MEASURING MULTIMODAL NETWORK CONNECTIVITY

PILOT GRANT REPORT

OCTOBER 2021

Federal Highway Administration (FHWA) Measuring Multimodal Network Connectivity Pilot Grant Program Final Report

Prepared By

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Acknowledgements

Cover page photo by Nathan McNeil, Portland State University

Executive Summary

In February 2018, the *Federal Highway Administration* (FHWA) published the Guidebook for Measuring Multimodal Network Connectivity, which outlines approaches to integrating pedestrian and bicycle network connectivity measures into State, metropolitan, and local transportation planning processes. Multimodal networks are defined as accessible, interconnected pedestrian and bicycle transportation facilities that allow users of all ages and abilities to safely and conveniently reach their destinations. Accessibility refers to accessible facilities for individuals with disabilities. Connectivity describes the ease with which people can travel across the transportation system. The Guidebook discusses how connectivity measures can help transportation practitioners identify high priority network gaps, implement cost-effective solutions that address multiple needs, optimize potential co-benefits, and measure the long-term impacts of strategic pedestrian and bicycle investments. Measuring multimodal network connectivity can help address goals related to safety improvements, system efficiency and equity, network performance, and access to key destinations. Complete and comfortable multimodal transportation networks can also help achieve mode shift and reduce the transportation sector's carbon emissions.

In November 2018, FHWA awarded $606,936 in grant funding to eight organizations across the country including State departments of transportation (DOTs) and metropolitan planning organizations (MPOs). The grant awards supported analysis of each respective community's multimodal transportation network through implementation of the principles from the Guidebook. The pilot projects implemented the broad themes and considerations from the FHWA multimodal connectivity planning process to improve data-driven planning outcomes. Grantees also participated in a series of four virtual peer exchange meetings held in summer 2020, which included summary presentations of pilot projects and discussions on shared experiences and lessons learned in implementing multimodal network connectivity approaches. This report provides an overview for researchers and transportation practitioners of current efforts furthering multimodal network analysis. By demonstrating the methods and results of multimodal network analysis at a variety of scales, these pilot projects are intended to provide examples for other transportation agencies to follow in measuring various aspects of their walking and bicycling networks to support connectivity. This report summarizes each pilot project and includes an assessment of grantees' experiences and lessons learned organized around four themes:

- **Data Completeness and Accuracy Challenges.** Grantees experienced similar challenges with missing or low-quality data to support identified metrics and performance targets, and they employed various methods to overcome these issues.
- **Novel Data Sources.** Grantees developed and explored new data sources to supplement traditional information and fill in information gaps.
- **Coordination and Partnerships.** Grantees highlighted the importance of effective collaboration among MPOs and local governments to leverage existing resources and share data.
- **Equity Considerations.** Grantees developed equity-related goals and metrics related to access to community destinations, leveraging data visualizations to identify network gaps and underserved populations as part of Environmental Justice analyses.

By putting into practice the tools outlined in the Guidebook, grantees identified a range of multimodal network gaps in their communities and established baseline information to support decision making on strategic active transportation investments.

Introduction

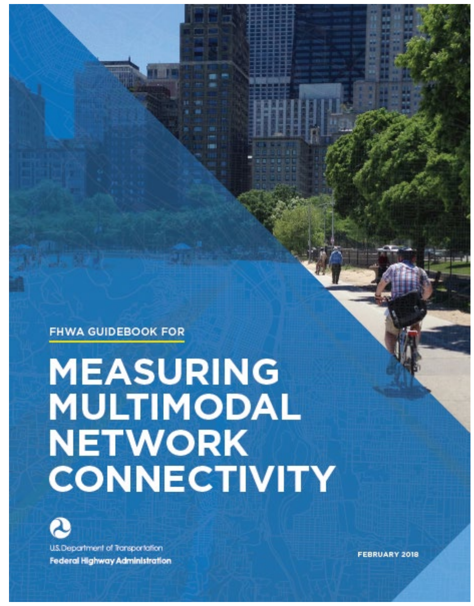

Figure 1: Guidebook for Measuring Multimodal Network Connectivity Cover (Source: FHWA)

In February 2018, the *Federal Highway Administration* (FHWA) published a Guidebook for Measuring Multimodal Network Connectivity, providing information on incorporating pedestrian and bicycle network connectivity measures into State, metropolitan, and local transportation planning processes.

In November 2018, FHWA awarded $606,936 in grant funding to eight organizations including State departments of transportation (DOTs) and metropolitan planning organizations (MPOs) to analyze each community's multimodal transportation network through implementation of the principles from the Guidebook. The pilot projects put into practice the broad themes and considerations from the FHWA multimodal connectivity planning process to improve data-driven planning outcomes.

