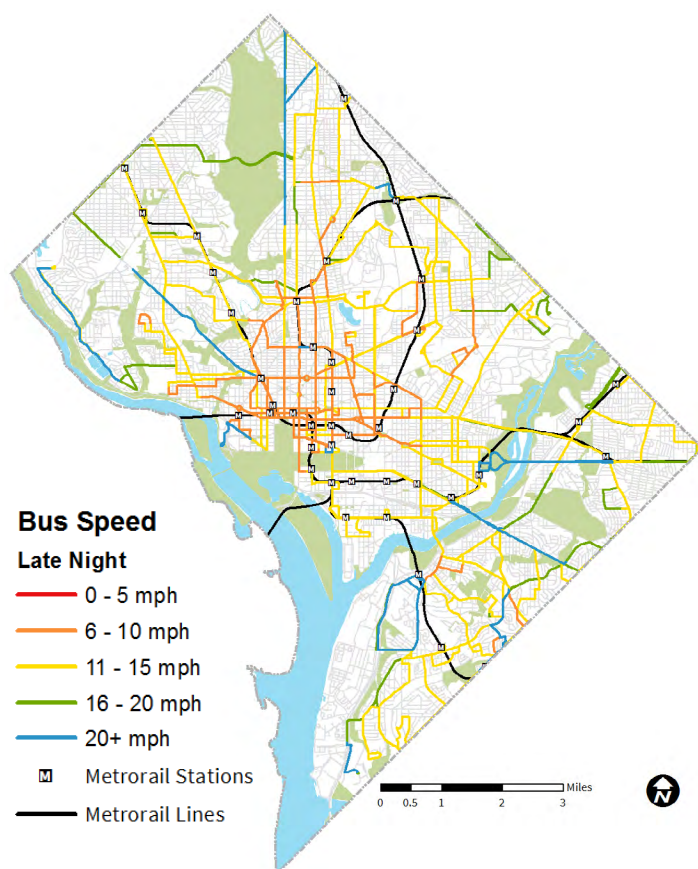
FIGURE 11 PM PEAK AGGREGATED BUS SPEED IN THE DISTRICT

Bus Speed
PM Peak
— 0 - 5 mph
— 6 - 10 mph
— 11 - 15 mph
— 16 - 20 mph
— 20+ mph
Ⓜ Metrorail Stations
— Metrorail Lines

FIGURE 12 LATE NIGHT AGGREGATED
BUS SPEED IN THE DISTRICT

Bus Speed
Late Night
— 0 - 5 mph
— 6 - 10 mph
— 11 - 15 mph
— 16 - 20 mph
— 20+ mph
Ⓜ   Metrorail Stations
—   Metrorail Lines

Key findings for bus speed include:

- During the PM peak period, average bus speed along most segments is less than 10 mph in the District.

- Average bus speeds in downtown are generally less than 5 mph. These segments may benefit from some of the transit preferential treatments DDOT is currently in the process of implementing, such as transit signal priority (TSP) and queue jump lanes.

- Late night average bus speeds are considerably higher than the speeds occurring during the peak periods. However, some segments, particularly in the downtown and some cross-street corridors experience speeds lower than 10 mph. Lower speeds during the late night period can be attributed to the closely-spaced signalized intersections, causing delay for buses even under "light" traffic and ridership conditions.

- Table 5 shows roadway segments with the slowest bus speeds for each time period. Results show that the K Street NW corridor causes major delays for buses, resulting in average bus speed of 3.5 mph both in the AM and PM peak periods.

TABLE 5 ROADWAY SEGMENTS WITH LOWEST BUS SPEEDS BY TIME PERIOD

| Time Period	Street	Street Segment	Speed (mph)
Early AM	Pennsylvania Avenue NW	9th St NW to 7th St NW	6.1 mph
AM Peak	13th Street NW	K St NW to H St NW	3.5 mph
	K Street NW	13th Street NW to 15th Street NW	
Midday	Columbia Road NW	14th St NW to Biltmore St NW	3.8 mph
PM Peak	K Street NW	K St NW to H St NW	3.5 mph
	K Street NW	13th Street NW to 15th Street NW	
Evening	H Street NW	13th Street NW to 7th St NW	4.3 mph
Late Night	Pennsylvania Avenue NW	9th St NW to 7th St NW	5.2 mph

Travel Time Reliability

This section focuses on the measures addressing travel time reliability. Unreliability in travel time can be far more frustrating than recurring congestion. Managing travel time variability improves travelers' experience and makes the overall system function better.

Auto Reliability – Planning Time Index

To assess and quantify auto reliability in the District, planning time index (PTI) is used based on the 2015 INRIX data. PTI is a measure of reliability defined as the ratio of 95th percentile travel time to the travel time in light of free flow traffic. A PTI of 2.0 indicates that for a trip that takes 20 minutes in light traffic, a traveler should budget 40 minutes to ensure on-time arrival 19 days out of 20 (95 percent of the time). **Figure 13** provides a graphical representation of TTI and PTI on an average weekday using District-wide travel time data from 2015.

FIGURE 13   GRAPHICAL REPRESENTATION OF TRAVEL TIME INDEX AND PLANNING TIME INDEX[4]

"Buffer" between expected (average) and 95th percentile travel times
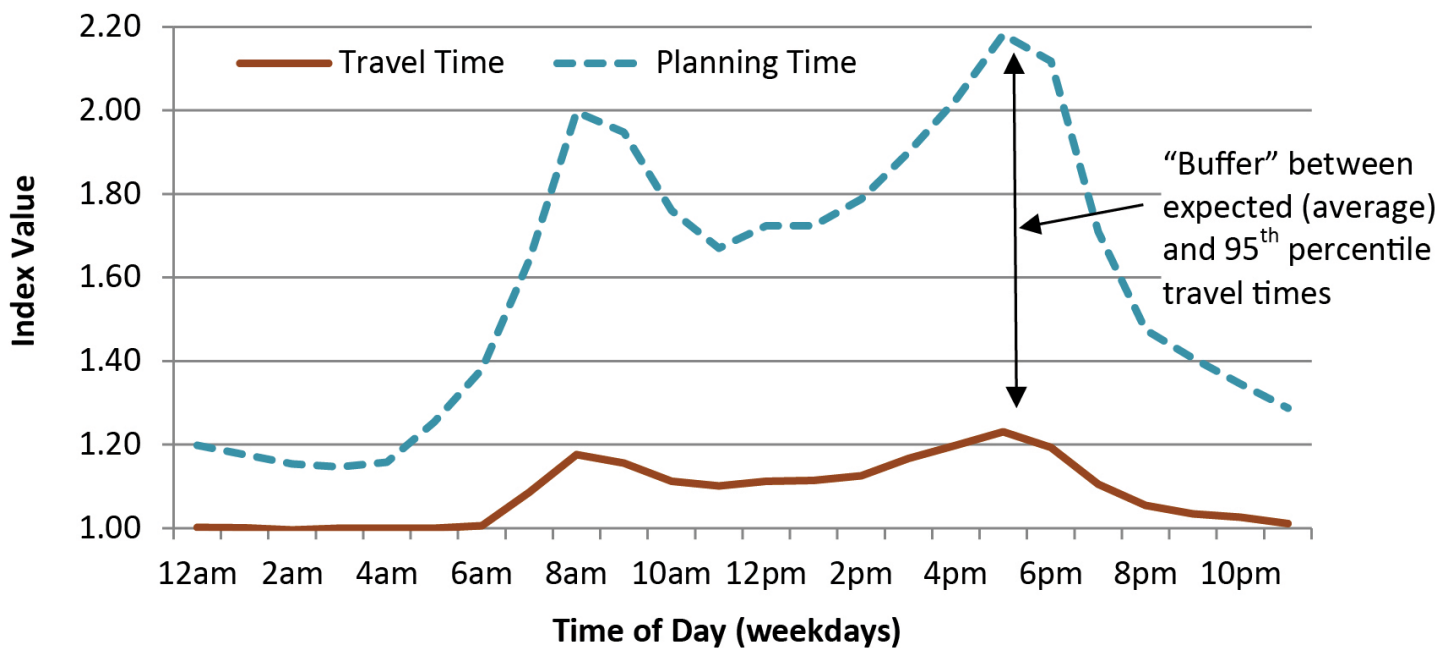
4   Adapted from Travel Time Reliability: Making It There On Time, All The Time. (2015). Federal Highway Administration. District data from INRIX, 2015.

Figure 14 provides a snapshot of auto travel time reliability in the District roadways based on the weekday PTI during the peak periods. Figure 15 shows PTI distribution for non-highway roads at different times during weekdays and weekends.

