# Transforming Mobility Barriers to Connectivity: Examining the Impact of the AeroATL Greenway Plan in Reconnecting Aerotropolis Communities Around Atlanta Airport

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## INTRODUCTION

Airports are key stakeholders in mobility networks. They help regions improve global competitiveness and drive local economies. However, at the micro level, an airport is a large and restricted land use that is difficult for the nearby residents to move around and an 'infrastructure sink' that congregates resources to serve aviation and related industries alone without considering the needs of the adjacent communities.

Hartsfield-Jackson Atlanta International Airport (H-JAIA) presents a great context that embodies the conflicting regional versus local connectivity priorities. H-JAIA, as the largest flight hub of the U.S. had 110 million passengers in 2019, making it the world's busiest airport by passenger traffic until 2019 (Hartsfield-Jackson Atlanta Airport, 2019). Yet, based on the Longitudinal Employer-Household Dynamics data in 2019, only 20% of its workers live by the airport. The disconnected communities nearby the airport are also well below the median income level and host a large African American population. In 2016, Aerotropolis Atlanta, a nonprofit public-private partnership organization, and the ATL Airport Community Improvement Districts, proposed a AeroATL Greenway Plan to improve walking and biking connectivity in the Aerotropolis region. The plan was funded by Atlanta Regional Commission (ARC) in 2017. This connectivity infrastructure envisions alleviating the car-centric traffic, providing a walkable public space, and connecting communities around H-JAIA.

This paper uses AeroATL Greenway Plan as a case study to critically examine such a connectivity infrastructure for Aerotropolis residents that contest the mobility barriers posed by H-JAIA airport and its surrounding built environment. We ask two research questions: 1) is H-JAIA a barrier to nearby residents' mobility, and 2) how well the AeroATL Greenway Plan can improve Aerotropolis residents' walking and biking trip distance and experience. For the first question, we use origin and destination flow data from Atlanta Regional Commission's Activity-based Model to quantify and visualize H-JAIA's barrier effect. For the second question, we model changes in trip distance and trip experience with six network scenarios and host a participatory modeling workshop with community members to discuss and validate scenario modeling results. We work with Aerotropolis Atlanta to understand contexts, set our goals, and engage with stakeholders.

This paper contributes a critical, network-centric perspective (and metrics) to analyze the barrier effect of H-JAIA on Aerotropolis residents' mobility flows, highlighting inequality between regional and local network flow systems. Our methodology also extends beyond analyses focusing on calibrating and predicting the impacts of the mitigation strategy (AeroATL Greenway Plan). Instead, we engage community stakeholders with a participatory modeling web tool that allows stakeholders' collective knowledge to interact with data and consolidate into insights. Such perspective and methods can help policy makers and planners to contest existing inequality in transportation connectivity infrastructure by supporting Aerotropolis residents' walking and biking trips.

## LITERATURE REVIEW

### Airport-centric Urbanism

The concept of Airport City, or Aerotropolis, turns the concept "city airport" to "airport city", in which a globally significant airport locates at the city center and concentric rings of uses radiate outward (Karsada & Lindsay, 2011). This notion resembles the classical concentric land use model where the land closest to the airports are prioritized for just-in-time logistics. More recent proposals of Aerotropolis take a different proposition from the airport as a utilitarian infrastructure and turn the airport city into a livable environment for people to meet, interact and communicate in an urban setting and a globally connected "public space" for social and business interactions that connect global cities network and its locality (Kasarda, 2013). As such, airports become key identifiers for 'global cities' (Sassen, 2005) and a mean to improve global competitiveness and engines to drive local economy (Wang & Hong, 2011). Thus, planning for airport cities is often associated with economic strategies to incorporate non-aviation industrial and commercial uses around the airports (Appold & Karsada, 2013; Peneda et. al, 2011).

The market-driven and economic-based development of the airport area has received criticism from planners and pushback from local communities. Researchers have raised environmental, economic, and social concerns that local regions may not benefit from the economic overflow of the airport expansion. Notably referenced by Kramer (2004), the Atlanta Hartsfield-Jackson International Airport exemplifies a failure where the development potential of the airport was halted by chronic noise problems, blighted and unattractive neighborhoods surrounding the airport, and the inability to coordinate regional collaborations. These neighborhoods tend to have higher proportions of people of color, renters, and low-income families (Woodburn, 2017). Angela Antipova and Esra Ozdenerol (2013)'s case study on Memphis International Airport also revealed that the existence of an airport does not promise fair job growth; many black and female workers living in the Aerotropolis are underrepresented in airport-related jobs. In addition, an airport is a 'sink of infrastructure', considering the massive investment of roads, public transit, land use, and information technology, and the institutions and capital investments poured into one location (Adey, 2006). Therefore, airports' surrounding communities are often overshadowed by airports' demand, where infrastructure is oriented to serve people transiting in and out of the area rather than the locals' needs.

