Public Transport Nodes as Urban Attractors: Developing Indices to Capture Level of Service and Infrastructure

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Abstract. Understanding how people move within cities and the infrastructure that supports this movement is essential for advancing sustainable urban planning strategies, such as the "X minute city" concept. Effective implementation of such strategies requires identifying both the flow of movement, shaped primarily by the configuration of the street network, and the infrastructure that enhances or consolidates it. Among the most influential amplifiers of movement are public transport nodes and stations, which function as key nodes in the urban fabric. These nodes not only concentrate flows of people as arrival and departure points, but also reflect the presence of long-term, resilient infrastructure, such as tram lines and railways, that help stabilize and strengthen movement patterns over time. This study introduces two indices to assess the potential of public transport nodes and stations, incorporating a multimodal perspective that considers level of service and the presence of dedicated infrastructure. The level of service index captures key operational characteristics, such as service frequency and connectivity, while the infrastructure index evaluates the structural resilience of public transport modes, considering multimodality and the presence of fixed infrastructure. These indices were developed using General Transit Feed Specification data for the Västra Götaland Region in Sweden, offering a spatial and operational representation of the regional public transport network. The development of these indices represents the first step in a broader methodology designed to integrate public transport, population distribution, and street network data to assess movement potential across urban areas. This approach supports the identification of areas in need of targeted interventions, whether to redistribute movement more efficiently, improve infrastructure, or reveal underused locations with potential to evolve into new local centers. These centers can play a vital role in realizing the vision of the X minute city, contributing to the creation of more accessible, resilient, and livable urban environments.

Keywords: Public Transport Index · Public Transport Nodes · Public Transport Stops and Stations · Urban Attractors · X-min-city

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O. Gervasi et al. (Eds.): ICCSA 2025 Workshops, LNCS 15892, pp. 241–255, 2026.
https://doi.org/10.1007/978-3-031-97638-4_16

1 Introduction

The 'X-minute city' concept [1] aims to establish new local centers that improve accessibility through active transport modes, promoting more livable and sustainable urban environments. However, the successful implementation of this concept depends on identifying locations within the urban fabric that meet key conditions for encouraging walking and supporting daily needs within a short distance. This approach seeks to enhance quality of life, reduce car dependency, and promote sustainable, human-centered urban development. While central areas often already have the necessary conditions for this transformation, achieving similar outcomes in suburban areas can be more challenging.

In this context, this paper argues that street network centrality, established as a reliable predictor of movement potential for both pedestrians and vehicles, along with its interaction with other movement amplifiers such as built and population density, land use, and public transport network presence, can serve as an effective tool to support planners in identifying suitable locations for interventions to improve the conditions to meet the requirements for the X-minute city. This integrated approach enables more informed decision-making and supports the development of sustainable, vibrant, human-centered urban environments.

The relationship between street network centrality, built and population density, and land use has been the focus of extensive academic research. Empirical studies have consistently demonstrated strong correlations between these spatial attributes and the volume and diversity of movement within urban environments [2–7]. These findings provide a robust foundation for understanding how urban form shapes movement patterns. However, while previous research has clarified the relationship between centrality, density, and land use, the role of public transport networks within this dynamic, although often recognized as a key driver of movement, remains insufficiently explored.

Public transport networks, composed of nodes (such as stops and stations) and links (the routes that connect them), play a dual role in shaping urban movement at local, citywide, and metropolitan scales. They not only facilitate the distribution of people across the city and region but also generate concentrated flows of movement around public transport nodes (stops and stations). The extent to which these nodes function as attractors at the local scale is strongly influenced by their integration with the surrounding street network and their ability to provide access to opportunities throughout the urban area. As key points of arrival and departure, these nodes stimulate activity in their immediate vicinity. Moreover, the presence of dedicated infrastructure, such as tramlines and railway corridors, can indicate areas with potential for long-term consolidation as local centers, supporting both residential and commercial development [8–15].

The role of public transport stops and stations as key drivers of local development has been widely studied, particularly within the framework of Transit-Oriented Development (TOD), popularized by Calthorpe (1993) [27]. TOD emphasizes the importance of public transport nodes as focal points for urban development, guiding growth toward well-connected areas to foster more sustainable and accessible cities. A central concept derived from TOD is Bertolini's (1996, 1999) [9, 10] node-place model, which highlights the significance of public transport accessibility in shaping local development potential. According to this model, transit nodes act as catalysts for urban growth, with their impact being influenced by their integration with the broader street network and

surrounding built environment. Curtis (2011) [12] further expands on this by noting that well-connected transit nodes can stimulate network effects, encouraging development in areas not traditionally considered centers of activity. Nevertheless, focusing solely on public transport nodes, without considering their interaction with the street network, overlooks the critical role that their interplay has in generating movement potential.

