Transportation Planning Capacity Building
(TPCB) Peer Program

Emerging Methods in Analysis and Implementation: Building out the 2.0 Bicycle Network

A TPCB Peer Exchange Event

Location: Washington, D.C.

Date: April 10-11, 2019

Host Agency: Arlington County, Virginia

National Peers: Josh Roll, Oregon Department of Transportation
Byron Rushing, Atlanta Regional Council

Local Peers: David Anspacher, Montgomery County Planning Department
Mike Goodno, District Department of Transportation
Patricia Shepherd, Montgomery County Planning Department
Nicole Wynands, Fairfax County Department of Transportation

Federal Agency: Federal Highway Administration

U.S. Department of Transportation
Federal Highway Administration

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This report highlights key recommendations and noteworthy practices identified Building out the 2.0 Bicycle Network peer exchange held in Washington DC on April 10-11, 2019. The peer exchange focused on traditional and emerging methods of bicycle planning analysis and implementation, with an emphasis on bicycle level of traffic stress (LTS) analysis.

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Contents

Executive Summary

The FHWA / FTA Transportation Planning Capacity Building (TPCB) Peer Exchange Program provides funding and planning support to Federal Aid recipients who wish to solicit the input of other State DOTs, MPOs, municipalities, and transit agencies on a given planning topic. Arlington County, VA applied to host such an exchange, bringing together peers from Oregon DOT (ODOT), the Atlanta Regional Council (ARC), Fairfax County, VA, Montgomery County, MD, and Washington D.C. on April 10-11, 2019. Facilitation and planning for the exchange were led by Darren Buck of the FHWA Office of Human Environment, and Mike Barry of the FHWA Office of Planning, with support from the U.S. DOT Volpe Center.

The peer exchange focused on "Building out the 2.0 Bicycle Network," a reference to the complexity of achieving a complete network of bicycle routes, without significant gaps, so as to provide broad and equitable to all parts of a jurisdiction. Completing such a network often requires bicycle infrastructure projects that go beyond the standard bike lanes, shared lane markings (sharrows), and wayfinding that these and many other communities across the country have been implementing for decades.

Exchange participants from the peer agencies represented planning, implementation, research, data management and analysis, and community involvement roles. To meet the challenge of building bicycle infrastructure projects that require more significant tradeoffs within the public right-of-way—protected bicycle facilities, two-way cycletracks, bicycle-signal-equipped intersections, etc.—each peer agency presented its most effective strategies for collecting, analyzing, and communicating performance-based information about the needs and benefits of such bicycle infrastructure projects.

Although collecting crash, mode split, and bicyclist count data are common and useful strategies for developing bicycle facilities, they are reflective tools that evaluate where a community is today. Arlington County was particularly interested in learning more about tools for planning future projects, and evaluating and defending decisions about what to build where. A key tool that holds promise for this is the use of ridership, traffic, and infrastructure data to develop a "Level of Traffic Stress" (LTS) network. An LTS analysis characterizes and maps the locations where cyclists of varying levels of experience feel comfortable traveling, on a scale of 1 (least stressful) to 4 or 5 (most stressful). By using the LTS rating system not only to assess existing conditions, but also to propose future scenarios at a broader planning stage, and again at a more detailed design and implementation scale, the peers discussed how much more effective they could be at illustrating the benefits of their plans and projects to leadership, advocacy and stakeholder groups, and the community at large.

While LTS is still a relatively new technique, pioneered by Northeastern University Professor Peter Furth in 2012, many communities have applied LTS analysis in some form to better understand how well their infrastructure accommodates people riding bikes. Using LTS as a scenario planning tool is a newer innovation, and promises to better leverage this network-based approach to evaluating proposed changes in more objective, performance-based terms. For example, a roadway project that proposes implementing a block of protected cycle facility and a HAWK crossing on a busy suburban arterial that bisects residential neighborhoods might seem unlikely; however, an LTS analysis might be the most effective way to demonstrate that such a project could double the potential travel reach of the 60 percent of cyclists who are only comfortable cycling on a relatively low-stress "LTS level 2" facility, by providing a compatibly low-stress link between the otherwise low-stress networks within the adjacent neighborhoods. By extension, this method can be used to evaluate how well or poorly connected pockets of low-stress network are, as a first step toward making the case for further improvements (see Figure 1a and 1b for an example based on LTS analysis from Dane County, WI).
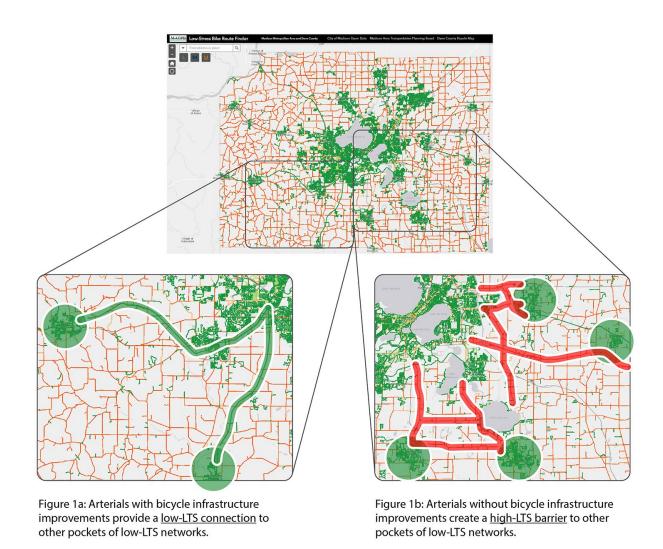
Figure 1a: Arterials with bicycle infrastructure improvements provide a low-LTS connection to other pockets of low-LTS networks.

Figure 1b: Arterials without bicycle infrastructure improvements create a high-LTS barrier to other pockets of low-LTS networks.

Figure 1: Bicycle LTS Webmap - Route finder interface, Dane County, WI
Source: Madison Area Transportation Planning Board (MATPB); Illustration: USDOT Volpe Center

Peer exchange participants discussed how communicating a performance-based analysis such as this would help turn a potentially subjective discussion about cost, traffic throughput, and scofflaw bicyclists into a more pragmatic debate about the merits of expanding a basic, continuous network of low-stress bicycle routes throughout a given community to provide access to local parks, schools, and other community destinations.

Another example in a more urban context that came up was the use of LTS to evaluate infrastructure options on an element-by-element level. At many intersections along bicycle routes, motor vehicle right turn volumes must be considered to evaluate potential right-hook risk for cyclists. By using LTS as a framework for establishing a targeted maximum level of stress for a given route, planners and engineers could more objectively determine where to invest in more costly (from a materials and signal timing perspective) interventions to separate right-turning vehicles from through bicycle traffic (see Figure 2a through 2d). This analysis would not only help establish consensus within the technical realm of planning and engineering departments; it could also prove a more effective means for defending such proposals in front of decision-makers, elected officials, stakeholders, and the community at large.

Figure 2a: Through bicycle and vehicle travel lanes, green paint and through intersection guidelines, no physical separation.

