Development of a Multi-Scale Slow-Speed Network Strategy

Conference Paper · January 2018

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[3 Tables and 7 Figures: 2,500 words]
[Text: 3,746 words]
Word count: 6,246 words

ABSTRACT

This strategic plan focuses on developing a multi-scale network for slow-speed transportation users (<=25 miles per hour). The slow mode options include sidewalk modes (0-12.5 mph) and on-street rolling modes with speeds ranging from 12.5-25 mph. The slow-speed network development consists of the three interconnected networks: Slow Zones (local network), Sub-regional Network, and Slow Mode Thruways (regional network). With special attention to Complete Street policies and compliance with Active Transportation Plan recommendations, the methodology aims at characterizing the streets and land use and applying GIS-based analysis techniques to detail the slow-mode infrastructures and their attributes. The method was thoroughly applied to the historical South Bay area in Los Angeles metropolitan region, and a multi-scale slow-speed network was designed as a real-world case study. Under the assumption that 11% to 20% of short trips will be made by zero-emission slow modes by year 2025, it shows that South-Bay-wide, the daily fuel consumption saving could amount from 17,100 to 31,000 gallons, and the carbon dioxide emissions could be reduced by 160 to 290 tons every day. The estimation indicates that the network-wide emission benefits could be significant given a well-implemented slow-speed network plan.

1 INTRODUCTION

Recently, local, regional, and state agencies are paying an increasing amount of attention to Complete Streets and slow speed transportation modes (*1*). Complete Streets policies provide directions on how to achieve safe access for all users of the roadway by placing a priority on slow speed modes (*2*, *3*). For this study, slow speed modes (<=25 miles per hour) are classified into two categories: sidewalk (i.e. pedestrians, wheelchairs) modes and on-street rolling modes. Specifically, sidewalk modes (0-12.5 mph) refer to the category designated for people on foot but also accommodates wheelchairs, push/pull-carts, skateboards, senior citizens using e-mobility scooters, joggers, and electric personal mobility assistive devices (EPAMDs) (*4*). As for on-street rolling modes, the speeds usually range from 12.5-25 mph. This category covers a range of roadway users that move faster than pedestrians but are also vulnerable on roadways when sharing roadways with motor vehicles. Bicyclists, specifically casual and commuting riders, drivers of neighborhood electric vehicles (NEVs) (*5*), and e-bikes users are the majority of this user group.

Slow modes cover a variety of accessibility options for people with limited transport options, such as schoolchildren, seniors, and persons with disabilities. Furthermore, researchers find slow modes also contribute to a great deal of environmental and public health benefits (*6*, *7*). Previous studies about slow speed modes are usually limited to one type of mode, e.g. pedestrians or cyclists. Many studies focus on data collection, travel demand modeling, or developing potential safety/experience improvements for slow modes. This project, however, envisions a future in which slow on-street mobility devices are widely used for transportation, benefiting a wider range of road and sidewalk users. In this study, we aim at developing a slow-speed network strategy plan and promotes livability, safety, and sustainability.

The development of slow speed network strategy consists of the following three interconnected networks: Slow Zones (local network), Sub-regional Network, and Slow Mode Thruways (regional network). We will introduce the development strategy in the following sections. Meanwhile, we will present the historical South Bay region of the Los Angeles metropolitan area as a real-world application.

2 METHODOLOGY OVERVIEWS

The overall goal of the Complete Streets is providing infrastructure for the full range of slow mode users. This project attempts to achieve this goal through planning a system of three interconnected networks from small to large scale, shown as in Figure 1. Each network can be reinforced by physical and digital wayfinding, making local and sub-regional destinations accessible by slow mode users.