This report provides an overview of each pilot project and an assessment of grantees' experiences and lessons learned. The purpose of this report is to provide an overview for researchers and practitioners on current practices in multimodal network analysis. By demonstrating the methods and results of multimodal network analysis at a variety of scales, these grant projects are intended to provide examples for other transportation agencies to follow in measuring various aspects of their walking and bicycling networks.

Background

Multimodal networks are defined as accessible, interconnected pedestrian and bicycle transportation facilities that allow users of all ages and abilities to safely and conveniently reach their destinations. Accessibility refers to accessible facilities for individuals with disabilities. Connectivity describes the ease with which people can travel across the transportation system. Connectivity measures can help transportation practitioners identify high priority network gaps, implement cost-effective solutions that address multiple needs, optimize potential co-benefits, and measure the long-term impacts of strategic pedestrian and bicycle investments. Measuring multimodal network connectivity can help address goals related to safety improvements, system efficiency and equity, network performance, and access to key destinations. Complete and comfortable multimodal transportation networks can also help achieve mode shift and reduce the transportation sector's carbon emissions.

The Guidebook describes five core components of multimodal network connectivity with a focus on active transportation, as listed below.

- **Network completeness**. How much of the transportation network is available to bicyclists and pedestrians?
- **Network density**. How dense are the available links and nodes of the pedestrian and bicycle network?
- **Route directness**. How far out of their way do users have to travel to find a facility they can or want to use?
- **Access to destinations**. What destinations can be reached using the transportation network?

- **Network quality**. How does the network support users of varying levels of experience, ages, abilities, and comfort with bicycling or walking?

FHWA encourages practitioners to consider the core components when defining and analyzing pedestrian and bicycle networks. The Guidebook outlines a five-step process to assist agencies with connectivity analyses and active transportation decision making: (1) identify the planning context; (2) define the analysis method; (3) assemble the data; (4) compute metrics; and (5) package results.

As shown in Figure 2, the framework helps agencies make decisions based on comprehensive visioning, clearly defined goals, and measurable objectives.

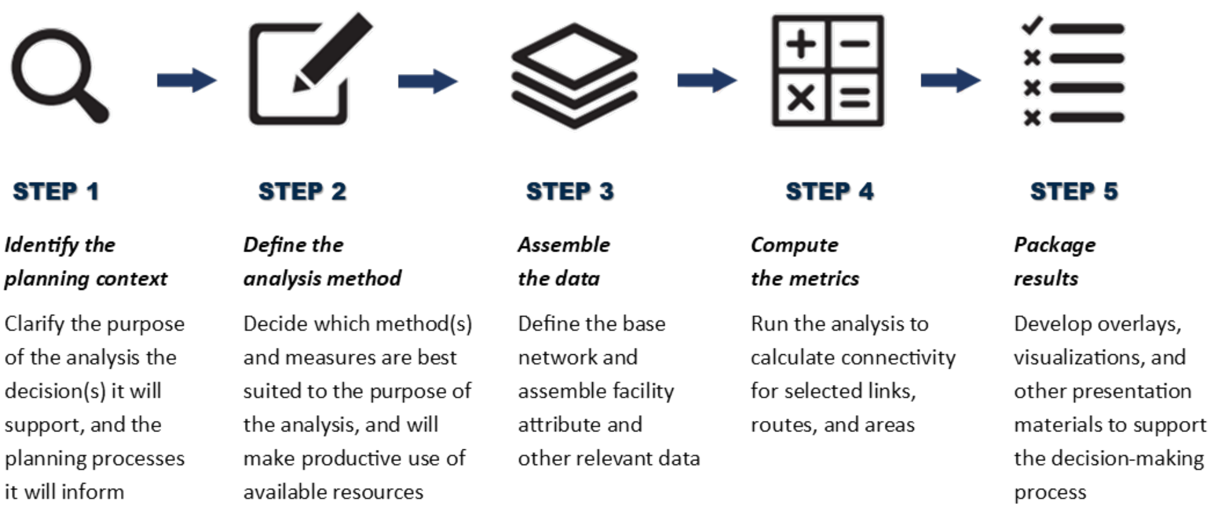

Figure 2: Steps of the Multimodal Network Connectivity Analysis Process (Source: FHWA)

The following describes each step of the multimodal connectivity analysis framework.

