Appendix B: Data Collection

MEMORANDUM

To: Marquis Williams, Project Manager, RTC Washoe

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Re: Data Collection Methodology Recommendations

Data Collection Methodology Recommendations

The RTC has engaged in data collection for bicycle, pedestrian, and wheelchair users for numerous years utilizing a similar method. While the data collected through this program has been a beneficial input for planning purposes, the RTC desires to leverage this program to collect more robust and informative data which can provide deeper insights into long-term trends for active transportation, project specific analysis, and tracking of performance metrics. The RTC recently shifted to using LiDAR technology for this data collection program instead of the prior method of manual screenline counts. This memo includes a discussion of the potential additional benefits of LiDAR data collection, ways that other agencies are using this technology for counts, and highlights LiDAR equipment for long-term bicycle and pedestrian data collection. The second section highlights recommendations for long-term and continuous data collection strategies which would allow the RTC to track performance measures and generate estimates of total usage throughout the area.

LiDAR Technology for Conducting Bicycle and Pedestrian Counts

Background

The Regional Transportation Commission of Washoe County (RTC) is currently using LiDAR systems from the University of Nevada Reno (UNR) to document year-to-year trends in the number of people using active transportation modes and generate estimates of overall mode shares at comparison locations. In addition to these counts, they have been able to track other roadways data like travel speeds, near misses, and crashes.

While the data gathered from this tracking process provides helpful information about roadway use and experience, tracking equipment is typically only out in the field for approximately three days per selected location. This memo discusses how the existing LiDAR counting operation could be improved by sharing methods for making LiDAR use most effective, highlighting other communities that are using LiDAR technology in their transportation work, exploring different companies/products producing effective LiDAR systems, and reviewing a variety of ways that LiDAR technology can be used beyond what RTC Washoe is already doing.

The Full Potential of LiDAR

With its ability to capture 3D images in real time, LiDAR is one of the most advanced tracking systems available that can be used by communities to improve the safety and function of roadways for all roadway users. Beyond bicycle and pedestrian counts, LiDAR technology can track a wide variety of additional roadway characteristics and interactions which may benefit the RTC including:

Vehicular Movement

- **Turning movement counts**: Turning movement counts can be tracked using LiDAR technology as a check to the travel demand model.
- **Compliance with traffic signals and stop signs**: LiDAR systems can record how frequently cars are obeying traffic signals and stop signs.

- **Vehicle to Everything (V2X) Applications**: This technology could support V2X applications and deliver the data collected to drivers to enable real-time decisions on the road[1]. This data transfer will be beneficial as more autonomous vehicles enter roadways.

Bicycle and Pedestrian Movement

- **Curb ramp data collection:** LiDAR can be used to assess how compliant a curb ramp is with ADA standards by looking at cross slopes and other elements of the curb ramp.
- **E-Bike use**: With some products, like Smart Sensor Solutions's BiCo 1.0, a high refresh rate means that faster micromobility vehicles, such as e-bikes, can be recorded. This can provide the RTC with an understanding of what percentage of bicycle users are using e-bikes.
- **Pedestrian jaywalking**: LiDAR technology can record the location of pedestrians as they cross, revealing areas with high levels of pedestrian jaywalking. This could indicate where pedestrian crossings should be considered or where existing crossing should be improved.
- **Crossing signal timing**: The timing needed for bicycles or pedestrians to cross the roadway at a signalized intersection can be made safer for those crossing by understanding how long crossings typically take based on LiDAR data.

Bicycle and Pedestrian/Vehicle Interaction

- **Conducting risk or exposure analyses:** potential to measure pedestrian exposure [to vehicular conflict] based on the number of pedestrians observed in the roadway.
- **Adjusting length of flashing yellow arrows (FYA):** where a FYA is present as a method for controlling left turns, push buttons activated by a pedestrian can temporarily turn off the FYA, but to allow for efficient flow of traffic, LiDAR technology can track when the pedestrian has completed their crossing of the street, then automatically turn the FYA back on[2] [3].

