BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

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TECHNICAL MEMORANDUM

DATE: **January 19, 2017**
TO: **Boston Region Metropolitan Planning Organization**
FROM: **Ryan Hicks and Casey-Marie Claude**
RE: **Pedestrian Level-of-Service Memorandum**

Many commuters travel in the Boston region by walking at some point during their daily routine. However, not all walkways, sidewalks, and pedestrian facilities in the Boston region are in the best condition to accommodate pedestrians. At present there is no formal way to determine the pedestrian friendliness of transportation facilities in the region. The goal of this study—which was funded through the Unified Planning Work Program—was to create a performance monitoring tool for the pedestrian environment. This tool could potentially be used to monitor pedestrian mobility for the development of the Long-Range Transportation Plan (LRTP) or to evaluate projects in the Transportation Improvement Program (TIP), among other uses. In addition to the beneficial use for the Boston Region Metropolitan Planning Organization (MPO), this tool could be used by planners, engineers, and other professional staff to evaluate the suitability of pedestrian facilities.

Over the years, several organizations nationwide researched and implemented pedestrian monitoring programs. Typically, these programs assessed pedestrian level of service (PLOS) to monitor the pedestrian environment. MPO staff noted, however, that the term “level of service” (LOS) has been stigmatized recently for two reasons:

- First, it is believed that the quality of a roadway or intersection should be measured for multiple transportation modes, rather than a single mode of travel.
- Secondly, many pedestrian infrastructure advocates believe that pedestrian facilities should be scored on several categories, such as safety or system preservation, rather than given one cumulative rating.

Therefore, this project focused on developing a Pedestrian Report Card Assessment (PRCA) rather than PLOS. The PRCA tool will set a standard for measuring the pedestrian friendliness of intersections and roadway segments, which planners can use to grade any intersection or street.

The first section of this memorandum summarizes pertinent research, analyses, and applications of pedestrian environment performance monitoring by various organizations over the last 15 years. The memorandum then discusses the considerations that went into selecting performance measures for use in the Boston region that are best suited for gauging progress towards MPO goals, test runs that were conducted on the performance measures by examining real time situations at selected intersections and roadway segments, and the creation of scoring criteria for each measure. This document concludes by presenting the final PRCA, a potential tool for scoring the quality of the pedestrian travel environment at a specific location.

1 LITERATURE REVIEW AND PREVIOUS STUDIES

This section provides an overview of various tools for measuring LOS that were discovered during a literature search. The strengths and weaknesses of each tool are discussed.

1.1 Sprinkle Consulting LOS Model

The Sprinkle Consulting LOS model was sponsored by the Florida Department of Transportation and was created by Sprinkle Consulting in 2001.[1] The model was created to ascertain how comfortable pedestrians are when using pedestrian facilities. To develop the model, Sprinkle Consulting relied on two methods of feedback. First, they conducted scenario planning to evaluate how pedestrians react in different traffic situations. Secondly, they distributed surveys to pedestrians in order to identify what makes an environment comfortable for pedestrians. The Sprinkle Consulting model is based on several factors: personal safety, personal security, architectural interest, sidewalk shade, pedestrian lighting and amenities, presence of other pedestrians, and conditions at intersections. The LOS is graded from A to F, with heavy vehicular traffic considered as having a negative effect on pedestrian safety.

In 2010, the Florida Department of Transportation began transitioning from the Sprinkle Consulting model to Art Plan, which is a different method for determining PLOS.[2] The only difference between the two methodologies is that the Art Plan

[1] Bruce Landis, P.E, AICP, Venkat Vattikuti, MS, Russell Ottenberg, AICP, Douglas McLeod and Martin Guttenplan, "Modeling the Roadside Walking Environment: A Pedestrian Level of Service," accessed September 1, 2016, http://www.sprinkleconsulting.com/Images/UserSubmitted/Modeling%20the%20Roadside%20Environment_A%20Pedestrian%20Level%20of%20Service.pdf

[2] Florida Department of Transportation, *2009 Quality Level of Service Handbook,* http://www.dot.state.fl.us/planning/systems/programs/sm/los/pdfs/2009FDOTQLOS_Handbook.pdf

method excludes pedestrian behavior and infrastructure conditions on adjacent roadways. Additionally, pedestrian comfort and pedestrian crowding are not considered in the Art Plan analysis.

There are several interactive tools that are based on the Sprinkle model, which will allow a user to analyze the pedestrian LOS at a specific location. One example of an interactive tool is Ride Illinois' BLOS/PLOS calculator, an online tool that calculates a LOS for bicyclists and pedestrians for a roadway segment or intersection.[3] The calculator computes both the BLOS and PLOS simultaneously. Similar to the Sprinkle Consulting LOS model, the Ride Illinois calculator focuses mostly on the comfort level of the pedestrian, rather than pedestrian behavior.