**Critical Perspectives on Airports in a Network of Flows**

Aside from their economic functions, airports are transportation infrastructure systems for moving travelers. The flows between airports have been used to create hierarchies of cities in the world (Dereudder & Witlox, 2005). In these networks of flows, airports are simply abstracted into nodes, but their built environments in urban space can incur dual reality. In theory, a node or an edge can be divisive or connecting depending on its typology (Andris et al., 2018). For example, highways and heavy-traffic roads can facilitate mobility connections among access points, but also create borders and reinforce the spatial and social segregation of activity spaces (Jin et al., 2021). Similarly, airports contrast with the surrounding communities' time, space, and flows arrangements. For example, Cidell (2013) argued that an airport is an incredibly mobile place, not only because it hosts transient air passengers, but also because its built environment changes at a much faster speed than the nearby communities. Many airport businesses are more dependent on remote suppliers and customers than those nearby (Shen & Cao, 2016). Still, studies have yet to apply such network perspective to analyze dynamics between airports and local communities or develop metrics to measure the impact of airports on local mobility flows. Little is known about what planning strategies can be used to mitigate airports' negative effects and the effectiveness of these strategies.

**Scenario Planning and Participatory Modeling**

Scenario planning and participatory modeling are similar planning approaches to engage diverse stakeholders in an iterative process to create and evaluate scenarios and support the decision-making actions of the group (Goodspeed, 2020; Hedelin et al., 2021). For example, typical steps in a scenario planning project include uncertainty analysis, scenario creation, scenario analysis, and planning and implementation (Goodspeed, 2020), while steps in an effective participatory modeling framework include define complex problem, develop concern profiles, co-develop models and scenarios, simulation, deliberate trade-offs, and implementation (Zellner, 2022). The former focuses on developing and exploring alternative planning scenarios, while the latter explicitly directs the collective efforts to interact with the model's quantitative results.

Prior applications of scenario planning and participatory modeling often model land use patterns and socio-environmental interactions (Goodspeed, 2020; Hedelin et al., 2021) as grid systems. Yet, transportation scenarios often require creation of new road networks and modeling of multidimensional flow dynamics (e.g., by mode, by trip purposes, by flow volumes) that are difficult to accomplish with one set of tools. Some case studies and tools were developed to address these challenges (Goodspeed, 2023; Lovelace et al., 2017) but the evaluation of the scenarios was limited to the regional scale (e.g., city or traffic analysis zone level).

In our case study, modeling AeroATL Greenway comes with two sets of scenarios: one set is related to which Greenway segments should be implemented first (i.e., we call them network scenarios), and the other set is related to what origin-destination trips are operated along the networks (i.e., we call them trip scenarios). The interactions between these two sets of scenarios create many uncertainties and nonlinear dynamics that cannot be deliberated with reasoning alone. In addition, the goal of the Greenway is to support connectivity priorities of Aerotropolis residents, which aligns with the values of scenario planning and participatory modeling.

Our research fills the gaps in the literature by proposing a network framing to conceptualize flow dynamics between H-JAIA and surrounding communities, a *Barrier Effect* metric to quantity H-JAIA's impact on local mobility, and a set of customized tools that can evaluate the impacts of the Greenway down to the route level.

## RESEARCH DESIGN: DATA AND METHODS

### Study Area and Scope

The study area for this paper includes traffic analysis zones (TAZs) that intersect with the AeroATL Greenway Plan. TAZs are spatial units designed by planning officials to record and simulate transportation modeling data. Figure 1 shows the extent of the study area centered by H-JAIA.

We use the AeroATL Greenway Plan (in short, the Greenway) Blueprint published by Aerotropolis Atlanta Alliance in 2018 to define the scope of the Greenway network. Though we display data along all segments of the Greenway in the web tool, our scenario computation focused on the existing bike paths and segments that are planned to be implemented first, which includes Model Miles (in short, MM) and Priority Network (in short, PN) (see Figure 1). Priority Network will build upon Model Miles (thus overlaps with Model Miles segments) but may not connect with the existing bike paths.