Other

- **Understanding pavement condition**: with its 3D visualization capabilities, LiDAR technology can be used to assess quality of pavement on both roadways and sidewalks/bike lanes and paths.

It should be noted that tracking these types of data is possible with some types of LiDAR technology and not others, and these types of data may not be able to be gathered for every project included in the 'LiDAR Technology Options' section. RTC may wish to collaborate with UNR in order to develop algorithms which support these expanded analyses or reach out to an equipment vendor listed below to review their capabilities for in-house analysis as well as functional control of traffic control devices such as traffic signals and pedestrian activated push buttons.

[1] *https://www.masstransitmag.com/technology/article/21236672/how-lidar-is-making-roads-safer-for-pedestrians-and-cyclists*
[2] *https://nitc.trec.pdx.edu/news/new-lidar-system-pinpoints-pedestrian-behavior-improve-efficiency-and-safety-intersections*
[3] *https://ascelibrary.org/doi/epdf/10.1061/JTEPBS.TEENG-7457*

Structural Adjustments to LiDAR Data Collection System

While the RTC is already benefiting from the short-term LiDAR tracking timeframe, they could expand the existing program to provide even more useful data for longer time periods using the following strategies:

Use Multiple LiDAR Sensors to Capture the Entirety of the Location

With just one LiDAR sensor in place, certain movements could be missed if the sensor is temporarily blocked or shifted out of place. Installing multiple LiDAR sensors or bringing in additional temporary LiDAR sensor setups at a project location, while providing some overlapping imagery, will provide multiple views of the same study area that can be combined to make sure the whole picture is being captured.

Installing Semi-permanent LiDAR Trackers

The mobility of RTC Washoe's current LiDAR system provides flexibility in tracking, but by installing a more permanent LiDAR system in key locations, a greater breadth and timeline of data can be gathered. A semi-permanent system that runs on for long periods of time makes for more accurate findings since anomalies can be ruled out as one-off occurrences. This will make road safety and bike & pedestrian experience improvements more effective since they are data-based. While these more permanent solutions will provide more robust data to communities, they also tend to come at a higher cost that will need to be considered by the agency. Several semi-permanent LiDAR options are detailed in "Other LiDAR Technology Options" below.

Other Agencies Using LiDAR Technology for Bicycle/Pedestrian Count Programs

National Institute for Transportation and Communities (NITC) Research Team in Arlington, TX

As part of a LiDAR pilot study, a group of researchers set up LiDAR devices at two intersections in Arlington, Texas to explore both pedestrian behavior and how to separate permissive left-turning vehicles from concurrent crossing pedestrians using a new signaling solution (explained in more detail under "What Else LiDAR Can Track" below).

Utah Department of Transportation (UDOT)

Based on the outcomes of the NITC project detailed above, UDOT employed a LiDAR project in Salt Lake City to detect pedestrian movements at signalized intersections. This is just one of the three LiDAR-based projects in the city that UDOT is working on to better understand how LiDAR has the potential to improve the flow and safety of traffic. UDOT is also working with LiDAR on more rural roadways (in collaboration with Mandli Communications) to deploy collection methods to improve roadway safety, maintenance, and preservation. UDOT feels that their use of LiDAR technology provides more return on investment than other tracking technologies or strategies used in the past due to its high level of accuracy and quality.

Chattanooga, TN (Department of Innovation Delivery and Performance)

The City of Chattanooga, TN has plans to work with Seoul Robotics to add LiDAR sensors to 86 intersections, an undertaking that is considered the largest-scale project of this variety in the United States[4]. This project aims to accommodate the growing popularity of electric vehicles all while pulling out data that can inform important lessons for infrastructure safety and design.