Morning Peak Planning Time Index   **Evening Peak Planning Time Index**

1.2   1.5   2.0   2.5   3.0
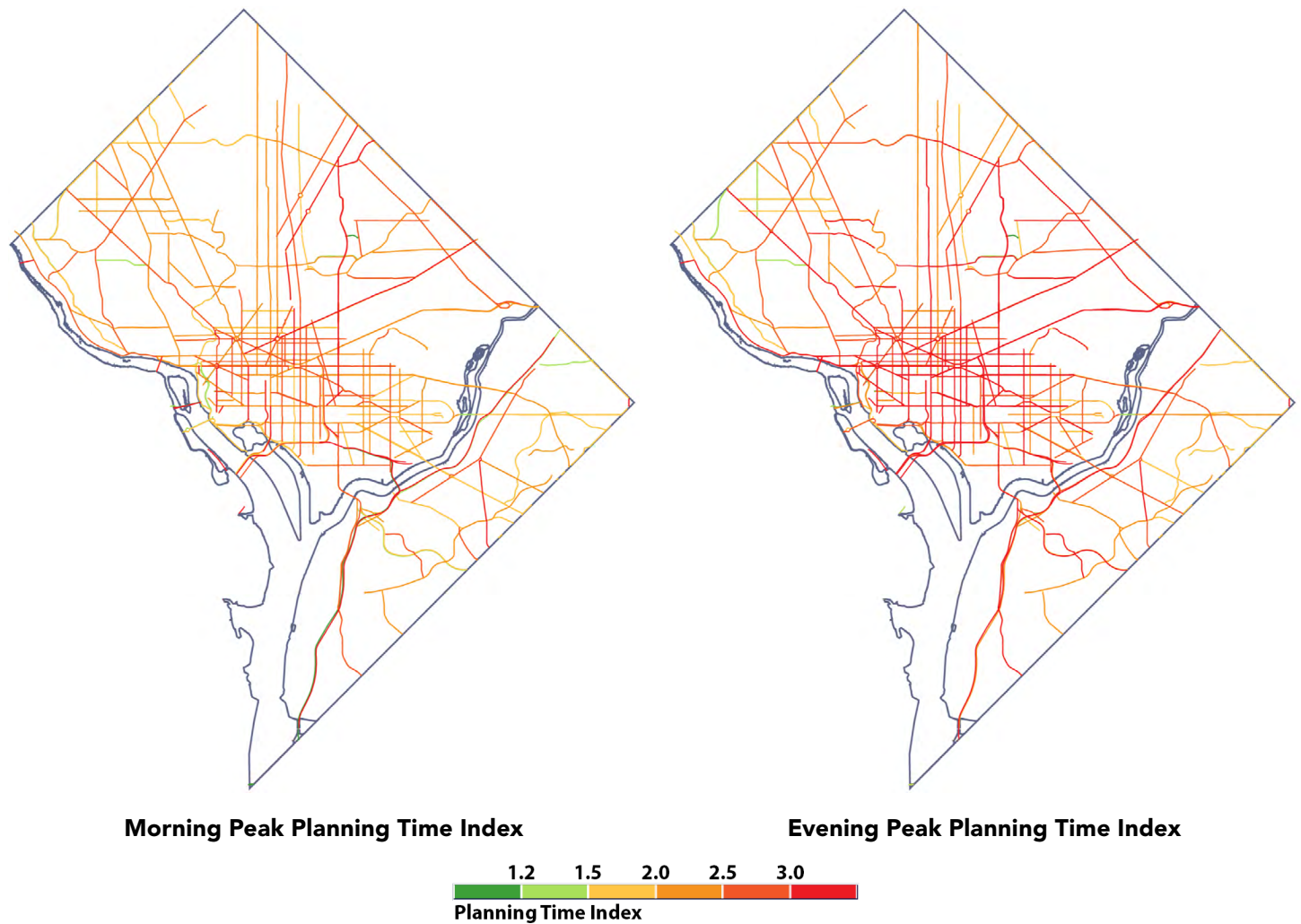
Planning Time Index
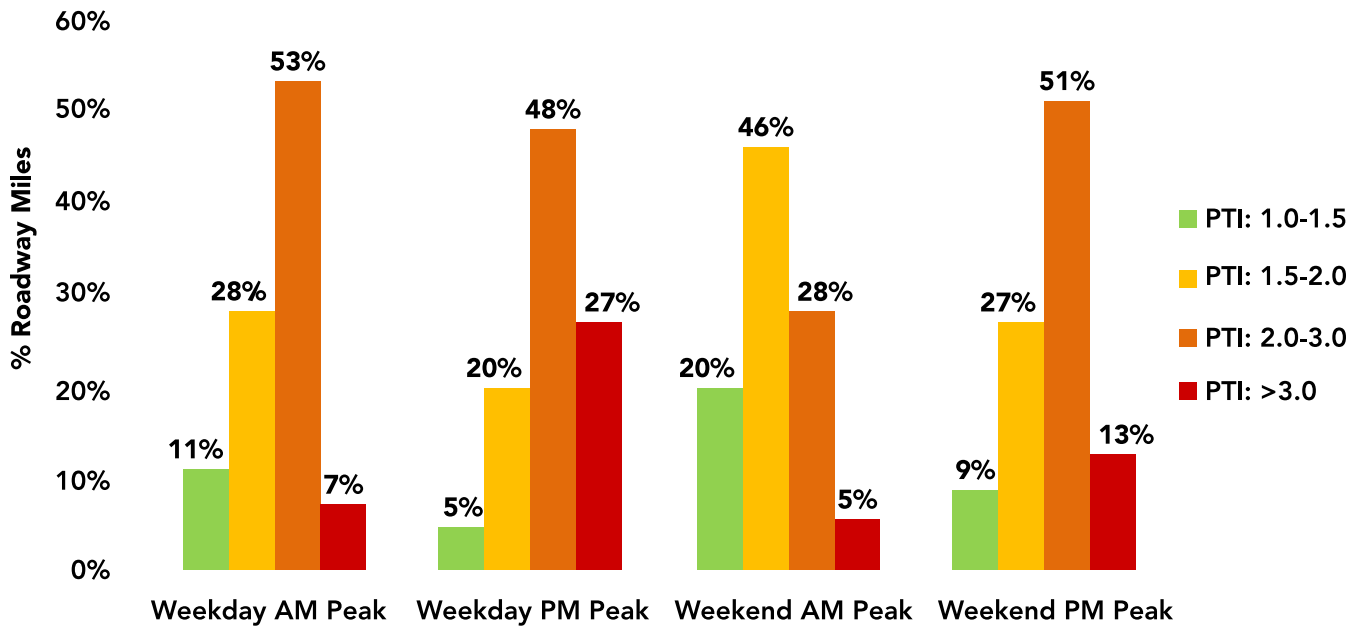
Key findings for the PTI analysis are:

- There is a strong correlation between TTI and PTI. Roadways with high levels of traffic congestion (i.e., high TTI) also experience unreliable traffic conditions (i.e., high PTI). As for auto congestion, auto travel time reliability is the worst worse in the weekday evening peak period.

- For non-highway roadways in the District, 75 percent of measured roadways during the PM peak and 60 percent during the AM Peak have a PTI that is higher than 2.0 during the peak hours on a weekday.

- The share of roadways with a PTI greater than 3.0 is significantly higher for the weekday PM peak period than for any other period. This is a very high level of variability that makes it difficult for travelers to accurately predict when they will get home or to after-work destinations.

- Similar to the TTI, inbound Key Bridge during the PM peak has the highest PTI in the District both during the weekday and weekend.

There are some limitations to using PTI, since each individual will value "on time performance" differently, but the reliability of the system plays a big role in the public's perception of congestion. People remember the time they were 30 minutes late to work more than the 19 times they arrived on time. And there can be real consequences for being late to work (lost job) or to pick up children from childcare (fines).

One of the challenges for managing traffic in the District is the number of crashes and high profile dignitary movements that require a police presence. In 2016, through September, there had been 72 dignitary moves, including 16 during peak hours. Crashes and police escorts contribute substantially to the variations in travel time.

Bus On-Time Performance

A transit vehicle is considered "on-time" if it departs a location within a certain number of minutes after and/or before the scheduled time.[5] From the transit operator's perspective, on-time performance reflects the quality of the schedule, the operations control, and the reliability of the roadways. For passengers, it reflects the quality of service and their ability to reach destinations or make transfers as planned.

This project analyzed on-time performance in terms of the difference between the scheduled and actual travel time between time points. WMATA's standards were used to determine if a trip was on-time. WMATA defines a bus on-time if it arrives between two minutes early (-2 minutes) and five minutes late (+5 minutes). On-time performance is calculated as the difference between how long it took the bus to travel between two time points and how long the schedule expected that trip to take. This is referred to as the "runtime difference." **Figure 16** displays AM peak runtime difference for roadway segments in the District. PM runtime differences follow a similar pattern.

Results show that for most segments, buses are on-time (shown in blue and green) for individual timepoints. A few roadway segments have arrivals that are earlier than 2 minutes (as shown in red), and a very few of the segments experience very late arrivals, as shown in orange. **Table 6** highlights the bus route segments with the worst on-time performance by time period and direction.

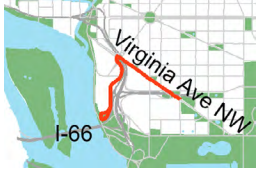**FIGURE 16** AM PEAK RUNTIME DIFFERENCE BETWEEN TIMEPOINTS
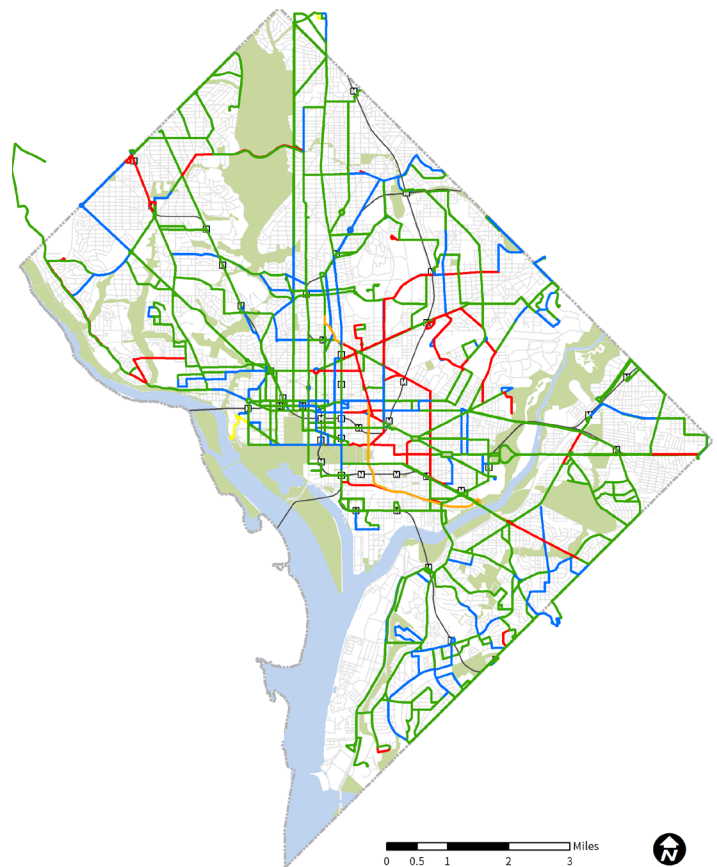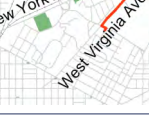

Runtime Difference

AM Peak

— More than 2 Minutes Early
— 2 Minutes to 1 Minute Early (WMATA On-Time)
— 1 Minute Early to 5 Minutes Late (WMATA On-Time)
— 5 Minutes to 7 Minutes Late
— More than 7 Minutes Late

WMATA

Ⓜ Metrorail Stations
— Metrorail Lines

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5   A Guidebook for Developing a Transit Performance-Measurement System, Transit Cooperative Research Program, Transportation Research Board, 2003.

