A USDOT NATIONAL UNIVERSITY TRANSPORTATION CENTER

# Environmental Impacts of Short Car Trip Replacement with Micromobility Modes

Corey Harper (PI), https://orcid.org/0000-0003-1956-5258

Zhufeng Fan, http://orcid.org/0000-0001-9040-9114

FINAL RESEARCH REPORT

**Contract # 69A3551747111**

## Problem Statement

Transportation is a basic social and economic need, but those mobility options conceived a generation ago may not be economically or environmentally sustainable with rising urban populations. According to the U.S. Department of Transportation (USDOT), the average U.S. household produces about 9.5 trips a day (United States Department of Transportation, 2019). About half of these trips are within three miles, but fewer than 2 percent of those trips are made by bicycle. Private vehicles like cars, pick-up trucks, and SUVs, account for almost 50 percent of short distance trips (i.e., trips within 3 miles), in most U.S. metro areas (INRIX, 2019). As a result, commuters are spending increased amounts of time in congestion, which has associated costs such as wasted fuel and emissions. Micromobility (defined as shared bikes, e-bikes and e-scooters) represent a significant opportunity to replace short distance trips made by personally owned vehicles (POVs) and provide first-and last-mile solutions for underserved public transit riders.

This research develops a methodology for estimating the upper bound number of short-distance POV trips that could be replaced by micromobility modes and applies this method to a case study in Seattle, WA to estimate the resulting environmental, congestion, and economic benefits. These estimates are based on a static traffic assignment model, which is used to assess how peak hour traffic conditions could change in scenarios where micromobility has replaced a portion of short car trips.

## Case Study Area

This paper focuses on assessing traffic impacts in Seattle, WA, in large part due to the fact that is an urban area with one of the greatest potentials to replace short car trips with micromobility modes, as currently, short car trips accounts for 48% of peak hour trips. As one of the most congested cities in the US and the suitable weather for cycling, the city of Seattle is also promoting the widespread use of micromobility. In order to capture trips that start and/or end the city of Seattle, we consider travel demand and road network data across the Puget Sound Region, which includes four counties (King; Pierce; Snohomish; and Kitsap). (Figure 1).