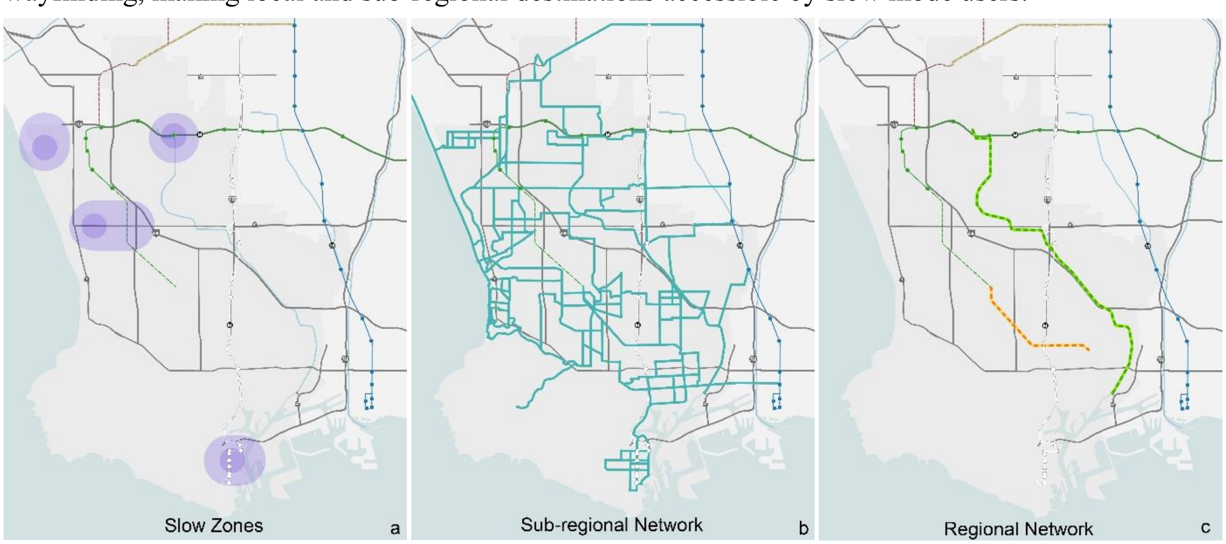

FIGURE 1 Interconnected networks at three scales.

2.1 Slow Zones- Local Network

The smallest scale of the strategic network is a series of signed and branded routes for slow modes on low speed-limit streets, which focus on selected pedestrian thoroughfares. These districts, which roughly envelop a half-mile to one-mile area around pedestrian corridors, are called Slow Zones. Selection of corridors should include the analysis of relevant demographic, economic and mobility metrics, evaluation of future development areas and trends, and local organizations' interests. In general, many areas of first/last mile travel to transit stations will make good candidates for Slow Zones.

This study applies a data-driven method to objectively prioritize areas using indicators that could support Slow Zone development throughout the study area. A rigorous spatial analysis method is used to break down data from larger geographic units (e.g. census blocks, traffic analysis zones) to the individual road block level. All data inputs are then aggregated at the road block level and assigned a composite ranking, allowing for a comparison across locations. The composite ranking is comprised of a calculation of the following variables by street blocks: residents density, workers density, students density (*8*), Neighborhood Mobility Area score (*9*), transit ridership volume (*10*), retail area, park area (*11*), safety, and street/intersection density (*12*). The safety index is derived from land use using a spatial match approach which scores industrial and vacant as less safe than high concentrations of retail and residential. Then all the factors are summarized with an equal weight of importance. The top 20% scoring blocks are colored as dark green in Figure 2.

