FEHR PEERS
Serving DC and the Mid-Atlantic
1003 K Street NW, Suite 209
Washington, DC 20001
202.854.2750

MEMORANDUM

Date: October 8, 2015

To: Eric Graye, M-NCPPC

From: Matthew Ridgway, Nat Bottigheimer, and Alex Rixey, Fehr & Peers

Subject: Performance Metrics Recommendations

DC15-0002

This memo builds on the Transportation Metrics Assessment memo by (1) documenting ideas for transportation performance metrics that address gaps in the County's ability to measure desired policy outcomes and (2) proposing a suite of selected transportation metrics for further evaluation. In a following memo, the County's existing and potential tools will be evaluated for their ability to calculate the proposed suite of metrics.

Table 4* is a pivot from Table 3b that includes ideas for changes and additions to transportation metrics such that they align with the Table 2 transportation policy goals. Existing metrics and preliminary assessments from Table 3b are included to illustrate the gaps in existing practice and facilitate the suggestion of new metrics. The metrics in this table stem from a review of industry modeling and reporting practices, internal Fehr & Peers staff discussions, and a brainstorming session with current and former M-NCPPC staff members.

Table 5 further distills Table 4 into a concise suite of metrics that can potentially address the County's modal and functional transportation goals as expressed in Table 2. These recommended metrics would strengthen the measurement of accessibility rather than continuing to focus on measures of mobility. Under an accessibility paradigm, travel is treated as beneficial to the extent that it accomplishes the purposes of the trips that individuals take.

A Person Trip (PT) is the desirable unit of transportation measurement, while other metrics such as Vehicle Miles Traveled (VMT) or Person Hours Traveled (PHT) are thought of as costs to accomplishing those trip purposes.

*Please note: Table numbering is sequential following from numbering in prior memos issued.

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Table 4 - Summary of Transportation Metrics Ideas

	Land use*	Network	Function	Useage	Safety
Auto	- Varying CLV standards by area Job accessibility by auto (Mobility Assessment Report) • Total Jobs • Retail mix – HBO Trips	None	- Congested speeds (TPAR) - HCM LOS (LATR/MCDOT) - CLV (LATR) • Drive money to bigger-picture projects • Layered networks with facility-specific objectives, rather than area-specific	- Counts (LATR) - Non-Auto Driver Mode Share (NADMS) • Parking Utilization (Over-provision of parking encourages more VT)	None	• Collisions (Fatality, Injury, PDO) per PMT or PT for each mode; need measure of exposure • Road Code target speeds - % of VMT on roads of different target speeds • Ped delay related to crossing against signal • Assessment of uncontrolled crossings
Transit	None Job accessibility by transit (MAR) DOT / WMATA – developments that gen. transit passengers to ID and address transit gaps (Transit Trips Generated?)	- Coverage (TPAR)	- Peak headway (TPAR) - Span of Service (TPAR)	- Non-Auto Driver Mode Share (NADMS) • Travel time and transit mode share between key O-D pairs (BRT pairs?) • Subdivide Road Code Urban and Suburban Areas; matrix of travel among cells	None	
Bicycles	None Simple buffer accessibility – easier for applicant to calculate at a site level Site plan review criteria: bike parking, on-site circulation, facilities on fronting roads Bike connection to nearest: school, transit stop (site-level) Accessibility by Level of Traffic Stress (LTS) – more complex • % of all person trips reachable • % of students/pop within bikeshed of school • Jobs accessibility by LTS	- Facility Inventory (LATR)	- Facility Inventory (LATR)	- Counts (LATR) - Non-Auto Driver Mode Share (NADMS)	None	
Pedestrian	None • Retail mix – HBO Trips • Pedestrian connection to nearest: school, transit stop (site-level) o Offsite capital improvements result in impact tax refund	- Facility Inventory (LATR)	- Facility Inventory (LATR)	- Counts (LATR) - Non-Auto Driver Mode Share (NADMS)	None	
Other Ideas	• Site orientation/design • CR Code (site) – incentive density • Concurrency / Proportional Staging • Quantify tripmaking characteristics relative to parking supply Vehicle Miles Traveled (VMT) per capita PMT per capita VHT per capita PHT per capita Percent lanes miles congested	• Route directness index • Intersection density • Block size	• PMT / PHT for transit and auto (origins *and* destinations?) Or total movement "relative transit mobility" • Person Delay	• Mode share for each mode (SOV, HOV, Transit, Bike, Ped) • Systematic count program • Transportation Management Districts – Biennial Reporting; employer surveys, but movement toward condo/apartment surveys • Mode share for JTW, traffic&ped count, marketing	

