Project ID: EEMS048

U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

The Spatial Distribution and Impacts of One-Way Carsharing

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Presenter: Tom Wenzel, LBNL
2018 DOE VTO Annual Merit Review
June 19, 2018

Argonne NATIONAL LABORATORY

INL Idaho National Laboratory

BERKELEY LAB

OAK RIDGE National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

ENERGY EFFICIENT MOBILITY SYSTEMS PROGRAM
INVESTIGATES

MOBILITY ENERGY PRODUCTIVITY

THROUGH FIVE EEMS ACTIVITY AREAS

Advanced R&D Projects

Living Labs

Smart Mobility Lab Consortium

HPC4Mobility & Big Transportation Data Analytics

Core Evaluation & Simulation Tools

Advanced Fueling Infrastructure

Connected & Automated Vehicles

Urban Science

SMART MOBILITY LAB

CONSORTIUM

7 labs, 30+ projects, 65 researchers,
$34M* over 3 years.

Mobility Decision Science

Multi-Modal Transport

*Based on anticipated funding

Overview

Timeline
- Start date: Oct 2016
- End date: Sep 2019
- INL: 100% complete
- LBNL: 22% complete

Budget
- Total funding
  - $150k INL
  - $225k LBNL
- Funding
  - FY17: LBNL $75k, INL $150k
  - FY18: LBNL $75k
  - FY19: LBNL $75k

Barriers
- Limited understanding of impacts of carsharing and transportation network companies (TNCs; i.e. Uber and Lyft) on energy consumption and their relationship with transit

Partners
- Project Lead: LBNL
- Partner: INL
- car2go provided data under previous contract with DOT FHWA
- Other sources of data on 5 cities

Objectives & Relevance

- Conduct early-stage R&D at the traveler level to better understand behavioral drivers of, and barriers to, increased mobility energy productivity of future integrated mobility systems
- Understand the energy implications from shifts in personal travel, including in public transit, to emerging transportation modes such as one-way carsharing
- Estimate the relationships between transit accessibility, urban form, and impacts from one-way carsharing
- Apply these relationships to other cities and in detailed agent-based model simulations

Objectives & Relevance (cont.)

- Why study one-way carsharing?
  - Unique existing data set with detailed user survey responses linked to their trip origins-destinations (O-Ds)
  - Similarities to/differences from TNCs
    - Not everyone wants to ride in a TNC with a stranger driving
    - One-way carsharing may be complementary to other shared modes (e.g., public transit, TNCs, bikesharing, etc.)
    - TNC: vehicle comes to user; carsharing: user walks to vehicle
    - With automated vehicles, one-way carsharing and TNCs converge into same service
  - Builds on existing survey of users on VMT and mode shift impacts to understand spatial factors of survey responses at very low cost to DOE
    - $1m from US DOT FHWA, car2go, City of Seattle, San Diego Assn of Governments
    - Survey conducted and analyzed by UC Berkeley
  - car2go program in San Diego had a unique all-EV fleet, which is future model for automated TNC services

Objectives & Relevance (cont.)

- Key research questions
  - What is the spatial distribution of the impacts on mode shift, vehicles owned, and driving induced by one-way carsharing?
  - How are these shifts in behavior associated with urban form and public transit infrastructure and services?
  - What can we learn about the ingredients cities and shared mobility systems need to have to change behavior?
  - What levels of public transit are needed for one-way carsharing to facilitate reduced car ownership and use?
  - Are certain patterns of home and work locations associated with modal shift induced by one-way carsharing?
  - Can the lessons learned in 5 cities predict impacts from one-way carsharing in other cities?
  - What other cities might benefit from increased public transit use induced by one-way carsharing?

