GIS Applications in Active Transportation Planning

Geographic Information Systems (GIS) play an important role in developing and improving pedestrian, bike, and transit networks. The studies reviewed for this project had a variety of goals, including: determining the relationship between sidewalk quality and transit ridership, road network connectivity and transit ridership, and population density and transit ridership; determining whether accidents between cars and pedestrians increase near parks; determining the cost in time to drivers of reallocating road space for bike lanes; visualizing existing and proposed low-stress bike networks and prioritizing proposed projects to improve the network; and improving the quality of transit metrics using smart card data and data from GPS equipped buses. Studies differed in their purpose. Some help planners identify network inefficiencies, some help them to prioritize projects, and some were designed to provide planners with metrics they could take to a skeptical public in support of their best-practice decisions.

Almost all data in the reviewed studies was readily available. This means the different tools developed by the authors can be used by planners across the globe with minimal effort or cost. Local road network data was used in all but one study, which, instead, used a hypothetical road network. In cases where the road data needed to include attributes such as the number of travel lanes and speed limit on each segment of road, the local municipality provided the data. In some cases, road data available from the Census Bureau provided enough detail. In one case, field work that identified the condition of existing sidewalks was needed to supplement the existing road network data.

All but two studies reviewed used demographic Census Bureau data – or the equivalent in the case of foreign studies – such as geographic boundaries, population density, and ethnic and socioeconomic status.

Each transit-oriented study required data from the associated transit agency on bus stop locations and ridership levels. One transit study used readily available data – smart card usage, the GPS location of buses, and bus stop locations – in tandem with a complicated GIS method to determine ridership, route, and network metrics that were not otherwise available.

Examples of study-specific datasets among the reviewed studies included a traffic accident dataset provided by the California Department of Transportation, residential parcel locations provided by the City of Seattle, and a dataset that included important destinations – such as grocery stores or employment centers – purchased from a private company.

Buffers were often used to determine study boundaries. In Kent and Woldeamanuel’s study on how sidewalk quality and road network connectivity impact transit ridership, the study’s boundaries were created using a 400-meter radial buffer around each bus stop on a chosen bus line. In Gerrett et al.’s study on the correlation between traffic accidents and proximity to parks, a 400-meter network buffer surrounding each park demarcated the study’s boundaries. This buffer, rather than creating a circular boundary around each park, extended from the parks via the road network. Accident sites from the CADOT point dataset were then selected based on whether they were inside or outside the buffer and compared.
Network analysis played a central role in two of the reviewed studies. Burke and Scott’s study on maximizing bike lane widths without significantly impacting automobile traffic flow used a hypothetical road network, then narrowed the width of each road segment to determine how wide a bike lane could be before an unacceptable delay was incurred on drivers using the network. In Lowry et al.’s study on improving the connectivity of Seattle’s low-stress bike network, the authors first analyzed cyclist behavior for the city’s existing bike network, then tested how that behavior would change if bike network improvements from the city’s bike master plan were implemented. Changes that resulted in the greatest improvement in low-stress network connectivity were then prioritized.

Most of the studies created tools that use complicated mathematical formulas to crunch extraordinary amounts of data into visually accessible maps, tables, and charts designed to better inform the public and decision makers. Saghapour et al.’s study created a tool to measure transit accessibility, which draws on transit data from every bus, light rail, and train station in greater Melbourne, Australia – about 19,000 sites in total. Jerrett et al.’s study on accidents near parks considers 608,000 different crashes spanning more than a decade. Ma and Wang’s method for generating reliable transit metrics using smart card data draws on data collected during more than 12 million daily smart card transactions. Clearly, these methods could not be accomplished without powerful database and GIS programs.

While two of the reviewed studies simply provide information about existing or historic conditions (Jerrett et al. & Ma and Wang), four of the studies go further, projecting outcomes based on proposed changes to a system. In Burke and Scott’s study on bike lane width, a baseline travel time through a road network is set using existing conditions. Then, the GIS tool generates an optimal network with maximum bike lane widths for every road segment based on a predefined value representing how much travel-time delay drivers will tolerate. The model can be manipulated in multiple ways. The delay tolerance value can be changed to be more or less conservative, or the planner can incorporate non-negotiable changes into the existing network to create a different baseline from which to make comparisons. In Kent and Woldeamanuel’s study, road network connectivity around bus stops was found to be closely correlated to transit ridership based on comparing existing connectivity conditions to ridership levels at each bus stop. In addition to calculating the existing level of network connectivity near each stop, the GIS tool calculates the potential connectivity. Then, by comparing the existing conditions to the potential conditions, planners can identify which areas should be targeted in terms of improving connectivity, and, in turn, ridership.