Figure 2b: Through bicycle and vehicle right turn lane with mixing zone, green paint and through intersection guidelines, no physical separation.

Figure 2c: Through bicycle and vehicle right turn lane, green paint and through intersection guidelines, no mixing zone, bicycle signal and phase separation from right turning vehicles.

Figure 2d: Through bicycle and vehicle right turn lane, through intersection guidelines, no mixing zone, bicycle signal and phase separation/concrete median separation from right turning vehicles.

Figure 2: Right hook protection for bicyclists: comparing infrastructure options using LTS analysis and cost-benefit analysis Illustration: USDOT Volpe Center

The TPCB peer exchange participants concluded the meeting with a discussion about the potential to build upon a community-level, regional, or even statewide and national LTS network analysis to assess progress toward broader goals, such as public health, happiness, and economic competitiveness. The peers agreed that LTS-based models could likely be built to estimate ridership increases, based on proposed bike infrastructure improvements. For example, a model that was calibrated to a specific location might predict a 20-percent increase in ridership on a facility that was upgraded from a standard bike lane to a protected bike lane. Then, that increased ridership figure could be translated into figures such as per capita reduction in heart disease, obesity, diabetes, depression and anxiety, and increases in retail sales. Additional research is needed to assess the potential of these ideas. A cursory search of the existing research literature suggests there is appetite for pursuing strategies like these, which apply a performance-based approach to increasingly complex bicycle facility design and implementation challenges, as communities across the country wade deeper into the development of their "2.0 Bicycle Networks."

Introduction

Peer Exchange Program

Transportation Planning Capacity Building (TPCB) Program

The Federal Highway Administration and Federal Transit Administration jointly administer the Transportation Planning Capacity Building (TPCB) Program, with support from the U.S. DOT Volpe Center. This program provides support for peer exchanges that bring together national and local experts on various transportation topics, based on the need of a requesting host agency. Michael Barry, GIS Specialist and member of the FHWA Office of Planning, led planning and organizational support for the exchange. Darren Buck, Pedestrian and Bicycle Program Coordinator with the FHWA Office of Human Environment, and previously of both the Washington D.C. and Alexandria, Virginia Departments of Transportation, served as subject matter expert and lead facilitator. Jonah Chiarenza, Community Planner with the U.S. DOT Volpe Center, assisted with exchange facilitation.

Arlington County Peer Exchange Request

David Patton, Bicycle and Pedestrian Planner for Arlington County's Department of Environmental Services requested assistance from the TPCB Program with bicycle LTS analysis. David led all planning and organizational support for Arlington County. Metropolitan Washington Council of Governments (MWCOG) had previously funded creation of an LTS analysis for Arlington County. Arlington's peer request was aimed at building on this investment by learning how to capitalize on the analysis to support infrastructure and operational improvements that increase the safety and comfort of people riding bikes.

Event Overview

Structure

The peer exchange took place at MWCOG in Washington, D.C. on April 10-11, 2019. The one and one-half day event included presentations from the host and peer agencies, and several panel discussions. In addition, flexible time was built into the schedule on day two. This allowed the participants to choose an activity format that best suited the group as a follow-on to the discussion from day one. The group selected a facilitated group exercise. See Appendix B: Peer Exchange Agenda for the workshop agenda.

Goals

Arlington County worked collaboratively with the U.S. DOT Volpe Center to establish two primary goals for the peer exchange: 1) Learn about examples of LTS and other related bicycle analysis techniques, and 2) discuss best practices for using analyses in bicycle infrastructure design, operations, and communication.

Peers and Participants

The peer exchange included two national peers: Atlanta Regional Council (ARC) from Georgia and Oregon Department of Transportation (ODOT). Three local peers also participated: Montgomery County, Maryland; Fairfax County, Virginia; and the Washington, D.C. District Department of Transportation (DDOT). In addition, Virginia Department of Transportation (VDOT) and MWCOG representatives attended the exchange and participated in discussions. Each peer brought unique experiences to bear as participants of the exchange, representing the perspectives of state, regional, county, and local municipal agencies.

Atlanta Regional Council, GA

The ARC has developed a regional perspective for walking and bicycling titled 'Walk. Bike. Thrive!' The plan is intended to increase walking and bicycling in a region where average trip distances are long, most trips are by car, and many residents have little transportation choice. To tackle daunting regional issues, ARC has adopted five core strategies to cumulatively build a more walkable and bikeable region: supporting walk- and bike-friendly community planning; ensuring safety and equity in the transportation network; promoting regional transit access; incrementally (but relentlessly) building complete streets; and connecting regional trails. Each of these strategies requires a different planning 'toolbox,' but all support daily trips, safety, and a robust regional economy. 'Walk. Bike. Thrive!' is supported by a series of supplemental reports detailing specific data and tactics for addressing each of the core strategies.

Data-driven decisions and evidence-based solutions are foundational to the 'Walk. Bike. Thrive!' program. For safety, the region employs systemic safety analysis to understand not just recent crash histories but roadway characteristics that contribute to higher risks for people walking and bicycling. The region has also formally recognized twelve proven safety countermeasures to help address typical roadway risks. For regional trail, transit access, and complete street connectivity, the region relies on simple gap analyses as well as more complex traffic stress measures to determine key areas for addressing gaps in the current trail and bikeway networks. ARC also assists local governments with data collection, simple data analysis, and technical training to help understand both the policy and technical perspectives of transportation planning, with a goal of supporting better regional outcomes.

> *Peer Contact:* Byron Rushing is a planner with the Atlanta Regional Council focused on walking, bicycling, trails, and livable communities. He currently serves as the President of the Association of Pedestrian and Bicycle Professionals, has degrees from Georgia Tech and Vanderbilt University, and has worked in public and private positions. Most of his walking and bicycle trips are with his wife and two young children.

Oregon Department of Transportation

ODOT has developed a refined pedestrian and bicycle segment and intersection LTS methodology and integrated its use into the state's Analysis Procedures Manual. ODOT has worked with multiple local jurisdictions to use LTS to analyze their networks as part of Transportation System Plan updates. Jurisdictions have used this analysis to prioritize pedestrian and bicycle improvements to complete low-stress networks parallel to arterials and around schools and parks, identify crossing improvement needs on bike boulevards, and identify improvements needed to bridge "islands" of low stress facilities. ODOT also has experience with the use of LTS to compare "no build" and various build alternatives for long range planning and NEPA efforts.

Several communities have adopted policy goals related to LTS such as aiming for all facilities to have an LTS score of 2 or less. ODOT has the perspective of how various approaches work within different local contexts, from the more active constituency of places with a prominent bicycle culture such as Portland to communities with more traditional emphasis on automotive travel.

> *Peer Contact:* Josh Roll is the Active and Sustainable Transportation Research Coordinator for the Oregon Department of Transportation, where he coordinates and conducts research. Josh has experience in most elements of the analyses process, starting with data collection and wrangling, data processing and cleaning, visualization and data exploration and finally modeling development and application. Josh contributes to quantifying the costs and benefits of different travel options to help decision-makers better prioritize investments that will mitigate the effects of inequality, reduce carbon emissions, and improve public health. Josh has experience working

with counties and regions to establish data collection and counting programs and turning those data into useful performance metrics that quantify the value of walking, biking, and investments in pedestrian and bicycle infrastructure.

