BTE-Sim: Fast Simulation Environment For Public Transportation

Rishav Sen, Toan Tran, Seyedmehdi Khaleghian, Mina Sartipi, Philip Pugliese, Himanshu Neema, Abhishek Dubey

These works have been supported by the Department of Energy, Office of Energy Efficiency and Renewable Energy, and National Science Foundation

Long-term Objectives

Chattanooga Area Regional Transportation Authority (CARTA)

- Energy per passenger mile
- Total energy consumed
- Availability of daily trips served by transit

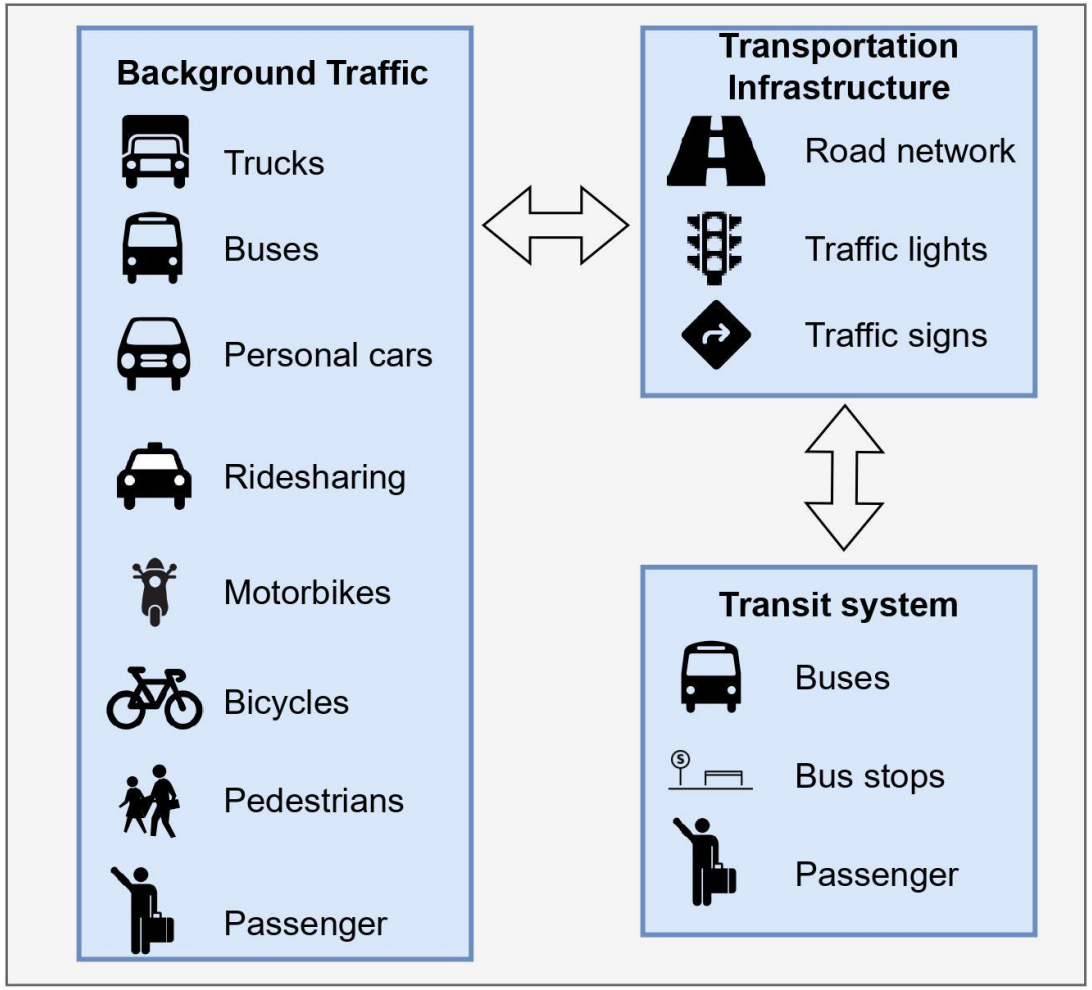
10%

The simulation environment

