# Infrastructure Analysis and Classification for Modelling Dynamic Boarding Locations for Autonomous Buses


## Master‘s Thesis of Aysha Jinan

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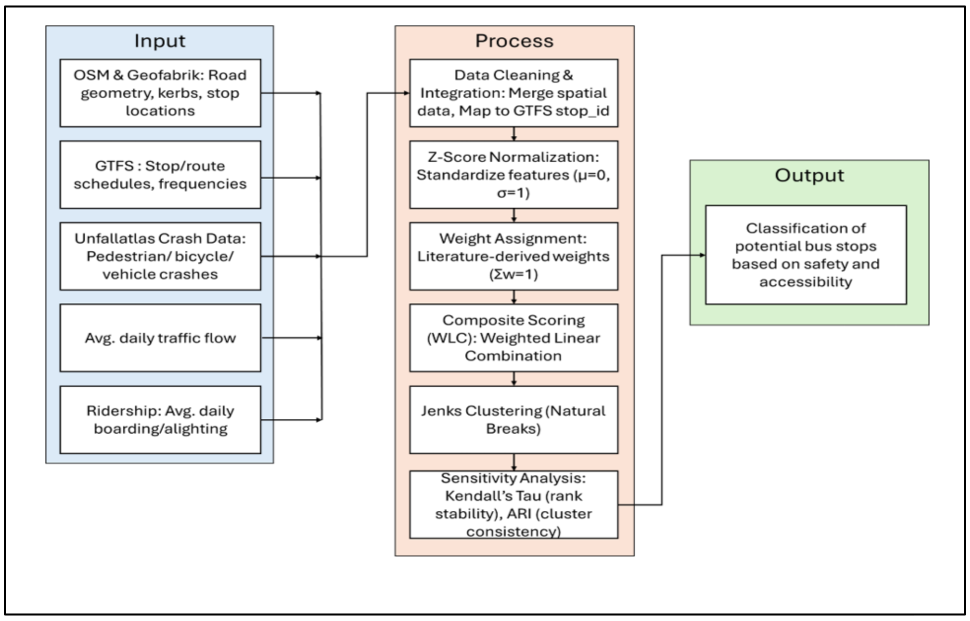


Fig 1: Methodology Flow chart : Bus Stop Evaluation Framework

## Methodology

The study follows a two-part methodology. First, existing bus stops in Munich were assessed using a weighted multi-criteria scoring approach. Parameters related to safety, accessibility and usage were collected, z-normalized and aggregated using literature-based weights to generate suitability scores, which were classified via Jenks Natural Breaks and tested through sensitivity and stability validation. Second, the road network from OpenStreetMap was segmented, filtered using legal and technical constraints, and aggregated into candidate segments. Each segment was evaluated under four categories (safety, accessibility, intermodal integration and demand), and scenario-based suitability scores (Safety-only, Balanced, On-demand) were clustered to identify optimal dynamic boarding locations. A 500 m grid and bootstrap validation ensured spatial distribution and robustness of results.

## Introduction & Objectives

Rapid urbanization and increasing reliance on private cars have placed unprecedented pressure on mobility systems, highlighting the need for more accessible and reliable public transport. Although shared on-demand services and push-and-pull strategies have attempted to address first- and last-mile connectivity, service gaps remain, particularly in low-density areas and for vulnerable users. With recent advances in autonomous vehicle technology, autonomous buses present a promising opportunity to enhance flexibility, service frequency and accessibility. However, their successful deployment hinges on the careful assessment of both existing bus stops and potential dynamic boarding locations, taking into account new technical, operational and legal requirements. Therefore, this thesis (1) reviews the legal, technical and non-technical requirements associated with autonomous vehicles and boarding locations, (2) analyses and classifies Munich's existing bus stop infrastructure based on safety and accessibility criteria, and (3) develops an algorithm to identify potential dynamic boarding segments across the road network and rank them from most to least suitable under different scenarios.

