Charlotte Transportation: Rethinking the Commute

Dylan Benson
School of Data Science
University of North Carolina at Charlotte
Charlotte, North Carolina, USA
dbenson4@charlotte.edu

Paige Picket
School of Data Science
University of North Carolina at Charlotte
Charlotte, North Carolina, USA
ppicket1@charlotte.edu

Fabiola Rojas
School of Data Science
University of North Carolina at Charlotte
Charlotte, North Carolina, USA
frojas4@charlotte.edu

Chris Weihrauch
School of Data Science
University of North Carolina at Charlotte
Charlotte, North Carolina, USA
cweihrau@charlotte.edu

Abstract

Charlotte is experiencing rapid population growth, which demands an efficient and equitable public transportation system. The Charlotte Area Transit System (CATS) experiences significant ridership despite a high car ownership rate, but several concerns highlight the need for improved transit accessibility. This study examines transit challenges, including declining ridership, service inefficiencies, and socioeconomic disparities in public transportation access. Prior research identifies demographic inequities in bus transit, gentrification effects of rail investments, and limited benefits from new transit expansions. Leveraging data from Charlotte's open data portal, we integrate ArcGIS mapping and optimization models to analyze the impact of proposed light rail and bus expansions on accessibility. Our research assesses whether transit investments effectively address mobility needs while ensuring equitable urban development.

CCS Concepts

• Information systems → Geographic information systems; **• Applied computing → Transportation**; **Urban computing**.

Keywords

Charlotte, North Carolina, Light Rail, Public Transportation, Accessibility, Data Science, Bus Transit

ACM Reference Format:
Dylan Benson, Paige Picket, Fabiola Rojas, and Chris Weihrauch. 2018. Charlotte Transportation: Rethinking the Commute. In *Proceedings of Make sure to enter the correct conference title from your rights confirmation email (Conference acronym 'XX).* ACM, New York, NY, USA, 4 pages. https://doi.org/XXXXXXX.XXXXXXX

Conference acronym 'XX, Woodstock, NY

ACM ISBN 978-1-4503-XXXX-X/2018/06
https://doi.org/XXXXXXX.XXXXXXX

1 Introduction

Charlotte is the third fastest-growing city in the United States, with its population expected to rise from 1.87 million to 2.74 million between 2010 and 2030 (World Population Review, 2025). Despite a high car ownership rate of 95Providing essential mobility for residents, reducing traffic congestion, and mitigating environmental impacts are critical concerns. Our project will not only dissect these challenges but also explore potential solutions. By mapping current access points and examining financial flows into transportation development, we aim to identify whether investments disproportionately benefit wealthier districts. Comparing existing infrastructure with proposed expansions will allow us to assess whether planned improvements effectively address disparities. Through a data-driven approach, we will analyze the proposed light rail expansions and stations to determine their impact on accessibility and their overall value to Charlotte's transit system. This research will provide insights into opportunities for creating efficient and equitable transportation for all residents.