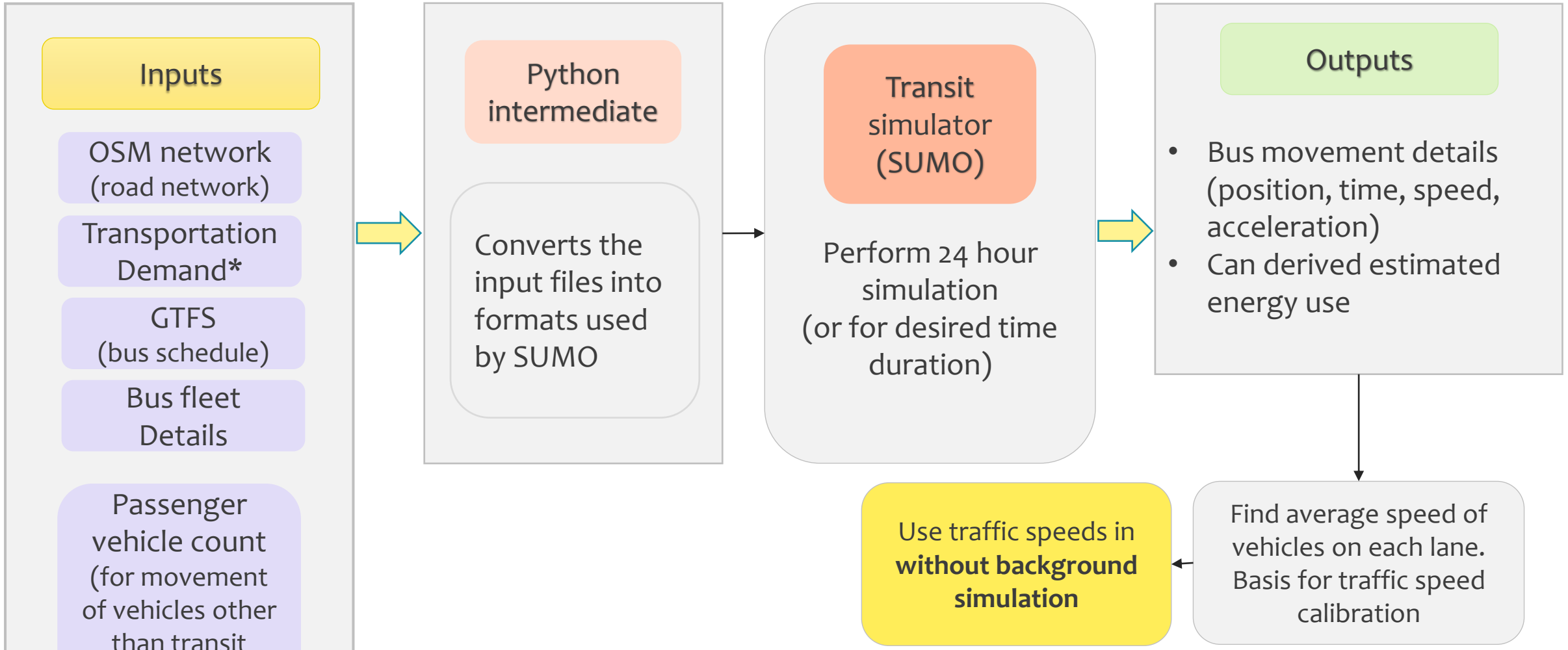
- Primary focus on public transit simulation
  - only the transit system's setting changes while the rest remains stable

- 3 main blocks of the system:
  - Transit system
  - Background traffic (other modes of transportation)
  - Transportation infrastructure

- Addressing the current challenges:
  - Scenario-specific simulation
  - Speeds up the simulation
  - Can be repeated with varying number of vehicles, in the same setting



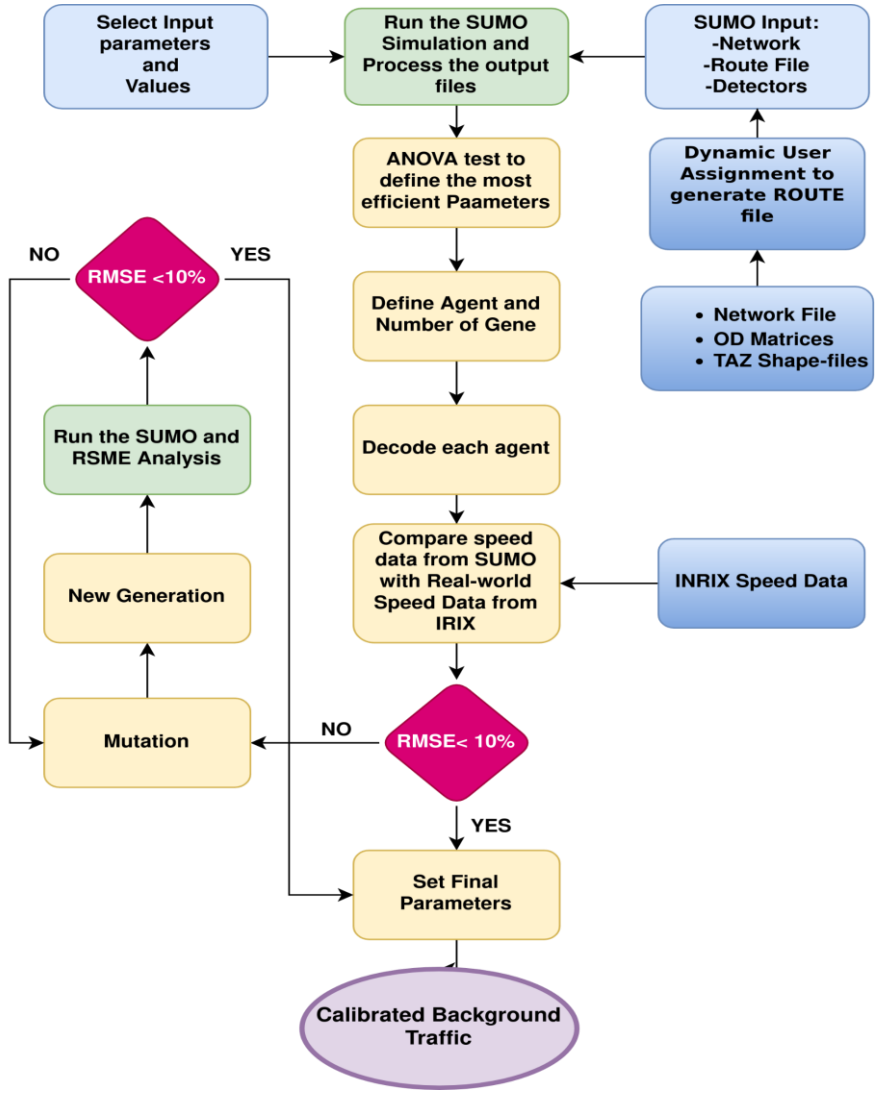
Transit simulation (with background traffic)