Montgomery County, MD

In September 2015 the Montgomery County Planning Department completed a report entitled "Proposed White Flint Separated Bike Lane Network" as part of its work on the Bicycle Master Plan Update. Elected officials, the Montgomery County Department of Transportation Director, bike advocates and residents supported the proposed vision for a low-stress bicycle network in the White Flint/North Bethesda area as well as countywide. Maryland-National Capital Park and Planning Commission (MNCPPC) developed a Bicycle Stress Map, launched in April 2016, which displays traffic stress in a way that helps the public make decisions about where to bicycle in the county so they feel safe and comfortable. In addition, the digital tool is helping planners understand the impediments to bicycling, where changes are most needed, and where to prioritize investments. Crash data are received from police. Bike counts are performed before and after bikeway facilities are implemented; increases in cycling help support the need to continue constructing these facilities to attract less confident cyclists to ride.

> *Peer Contact:* Patricia Shepherd, AICP, has over 35 years of experience as an urban designer and transportation planner in the private and public sector. She has spent the last 29 years in Montgomery County as a project manager implementing streetscape and commercial revitalization projects and public urban plazas and parks, with the last ten years focused on transportation planning projects, specifically the design and construction of bike paths and separated bike lanes.

> *Peer Contact:* David Anspacher, Transportation Supervisor at the Montgomery County Planning Department, is the Project Manager for Montgomery County's Bicycle Master Plan.

Fairfax County, VA

Fairfax County has developed an LTS analysis of its bicycle network and documented LTS ratings on a map. Over the last several years, the County has increased focus on developing bicycle infrastructure and has worked with VDOT to implement road diets to provide a more comfortable bicycling environment. Fairfax is also developing a bicycle ridership forecasting model to help understand trends and evaluate projects' ability to increase ridership.

> *Peer Contact:* Nicole Wynands is the Bicycle Program Manager for Fairfax County, Virginia. Previously, she managed the Bicycle Friendly Community Program for the League of American Bicyclists, and worked on transportation projects in South Asia at The World Bank.

Washington, DC Department of Transportation

DDOT has an LTS analysis for the entire city that was completed by a consulting firm. The department is eager to develop the in-house capacity to run the modeling for this analysis to expand DDOT's ability to measure system performance. Current performance is evaluated primarily as miles of bicycle lanes completed, but staff would prefer other methods of evaluation, specifically changes in ridership and in the comfort of the system over time, as projects are implemented. LTS is one of several tools to help DDOT accomplish this, along with the use of safety data.

> *Peer Contact:* Mike Goodno is a planner with DDOT. His focus is on the planning, design, outreach, and implementation of the city's on-road bicycle network.

State of the Practice

Bicycle planning and analysis are evolving to mirror the modern elements of motor vehicle traffic planning and analysis. This evolution continues and is accelerating as new data sources emerge and planners develop new analysis tools. Similarly, municipalities traditionally implement bicycle facilities and motor vehicle projects in the same way. This too is evolving as planners and designers pursue new formats of bicycle infrastructure and new implementation strategies.

Traditional Methods

Traditional methods of bicycle planning and analysis have relied on bicyclist counts at designated times and locations. Typically, these counts are completed no more than a few times a year, or in advance of specific roadway redesign projects. Police records are the primary source for injury and fatal crash information and often represent a relatively sparse source of safety data for a number of reasons[1]. Finally, bicycle rider intercept and online surveys may provide more qualitative information for planning, but this source of data can be hard to collect from a statistically relevant population.

Planning goals are typically focused on annual metrics like bicycle mileage added, mode shift, the number of people riding bikes, or the number of bicyclist injuries and fatalities. To advance these goals, designers have historically developed roadway striping plans that provide space in the roadway for painted bike lanes or shared lane markings (sharrows) as part of planned roadway resurfacing or restriping projects. As supplementary improvements, designers also distribute bicycle racks and post wayfinding signs along designated bicycle routes.

Emerging Methods

Emerging methods of bicycle planning and analysis take advantage of new ways to collect traditional information, new types of data, and new ways of analyzing those data. Many municipalities now install permanent bicycle traffic counters on bicycle routes, and some also install real-time bike counters that display daily and annual bicycle count data in key locations. Having more consistent count data across a larger number of locations gives planners a broader and more complete picture of existing conditions, and on a more frequent interval. New types of data include information from third-party mobile transportation applications that can aggregate, anonymize, and share bicycle trip origin, destination, and route choice data with planners. Some public health departments have also explored ways to supplement traffic crash data with hospital records, which can help fill gaps in the collision record when police have not generated a crash report. These more rigorous and complete data sets can help planners determine where to make larger investments in newer and potentially more complex formats of bicycle facility, including protected and two-way bicycle lanes, bicycle signal hardware, and other strategies.

The Role of Geographic Information Systems (GIS)

Geographic Information Systems (GIS) is a common tools used by transportation departments to map existing infrastructure asset data. As more departments adopt and become familiar with GIS, the coverage, accuracy, and detail of their asset data is improving. By marrying improved crash, count, and trip route information to better infrastructure data, planners can analyze how ridership volumes react to changes made to the bicycle network. For example, new or improved segments along a bike route may

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[1] Low bicycle mode share relative to motor vehicle traffic results in many routes with little or no bicycle traffic. This may result in skewed crash records that do not reflect actual collision risk across a whole network. In addition, some bicycle crashes likely go unreported, and research shows underserved and low-income neighborhoods—for whom bicycles may be a more likely form of transportation—underreport all crash types.

increase preference for and ridership along that route, which can inform decision-making about future bicycle infrastructure projects.

LTS Analysis

LTS analysis is a key metric that brings together these data in a network-wide analysis. LTS ranks roadway and trail segments, and in some cases, intersections, on a four- or five-point scale based on the level of stress an average bicycle rider is anticipated to experience while riding through that location. As the quality of the data that feed these analyses improve, the accuracy of and potential for follow-on analyses grow.

Communicating Benefits

Finally, an overarching development across transportation planning, and of particular importance in bicycle planning, is the practice of using innovative approaches communicate and conduct public outreach. Planners can focus on the global benefits of bicycle infrastructure, including safety benefits for all road users, as well as public health and environmental benefits. In addition, temporary or "pilot" demonstration projects are becoming more common ways to engage stakeholders. Pilot projects also allow planners and designers to evaluate and iterate on new infrastructure designs in a real-world environment.

Presentations and Notable Practices

Host Presentation

Arlington County

Giving the first presentation, Ritch Viola, Principal Planner with the Arlington Department of Environmental Services, established the context of bicycle planning in Arlington County. Bicycle planning has been ongoing since the 1960s in Arlington County. While the historic emphasis has been on building off-street trails, the County has been increasingly pursuing on-street bicycle facilities over the last decade. Arlington identifies connections to community resources, such as schools, for targeted bicycle improvements. For these improvements, outreach to the school district and to individual schools has proven important, both to develop partners that help advocate for active transportation improvements, and to ensure the proposed improvements are in line with local community needs. Ritch presented common challenges in Arlington, which framed the conversations to follow with the peer agencies and other participants and federal staff.