Strengths

- The Sprinkle Consulting model puts an emphasis on measuring pedestrian comfort.
- The model uses surveys from pedestrians to determine standards by which to measure the comfort of the pedestrian environment.

Weaknesses

- Pedestrian behavior is not extensively factored into the model.
- This model uses a typical, single-grade method when calculating PLOS, which is not ideal for measuring the suitability of pedestrian infrastructure.

[3] Ride Illinois, "BLOS/PLOS Calculator Form," http://rideillinois.org/blos/blosform.htm

1.2 Bicycle and Pedestrian Connectivity Study

The Old Colony MPO, which serves an area south of Boston, developed models for both BLOS and PLOS as a result of its Bicycle and Pedestrian Connectivity study.[4] These models include elements from the Sprinkle Consulting model and the Pedestrian Infrastructure Index model, which was developed by the Federal Highway Administration (FHWA). In addition to using elements of these models, the Old Colony MPO added its own evaluation criteria to its model.

The Old Colony MPO used approximately 30 attributes to evaluate if the LOS is suitable in a certain area. It used a variety of sources, including geographic information system (GIS) maps, surveyed sources, and Google Street View. Similar to the Sprinkle Consulting model, the Old Colony MPO defines their PLOS as a walker's perception of comfort and safety. They created a standard to use for individual projects, but were not able to fully implement it for the entire region due to the lack of data. The standard was used, however, to create a PLOS map of a small neighborhood in connection with another transportation study.

In the Bicycle and Pedestrian Connectivity study, the Old Colony MPO recommended tying the performance measures used to determine PLOS to the MPO's goals and objectives and set a standard for all new roadways to have a BLOS and PLOS of C or better.

Strengths

- The Old Colony MPO uses a wide variety of performance measures to calculate PLOS.
- Their models add elements to the Sprinkle Consulting model and the Pedestrian Infrastructure Index model.

Weaknesses

- The model has not calculated BLOS and PLOS for the entire roadway network
- Pedestrian behavior is absent from this model.

[4] Old Colony Planning Council, "Bicycle and Pedestrian Connectivity Study" presentation, http://www.ocpcrpa.org/docs/projects/bikeped/Bicycle_and_Pedestrian_Connectivity_Study_Presentation.pdf

1.3 Walk Score

The Walk Score application, which was invented in 2007 by Jesse Kocher and Matt Lerner, helps apartment seekers determine the walkability of a neighborhood.[5] Walk Score rates a neighborhood between 0 and 100 based on a range of criteria, including proximity to amenities, such as grocery stores and restaurants. Points are awarded for amenities that are located within a 30-minute walk. Amenities must be within a quarter mile to receive the highest number of points. Walk Score also factors in conditions such as population density, intersection density, and roadway block length.

Strengths

- Walk Score is very effective at factoring the presence of nearby amenities such as grocery stores and restaurants into the score, which could be an indicator of how often pedestrians traverse through an area.

Weaknesses

- Walk Score does not factor in pedestrian infrastructure, such as sidewalk presence or pedestrian signals.
- Walk Score does not factor in pedestrian behavior, such as pedestrian volumes or pedestrian delay.

1.4 Highway Capacity Manual

The Highway Capacity Manual (HCM) pedestrian model, developed in 2010 by the Transportation Research Board, uses several criteria to determine PLOS.[6] This process includes a step-by-step method, which analyzes pedestrian movements and infrastructure, and an evaluation of performance measures. The pedestrian behavioral performance measures are focused on the pedestrians' ability to choose their desired travel speed or the ability to pass other pedestrians. The HCM also looks at environmental factors, with a focus on the infrastructure surrounding a walkway. Safety factors are also included in the HCM pedestrian model. The HCM model is influenced by the interaction of other modes, such as bicycles, transit, and automobiles.

Three components are needed for input into the model: LOS score, average speed of pedestrians, and circulation area. The HCM also has an evaluation criterion that analyzes off-street pedestrian facilities, such as trails. The HCM

[5] Walk score description available online at https://www.walkscore.com/how-it-works/

[6] Transportation Research Board, *Highway Capacity Manual* (2010 edition), http://hcm.trb.org/?qr=1

model is limited in that it cannot evaluate a facility's performance at all-way stop-sign-controlled intersections, roundabouts, or signalized ramps.

Strengths

- The HCM has very useful performance measures, which can be used as strong indicators of pedestrian friendliness.
- The HCM model allows users to calculate pedestrian scores for both intersections and roadway links.

Weaknesses

- Collecting data for the recommended measures may be difficult.
- Pedestrian scores derived from the HCM model are measured on a grade scale, which is currently not recommended by many planners and engineers in the United States.