*Location efficiency and development quality

Preliminary Assessment of Metric Applicability to Goals: Good Fair Poor

Assessment criteria include: 1) Applicability of the metrics to identified goals; 2) Quantifiable metric; 3) established threshold; 4) Limited adverse effects on other goals.

Table 5 – Transportation Metric Recommendations

	Land use*	Network	Function		Usage	Safety
Auto	**Accessibility by Travel Time by Mode** • Jobs accessible • Person trips accessible		**Traveler Experience** • VHT o per capita o per person trip • VHT in congestion	**Intersection Performance: Person Delay**	**Person Trips** • By Mode o Raw o Per Capita o Per PHT • Per VMT **Mode Share**	**Collisions per Person Trip**
Transit			• Frequency of Service • Span of Service • Reliability			
Bicycles			• Bicyclist Comfort			
Pedestrian			• Pedestrian Comfort			

*Location efficiency and development quality

RECOMMENDED METRICS

The remainder of this memo provides further detail on the metric concepts presented in Table 5:

Recommended Performance Metrics			
Metric	**Detail**	**Functional Areas Addressed**	**Applicable Scales**
Accessibility	of jobs and other person trips by all modes within a range of travel times	Land Use Network Function	Countywide Planning Area Site
Traveler Experience	separate measures for each mode, applied selectively according to modal priority networks	Function	Countywide* Planning Area Corridor Intersection
Intersection Performance	measured in terms of person delay for all modes	Function	Corridor Intersection
Person Trips	by mode and in relation to measures of travel cost	Usage	Countywide Planning Area Corridor Site
Mode Share	% of person trips made using each mode	Usage	Countywide Planning Area Corridor Site
Collisions	by mode, normalized by person trips	Safety	Countywide Planning Area Corridor Intersection

*Varies by mode.

ACCESSIBILITY

Accessibility metrics address combined goals related to Land Use, Network and Function. Improvements to any one of these areas—such as more jobs in proximity to housing, a more complete and connected street grid, or improved operation of existing transportation infrastructure—can be reflected in an improved measure of accessibility. In urbanizing areas, increasing development often leads to automobile travel delay that reduces the ability to drive long distances at high speeds; however, increasing development also affords new opportunities within a shorter distance from home for accomplishing the end purposes of travel, like commuting to work, running errands, or visiting friends and family. While conventional performance measures of mobility, like congested travel speeds and intersection level of service, capture only the negative effects of increasing development, accessibility measures account for both changes in travel speeds and the opportunities afforded by co-locating land uses such that there are more potential short-distance trips. This study recommends measuring accessibility to jobs individually, as well as accessibility to the destinations of all trip purposes.