2 Background

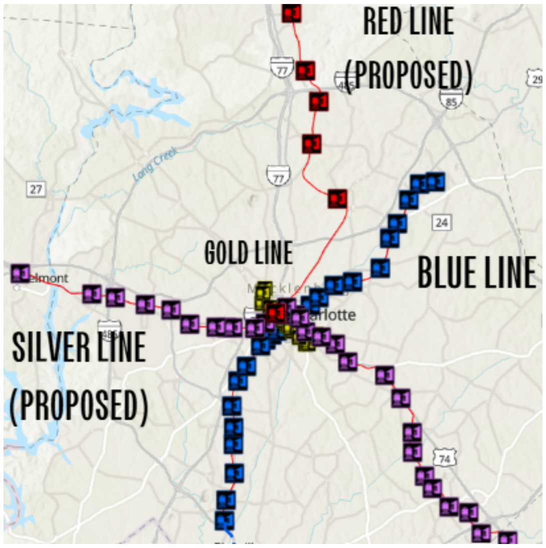
Charlotte's public transportation system plays a crucial role in urban mobility and economic development, but it faces ongoing challenges, including declining ridership, service inefficiencies, and safety concerns. The city's transit network consists of a bus system and a light rail system, both of which are essential for residents who rely on public transit for commuting and daily activities. However, recent studies highlight significant disparities in accessibility, safety, and service quality, particularly among different demographic groups. The need for targeted improvements, including technological advancements such as real-time tracking applications, is evident as Charlotte seeks to enhance the efficiency and equity of its transit system. Public bus transit in Charlotte is marked by long wait times, safety concerns, and inefficiencies that disproportionately affect certain demographics. Hosseini et al. (2024) conducted a survey-based study on bus transit in Charlotte, revealing that East Charlotte residents and women face longer wait times, Black residents report heightened safety concerns, and infrequent and higher-income users cite privacy issues. The study emphasizes strong support for technological improvements, such as real-time tracking apps, to enhance service reliability and user experience. These findings underscore the need for targeted policy interventions to improve bus transit while ensuring accessibility and inclusivity. Similarly, the CityLYNX Gold Line Fare Analysis offers further insights into these issues, specifically examining the impact of fare structures on access to Charlotte's CATS system. The fare analysis held directly by the CATS system provides a comprehensive evaluation of the fare structure's equity and effectiveness in Charlotte's transit system. The report talks about how fare-free operations significantly increased ridership, particularly benefiting low-income and transit-dependent populations. The analysis also highlights the disproportionate impact that fare implementation could have on marginalized communities. The report's findings suggest that maintaining a fare-free model or introducing a minimal fare with targeted support measures may enhance accessibility while minimizing negative effects. Beyond buses, transit investments—particularly in light rail—have had significant socioeconomic impacts on Charlotte's neighborhoods. Schmidt et al. (2024) analyzed how new urban rail lines have affected neighborhood demographics and property values. Their research found that lower-income areas near transit lines experience gentrification, leading to potential displacement, while middle-income neighborhoods primarily see rising property values. These findings highlight the equity concerns surrounding transit development, as investments in infrastructure can unintentionally push out the very residents who rely on public transportation the most. The broader implications suggest the necessity for transit planning policies that mitigate displacement while promoting economic development. The impact of new transit investments on commuting patterns is another key area of concern. Li et al. (2024) examined the effects of new light rail transit (LRT) lines in Charlotte, Dallas, and Los Angeles, using restricted Census Bureau microdata. Their findings indicate that Charlotte experienced a 10The broader implications of Charlotte's transit challenges and investments highlight the necessity for a balanced approach that prioritizes accessibility, equity, and economic sustainability. Effective transit planning must address disparities, ensure affordability, and integrate technology for better service. Moreover, the impact of transit expansion on neighborhood demographics and property values calls for policies that prevent displacement while fostering inclusive economic growth. As Charlotte continues to develop its transit infrastructure, data-driven research will be critical in guiding equitable and efficient urban mobility solutions.

3 Data Description

Our primary dataset comes from the City of Charlotte's open data portal, which provides spatial data on the current and proposed routes for the LYNX light rail and CATS bus system. This dataset includes geographic information such as route maps and station coordinates. We plan to integrate this data into ArcGIS to create an interactive transportation map. Additionally, we will develop an optimization model to assess whether the proposed expansions effectively enhance transit efficiency. Our main objective is to evaluate transit accessibility across different districts based on proximity to light rail and bus stations. Districts can be defined in multiple ways, including zip codes, area codes, council districts, and neighborhoods. While neighborhoods offer a more localized perspective, their boundaries are often subjective and inconsistent. Therefore, we will primarily focus on zip codes and council districts for a more standardized analysis. To achieve this, we will build models incorporating both the current and proposed transit networks. These models will allow us to measure Charlotte's current level of accessibility and determine whether the planned transit additions will improve connectivity. If the proposed expansions do not significantly enhance accessibility, we will explore other factors influencing the expansion, such as economic development or population growth. Ultimately, this project will provide insights into both the present state of Charlotte's transit system and the potential impact of future developments.