Vehicle double-parking and on-street loading/unloading create hazardous conditions for people riding bikes in bicycle lanes, as well as other roadway users. Anecdotal reports cite frequent offenses by Lyft, Uber, and taxi vehicles, as well as freight and delivery trucks. Limited enforcement capacity in Arlington restricts the ability of police to keep bike lanes clear and cite operators to discourage repeat offenses. Insufficient freight and passenger loading provisions in the right of way also contribute to the problem, as operators are left with few alternatives to parking in bike lanes.

Distracted drivers and increased congestion lead to more perilous conditions for people riding bikes and other roadway users. Bicycle infrastructure designs that mitigate these bike-lane-blocking and driver/traffic conflicts (e.g., protected or separated bike lanes) can lead to challenging trade-offs with on-street parking or motor vehicle lanes (capacity). As such, implementation takes longer, because projects grow in complexity. There are good reasons for this, however, as complex projects require: more public engagement; federal/state oversight associated with funding for more expensive features such as signal hardware, roadway geometry changes, construction of protected bike lanes, relocated

parking; longer-term leadership to deliver projects over extended timelines and multiple phases to meet higher community expectations; and, more time for environmental review.

Arlington is host to a large network of off-street trails, including the Mt. Vernon Trail, and has also experienced an explosion of dockless shared "micromobility" providers. Initially dockless bikes, and now more prevalently deployments of dockless e-scooters, these shared micromobility options are adding to demand for low-speed, separated facilities that do not conflict with motor vehicles or pedestrians.

Peer Presentations

Peer presentations focused on two topics related to LTS: 1) analysis and 2) implementation. The first series of presentations detailed the achievements and challenges faced by each peer agency in performing bicycle network analysis at the state, regional, county, and municipal level. Achievements include the development of manual and automated count programs, crash analyses, and the creation of LTS analyses, while challenges included limitations in data about infrastructure, ridership, demographics, and other information to feed analyses. The second series of presentations focused on implementation strategies to get bicycle improvement and safety projects built. Achievements include the use of LTS and other data-driven analyses to communicate the need for, and benefits of, such improvements. By linking bicycle network investments to city, county, regional, and statewide goals and performance objectives, the peers shared the importance of providing objective information and targeting a broader coalition of stakeholders and decision-makers.

Oregon DOT

Josh Roll presented on the experience of statewide bicycle analysis, which includes understanding statewide and regional trends, and assisting both rural and urban communities with analysis. Among the challenges ODOT faces is poor quality data, overall. This challenge is especially notable as it manifests a lack of understanding about the connection between travel demand and availability of multimodal options for people. Statewide data sources include Census journey to work information, travel surveys, and sporadic 2-hour counts at locations across Oregon. However, these data do not describe what is happening at the individual level – how a given person makes decisions about how they travel. On the other end of the spectrum, too much data can be a challenge in itself. Josh noted the risk of potentially overwhelming people. In such cases, people may retreat to their previously held perceptions about what or why something is a certain way, impeding progress toward more proactive improvements to achieve statewide transportation goals.

Josh shared the following needs and ongoing projects identified by Oregon's Active Transportation Research Program. These include developing better data and tools, meaning more focused, accurate, and descriptive information about bicycle infrastructure and traveler behavior and perceptions. Higher quality individual data points are critical to make statewide data useful at the state and local levels – achieved through more effective travel surveys with questions that draw out information about pedestrian and bicycle habits. Josh noted the use of third party "big" data sources, which may eliminate the need for traditional survey questions and methods. He posed questions about whether this change could allow for new surveys, perhaps used for complementary but different information. Emerging data sets include those provided by nationally-available aggregators like StreetLight, apps like Strava and Ride Report, and local public apps like CycleLane and BikeOR. However, Josh noted that this data must be purchased (from private apps) or is subject to the challenge of getting users to voluntarily contribute their information (via publicly produced apps). To improve the capacity of the state to perform analysis, Josh recommended that bicycle facilities be tagged in mapping database systems based on an LTS methodology and be "routable," meaning navigation apps are able to read the networks' "stress levels"

on each segment and intersection, and allow travelers to select a route of lower or higher stress (with resultant speed/distance/convenience trade-offs).

Josh also noted that bicycle count data should be improved statewide. He shared that progress is underway, as ODOT and the company Eco-Counter have worked together for statewide access to counts, including automating data transmission and cleaning, and by establishing permanent count sites (see Figure 3). For counts at temporary locations, Josh recommended collecting a minimum of seven days of data, because shorter durations can be misleading due to various conditions, including weather and event-based anomalies. In some locations, devices can collect all modes' data. Particularly in more rural locations, using these combination count sites can allow the state to get more data on pedestrian and bicycle counts by joining deployments for vehicle counts on lower-volume roads.
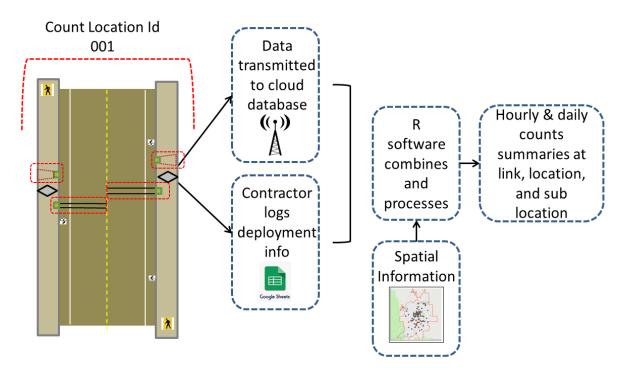