*Assumption: 25-30% of city's people are moving during the day

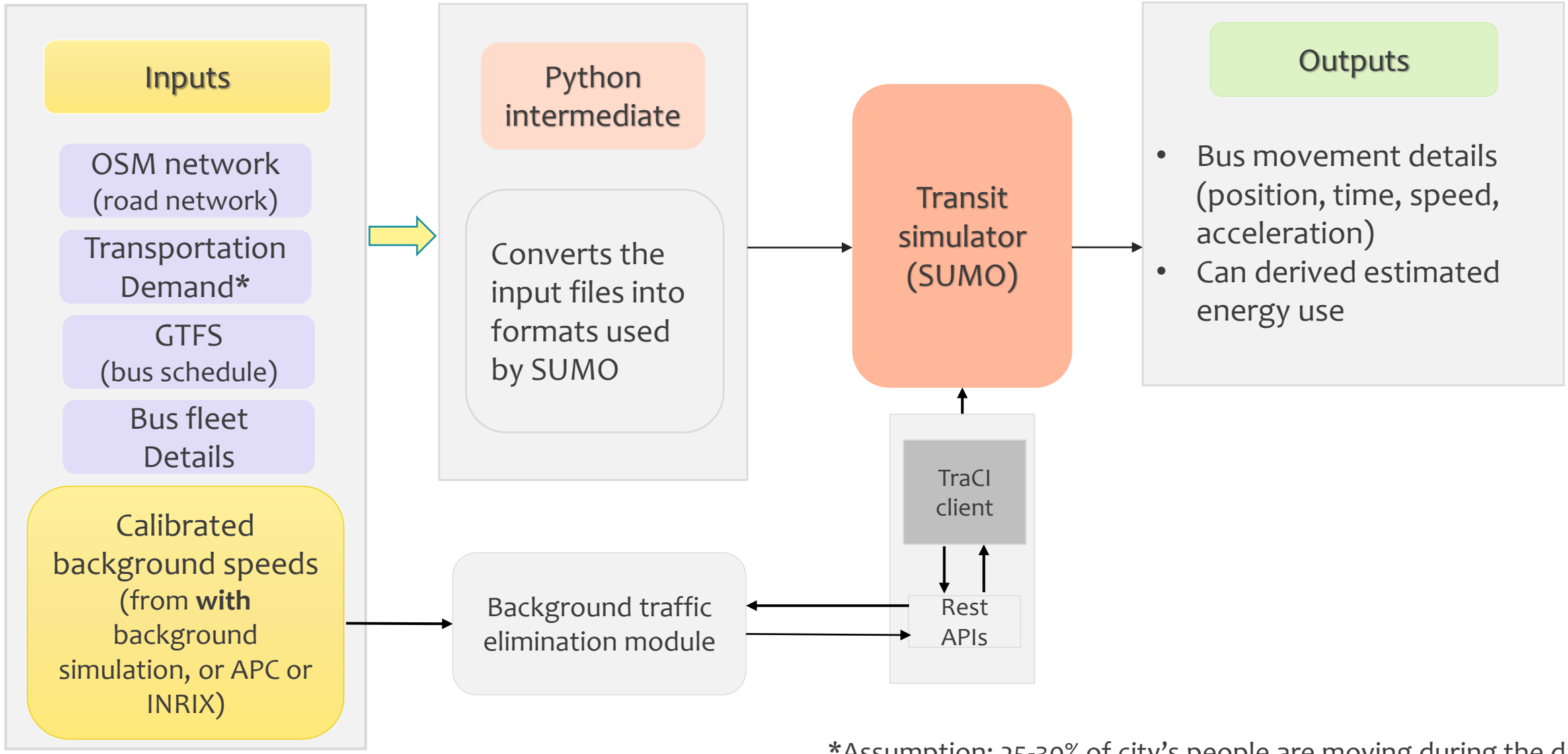
N.B: Background traffic is all other cars and passenger vehicles except transit buses

Calibration procedure



* ANOVA - Analysis of Variance

Transit simulation (without background traffic)