4 Methodology

This study evaluates Charlotte's current and proposed LYNX transit systems using spatial and statistical analysis to assess accessibility and equity. We used datasets from the City of Charlotte's open data portal, focusing on three transit lines: Blue, Gold, and Silver. Each dataset included station names, geographic coordinates, and multimodal attributes such as ParknRide and BikeLocker availability. One of the key challenges encountered during data preprocessing was the presence of missing GeoID values in the Silver Line dataset. Because these identifiers are crucial for accurate geospatial mapping, we chose not to impute them to avoid introducing errors. Instead, we acknowledged these gaps as a limitation to the spatial precision of our results. We standardized and cleaned the data by converting coordinate values and ensuring consistency across station labels and attributes. Our geospatial analysis was conducted using ArcGIS. We plotted station coordinates to visualize the distribution of active and proposed stops and to identify clusters of transit investments. Separate layers were created for each line, enabling visual comparisons of spatial trends. In particular, we assessed whether certain areas were underserved or overserved based on the density and location of transit infrastructure. Cluster analysis helped reveal focal points of investment and areas with potentially inequitable coverage. In addition to spatial visualization, we conducted statistical testing to examine differences in accessibility features. We used Chi-Square and Kruskal-Wallis tests to determine whether the availability of ParknRide and BikeLocker amenities differed significantly between current and proposed stations. The null hypothesis (H) stated there would be no difference in these features between the two groups, while the alternative hypothesis (H) proposed that differences would exist. We also ran correlation analyses between station coordinates and parking capacity to uncover potential spatial dependencies in infrastructure planning. Despite our efforts, there were key data limitations. The missing GeoID values in the Silver Line dataset restricted geospatial accuracy. Additionally, we lacked demographic and ridership data, which limited our ability to evaluate equity outcomes directly. To mitigate this, future analyses should incorporate proxy indicators such as median household income, car ownership rates, or transit dependency by zip code. These measures would allow for more effective analysis on the equitable distribution of transit resources. 1



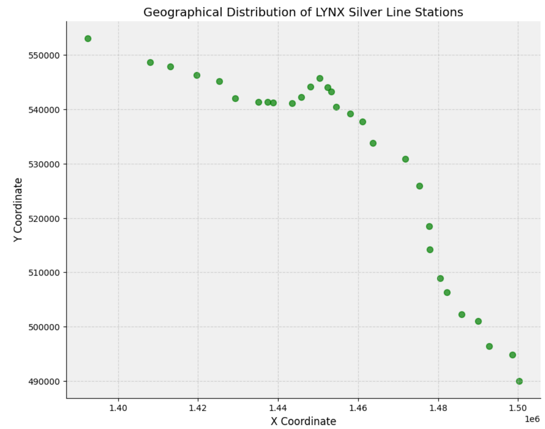
h

Figure 1: Current and Proposed Light Rail Stops

5 Results

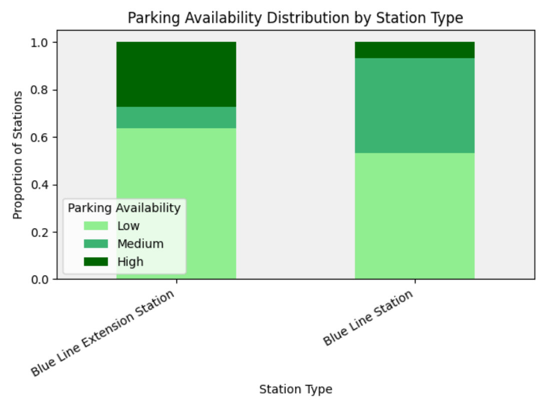
Our analysis of the LYNX transit line datasets revealed key spatial, structural, and accessibility insights across the Silver, Gold, and Blue lines. The Silver Line dataset highlighted a broad geographic distribution of stations, with naming conventions featuring common prefixes and suffixes. Phase A included the largest number of stations and showed a notable correlation with ParknRide availability, indicating a planning emphasis on accessibility. However, the absence of a GeoID column limited geographic precision in mapping and identifying spatial trends, posing a challenge for more granular spatial analysis.