1.5 Guidebook for Developing Pedestrian and Bicycle Performance Measures

The FHWA released the Guidebook for Developing Pedestrian and Bicycle Performance Measures in March 2016.[7] This guidebook includes suggestions about how an organization can start monitoring bicycle and pedestrian facility performance based on seven common community goals: Connectivity, Economy, Environment, Equity, Health, Livability, and Safety. Performance measures were determined based on how they evaluate six categories: Accessibility, Compliance, Demand, Reliability, Mobility, and Infrastructure. The FHWA recommends engaging the public and stakeholders by requesting that they submit performance monitoring input. The FHWA also recommends selecting performance measures for which the MPO can obtain measureable data.

Strengths

- This guidebook provides a thorough analysis of many possible performance measures that can be used to evaluate pedestrian facilities.

Weaknesses

- Some of the categories can be difficult to measure at times due to the lack of data.

[7] US Department of Transportation, Federal Highway Administration, *Guidebook for Developing Pedestrian and Bicycle Performance Measures*, https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/

1.6 Local Access Score Tool

The Metropolitan Area Planning Council (MAPC) is a regional planning agency located in Boston. MAPC conducts planning for transportation, land use, public safety, economic development, social equity, and housing stock in the Boston region. In 2016, MAPC has created its Local Access Score Tool, which shows pedestrian and bicycle utility scores for roadway segments and shared-use paths.[8] The travel demand model is used for calculating the utility scores. The results are based on the nearby population, their destinations and the modes that they take during their commute.[9] This tool indicates how much each roadway segment would be used by bicyclists and pedestrians if there were adequate facilities for them to comfortably travel.

Strengths

- The Local Access Score Tool helps planners and engineers prioritize investments based on predicted pedestrian activities.

Weaknesses

- Local access score focuses exclusively on origin and destination movements to calculate the utility scores.

1.7 Other Pedestrian Studies and Models

Other pedestrian studies and models identified in the literature search include the following:

- Synchro is a modeling program that allows users to simulate improvements to an intersection, including pedestrian infrastructure improvements, such as the addition of actuated signal features.
- The Pedestrian and Bicyclist Level-of-Service on Roadway Segments study was sponsored by the Danish Road Directorate and used to determine the satisfaction of pedestrians who travel on roadway segments between intersections. This study relied strongly on surveys taken by pedestrians from various demographic backgrounds.
- The Multimodal Level-of-Service Analysis for Urban Streets: Users Guide (2009) is a study that was headed by Dowling Associates. The product of this study was intended to be used for evaluating urban roadways. In this

[8] Metropolitan Area Planning Council, “Local Access Score,” http://localaccess.mapc.org/

[9] Metropolitan Area Planning Council, “Planning Active Streets Tool: A New Resource for Massachusetts” presentation, http://masscptc.org/documents/conferencedocs/2016/Session%205%20%20Complete%20Streets/Planning%20Active%20Streets%20Tool.pdf

model, the automobile, pedestrian, bicycle, and transit modes each have their own LOS formula. However, each of the four LOS metrics affects one another (for example, automobile speeds will affect PLOS).[10]

1.8 SUMMARY

Many of these pedestrian tools focus on infrastructure rather than pedestrian behavior, partially because of the scarcity of data, such as pedestrian traffic volumes and pedestrian travel speeds. However, there is a distinct possibility that these data types will become more readily available in the coming years due to the improvement of technology. For example, global positioning system (GPS) monitoring is improving and will become more prevalent with the use of devices such as activity trackers. The expansion of GPS monitoring will allow better tracking of pedestrian volumes, travel speed, and delay. For the time being, there are both benefits and limitations to the existing models used to assess the quality of the pedestrian environment. The merits and disadvantages of the resources for use by the Boston Region MPO are listed below. Additionally, Table 1 lists some information about each model.

- The Sprinkle Consulting model is effective at monitoring the comfort of pedestrian facilities, but fails to monitor pedestrian behavior.
- The MAPC project is intriguing, and it will be crucial for the Boston Region MPO and MAPC to work together on the projects that focus on bicycle and pedestrian movements.
- The Old Colony MPO's PLOS model is similar to what the Boston Region MPO wants to achieve with the pedestrian LOS project. Therefore, it would be advisable to create a tool that is similar to the one that the Old Colony MPO has developed.
- The HCM model is effective when applied to a small project area with a large amount of data available from field studies, but some of the performance measures would be difficult to apply on a regional or even a corridor level due to the lack of data. The PLOS tool, Art Plan, is embedded in the HCM. However, this tool does not consider conditions for adjacent roadways.
- The FHWA suggests some good performance measures. However, it is often difficult to obtain data.
- Walk Score does not factor in pedestrian comfort, pedestrian movement, connectivity of pedestrian facilities, sidewalks, or how many lanes of traffic a pedestrian must cross. It seems that the walk score is applied on over a particular area rather than a specific location.