Milestones

Date	Pillar	Milestone	Status
Sep 2017 (INL)	Multimodal	Compile socio-economic and transit data on 5 cities into a database	Completed
Dec 2018 (LBNL)	Multimodal	Develop statistical models to estimate relationship between spatial distribution of car2go impacts and characteristics in each city	On schedule
Mar 2019 (LBNL)	Multimodal	Use models to estimate energy and other impacts of one-way carsharing in a new city	On schedule
Sep 2019 (LBNL)	Multimodal	Write journal article summarizing results Use findings as inputs to LBNL BEAM model to simulate one-way carsharing in SF Bay Area	On schedule

Approach

- Analyze the spatial distribution of 9,500 car2go survey respondents in five North American cities
  - San Diego
  - Seattle
  - Washington DC
  - Calgary
  - Vancouver
- UCB survey responses provide info on
  - Home/work location
  - Mode shift
  - Vehicle shedding
  - Vehicle suppression
  - Change in VMT
  - Vehicle activity
- Individual trip data (LBNL)
  - All car2go trips in one year (>1m trips across 5 cities)
  - Origins/destinations (O/Ds) and measured distance of each trip
  - Trips taken by survey respondents identified
- Create database of characteristics in each city (INL)
  - Census tract demographics
  - Public transit system infrastructure
  - Transit ridership data
  - Transit schedule data (GTFS)
  - Urban land use and form
- Use data visualization and regression to estimate relationships between census tract characteristics and car2go use and impacts in each city (LBNL)

Technical Accomplishments (Previous)

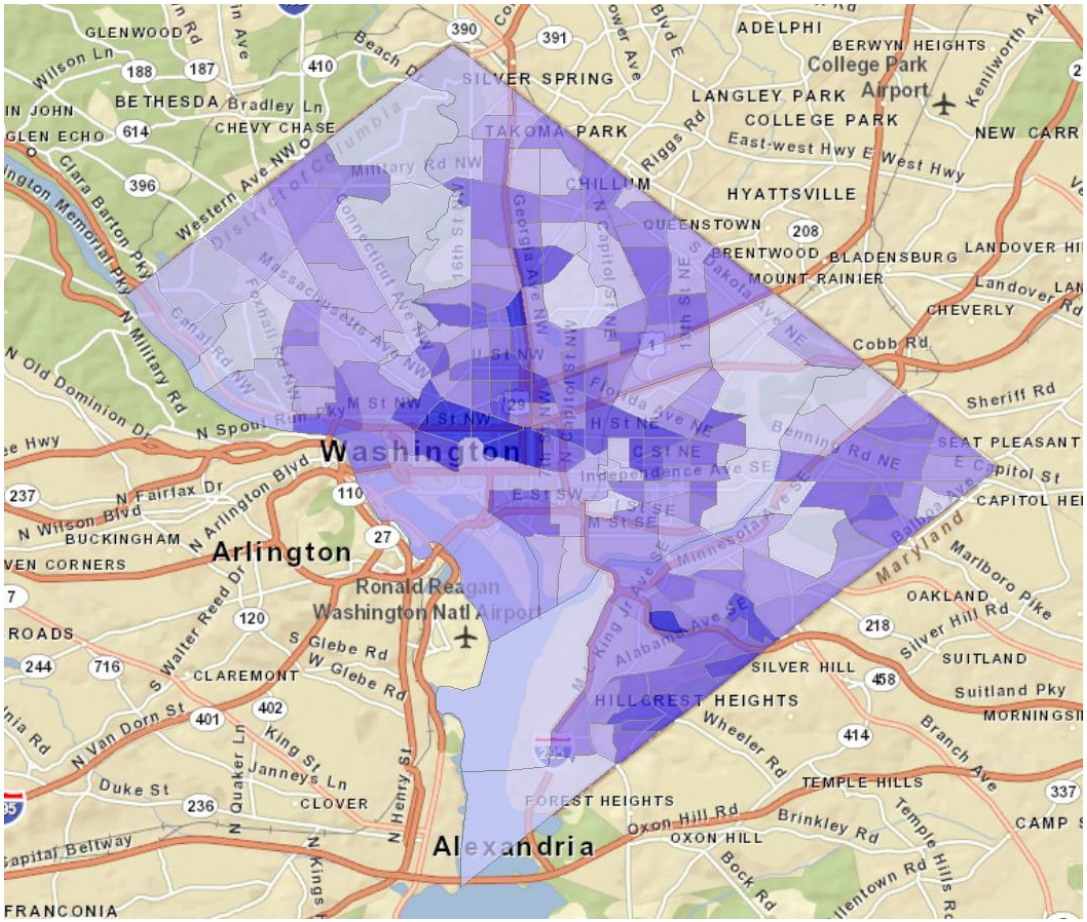
- Car2go is the largest one-way carsharing operator in the world
  - In 30 major cities, mostly in Europe and North America
  - Members pick up a vehicle in a zone and park it within the zone
  - Rental is per minute; payment includes parking, insurance and fuel
- Previous analysis of surveys of 9,500 users in 5 cities
  - 20% to 50% decreased transit use; 3% to 11% increased public transit use
  - 10% to 34% increased walking; 9% to 12% decreased walking
  - 2% to 5% shed existing vehicles
  - 7% to 10% did not purchase a new vehicle (suppression)
- Previous analysis estimated changes in VMT from car2go
  - Self-reported shift from/to other modes
  - Increased VMT from redistributing vehicles (3% to 8% in non-EV systems, 17% in all-EV system)
  - Self-reported from vehicle shedding; estimated from vehicle suppression
- Per household reductions
  - reduced VMT by 6% to 16%, and energy use by 4% to 18%, depending on city
  - lowest reductions in Calgary and San Diego, highest in Vancouver and Washington