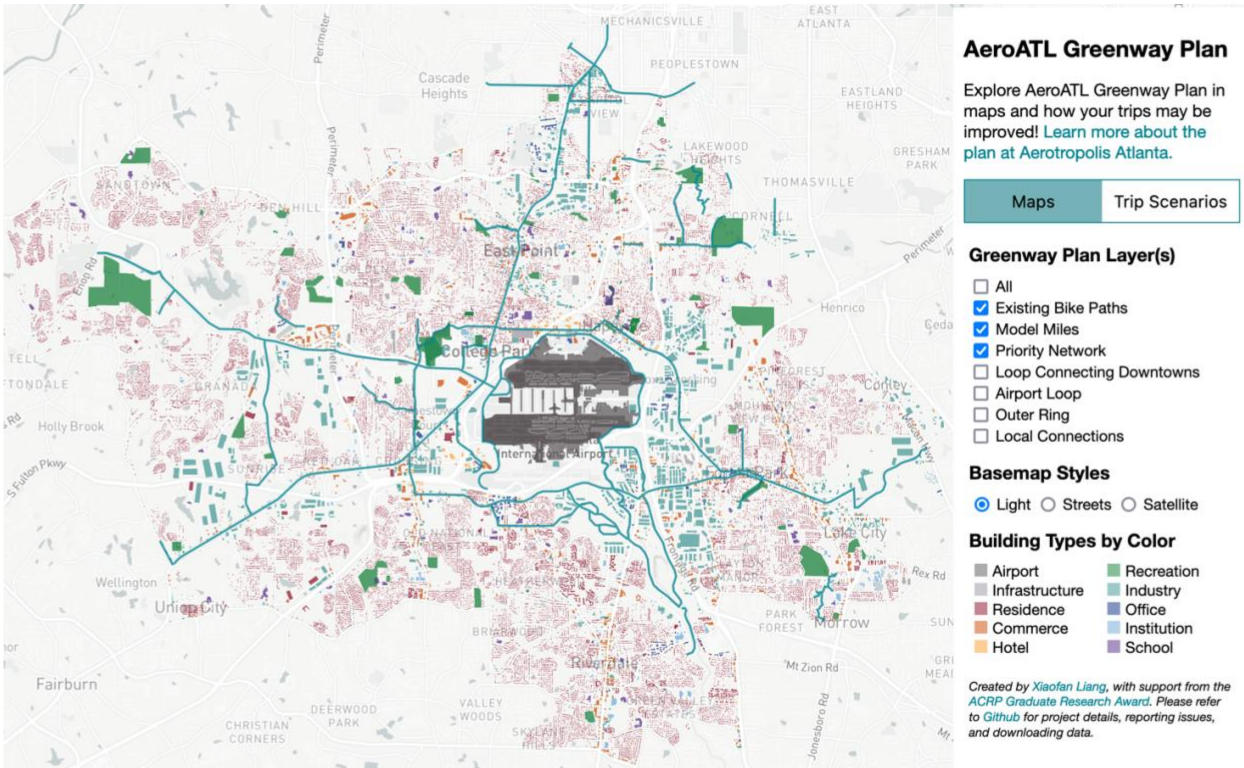


Figure 1: An image of the AeroATL Greenway Plan web tool (on the *Maps* tab) that shows the study area, parcel-level land uses, and parts of the Greenway Plan (teal lines) used in scenario modeling computation (existing bike paths, Model Miles, and Priority Network).

**Data**

All the data are clipped and filtered to interactions within the study area. First, we extracted origin and destination (OD) flow data (n=301772) from Atlanta Regional Commission (ARC)'s the most updated Activity-based Travel Demand Model in 2019. Each row of the OD data represents a simulated trip with the origin TAZ, destination TAZ, trip purpose (e.g., work), trip distance, and trip mode. We use this dataset to quantify and visualize the barrier effect of H-JAIA.

Building polygon shapefiles are computer-generated building footprints from Microsoft Maps, publicly available through GitHub. This building dataset is then spatially joined with TAZ shapefiles (acquired through ARC), land use parcels (acquired through Fulton and Clayton County GIS offices), and the job count data from Longitudinal Employer-Household Dynamics (LEHD) dataset. We use the building-level information to disaggregate the TAZ level ODs to building level ODs and compute routing distances between buildings under various network scenarios.

Our network scenarios include road networks from three sources: 1) the Greenway Plan, 2) existing bike path shapefiles published by ARC, and 3) road data from OpenStreetMap (OSM). We then manually integrated these three networks in QGIS for routing, such as snapping the Greenway Plan and the existing bike paths along the OSM road networks and connecting the breakpoints at each intersection across all three networks.

**Method: Measurement of H-JAIA's Barrier Effect**

We define a built environment's *Barrier Effect* as the extra cost to travel across it, measured by the ratio between its two surrounding points' Euclidean distance (i.e., shortest possible distance) versus travel distance. We adapted this term from landscape ecology research that examine how built environment, such as highways and specific urban forms, impede animals' movements (Forman & Alexander, 1998). If the *Barrier Effect* is high (i.e., low ratio between Euclidean vs. travel distance) between two points, we assume the built environment between the two points inhibits efficient travels and vice versa. Thus, this metric is flexible to measure the barrier effect of an area in any shape.

We use the Activity-based Model's TAZ-to-TAZ OD data to represent travel demands around H-JAIA. Trips from and to the H-JAIA TAZ are removed. Then we calculated the *Barrier Effect* between TAZ centroids in each mode (driving alone, biking, and walking) and visualized on maps. If H-JAIA and its surrounding environment are mobility barriers, we expect to see a high *Barrier Effect* for trips across the airport or its nearby area.

**Method: Scenario Modeling and Computation**

Our scenario modeling compares six network scenarios and computes two metrics for each. We call the network with existing roads and bike paths the *base* scenario, representing the baseline for comparison. Implementation of Model Miles in addition to the *base* scenario is the *MM* scenario, and the implementation of Priority Network in addition to the *MM* scenario is the *PN* scenario. Since we measure the impact of the Greenway through two modes (walking and biking), each of the three scenarios have two sets of road weights, leading to six network scenarios in total.

We use two metrics to evaluate the network scenarios: 1) trip distance, i.e., whether the Greenway implementation reduce travel (routing) distance for walking and biking trips, and 2) trip experience, i.e., whether the Greenway implementation increases the percentage of trip distance on the Greenway and residential roads. Only roads and ODs happened within the TAZs intersected with network scenarios are included in this analysis.