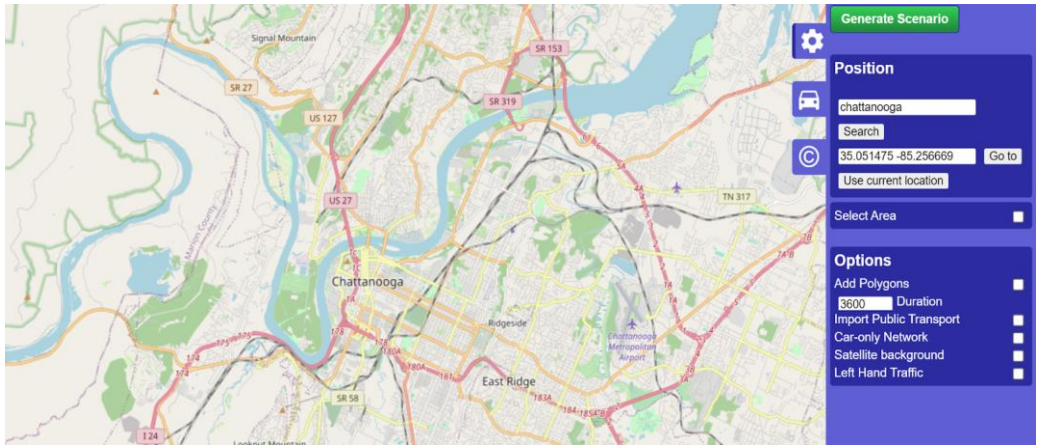


*Assumption: 25-30% of city's people are moving during the day

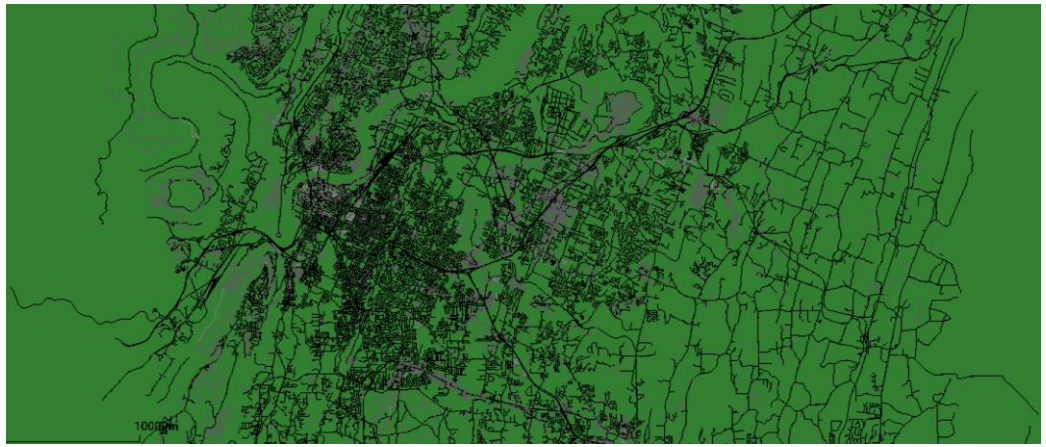
Preparing the Network for Simulation

*OSM - OpenStreetMaps

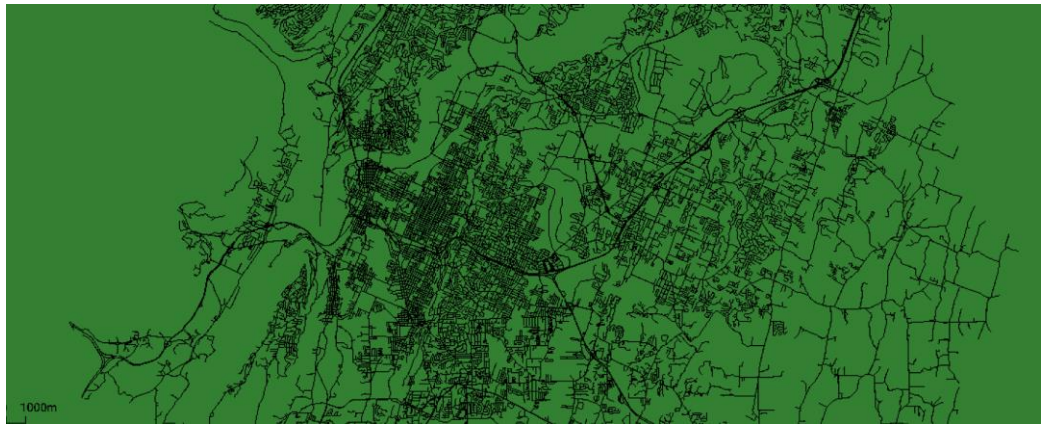
1- Import Network from OSM*



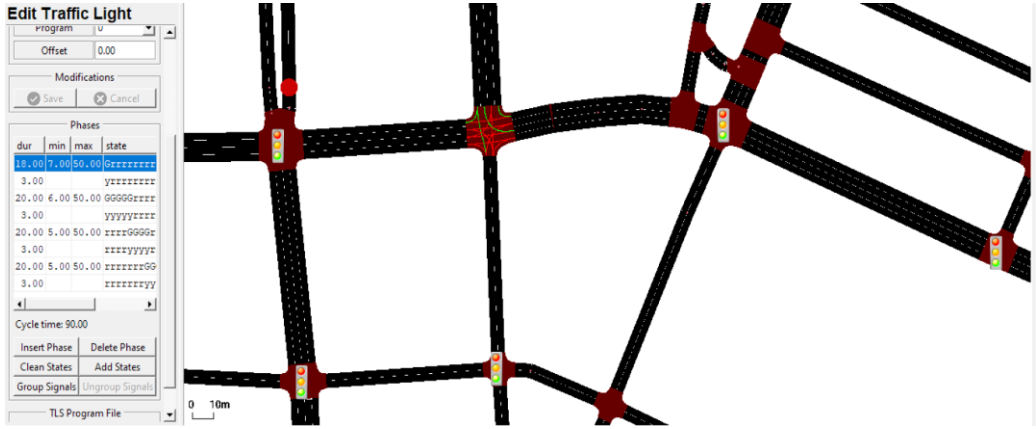
2- Import network into SUMO (netconvert tool)



3- Edit using netconvert :
Remove railroad, polygons, walk-road, unnecessary edges



4 - Edit traffic lights and intersection controlling detectors



Origin Destination Pair Generation

The geographic area under consideration is **Chattanooga**, Tennessee. The city is further divided into **census tracts.** We find the movement matrix of people travelling for jobs (LODES) from census tract to census tract. The generated od pairs are used as requests for our solver.