TABLE 6 BUS ROUTE SEGMENTS WITH EARLIEST AND LATEST ARRIVALS BY TIME PERIOD

Time Period	Early Arrival	Route & Direction	Route Segment	Route Image	Late Arrival	Route & Direction	Route Segment	Route Image
Early AM	4.0 Minutes	32 West	Eye St NW & 17th St NW to Virginia Ave NW & E St NW		5.0 Minutes	80 South	Virginia Ave NW & 21st St NW to Kennedy Center	
AM Peak	5.9 Minutes	W4 North	Benning Road SE & East Capitol St to Southern Ave SE & Ridge Rd SE		5.0 Minutes			
Midday	5.6 Minutes	N3 East	23rd St NW & Eye St NW to 20th St NW & Massachusetts Ave NW		5.4 Minutes	90 North	U St NW & 14th St NW to Calvert St NW & Biltmore St NW	
PM Peak	7.2 Minutes	W5 West	Anacostia Metrorail Station to St Elizabeths Gate 4		6.1 Minutes			
Evening	7.0 Minutes	V1 East	H St SE & 46th Pl SE to Minnesota Ave SE & B St SE		5.6 Minutes			
Late Night	3.9 Minutes	90 South	8th St NE & H St NE to North Capitol St & Florida Ave NE		4.1 Minutes	L2 South	Connecticut Ave NW & Eye St NW to Connecticut Ave NW & T St NW	
	3.9 Minutes	D4	West Virginia Ave NE & Mount Olivet Rd NE to New York Ave NE & Fenwick St NE					

Key findings:

- In general, during the Early AM and Late Night periods, buses are more likely to arrive later than the scheduled arrival time. During the AM Peak, Midday, and PM Peak periods, buses tend to arrive earlier than scheduled arrival time. This reflects the buffer built into the schedule to account for less reliable travel times during those periods (as seen in the PTI section).

- The same bus routes and segments tend to be the ones that are the latest. The end of the route for the 90 North is the latest segment from midday through early evening. This may indicate that the schedule has not been adjusted recently and/or that there were unexpected conditions in the Adams Morgan area during the period this analysis was conducted.

Bus on-time performance is most useful as a measure when combined with other metrics because schedule adherence does not fully capture the variability of travel times along a route. The runtime for a route is varied throughout the day in response to expected travel times on street. So, a trip that takes 20 minutes in the early morning may be scheduled to take 30 minutes in the peak periods due to congestion. On-time performance reflects the ability of the transit agency to adjust schedules to reflect typical runtimes as well as the conditions encountered en route (e.g., roadway congestion, unusually low or high ridership).

Accessibility

Accessibility can be understood in two aspects: access to modes and access to destinations. Access to modes assesses which modes a traveler can potentially use. If bus service or a bikeshare station is not nearby to them, people will not choose that option. Having access to more modes increases travelers' flexibility, particularly in an urban environment. Modes and routes travelers use are not fixed and many regular District travelers have a backup route when conditions deteriorate on one mode (e.g. if a Metrorail line has issues, they may switch to bus or bikeshare). Thus, the network available to each user affects how they choose to travel, as well as to where and when they choose to travel. Accessibility metrics of this type focus on the share of the population (residents or employees) that are able to access different modes.

Access to destinations recognizes that traveling is generally destination-driven: people do not travel just to travel, but instead travel to get to jobs, shops, or services. When the network is congested, it typically takes longer to get around and therefore reduces how many jobs, goods, or services an individual can reach quickly. However, even with congestion, most destinations will remain accessible if trips are typically short. Accessibility metrics of this type focus on how many opportunities (jobs, shopping, etc.) a traveler can get to within a set travel time by a particular travel mode.

This project focuses on the access to modes. The project team selected three performance measures to address multimodal accessibility in the District: (1) transit coverage area, (2) bicycle coverage area, and (3) pedestrian friendliness index (PFI). Accessibility to jobs is an addition anticipated in future efforts.

Transit Coverage Area

To assess transit coverage in the District, this project calculated the area within walking distance, or walkshed, of bus stops and Metrorail stations. WMATA's General Transit Feed Specification (GTFS) data from October 2015 to April 2016 was the basis of the walkshed analysis. The GTFS database is a record of the transit schedule for Metrorail, Metrobus, and DC Circulator and is arranged by stop, routes, and trips. The walking distances used were ¼ mile (or a 5 minute walk) to Metrobus and ½ mile (10 minutes) to Metrorail, following actual walking routes. These are distances commonly used in transit analyses.[6]

Bus Walkshed

Figure 17 depicts the areas of the District that are within an approximately 5-minute walk (¼ mile) of bus stops with buses coming every 10 minutes or less in the AM peak period. A bus every 10 minutes is widely used in transportation analyses as the threshold for high-frequency bus service.[7] A 5-minute walk is generally indicative of a comfortable walking distance. In the District, many people walk farther to access transit, especially if it is frequent and reliable. In comparison, **Figure 18** depicts the bus walkshed during the Early AM period and illustrates the reduced availability of high-frequency bus service during the non-peak period. The walksheds during the PM peak and other off-peak periods exhibit similar patterns.

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6   Transit Capacity and Quality of Service Manual, Second Edition. Transportation Research Board, 2003.

7   Figliozzi, Miguel A., Wu-chi Feng, Gerardo Lafferriere, and Wei Feng. A Study of Headway Maintenance for Bus Routes: Causes and Effects of "Bus Bunching" in Extensive and Congested Service Areas. OTREC-RR-12-09.Portland, OR: Transportation Research and Education Center (TREC), 2012.
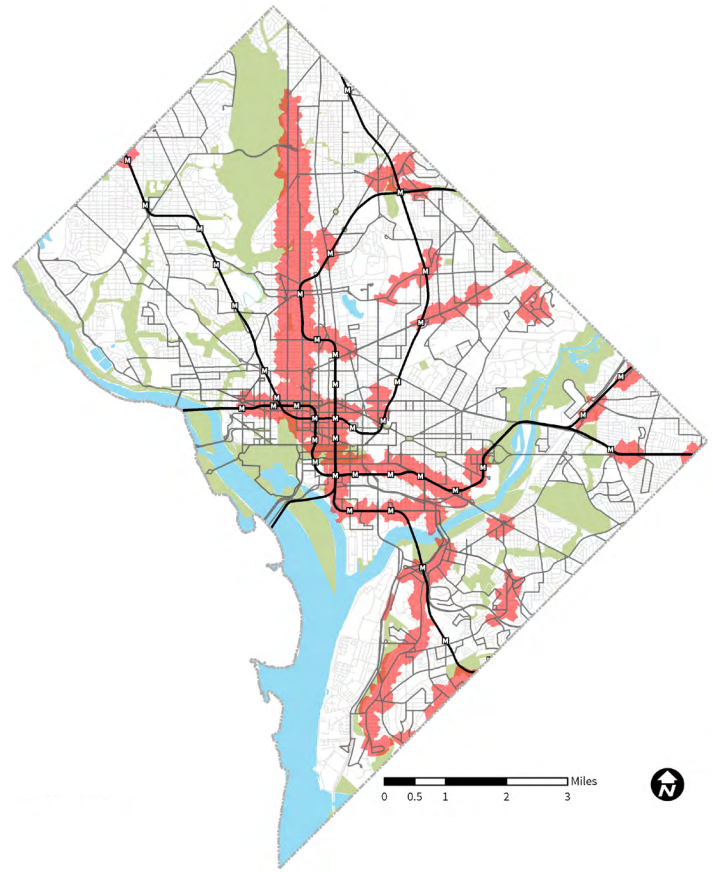
FIGURE 17 METROBUS AM PEAK
PERIOD WALKSHED
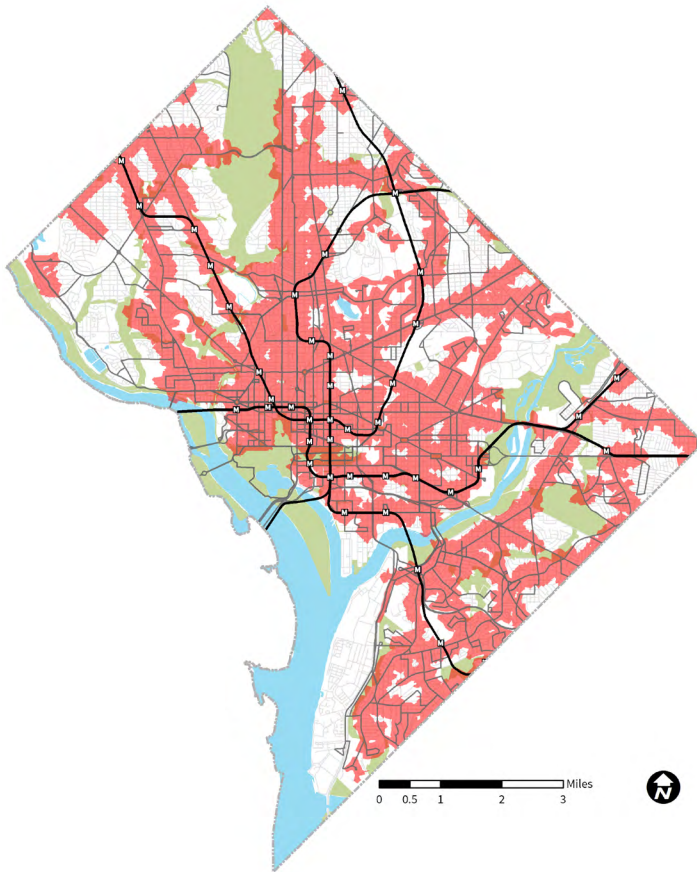
**Metro Bus - AM Peak Period
10 min or Better Frequency**

- 🟥 Walkable Area Within 1/4 mile of Stop
- Ⓜ Metrorail Stations
- ── Metrorail Lines
- ── Bus Routes

FIGURE 18 METROBUS EARLY AM
PERIOD BUS COVERAGE

**Metro Bus - Early Period
10 min or Better Frequency**

- 🟥 Walkable Area Within 1/4 mile of Stop
- Ⓜ Metrorail Stations
- ── Metrorail Lines
- ── Bus Routes

Key bus walkshed findings are:

- The majority of the District has access to 10-minute or better bus service in the AM peak period, with most exceptions being park land or low-density residential neighborhoods (northwest, northeast, and upper central).

- During the Early AM and Early Night periods (i.e., off-peak period), bus coverage is substantially more limited with the exceptions of 14th Street NW (50s routes), 16th Street NW (S routes), ML King Jr Avenue (A and W routes), and downtown (multiple routes).