Figure 2 shows detailed steps to integrate and process data from various sources for scenario modeling and computation. Few simulated trips in ARC Activity-based Model have walking or biking mode, so we assign those with travel distances less than or equal to two miles (40 mins walk) and three miles (15 mins bike ride) as possible walking and biking trips, respectively. Since many Model Miles segments are only a few hundred meters, a scale too small to be captured by TAZ level OD flows, we disaggregate the OD flows to the building level. Each TAZ trip is first matched to buildings with the corresponding TAZ and land use for the trip purpose (e.g., office land use is matched with work purpose). Then we assign the trip to buildings more likely to have large footprints and high job counts. Lastly, R package *dodgr* is used to compute trip (routing) distances (total and breakdown by road types) for each network scenario.

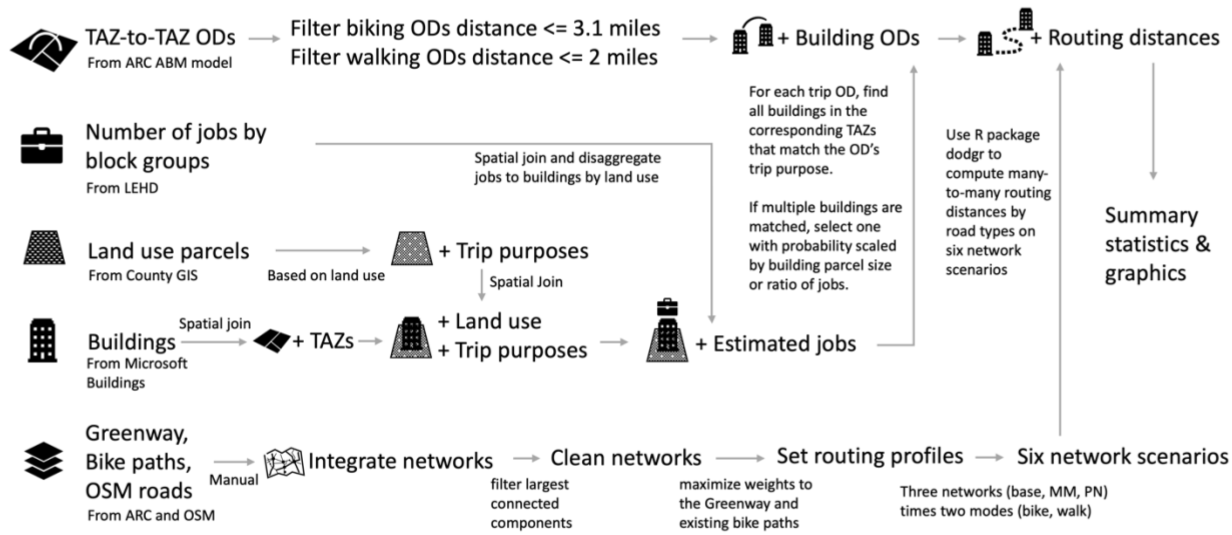



Figure 2: Methodology workflow shows how various data are integrated to calculate routing distances under different network scenarios.

**Method: Participatory Modeling Workshop**

We host a one-hour, in-person participatory modeling workshop with Aerotropolis Atlanta's Community Development Collective members on June 13, 2023. Participants include ten people from local jurisdictions nearby H-JAIA, Aerotropolis Atlanta leadership, and regional planning agencies (e.g., Georgia Department of Transportation). The goal of the workshop is to use the interactive web tool we developed to help community stakeholders better understand how the Greenway may affect their communities' biking and walking trips and to discuss how well the model outcomes from the web tool align with their experience.

The workshop includes four steps: 1) an introduction presentation that sets the contexts, 2) a demo of the web tool, 3) a group activity to formulate questions and experiment trip scenarios (i.e., origin-destination pairs) with the web tool, and 4) a group sharing to convene the insights and next-steps (see details of workshop agenda and worksheet in Appendix). We ask participants to fill in a survey (i.e., worksheet) for step 3 and 4 and report the qualitative coding of the results in step 4 in this manuscript. The workshop steps are designed to align with a framework of effective participatory modeling as articulated in the Literature Review section.

Our web tool is publicly available (https://xiaofanliang.github.io/AeroATLGreenway/) and has two tabs (see Figure 1 and Figure 3). In the *Maps* tab, users can filter different Greenway Plan segments, change basemap styles to highlight different built environment features, and hover to individual buildings to see attributes (such as building land use). In the *Trip Scenarios* tab, users can select any origin and destination locations on the map, and the tool will visualize the route with and without Priority Network implemented (i.e., *base* network scenario vs. *PN* network scenario). The web tool will also report total trip distance and the percentage of trip distance on the Greenway to help users conceptualize the benefits of the Greenway. This particular design serves practical needs of Aerotropolis Atlanta to easily maintain and access the tool which is flexible enough to engage diverse stakeholders inquires and areas of interest.

We implement the web tool through Mapbox JS. However, Mapbox JS does not support routing computation on user-customized networks (i.e., the Greenway Plan). Thus, we create a web API (with R *plumber* package) for the same R codes we use in scenario modeling, containerize the API through

Docker, and host the API on Google Cloud Run. As such, when users select an origin and destination on the web tool, a request is sent to both the Mapbox JS Direction Plugin and our custom API to retrieve routing geometry and statistics with the existing road networks and the Greenway (i.e., PN scenario), respectively.