GIS is already a mainstay of transportation planning, and its role will only grow as more data becomes available. Studies like Ma and Wang’s that incorporate smart card data gathered as people board buses, and GPS data collected by the network’s buses will likely become more common in the future as more bus networks transition to these systems. The Rhode Island Transit Authority’s bus fleet was only recently fitted with GPS devices and the agency plans to transition to smart cards in the near future. These changes that will result in more available data for RIPTA planners to draw on to improve the transit system.

An important lesson can be learned from Ma and Wang’s experience. Beijing’s smart card system did not collect many of the data points the authors needed to achieve their goals. Instead, they had to come up with complicated methods of getting the data using relational databases and well-grounded assumptions about rider behavior. The designers of smart card systems should communicate with transportation planners early in their design process to ensure the data planners need to analyze and
improve transit systems are collected during smart card transactions – even if that data is not the primary reason for implementing the system.

GPS data related to biking is also likely to play an increased role in planning and tracking the success of bike infrastructure in the future. With many people using smart phones to track their riding activity there is a wealth of information about where and when people are riding. This data should be leveraged to ensure that bicycle infrastructure is being built where it is needed most, and, once it is built, data should continue to be collected to show how the infrastructure impacts ridership over time.
Annotated Bibliography


In this paper, Kent and Woldeamanuel describe a new methodology for determining the quality of sidewalks and connectivity of the street network near transit stops, and then analyze how these metrics impact ridership. The study focused on the Orange Line Bus Rapid Transit in San Fernando Valley, CA, and makes use of GIS in various ways. First, GIS was used to determine the geographic boundaries of the study by creating a 400-meter radial buffer around each of the Orange Line’s 18 stops. Second, in tandem with field observations, GIS was used to store the quality of every sidewalk segment within the study area on a scale of 0-2 so the data could be used to calculate overall sidewalk quality surrounding each transit stop. Third, GIS was used to store the connective properties of each intersection within the study area on a scale of 0-2 so the data could be used to determine overall connectivity of streets surrounding each transit stop. The study found a strong correlation between connectivity of the network near transit stops and ridership, but no correlation between quality of sidewalks near transit stops. The study is important to planners because it determined that among other thing, the ease with which a person can navigate to a transit stop has an impact on transit ridership.


This very technical article by Jerrett et al. analyzed car/pedestrian and/or bike accidents in and around Los Angeles, specifically studying whether the frequency of such crashes was greater near parks. GIS was used to create a 400-meter network buffer around 1,669 parks, and then crash data from the California Highway Patrol and georeferenced by the University of California, Berkley, was used to determine the frequency of crashes inside and outside the buffers. The study took into consideration vehicle miles traveled (VMT), population, and the number of trips made by foot or bike in each area. The study also considered how results differed in low income neighborhoods and communities of color. The authors concluded that 50 percent more car/pedestrian and/or bike accidents happen within the quarter mile park buffer than without, and that low-income neighborhoods and communities of color are more likely to experience such accidents even after controlling for VMT, population, and pedestrian trips. The authors recommend that planners pay special attention to pedestrian facilities around parks, especially for parks in low income or minority neighborhoods. This study is made possible only by the use of GIS software; the crash dataset used for this study, for instance, included 608,000 crashes.


Burke and Scott claim that planners often do not add adequately wide bike lanes to roads due to the car-driving public’s perception that doing so increases drive times unacceptably and planners’ inability to demonstrate otherwise. In this paper, they introduce a tool that allows planners to determine the impact on network-wide drive times of bike lanes of various widths. The goal is to provide planners with...
the means to reassure the public that its concerns about increased drive-times have been accounted for during the planning process.

The study built off prior research of Scott et al. (2006), which created the Network Robustness Index (NRI) in order to determine the network-wide drive time impacts of removing a road segment from a road network. The NRI model was refashioned to calculate car-travel delay resulting from reduced car-lane-width – the usually-unavoidable consequence of adding a bike lane. Set bike lane widths ranging from 4-12 feet were used in the study. A hypothetical network was built using the GIS software TransCAD. When the model was run, the program returned the widest bike-lane width possible on each road segment based on a predefined tolerance for delay created by the planner. In the study’s sample, the tolerance level was set at a 2-second delay per segment, which the authors considered conservative.