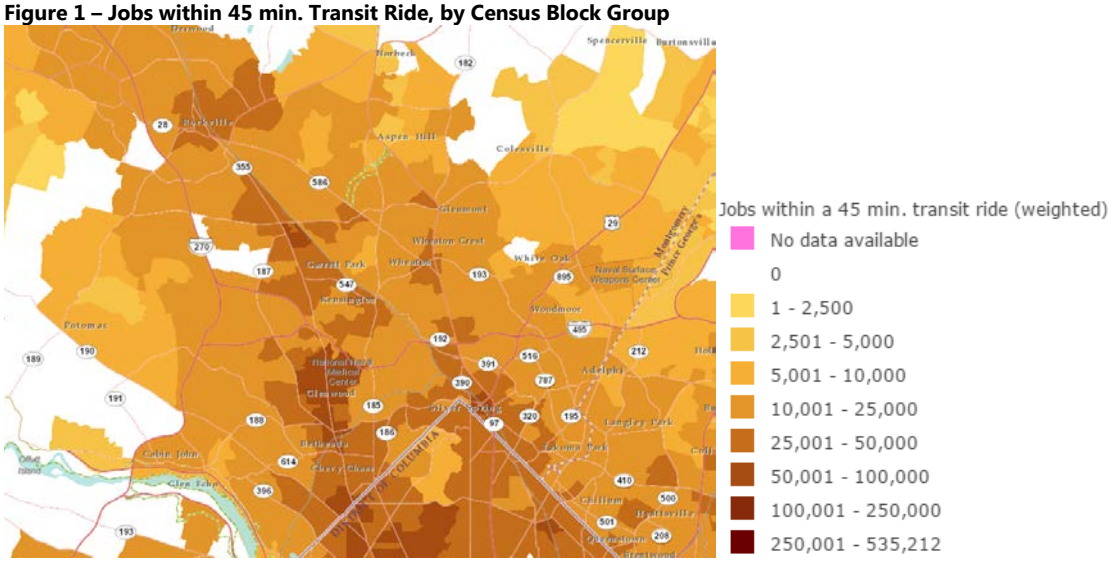
Jobs Accessible by Travel Time by Mode

Jobs Accessible by Travel Time by Mode measures the number of jobs that can be reached from a given geographic location (likely a Transportation Analysis Zone or "TAZ") within a given duration of travel (such as within a 30-minute trip) using a particular mode (auto, transit, biking, and walking). This metric represents the opportunities available to residents of the TAZ. The metric can be expressed as a numeric value, indicating the total number of jobs accessible, or a percentage of regional jobs, to indicate relative accessibility.

By selecting a particular travel time interval and mode, results for multiple TAZs can be mapped to illustrate areas of higher and lower accessibility to employment (see Figure 1 on the next page).

The accessibility of multiple TAZs can be aggregated to a larger geography, such as a Policy Area or the entire County by taking an average, weighting each TAZ's score by its population. This measure represents the overall accessibility of jobs to Montgomery County residents.

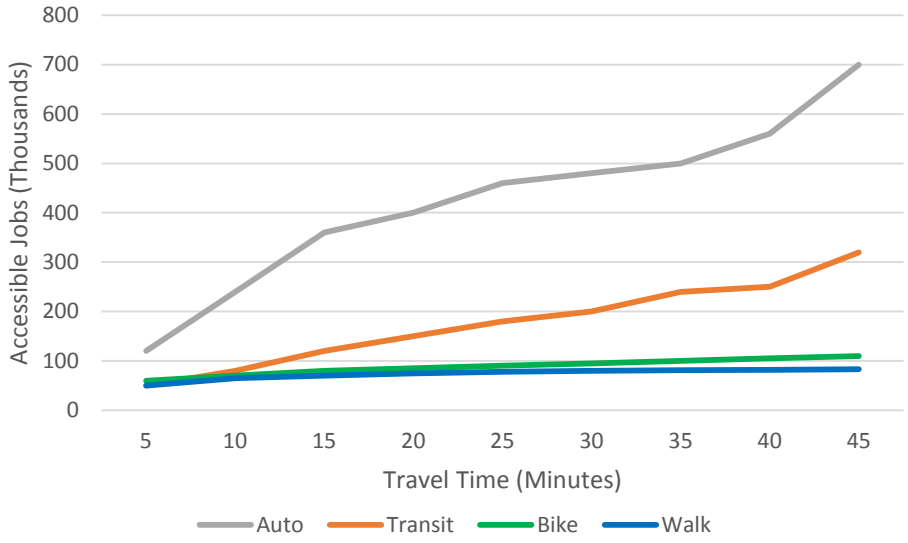
Figure 1 – Jobs within 45 min. Transit Ride, by Census Block Group



Source: EPA Smart Location Database

Curves of accessibility by travel time by mode for a particular geography can also be constructed to provide a direct comparison of modal accessibility (see Figure 2).