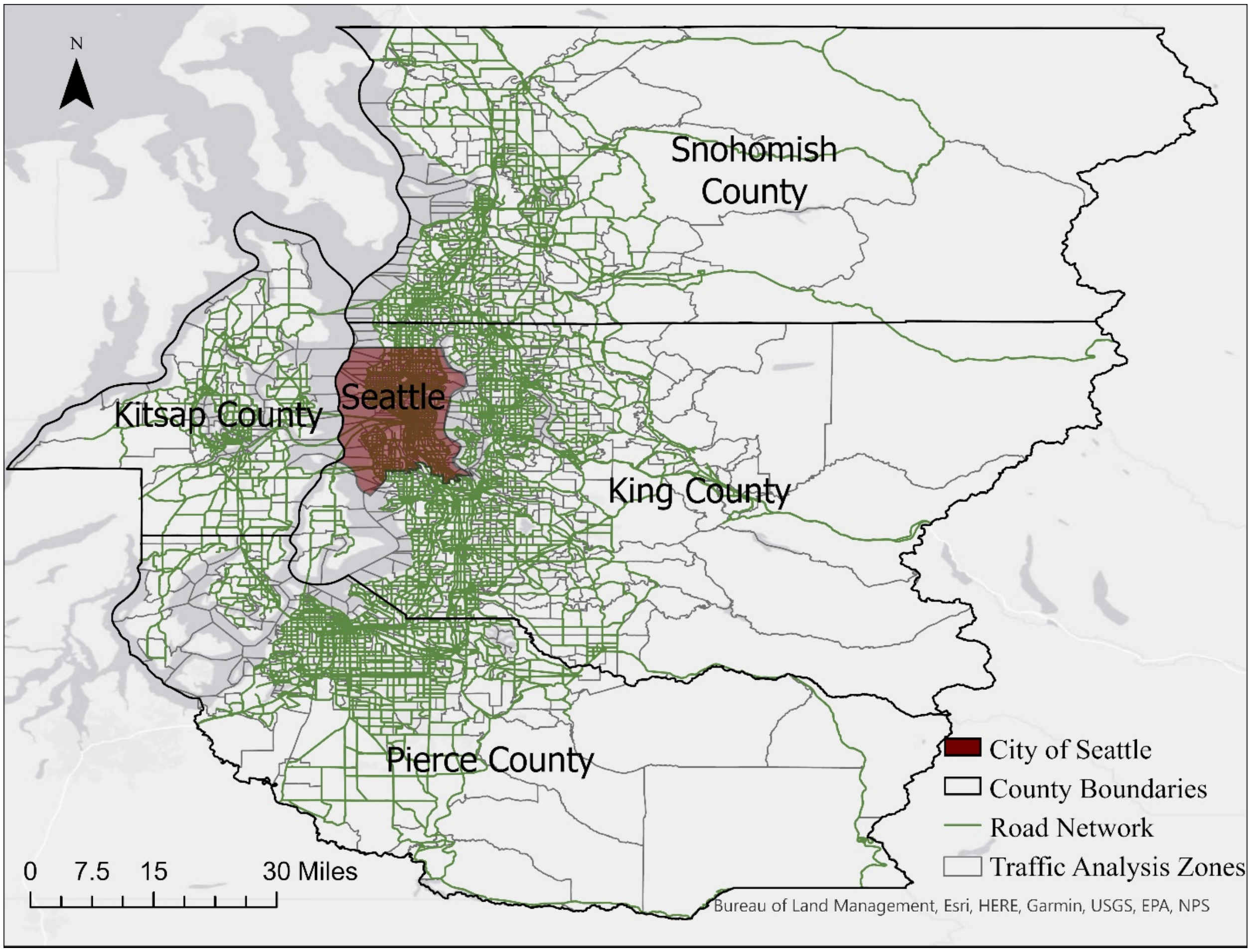



**Figure 1** Case Study Area

## Data

The primary data source used to estimate the upper bound number of short-car trips that could be replaced with micromobility modes, is the Puget Sound Regional Council (PSRC) 2014 Spring Household Survey. PSRC periodically releases information on the travel and transportation characteristics of the Puget Sound Region by conducting a representative regional survey, to assist policymakers and transportation planners in quantifying travel behavior and analyzing changes in travel characteristics over time.

In addition to travel survey data, weather is also an important factor when estimating the upper bound micromobility replacement potential, since a short car trip can only be replaced in good weather conditions. In this research, we scraped weather data from the Darksky API, which records hourly historical weather information in Seattle covering the whole travel survey data collection time period (Spring 2014). Weather features of concern are precipitation and wind speed. More information on how this weather data was utilized can be found in the Methods section of the paper.

In this analysis, we leverage on the PSRC's regional planning model to develop our traffic assignment model, which contains a urban road network and travel demands containing trips information. The PSRC road network, is the basis of traffic simulations for regional planning in the Puget Sound Region. The PSRC road network is a simplified version of the true road network. While it contains all the primary and secondary roads, it aggregates tertiary and local roads into simplified road segment representations to make traffic simulations computationally efficient. The PSRC road network does not represent toll stations, carpool or express lanes, traffic signals, and yield/stop signs. The network consists of 50 thousand directed road links, 25 thousand intersection nodes, and 3,700 traffic analysis zones (TAZs). For each link, information on posted speed limit, allowable travel modes, hourly lane capacity, link tolls, and volume delay functions are provided.

Demand data, contains information on the number of trips made by Private-Owned Vehicles (POVs), trucks, bikes, light rail, and walking for each unique O-D pair during PM peak hours, was also provided by PSRC. This data was generated using activity-based models for the year 2014 to represent trips in a typical workday. POV demands are provided in terms of Single Occupancy Vehicles (SOV) trips and High Occupancy Vehicles (HOV2 and HOV3) trips. Trucks demands are provided in terms of medium trucks and heavy trucks. During peak hour travel times, over 70% of trips in the Puget Sound Region are done by POVs, 20% by walking, and the rest by other modes (e.g., biking and transit).