The paper compares the model’s results to those generated by using what the authors describe as the industry’s “rule of thumb” for bike lane widths – based on road speed and traffic volume. The model recommended wider bike-lane widths on many road segments compared to the rule of thumb, but also recommended not including bike lanes – due to unacceptable drive-time delays – on some segments that the rule of thumb recommended including the widest style of bike lane. The NRI model network, despite generally recommending wider bike lanes than the rule of thumb, offered comparatively shorter network drive times.


Saghapour et al.’s study introduces a method of determining accessibility to public transit, which can be used to determine how ridership varies depending on accessibility. The exceedingly technical approach builds on prior research by incorporating population density into calculations that previously did not include them. The study identified, with better precision than previous models, how well served different geographic units are by public transit. Further, it concludes that better accessibility to public transit results in higher use of public transit. With these results in mind, planners can determine where improving public transit accessibility is likely to result in the greatest ridership gains – for example, boosting public transit accessibility in a poorly served neighborhood will likely result in greater gains that improving transit in a neighborhood that already has good public transit accessibility.

The interesting aspect of this study is how broad the study range is. The study covers the entire Melbourne, Australia, metro area, and considers 17,800 bus stops, 1,700 tram stops, and 240 train stations. Undertaking the complicated data crunching involved in this study without GIS would be impossible. With GIS, on the other hand, the method can be used in any major metro region across the globe with relative ease. Such a study, while beyond my current level of understanding, emphasizes the seemingly limitless capabilities of GIS to implement models that would otherwise be impossible.


Lowry, Furth, and Hadden-Loh introduce a method of classifying the level of stress individual streets present to cyclists. The Stress level is based on a street’s number of lanes, speed limit, and available bike accommodations. The GIS tool developed in the study can map the extent of a city’s existing low-stress
bicycle network, and, for comparison purposes, map the effect of proposed changes to the network. Further, the tool prioritizes the projects included in the proposed network changes based on how each project improves the connectivity of the low-stress bike network.

The data required for this method is readily available. The authors, who tested their method in Seattle, Washington, used residential parcel maps and street networks data provided by the city, and a dataset of important locations, such as grocery stores and centers of employment, purchased from a private company. The method included a high volume of data, and could not be accomplished with the aid of a GIS program. The calculations included 169,000 road network links, 162,000 residential origin points, 22,000 important destinations points.

One interesting finding was the low priority of a sound-side bike path included in Seattle’s Bike Master Plan. It sounds similar to a segment of the East Bay Bike Path in Rhode Island. The GIS tool, which sets priority based on increased connectivity between origins and destinations via low-stress roads, did not see value in the non-central, limited access piece of infrastructure. This highlighted the difference between two categories of bike infrastructure, recreational (i.e. the East Bay Bike Path) and utilitarian (i.e. a separated bike lane on an arterial road). Neither is necessarily a bad investment, but it is important for cities to know the purpose behind their investments when selecting projects to ensure they get the results they are after.


Ma and Wang introduce a method for using transit riders’ smart card data and data from GPS-equipped buses to better measure a variety of transit network indicators including network-level speed, route-level travel time reliability, and stop-level ridership. The purpose of the study is to provide transit planners with better metrics with which to make decisions about how to improve transit service.

The method incorporates data stored in georeferenced databases, such as stop locations, and non-georeferenced data stored in different databases, such as smart card usage, by using a relational database with keys common to each individual database. Further, the method slims down the computational overhead of similar tools, making it more appropriate for internet-based applications. Ma and Wang emphasized reducing unnecessary computations in their method in part because of the volume of their data set. For example, within the study area of Beijing, China, 12 million smart-card transactions are completed on 696 transit routes per day – about 8 gigabytes of computer data.

An interesting aspect of this study was the complicated method the authors used to determine the origin and destination location of individual riders. The smart cards in Beijing do not record this data, so the authors compared the time the user scanned their card with GPS location of the bus they were boarding to determine their approximate location, then compare that location to nearby bus stops to infer which stop was being used. Because riders do not scan themselves off the bus, the method for determining each rider’s destination was even more involved.