

Bridges of the BeltLine¹:

IoT Research in Progress Brief February 2021

The Project:

The Atlanta BeltLine weaves under, over, and through a multitude of overpasses, footbridges, and tunnels. As in any city, this significant feature is simultaneously an asset and a potential hazard. These types of structures are "vulnerable critical facilities" that should be included in emergency risk assessments and mitigation planning (FEMA, 2013). As such, *Bridges of the BeltLine* was proposed as a mixed-methods study to understand how the Atlanta BeltLine can be used as an emergency management asset. The project focuses on the Eastside Trail, using surveys, extant data provided by Atlanta BeltLine, Inc. (ABI), and application of IoT technology (wireless sensors) to collect people flow data at places along the pathway that have been identified as critical, and also at ingress and egress points to estimate the number of people who traverse the designated sections. The methodology employed is consistent with other multiuse trail and/or citywide pedestrian and traffic monitoring efforts, including those conducted in Minnesota (Lindsey, Petesch, Vorvick, Holdhusen, 2017), Chicago (Lindsey, Gobster, Sachdeva, 2019), Cincinnati Metropolitan Region, Ohio (Lindsey, Singer-Berk, Johnston, Adcock, Folkerth, & West, 2019), and the Buffalo Valley Rail Trail in Union County, Pennsylvania (Oswald, Beiler, McGoff, McLaughlin, 2017).

Multiuse trail development has been an aspirational and realized method to promote the public, economic, and environmental health of urban and suburban communities. These pathways provide nonmotorized access to neighborhoods and businesses, aspiring to be a commuting alternative, a recreational oasis, and an economic boon for local economies. Repurposing of unused railways and canals to create greenspace is supported by federal dollars via MAP-21, the *Moving Ahead for Progress in the 21st Century Act* (P.L. 112-141), and by regional and local investments and private funders. Along with these investments comes a requirement to report on return. Do the trails have their intended effect? How and to what extent are the communities being served by the trail? What impact have these trails had on recreation and tourism, public health, crime, transportation, land development, real estate, the environment? These are the primary questions found in the literature on multiuse trails (Scherrer, et al., 2020). While public safety issues are addressed in the literature, they center on designing safe spaces (e.g., lighting, directional signage, emergency vehicle access) and ensuring resident and visitor perceptions of safety are positive (Luymes & Tamminga, 1995). These are important factors, but absent from the multiuse trail literature is the topic of emergency planning and mitigation.

One conceivable emergency response use case is leveraging the BeltLine as a nonmotorized evacuation route and alternative means of accessing community assets when roadways and highways are unpassable. Figure 1 shows two occurrences in Atlanta's recent history that impacted traffic congestion and, by extension, linkage to local amenities. After several meetings and correspondence with the ABI leadership to gain authorization to conduct research on the BeltLine, it became apparent that ABI's primary interest is in understanding which communities are being served by the BeltLine and whether it has changed commuting and travel behaviors or created new demand.

¹ For further information on the project, contact Salimah LaForce <u>salimah@cacp.gatech.edu</u>

Figure 1: 2014 Snow Jam Atlanta and the Interstate 85 Bridge Collapse (2017)



As a result, we have pivoted the project's purpose to include understanding which communities are being served and for what kind of use. As such, the project's purpose is now two-fold: to facilitate understanding of (a) whether the BeltLine is serving the adjacent communities and purpose of use, and (b) inform emergency mitigation, planning, and response. We will implement a prototype people flow system at street level access points, shopping and dining access points, and housing access points. These data will complement data collected via an intercept survey² that describes BeltLine users, querying on demographics, reasons, frequency, duration of use, distance traveled to the BeltLine, mode of transportation to and on the BeltLine, and more. The BeltLine has a few EcoCounter break-beam/magnetic loop systems³ already deployed in select locations, and we intend to get hourly data from those systems. These data still apply to the project's original purpose, but the expanded purpose enables the project's results to have an additional and immediate use for ABI in making data-driven decisions concerning BeltLine improvement projects and the continued development of the unpaved sections. The Bridges of the BeltLine moniker's meaning has pivoted from being concerned with the physical bridges to conceptually bridging communities.

Project Status:

<u>Survey.</u> The project has received Institutional Review Board (IRB) approval to conduct the intercept surveys. The survey instrument has been developed and vetted amongst team members and ABI. It is a 22-item survey and includes "display if" logic on certain question options to assess whether commuters are using the BeltLine to connect to public transportation and whether the use of the BeltLine has supplanted other transportation modes, particularly driving. Based on the survey questions, the results should supply valuable insights that can inform several domains, including emergency management, community development and underserved communities, sustainability, and resiliency.