Previous studies, such as those by Chiaradia et al. (2005) [28] and Law et al. (2012) [29], have attempted to connect public transport nodes with the street network by examining the impact of public transport stations on movement on surrounding streets. These studies revealed significant effects of public transport services on movement patterns around stations. Although both approaches focus on how a single mode of public transport interacts with street network centrality, adopting a multimodal perspective—considering the combined impact of different transport modes, their operations, and infrastructure on stops and stations—offers a more comprehensive understanding of how these elements together enhance local movement potential around public transport nodes.

To advance the understanding of this relationship, this study introduces two public transport indices that adopt a multimodal perspective. These indices, assigned to the nodes, support a more nuanced analysis of how these stops and stations connect to the street network and how their combined effects influence movement patterns.

The first index evaluates level of service (LoS) and coverage, which are closely associated with the volume of movement generated by a public transport node in its surrounding streets. It considers factors such as service frequency and the range of accessible destinations, capturing how nodes enable movement throughout the city and region [16–23]. The second index focuses on infrastructure resilience. Public transport modes supported by dedicated infrastructure, such as trams, trains, and ferries, often indicate a more stable and long-lasting presence in the network, contributing to more consistent and consolidated development of local centres [15, 24].

Public transport models were developed based on the methodology proposed by Lopes et al. (2023, 2024) [30, 31]. This approach utilizes General Transit Feed Specification (GTFS) data, along with other open data sources, to capture the geographic, infrastructural, and operational characteristics of the public transport network.

This study demonstrates the potential of the proposed indices in capturing how public transport networks contribute to movement potential at public transport stops and stations, focused on the Västra Götaland region in Sweden. The findings represent a key step within a broader methodology that integrates population distribution and street network data to evaluate movement potential and the performance of public transport infrastructure across urban areas. By quantifying both service quality and infrastructural resilience, the approach supports the identification of areas where targeted interventions can enhance mobility through redistribution of flows and infrastructure improvements. It also reveals underutilized locations with the potential to evolve into vibrant local centers, contributing to the realization of the ‘X-minute city’ and fostering more accessible, efficient, and sustainable urban environments.

The paper is structured as follows to present the proposed indices. Section 1 introduces the study, followed by Sect. 2, which outlines the datasets and methodologies used. Section 3 presents the results, and Sect. 4 offers a discussion and concluding remarks, analyzing the main findings and their implications.

2 Dataset and Methods

The creation of the indices followed a two-step methodology. First, multimodal public transport network models were developed using the methodology proposed by Lopes et al. (2023, 2024) [30, 31]. In the second step, information extracted from these models was used to construct both public transport indices.

2.1 GTFS Data

GTFS (General Transit Feed Specification) is a standardized data format widely used to describe public transport systems. It provides detailed information on node locations, routes, trips, and schedules, enabling accurate representation of transit services. A GTFS dataset is composed of a series of structured text files, each corresponding to a specific aspect of the public transport system. These files are routinely published by public transport operators across countries, regions, and municipalities to share timetable information and support applications such as multimodal routing, accessibility analysis, and the development of multimodal transport models.

The core components of a GTFS dataset include:

- **stops.txt:** lists all nodes along transit routes, including unique identifiers, names, and precise geographic coordinates (latitude and longitude).
- **routes.txt:** describes each route operated by transit agencies, with identifiers, route names, and other relevant details.
- **trips.txt:** contains information about individual trips associated with specific routes, including trip IDs, route IDs, and service IDs.
- **stop_times.txt:** details the scheduled arrival and departure times of vehicles at each node, including trip IDs, node IDs, times, and node sequences.
- **calendar.txt:** specifies the regular service schedule, including service IDs, start and end dates, and operational days of the week.
- **calendar_dates.txt:** lists exceptions to the regular service schedule, indicating dates when services are added or removed.

The GTFS data for the Västra Götaland region in Sweden was obtained from Trafiklab (2025) [32] and reflects the infrastructure and level of service for the period from March to June 2025.

2.2 The Multimodal Public Transport Network Model

This study adopts a multimodal public transport network modeling approach based on the methodology by Lopes et al. (2023, 2024) [30, 31]. The authors developed seven models derived from GTFS data, with different levels of temporal, spatial, and topological aggregation, suitable for different types of analyses and planning needs. Specifically, Model 1 represents a first level of aggregation, where the daily trips of the same public transport route are aggregated into a frequency per hour, over the whole day and over different periods of the day (e.g. morning peak, afternoon, evening peak, night). This model aggregates operational data (i.e. trips) while preserving fine geographic detail (i.e.

stop locations), making it ideal for analyzing the influence of public transport nodes on street-level movement.

The model was implemented in Python using several supporting libraries, including Pandas (version 2.2.3), GeoPandas (version 1.0.1), NumPy (version 2.1.3), Shapely (version 2.0.6), and OSMnx (version 1.9.2).