[10] Richard Dowling, *Multimodal Level of Service Analysis for Urban Streets: Users Guide* (2009)

Table 1
Comparison of Pedestrian Monitoring Methods

PLOS method	Modes measured	Method of analyzing pedestrian behavior	Method of Measuring	Estimated number of factors/ performance measures	Measured network
Sprinkle Consulting Model	Pedestrian Bicycle	Vehicle annual average daily traffic (AADT)	Grade scale	12	Sidewalks Roadways
Old Colony MPO Model	Pedestrian Bicycle	Vehicle AADT	Grade scale	30+	Sidewalks Roadways
Walk Score	Pedestrian Bicycle Transit	None	Point scale between 0 and 100	12	General area
Highway Capacity Manual	Pedestrian Bicycle Highway	Average travel time Vehicle volumes Occupied street parking	Grade scale	10	Sidewalks Trails Roadways
FHWA Guidebook	Pedestrian Bicycle	Average travel time Crashes Delay Person throughput and volume	User determined	30	Sidewalks Trails Roadways
MAPC Local Access Score Tool	Pedestrian Bicycle	Trip origin and destination	Point scale between 0 and 100	8	Sidewalks Trails Roadways

2 MARKING PROGRESS TOWARD GOALS AND OBJECTIVES

In order to create a PRCA tool, MPO staff determined that it was best to assemble elements from all of the models listed above and add other measures that would be prioritized with consideration of data availability. As an end product, the performance measures selected for the PRCA must gauge the progress toward goals for improving the pedestrian environment on roadway segments and signalized intersections. The following sections describe types of performance measures, the MPO's goals, and objectives for a PRCA for the Boston region.

2.1 Performance Measurement

A robust PRCA monitors infrastructure that facilitates the movement of pedestrians in the transportation network, and analyzes the presence and behavior of travelers. A major purpose of the PRCA is to identify areas where people are expected to rely heavily on pedestrian facilities.

Types of PLOS Measures

Performance measures that are used for this tool are categorized as either infrastructure or mobility performance measures. Infrastructure performance

measures are used to analyze the existing transportation facilities or environment to determine if a location is suitable for pedestrian travel. These measures monitor the condition and presence of sidewalks, roadways, crosswalks, and signals. Data that are used to monitor infrastructure performance measures are usually static and do not change from day to day. Data for infrastructure performance measures usually come from roadway inventories or intersection surveys.

Examples of infrastructure performance measures include the following:

- Sidewalk presence
- Lighting presence
- Crossing opportunities

Mobility performance measures are used to analyze the presence and behavior of travelers. Mobility performance measures include pedestrian counts, pedestrian travel speed, and vehicle movements. Mobility performance measure statistics can often vary from day to day, whereas infrastructure performance measures are usually fixed unless the infrastructure is under construction. Data for mobility performance measures usually come from vehicle or pedestrian traffic monitoring efforts.

Examples of mobility performance measures include the following:

- Average vehicle travel speeds
- Pedestrian crashes
- Pedestrian volumes

Transportation Equity Factors

Even though monitoring transportation equity is not required for the PRCA, it is strongly recommended. Areas where residents are dependent on pedestrian facilities are places where it is especially important to provide high quality pedestrian environments. Locations where there are high percentages of households that do not own vehicles or where residents are less likely to own cars because of low incomes are examples of the types of places where one might expect high use of pedestrian facilities. Additionally, it is very important to provide high quality pedestrian environments near schools and locations where there are large elderly populations who may not be able to drive.

The PRCA provides the option to analyze four factors, referred to by MPO staff as transportation equity factors, to determine if a specific area is a place where one might expect high pedestrian use:

- Areas that are located in an environmental justice zone, as defined by the MPO
- Areas where more than 8.9 percent of the population is over 75 years of age
- Areas where more than 27.5 percent of households do not own a vehicle
- Traffic analysis zones (TAZs) that are located within a quarter mile of a school or college

These factors address aspects of transportation equity, which is a key goal of the Boston Region MPO's LRTP. For a detailed description of each transportation equity factor, refer to Appendix C.

Roadway segments and intersections are classified based on the number of transportation equity factors that apply to them. For example, a location with zero or one factor is classified as having low usage; a location with two factors has moderate usage; and a location with three or four factors has high usage. The higher the presence of transportation factors at a location, the more important it is that there is a high quality pedestrian environment along the roadway segment or at the intersection.