- During the Late Night period, none of the stations have a bus every 10-minutes or less in the District, resulting in zero high-frequency bus walkshed.
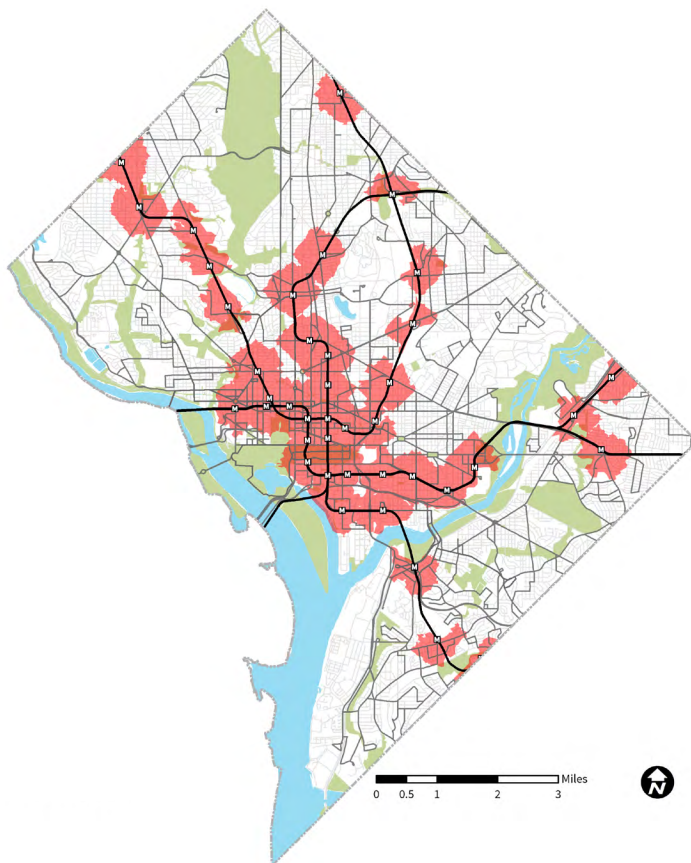
Metrorail Walkshed

High frequency Metrorail service is defined as a train every five minutes or less in this project. **Figure 19** displays the areas of the District that are within a 10-minute walk (½ mile) of high frequency rail service in the AM peak period. **Figure 20** depicts the high-frequency Metrorail walkshed during the Early AM period.

Key Metrorail walkshed findings are:

- During the AM peak period, the majority of the central area of the District (U Street/Florida Avenue to both rivers) has access to 5-minute or better rail service within a 10-minute walk period.

- In the off-peak time periods, only stations where multiple lines overlap (e.g., Fort Totten Station, Blue/Orange/Silver lines where shared) provide to 5-minute or better rail service. Only two stations, Cleveland Park and Van Ness, have trains less frequently than every 10 minutes.

- The walksheds are also generally large around Tenleytown, Columbia Heights, Georgia Avenue/Petworth, Anacostia, and Benning Road. Many peripheral stations, however, have relatively small walksheds due to barriers to walking and more irregular roadway networks.

- The road/sidewalk network around the Rhode Island and Fort Totten Metrorail Stations limits pedestrian access to the stations.

- There are sizeable gaps in coverage along the Red Line even though the stations are relatively close together.
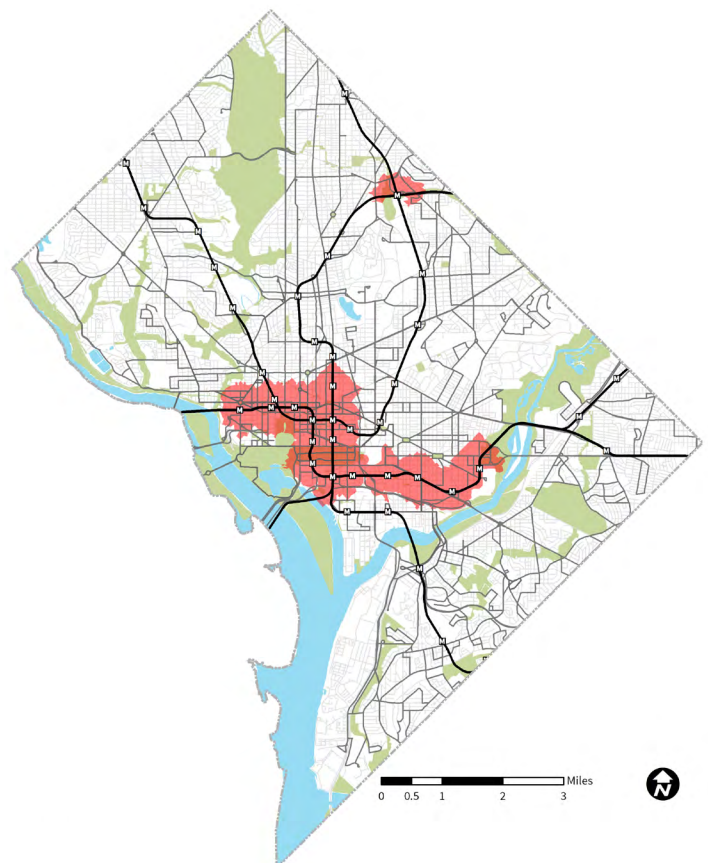
FIGURE 19 METRORAIL AM PEAK PERIOD WALKSHED

**Metro Rail - AM Peak Period
5min or Better Frequency**

▮ Walkable Area Within 1/2 mile of Station
Ⓜ Metrorail Stations
— Metrorail Lines
— Bus Routes

FIGURE 20 METRORAIL EARLY AM PERIOD WALKSHED

**Metro Rail - Early Period
5min or Better Frequency**

▮ Walkable Area Within 1/2 mile of Station
Ⓜ Metrorail Stations
— Metrorail Lines
— Bus Routes

Bicycle Coverage Area

Bicycle coverage area for the District is evaluated using two accessibility measures: (1) accessibility to Capital Bikeshare stations, and (2) accessibility to low-stress bicycling facilities. Bicycling in cities is highly dependent on the presence of low-traffic stress bicycle infrastructure (e.g., cycle tracks, bike lanes, multi-use paths, etc.) as well as on bikeshare station density. Therefore, understanding gaps in bicycle accessibility in the system will help identify future projects to improve access and comfort, which in turn help to increase in bicycle usage in the District.
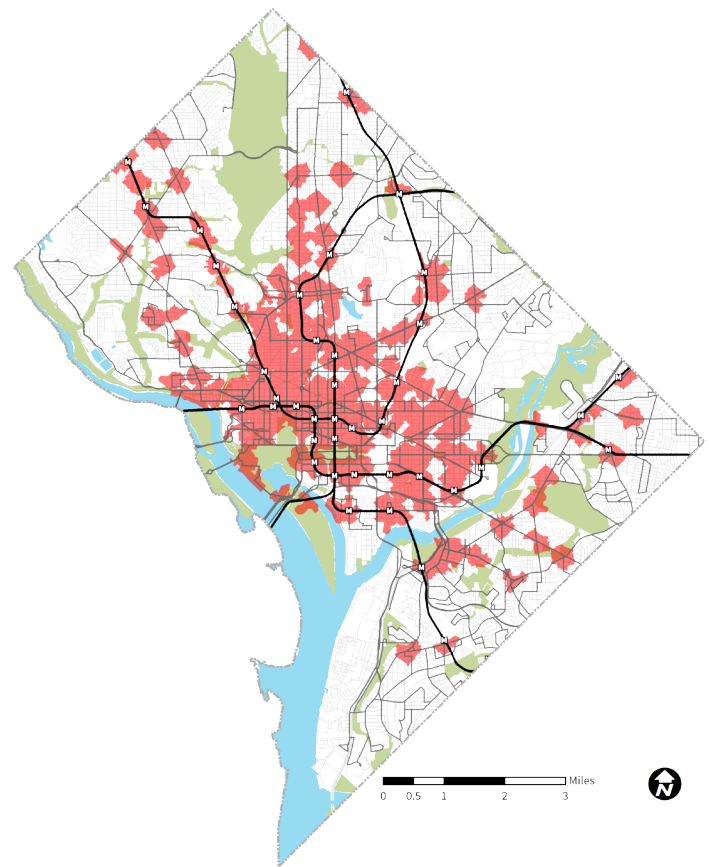
Bikeshare Walkshed

As with transit coverage, the walkshed was calculated around each Capital Bikeshare station. **Figure 21** shows the areas in the District that are within a 5-minute walk (¼ mile) walk of a bikeshare station. Since bikeshare stations are open 24-hours, the bikeshare walkshed remains constant throughout the day.

Key findings are summarized below:

• Although bikeshare stations can be found in nearly every neighborhood throughout the District, there is a definite concentration in the central core and the neighborhoods directly adjacent to the central core. This area is stretches from Georgetown to Mt. Pleasant, down Florida Avenue to the Starburst intersection, and down to and along the Anacostia River.

• Most Metrorail stations in the District have Bikeshare to improve first/last mile connections, thus a pattern following the Metrorail system is apparent.

• Fewer stations are present in the low density residential neighborhoods of the District.

FIGURE 21 CAPITAL BIKESHARE WALKSHED

Capital Bike Share

▮	Walkable Area Within 5-minute Walk of Station
Ⓜ	Metrorail Stations
▬	Metrorail Lines
──	Bus Routes

Bicycle Level of Traffic Stress

To understand access to bicycle facilities, this project uses the bicycle level of traffic stress (LTS) method to provide a meaningful network-level assessment of bicycle facility availability.[8] LTS evaluates the impact of infrastructure and traffic on a cyclist's experience by classifying road segments into one of four "stress levels" for bicycling. These stress levels are inspired by the "Four Types of Cyclists" popularized by the City of Portland and correlated to the theorized comfort level of different types of cyclists:[9]

- LTS 1: a level of traffic stress that most children can tolerate, roads are quiet and comfortable

- LTS 2: a level tolerable for the mainstream adult population who may not ride a bicycle regularly

- LTS 3: a level tolerated by American cyclists who are "enthused and confident" but prefer dedicated space for cycling

- LTS 4: a level tolerated only by those cyclists characterized as "strong and fearless"

The LTS method recognizes that cyclists are sensitive to traffic conditions and are likely to only choose to bicycle for transportation if their trip can be completed on streets at or below their individual stress comfort level. Thus, providing better low-stress connections has the potential to attract more riders and improve bicycle accessibility.