Technical Accomplishments and Progress

- INL developed database of socio-economic characteristics and public transit information in 5 cities
  - EPA Smart Location Database, by Census block group
    - Population, number households, employment by type
    - Total land area to calculate densities
    - Household vehicle ownership and workers, by income
    - Trip productions and attractions
    - Road network density, proximity to public transit, frequency of transit, job accessibility
  - General Transit Feed System data
    - Transit station and bus stop locations
    - Transit routes, schedules, frequencies
  - Detailed data for Washington Metro

Technical Accomplishments and Progress

Washington DC transit (bus/Metro) stops per square km

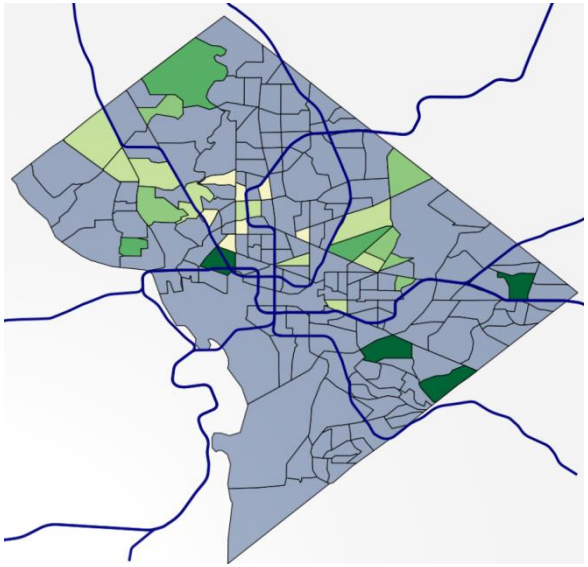


Technical Accomplishments and Progress

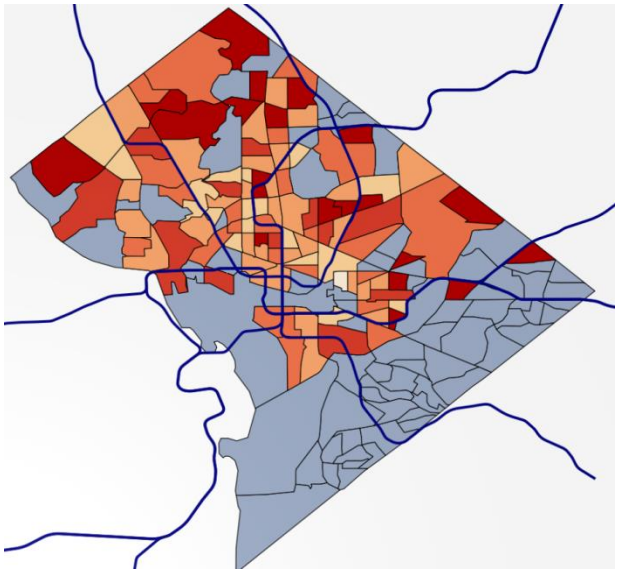
- LBNL conducted literature review
- LBNL geocoded survey respondents to zip codes
- LBNL began visualization analysis of survey respondents