1. **Identify the planning context.** The first step of the process requires agencies to define the purpose of a network connectivity analysis, including the specific questions, issues, or decisions that the analysis will help inform. As part of this initial assessment, agencies might determine overarching goals for the study and identify related plans and policies that may be informed by the analysis, such as active transportation plans or pedestrian and bicycle count programs.
2. **Define the analysis method**. The second step of the process requires agencies to determine an approach to data analysis, including the types of data metrics to support goals. The Guidebook outlines a variety of methods for agencies to select from that focus on the efficacy of the network's design, the land use context to identify network gaps, and overall usefulness or performance of the system based on the experiences of nonmotorized users. Depending on the identified planning context, agencies might incorporate multiple, aggregated measures to support a more comprehensive analysis that captures a wide range of community needs.
3. **Assemble the data**. The third step of the process requires agencies to compile the data sources, which may include spatial definitions of the pedestrian and bicycle network, as well as the data needed to rate the network components. This process may be iterative, as analysis goals, network definitions, or methods may need to be modified to fit available data and resources.

4. **Compute metrics**. The fourth step of the process requires agencies to score connectivity at one or more scales: link, route, area or network.
5. **Package results**. The final step of the process requires agencies to compile the data findings into maps, charts, and other visualization tools based on the identified planning context and study purpose. This step presents the results of the connectivity analysis in a user-friendly format to support transportation decision making.

Project Descriptions

This section provides a high-level overview of each grantee's project, including identification of the project's purpose and goals.

Washington State DOT

The Washington State DOT (WSDOT) developed a process to evaluate the "permeability" of State highways (i.e., the extent to which highways act as barriers to active transportation) to better understand access to destinations. WSDOT measured permeability using a Route Directness Index (RDI) that captured the extent to which out of direction travel impacted active travel networks. Indirect routes mean more time, more effort, and more exposure to the elements for people who may be walking or rolling a wheelchair. The project also considered the extent to which high traffic stress interacts with permeability. The additional new local roadway connections to existing State highway crossings (or in some cases, the development of new State highway crossings) could allow for more direct trips between destinations. Also, modifying existing highway crossing facilities for active transportation would maximize the utility of the existing network. The assessment aimed to understand the available tools for identifying and prioritizing areas in need of new or modified crossings for pedestrians and bicyclists, with a focus on developing an equitable transportation system with options for those without access to a car or public transit, including people with disabilities.

Utah DOT

The Utah DOT (UDOT) developed a set of metrics to measure multimodal network connectivity along the urbanized Wasatch Front. UDOT intends to use the metrics in multiple planning contexts, particularly for its "Solutions Development" process. This framework allows practitioners to identify gaps and opportunities that inform projects aligning with the community's vision, existing transportation network, natural environment, and land use patterns. The metrics selected for the project include: (1) percent of street miles with designated bicycle facilities, (2) weighted intersection density, (3) out-of-direction travel as a percentage of shortest route, (4) multimodal travelsheds, and (5) bicycle level of traffic stress. UDOT integrated the metrics into an online mapping portal, and developed regional maps and visualizations. UDOT conducted a travelshed analysis to measure the degree to which users can travel to and from key destinations using alternative transportation modes.

Corvallis and Albany Area MPOs

The Corvallis and Albany Area MPOs in Oregon evaluated the completeness of the pedestrian and bicycle networks, along with their network quality, and access to community destinations. The project aimed to address the edges of the MPO boundaries and existing intercity connections, which are currently low-quality or nonexistent. The project team looked at the access to jobs and community destinations within the two MPOs via low stress bicycle routes or connected sidewalks. The project aimed to prioritize multimodal projects on a regional scale to: (1) make the most efficient use of new funding, (2) reduce transportation costs for those that live in one community but work in another, and (3) provide improved access to employment for traditionally underserved populations in the region. After mapping the completeness and quality of sidewalk and bicycle networks, the project team reviewed the data for regional gaps in comparison with community destinations.

New Hampshire MPOs and Plymouth State University

The New Hampshire MPOs aimed to improve both regional and local bicycle planning through further development and refinement of a shared model for evaluating Bicycle Level of Traffic Stress (BLTS). The project team included four of the State's MPOs, a rural regional planning commission, as well as Plymouth State University which led the development of the BLTS model and bicycle network analysis. The BLTS tool allows practitioners to assess the quality of bicycle accommodations on the regional road network and to identify connectivity gaps for improvement. It supports assessment of destinations that can be reached by bicycle on low-stress roadways. The project focused on establishing consistent bicycle data collection and modelling across multiple regions, incorporating the BLTS analysis into performance-based planning in order to improve project identification and prioritization and measure progress toward a more extensive network of low stress bicycle facilities.

MetroPlan Orlando and the East Central Florida Regional Planning Council

MetroPlan Orlando and the East Central Florida Regional Planning Council (ECFRPC) developed a comprehensive transportation and land use data tool (Land Overlaid on Transportation Information System or LOTIS) by expanding an existing route condition tool. The project team identified pedestrian and bicycle crash points, and calculated per mile pedestrian and bicycle crash rates for various roadway characteristics such as road mileage, speed, number of lanes, presence of sidewalks and bicycle lanes. The pilot also cross-referenced crash data with points of interest including grocery stores, libraries, schools, and restaurants. The project aimed to develop a tool that unified transportation and land use planning data.