Each row in either dataset represents a single trip by one person. The trip represents movement to the job location and then back to home, at certain times of the day, which are sampled from a given set of regular job start and job end times.

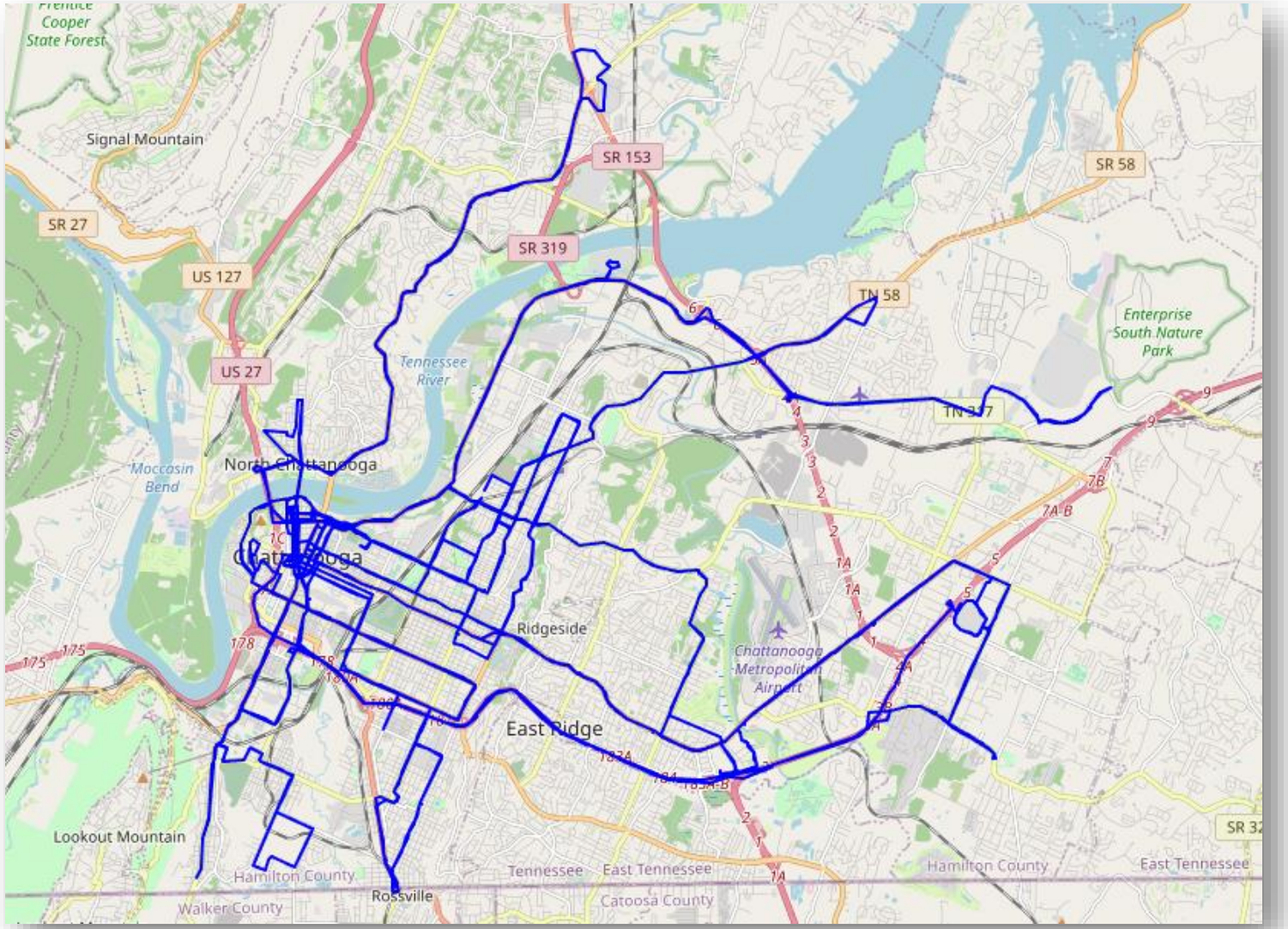
Data

- Geographic data
- People movement
  - LODES dataset
- Residential and Work locations
- Microsoft Buildings dataset

Process

The home location acts as the **origin**, while the work location acts as the **destination.** By uniform sampling across the home and commercial locations, a combination of the home location, work location, travel start time, and return time is generated.