Figure 3: Diagram showing count data collection automation from ODOT

Josh noted that ODOT and the Oregon Health Authority partnered to apply an Integrated Transport and Health Impact Model to measure health improvement indicators in relation to use of non-auto models for travel. This model showed promising results for increased heath from active transportation use, based on the travel survey data of Oregonians. This is a powerful tool for documenting the value of improved bicycle and pedestrian infrastructure. Other partnerships with public health organizations include the use of hospital data to supplement police crash reports. ODOT is also working on a data fusion project to connect data from the National Emergency Management System with National Highway Traffic Safety Administration crash data, coordinating with the Oregon Transportation Records Coordination Committee on this project. Communicating the benefits of projects, and understanding how to communicate different elements of a project to different audiences, is important for getting projects built. Josh shared an example of this: the Central Lane project, which maps a project's various elements to intended internal audiences and partners (see Figure 4).
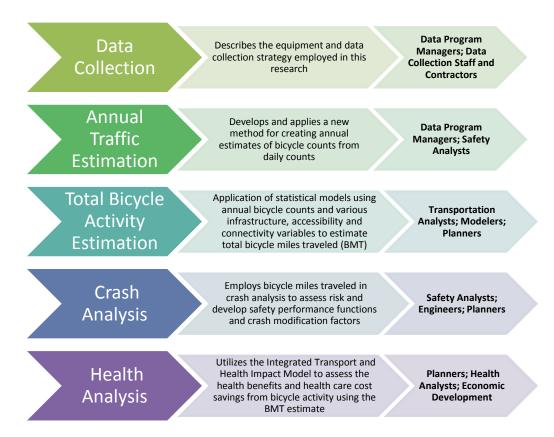
Data Collection	Describes the equipment and data collection strategy employed in this research	**Data Program Managers; Data Collection Staff and Contractors**
Annual Traffic Estimation	Develops and applies a new method for creating annual estimates of bicycle counts from daily counts	**Data Program Managers; Safety Analysts**
Total Bicycle Activity Estimation	Application of statistical models using annual bicycle counts and various infrastructure, accessibility and connectivity variables to estimate total bicycle miles traveled (BMT)	**Transportation Analysts; Modelers; Planners**
Crash Analysis	Employs bicycle miles traveled in crash analysis to assess risk and develop safety performance functions and crash modification factors	**Safety Analysts; Engineers; Planners**
Health Analysis	Utilizes the Integrated Transport and Health Impact Model to assess the health benefits and health care cost savings from bicycle activity using the BMT estimate	**Planners; Health Analysts; Economic Development**

Figure 4: Diagram from Oregon's Central Lane project showing the different project elements, their purpose, and their intended audiences

Atlanta Regional Council

Byron Rushing shared ARC's "Walk Bike Thrive" (WBT) active transportation plan. The plan is based on a desire to improve inter-regional travel for walking and bicycling trips. Byron showed a plan from 1972 to demonstrate that the concept has been around for a long time, and that local trips and connections to transit are among the key features, both then and now. In contrast, a 2007 regional active transportation plan overshot the capacity of the Metropolitan Planning Organization (MPO) and its member communities to implement what ended up being a much larger vision. This vision was deemed too regional, not corresponding with how people actually travel via walking and biking, aligned with state routes rather than preferred local routes, and too expensive to implement (see Figure 5).
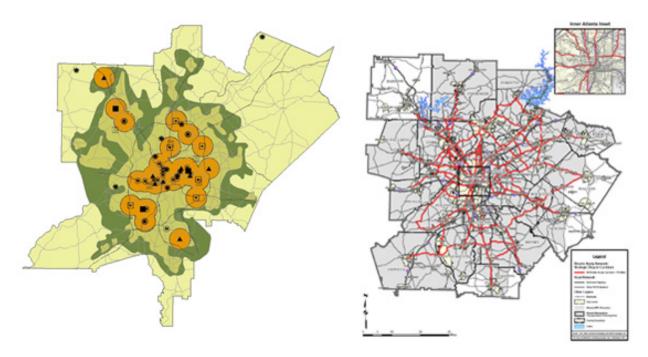
Figure 5: 1972 (left) and 2007 (right) maps showing Atlanta Regional Active Transportation Plans

With this context as backdrop, WBT sought to develop a different kind of regional plan, one that was more "humanized," in Byron's words. ARC achieved this by analyzing how people use the existing regional network of active transportation routes. The plan is a people-first plan that avoids lumping travelers into "cyclist" or "pedestrian" categories, and rather recognizes that the same person may choose to drive to work, cycle for recreation, and walk for local trips to neighborhood schools and parks. The plan also recognizes the role that walking and bicycling play in supporting transit, and vice versa. Byron mentioned a common refrain: "if you're not a transit advocate, you're not a bicycling advocate."

An analysis for the plan demonstrates trip distance distribution by mode (see Figure 6). This analysis shows that 50 percent of walking trips are less than 0.7 miles and 50 percent of bicycling trips are less than 2.4 miles. The data behind the chart also indicated that, although transit covers a lot of distance, it relies heavily on first/last mile connections, which—with the right infrastructure improvements—could be active transportation trips. Byron shared several strategies that make the plan successful. "Humanizing the plan" was important to show how and why people use the existing active transportation network, so that readers connect the proposed improvements to people and their experience, safety, and convenience, rather than to specific infrastructure or operational changes alone. The plan emphasized graphics to engage the reader, and hard copies were printed and distributed to other departments to ensure people knew about the plan and had the opportunity to view and study its contents.
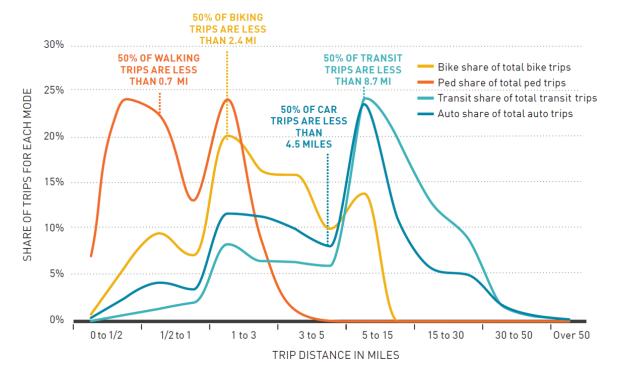
TRIP DISTANCES DISTRIBUTION BY MODE SHARE

Figure 6: Trip distance distribution by mode share chart from ARC Walk Bike Thrive! Plan (ARC activity-based travel demand model)

The plan also documented large volumes of geospatial and technical information about the Atlanta region, including a "regional data atlas." Plan data include the geographic distribution of transportation
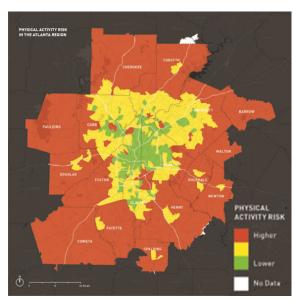

Figure 7: Health Impact Assessment data from PLAN2040

safety risk, showing where certain hot spots appear and where safer routes lie. Demonstrating disproportionate risk is an important way to contextualize the need for active transportation improvements – for example, the plan shows that walking and bicycling trips account for only 5.3 percent of trips but 18 percent of roadway crashes. Other data included in the plan show where investments in the active transportation network could generate higher returns – these include a "propensity" map that shows potential latent demand for bicycle and pedestrian trips and a "livability centers" map that documents the location of clusters of high-quality walking and bicycling routes. Finally, the plan includes information gathered through health impact assessments (see Figure 7).