2.2 Goals and Objectives

The MPO has adopted six goals and associated objectives as part of its LRTP. The goal areas are as follows:

- Safety
- System Preservation
- Capacity Management and Mobility
- Economic Vitality
- Clean Air and Clean Communities
- Transportation Equity

To provide the optimum pedestrian network for the Boston region, it is important to move toward achieving these goals. The PRCA grades the quality of the walking environment under the following four goal areas:

1. Safety

   This goal area focuses on the overall safety of pedestrians. Progress toward safety goals is often evaluated by monitoring Highway Safety Improvement

Program (HSIP) pedestrian cluster locations.[11] Safety can also be assessed by determining if pedestrian travel facilities are properly separated from automobile travel facilities (considering, for example, the buffer space between a sidewalk and a roadway).

2. System Preservation

   The System Preservation goal area focuses on the condition of pedestrian infrastructure that is located along roadways and at intersections, including sidewalks and pedestrian signals.

3. Capacity Management and Mobility

   The Capacity Management and Mobility goal area focuses on how people and vehicles move throughout the transportation network and the connectivity of the transportation network. This goal area also emphasizes the need to ensure that transportation infrastructure meets the Americans with Disabilities Act (ADA) standards.

4. Economic Vitality

   The Economic Vitality goal area focuses on the vibrancy, or energy and liveliness, of the pedestrian network. Economic vitality is often measured using pedestrian counts.

The Clean Air and Clean Communities goal is monitored through the TIP selection process rather than the PRCA. The reason for this is because air quality standards are required to be met in order for a project to be included in the TIP and receive federal funding. Additionally, transportation equity is a recommended but not a requisite goal for the PRCA. Monitoring transportation equity in the PRCA is strongly encouraged as many people who live in areas that have a high presence of transportation equity factors often rely heavily on pedestrian facilities for their commute.

The objectives created to monitor progress towards achieving the goals are listed below:

[11] An HSIP cluster is a location which ranks in the top five percent of all crash clusters in the region based on Equivalent Property Damage Only (EPDO) scores. EPDO scoring is a method for assessing the frequency and severity of crashes at a given location over a period of time. This method assigns weighting factors to indicate the severity of a crash; a crash that causes a fatality is weighted by 10, a crash causing injury is weighted by 5, and a crash resulting in property damage is weighted by 1.

- Objective #1: Address pedestrian safety at areas with a high number of pedestrian crashes (Safety)

- Objective #2: Improve pedestrian safety in areas not at a HSIP pedestrian cluster location (Safety)

- Objective #3: Improve safety for school-related travel on regional and local arterials (Safety)

- Objective #4: Improve existing pedestrian and bicycling infrastructure (System Preservation)

- Objective #5: Use existing capacity of transportation facilities more efficiently and increase healthy transportation capacity (Capacity Management and Mobility)

- Objective #6: Increase walkability and support communities to promote walkability (Capacity Management and Mobility)

- Objective #7: Improve pedestrian access to rapid transit (especially north-side Orange Line stations and south-side Red Line stations) (Capacity Management and Mobility)

- Objective #8: Implement bicycle and pedestrian investments that encourage support of local businesses (Economic Vitality)

3 SELECTION OF PERFORMANCE MEASURES

The process the MPO staff used to evaluate performance measures is described in this section, along with a discussion of the measures and scoring criteria staff recommends using in the PRCA for the Boston region.

3.1 Process for Selecting Performance Measures

During the process of selecting performance measures for the PRCA Tool, MPO staff met internally to discuss the pros and cons of every performance measure under consideration. First, staff compiled a list of potential performance measures that could be used for the PRCA. Then they defined each performance measure using staff input and research from previous PLOS studies. Additionally, they distributed a survey to planners and engineers in the Boston region to poll them on the utility of each performance measure.

Two surveying efforts were conducted. The first was an internal poll, in which Boston Region MPO staff members were invited to comment on potential performance measures. The second polled planners and engineers from the Boston region with extensive knowledge about bicycle and pedestrian facilities.

The online survey was created on Google Forms and was distributed to a total of 19 participants. The survey was restricted to professionals in the field because the proposed performance measures were technical and detailed responses were requested. Some of the municipalities and organizations surveyed included the following:

- City of Boston
- City of Cambridge
- Massachusetts Department of Transportation (MassDOT)
- Livable Streets
- Northeastern University
- WalkBoston
- MAPC

The survey consisted of four sections. The first section asked questions about the respondents, such as the organizations that they represent and their commute to work. In the second section, the survey then asked if the performance measure definitions are clear, if the performance measures influence pedestrian level of comfort, and if the performance measures should be used for grading the PRCA. The third section focused on transportation equity and assessing the importance of ensuring good PLOS in areas where the population relies heavily on pedestrian infrastructure. The final section asked various questions in regards to how the respondents feel about the pedestrian

network in the Boston region. For full results and a copy of the survey, refer to Appendix F and G.