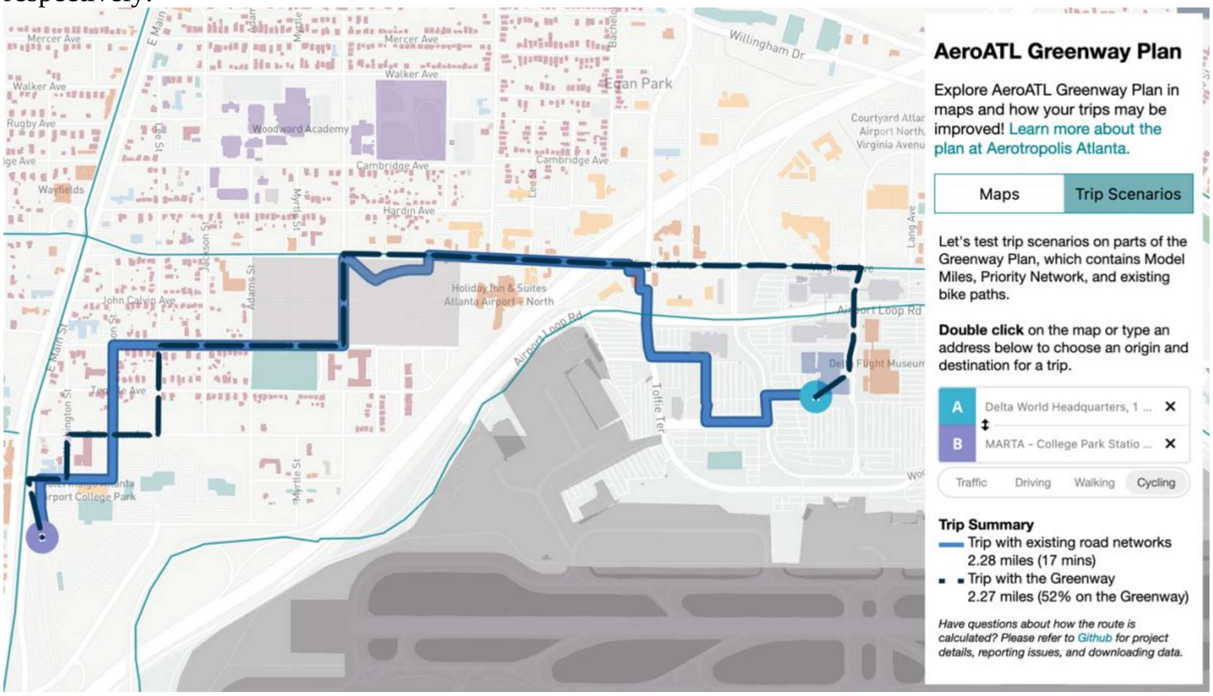



Figure 3: An image of the AeroATL Greenway Plan web tool (on the *Trip Scenarios* tab) that shows the interface for users to select the origin and destination for a trip scenario, the mode of the trip, and trip statistics in summary. The solid blue line shows the route without the Greenway, and the dashed black line indicates the route with the Greenway (*PN* scenario).

## RESULTS

### Barrier Effect of Atlanta Hartsfield-Jackson International Airport (H-JAIA)

Figure 4 shows trips that encounter a high barrier effect in the study area. Not surprisingly, these trips concentrate around and across the H-JAIA, with travel distances two times (or longer) than their Euclidean distance (i.e., a ratio of 0.5). We found three elements that correlate with a high barrier effect based on descriptive observations of the base maps. First, H-JAIA, as a large and restricted land use, increases travel distances for trips that need to go across H-JAIA. The barrier is so big that few walking and biking trips are possible across the airport. Second, multiple highways (yellow lines in the base map) surround H-JAIA to efficiently move regional travelers in and outside of the airport. However, these highways also underpin many dark red lines (i.e., trips with a high barrier effect), indicating a lack of direct crossings for local mobility. While the first two elements are related to airport land uses, natural environments such as camp creak (Northwest of H-JAIA) and flint river (Southeast of H-JAIA) and poorly designed urban road networks can also be linear barriers that impede efficient local flows.

H-JAIA's barrier effect is also more prominent on biking and walking trips in the study area: only 7% of all trips in the study area are walking or biking based on the ARC's Activity-based Model, while more than 50% are predicted to be driving alone. Though these percentages are close to the average mode split in the Atlanta metro area, the gap still indicates uninviting built environments around H-JAIA for walking and biking purposes. In addition, 5.7% of biking and walking trips in the study area encounter high barrier effect (ratio of 0.5 or lower), compared with 4.2% of driving alone trips. These observations confirm our hypothesis that H-JAIA and its surrounding environment are mobility barriers for residents, with greater impacts on biking and walking trips than driving trips.