Eastgate Regional Council of Governments

The Eastgate Regional Council of Governments (Eastgate) analyzed pedestrian and bicycle level of service, bicycling suitability, walksheds, and roadways that act as barriers to multimodal transportation in several activity centers in the Youngstown-Warren metropolitan area in Ohio. This study set a foundation for a forthcoming Regional Multimodal Plan, ensuring multimodal connectivity is considered in the planning and project prioritization process, and generating a base conditions profile and suitable assessment techniques from which ongoing evaluations can be conducted. Eastgate identified isolated walksheds for connectivity improvements in order to increase the number of people that can access destinations within the activity centers.

Houston-Galveston Area Council

The Houston-Galveston Area Council (H-GAC) conducted a multimodal network analysis in two geographically distinct study areas in Texas, including the City of Sugar Land and the Metropolitan Transit Authority of Harris County (METRO) Hillcroft Transit Center. The City of Sugar Land is a suburban community with an extensive network of local streets, waterways, State highways, and other design features that often pose connectivity issues. The METRO Hillcroft Transit Center is one of the highest used transit centers in the region with a relatively high pedestrian and bicycle usage. As with most transit centers in the area, the Hillcroft Transit Center is challenging to access without a vehicle. H-GAC analyzed existing and planned infrastructure with a focus on network completeness and network quality to better understand the challenges and needs of pedestrians and bicyclists in suburban and dense urban settings. Since each area is designed to serve different users, the analysis for the City of Sugar Land focused on access to destinations while METRO Hillcroft Transit Center focused on route directness and first or last mile connections.

Mid-America Regional Council

The Mid-America Regional Council (MARC) analyzed mobility hubs identified in the agency's long-range transportation plan for the Kansas City region. The Smart Moves 3.0 Plan envisions a region with viable mobility solutions for residents, businesses and communities. The plan identified 60 mobility hubs, which the MPO defines as areas containing a variety of transit and mobility services that may include the following attributes: buses, Kansas City streetcar, bicycle or car rentals, micromobility options (e.g., electric scooter, bikeshare), ridehailing, vanpools, dedicated curb space, and/or electric vehicle charging stations. The pilot project analyzed 20 mobility hubs to better understand bicycling and pedestrian activities, as well as infrastructure gaps. Staff created one-mile buffers around each mobility hub using Geographic Information Systems (GIS), and calculated the bicycle and pedestrian level of service and bicycle level of traffic stress.

Experiences and Lessons Learned

This section describes the grantees' experiences and lessons learned in implementing the multimodal network connectivity process and is organized thematically around four areas: data completeness and accuracy challenges, novel data sources, coordination and partnerships, and equity considerations. This section draws from grantees' reports and from a series of four virtual peer exchange meetings held in summer 2020, where grantees provided summary presentations of their projects, and discussed common experiences and lessons learned.

Data Completeness and Accuracy Challenges

Complete and accurate data is important to produce high-quality analyses, provide a baseline for future planning, and inform data-driven project prioritization. This section considers challenges grantees encountered regarding missing or low-quality data and how grantees managed those data issues.

- **Unavailable or inaccurate data imposes constraints**. The Corvallis and Albany Area MPOs had rich data within their geographies, but data was unavailable beyond their borders, making inter-MPO analysis difficult. WSDOT encountered analogous challenges with data availability across appropriate geographies: lack of complete pedestrian and bicycle network data at the State level limited the ability to conduct analyses for specific active transportation networks. The Eastgate analyzed functional classification of roads because data was unavailable for the full set of roads and they were unable to fully characterize connectivity. Similarly, the New Hampshire MPOs found that datasets contained only a subset of needed information for analysis (e.g., road attribute inputs such as speed limit and/or traffic volume) or lacked needed granularity (e.g., annual average daily traffic). UDOT found that regional bicycle facility data contained several inaccuracies, such as roads identified as having bicycle facilities when none were in fact present. MARC identified data points necessary for a bicycle and/or pedestrian level of service analysis, including traffic volume and infrastructure elements such as presence or width of bicycle lanes, parking lanes, through lanes, roadway buffers, curbs, and other street characteristics. MARC found that several of the data required for its analysis were not readily available in the MPO's datasets since the agency does not create or maintain data on a local level, relying on participating communities and counties to collect and share their data.