[4] *https://www.emergingtechbrew.com/stories/2023/02/21/why-chattanooga-is-betting-on-lidar-for-traffic-management*

The City of Madison, WI

The City of Madison worked with Mandli and their LiDAR product, Maverick, to collect data along the Capital City Bike Trail. The goal of the project was to find flaws in the trail's pavement, look for plant life that was encroaching onto the trail, and other characteristics that could be improved to make for a better trail experience. The City also used Maverick attached to a Segway to collect data in areas that were not accessible by car, including sidewalks and walkways around the Wisconsin State Capitol building and the Monona Terrace. The LiDAR technology collected a series of data points including compliance with the Americans with Disabilities Act (ADA) safety standards, including sidewalk width, cross-slops, curb ramps, trip hazards, damage to pavement, and encroachment of plant life[5].

San Francisco Metro Transit Authority (SFMTA)

SFMTA began a pilot project in 2021 to use LiDAR technology to balance the needs of all roadway users. The project aimed to prioritize transit, emergency vehicle and pedestrian flows, and build dashboards to improve data-driven decision-making processes[6].

LiDAR Technology Options

A wide variety of LiDAR sensors and corresponding analysis software are currently available, and with the growing use of LiDAR systems, the technology available will only continue to improve. Table 1, below, highlights a few of the many options that RTC Washoe might consider using to expand their program.

Table 1. Other LiDAR Technology Options

Company	Product	Description	Benefits	Links
Clearview Intelligence	Connex Active (LiDAR Option)	The Connex Active is a real-time bicycle and pedestrian detector that uses LiDAR technology to count and differentiate between the two modes.	• Non-invasive installation • Real-time data • Can be solar-powered • Long-term and continuous data collection	• Product Webpage • Spec Sheet:
Smart Sensor Solutions	3D LiDAR Pedestrian and Bike Counter (BiCo 1.0)	The BiCo 1.0 uses 3D laser technology and ensures reliable bicycle counting with a counting accuracy of up to 97%. Its reliable 3D technology captures any scenes and objects in the infrastructure area.	• Can also record faster bikes such as e-bikes • Weather resistant • Long-term and continuous data collection	• Product Webpage • Spec Sheet

[5] *https://www.mandli.com/maverick/use-cases/sidewalk/*
[6] *https://www.sfmta.com/blog/smarter-traffic-signals-prioritize-transit-and-people*

Company	Product	Description	Benefits	Links
Velodyne Lidar	BlueCity (LiDAR + AI)	BlueCity is a cost-effective solution for capturing multimodal traffic data in real-time using lidar technology and an AI-based perception software layer.	• Non-invasive installation • 3D LiDAR sensors combine with AI software to provide helpful visualization of the data • Long-term and continuous data collection	• Product Webpage • Product Video
Mandli	Maverick	The Mandli Maverick is a LiDAR system that can be mounted on a vehicle to provide mobile data collection.	• Mobile option that can be easily installed on any vehicle • Real-time feedback and data viewing for in-field QC	• Product Webpage • Spec Sheet

LiDAR Data Collection Summary

LiDAR technology is an efficient way of collecting bike and pedestrian counts that can also be used to understand roadway quality, safety, and performance. With the rise of autonomous vehicle technology that involves LiDAR sensors, and the growing list of roadway characteristics that LiDAR can help track, it is likely that this technology is here to stay and will only become more useful with time. RTC Washoe could consider expanding and improving their LiDAR tracking system to gather more roadway data, and thus, producing more data-driven roadway projects in the future.