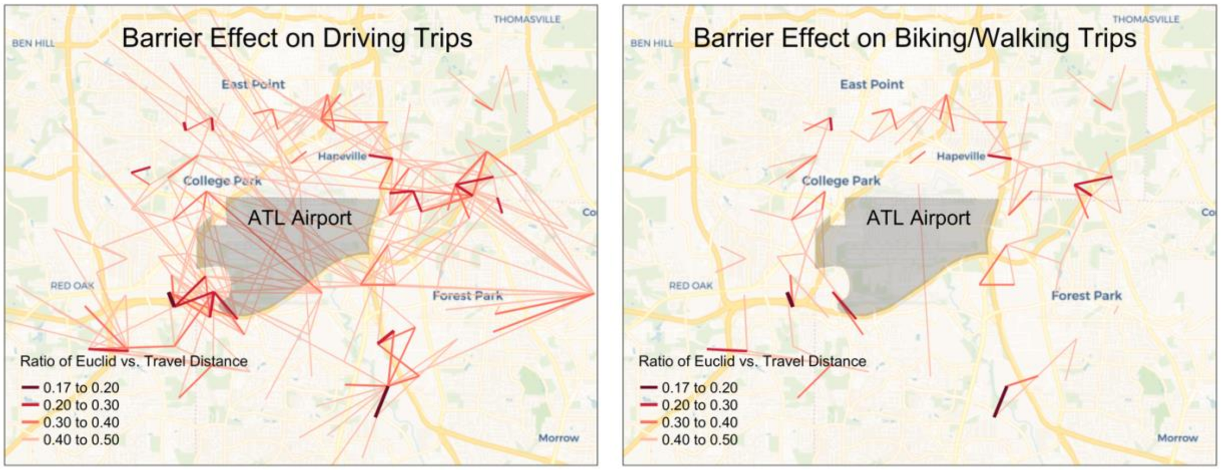



Figure 4: H-JAIA's barrier effect on driving, biking, and walking trips in the study area. Each line represents a trip between two traffic analysis zones (TAZs). Darker line color represents a high barrier effect, which means the travel distance is much longer than the shortest possible distance (i.e., Euclidean distance). The base map shows highways (in yellow) and rivers (in light blue).

**AeroATL Greenway Plan's Impact on Walking and Biking Trips**

To what extent can AeroATL Greenway Plan reduce H-JAIA's barrier effect and support local walking and biking trips? Figure 5 shows that, compared with the *base* scenario, implementation of the Model Miles (*MM*) and Priority Network (*PN*) in the Greenway Plan has minimal effect on the total walking or biking trip distances, but yields positive impacts on trip experience, especially in the *PN* scenario. With the breakdown of trip distance road types, we can see that under *MM* scenario, only 8-10% of trip distance will be covered by the Greenway. However, under the *PN* scenario, 37-38% of trip distance can be on the Greenway, and the proportion on primary, secondary, and tertiary roads are cut by half. Moreover, in the *PN* scenario, 77% of walking and 66% of biking trip distances can be on residential roads or the Greenway, which presents greater incentives for a mode switch from driving.

The greater impact of the *PN* scenario may have several causes. First, Model Miles are very fragmented (see Figure 6), while Priority Network unites these segments into a larger interconnected network, thus increasing trip distances that can be on the Greenway. Second, the interconnectivity of the Priority Network also incentives switching to alternative routes that favor the Greenway or residential roads.

We further mapped walking and biking trip origin-destination (ODs) pairs with significant benefits in the *MM* or *PN* scenario, defined as trips that will reduce more than 400 meters in travel distance or increase 50% more distance on the Greenway or residential roads. Figure 6 shows that different Greenway segments provide different types of benefits. Most ODs benefited are located closer to the center of network (i.e., H-JAIA) and less at the fringe. For example, in the *MM* scenario, *Airport City Connector* segment helps reduce trip distances in the College Park area, while the *Porsche Avenue Trail* segment helps improve walking and biking experience at downtown Hapeville. Other segments, such as *Wolf Creek Trail* and *Flint River Connection*, are designed to serve recreational rather than commuting purposes, and thus are underrated in our benefits metrics. Combined with local knowledge, local planners can further examine these benefit hotspots to gain insights.