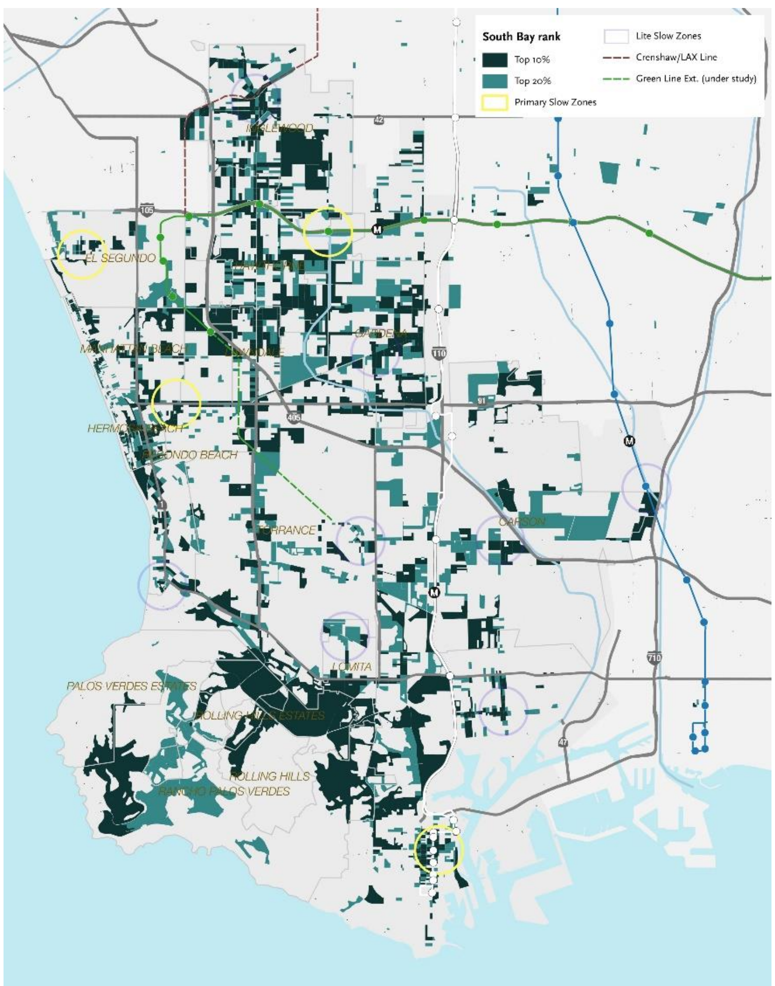

FIGURE 2 Map of composite ranking of street blocks and selected Slow Zones in South Bay.

In this project, twelve distinct Slow Zones have been identified in the South Bay. Four of the twelve areas are studied in-depth, as marked by purple-color circles in Figure 1a.The four primary Slow Zones include San Pedro, North Redondo, El Segundo, and Hawthorne.

To inspect the street conditions for slow mode users within Slow Zones, detailed sidewalk data such as pavement condition, crosswalks are needed. Data at this level of details, however, are not available. To obtain such data, the team created a standardized Walk Audit approach for evaluating infrastructure for slow modes and collecting data on sidewalks and street edges within Slow Zones. Walk Audit is a critical component of this study, which integrates metrics from LA Metro's First/Last Mile Strategic Plan audits with additional measures regarding the quantity and quality of physical infrastructure (*13*).

Information on the following infrastructure elements within a quarter-mile of Slow Zones was collected: sidewalks, street edges, corners, crossings, information/signage, and physical barriers on sidewalks (geo-tagged photos). A smartphone application was created by the team member using an established platform (*14*), and the application interfaces are presented in Figure 3.

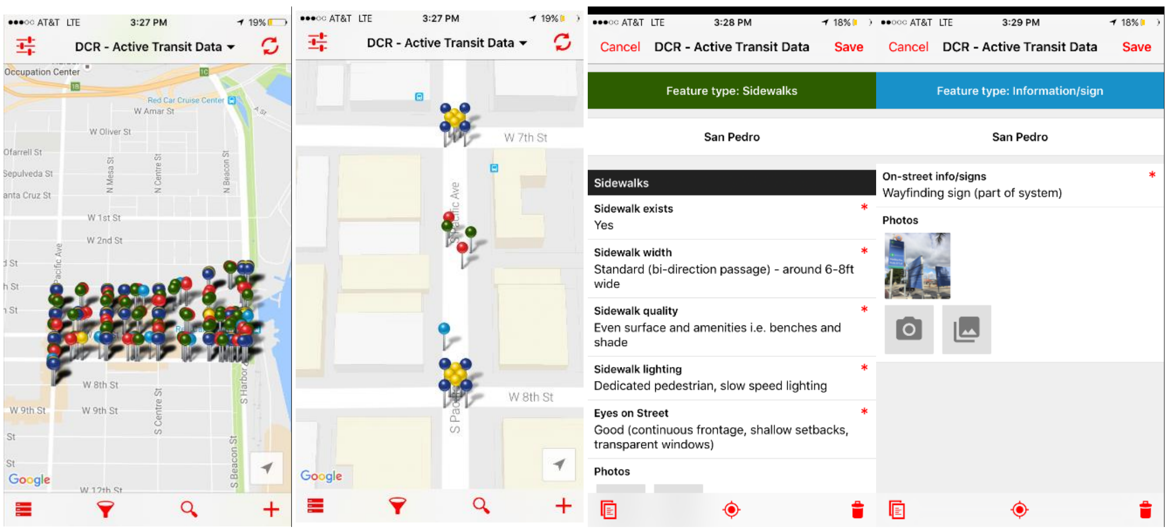

FIGURE 3 Application interfaces and example data of Walk Audit.