Washington DC car2go survey respondents

Fraction increasing public transit use



Fraction decreasing public transit use



Response to FY17 Reviewers

Project not reviewed in FY17

Collaborations and Coordination

U.S. Department of Transportation Federal Highway Administration

– Funding for initial survey of car2go users in 5 cities

SANDAG

City of Seattle

car2go

– Individual trip data in 5 cities (San Diego, Seattle, Washington DC, Calgary, Vancouver)

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– INL: Developed database of characteristics of 5 cities
– LBNL: analyzing spatial distribution of car2go survey respondents and all users, using data visualization and statistical analysis
– Findings to be used in regional system modeling efforts (BEAM)

Remaining Challenges

- None

FY18 Remaining Work and Future Research

- Finish visualization analysis of relationship between spatial distribution of car2go impacts and characteristics in each city (FY19 Q1)
- Develop statistical models to estimate relationship (FY19 Q1)
  - Binary logit model at household level (survey response car2go impacts as discrete binary variables)
  - Logistic regression model at Census tract level (survey response car2go impacts as a percentage of all users in tract)
- Use models to estimate energy and other impacts of one-way carsharing in a new city (DOT Smart City Finalist such as Kansas City, Pittsburgh, SF, Columbus, or others; FY19 Q2)
- Write report and/or journal article summarizing results (FY19 Q4)
- Use findings as inputs to LBNL BEAM model to simulate one-way carsharing in SF Bay Area (FY19 Q4)

Any proposed future work is subject to change based on funding levels

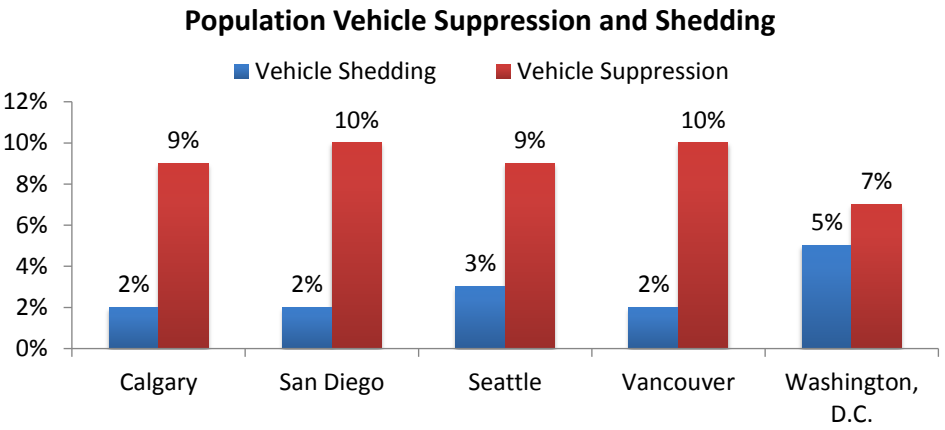
Summary

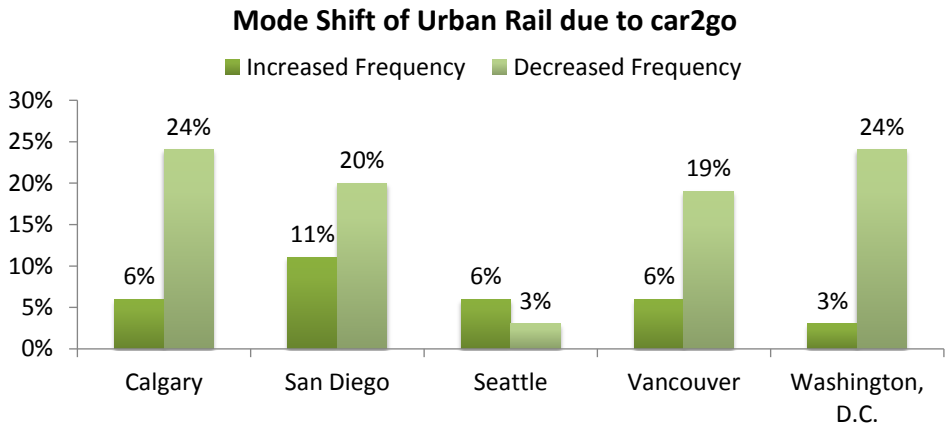
- Research aims to improve understanding of one-way carsharing impacts in different built environments
- Findings can be applied to other types of shared mobility modes in other environments
- A better understanding of how systems perform in specific environments can support more efficient decisions on designing public transit
- Under what circumstances do one-way carsharing and other shared mobility systems support or undermine public transit?
- What metrics define when mobility systems are most efficient in specific environments?