Table 7 provides the LTS scoring method for mixed traffic streets, or those streets without any dedicated bicycle infrastructure. On these streets, the key variables are traffic speed and the number of lanes (street width).

TABLE 7 DESCRIPTION OF FOUR LEVELS OF TRAFFIC STRESS (LTS) ON STREETS WITHOUT BICYCLE INFRASTRUCTURE[8]

Speed Limit	Street Width		
	2-3 LANES	**4-5 LANES**	**6+ LANES**
Up to 25 mph	LTS 1[a] or 2[a]	LTS 3	LTS 4
30 mph	LTS 2[a] or 3[a]	LTS 4	LTS 4
35+ mph	LTS 4	LTS 4	LTS 4

[a]: Use lower value for streets without marked centerlines or classified as residential and with fewer than three lanes; use higher value otherwise.

Figure 22 depicts the results of the initial LTS analysis for the District and **Figure 23** shows the percent of LTS linear miles by Ward in the District. These results should be seen a starting measure, with additional refinements to follow. In particular, the project team only calculated the LTS for roadway segments, not the intersections. It was assumed for this analysis that the street ratings would apply to the intersections, but there is a separate methodology to calculate the traffic stress criteria for intersection approaches. DDOT staff intend to do this in the future.

Key findings of the LTS analysis are:

- Wards 2 and 6 have the highest percentage of high stress streets (by linear mile), and Wards 4, 7, and 8 have the lowest percentage of high stress streets.

- Roadways for river crossings lack low-stress bike facilities (unless cyclists use the sidewalk), which becomes a barrier for all but the most confident cyclists.

- Most major arterials (e.g., 16th Street NW or Connecticut Avenue NW) have LTS 4, however the lack of low-stress facilities on these arterials are mainly compensated for by providing low LTS facilities on parallel roadways, such as 15th Street NW, to improve connectivity.

8   Mekuria, Maaza C., Furth, Peter G. and Nixon, Hilary. Low-Stress Bicycling and Network Connectivity. Mineta Transportation Institute, 2012.

9   Geller, R. (n.d.). Retrieved July 8, 2016, from Four Types of Cyclists: https://www.portlandoregon.gov/transportation/article/158497

FIGURE 22 DISTRICT BICYCLE LEVEL OF TRAFFIC STRESS

Legend:
- Limited Access Areas
- LTS 1 Streets
- LTS 2 Streets
- LTS 3 Streets
- LTS 4 Streets
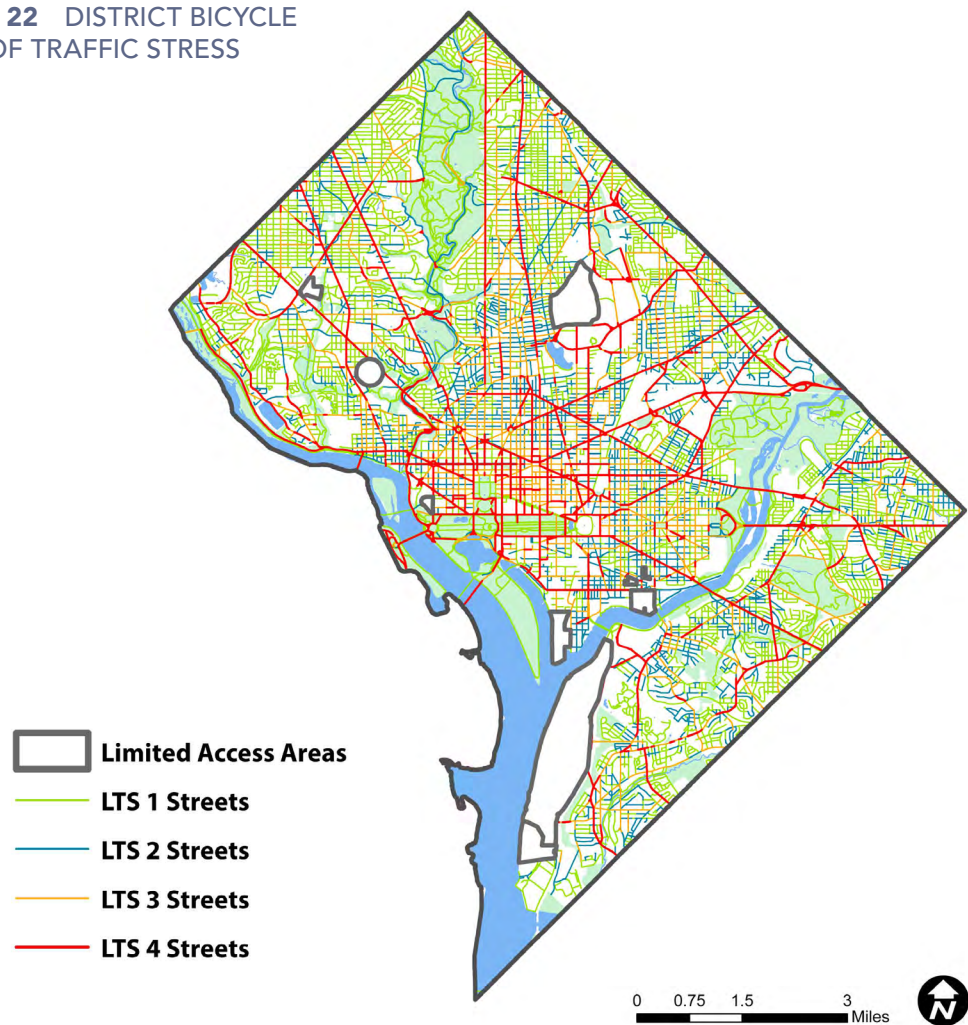
FIGURE 23 PERCENT OF LEVEL OF TRAFFIC STRESS (LTS) MILES BY WARD IN THE DISTRICT

Y-axis: Percent of LTS Linear Miles

Legend:
- % LTS 1
- % LTS 2
- % LTS 3
- % LTS 4

Wards: Ward 1, Ward 2, Ward 3, Ward 4, Ward 5, Ward 6, Ward 7, Ward 8
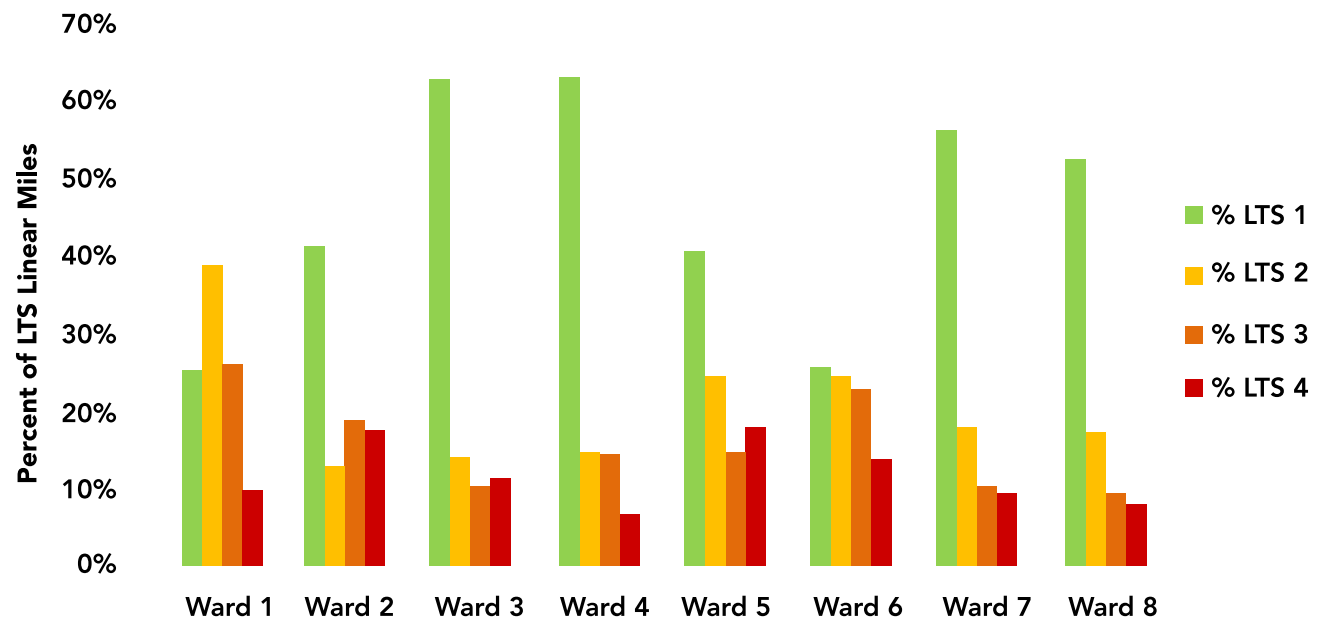
Pedestrian Friendliness Index

In order to evaluate pedestrian accessibility in the District and identify critical gaps in the pedestrian network, the project team completed a Pedestrian Friendliness Index (PFI) analysis on all District census blocks. PFI characterizes the walkability of neighborhoods based on the network design, sidewalk availability, and building accessibility. It assigns neighborhoods a score indicating how "friendly" they are to pedestrians compared to surrounding neighborhoods.[10] Neighborhoods that earn a low score under the PFI methodology generally have longer block lengths, lower density, disconnected streets, fewer sidewalks (or gaps), and larger building setbacks than neighborhoods that merit a high PFI score. The PFI method recognizes that pedestrians are sensitive to the built environment, and are less likely to walk for transportation if their trip cannot be completed comfortably and efficiently. Consequently, the PFI method highlights neighborhoods that could benefit from targeted improvements to the pedestrian network and surrounding land uses.

The results of the PFI analysis are shown in **Figure 24**.

