Route_Dynamics: An open-source package for predicting battery load on King County Metro Bus routes

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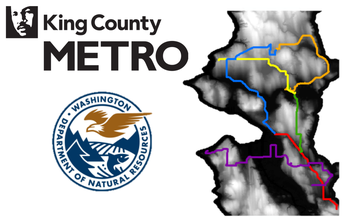
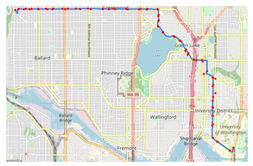
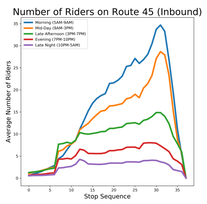
Purpose

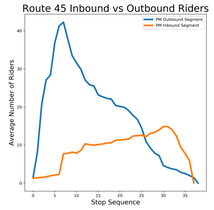
- King County Metro is transitioning to a fully electrified fleet, including diesel hybrid-electric, electric trolleys, and battery-electric vehicles.
- Metro's battery maintenance protocol is currently reactive.
- The vehicle drive train, drive cycle, and route characteristics are not considered in battery replacement and route planning.
- There is an opportunity to lower costs using a predictive maintenance model

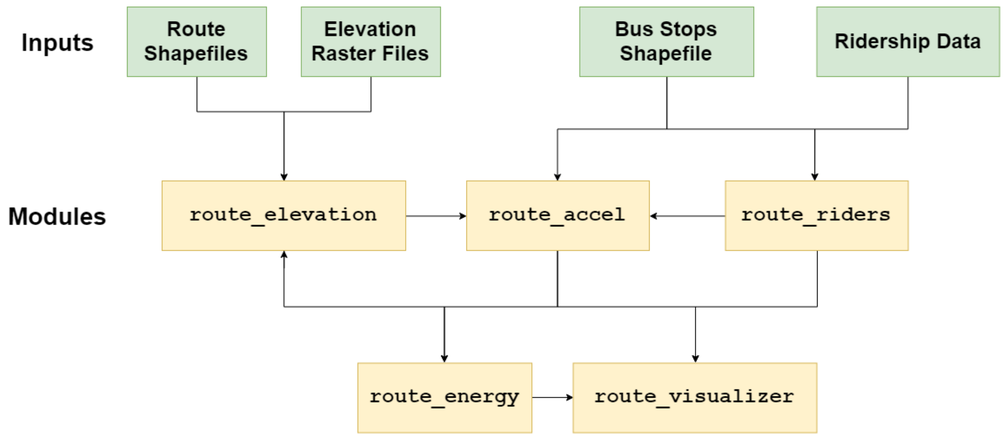
Package Overview











Functionality

route_elevation

Goal: To merge route shapefile and elevation data

route_accel

Goal: To create a drive cycle based on route events

route_riders

Goal: Give the average number of riders for each bus stop along a selected route

route_energy

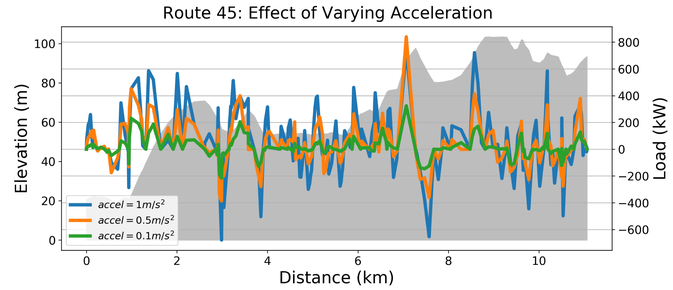
Goal: To calculate vehicle power requirements