As an example, the walk audit results for the pedestrian core of El Segundo Slow Zone is displayed in Figure 4. This evaluation system was developed to enable scoring for each feature (sidewalk, crossing or corner) - a higher score indicates better support for pedestrian and rolling modes. Figure 4 also summarized the percentage of total road miles in each category, and it shows that the sidewalk which well supports pedestrian modes only makes up 7% of the total length of the roads that are surveyed, indicating that El Segundo core area needs major improvement in order to support slow mode users.

The recommendations labeled in Figure 5 emphasize connectivity, safety, and major areas which need infrastructure improvements. The audit results can be used by a variety of audiences, including statewide and regional planning agencies, local planning departments, and community-level organizations.

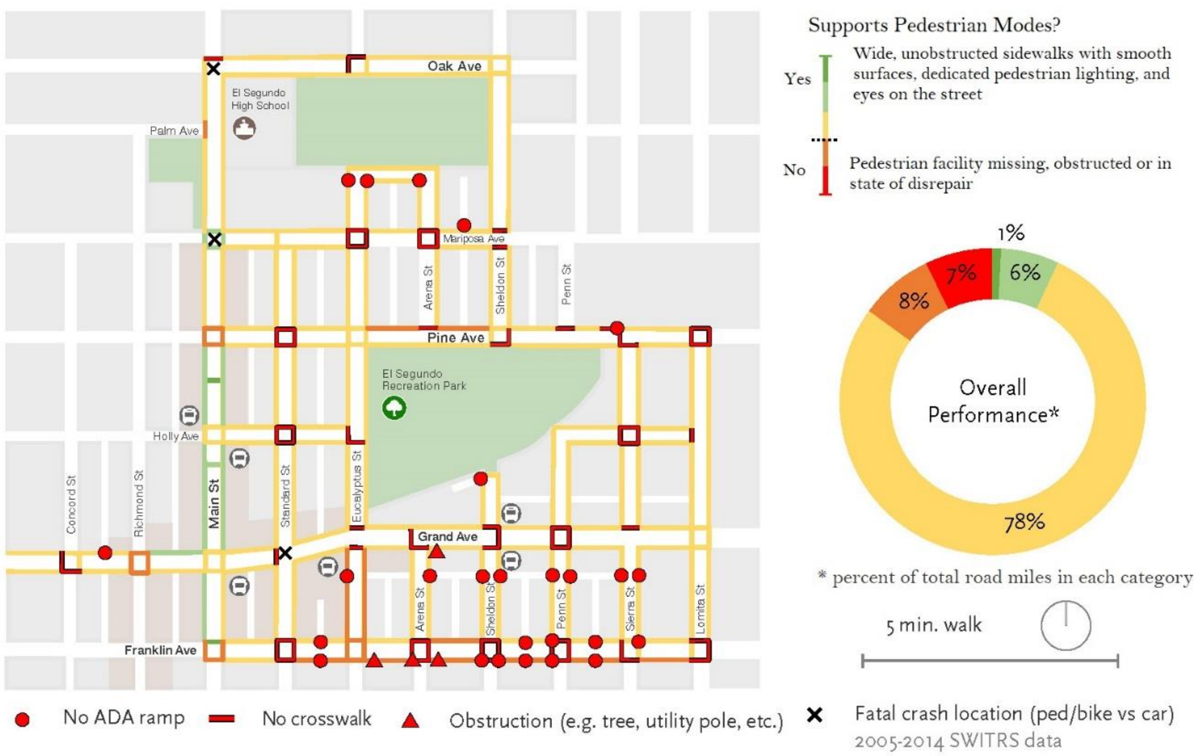

FIGURE 4 Walk Audit results for El Segundo Slow Zone pedestrian core.