FIGURE 24 DISTRICT PEDESTRIAN FRIENDLINESS INDEX (PFI) RESULTS
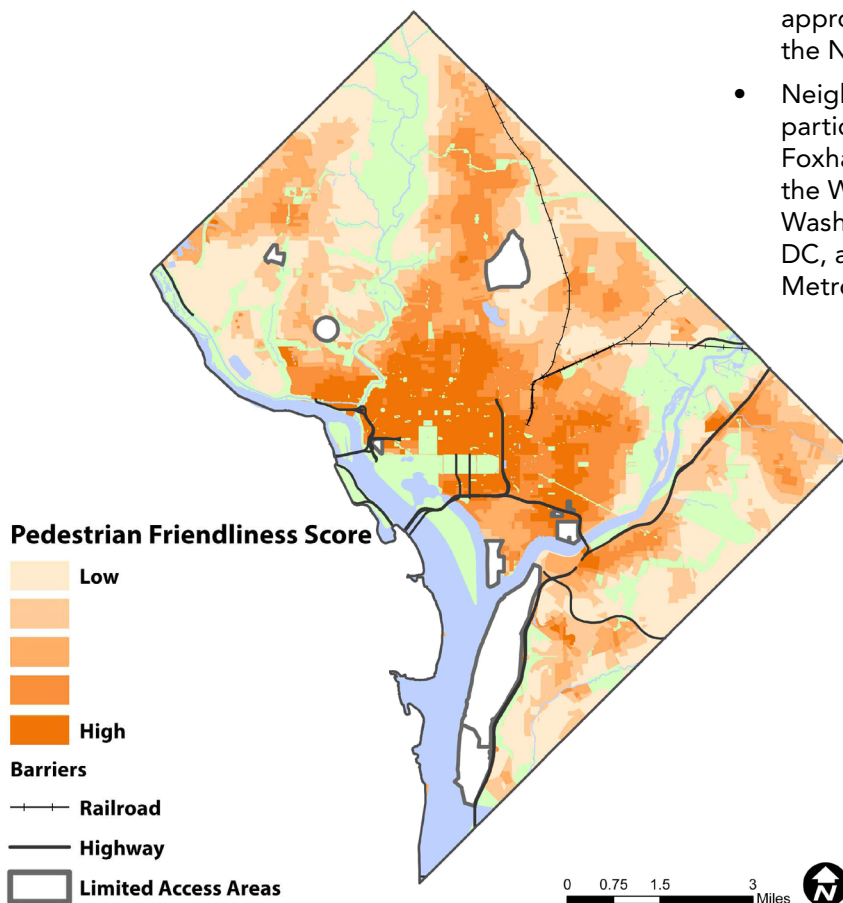
Key findings of the PFI analysis are summarized as follows:

- Downtown DC and its robust street grid combined with ample sidewalks result in some of the highest PFI scores in the District.

- Wards 2, 6 and 1 generally have high PFI scores, with minor exceptions including Mount Pleasant, northwest Dupont, southwest Waterfront, and the areas near Howard University and the Washington Hospital Center. The lower PFI scores assigned to neighborhoods such as Mount Pleasant and northwest Dupont highlight the fact that the presence of subjectively pleasant, tree lined streets are not alone sufficient to foster a truly accessible pedestrian environment. The long, curvilinear blocks and lack of four-way connections in these neighborhoods make it less convenient for residents to travel to nearby destinations on foot.

- High PFI scores are less frequent in the wards further from downtown. Ward 3 in northwest DC and Wards 7 and 8 in southeast DC have some of the lowest PFI scores in the District. The street network in these Wards is arguably more suburban in nature than in downtown, with larger blocks and building setbacks, winding roads, and gaps in sidewalk coverage. Pedestrian connectivity also falls off in the blocks approaching major parks such as Rock Creek Park and the National Arboretum.

- Neighborhoods and areas that are notable for particularly low PFI scores include the Palisades and Foxhall Village neighborhoods in northwest DC, the Woodland, Westover View, Penn Branch and Washington Highlands neighborhoods in southeast DC, and key destinations adjoining Stadium Armory Metro Station.

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10   Parks, J. R. and J. L. Schofer. Characterizing Neighborhood Pedestrian Environments with Secondary Data. Transportation Research Part D 11, pp. 250-263, 2006.

INFORMING DECISION MAKING

Planning efforts such as *moveDC* and the *Sustainable DC* provided the District a vision and goals for its transportation system. The *District Mobility Project* provides a framework for monitoring progress towards those mobility goals and provides data to assist with prioritizing investments to improve multimodal mobility.

Management and Monitoring Program

The District Mobility Project serves as the initiation of a DDOT system mobility management and monitoring program. Through a management and monitoring program, DDOT can standardize and expand ongoing efforts to evaluate travel conditions.

The program is guided by four principles:

- **Assessing multimodal system performance regularly:** A first step in system management is continued self-assessment. It is the evaluation of how the system is performing for a set of metrics. This project has laid the groundwork by defining system performance and identifying the supporting performance metrics. Measurement and evaluation should occur on at least an annual basis.

- **Maintaining a long term monitoring perspective:** Annual measurement and assessment provides the opportunity to identify trends and determine if strategies are having the desired effect. In the dynamic environment of a city, there are often changes within the system that are subtle and difficult to quantify at a microscopic level, but are easily observable over a longer period of time. Year-to-year fluctuations may not show a desired outcome but longer term assessments may indicate that strategies are helping to make progress towards mobility goals.

- **Identifying and Prioritizing Projects:** The data and metrics calculated in this project provide baseline data and metrics to support other projects. Using this data and the identified performance measures in studies and project evaluations will provide a more consistent understanding of mobility opportunities and impacts. This aligns with other efforts to define consistent metrics for planning studies.

- **Creating transparent metrics and open data:** A final objective for transportation system management and monitoring is the development of transparent communication with policymakers, regional partners, and the public. Through regular assessments of system performance using consistent measures and the sharing of the data behind those measures, the public can understand the need for projects and regional partners can start from a better baseline to identify feasible and mutually beneficial strategies.

Further development of the system mobility management and monitoring program will improve the efficiency and effectiveness of decision-making by DDOT staff and District policymakers by providing better methods of evaluating congestion and better data to integrate into all agency processes, from research and planning to operations and design. In the near-term, data from the monitoring program will help DDOT staff to identify strategies and actions on active projects in targeted areas. In the mid-term, performance measure results will provide information to prioritize strategies that may require supplemental planning, design, and funding. Longer term opportunities with system performance information will aid in envisioning initiatives to achieve goals.

Investment Plan

The last element of this project and a part of the monitoring program described above is to take the outputs from the performance measures and identify potential actions to address (or begin to address) multimodal congestion in the District. There are two components to the resulting investment plan. First, the project team identified a set of focus areas with overlapping concerns between modes and mobility categories. These focus areas suggest where to target investments in the coming years. Second, there are a set of actions by year, which include implementing the monitoring plan, actions needed to address the focus areas, and broader system-wide efforts that can help to mitigate congestion more generally.

This will be a plan in motion. Plans and projects will become more refined as out-years get closer to the present. The refinement is a natural result of the planning process, which brings greater definition as ideas become plans, then designs, and finally construction or operations projects. The plan will also be refined as DDOT staff learns from studies, assessments, and post-implementation evaluations. The recommendations for future years are focused on achieving the other transportation system management and monitoring plan objectives as well as developing and implementing strategies and projects that can improve system performance.

There are caveats to this process. First, not all studies or assessments conducted in response to identified congestion issues will necessarily lead to recommendations to implement or make changes. Sometimes the evaluation or piloting of an idea will show that not pursuing that idea is better. Second, the District is a dynamic place. The most congested areas today may not be the highest priorities in several years, as land uses, system users, and system technologies change. The transportation system management and monitoring plan is meant to serve as an input into that ongoing evaluation. Lastly, congestion in the District is a challenge and one of several priorities for the transportation system. While DDOT and other agencies can work to reduce congestion, they are doing so in a constrained environment while also trying to serve other operational objectives such as improving safety and managing asset condition. This is why the monitoring plan focuses on the longer term view and how incremental changes add up to larger impacts.

Mobility Maps

Results from each performance measure provide insights into a part of system mobility in the District. To understand mobility issues more broadly, performance deficiencies for each metric were mapped and grouped by mobility category. Deficiencies for each measure were identified as higher frequency of issues, such as high bus overcrowding during multiple time periods. By overlaying the deficiencies by mobility category, common locations of mobility challenges are identified.

Figures 25-27 summarize the mobility challenges by congestion, reliability, and accessibility. Considering the District's transportation system through the lens of the three mobility categories provides DDOT a unique opportunity to strategically select project opportunities and apply multimodal congestion management strategies to these prioritized areas. Each individual mobility map can be utilized to determine where resources could be needed to address particular mobility challenges.

Figure 25 overlays congestion issues: roadways with a TTI greater than two in the morning and evening peaks, the busiest bus stops, high ridership bus routes, and bus routes that are slow and/or overcrowded. Several of these mobility issues overlap, particularly in the core of the District.

FIGURE 25   CONGESTION MOBILITY MAP

Auto

- - - - -   Travel Time Index greater than 2.0 in the AM and PM peak

Transit

●   Bus stops with highest number of boardings

- - - - -   Bus routes with low speeds and/or high V/C ratios

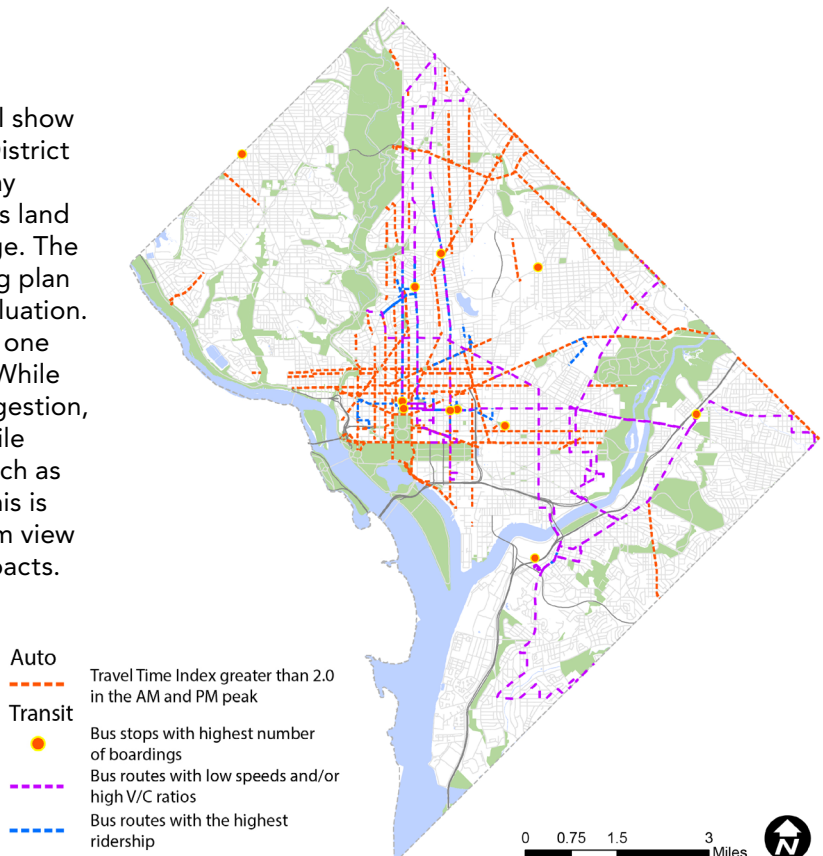- - - - -   Bus routes with the highest ridership

0   0.75   1.5   3 Miles

Figure 26 shows reliability issues: roadways with a PTI greater than three in the morning and evening peaks and bus lines with the earliest and latest arrivals. The issue areas are similar to many of the congestion ones, though with more dispersion to the major commute and crosstown corridors.