Montgomery County

David Anspacher briefly described Montgomery County's approach to bicycle planning. David stated that they want to elevate the sophistication of planning for bikes to be equivalent to that of automotive planning. The County Bike Plan includes a rigorous vision, goals, objectives, and performance metrics with targets, as well as a plan for data collection. Montgomery County customized its LTS assessment to make it work in a suburban context, developing an award-winning bicycle stress mapping tool. The planning process incorporated a regional travel demand model and LTS network overlay to assess potential demand (see Figure 6). These data are publicly available through an interactive, web-based GIS tool called the MCATLAS.
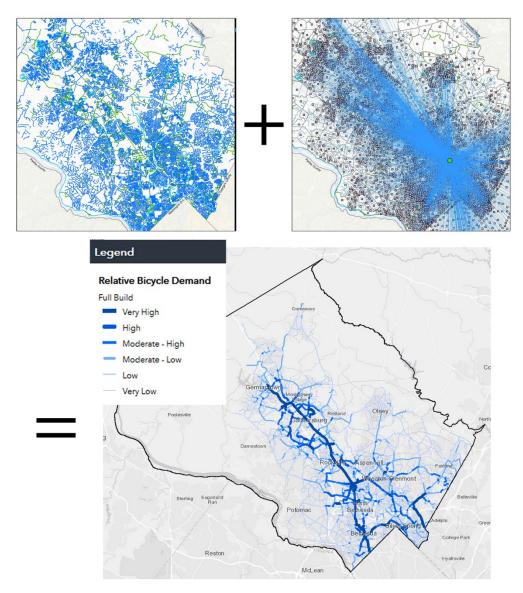

Figure 8: Montgomery County maps showing the LTS network (upper left) and regional travel demand modeling (upper right), which were overlaid to produce the relative bicycle demand map (bottom)

Fairfax County

Nicole Wynands presented work on Fairfax County's bicycle planning efforts. Data collection is a primary focus and growth area for Fairfax. Existing sources of data include the US Census American Community Survey (ACS) and an annual volunteer-based bike count program at 33 locations – the County keeps a list

of some 150 volunteers for assistance with this program. Fairfax also uses mobile count equipment and intends to install permanent counters as well. Nicole mentioned that engineers also participate in the counts, which allows them to observe how people use the infrastructure that they are building. Nicole noted that the County has had success working with local politicians to get support for projects without large amounts of data, and she tries not to overwhelm stakeholders with too much information in general. Indeed, in some circumstances, Nicole found that less is more. With lots of data, she noted, sometimes an audience may veer into a discussion of validity and questioning data sources. With an audience like this, providing simpler facts, such as bicycle ridership or collision before/after counts, may be more successful.

Nicole said that mapping all the bicycle paths, especially the many off-street paths in the County, is an important goal, and work is progressing on that front. Fairfax needed to adjust the traditional LTS methodology for a more suburban context, similar to Montgomery County. Nicole noted that Fairfax found it necessary to rate trails and roads separately. She also mentioned the need to calibrate LTS through outreach with bicycle riders to really understand how people perceive the level of stress or comfort on a given segment or intersection. Fairfax has used this information to help understand where connections need to be improved for local trips, primarily focusing on linking housing to local schools and parks, with less emphasis on "commute to work" trips.

Nicole shared a number of communications resources that Fairfax uses to help various audiences understand the County's plans, including people who may not chose to ride a bike or walk. One example graphic shows the benefits of bicycle infrastructure in calming traffic, which is helpful for people traveling via all modes (see Figure 9). Another highlights the County's Bicycle Ridership Forecasting Model. This model allows the planner to compare the ridership potential of bike lanes, buffered bike lanes/protected bike lanes and off-street bike facilities. It takes into account facility proximity to transit, population growth, census-tract-level ACS mode share data, and it includes all type of bike trips (commuting, utilitarian, recreational). This is a great tool for practitioners to compare cost and promote the benefits of different options and to communicate to stakeholders why those choices are being made to stakeholders.
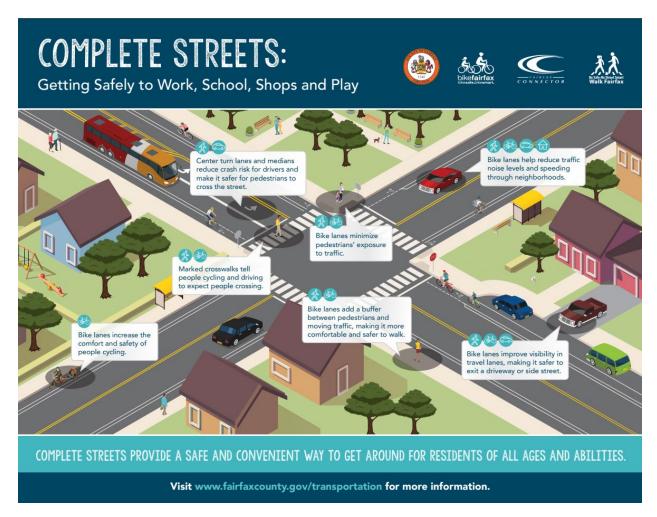
Figure 9: Fairfax County communications piece showing the benefits of complete streets for all roadway users

DDOT

Mike Goodno showed how DDOT uses LTS to analyze bicycling conditions and plan bicycle improvements. DDOT developed a citywide map of LTS and has performed a gap analysis to assess where connections in the network should be made (see Figure 10). These connections include specific efforts to expand LTS 1 category networks by linking them together with low stress routes. DDOT has also used the LTS analysis to see how well different census blocks are connected via continuous, uninterrupted LTS 1, LTS 1 and LTS 2, and all four LTS segments (Figure 11). DDOT also has a District Mobility Project that is looking at ways to measure congestion and incorporating LTS as one of the analytical tools. DDOT is currently undertaking a rebuild of its GIS, cleaning, updating, and validating geospatial data to provide the best raw material for analyses like LTS based on the FHWA Model Inventory of Roadway Elements (MIRE).
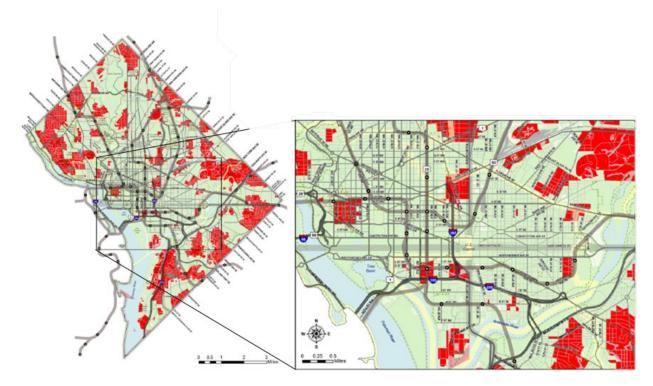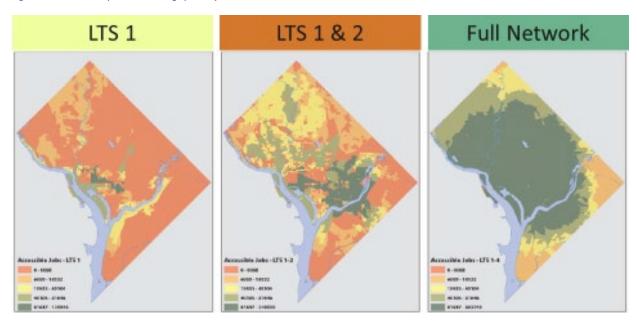
Figure 10: DDOT Bicycle network gap analysis

Figure 11: DDOT Analysis of bicycle network access to jobs via various combinations of uninterrupted LTS network segments