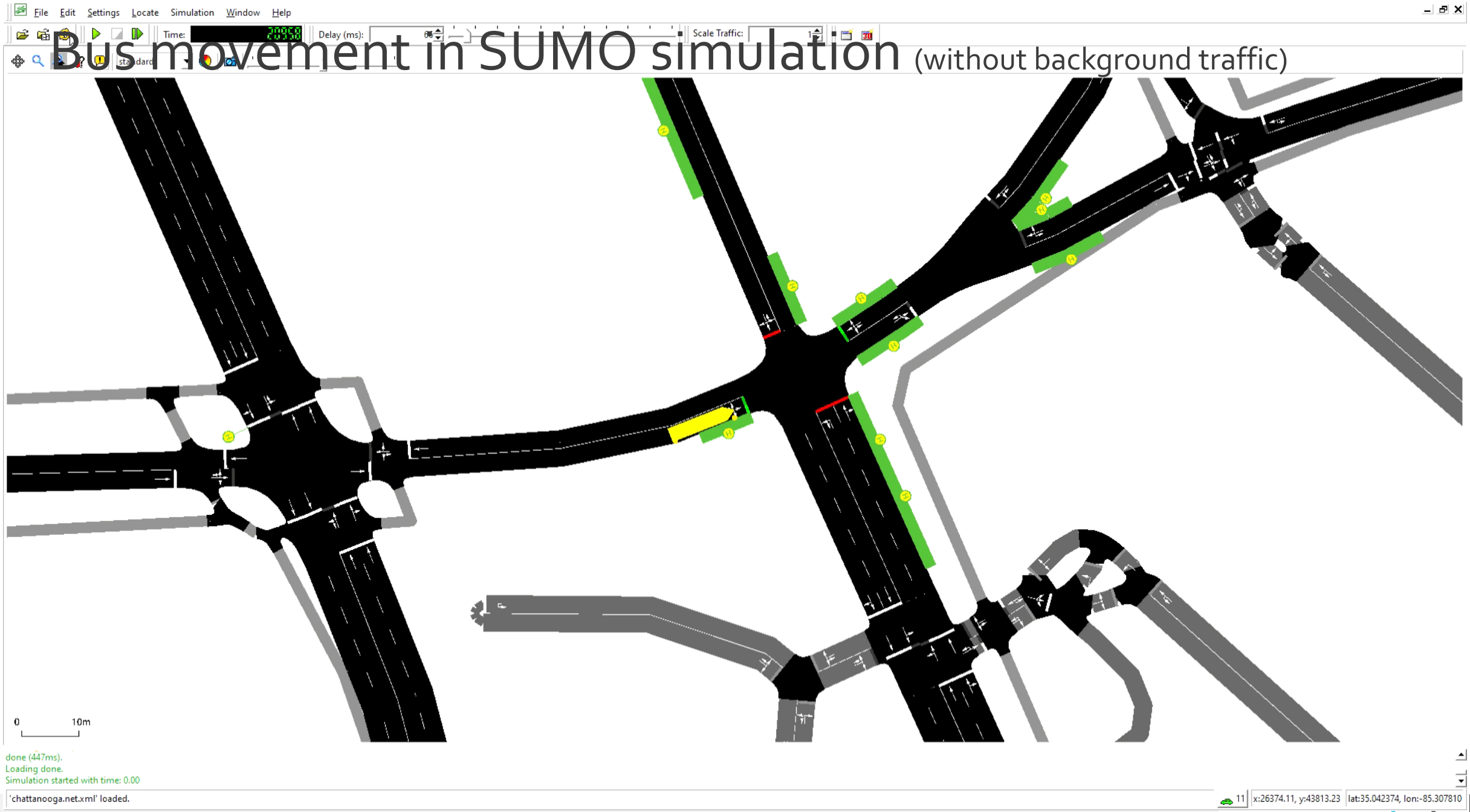
Current bus routes (GTFS)



— CARTA transit lines

* bus fleet information also obtained from CARTA

Bus movement in SUMO simulation (without background traffic)