Figure 2 - Hypothetical example of Jobs-Accessibility-by-Travel-Time Curves



Source: Fehr & Peers

The metric can be calculated for both peak and off-peak periods to illustrate the effect of peak period congestion on jobs accessibility.

Person Trips Accessible by Travel Time by Mode

Analogous to the Jobs Accessibility metric described above, Person Trips Accessible by Mode measures the number of trip purposes that can be accomplished from a given location, within a given duration of travel using a particular mode. However, rather than representing total trip-making opportunities (e.g. total number of accessible restaurants), this is an outcome metric that illustrates the percent of a household's trips that could be accomplished within each time interval by each mode.

This metric could be applied to all non-commute trips as a complement to the jobs accessibility metric, or further subdivided for different trip purposes, such as shopping and other trips. As before, both peak and off-peak versions can be calculated.

TRAVELER EXPERIENCE

One approach to measuring the performance of a transportation system is from the perspective of its users. The Traveler Experience metrics address goals related to the Function of the transportation system. This study recommends a metric or set of metrics for each mode and recommends that a network of modal priorities be established so that modal metrics are applied in appropriate contexts. Although the intent is for the collective network of layered transportation infrastructure to form a complete transportation system that serves all modes, explicit emphasis on performance for particular modes on particular corridors allows for evaluations that support context-appropriate goals. For example, rather than subjecting all roadways to automobile-focused metrics like intersection level of service, this system would target these metrics to corridors where automobility is prioritized; areas would also be identified for prioritizing pedestrian comfort, comfort for people bicycling, and transit performance. Modal-specific metrics are described below.

Auto – Vehicle Hours of Travel (VHT) per Capita or per Person Trip

Vehicle Hours of Travel (VHT), the amount of time spent traveling by automobile, is one measure of the user experience of the auto mode. This measure could be normalized by population to express VHT per Capita, which provides insight into how much time the average Montgomery County driver spends in a car. Normalizing by person trips to calculate Vehicle Hours of Travel per Person Trip (VHT/PT) would provide insight into the average amount of automobile travel time needed to accomplish a trip. This version of the metric would respond to a variety of travel improvements, including:

- **Reduced congestion** – reduced travel time for the same origin-destination pair will result in reduced VHT/PT
- **Reduced trip lengths** – may reduce travel time, resulting in reduced VHT/PT
- **Shifts to non-auto modes** – maintains the number of person trips but removes vehicle travel, reducing VHT/PT

Auto – Vehicle Hours of Travel (VHT) in Congestion

Even for the same duration of auto travel, traveling in congestion can be stressful for automobile travelers. The percent of total Vehicle Hours of Travel (VHT) spent in congestion provides an additional measure of the quality of the traveler experience. Congested conditions can be identified when the ratio of volume to capacity exceeds 1.0. Variations of this metric include Congested Vehicle Hours of Travel per Capita and Congested Vehicle Hours of Travel per Person Trip.

Transit – Frequency of Service

Frequency of Service addresses the passenger's ability to board transit at a time that conveniently suits their travel schedule. Transit that runs at higher frequency allows passengers to make unscheduled trips as needed and helps to minimize wait times. Transportation Policy Area Review (TPAR) includes a measure of Frequency of Service for average peak bus headways. This metric can be expanded to provide similar information for off-peak and weekend bus service to support a transit system that is a viable alternative to single occupancy vehicle travel, which may increase propensity for lower vehicle ownership. In addition to TPAR's application of this metric at the Policy Area level, the metric can be applied to specific corridors identified for transit priority.