2.3 The Indices

This paper introduces two composite indices. The first index is based on the level of service (LoS) and coverage, relates to the volume of movement on the streets. The second index focuses on the presence of dedicated public transport infrastructure, is associated with the potential for long-term stability in the areas where public transport is present.

Both indices were developed separately but followed the same underlying methodology. First, attributes of the public transport system that are representative for each index were selected from the public transport model. Next, scores were assigned to each attribute, where $\boldsymbol{p_{ij}}$ represents the scores for each component $\boldsymbol{j}$ within the index i, and $\boldsymbol{\omega_{ij}}$ represents the weight assigned to each component. These scores were subsequently weighted and summed according to Eq. 1, ultimately resulting in the final index $\boldsymbol{I_i}$.

$$\boldsymbol{I_i} = \sum_{j \in \boldsymbol{C_i}} \boldsymbol{\omega_{ij}} \cdot \boldsymbol{p_{ij}} \tag{1}$$

The index was created by aggregating, scoring, and summarizing the multimodal public transport network data using Python libraries such as Pandas (v2.2.3), GeoPandas (v1.0.1), and NumPy (v2.1.3).

Level of Service (LoS) and Coverage index (Index 1)
For the LoS and Coverage composite index, several attributes were considered, including the frequency of services at each node, the number of routes passing through each node, the number of stops/stations reachable from each node, and the distances between stops/stations along all routes passing through the node.

LoS is represented by two primary attributes: frequency and number of routes. The frequency of public transport is a strong indicator of service quality, reflecting both the demand for transport services and the potential usage of a given node [16–23]. A higher frequency of services at a node indicates greater potential for movement around that node, as passengers can rely on more frequent transport options.

Coverage is represented by the number of reachable nodes for each route passing through a given node, as well as the distances between these nodes. Coverage is closely linked to the overall distribution potential of the public transport network and directly relates to accessibility [25], the ease with which individuals can reach different locations within the urban environment from each node [18–22]. In this paper, accessibility is seen as a key factor influencing individuals' choice of nodes, with stops and stations offering higher accessibility more likely to attract people.

The number of routes passing through each node serves as a hybrid measure, incorporating elements of both LoS and coverage. This attribute is strongly correlated with

frequency, as the frequency of service depends on how many routes pass by a node, directly reflecting service quality. Additionally, it indicates the potential for more effective distribution of people across a broader area, making more destinations accessible. As a result, the node becomes more attractive to a larger number of people.

The scores for each attribute were calculated individually, using procedures appropriate to the nature and scale of the data (see details in the following sections). Once computed, the scores were normalized and aggregated into a composite index using a weighted sum approach. The weighting was designed to ensure a balanced contribution from both LoS and Coverage aspects, with each accounting for 50% of the final index. Frequency was assigned a weight of 40%, representing LoS. The number of reachable nodes and the distance between nodes were each assigned a weight of 20%, reflecting Coverage. Additionally, the number of routes was given a weight of 20%, as it represents elements of both Level of Service and Coverage (Eq. 2). In this case, following Eq. 2:

$$\omega i, \text{frequency} = 0.40, \omega i, \text{routes} = 0.20, \omega i, \text{reachable nodes} = 0.20, \omega i, \text{distance} = 0.20 \quad (2)$$

Scoring the Frequency

The frequency of a route is determined by the number of trips made within a specified time interval. A higher number of trips within the interval corresponds to a higher frequency, while fewer trips indicate a lower frequency. In the public transport models used in this paper, a 3-h interval is defined. These intervals were established based on the characteristics of the public transport service, reflecting the distinct frequency patterns throughout the day.

To ensure consistency and comparability in the analysis, the study focuses specifically on the morning peak period (06:00 to 09:00) on a typical weekday, Wednesday. This time window was selected since it represents a critical period for commuting and exhibits the most consistent and intensive service levels across various public transport modes. Wednesday was chosen to minimize the variability often observed on Fridays and weekends, which typically feature irregular service patterns.

The frequency score for each node was assigned a value ranging from 0 to 4, following the parameters inspired by the Transit Capacity and Quality of Service Manual (TCQSM)[19]. See Table 1.

Table 1. Scores for Frequency

Score	Frequency (min)	Description
4	0–5	Very high frequency
3	>5–10	High frequency
2	>10–15	Moderated frequency
1	>15–20	Low frequency
0	>20	Very low frequency

Scoring the Route Count

The route count for each node is determined by the number of distinct routes passing through it within a specified time period. To ensure consistency, only the routes that pass through each node during the morning peak period (06:00 to 09:00) on Wednesday were considered.

After counting the routes for each node, the nodes were divided into quintiles. Quintiles are an effective way to represent the distribution of routes, as they classify nodes into five equally sized groups based on their route count. This method highlights the variability in route availability and the relative accessibility of each node. The scoring ranges from 0 to 4, with 0 indicating the lowest quintile (no routes) and 4 indicating the highest quintile (most routes). This approach enables a clear, comparative assessment of service levels across different nodes. See Table 2.