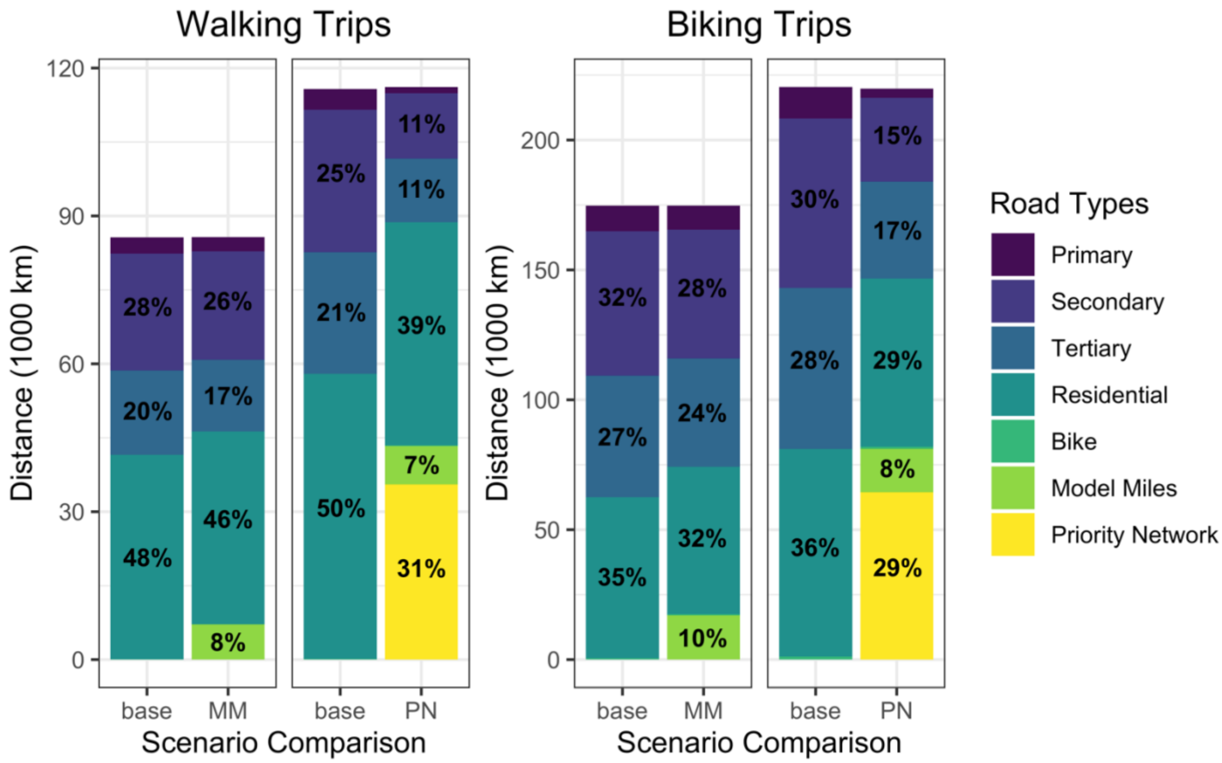
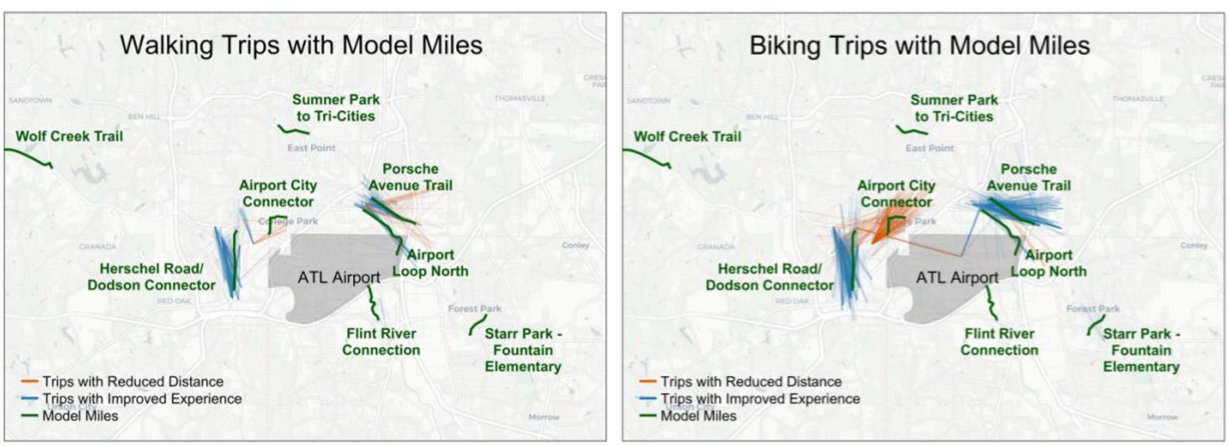



Figure 5: Comparing trip distance and distance by road types (trip experience) for walking and biking modes, under *base*, Model Miles (*MM*), and Priority Network (*PN*) network scenarios. The *PN* scenario includes a wider road network and assesses more OD trips than *MM* scenario.



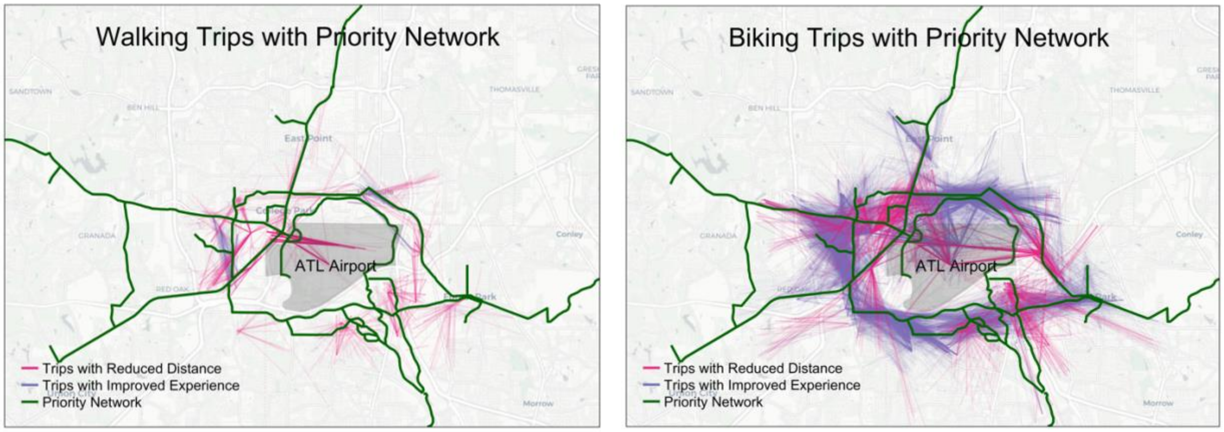


Figure 6: Spatial distribution of walking and biking trips that have significant benefits on reduced distance or improved experience. Each line is an origin and destination pair from one building to another.