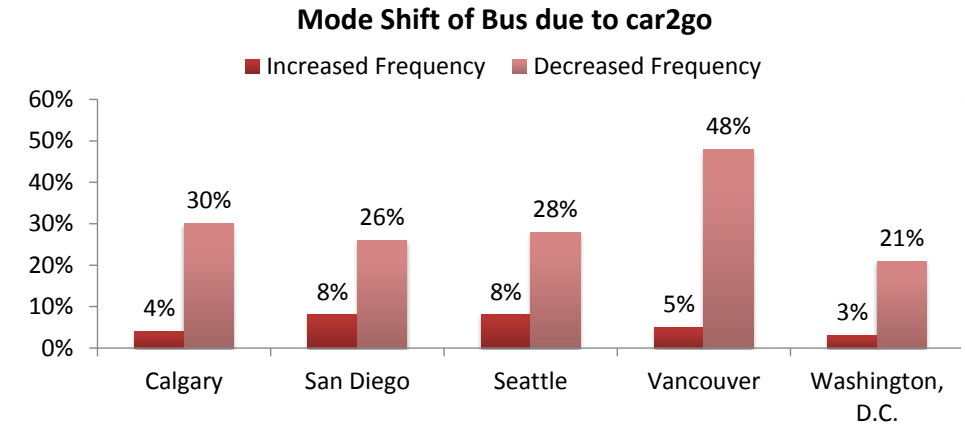
QUESTIONS?