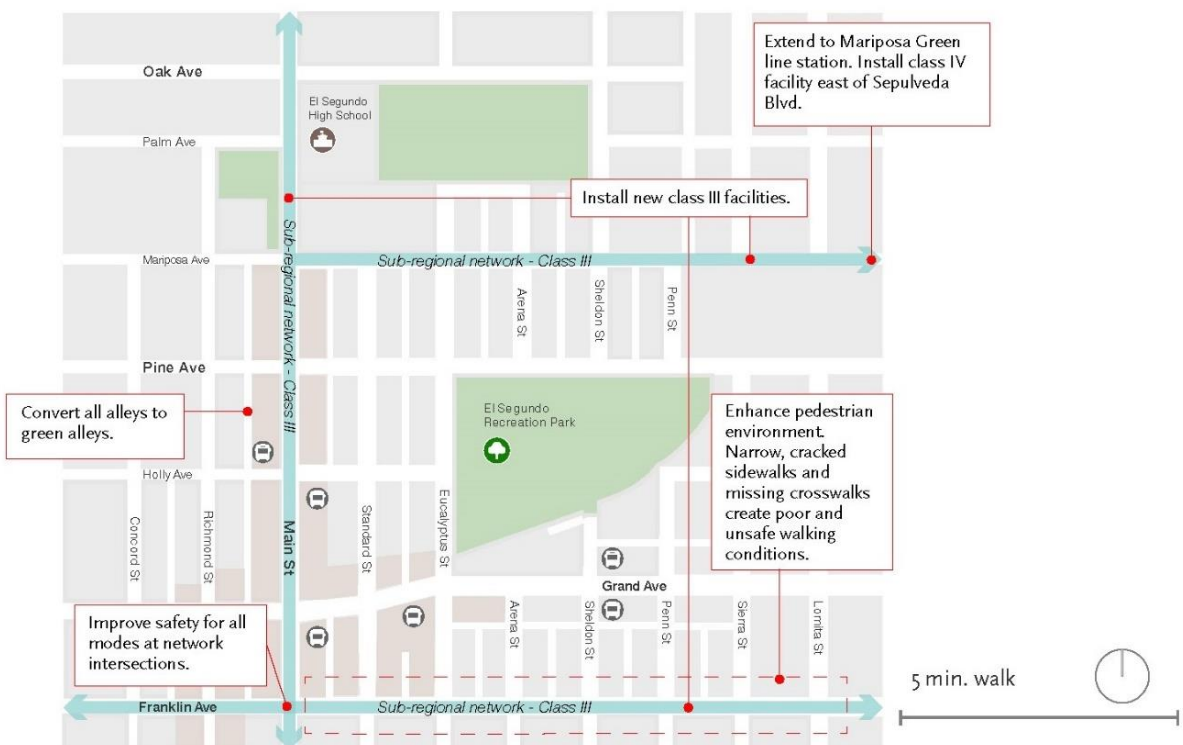

FIGURE 5 Recommendations for El Segundo Slow Zone pedestrian core.

2.2 Sub-regional Network

As introduced, Slow Zones are at smallest scale in the strategic network plan. Sub-regional Network, on the other hand, refers to the routes for on-street slow modes (e.g. bicyclists, NEVs) that connect the Slow Zones and traverse the study area. The network mostly consists of existing residential streets, which could be combined with physical and digital wayfinding and provide efficient access to slow mode users. Further, compared to arterials, residential streets also present the lowest cost for both implementation and maintenance of the Slow-Speed Network.

The method of selecting Sub-regional Network is based on the street attributes and the connectivity with destinations and Slow Zones. Take South Bay as an example, the following steps are applied:

1) Research the active transportation master plan from local and regional planning agencies. In the case study of South Bay, LA Metro's Proposed Active Transportation Network (ATN) was largely utilized.

2) The ATN was overlaid on destinations in the South Bay (derived from land use) to assess how well the network served trips to the retail, workplaces, and recreational destinations as well as the proposed Slow Zones.

3) Additional links were selected based on existing and proposed bike facilities (from the South Bay Bicycle Master Plan and relevant City plans) to fill in gaps between key destinations, including Slow Zones. Street with speed limit under 30 mph and low-traffic-volume routes with flat topography that could accommodate most slow modes were given priority.

4) All inputs were refined based on map filtering, field visits, and stakeholders' input to create the proposed Sub-regional Network.

Figure 6 displays the map of the Sub-regional Network around the El Segundo Slow Zone (marked in a purple circle). Refer to Figure 4 and Figure 5, the Sub-regional Network has connected the core of El Segundo to the surrounding destinations with low-speed-limit and assessable local streets. The Sub-regional Network for the entire South Bay is shown in Figure 7.