**Qualitative Interpretations of Participatory Modeling Workshop Survey**

*Workshop Step 4 (Group Sharing): Does the web tool show that the trips(s) using the Greenway are better? Do you agree?*

All participants (n=10) have reported that the trip scenarios with Greenway are better, and they also agreed with the evaluations from the web tool. Based on the trips participants modeled with the web tool (in step 3), 80% have shorter distance (though most of the difference in distance is within half a mile) with the Greenway, with at least 80% of trip distances covered by the Greenway. Yet, one participant pointed out that, “only places nearby the Greenway can maximize the trip benefits. You have to be in the network” (Anonymous, answer in the worksheet). In addition, one person brought up that for the same origin and destination pairs, some suggested biking routes are much longer than the walking routes. This is because the routing algorithm favors biking routes through roads with less traffic but does not do the same for pedestrians. Still, this conversation challenges the model assumption, as bikers and pedestrians in real life may not follow routes suggested by the routing algorithm. As one participant said, “the final test is to actually walk or bike it to see if I am ready to traverse this way” (Anonymous, answer in the worksheet).

*Workshop Step 4 (Group Sharing): What did you learn from using this web tool? Does the web tool change your perception of the Greenway and if so, how?*

Most participants (n=8, two did not say explicitly) learned that the study area has few walking and biking infrastructure, but huge potential for multimodal planning (e.g., “the tool shows me that I could walk more to my local spots because most destinations are within a mile”, anonymous, answer in the worksheet). The web tool’s visualization and the trip scenario comparison also help the participants gain trust and commitment to the Greenway Plan (e.g., “To see it visually, I am more onboard”, anonymous, answer in the worksheet). The groups also agreed on the importance of network interconnectivity: both the existing bike lanes and Model Miles are very fragmented, and local jurisdictions should advocate for the more connected Priority Network.

Overall, the combination of the workshop and the web tool has proven effective at promoting stakeholder trust and actions. Specifically, Aerotropolis Atlanta leadership found the tool effective in communicating the Greenway plan to community and business stakeholders and would like to use the web tool to help design and evaluate the next blueprint for the AeroATL Greenway.

Figure 7: Pictures of the Participatory Modeling Workshop. Credits: Sulisay Phonekeo.

**Discussion**

This paper introduces a case study showing the contrasting roles of two network infrastructure, Hartsfield-Jackson Atlanta International Airport (H-JAIA) and AeroATL Greenway Plan, at moderating local mobility flows. Our results show that H-JAIA and its surrounding environment impede efficient travels between origin and destinations in Aerotropolis (study area), especially for biking and walking trips. In contrast, the AeroATL Greenway Plan can contest this dynamic by improving Aerotropolis residents' walking and biking trip experience, with stronger impacts observed with Priority Network implemented. Yet, the impacts can be limited for a few reasons. First, the effect of the Greenway is highly heterogenous in space. Some Greenway segments following the existing road networks can improve trip experience, while others traversing through parks for recreational purposes have little benefits in trip distance or experience. Second, the first phase implementation (i.e., Model Miles) of the Greenway is quite fragmented because each of the seven local jurisdictions decided on one segment, resulting in a lack of interconnectivity between the segments.

Our study suggests that the local jurisdictions should move toward the Priority Network scenario and consolidate the specific design of the Greenway Plan. An interconnected biking and walking network brings disproportionally more benefits per distance because it opens possibilities for trips to be re-routed through the Greenway, incentives residents to switch from driving to biking or walking mode, and attracts locals to the Greenway for recreational purposes. In addition, the specific design of the Greenway, such as whether it connects to an intersection, follows the existing roads, travels in both directions, and breaks a dead end, will make a big difference in the effectiveness of the Greenway and will help ensure a more robust routing outcome. The web tool we developed in this study can be helpful to evaluate these designs, allowing stakeholders with diverse interests to see the impacts of the Greenway with specific trip scenarios.

This study comes with some limitations. Since the paper focuses on a narrative contesting whose (regional traveler vs. local residents) and what types of connectivity (driving vs. walking and biking) is being prioritized in the Aerotropolis area, we did not expand each sub-analysis to the fullest extent. For example, other measurements of the *Barrier Effect* may capture the direction and strength of flows beyond a ratio of distances. An agent-based model may complement the computation in scenario modeling to account for the dynamics of time and traffic and repeat the stochastic distributions of building-level trips  multiple times to average the results. The participatory modeling workshop can also extend to more sessions so that participants have more time to formulate shared concerns and scenarios, which are crucial to the success of this type of practice. Nonetheless, our study contributes to a network-based perspective to conceptualize the connectivity inequality in the Aerotropolis context and a case study of supporting the planning of connectivity infrastructure (i.e., the Greenway) for the Aerotropolis residents with scenario computation and participatory modeling.

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