- **Analysis must conform to the quality and quantity of base data available**. The Corvallis and Albany Area MPOs combined steps 2 and 3 of the multimodal connectivity analysis process (i.e., defining the analysis method and assembling the data) in an iterative manner, and ultimately analyzed network completeness, network quality, and access to destinations based on their confidence with which these methods could be implemented with available data. Additionally, as part of WSDOT's route directness analysis, the agency learned that the data needed to model complex pedestrian routing choice based on multiple intersection legs and marked crossings was not available. As a workaround, WSDOT used simplified network geometry representing roadways and intersections as lines and nodes, and refined the analysis results based on available data attributes such as traffic controls.

  H-GAC's multimodal network analysis for the City of Sugar Land integrated data from the Bicycle and Pedestrian Environmental Quality Index (BEQI and PEQI) with StarMap, which is a GIS layer containing line features of street centerlines for the State of Texas. BEQI and PEQI use several indicators to assess streetscape conditions for active transportation users, including intersection safety (e.g., number of intersection treatments such as traffic signals, stop signs, crosswalks, pedestrian signals, no turn on red, and specific bicycle infrastructure through intersections), street design (e.g., number of lanes in each direction, width of bicycle lane, roadway classification), vehicle traffic, user safety (e.g., bicycle lane signs, pedestrian and bicycle scale lighting, street lights, and line of sight), and land use.

  H-GAC noted several limitations with using StarMap as base map data, including how it displayed shorter roadway segments and access points into a development area instead of following roadway infrastructure intersections. To address this obstacle, H-GAC manually combined segments to better match the physical transportation infrastructure and reduce errors. MARC addressed information gaps for the bicycle analysis by examining road segments using aerial and street level imagery, and drew all sidewalk data used for the pedestrian analysis, which slowed down the process.

- **There are unknowns and limitations on modeling nonmotorized travel demand and understanding behavior.** For instance, the Corvallis and Albany Area MPOs identified travel demand model shortcomings due to limited capacity to estimate demand for walking or bicycling. There is variability across grantees in defining walking, bicycle, and transit travelsheds (e.g., in different times and distances) and in modeling complex pedestrian routing choices lacking detailed data. Finally, perceptions of traffic stress, both for walking and bicycling, can be subjective—grantees relied on public comments and input from local pedestrians and bicyclists to validate measures of traffic-stress.

- **Data limitations require creative problem-solving.** The Corvallis and Albany Area MPOs stated in peer exchanges that they were missing data on traffic volume for neighborhood streets, and had to assume bicycle level of traffic stress for those streets. Similarly, the Eastgate stated that they simplified their pedestrian network connectivity analysis by assuming sidewalks were connected at each intersection without having actual data on Americans with Disabilities Act and other accessibility elements of pedestrian infrastructure (e.g., curb ramps and crosswalks). UDOT needed speed limit data to develop its bicycle level of traffic stress level metric; however, this data was only available for State-owned highways, so UDOT assigned general speed limits based on available data on roadway functional classification. Likewise, New Hampshire MPOs used "placeholder" data for shoulder widths for lower tier State highways to develop bicycle level of traffic stress measures. Grantees often had to improvise these data proxies during the analysis project, as they were not foreseen when the project began.

Novel Data Sources

To mitigate challenges of incomplete, low-quality, or otherwise unavailable data, agencies might look to develop and/or explore the use of novel data sources and/or existing resources to help fill in information gaps. This section describes grantees' experiences producing and using novel data sources.

- **Integration of innovative data sources and replicable processes helps establish baseline information, validate data findings, and/or supplement data gaps, but may lead to potential pitfalls in data reliability, accuracy, and bias.** Agencies recognize that utilizing innovative data sources may require additional staff coordination to package the findings, ground-truth the information, and mitigate any potential pitfalls. Innovative data sources may include crowdsourcing and mobile-phone intercept data such as pedestrian and bicycle counts from Strava Metro. Although Strava data is useful on its own, UDOT notes that the data represents a subset of total bicycle trips since not every bicyclist uses the Strava mobile app for every ride. These limitations in exposure data may be biased towards certain rider demographics and geographic locations. UDOT is collaborating with its partners to install additional pedestrian and bicycle counters with capabilities to augment and calibrate the Strava data for more accurate total counts. Several grantees overlaid geospatial data with Google Maps and Google Street View as a data proxy to fill in information gaps and to support data quality assurance. For example, after collecting polygon data in ArcGIS, the MetroPlan Orlando LOTIS project used Google Maps as part of a quality assurance process to confirm the location of community features such as restaurants, lakes, and wetlands. The New Hampshire MPOs relied on a combination of data sources including Google Maps and Google Street View data, a point file of speed signposts, and locally or regionally collected speed and volume data as part of supplemental data collection. Lacking complete local system data, WSDOT looked to Open Street Maps (OSM) as a way to establish local connections with State highways. Unfortunately, OSM is not as well developed for all communities, and existing WSDOT highway linework does not readily interface with OSM or other local roadway data sources. The grantees indicated that establishing new, replicable processes can validate data and supplement gaps. Developing data collection guides maintains consistent data collection methods and helps ensure accurate results in crowdsourcing or large-scale collection efforts. For example, Plymouth State University developed a data collection guide and provided orientation trainings to assist the New Hampshire MPOs with their supplemental data collection efforts. The guide helped ensure similar methodologies for collecting supplemental data on bicycle and parking lane widths, speed, residential area designations, and presence of midblock crossings across the five regions.