Results

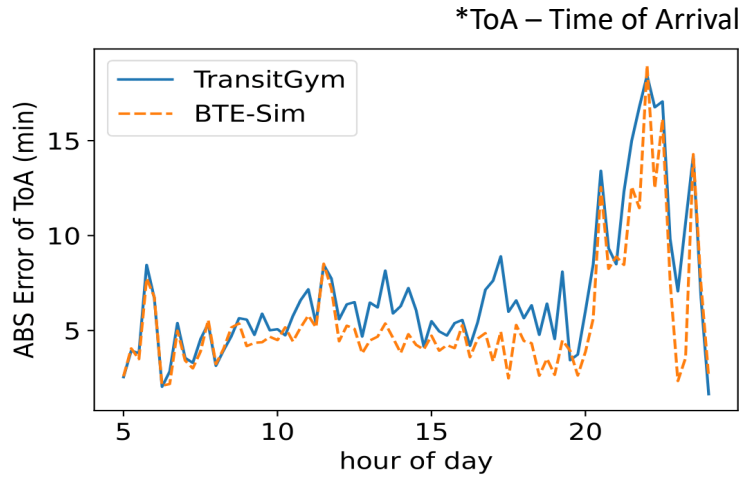


Fig1. Comparing the accuracy of the simulation methods

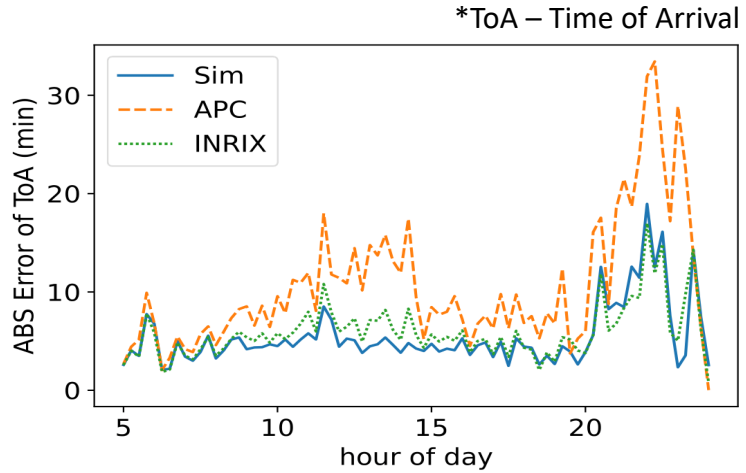


Fig2. Visualizing accuracy of the background traffic data sources

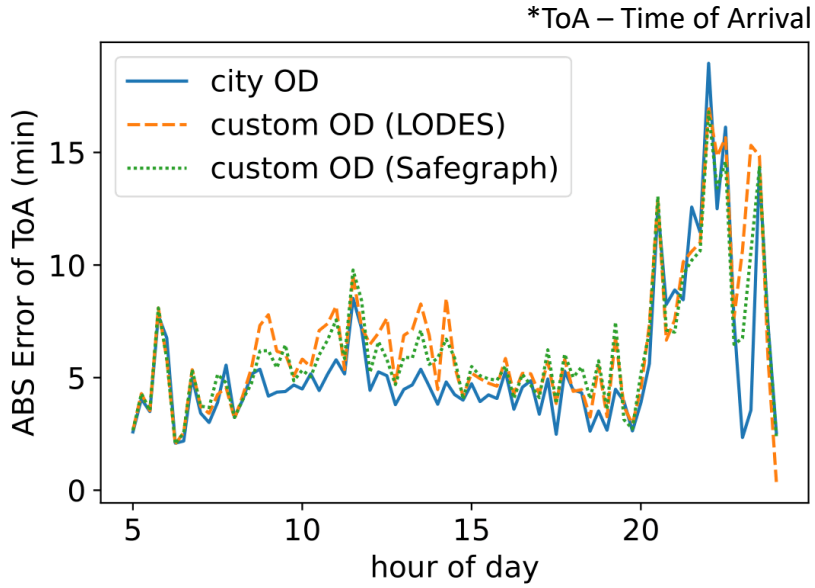


Fig3. Performance over varying travel origin-destination data

No. of vehicles	BTE-Sim (minutes)	Transit-Gym (minutes)
100k	2.21	27.7
400k	5.11	244
800k	7.81	1,011
1400k	8.27	2,478

Fig4. Computation time of BTE-Sim vs Transit-Gym (on same system)