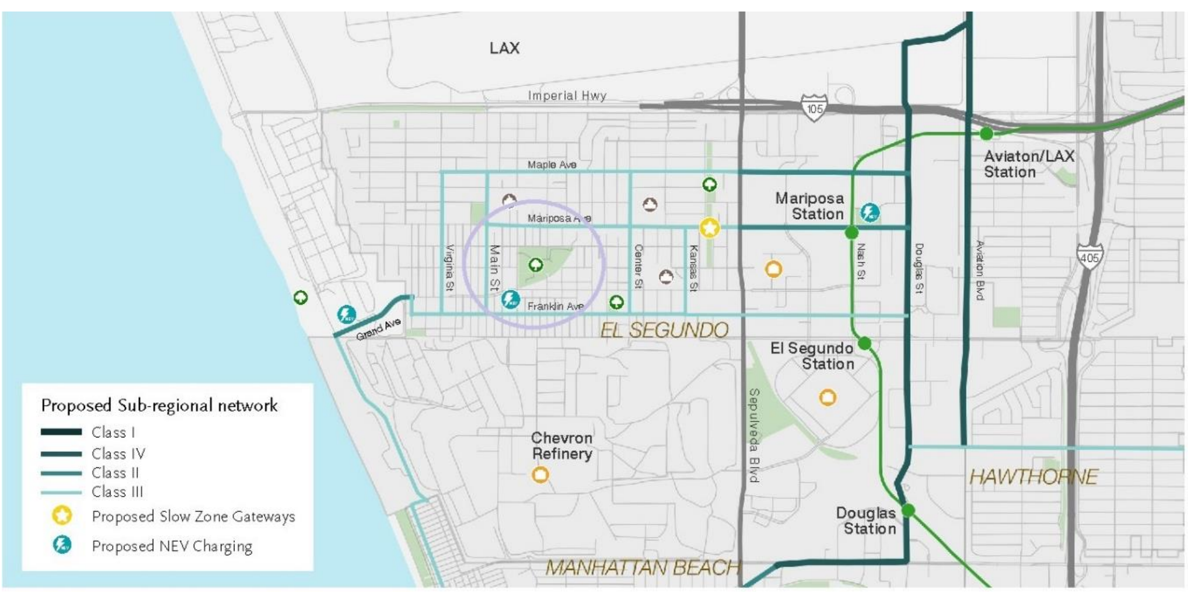

FIGURE 6 Sub-regional network in the El Segundo Slow Zone.

2.3 Slow Mode Thruways - Regional Network

Similar to freeways for motor vehicles, the slow mode thruways provide users the dedicated Right of Ways (ROWs) with the highest capacity compared with the two previously introduced networks. These slow mode thruways, which are essentially re-purposed ROWs, could be viewed as a part of a future countywide multi-modal transportation and recreational network. In the South Bay, candidates for such facilities include existing multi-use paths such as a segment of the Harbor Subdivision ROW that extends south of the Green Line, and the 16-mile length of the Dominguez Channel, which could provide trans-South-Bay slow mode connectivity to jobs, residential areas, and regional amenities. Off-street ROWs in Figure 7 are ideal corridors for dedicated slow speed routes. Figure 7 also shows how the three levels of networks – Slow Zones, Sub-regional, and Regional Network complement each other and provide access to a large portion of South Bay for a full range of slow speed users.

FIGURE 7 Map of Sub-regional, Regional Network (ROW) and the facilities in South Bay.

Additional slow speed thruways may be desired to provide high volume routes between very active slow zones. When suitable ROWs are not available, existing roads or portions of roads may become candidates for dedicated slow mode designation. This determination may be justified when the increased use of slow speed modes leads to a reduction of standard vehicular volumes along the designated route. The dedication of existing roadway ROWs to slow speed modes may require a combination of physical barriers from on-road traffic, parking modifications, and infrastructure reconfiguration to ensure slow mode users' safety and travel experience. The shift to a dedicated slow-speed thruway should be considered when parallel routes are insufficient to accommodate the slow speed mode travel demand.

The existing South Bay arterial infrastructure is divided into grids traversed by major roadways for motor vehicles. The slow speed network thruways provide high-volume routes between regions of greatest slow mode demand. These dedicated slow mode thruways serve as an alternative to the grid, negotiating ways around infrastructural barriers such as freeways and high-speed roadways. The connectivity between network components; between the on-street sub-regional network to the slow mode thruways and to the denser on-street and pedestrian networks, is key to the slow zone network strategy: a "more complete" Complete Streets system.