Project LISA

Mike Goodno and Jonah Chiarenza presented an LTS-related student project for which they served as part of a team of advisors. The Olin College of Engineering team was composed of five computer science students and Project LISA (Level of Intersection Stress Analysis) was their senior capstone project, supported by the Santos Family Foundation. Across the country, there is an explosion in the availability of active transportation user data in cities. Bikeshare and scooter-share "micromobility" user data are becoming more readily available with each passing month, in part because data sharing agreements can be brokered as part of permitting programs. These data provide far more detail about a network than

can be gleaned from crash records alone. When paired with geographic information about a city's infrastructure, such user data can be used to learn where—and infer why—people are choosing to travel via both long-standing and emerging active transportation modes (see Figure 12). Applied to the right model, these travel and infrastructure data have the power to help transportation planners and engineers make more informed decisions about what—and where—infrastructure should be improved for people riding bikes, scooters, and whichever new low-speed mobility device arrives in cities next.
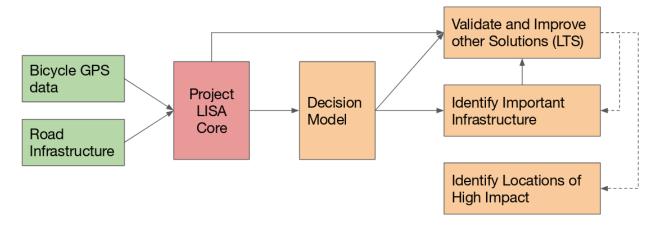

Figure 12: Project LISA computational structure

The core of Project LISA is a foundational tool—a computational model that can be assembled for any city's active transportation travel network, and then populated with user travel, operational, and infrastructure data. While the focus of the initial work has been on bicycle data, this model could serve multimodal applications in transportation planning, design, implementation, and evaluation. MIRE data from DDOT served as the raw material for Project LISA. The project team built a network, called a "graph," from centerline and other linear asset data. This graph is more detailed than segments and nodes. The graph shows all possible user pathways through the street network—critically, this means the model incorporates not only information about the infrastructure typically defined at mid-block locations, but also data from segments as they change on the approach to intersections (such as turning lanes) and data about the designs of the intersections themselves (such as the presence of 2-stage turn boxes)—key contributors to the relative stress of a given route (see Figure 13). This new way of identifying roadway elements allows a planner to model and validate LTS ratings with greater specificity and granularity than traditional segment-based LTS analysis. The resulting analysis more accurately reflects the real-world stress experienced when bicycling through a series of segments and intersections.
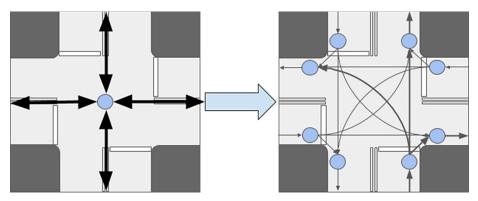

Figure 13: Graph expansion process - from simple segment-node format to exploded approach-node-intersection-node-departure format, which allows far greater detail about the infrastructure elements and roadway movements (left turn, straight, right turn) that influence the level of stress someone feels while navigating towards, through, and away from the intersection.

Jonah Chiarenza and Alex Epstein at the U.S. DOT Volpe Center guided the team to create a model with an adaptable framework for future development. This model could be expanded to provide a set of tools that will allow cities to apply a rigorous, nuanced, and firmly data-driven approach to the planning and design of all facilities, including bicycle facilities. Among these potential applications are the ability to quantitatively identify hotspots, evaluate and target potential improvements, and measure and validate outcomes. Cities seeking to increase active transportation could use the model to evaluate and support more controversial trade-offs in roadway design based on increased confidence in forecasted ridership impacts. Eventually, this LTS model could be used to calculate larger impacts from potential infrastructure changes, going beyond ridership forecasts to forecast economic, public health, and other benefits.

Conclusions

Themes

Following the peers' presentations and discussion, Darren Buck identified the following themes that emerged for successfully performing bicycle network analysis and implementing bicycle network improvements:

- Understand the local context and apply tools and techniques strategically based on this context.
- Identify and prioritize how data sources and analyses are applied to various needs, realizing that different tools are better at solving different problems.
- Be proactive in learning about and integrating new data sources as appropriate, to improve capabilities and increase the quality of bicycle/active transportation planning analysis.
- Realize that data collection not only describes existing and historic conditions, but can be used to forecast future trends.
- Work with GIS and other technical staff to modernize asset data and implement LTS modeling and scenario planning to understand and communicate how a bicycle network can be improved, and better understand the costs and benefits of various projects.

Government Agency Roles

Throughout the peer exchange, participants considered the roles each level of government could play to support the build-out of more complete, comfortable, and safe bicycle networks. The following section summarizes participants' consensus at four primary scales of government.

Federal

Participants felt one of the most helpful federal roles is to document and share national best practices. Although every location is unique in certain ways, there are enough commonalities in the contexts of various places, their transportation characteristics, and goals, that there is value in highlighting the best examples available across a range of places and project types. Particularly because the design of bicycle infrastructure is evolving so quickly, with many variations on a given theme, the federal role of helping to organize and present case studies is of value as states, counties, and cities iterate and experiment with their infrastructure designs and implementation strategies and look to their peers for examples of successful projects and programs. Federal transportation performance reporting requirements were also noted as a potential avenue for consolidation and publication of nationally consistent, comparable performance metrics about the quality of bicycle networks across states and MPOs.

State

Both state and federal agencies play an important role in funding and conducting research. Particularly through the use of pooled fund studies, and in partnership with academic organizations, states can contribute to the development of new methods, including improved LTS modeling and implementation strategies. States also play an important role in overseeing statewide data collection for federal transportation performance reporting requirements. Participants indicated that these statewide data can and should include information about active transportation and feed into analyses that not only track performance, but also support scenario modeling to plan for future investments.

Regional

As regional bodies, MPOs play an important role in developing cross-jurisdictional plans and analyses that ensure regional access improvements are coordinated across boundaries. MPOs are concerned with the connection between land use and transportation, as well as air quality impacts and mitigations. Higher-level LTS analyses are well-suited to this regional scale. In particular, regional organizations can produce helpful analyses that overlay network access information—such as bicycle LTS—with geographic, economic, and demographic information—such as the locations of schools, parks, transit hubs, job centers, and underserved areas. Such overlays can help a region understand where gaps in the network exist, and prioritize projects in those locations.

Local

Finally, cities and counties continue to play a front-line role in using national best practices, applying statewide data, and coordinating with regional plans to conduct local analyses and navigate the local challenges of project implementation. In most US cities and counties, a majority of roads and trails are owned and maintained under local authority.[2] Along with most of the infrastructure, cities and counties typically own and maintain GIS data about that infrastructure, and conduct or oversee the planning, engineering, and construction of improvements. From a behavioral perspective, most bicycle trips are of a relatively short distance, so they often take place entirely within a given city or county. As such, local agencies are well-positioned to plan for most or all of a given user's bicycling trip. For these reasons, the peers agreed that the city and county scale of government are likely to reap the greatest insights from LTS analysis. The detailed geographic and count-based inputs and the segment and intersection-level outputs of a robust LTS analysis can significantly help a local agency plan, prioritize, advocate for, and validate bicycle improvements.