Staff considered the survey responses and the availability of data for monitoring system performance when selecting the final performance measures for use in the PRCA. Some performance measures were not selected due to the lack of data.

3.2 Selected Performance Measures

MPO staff recommends the use of 13 specific performance measures for grading PRCA. Each of the performance measures gauge one of four goals that were adopted in the PRCA. Table 2 lists each selected performance measure, the performance measure type, the network it measures, and the PRCA goal that it gauges. Additionally, the selected performance measures are described in the following subsection. For a full description of all performance measures, including those not selected, refer to Appendix A.

Table 2
Selected Performance Measures

Performance Measure	Performance Measure Type	Measure applies to roadway segment, intersection, or both	Boston Region MPO Goal
Sidewalk Presence	Infrastructure	Both	Capacity Management and Mobility
Crossing Opportunities	Infrastructure	Both	Capacity Management and Mobility
Walkway Width	Infrastructure	Roadway segments	Capacity Management and Mobility
Pedestrian Delay	Infrastructure	Intersections	Capacity Management and Mobility
Curb Ramps	Infrastructure	Intersections	Capacity Management and Mobility
Pedestrian Volumes	Mobility	Both	Economic Vitality
Adjacent Bicycle Right of Way	Infrastructure	Roadway segments	Economic Vitality
Pedestrian Crashes	Mobility	Both	Safety
Vehicle-Pedestrian Buffer	Infrastructure	Roadway segments	Safety
Average Vehicle Travel Speeds	Mobility	Both	Safety
Sufficient Crossing Time Index	Infrastructure	Intersections	Safety
Pedestrian Signal Presence	Infrastructure	Intersections	Safety
Sidewalk Condition	Infrastructure	Both	System Preservation

Infrastructure Performance Measures

Sidewalk Condition

The Sidewalk Condition performance measure documents the condition of sidewalks along roadway segments and intersections. Sidewalk condition directly impacts pedestrian safety, which is a major grading category in the PRCA.

Sidewalk Presence

The Sidewalk Presence performance measure indicates whether sidewalks are present along a street segment or at an intersection. The presence of a sidewalk along a street has a positive impact on the PRCA's Capacity Management and Mobility grade. The score for this performance measure is dependent on if there is a sidewalk present on either one or both sides of a roadway segment.

Pedestrian Signal Presence

The Pedestrian Signal Presence performance measure quantifies the characteristics of pedestrian signals. Pedestrian signal phases can either be exclusive or concurrent. Concurrent pedestrian signal phases accompanied by "no turn on red" signage receive the highest grades because they allow pedestrians to cross more frequently than exclusive pedestrian signals – which often require pedestrians to wait through the entire signal cycle before they are allowed to cross an intersection – and because the signs reduce the likelihood of pedestrian-vehicle collisions. Additionally, it is recommended that Leading Pedestrian Interval (LPI) is present at intersections, as LPI's allows pedestrians extra time to begin their way across an intersection before traffic lights for vehicles turn green.

Crossing Opportunities

The Crossing Opportunities performance measure reflects the number of crosswalks that are present. For roadway segments, the measure is reported as the number of crosswalks per linear mile. The greater the number of marked crosswalks, the more flexible pedestrian travel becomes, thereby increasing mobility. Additionally, the presence of a crosswalk alerts drivers that pedestrians may be crossing the roadway. Crossing opportunities are measured at intersections by analyzing the presence of crosswalks at each approach.

Curb Ramps

The Curb Ramp performance measure identifies the presence of curb ramps at intersections. Intersections with curb ramps at all pedestrian approaches facilitate pedestrian travel, thereby increasing mobility. Curb ramps should be perpendicular to the curb, positioned to guide pedestrians into the crosswalk. The position of curb ramps is especially important for mobility-impaired and vulnerable pedestrians.

Vehicle-Pedestrian Buffer

The Vehicle-Pedestrian Buffer measures the total distance between vehicular traffic and pedestrian traffic. A vehicle-pedestrian buffer should be at least five-feet wide. A buffer is good for reducing vehicle-pedestrian traffic incidents, which often result in bodily injuries or fatalities.

Walkway Width

The Walkway Width performance measure is an important calculation because the width of a walkway impacts its accessibility. An accessible sidewalk should be at least five-feet wide to allow two wheelchairs to pass one another while traveling along the pedestrian corridor. Mobility is greater in locations where there are a high percentage of sidewalks at least five-feet wide.