3 ENVIRONMENTAL BENEFITS

Given the previous network selection and design, it is of great interest for planners, policy-makers, and slow mode users to understand the magnitude of emission reduction as a result of promoting slow speed modes.

3.1 Short Trips Estimation

Because slow mode travelers are able to travel a limited distance within a 60-minute travel time, we believe that short trips are largely related to slow modes traveling. To estimate the emission reduction in year 2025 from the increased use of slow modes and EPAMDs, we resort to the short trips estimation provided by the modeling and forecasting department in Southern California Association of Governments. The short trips are defined as trips under 3 miles, and the data format is illustrated in Table 1. The short trips are modeled based on Traffic Analysis Zone (TAZ) as geographical units. There are more than one hundred parameters regarding socioeconomic status, demographics, and policy applied as inputs for trip prediction (*15*).

TABLE 1 Example of Short Trips Data

Notes	Origin TAZ ID	Destination TAZ ID	Number of single occupancy vehicle	Number of vehicles of two persons	Number of vehicles of three persons and above	Number of trucks	Distance of trips in mile
Row1	20211000	20211000	28	5	4	0	1.37
Row2	20211000	60192000	5	1	1	0	2.72
Row3	20212000	20211000	209	41	34	0	0.47
Row4	20212000	20213000	57	9	7	1	2.42
Row5	20212000	20214000	65	28	32	1	2.49

Table 1 gives a sample of short trips data. Based on the TAZs location and their unique TAZ ID, each TAZ in South Bay can be selected and the ID can be matched with the short trips table. Three types of short trips can be assigned to each TAZ:

- Internal trips, which means that Origin TAZ ID equals the Destination TAZ ID (e.g., Row 1 in Table 1).
- Outgoing trips, which means that Destination TAZ ID is different with the Origin ID (e.g. Row 2 in Table 1).
- Incoming trips, which means that Origin TAZ ID is different with the Destination ID (e.g. Row 3 in Table 1).

The summation of the three type of short trips will be the total short trips for each TAZ within South Bay boundary. SCAG has provided short trip data of baseline scenarios for year 2021 and 2031. The number of short trips in year 2025 is based on linear interpolation between year 2021 and 2031. The Vehicle Miles Traveled (VMT) of short trips in LA County in year 2025 is estimated to be 9.9 million miles/day based on the trip data.

3.2 Emissions Prediction

In order to estimate the emission benefits, we first extracted the aggregated VMT and emissions made by light-duty automobiles and light-duty trucks in LA County from the California Emission Model EMFAC2014 (*16*). The values are summarized in Table 2.

TABLE 2 Aggregated VMT and Emissions Made by Light-Duty Automobile and Light-Duty Trucks in LA County (year 2025)

Vehicle Population	VMT (miles/day)	Fuel Consumption (1000 gallons/day)	NOx (tons/day)	CO (tons/day)	CO2 (tons/day)	PM10 (tons/day)	PM2.5 (tons/day)
5,705,005	1.88E+08	6,669.1	13.5	177.8	62,408.9	9.9	4.2

To find the relation between short trips and slow modes, and predict the energy benefits, several assumptions are made due to limited data availability.

First, based on an off-model analysis from SCAG, the VMT reduction from active transportation in 2035 is estimated to reach 0.8% compared with 0.4% in year 2016 (*17*). Therefore, we interpolate that the VMT reduction from active transportation in the target year 2025 will be 0.6%.

Second, Table 2 shows that the light-duty-vehicle VMT in Los Angeles County is projected to be 188 million miles/day in year 2025. Based on the first 0.6% assumption, the total VMT of active transportation will amount to 1.1 million miles/day.

Thirdly, recall that the VMT of short trips for LA County in year 2025 is estimated to be 9.9 million miles/day based on the trip data (Section 3.1). We assume that the active transportation are mostly slow-mode traveling. If we divide the VMT of active transportation (1.1 million miles/day) by the VMT of short trips (9.9 million miles/day), the ratio will be 11%, which means that under the assumptions, at least 11% of the short trips are made by slow modes. At the same time, EPAMDs and NEVs are not counted due to a lack of data resources. Therefore, we think that 11% to 20% short trips are made by slow modes in year 2025 is a reasonable estimation. Above all, we assume that all slow modes are zero-emission.