The Future of LTS

The peer exchange ended with discussion on the specific potential for LTS analysis to contribute to better bicycle infrastructure by continuing to evolve as part of the planning and evaluation process. Facilitators posed a series of questions to spur conversation.

Can LTS analysis serve as a link between investment in bicycle infrastructure and public health outcomes?

Participants agreed that LTS can help translate the benefits that more bicycling yields, including public health benefits. LTS is a good methodology for tracking changes over time as projects that reduce bicycling stress are implemented. Through future research, LTS models could be developed and calibrated to a given city, county, region, or state. These models could translate potential infrastructure investments into decreases in overall network LTS, which could then be translated into increases in

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[2] In Virginia, the Virginia Department of Transportation maintains most of the roads within county boundaries. Arlington County is one of the few exceptions that has local control of most roads.

ridership and physical activity and decreases in vehicle miles traveled (VMT). These forecasts could in turn be translated into forecasts for reduced obesity and chronic illness; reduced noise and air pollution; reduced transportation-related injuries and fatalities, increased heart, lung, and mental health; and increased tourism, local spending, property value, and tax revenues.

Can LTS serve as a municipal performance metric?

Participants suggested that a municipal performance-based plan could use LTS as a metric, in addition to counting ridership, bicycle lane-miles striped, safety data, and other currently used performance metrics. A city or county could establish a baseline set of road miles or network percentage at each LTS, and a time-based target for changing that mileage or network percentage to a different ratio, with an increase in lower-stress miles and decrease in higher-stress miles. Incorporating an objective metric like LTS into a performance-based approach to transportation planning could help encourage decision-makers to prioritize projects that would advance this particular performance measure, and allow them the opportunity to tout measurable accomplishments.

With statewide or federal standardization, a common LTS methodology could also be used to compare performance between cities, counties, or states. A potential national reporting requirement could be a way to standardize a national protocol for labeling bicycle facilities according to LTS.

Can LTS be an effective "language" for speaking to elected officials, decision-makers, and the public?

Although LTS is a technical metric, it translates into a very relatable subject – namely stress/comfort. Participants all noted that word choice was important to communicating effectively, and that conversations were generally trending away from talking about "mode shift" and towards making roads "safer and more comfortable" for people who want to walk and ride bicycles. This nuance can make the difference between someone perceiving a project as forcing them to change how they get around and someone perceiving a project as giving people more transportation options to choose from. Using this language, LTS can help planners and engineers communicate project benefits to elected officials and decision-makers, who can in turn communicate to the public about projects that aim to decrease stress and increase comfort and safety.

Appendix A: Key Contacts

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Appendix B: Peer Exchange Agenda

Emerging Methods in Analysis and Implementation: Building out the 2.0 Bike Network

Dates: April 10 – 11, 2019
Location: Metropolitan Washington Council of Governments

DAY 1 – April 10, 2019 – Rooms 4 & 5

Time	Session	Speaker(s)
8:00 – 8:30 am	**Registration and Check-in**	
8:30 – 9:00 am	**Opening and Introductions** • *TPEA Program* • *Welcome* • *Introductions*	• **Michael Barry** GIS Specialist/Transportation Planner, FHWA Office of Planning • **David Patton** Bicycle and Pedestrian Planner, Arlington County • **Jessie Yung** FHWA Virginia Division Administrator
9:00 – 9:15 am	**Overview of and Goals for Peer Exchange**	• **Jonah Chiarenza, AICP** Transportation Planner, U.S. DOT Volpe National Transportation Systems Center
9:15 – 9:45 am	**Arlington County Bicycle Program Accomplishments & Challenges**	• **Ritch Viola** Bicycle and Pedestrian Program Manager, Arlington County
9:45 – 10:00	*Break*	
10:00 – 11:30 am	**Peer Perspectives:** *Quick Takes on Bike Network Analysis – Success and Shortcomings in:* • *Traditional Data Sources* • *Emerging Data Sources* • *LTS Analysis* • *Other Analyses*	• **Peers** • **Facilitator: Darren Buck** Office of Human Environment, Pedestrian and Bicycle Program Lead
11:30 am – 12:00 pm	**Full Group Discussion:** *Data and Analysis; Reflections on Peer Discussions*	• **All Participants** • **Facilitator: Darren Buck** Office of Human Environment, Pedestrian and Bicycle Program Lead
12:00 – 1:15	*Lunch*	
1:15 – 2:45 pm	**Peer Perspectives:** *Quick Takes on Bike Network Implementation: How to and practical applications* • *Beyond Crash Analysis*	• **Peers** • **Facilitator: Darren Buck** Office of Human Environment, Pedestrian and Bicycle Program Lead

Time	Session	Speaker(s)
	• *Communicating Analysis* • *Communicating Benefits* • *Knowing Your Audience*	
2:45 – 3:15 pm	**Full Group Discussion:** *Application and Implementation; Reflections on Peer Discussions*	• **All Participants** • **Facilitator: Darren Buck** Office of Human Environment, Pedestrian and Bicycle Program Lead
3:15 – 3:30 pm	*Break*	
3:30 – 4:00 pm	**Measuring Multimodal Connectivity and Ongoing Pilots:** *FHWA Resources*	• **Darren Buck** Office of Human Environment, Pedestrian and Bicycle Program Lead
4:00 – 4:30 pm	**Full Group Discussion:** *Opportunities for Arlington, VA*	• **Christine Sherman** Principal Planner, Arlington County • **David Patton** Bicycle and Pedestrian Planner, Arlington County
4:30 – 5:00 pm	**Day 1 Wrap-up and Concluding Remarks**	• **Darren Buck** Office of Human Environment, Pedestrian and Bicycle Program Lead • **David Patton** Bicycle and Pedestrian Planner, Arlington County
5:00 pm	**Adjourn**	

DAY 2 – April 11, 2019 – Room 1

Time	Session	Speaker(s)
8:00 – 8:30 am	**Registration and Check-in**	
8:30 – 9:45 am	**LISA:** *Level of Intersection Stress Assessment Pilot Methodology from Olin School of Engineering Research Project*	• **Jonah Chiarenza, AICP** Transportation Planner, U.S. DOT Volpe National Transportation Systems Center • **Mike Goodno** Bicycle Program Specialist, District DOT, Washington, DC
9:45 – 10:00	*Break*	
10:00 – 11:30 am	**Facilitated Discussion on the Future of LTS Analysis**	• **Jonah Chiarenza, AICP** Transportation Planner, U.S. DOT Volpe National Transportation Systems Center • **Darren Buck** Office of Human Environment, Pedestrian and Bicycle Program Lead
11:30 am – 12:00 pm	**Day 2 Wrap-up and Conclusions**	• **Michael Barry** GIS Specialist/Transportation Planner, FHWA Office of Planning • **David Patton** Bicycle and Pedestrian Planner, Arlington VA
12:45 pm	**Adjourn**	