Transit – Span of Service

Span of Service addresses the passenger's ability to travel at various times of day. Transportation Policy Area Review (TPAR) also includes a measure of Span of Service for weekday bus service. This metric can be expanded to provide similar information for weekend bus service to support a transit system that enables lower vehicle ownership. In addition to TPAR's application of this metric at the Policy Area level, the metric can be applied to specific corridors identified for transit priority.

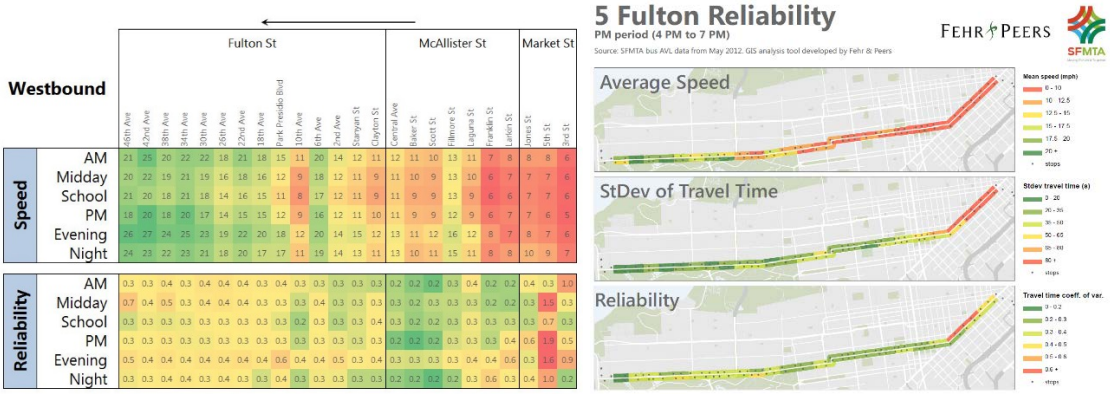
Transit – Reliability

Transit Reliability indicates the consistency with which transit vehicles arrive on a predictable schedule. The metric can be expressed as a function of the variability of travel time relative to speed

(the coefficient of variation of travel time). This metric can be computed for individual routes and times of day to identify low-performance time periods and geographic locations. The metric can be applied to specific corridors identified for transit priority.

In Figure 3 below, Average Speed is a typical measure of transit reliability; Standard Deviation (StDev) of Travel Time, shown in the second map on the right, denotes the raw magnitude of variability of travel time by transit route segment; and Reliability represents the ratio of Standard Deviation of Travel Time for each route segment to the Average Travel Time for each route segment (where average travel time is a direct function of average speed and segment length).

Figure 3 – Example Travel Time Reliability Analysis



Source: Fehr & Peers

Bicycle – Bicyclist Comfort

Bicyclist Comfort is a measure of the quality of the built environment of bicycling. The Level of Traffic Stress (LTS) methodology presented in *Low Stress Bicycling and Network Connectivity* (Mekuria, Furth, and Nixon, 2012) is currently the best-practice performance measure for bicyclist comfort. The methodology applies several roadway criteria to determine a facility's LTS score, which can be used to inform whether different groups of potential cyclists would use the facility. Montgomery County has already assembled a database of LTS on roadways in the County as part of the Bicycle Master Plan process. A goal could be set to reach the lowest levels of stress (LTS 1 or 2, which are suitable for a wide population of potential cyclists) on corridors that are prioritized for bicycles. In the Accessibility analysis recommendations above, LTS could also be used to quantify not just how many destinations are accessible by bicycle, but how many are accessible on low stress bikeways.