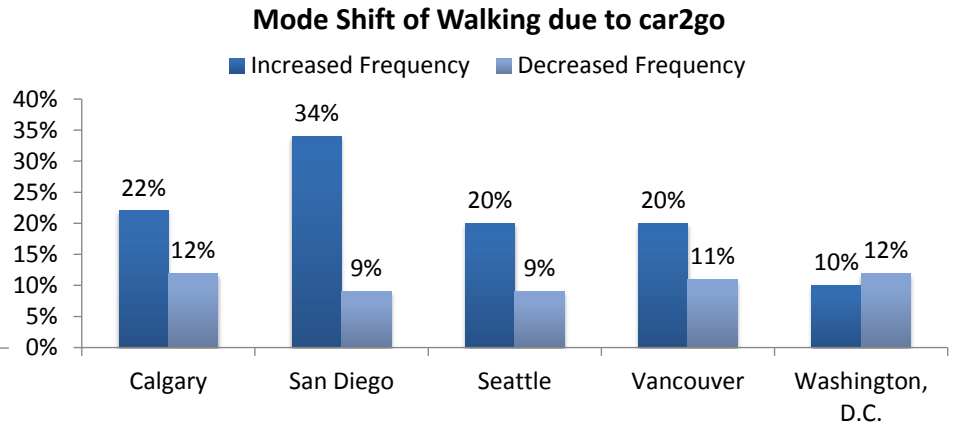
Technical Back-Up Slides

Select Population and Sample Impacts





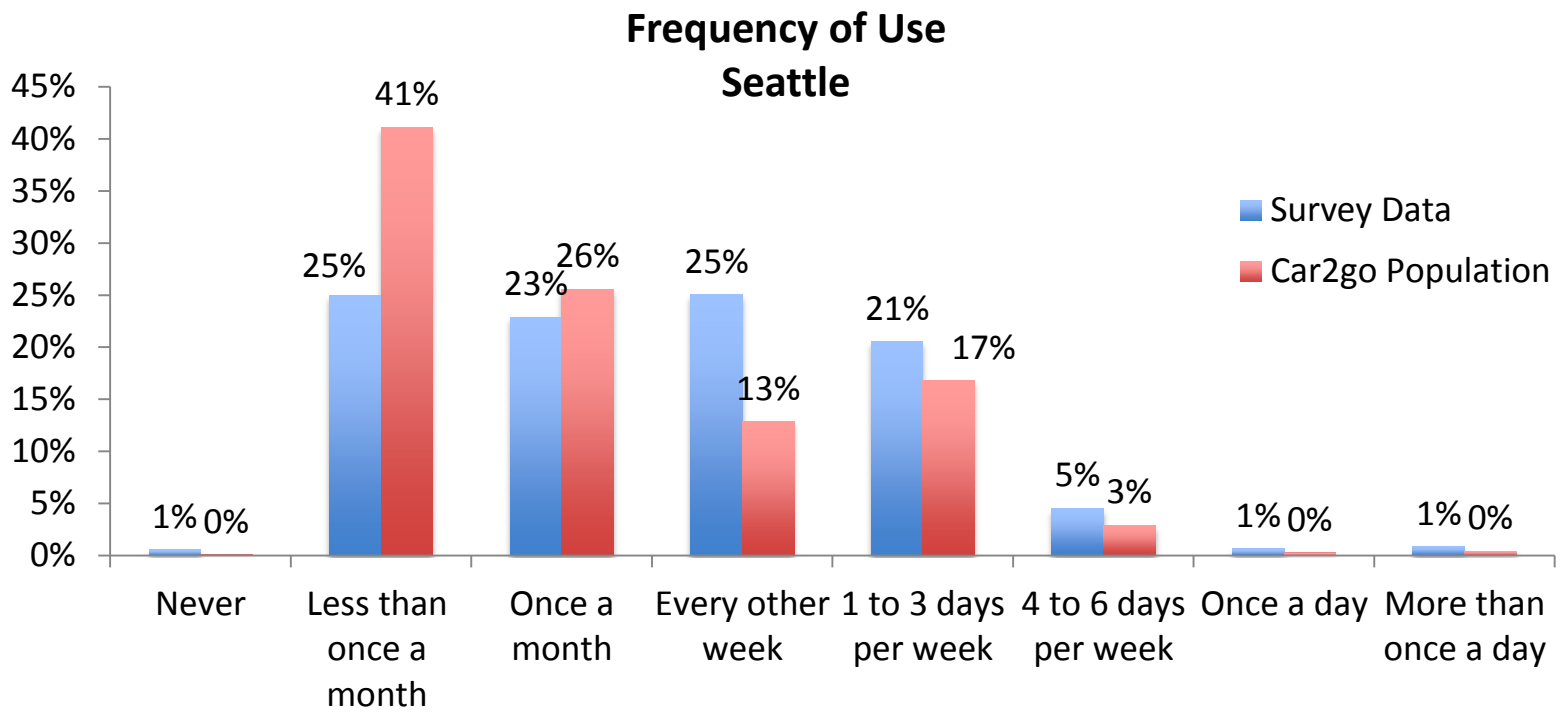




- Between 20% to 50% decreased transit use
- Between 3% to 11% increased transit use
- 10% to 34% increased, while 9% to 12% decreased walking

- 2% to 5% shed existing vehicles
- 7% to 10% did not purchase a new, (vehicle suppression)