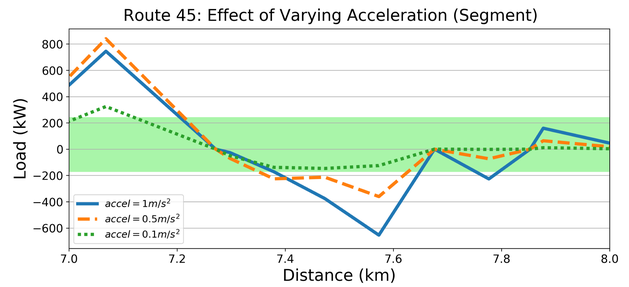
route_visualizer

Goal: To display selected route on a map

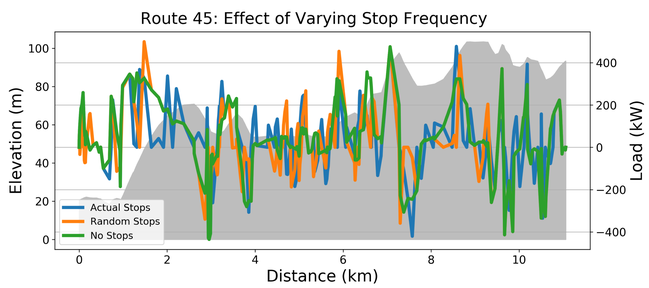
Results

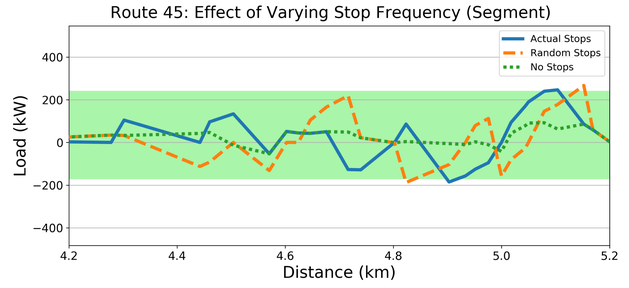
Plots on the left show the load profiles for the entire route with the elevation profile as the background. The plots on the right show a 1 km segment of the route. The green shaded area has an upper bound of 240 kW, the limit of the electric motor, and a lower limit of -170 kW, the limit of power the batteries can receive from regenerative braking.



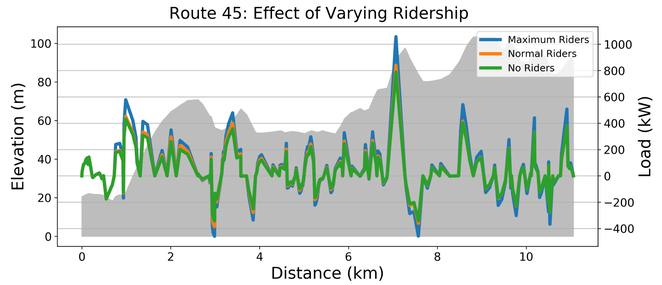


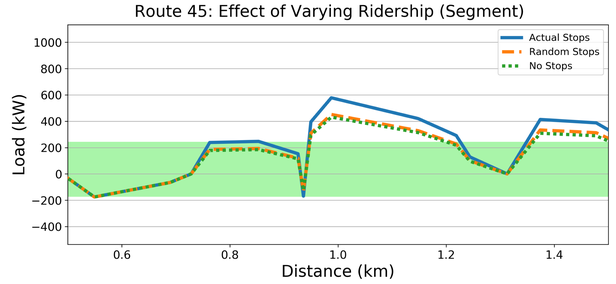
The scenario with a constant acceleration of 1 m/s^2 is the most energy intensive.





The scenario with no stops was the least energy intensive and the other two were about the same.





The scenario with maximum riders is the most energy intensive.

Base-case parameters: Acceleration = 0.5 m/s^2, Velocity Limit = 35 mph, Empty bus mass = 19051 kg

Future Work

- Add more points (e.g. interpolation) for higher resolution along the route for a smoother elevation profile and load profiles
- Combine elevation surface and terrain models to account for bridges and overpasses
- Create package module for data cleaning to minimize the need for ArcMap
- Create a database that links load profiles to specific routes, bus IDs, and module IDs

Route Dynamics

References: [1] King County GIS Data Portal. (2017, April), [2] WA Department of Natural Resources, Lidar Portal. (2016)