Development. There have been two important changes in technical development. We are primarily pursuing a low-power, low-cost doppler radar system for people detection, and we have shifted focus from LoRaWAN to NB-IoT for data backhaul. With support from Kore Wireless, integration of a new radio module

² An intercept survey method is onsite data collection.

³ https://www.eco-compteur.com/en/produits/multi-range/multi-nature-2/

for data backhaul has begun with the nRF9160, using the NB-IoT cellular technology. This approach takes slightly more power than the originally planned LoRaWAN system but avoids the uncertainty of building out our own LoRaWAN coverage, as existing cellular networks can be used. It also allows for scaling up or reusing the design later, alleviating concerns about the data backhaul infrastructure. Various sensing technologies were evaluated, and discussions with ABI, Inc. resulted in designing a small, unobtrusive system to make unattended multi-day deployment more acceptable. The small size limits our available electrical power, as it limits both solar power and battery size.

Many trail use monitoring systems are available, but each has its strengths and weaknesses. For example, passive infrared monitors are an option, but when used alone, cannot separate modality type and require the integration of another sensing technology, such as inductive loops (Lindsey et al., 2019.) An initial consideration in determining which type of sensor to use was the exact counting of people in groups, as undercounts due to occlusion are a common limiting factor to system accuracy (Lindsey, Gobster, Sachdeva, 2019). Furthermore, this study aims to develop a sensor that can differentiate user modality types (e.g., walkers, cyclists, scooters). Several higher power, more complex systems were investigated and eventually dismissed. Steerable radar arrays require complex integration and higher power, as well as mounting options. Embedded camera-based facial detection algorithms can capture separate people in groups, but their use invokes privacy concerns, and they require substantial on-device data processing. Optical break-beam sensors have acceptable accuracy levels but would not be able to differentiate travel modality type without multiple sensors a few feet apart, complicating installation.

The power and size constraints, combined with the project timeline constraints, led to focusing on non-steerable 24-GHz doppler radar modules. While this system will not be able to accurately count individual people in large groups, it will be able to separate people by speed, giving us a method for identifying transportation modality while maintaining counting accuracy similar to the current Eco-counter sensors that the BeltLine has installed. We anticipate that installing doppler radar modules at the lower-density access paths to the BeltLine will reveal what kinds of trips BeltLine users are taking and where they are coming from, rather than just people count along the main trail.

Conversations with the ABI, Inc. and Georgia Tech's IRB have led to the use of technologies that are inherently privacy-preserving. As a result, sensing systems like our radar approach or the currently installed optical break-beam approach are preferred over systems based on cameras or uniquely identifying people by their cell phone's radio. However, this project's prototype system is less expensive, more easily installed, and once tested, refined, and validated, could provide an economically and technically sound alternative to what is currently available.

Anticipated findings and possible sustainability:

The knowledge generated by Bridges of the BeltLine will, 1) provide an evidence base to inform future development of low-cost, low power integrated sensor network for measuring the impact of multiuse trails on the adjacent communities, and 2) increase knowledge among local and state emergency managers about how the BeltLine can be used as an emergency response asset. This project will pilot the developed sensor system and intercept survey. Pilot studies provide many needed details about how subsequent improvements can be made to the study's measures, methods, and products. As such, upon study completion, to document and detail the overall effectiveness of performance, the project will conduct a summative evaluation to compile information about its outputs and determine their likelihood for bringing about desired outcomes, societal impacts, and areas for improvement. The evaluation's primary goal is to assess whether and to what extent the project activities and objectives have been met. The evaluation results will be used to inform how the pilot project can be scaled. Both the findings of the pilot study's preliminary data and the summative evaluation will be used to pursue future funding.

Anticipated Deliverables and Next Steps:

In addition to the project's data products (senor and survey), we will also have developed and demonstrated a people-counting system for monitoring flow into, out of, and along multiuse trails like the BeltLine. This includes an important capability specifically useful for studying urban mobility and multiuse trails: the ability to differentiate nonmotorized traffic by speed. We plan to publish our sensor system's designs and validation information for use by other researchers and citizen scientists, adding to the growing capabilities of low-power wireless sensor networks for use in smart cities and communities.

Bridges of the BeltLine will support knowledge translation through a dissemination program and a complementary set of utilization activities to ensure the usability of research products. Research findings will be disseminated to four direct target audiences for the project: 1) local and state emergency managers, 2) city and state officials, 3) the ABI, Inc., Atlanta BeltLine Board of Directors and other associated organizations, and 4) the academic community. In the longer term, this applied knowledge will impact (1) emergency planning and mitigation measures, (2) the disaster resiliency of the communities that are connected by the Atlanta BeltLine, (3) and the ecological impact of multiuse trails.

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Technical Advisor:

Kore Wireless provided expert knowledge on the current developments and tradeoffs in low-power IoT sensors, specifically data backhaul and sensing technologies. Their help and support have been key in several important implementation decisions.

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