Sufficient Crossing Time Index

The Sufficient Crossing Time Index performance measure determines whether there is adequate time for pedestrians to complete a crossing of a signalized intersection at a speed of 3.5 feet per second during the combined duration of the pedestrian change and red clearance/buffer intervals of a traffic signal cycle. The FHWA recommends that all pedestrian crossing times be based on walking speeds no faster than 3.5 feet per second in order to accommodate all populations.

Adjacent Bicycle Right of Way

The Adjacent Bicycle Right of Way performance measure evaluates if there are adjacent bicycle facilities such as bike lanes, sharrows, and extra wide shoulders on roadway facilities. Roadways with bicycle facilities often correlate with the economic prosperity of an area. Additionally, providing bicyclists separate facilities will encourage them to ride in bicycle lanes or a roadway rather than sidewalks. Pedestrian comfort is often lower when bicyclists and pedestrians share the same right of way, mostly because of the difference in speed of travel between bicyclists and pedestrians.

Pedestrian Delay

The Pedestrian Delay performance measure tracks the amount of time a pedestrian must wait at an intersection for a walk signal. Long delays can encourage pedestrians to engage in dangerous behavior, such as dashing across an intersection ahead of oncoming vehicular traffic.

Mobility Performance Measures

Average Vehicle Travel Speeds

The Average Vehicle Travel Speeds performance measure represents the average speed at which vehicles travel along a roadway segment. Vehicle speeds are preferred over speed limits because they reflect the actual speed of vehicle traffic as opposed to the speed at which vehicles are expected to travel. High vehicle travel speeds increase pedestrian stress and decrease safety.

Pedestrian Crashes

The Pedestrian Crashes performance measure documents areas where pedestrian crashes are common. Due to a lack of pedestrian volume counts, this performance measure will be assessed by the location of HSIP Pedestrian Crash Clusters.

Pedestrian Volumes

The Pedestrian Volumes performance measure represents the number of pedestrians traveling through a location over a period of time. High pedestrian volumes can indicate high economic vitality in an area because large numbers of pedestrians indicate that a location is busy and vibrant. Such areas encourage people to congregate and conduct business. Therefore, locations that have high pedestrian volumes will typical score high in the economic vitality category.

3.3 Performance Measure Scoring and Weighting

After MPO staff selected performance measures for PRCA grading at intersections and along roadway segments, they created scoring criteria for every performance measure. A score of one is the worst score possible while a score of three is the best. Appendix D lists three possible conditions for each performance measure and the score that a grader should give for each performance measure condition.

Once MPO staff created the scoring criteria for the performance measures for PRCA grading at intersections and along roadway segments, they assigned a weight to each measure. The weighting allows performance measures with the greatest impact on the quality of pedestrian travel to affect PRCA scores more than other performance measures with less significant impacts. The weights MPO staff assigned to each performance measure reflect several considerations:

- Usefulness of the performance measure

- Relevance of the performance measure
- Area of application (intersection or roadway segment)
- Survey evaluation results

MPO staff found the performance measures that best reflect the pedestrian experience at intersections and along roadway segments to be the most important and therefore assigned those measures the most weight. Performance measures for pedestrian crashes, pedestrian delay, and crossing time index were all rated more highly, for example, than performance measures that document the physical environment, such as walkway width, pedestrian signal type, pedestrian-vehicle buffer width, and curb ramp presence. The tables below indicate the weights that MPO staff associated with each performance measure. Table 3 lists the performance measures used to grade the roadway segments and Table 4 lists the performance measures for intersections.

The weight assigned to each measure factors into PRCA grading when the weight of each performance measure is multiplied by the score assigned to a specific location. The weighted scores of the performance measures in each PRCA category are then added together and divided by the number of weights assigned for each category.

Table 3
Roadway Segment Performance Measure Weights

Performance Measure	Boston Region MPO Goal	Weight
Sidewalk Presence	Capacity Management and Mobility	3
Crossing Opportunities	Capacity Management and Mobility	2
Walkway Width	Capacity Management and Mobility	1
Pedestrian Volumes	Economic Vitality	1
Adjacent Bicycle Accommodations	Economic Vitality	1
Pedestrian Crashes	Safety	3
Pedestrian-Vehicle Buffer	Safety	1
Vehicle Travel Speed	Safety	1
Sidewalk Condition	System Preservation	1

Table 4
Intersection Performance Measure Weights

Performance Measure	Boston Region MPO Goal	Weight
Pedestrian Delay	Capacity Management and Mobility	3
Sidewalk Presence	Capacity Management and Mobility	2
Curb Ramps	Capacity Management and Mobility	1
Crossing Opportunities	Capacity Management and Mobility	1
Pedestrian Volumes	Economic Vitality	1
Sufficient Crossing Time (Index)	Safety	3
Pedestrian Crashes	Safety	3
Pedestrian Signal Presence	Safety	1
Vehicle Travel Speed	Safety	1
Sidewalk Condition	System Preservation	1

4 TEST RUNS

Each potential performance measure was tested on five roadway segments and five intersections that are located throughout the Boston region. MPO staff recorded their calculations for each performance measure at each location. The scores for every performance measure were based on the information MPO staff

collected for each intersection or roadway segment. The scoring criteria for the performance measures are specified in Appendix D.