Translation of Impacts to the Population



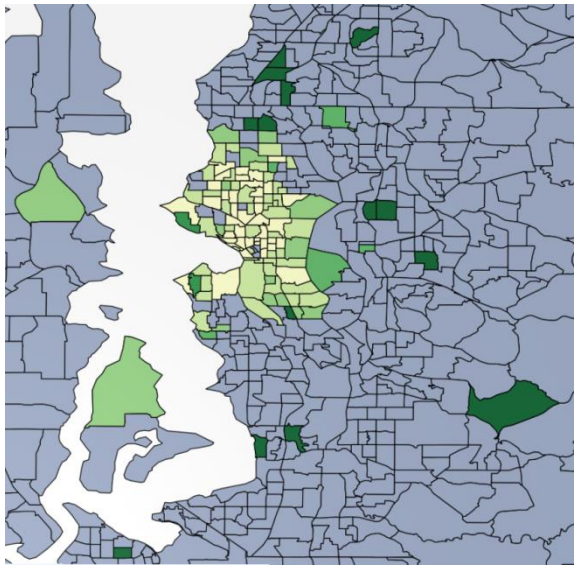
- We have found that the frequency of use by survey sample of shared mobility users is skewed towards higher frequency users, relative to the population.
- Used service more than once a month: half of survey respondents vs. one-third of all car2go users
- This can create a bias in impacts if raw sample impacts are multiplied by the population.

Population Level Impacts from One-way Carsharing via car2go

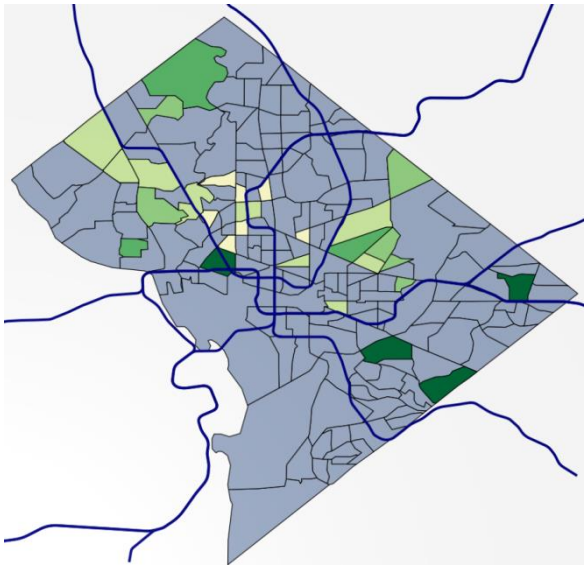
City	Vehicles Sold per car2go vehicle	Vehicles Suppressed (foregone purchases) per car2go vehicle	Total Vehicles Removed per Carsharing Vehicle	Range of Vehicles Removed per Carsharing Vehicle	% Reduction in VMT by Car2go Hhd	% Reduction in GHGs by Car2go Hhd
Calgary, AB (n=1,498)	2	9	11	2 to 11	-6%	-4%
San Diego, CA (n=824)	1	6	7	1 to 7	-7%	-6%
Seattle, WA (n=2,887)	3	7	10	3 to 10	-10%	-10%
Vancouver, BC (n=1,010)	2	7	9	2 to 9	-16%	-15%
Washington, D.C. (n=1,127)	3	5	8	3 to 8	-16%	-18%