- **It may be very resource intensive to develop, evaluate, and implement new data sources or measures, but the efforts can yield significant gains.** UDOT indicated that developing or integrating automated data processes may require significant staff time and resources upfront, however it allows for rapid regeneration of datasets by removing the need for manual data entry. UDOT partnered with the Utah Automated Geographic Reference Center to develop an automated data process based on the latest updates made to the State's GIS data, allowing practitioners to quickly create new datasets as needed. Efforts to develop automated data processing ensures that the data will be used for future planning by removing the burden of manual data entry. The New Hampshire MPOs' data assembly activities required a considerable amount of time in reviewing and refining existing road network data from the State DOT, including collection of information not included in the State's data layer. The project team ran data models to determine a baseline set of BLTS ratings for public roadways in the study area. As part of the evaluation process, the project team presented the baseline BLTS ratings to the community to determine how model results compared to public perception or stress levels. The project team held 12 outreach events across five planning regions and provided virtual tools for public involvement (e.g., commentary through interactive online maps). Fully vetting new data sources or metrics with the broader community not only provides more accurate results, but it engages the community as part of the planning process.

- **Explore the potential to expand existing planning efforts and/or modify existing data tools to support active transportation connectivity analyses.** Some grantees sought opportunities to expand existing efforts or resources using the multimodal connectivity framework, particularly for efforts with complimentary goals. WSDOT developed a Multimodal Permeability Pilot in coordination with the development of the agency's Active Transportation Plan. Although both planning efforts have distinct approaches, they share similar data analysis tasks to determine how the State roadway network aligns with pedestrian and bicycle needs. MetroPlan Florida and ECFRPC expanded the scope of an existing "Route Condition Tool," which focused primarily on road network conditions, to develop the LOTIS database. The LOTIS tool factors active transportation goals, incorporating street feature and proximity data for roadway segments and comprehensive land use data metrics.

Coordination and Partnerships

Coordination across jurisdictions is key to produce, share, analyze, and apply multimodal network connectivity data. This section considers challenges grantees encountered working with data generated by different organizations and conducting context-appropriate analysis as well as how grantees collaborated to manage those issues.

- **Data collected across jurisdictions may not be easily comparable.** For example, separate jurisdictions in Oregon develop their own unsynchronized plans and urban growth boundaries result in planning gaps between jurisdictions. The Corvallis and Albany Area MPOs encountered challenges generalizing the cross-jurisdictional data across the region, displaying the different evaluation systems used in separate planning efforts, and creating universal definitions for different metrics and measures.

- **Differing analytical needs and contexts may make uniform tools and analyses impractical.** Developing standardized statewide tools with varied geographic contexts can be challenging.

The New Hampshire MPOs noted that different roadway attributes are important to characterizing bicycle level of traffic stress in urban versus rural contexts (e.g., bicycle lanes are less common in rural areas but wide roadway shoulders may provide for bicyclist comfort). As a result, a single statewide bicycle level of traffic stress methodology may not be appropriate.

- **Grantees benefited from leveraging existing resources and relationships.** The New Hampshire MPOs' pilot project used data from an earlier Plymouth State University effort to develop LTS system. H-GAC used its ACE map application to identify activity centers and assess the built environment based on a set of indicators related to density, connectivity, and access to destinations. H-GAC also utilized City of Sugar Land's BEQI and PEQI—which was originally developed by the San Francisco Department of Health—to measure the quality of sidewalks and bicycle facilities in Sugar Land and in the METRO Hillcroft Transit Center. The agency developed a storyboard through ArcGIS Web AppBuilder, which provided a central location for data collection and analysis, and presentation of findings to the broader community. Corvallis and Albany Area MPOs relied on technical advisory committees to help fill data gaps and identify appropriate analytical methods. UDOT had previously engaged with its project partners on other related efforts which helped streamline coordination on the pilot project, which was a natural next step based on related work performed by the agency's partners, such as active transportation studies. UDOT worked with its project partners to identify regionally significant destinations across the Wasatch Front to determine additional pedestrian and bicycle data needs.
- **Partner agencies must have sufficient technical capacity to work with geospatial and active transportation data**. WSDOT noted that developing new data measures can require substantial technical knowledge to automate calculations on a large geographic scale area. If the scale of the analysis increases, the interpretation of results can be challenging especially if there are varied data definitions and methods in place. H-GAC indicated that data assembly efforts rely on the data collector's subjective observations of transportation infrastructure quality. To assist with data collection training, H-GAC created a video tutorial and provided collectors with the City of Sugar Land's design manual for pedestrian and bicycle facilities as a resource. However, some collectors noted the training was not thorough enough and highlighted the need for more detailed information to reduce subjectivity and maintain consistency in data collection.
- **Data-driven decision making relies on effective communication between MPOs and local governments.** Eastgate identified a challenge of applying the data to support decision making because decisions about investments are made by municipalities that own and maintain infrastructure, while the MPO collects and maintains the data.