Figure 27 identifies where there are potential issues accessing and using non-automobile modes. The map shows high stress bicycle intersections; streets that are on the edge of comfortable for a greater range of riders (LTS 3) and short segments of very stressful streets (LTS 4) that could provide greater connectivity if less stressful; ANCs that lack bikeshare facilities and those with the high concentrations of stressful streets (LTS 4); transit stations with poor walking access or with limited frequency of service; and ANCs with very few high frequency bus stops.
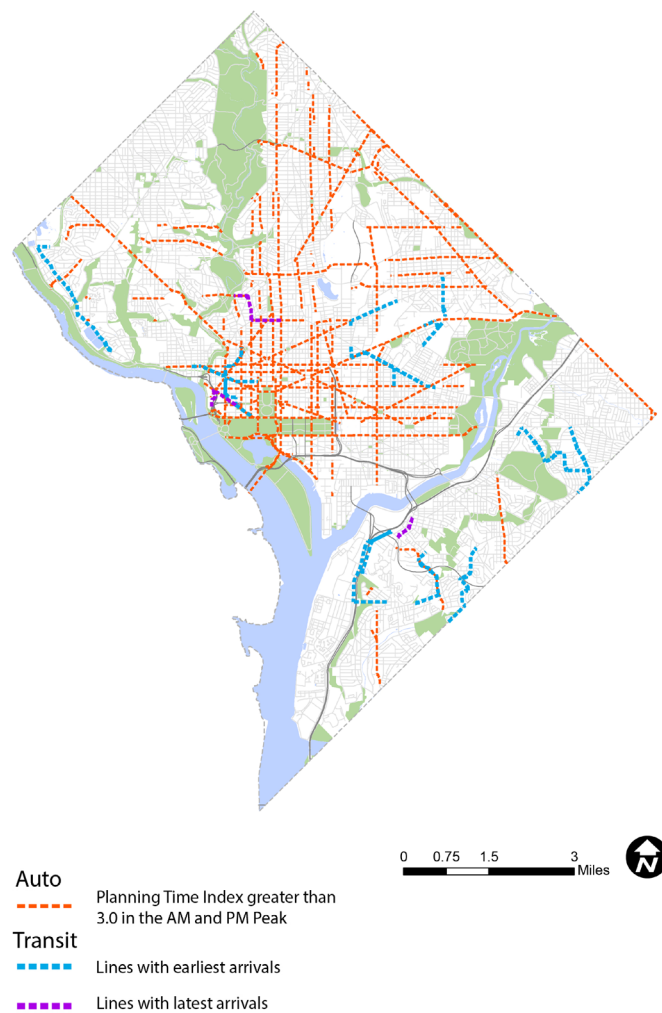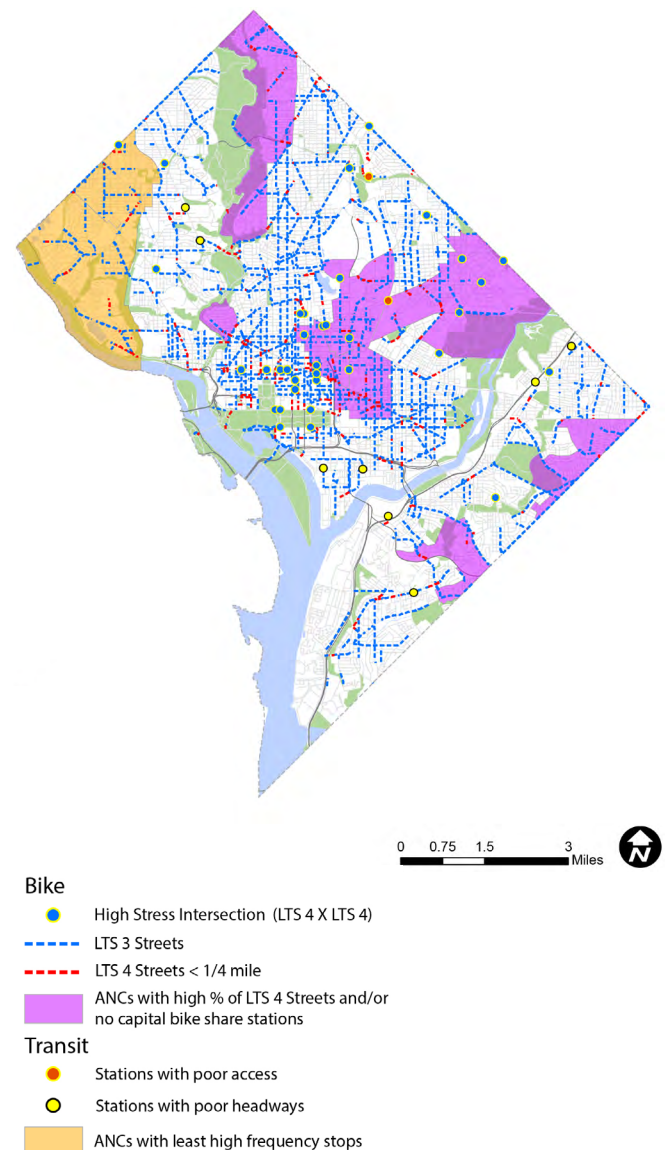
FIGURE 26 RELIABILITY MOBILITY MAP

Auto
- - - - Planning Time Index greater than 3.0 in the AM and PM Peak

Transit
- - - - Lines with earliest arrivals
- - - - Lines with latest arrivals

FIGURE 27 ACCESSIBILITY MOBILITY MAP

Bike
- High Stress Intersection (LTS 4 X LTS 4)
- - - - LTS 3 Streets
- - - - LTS 4 Streets < 1/4 mile
- ANCs with high % of LTS 4 Streets and/or no capital bike share stations

Transit
- Stations with poor access
- Stations with poor headways
- ANCs with least high frequency stops

Focus Areas

To help inform system investments more broadly, the project team identified a set of focus areas with deficiencies across different mobility categories. The focus areas are the result of the project team comparing the individual mobility category maps and then also taking into consideration potential challenges that could contribute to metric deficiencies, such as high bus ridership and poor network connectivity. The identified focus areas are shown in **Figure 28**.

After identifying and characterizing the focus area locations, the project team identified and documented prior efforts within the focus areas. Prior efforts can include partner agency led projects, such as WMATA bus line studies. In addition to identifying completed projects, DDOT staff identified planned near-term projects. **Table 8** summarizes the focus area locations as well as completed and planned projects.
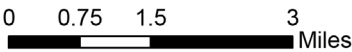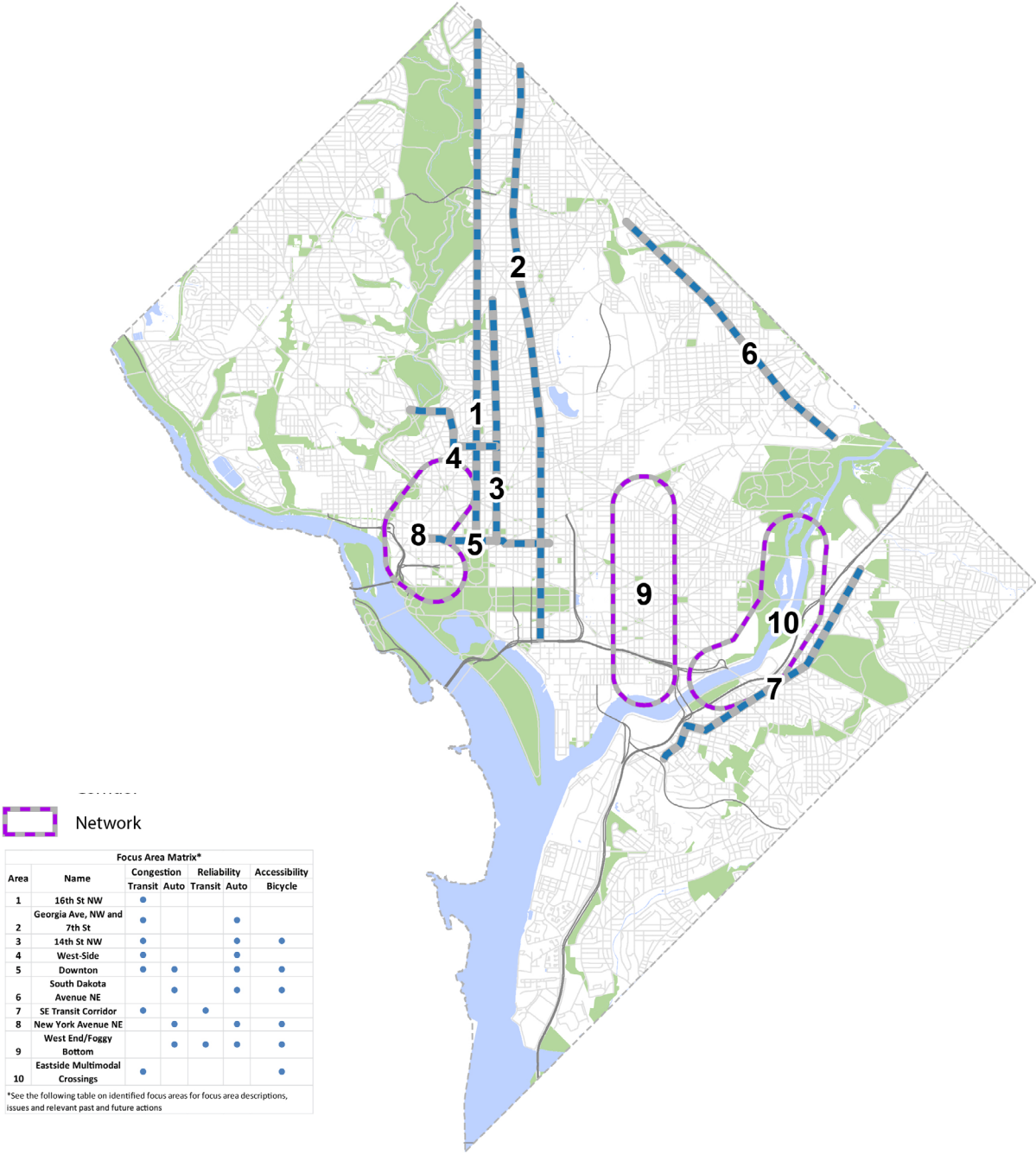
FIGURE 28 DISTRICT FOCUS AREA MAPS