The Gold Line consisted of 35 stops, evenly split between operational and proposed statuses. Visual mapping revealed that proposed stops tend to cluster in high-traffic and high-income neighborhoods, pointing to strategic expansion plans. Naming analysis found that most stop names were unique, supporting the line's role in serving diverse areas. A moderate negative correlation between X and Y coordinates suggested a deliberate linear route structure, likely shaped by city planning and transit flow. Cluster analysis of stop distances identified several focal points where investments may be concentrated, potentially driven by surrounding population density and economic activity. For the Blue Line, correlation analysis indicated a moderate positive relationship between station coordinates and parking space availability. Stations with ParknRide access consistently featured significantly higher parking capacities than those without, emphasizing their role in extending accessibility. Additionally, stations offering BikeLocker facilities also had above-average parking capacities, underscoring a commitment to multimodal transit solutions. Outlier stations, specifically University City Blvd and I-485/South Blvd, stood out with exceptionally high parking capacities, reinforcing their function as major transit hubs and potential priority locations for future infrastructure investment. To evaluate differences in parking availability between the current and proposed Blue Line routes, we applied Chi-Square and Kruskal-Wallis tests. Both tests returned high p-values, leading us to fail to reject the null hypothesis. This indicates no statistically significant difference in ParknRide availability between the current and proposed routes. However, both routes generally showed low ParknRide access, revealing a broader accessibility gap in the system. To address this, we recommend further analysis incorporating ridership data, especially for ParknRide users, as well as qualitative methods such as surveys or focus groups. Comparative studies with similar transit systems could offer valuable context. Additionally, exploring factors like LYNX connectivity, bike and pedestrian infrastructure, and integration with ride-sharing services could help identify ways to close accessibility gaps. Optimizing parking management through real-time data and performance tracking, along with exploring the feasibility of expanding ParknRide capacity, may further support long-term transit accessibility improvements.



h

Figure 2: LYNX Silver Line GeoDistribution

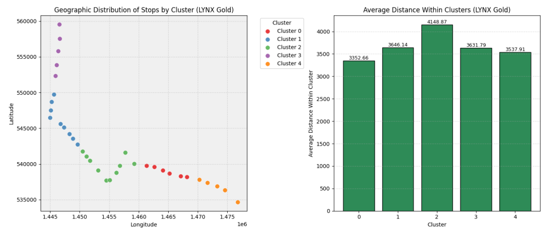


h

Figure 3: LYNX Blue Line ParknRide Availability

6 Discussion

Firstly, the observed clustering of proposed stations, particularly in the Gold and Silver Line datasets, suggests a targeted expansion strategy. These clusters align with areas of projected population growth and existing urban development, supporting the notion that



h

Figure 4: Cluster Analysis of LYNX Gold Rail Stops

infrastructure investments are being made with economic revitalization in mind. However, our findings also highlight that these expansions do not uniformly enhance accessibility across all council districts or zip codes. This indicates a potential misalignment between transit investment goals and equitable access, especially for historically underserved communities.

Secondly, the correlation between multimodal amenities (such as ParknRide and BikeLocker availability) and parking capacity, especially on the Blue Line, underscores the role of transit hubs in promoting commuter flexibility. These features suggest efforts to encourage non-automobile modes of access to stations, which is promising. However, the fact that these high-capacity, multimodal stations are concentrated in select areas raises questions about whether such infrastructure is equitably distributed. Without ridership data or demographic overlays, it's difficult to determine whether these investments are serving the most transit-dependent populations.

Furthermore, the structured naming conventions and spatial layouts, particularly on the Silver Line, reflect strategic planning meant to facilitate navigation and integration. Yet the absence of key geospatial identifiers (e.g., missing GeoID values) in some datasets limits the precision of spatial analysis, reducing our ability to assess exact accessibility outcomes and regional coverage. This represents a critical data limitation that constrains the granularity of our conclusions.

While our methodology focused primarily on mapping, correlation, and outlier detection, it lacked integration with demographic and ridership data, which would have significantly enhanced the analysis. The lack of direct measures of ridership, commute patterns, or population density around stations restricts our ability to evaluate whether expansions will result in meaningful increases in accessibility or reinforce existing usage patterns.

Despite these limitations, our findings provide valuable insight into how Charlotte's transit system is evolving. The proposed expansions prioritize connectivity and multimodal integration but may fall short in addressing the accessibility needs of low-income and transit-reliant populations. Our study suggests that future investment decisions should more explicitly incorporate demographic and usage data to ensure equitable service delivery.