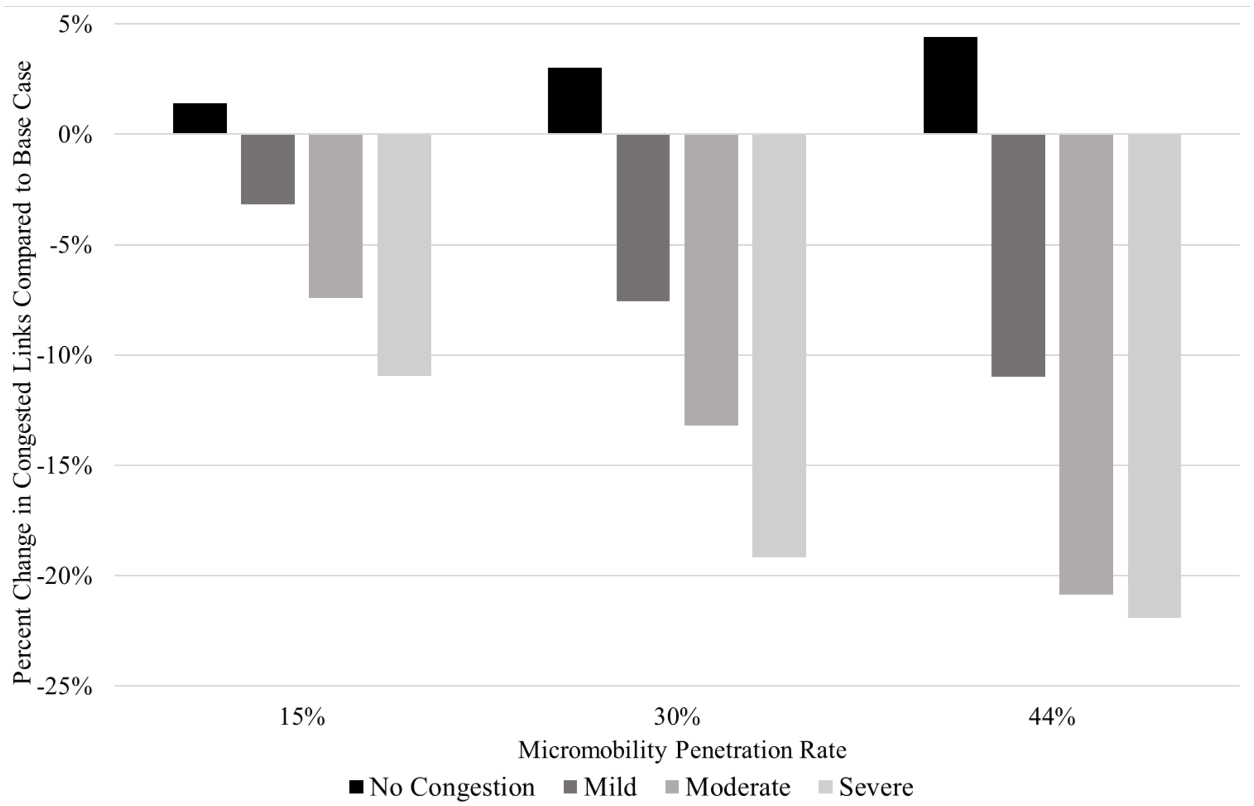
## Methdology

Our proposed method has two main components: 1) data analysis and 2) traffic simulation. The former aims at estimating an upper bound short car trip replacement rate taking into account trip (e.g., trip purpose) and person data (e.g., age) and weather conditions (e.g., precipitation). We first gather Seattle household survey data and weather data, identify short trips done by POVs, and estimate the upper bound potential for micromobility to replace short car trips. Demand scenarios, from 0% short car trip replacement to the upper bound are incorporated into static traffic assignment model and compared to base case conditions. Finally, we simulate updated traffic conditions based on updated demand scenarios, and discuss benefits on congestion, emissions, and energy use, according to traffic simulation results.