Spatial Distribution of Impacts
Mapping the Increase in Public Transit

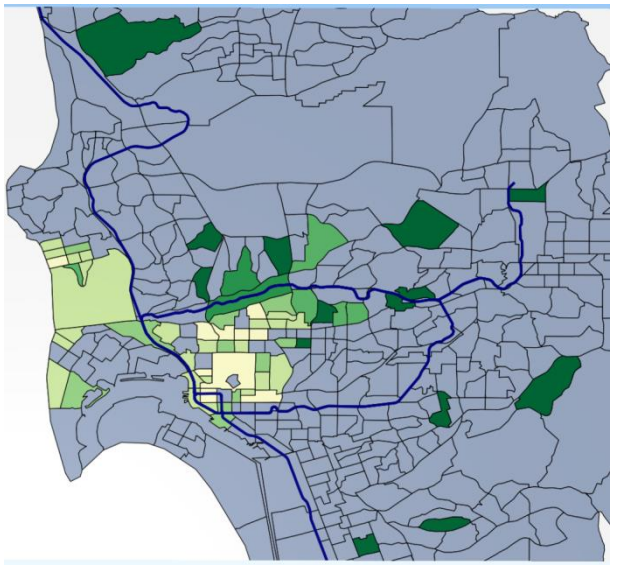
Seattle



Washington DC



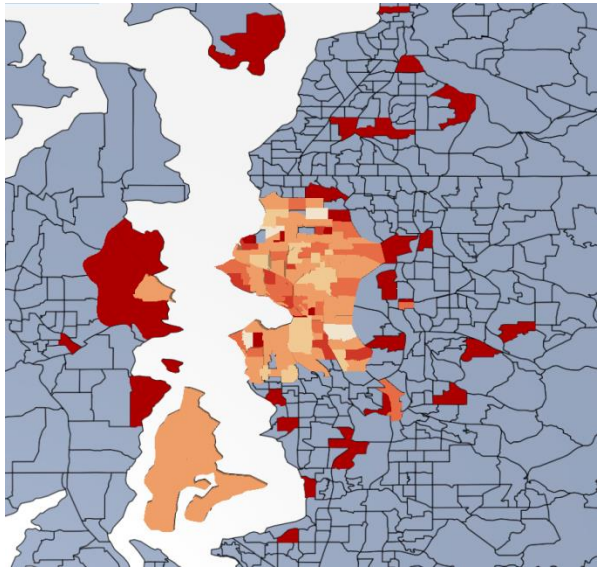
San Diego



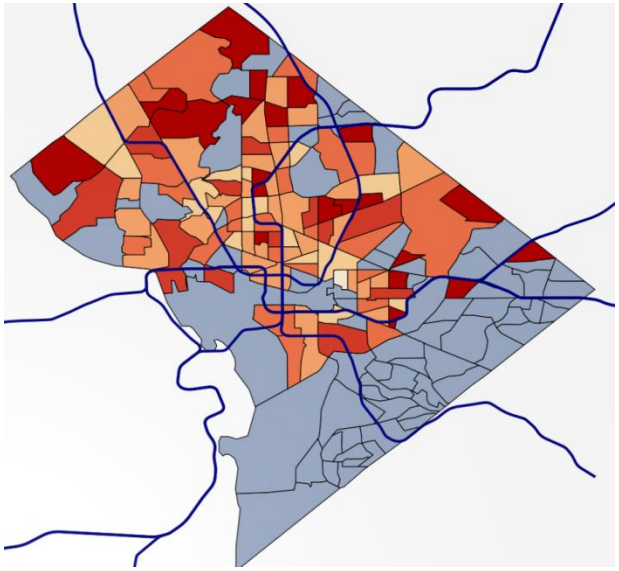
- Reported increases in public transit due to car2go
  – (darker = greater percent of respondents increasing transit)
- Zip codes in suburban areas have largest increases in transit use, but also fewest overall car2go trips.

Spatial Distribution of Impacts
Mapping the Decrease in Public Transit

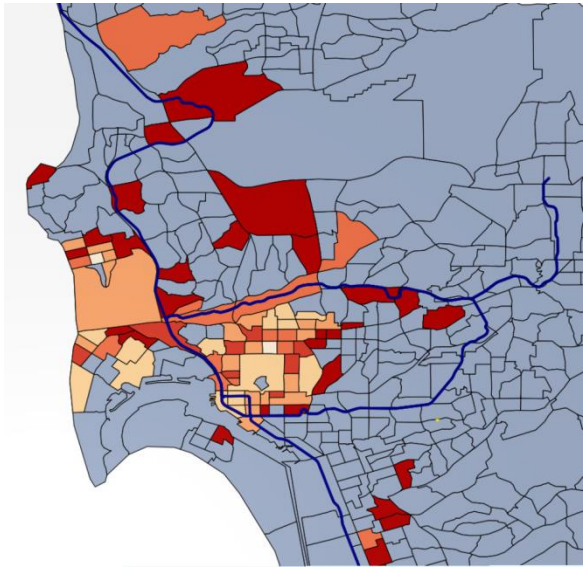
Seattle



Washington DC



San Diego



- Reported reductions in public transit use due to car2go (darker = larger decrease)
- In general patterns are similar, with largest decreases in suburbs
- More zip codes in downtown DC show a decrease (red) than an increase (green) in transit
- Other impacts being mapped: specific mode shift, VMT change, vehicle shedding/suppression.