Ultimately, while the proposed transit improvements do show promise in enhancing certain aspects of connectivity and efficiency, the current data and our findings indicate that more work is needed to achieve Charlotte's stated goals of equitable and inclusive mobility. Policymakers should consider these insights when allocating resources and planning future transit developments to ensure that all communities benefit equitably from infrastructure investments. Future work could involve spatial clustering techniques to categorize stations based on geographic and operational characteristics. Integrating transit station data with ridership statistics, population density, or road networks would enhance the analysis by providing insight into demand patterns. Additionally, predictive modeling using regression or machine learning could help estimate parking demand and station usage, contingent on access to detailed ridership data, commuter patterns, and demographic trends.

References

[1] Lewis Alexander Bell. 2008. *Urban Politics and the Role of Planners in the Decision to Build Light Rail in Charlotte.* Master's thesis. Florida State University, College of Social Sciences. Advisor(s) Gregory L. Thompson. Defended on October 27, 2008..

[2] Subeh Chowdhury, Kasey Zhai, and Asif Khan. 2016. The Effects of Access and Accessibility on Public Transport Users' Attitudes. *Journal of Public Transportation* 19, 1 (2016), 97–113. doi:10.5038/2375-0901.19.1.7

[3] J. Claire Schuch and Isabelle Nilsson. 2022. Rail Transit, for Who? perceptions and factors influencing light rail ridership in Charlotte, NC. *Travel Behaviour and Society* 27 (2022), 38–46. doi:10.1016/j.tbs.2021.06.001

[4] Alastair Morrison David O'Sullivan and John Shearer. 2000. Using desktop GIS for the investigation of accessibility by public transport: an isochrone approach. *International Journal of Geographical Information Science* 14, 1 (2000), 85–104. doi:10.1080/136588100240976 arXiv:https://doi.org/10.1080/136588100240976

[5] Ian Hamilton, Kristin Kersavage, R.J. Porter, Vikash Gayah, Josie Sanchez, Keith Smith, Carol Tan, and Ana Maria Eigen. 2022. Application of Emerging Data Sources for Pedestrian Safety Analysis in Charlotte, NC. *Transportation Research Record* 2676, 11 (2022), 396–407. doi:10.1177/03611981221093330 arXiv:https://doi.org/10.1177/03611981221093330

[6] Sanaz Sadat Hosseini, Babak Rahimi Ardabili, Mona Azarbayjani, and Hamed Tabkhi. 2025. Demographic disparities, service efficiency, safety, and user satisfaction in public bus transit system: A survey-based case study in the city of Charlotte, NC. *Transportation Research Interdisciplinary Perspectives* 29 (2025), 101296. doi:10.1016/j.trip.2024.101296

[7] Wei Li, Haotian Zhong, and Marlon G. Boarnet. 2024. Effects of new transit lines on commuting: Evidence from restricted-use Census Bureau microdata. *Applied Geography* 164 (2024), 103202. doi:10.1016/j.apgeog.2024.103202

[8] Susan Vanessa Mayer. 2013. *From Rails to Roads: Public Transportation in Charlotte, North Carolina, 1890-1960.* Master's thesis. The University of North Carolina at Charlotte, Charlotte.

[9] Muhammad Atiullah Saif, Mohammad Maghrour Zefreh, and Adam Torok. 2019. Public Transport Accessibility: A Literature Review. *Periodica Polytechnica Transportation Engineering* 47, 1 (2019), 36–43. doi:10.3311/PPtr.12072

[10] Adam Schmidt and Eleni Bardaka. 2024. The role of transit investments and initial neighborhood attributes on gentrification outcomes. *Transportation Research Part D: Transport and Environment* 137 (2024), 104463. doi:10.1016/j.trd.2024.104463

[11] Sara Tornabene and Isabelle Nilsson. 2021. Rail transit investments and economic development: Challenges for small businesses. *Journal of Transport Geography* 94 (2021), 103087. doi:10.1016/j.jtrangeo.2021.103087

[1] [6] [11] [9] [4] [2] [8] [3] [5] [10] [7]