With all the assumptions above, we are able to estimate the emission reduction based on short trips projection in South Bay region, as shown in Equation 1.

$$\boldsymbol{Ems_{ssz}} = \frac{\boldsymbol{N_{ssz} \cdot ST\_len \cdot Ems_{LA\_County}}}{\boldsymbol{VMT_{LA\_County}}} \quad \textbf{(1)}$$

where Ems_{ssz} means emission mass (tons/day) of one type of airborne pollutant in each slow speed zone, N_{ssz} is the number of short trips in each slow zone (trips/day), which can be found in Table 3. ST_len is the short trip length, which is generalized to be 3 miles/trip. Ems_{LA_County} (tons/day) labels the emission mass of the pollutant in LA County, and VMT_{LA_County} (miles/day) is the vehicle miles traveled in LA County (both are listed in Table 2).

The estimation values are based on the upper bound of 20% and are listed in Table 3. The emission for each pollutant or CO_2 is a total summation. For example, the values for particulate matter (PM2.5 and PM10) include exhaust emission and brake/tire wear. Carbon monoxide (CO) and carbon dioxide (CO_2) values include start, running, and idling emission. Under the assumptions that 11% to 20% of short trips will be made by zero-emission slow modes by year 2025, it shows that South Bay wide, the daily fuel consumption saving could amount from 17,100 to 31,000 gallons, and the carbon dioxide emissions could be reduced by 160 to 290 tons every day. The environmental benefits in terms of emission mass reduction are significant and could be largely enhanced with a well-planned and implemented slow-speed network.

TABLE 3 Zero-Emission Short Trips and Emission Reduction per Day for the South Bay in the Year 2025

Area	# zero emission slow speed short trips	VMT	Fuel Saving (1000 gallons/day)	CO (kg/day)	NO_x (kg/day)	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	CO_2 (tons/day)
El Segundo	3,774	11,322	0.4	10.7	0.8	0.6	0.3	3.8
San Pedro	8,406	25,219	0.89	23.8	1.8	1.3	0.6	8.4
North Redondo	15,819	47,456	1.68	44.8	3.4	2.5	1.1	15.7
Hawthorne	7,111	21,332	0.76	20.1	1.5	1.1	0.5	7.1
South Bay	292,081	876,242	31.02	827.1	62.9	45.9	19.6	290.2

4 DISCUSSION AND FUTURE DIRECTIONS

This regional slow-speed network plan aims to improve localized mobility, complement transit operations, and strengthen community interaction while providing greener transportation solutions. The slow mode options provide a framework compatible with Complete Street scenarios and Active Transportation Plans which are proposed and implemented internationally. The team's goal and ambition have been to demonstrate a feasible approach to integrate a greater proportion of slow speed mobility modes within an existing motor-vehicle-centric roadway infrastructure.

The successful designation, integration, and operation of a slow speed network require improvements and enhancements to local, intra-regional, inter-regional facilities. The approach presented in this study provides methods to characterize the local and regional attributes and optimize the improvements to facilitate slow modes. When existing databases are insufficient to fully characterize the network, specific walk audits and associated applications provide the data required for comprehensive slow mode analysis. The incorporation of infrastructure, network, and travel demand data within a GIS environment allows for scenario comparison and evaluation. The integrated analysis approach allows for the determination of mobility and emissions benefits at the local and regional level.

The slow mode mobility evaluation is limited by the availability of infrastructure, travel demand, and mode choice data. Provided with suitable and sufficient data, more regions can be evaluated for mobility and emissions benefits resulting from increased slow mode mobility which utilizes the presented analysis methods. The research team is further evaluating methods to simplify and streamline the data acquisition and data integration allowing for case study applications in other regions.

ACKNOWLEDGEMENT

We would like to thank our funding agency, LA Metro, for the great support. Thanks to all the team members' inputs: Project Manager - Jacob Lieb, Executive Director of South Bay Cities Council of Government - Jacki Bacharach, Transportation Director - Stephen Lantz, and Walter Siembab. In addition, we would like to thank Dr. Hsi-Hwa Hu, Dr. KiHong Kim, and Dr. Mana Sangkapichai from SCAG for providing and explaining data for estimating the emission benefits of this project.

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