Equity Considerations

Conducting multimodal network analysis through an equity lens helps determine how network connectivity is distributed across a community or region, identifying gaps and areas for improvement. Grantees incorporated equity-related goals and targets related to access to destinations and origin-destination trips through community engagement and data-driven planning. In assembling data, grantees leveraged mapping visualizations by overlaying roadway data with sociodemographic, safety, or other geographic attributes. This section describes grantees' efforts to address equity and identify network gaps through the multimodal network analysis process.

- **Grantees oriented their projects around explicitly equity-related goals.** The Corvallis and Albany MPOs' work informed the region's efforts to prioritize multimodal projects across the region to ultimately improve access to employment for traditionally underserved populations. Eastgate similarly identified their role as a provider of data and information to help local communities "develop[] … equitable projects aimed at accommodating all road users and making transportation all across the region more accessible, efficient, and less burdensome for those who do not have access to a personal vehicle, whether that be for reasons relating to age, economic, physical ability, or other reasons."
- **Incorporating equity factors into performance-based planning helps achieve targets.** New Hampshire MPO's BLTS pilot project aimed to identify an effective approach and shared methodology to integrating BLTS data into project scoring criteria. Prior to the project, NHDOT and four MPOs established in 2012 a shared set of project scoring criteria to support MPOs in prioritizing projects for inclusion in metropolitan transportation plans, including the State Ten Year Transportation Improvement Plan. The MPOs agreed the most appropriate area to incorporate BLTS analysis would be under the existing criteria for Alternative Modes and Network Significance, particularly the subcategory of Facility Importance within Network Significance. However, several MPOs took different approaches to this based on their regional context. The Central NH Regional Planning Commission used three criteria for project scoring including centrality, village or land use context, and regional network. The Central NH Regional Planning Commission used the criteria "to find a balance between raw connectivity values and equity between urban and village land use types common to the region, while also incorporating regional connectivity and the rail trail network." WSDOT's Multimodal Permeability Pilot project established a process to better define the effects of State highways on local networks, identifying challenging crossings areas, particularly locations closer to community destinations, and opportunities for improvement. WSDOT noted that the tools and metrics developed for the project support several applications including its Mobility Performance Framework, which incorporates performance-based, data-driven decision making. The framework establishes a goal on accessibility which aims to improve connectivity between goods and services across modes, abilities, and socioeconomic groups; it includes measures related to housing and jobs density, availability and connectivity of pedestrian facilities, and access to services for people with disabilities. WSDOT notes that people with disabilities may experience greater impacts from low highway permeability if they are required to travel out of their way to reach a crossing.
- **Data visualizations and mapping help inform Environmental Justice (EJ) analyses by identifying and prioritizing network gaps.** New Hampshire MPO's BLTS analysis and mapping displays the percent of available bicycle routes on a low stress network, and helps planners see the distribution of connectivity. The project team created origin and destination score maps to identify underserved neighborhoods or destinations with limited access. Maps displayed centrality ratings for road segments to indicate the level of origin-destination connectivity, including stress level, which can be useful tools for identifying and prioritizing network gaps. The project team overlaid data from regional Title VI Civil Rights plans and the Centers for Disease Control and Prevention's Social Vulnerability Index (SVI) calculated at the Census-tract level on origin score maps to support EJ analyses. SVI considers factors such as poverty, racial and ethnic makeup, and access to destinations.

In defining activity centers as part of their connectivity analysis, Eastgate included "job hubs," a concept encompassing the notion of equitable access to economic opportunity. The MPO also relied on American Community Survey data regarding household vehicle access to contextualize their analysis. The LOTIS data tool developed by MetroPlan Orlando and ECFRPC includes features related to access to destinations, which can be used to support gap analysis for various proximity types. The LOTIS tool outputs proximity scores for road segments on a scale of 0-10 related to food, transit, healthcare access, and other topics. The proximity scores identify the availability of community destinations within a 10-minute walk. For example, the tool can show gaps in food coverage by overlaying groceries stores market's convenience stores and restaurants data layers. Lower proximity scores identify network gaps, and help inform prioritization of projects or initiatives that can increase access to destinations and quality of life for EJ populations, such as identifying areas that lack sidewalks and vacant parcels for potential redevelopment to eliminate food gaps.