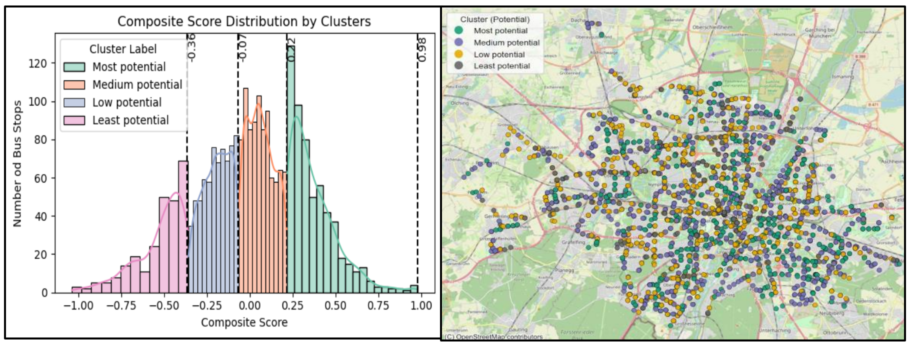


Fig 3a: Composite score distribution by potential label b) Spatial distribution of bus stops

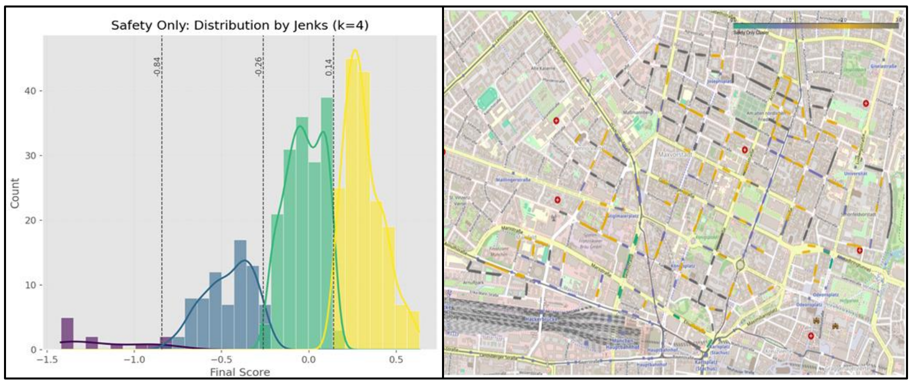


Fig 4a: Composite score distribution by potential label b) Spatial distribution of segments

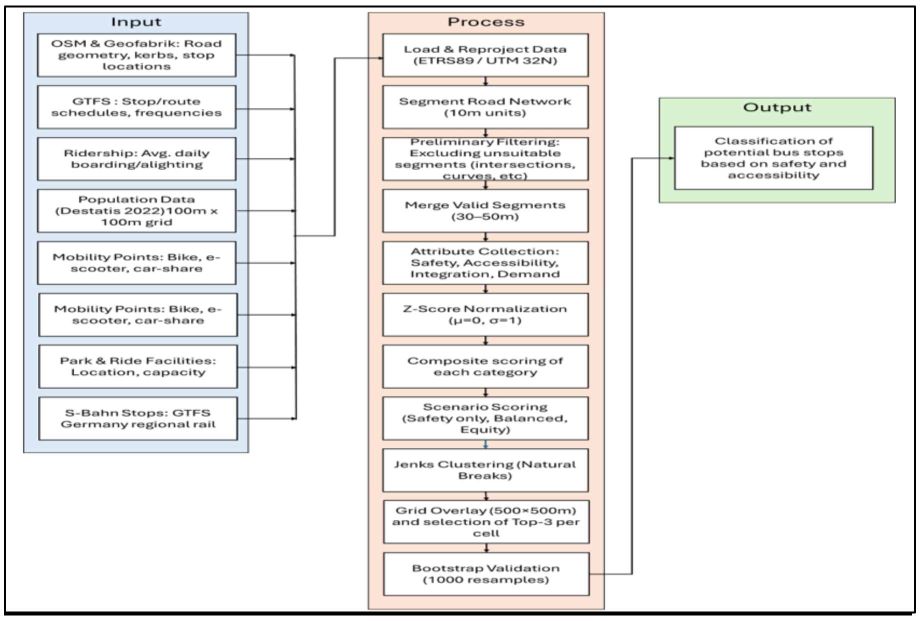


Fig 2: Methodology Flow chart : Network Analysis

## Results & Conclusion

The stop-level scoring revealed four clear suitability classes, with high-potential stops combining strong accessibility, low speeds and high demand, while low-potential ones lacked key safety and pedestrian features. In the network analysis of 418 segments, safety-only, balanced and on-demand scenarios produced distinct spatial priorities, ranging from calm residential streets to high-ridership corridors near major transit hubs. Sensitivity and bootstrap tests showed that both rankings and clusters remain stable under varying weights. Overall, the multi-criteria, scenario-based approach provides a reliable tool for identifying and prioritising dynamic boarding locations for autonomous buses.