Pedestrian – Pedestrian Comfort

Pedestrian Comfort is similar to bicycle LTS. It uses auto travel characteristics – speed and traffic volume – as well built environment factors that measure the degree of separation between autos and pedestrians - sidewalk width, presence of buffer between the sidewalk and travel lanes - to derive a comfort scale. As with bicycle LTS, separate pedestrian comfort indices can be developed for roadway segments and intersections.

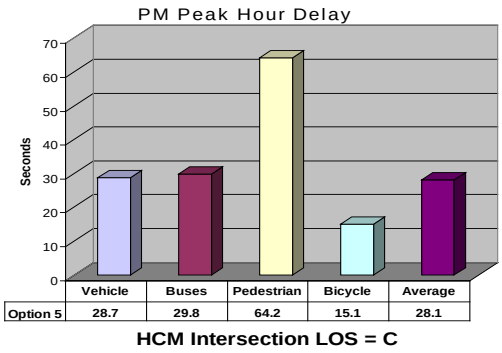
INTERSECTION PERFORMANCE

Person Delay

While conventional level of service analysis quantifies the delay per automobile at an intersection, Person Delay measures the delay for users of all modes, including auto, transit, trucks, bicycle, and walking. Person delay can be measured individually for each mode and combined through a simple average or weighted by the volume of users to create an overall person delay for the intersection.

Working to minimize overall Person Delay may privilege the auto mode in areas where automobile traffic is dominant. However, as with the Traveler Experience metrics, intersection performance can be evaluated in the context of modal priority networks in response to policy goals. Maximum delay thresholds could be set for each mode to ensure that no single mode experiences an unacceptable level of delay. A particular mode could also be prioritized, such as minimizing pedestrian delay in a pedestrian priority area.

Figure 4 - Example Person Delay Calculation in Davis, CA



Source: Fehr & Peers

It may be important to note that some agencies have shied away from using Person Delay, fearing that it creates significant additional data collection and analysis, but recent evolutions of software make it such that reporting Person Delay requires only a few additional data points, largely counts of pedestrians, bicycles and transit vehicles, data which are now routinely collected as part of traffic counts in Montgomery County.

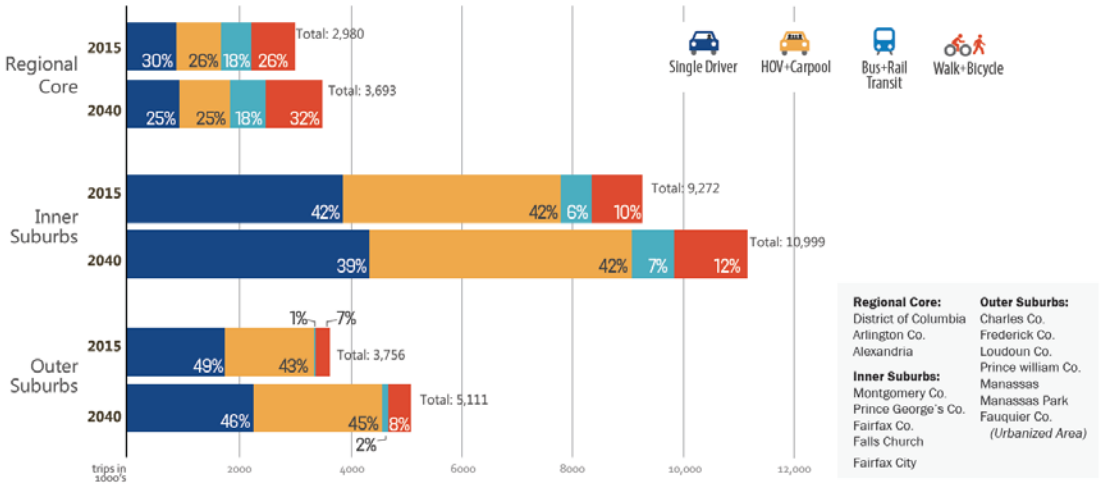
PERSON TRIPS

The ability to complete Person Trips is a key goal of the passenger transportation system. Tracking the number of person trips and the ratio of person trips to other transportation measures for individual modes provides insight into the overall composition of travel and the costs of that travel.