Network

		Focus Area Matrix*				
		Congestion		Reliability		Accessibility
Area	Name	Transit	Auto	Transit	Auto	Bicycle
1	16th St NW	●				
2	Georgia Ave, NW and 7th St	●			●	
3	14th St NW	●			●	●
4	West-Side	●			●	
5	Downton	●	●		●	●
6	South Dakota Avenue NE		●		●	●
7	SE Transit Corridor	●		●		
8	New York Avenue NE		●		●	●
9	West End/Foggy Bottom		●	●	●	●
10	Eastside Multimodal Crossings	●				●

*See the following table on identified focus areas for focus area descriptions, issues and relevant past and future actions

0   0.75   1.5   3
                           Miles

TABLE 8 IDENTIFIED FOCUS AREAS – REASONS FOR INCLUSIONS, PREVIOUS ACTION, AND PLANNED ACTIONS

Area	Name	Area Description	Challenges	Previous Actions	Planned Actions
1	16th Street, NW	Corridor: H Street NW to Eastern Avenue NW	• High bus ridership • Low bus speeds • Bus overcrowding	• 16th Street NW Transit Priority Planning Study • Traffic signal timing optimization	• 16th Street Transit Priority project • Transit Signal Priority Implementation • Traffic signal timing optimization
2	Georgia Avenue, NW and 7th Street	Corridor: U Street NW to Arkansas Avenue NW and L'Enfant Plaza to U Street NW	• High bus ridership • Low bus speeds • Bus overcrowding • Highly variable travel time	• North/South Transit study • Lower Georgia Avenue Transportation and Streetscape Improvements • Bus lane • Traffic signal timing optimization • Metrobus improvements (2007); Priority Corridor Network	• Transit Signal Priority Implementation • Traffic signal timing optimization • Bus Priority Corridor Network Plan
3	14th Street NW	Corridor: H Street NW to Arkansas Avenue NW	• High bus ridership • Low bus speeds • Bus overcrowding • Highly variable travel time • High stress bicycle network	• 14th Street Streetscape study • Traffic signal timing optimization • Metrobus 14th Street Line Study	• 14th Street Streetscape construction • Transit Signal Priority Implementation • Traffic signal timing optimization • Bus Priority Corridor Network Plan
4	West-side (U Street/ Adams Morgan)	Corridor: Connecticut Avenue NW to 14th Street NW along Calvert Street and U Street	• High bus ridership • Low bus speeds • Bus overcrowding • Highly variable travel time	• Traffic signal timing optimization • U Street NW Streetscape • Metrobus 90s Line Study	• Traffic signal timing optimization • Circulator Transit Development Plan • Bus Priority Corridor Network Plan
5	Downtown (H Street / I Street)	Corridor: 23rd Street NW to 6th Street NW	• High bus ridership • Low bus speeds • Bus overcrowding • Highly variable travel time • High stress bicycle network	• Downtown West Transportation Study • Traffic signal timing optimization • WMATA H/I Street Bus Improvements Study	• Transit Signal Priority Implementation • Traffic signal timing optimization • Implement transit improvements, which many include exclusive transit lanes
6	South Dakota Avenue NE	Corridor: New York Avenue NE to Riggs Road NE	• Highly variable travel time • High stress bicycle intersections	• Riggs Rd/South Dakota Ave NE Improvements • Metrobus 80 Line Study	• Traffic signal timing optimization
7	SE Transit Corridor	Corridor: Anacostia Metro to Minnesota Avenue Metro along MLK and Minnesota Avenue	• High bus ridership • Bus overcrowding • Low bus reliability	• DC Streetcar Anacostia Extension • Traffic signal timing optimization • Metrobus A Line Study and B2 Service Evaluation Study	• Bus Priority Corridor Network Plan • Traffic signal timing optimization
8	New York Avenue NE	Corridor: I-395 to District-Maryland boundary	• Highly variable travel time • High stress bicycle intersections	• Traffic signal timing optimization • Trail concept plan	• Trail and streetscape studies • Traffic signal timing optimization
9	West End / Foggy Bottom	Network: 17th Street NW and 23rd Street NW and Constitution Avenue NW and M Street NW	• Low bus reliability • Highly variable travel time • High stress bicycle network	• Traffic signal timing optimization • Downtown West Transportation Study • Metrobus 30s Line Study	• Transit Signal Priority Implementation • Traffic signal timing optimization • Bus Priority Corridor Network Plan • Assess feasibility and implementation of protected bike lanes
10	Eastside Multimodal Crossing	Network: Anacostia River and CSX Crossings	• High bus ridership • High stress bicycle network	• Anacostia Waterfront Initiative • Middle Anacostia Environmental Assessment	• Rebuild Benning Road CSX Bridge • Bike bridge over rail • River trails

Action Plan

The final element of the investment plan is a one, three, and five year plan to take action on the needs and opportunities identified through this effort and the ongoing management and monitoring program. The actions are split into two categories: "Process and Evaluation" and "Projects." Recommendations within the first category focus on expanding the management and monitoring plan and integrating it within DDOT's work plan. The items within the second category focus on projects that are identified from the focus area assessment.

It is envisioned that each future year recommendations will continually be assessed and revised. On the planning side in particular, the metrics and focus area identification process will be used to identify a prioritized list of studies in the first year. The highest priority group of studies will enter the planning process over the next few years. By the third year, some will have recommendations ready to move into the design process. By the fifth year, those designs will be under construction and the most complicated studies will be done and moving into design and construction as well. At the same time, as the initial studies are completed, the prioritized list will be revisited and the next highest priorities will begin as studies by year three and the cyclical, iterative process of prioritization, planning, design, and construction will continue.

Year 1

Process and Evaluation

1. Develop an online visualization tool summarizing the District Mobility project goals, performance measure results, findings, and recommendations.

2. Develop additional performance measures and refine existing measures and data sources to better support system management and monitoring.

3. Incorporate this project's data and analysis into projects to strengthen the planning and programming process, including the development of budget priorities and project identification. Develop a prioritized list of studies and define a process for updating that list annually. Plan to initiate the highest priority studies in year two.

4. Identify where asset management and safety projects overlap with congestion issues and propose synergistic projects that address congestion along with the original project need.

5. Initiate development of a multiagency strategic plan with District partners (Office of Planning, Washington Metropolitan Area Transit Authority, MWCOG, etc.) to enhance coordination and collaboration on mobility assessment and investments.

6. Evaluate the agency's key performance indicators (KPIs) to identify opportunities to leverage the measures and data developed in this project to better indicate agency performance.

Projects

7. Implement monitoring and active management of traffic signal timing across the District.

8. Design the 16th Street Transit Priority Project elements to demonstrate high quality transit priority investments.

9. Automate the deployment strategies for Traffic Control Officers (TCOs) and Roadway Operation Patrol (ROP).

10. Conduct an evaluation for locating dynamic message signs (DMS) along major arterial facilities.

11. Assess the feasibility for a performance towing program targeted to key congested routes.

12. Integrate data and video from operations and monitoring systems into an Advanced Traffic Management System (ATMS).

13. Install fiber optic network on freeway system to support intelligent transportation system (ITS) devices.

14. Upgrade and expand the CCTV camera network.

Year 3

Process and Evaluation

1. Update the online visualization tool to include performance measures for the periods 2015-2018. The update should integrate annual performance measure assessments from the prior years. Additionally, preliminary trends for the time periods should be reported.

2. Review and assess performance measure data collection and analysis process to include opportunities related to new data collection techniques and technologies.

3. Assess data management strategies related to the potential for higher resolution data from various transportation systems including connected vehicles, traffic signal state, and on-street parking meters.

4. Implement an upgrade program for DC Circulator onboard equipment for vehicle data logging and performance measurement.

Projects

5. In coordination with WMATA, define a plan to update the priority transit corridor networks within the District. The effort should include an assessment of existing improvement plans as well as strategies for supplemental transit service. Objectives can include meeting demand along high ridership areas as well as increasing higher frequency transit service.

6. Evaluate locations for additional CCTV cameras.

7. Update ITS Master Plan.

8. Explore establishing ITS hubs to increase ITS system redundancy and resiliency.

9. Construct the 16th Street Priority Transit Priority projects to demonstrate high quality transit priority investments.

10. Complete a study of freeway operations with a focus on interchanges with problematic merge/weave movements and explore the potential for managed lanes.

11. Complete first set of prioritized planning studies and begin design and preliminary engineering from their findings.

12. Begin second set of prioritized planning studies.

Year 5

Process and Evaluation

1. Update the online visualization tool to include annual performance measures for the periods 2015-2020. The update should include trends for the time periods as well as an update to the transportation system management and monitoring plan.

2. Include DC Circulator data within the transit performance measures.

3. Conduct an evaluation of completed projects and resultant impact to achieving transportation goals.

Projects

4. Assess future transit capital investment needs to meet operational goals. Considerations should include additional rolling stock as well as upgrades to maintenance facilities.

5. Implement improvements recommended in ITS Master Plan. This may specifically include a new centralized traffic management center reflecting national best practice.

6. Begin construction on projects identified in the first set of prioritized planning studies.

7. Complete second set of prioritized planning studies and begin design and preliminary engineering from their findings.

8. Begin third set of prioritized planning studies.

9. Update the long range transportation plan based on land use and transportation trends.

ACKNOWLEDGEMENTS

Notice

For additional information, please contact the DDOT Research Program **ddot.research@dc.gov**

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