## Results and Recommendations

### Seattle Traffic Congestion Alleviation

Figure 2 depicts the percent change in congested links at different micromobility penetration rates when compared to the base case scenario. In base case scenario, there are 73 links with severe congestion, 490 links with moderate or more congestion, 2,285 links with mild congestion, and 6,792 links with no congestion. As expected, when the micromobility penetration rate increases, we see a larger portion of links become less congested. At the upper bound penetration rate, non-congested links increase about 5%,the number of severely and moderately congested link decrease by over 20%, and mildly congested links over 10%. This does not mean these congested roads have converted to non-congested, rather, the overall urban traffic situation has been improved and those links that are under lower congestion levels may become free-flow roads. It shows that the replacing short car trips with micromobility is an effective strategy to reduce traffic congestion in urban areas.




Note: Links where the ratio of current speed to free flow speed is greater than or equal to 0.95, is defined as "no congestion"; 0.8-0.95 as "mild congestion"; 0.6-0.8 as moderate congestion; and less than 0.6 as "severe congestion".

**Figure 2** Percent Change in Number of Congested Links under Different Micromobility Penetration Rates

## Impacts to Vehicle Miles Traveled, Emissions, and Energy Use

TABLE 1 shows the reductions in emissions and energy use if short car trips were replaced with with micromobility modes under different penetration rates. It is shown that at the upper bound penetration rate, switching to micromobility modes from short car trips could reduce transportation emissions and energy use by about 5%. This is equivalent to 13 tons carbon dioxide ($CO_2$), and 188 Giga Joules (GJ) per workday during 3-4PM peak hours, which translates to 2,860 tons of $CO_2$ and 41,382 GJ, assuming there are 220 workdays in a calendar year. These conclusions suggest that encouraging healthy people to use bike/scooter for transportation instead of driving a car for a short trip is plausible and effective for alleviating urban traffic congestion and reducing transportation energy use and emissions.

**TABLE 1** Emissions and Energy Savings

| Micromobility Penetration Rate | Number of Short Trips Replaced in Peak Hours | Total Daily Decrease in Peak Hour VMT | Total weekday daily decrease in 3-4PM peak hour emissions ($CO_2$ tons) | Total weekday daily decrease in 3-4PM peak hour energy use (GJ) | % Decrease in VMT, Emissions, and Energy |
|---|---|---|---|---|---|
| 15% | 6,044 | 9,547 | 3.7 | 52.8 | 1.41 |
| 30% | 14,643 | 23,259 | 9.0 | 128.5 | 3.44 |
| 44% | 21,478 | 34,100 | 13.2 | 188.4 | 5.05 |

Note: VMT = Vehicle Miles Traveled

## Policy Recommendations

In order to encourage micromobility ridership in urban areas, public agencies in conjunction with micromobility providers should seek to: 1) establish economic incentives such as allowing free rides for transit riders, similar to the partnership between Healthy ride bikeshare company and the Port Authority of Allegheny County, 2) municipalities could consider implementing congestion fees for drivers who wish to the downtown area, and 3) bikeshare providers should distribute bikeshare stations equitably across a region as stations are typically located near shopping centers and transit hubs, which are not easily accessible to low-income populations.

**References**


1. Puget Sound Regional Council. Spring 2014 Household Survey. https://www.psrc.org/travel-surveys-spring-2014-household-survey. Accessed Jun. 2, 2021.
2. Transportation Research Board. *Highway Capacity Manual, Sixth Edition*. 2016.
3. Harper, C. D., C. T. Hendrickson, and C. Samaras. Exploring the Economic, Environmental, and Travel Implications of Changes in Parking Choices Due to Driverless Vehicles: An Agent-Based Simulation Approach. *Journal of Urban Planning and Development*, Vol. 144, No. 4, 2018, p. 04018043. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000488.
4. National Highway Traffic Safety Administration. https://www.nhtsa.gov/. Accessed May 6,

2021.

5. Seattle Office of Sustainability and Environment. https://www.seattle.gov/environment. Accessed Jul. 28, 2021.

6. U.S. Energy Information Administration. https://www.eia.gov/index.php. Accessed May 6, 2021.

7. Local Governments for Sustainability. *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions*. Jul. 2019.