Raw Person Trips by Mode

An accounting of raw Person Trips by Mode provides information on the overall magnitude and modal composition of travel.

Figure 5 - Example Summary of Person Trips by Mode



Source: National Capital Region Transportation Planning Board Performance Analysis of the Draft 2015 CLRP

Person Trips Per Capita by Mode

Person Trips per Capita enables comparisons of levels of travel across time and geographies. For example, increased levels of development in a future scenario my result in more overall trip-making and more overall person trips in automobiles, but fewer vehicle trips per capita.

Person Trips per Person Hour of Travel by Mode

Dividing the total number of person trips by the total person hours of travel yields Person Trips per Person Hour of Travel (PT/PHT), which gives an indication of the amount of time travelers need to spend to accomplish their trips. Calculating this measure for each mode puts all modes on an equal footing in terms of the time cost of travel. This metric will reflect improvements that reduce trip durations, including improved connectivity, improved transit service, reduced congestion, and more mixed-use trip destination options.

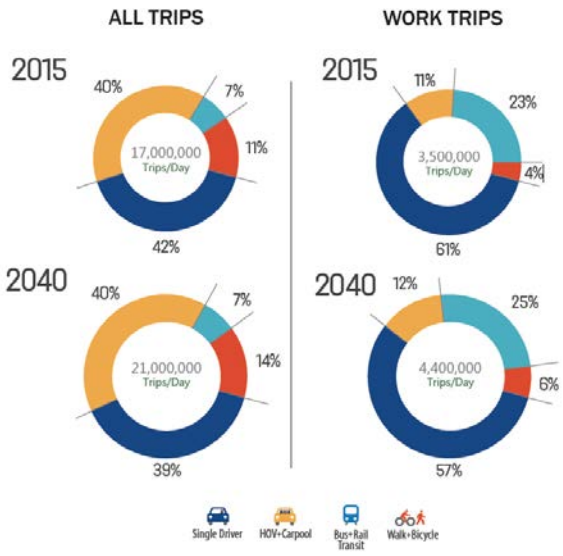
Person Trips per Vehicle Mile Traveled

The ratio of total Person Trips to total Vehicle Miles Traveled (PT/VMT) would be an aggregate measure of person trip making relative to the amount of vehicle travel. Shorter trip lengths and shifts to other modes would improve the outcome of this metric, indicating that the same amount of trip-making activity could be accomplished with fewer vehicles miles of travel.

MODE SHARE

Mode Share is the expression of Person Trips by Mode in percentage terms. This allows an understanding of the composition of travel while controlling for any changes in the total amount of trip-making, making it easier to compare over time and across geographies.

Figure 6 - Example Mode Share Summary



Source: National Capital Region Transportation Planning Board Performance Analysis of the Draft 2015 CLRP

COLLISIONS PER PERSON TRIP

Collisions can be reported for each mode, including auto, transit, bicycle, and pedestrian. Dividing by the number of person trips on that mode helps to control for exposure and frames the metric as a ratio of cost (number of collisions) to benefits (number of complete person trips) per mode. A more positive framing could be the inverse ratio: Person Trips per Collision by mode, which reflects the number of valuable trips completed per costly collision. When collisions involve multiple modes (e.g., an automobile collides with a pedestrian) the collision should be counted for both modes. Separate ratios could also be established based on collision severity, including fatal, severe injury, other injury, and Property Damage Only (PDO).

NEXT STEPS

We request your feedback on the metrics recommended in this memo. The next steps will include an evaluation of the County's transportation analysis tools and evaluation of additional tools that can measure new, desired outcomes, based on your feedback about the metrics identified here. Ultimately, these performance metrics will also need a supporting policy framework that establishes targets and goals for the application of each metric.