Continuous Long-Term Data Collection for Performance Measure Tracking

The previous iteration of the RTC Washoe Bicycle, Pedestrian, and Wheelchair data collection program focused on collecting short-term two-hour count data using manual video counts during key months of activity throughout the year. While this approach mirrors the standard practices at the time of program inception from the National Bicycle and Pedestrian Documentation Program (NBPDP), advancements in data collection, storage, and processing have significantly changed the landscape of available data and reasonable analysis approaches. Additionally, collecting two-hour count data exclusively may be overly impacted by fluctuations in usage by time of year, weather, adverse climate events (i.e., extreme heat events or poor air quality days), and other factors to draw conclusions about long-term trends in active transportation across the region. Recent adjustments to the data collection program include using LiDAR sensors to extend the data collection period to multiple days which expands the total amount of day collected but does not provide insights into fluctuations throughout a week, month, or year. By expanding the program to incorporate continuous data collection, the RTC will be able to identify how active transportation activity is changing over time on a holistic sense as compared to small windows of time. Furthermore, incorporating data collection equipment into regular roadway maintenance programs and roadway construction projects will help the RTC to significantly increase the amount of data collected across the region at regular intervals at a lower overall cost per piece of data collection equipment than installing single counters into existing roadways outside of a roadway reconstruction, maintenance.

In order to gain a deeper understanding of long-term trends of active transportation in the Truckee Meadows, it is recommended that the RTC incorporate long-term data collection methods into the Bicycle, Pedestrian, and Wheelchair count program. This may be accomplished by implementing the following methods:

Pavement Preservation & Maintenance Program

The RTC repaves all regional roads on a seven-year cycle which provides a clear path to incorporate continuous data collection technology within on-street bicycle facilities within a relatively short timeframe with relatively low implementation costs. This would be accomplished by establishing an RTC policy to install continuous bicycle counters at regular intervals along any on-street bicycle facility that is repaved or resurfaced as part of the pavement preservation program. Continuous bicycle counters that the RTC could consider under this strategy include radar sensors (Sensys Network – FlexRadar/MicroRadar) or inductive loops (EcoCounter – ZELT).

Traffic Signal Video Camera Count Technology

Traffic signals which utilize video detection may incorporate technology which allows for additional passive data collection for active transportation. This includes the GridSmart Bell Camera and Iteris Vantage video detection systems which utilize AI to count movements from vehicles and may be calibrated to count pedestrians and bicyclists with the purchase of an additional module. The City of Reno currently uses GridSmart Bell Cameras for video detection at multiple traffic signals within the City and has some level of access to the specialized bicycle and pedestrian module. It is recommended that the City of Reno provide regular data updates or direct access to this data for the RTC in order to leverage this data which is currently passively collected but has been under utilized locally to date.

Long-term Data Collection & Public Art Installation

Data collection may also be incorporated with other activities such as public art installations. For example, the RTC may consider installing long-term permanent counters along bicycle facilities. These counters may include a real-time display of the annual and daily counts of bicyclists, as shown in Figure 1, or without a display such as the LiDAR data collection technologies identified in Table 1 (above). These displays may be incorporated into a unique art installation which would represent the unique style and character of the area and provide an opportunity for the community to engage with the corresponding bicycle facility project. These counters would be strong indicators of the commitment to improving bicycling from local entities while providing long-term continuous data to support future decision making. It is important to note that funding for art installations would need to be provided by local entities or another outside source due to existing restrictions for RTCs' local, state, and federal funds.

Figure 1. Eco-Counter Real-Time Display (Source: Eco-Counter)

User Reported Data & Local Extrapolation

The smartphone application Strava allows users to self-report and record walking and biking trips either for recreation or for commuting. While this data represents a small portion of the total bicycle or pedestrian trips in an area and may be slightly skewed towards recreation-based trips, it provides an opportunity for the RTC to develop regional wide estimates for total annual usage. This is accomplished by installing short-term counting equipment, such as the EcoCounter Mobile MULTI, at a select number of locations with active transportation users over a period of a month or more; this should include at least five locations to control for variations across the region and each counter should be calibrated to ensure accuracy. Collected data from these counters will identify the total number of bicyclists and/or pedestrians who traveled along that route during the select period and can be compared with Strava data[7]. From this comparison of actual volumes and Strava reported volumes the RTC would establish an adjustment factor to be applied to Strava data across the Truckee Meadows.

[7] StravaMetro is a free resource provided to public entities who are working to improve bicycle and pedestrian transportation following a short application process.