The weighted scores of all the performance measures within the same category are averaged, as explained above, and given a grade of poor, fair, or good based on the average weighted category score. The average weighted scores are classified as follows:

- Good – Score is 2.3 or more (maximum 3.0)
- Fair– Score is between 1.7 and 2.3
- Poor – Score is 1.7 or less (minimum 0)

Table 5 and Table 6 list the PRCA grades MPO staff calculated for each category during test runs on selected intersections and roadway segments. For detailed information about every performance measure at each intersection or roadway segment, refer to Appendix E. Table 5 and Table 6 also indicate whether there are transportation equity issues at each location; this was determined using the transportation equity factors described in section 2.1. Transportation equity factors do not directly affect the score of the other PRCA categories. However, the higher the presence of transportation equity factors, the more important it is for the location to earn “good” scores in each category of the PRCA.

Table 5
Results from Test Run
Intersections

Intersection	Municipality	Capacity Management and Mobility	Economic Vitality	Safety	System Preservation	Transportation Equity Factor Presence
US 3 and Route 2A/Mystic Valley Parkway	Arlington	Fair	Fair	Good	Poor	Moderate
Lowell Street and East Street	Lexington	Poor	Poor	Fair	Poor	High
Route 129 and Route 1A	Lynn	Fair	Fair	Good	Good	High
Bolton Street and Lincoln Street	Marlborough	Fair	Poor	Good	Good	Moderate
Route 109 and Route 27	Medfield	Fair	Poor	Fair	Fair	Low

Table 6
Results from Test Run
Roadway Segments

Roadway Segment	Municipality	Capacity Management and Mobility	Economic Vitality	Safety	System Preservation	Transportation Equity Factor Presence
Route 9 from Francis Street/Tremont Street to Louis Prang Street/Ruggles Street	Boston	Good	Good	Good	Good	High
Route 62 from US 3 to Bedford Street	Bedford	Good	Poor	Good	Good	Moderate
Route 140 from Main Street to Chestnut Street	Franklin	Good	Fair	Good	Good	Low
Beacon Street from Washington Street to Harvard Avenue	Brookline	Good	Fair	Fair	Good	High
Dexter Street to Route 16	Everett	Good	Good	Good	Good	Moderate

5 RECOMMENDATIONS AND NEXT STEPS

5.1 Recommendations

MPO staff recommends adoption of the PRCA methodology for grading the quality of the pedestrian environment at intersections and along roadways in the Boston region. Municipal employees and the public can grade PRCAs for any intersection or roadway segment, as long as they have access to accurate data or are willing to conduct field work to collect the necessary information. The PRCA grades the quality of the pedestrian environment using multiple categories to give a score for several goals, rather than one cumulative score.

For the best interest of the Boston region and for the development of the next LRTP, it is recommended that the MPO pursue a follow up project which would create a PRCA monitoring program for the MPO. If the PRCA monitoring program project is approved, MPO staff will calculate the PRCA for select intersections and roadway segments throughout the Boston region. A dashboard can be developed for planners, engineers, and the general public to use for analyzing the pedestrian friendliness of intersections and roadway segments around the region.

5.2 Next steps

Outreach

The next step is to begin PRCA outreach efforts, which will inform planners and engineers from local communities about the PRCA tool. MPO staff will present

this methodology to the MPO board and at local conferences. This memorandum will be posted on the MPO's website, under the Livability section. Additionally, staff will work with the MPO's outreach coordinator and the MassDOT Director of Sustainability to determine other innovative ways to inform the public and professionals about this tool, as part of the Congestion Management Process (CMP), LRTP needs assessment, and Transportation Improvement Program (TIP) work.

Dashboard Project

This project focused on developing a methodology that outlines the proper way to monitor PRCA grades. The next step is to focus on the implementation of this project. In early 2017, MPO staff will compose a proposal for a follow up project for creating a dashboard that would monitor PRCA grading on roadways and at intersections in the Boston region. This new project will include collecting the raw data for the selected performance measures throughout the entire defined network. The information would be used to calculate performance measure scores, which will be used to evaluate the performance of roadways and intersections. Once developed, the dashboard will be available to the public on the MPO's website. This project will be proposed for federal fiscal years 2017-18.

RH/rh/cmc