UDOT integrated a set of metrics to measure multimodal network connectivity along the urbanized Wasatch Front into an online mapping portal, and developed regional maps and visualizations capturing residents' access to key services. One of the metrics include multimodal travelsheds, and UDOT incorporated data from the Utah Transit Authority's transit routes. UDOT conducted the analysis through an access to opportunity lens, which aims to quantify connectivity and other spatial relationships between housing, employment, and businesses.

Next Steps

Based on their experiences and lessons learned, grantees proposed several next steps to build on their pilot projects and advance the state of the practice regarding planning multimodal networks.

- **Maintain data through long-term funding support.** The New Hampshire MPOs indicated grant programs often support the development of novel data applications over a one or two-year period, and there is a lack of funding for data management and maintaining up-to-date datasets. Future grant funding could consider separate programs to not only support similar pilot projects in other communities, but also allocate funding or other resources to maintain data or update previously developed tools. Similarly, the UDOT noted its potential next steps include ongoing data improvements and additional automation of metrics.

- **Extend the pilot analysis and develop or validate new data sources.** For instance, the Corvallis and Albany Area MPOs propose implementing a revised approach to more objectively measure access to destinations. The WSDOT project developed a statewide summary for population centers (e.g. cities, towns, and/or Census Designated Places) versus rural areas based on results of a regional analysis. As part of next steps, WSDOT suggests developing a comparison of population centers by geographic size to better understand and compare permeability.

- **Use pilot data to drive pedestrian and bicycle infrastructure decision making.** Eastgate proposes several strategies to further incentivize localities to invest in pedestrian and bicycle infrastructure projects based on data collected through the pilot program. Strategies include expansion of technical assistance programs, changes to project prioritization scoring methods, increasing funding allocated to bicycle and pedestrian programs, and implementation of an MPO-level complete streets policy. Similarly, although the New Hampshire MPOs focused on integrating BLTS analysis into regional performance-based planning as well as project identification and prioritization, the project team emphasizes the adaptability of the BLTS tools for municipal-level planning. The BLTS data tools will be integrated into local planning efforts to provide more robust, complete information such as through municipal master plan chapters and active transportation plans. WSDOT is working on a follow-on project that seeks to refine route directness and level of traffic stress data and integrate them into the agency's existing decision-making processes for planning, scoping and design. A critical question in this follow-on project is deciding just how much out of direction travel is considered acceptable for people walking and bicycling. The project will involve multiple business areas within WSDOT and with local agency partners.

Building on insights garnered from the pilot grant program, FHWA has identified potential next steps around continued engagement, future research opportunities, and resource development to support planning multimodal networks. For example, FHWA may consider:

- Hosting peer exchanges or webinar series on multimodal network analysis featuring presentations from pilot projects and other noteworthy examples to support continued engagement on experiences and lessons learned,
- Supporting further research to identify new and validate existing data sources, including refinement of existing data tools to support implementation of multimodal network analysis,
- Conducting additional pilots to explore connectivity analysis methods and measures that were only marginally addressed through completed pilot projects such as network density, route directness, and network quality,
- Supporting multimodal network analysis pilots specifically addressing specialized analysis scenarios, such as walk- and bike-sheds around schools or connectivity in EJ areas,
- Establishing a technical-transfer activity to help mainstream the practice of multimodal network connectivity.

Conclusion

This report provides a summary of the eight projects funded through FHWA's Measuring Multimodal Networking Connectivity Pilot Grant Program. In November 2018, FHWA awarded pilot grants to support the improvement of State, metropolitan, and local multimodal transportation networks through implementation of the principles identified in the FHWA Guidebook for Measuring Multimodal Network Connectivity. In addition to developing pilot projects, grantees participated in a series of peer exchanges to share experiences and lessons learned in their multimodal network analysis approaches. Since the connectivity analysis process relies on data-driven planning, the grantees experienced similar challenges in obtaining readily available data to support identified metrics and performance targets. The pilot projects shared common experiences and lessons learned related to data completeness and accuracy and use of novel data sources. Projects also highlighted integration of equity-related goals and metrics, including trip origin, destination access, and access for people with disabilities. Grantees used mapping and/or developed visualization tools, such as the Florida MPOs' land use and transportation LOTIS tool, to identify network gaps and underserved populations as part of EJ analyses. Insights on coordination and partnerships also demonstrate how the grantees leveraged existing resources and relationships to achieve planning outcomes. Overall, the pilot projects identified high priority network gaps and established baseline information to support decision making on strategic active transportation investments.