Further results

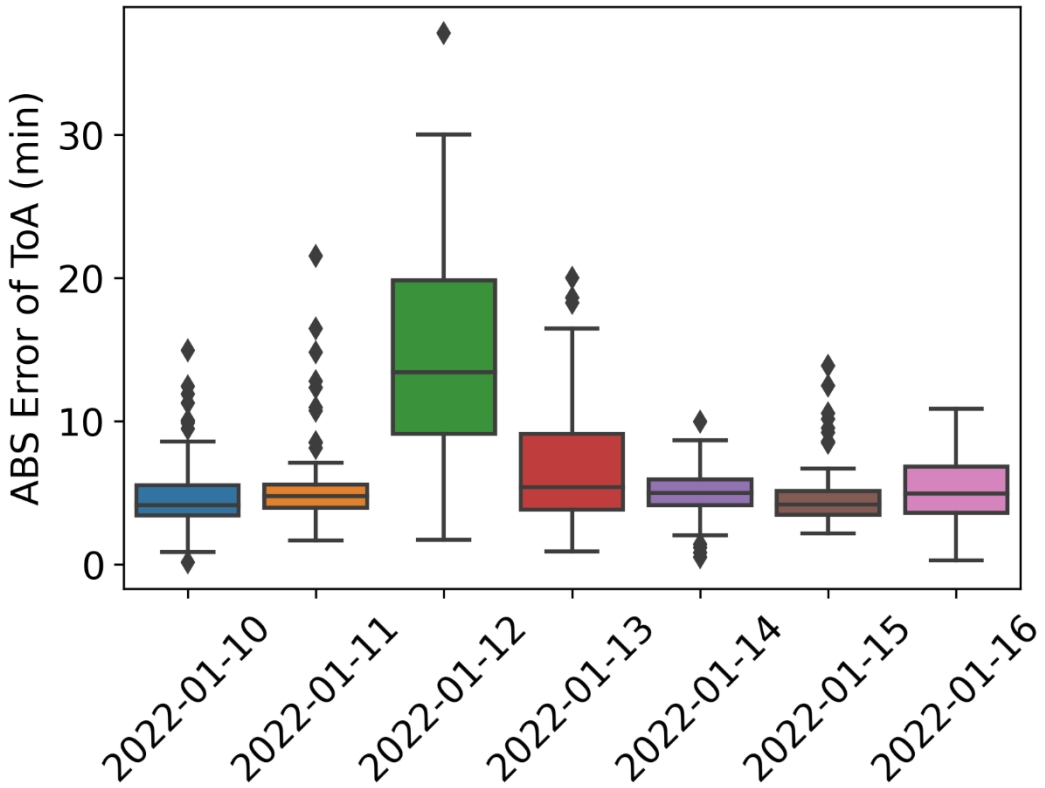


Fig5. Bus arrival times for different dates (compared to baseline)

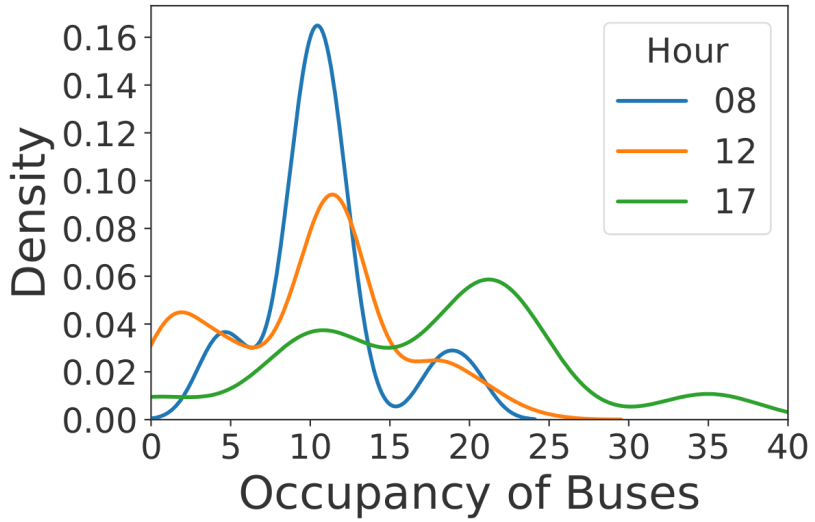


Fig6. Probability density function (pdf) of occupancy

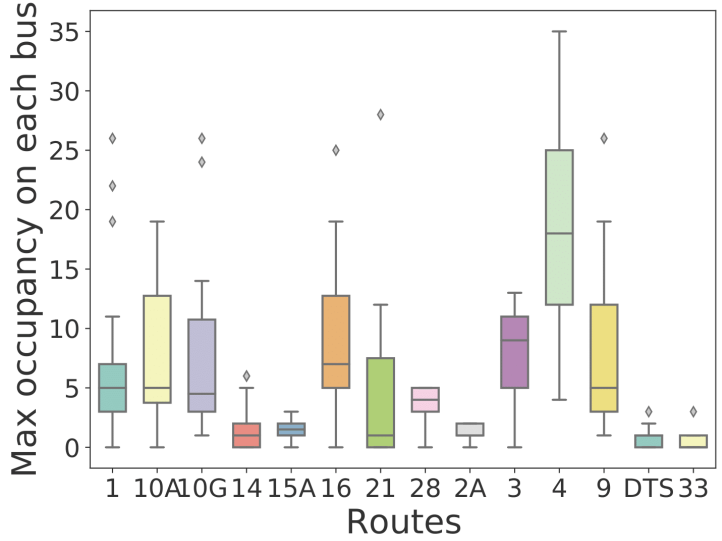


Fig7. Maximum occupancy on each of the routes

Conclusion: BTE-Sim

- Ability to simulate a region's transit system while accounting for its population and non-transit users
- Considerable improvements in simulation time and computing resources over regular simulation.
- Can also be used for multiple purposes:
  - proposing new transit routes
  - changing sections of existing routes
  - estimating energy consumption on each trip
  - new types of transit vehicles
  - alternate modes of public transportation (like micro-transit)

THANK YOU