Table 2. Scores for Route Count

Score	Number of Routes	Description
4	3–14	Top 20% (highest route count by node)
3	2–3	The 20% to 40% range (above average)
2	1–2	The 40% to 60% range (slightly above average)
1	1–1	The 60% to 80% range (below average)
0	0	Bottom 20% (lowest route count by node)

Scoring the Number of Reachable Nodes

To score the number of reachable nodes, it was essential to account for the profile of the routes passing through each node. For each route, the number of nodes it serves was recorded. These values were then categorized into quintiles, which were subsequently assigned to each node. The scoring system follows a range from 0 to 4, where 0 represents nodes with the fewest reachable nodes and 4 represents nodes with the greatest number of reachable nodes (Table 3). Each node is represented by the highest quintile assigned to any route passing through it in the index, highlighting the node's highest performance in terms of accessibility.

Table 3. Scores for Number of Reachable Nodes

Score	Number of Reachable Nodes	Description
4	45–100	Top 20% (highest number of reachable nodes)
3	34–45	The 20% to 40% range (above average)
2	25–34	The 40% to 60% range (slightly above average)
1	19–25	The 60% to 80% range (below average)
0	1–19	Bottom 20% (lowest number of reachable nodes)

Scoring the Average Distance Between Reachable Nodes
The distance between nodes is an attribute derived from the routes passing through each node and the maximum number of reachable nodes. Each route in the dataset is assigned a coverage value in meters, based on the total distance it spans. To calculate the average transport network distance between nodes, the total route length is divided by the maximum number of nodes served by the route. These calculated distances are then categorized into quintiles. Longer distances between nodes generally correspond to faster, long-distance services such as intermunicipal trains or express buses, which connect wider areas (Table 4). Conversely, shorter distances indicate more localized routes, characteristic of urban public transport services that cater to shorter trips with higher node frequencies. Each node is assigned the highest quintile value from any route passing through it, reflecting its highest performance in terms of multi-scalarity and accessibility.

Table 4. Scores for Average Distance Between Reachable Nodes

Score	Number of Reachable Nodes	Description
4	1224–162709	Top 20% (longest average distance between nodes)
3	954–1224	The 20% to 40% range (above average)
2	776–954	The 40% to 60% range (slightly above average)
1	617–776	The 60% to 80% range (below average)
0	0–617	Bottom 20% (shortest average distance between nodes)

Dedicated Infrastructure index (Index 2)
For the Dedicated Infrastructure composite index, two key attributes of the public transport system were considered: the presence of dedicated infrastructure at each node, such as rail tracks or docks, and the proximity of nodes to dedicated infrastructure, specifically the potential for transfer to a node with dedicated infrastructure within 200 m.

The presence and proximity of dedicated public transport infrastructure, such as rail tracks, tram tracks, subways, and docks, play a crucial role in driving the development of new locations. This infrastructure not only provides long-term stability but also ensures reliable and efficient public transport services, making areas more attractive for residential and commercial investments [8, 10, 12, 14, 24].

As with Index 1, for Index 2, the scores for each attribute were calculated individually using methods appropriate to the nature of the data (see details in the following sections). Once the scores were computed, they were aggregated into a composite index using a weighted sum approach. The weighting was designed to reflect the hierarchy between the presence of infrastructure at a node and the proximity to a node with infrastructure. Specifically, the presence of dedicated infrastructure was weighted at 70%, while the proximity to infrastructure was weighted at 30% (Eq. 3). In this case, following the Eq. 1:

$$\omega i, \text{presence} = 0.70, \omega i, \text{proximity} = 0.3 \tag{3}$$

Scoring the Presence of Dedicated Infrastructure
To score the presence of dedicated infrastructure in a node, a condition based on the multimodality of the stop was established. First, modes that require dedicated and less mutable infrastructure were assigned to the nodes, based on the available data. In the case of Västra Götaland, tram, train, and ferry were considered as modes requiring dedicated infrastructure, while buses and communal taxis were excluded due to their greater flexibility and potential for route changes. Afterwards, each node was assessed to determine the number of different modes serving it. If the node is served only by buses or communal taxis, it was assigned a score of 0. If only one mode that requires dedicated infrastructure passes through the node, the score was 1. If two modes pass through the node, the score is 2, and if three modes pass through the node, the score is 3 (Table 5).

Table 5. Scores for Present of Dedicated Infrastructure

Score	Description
3	3 modes requiring Dedicated Infrastructure
2	2 modes requiring Dedicated Infrastructure
1	1 mode requiring Dedicated Infrastructure
0	0 modes requiring Dedicated Infrastructure

Scoring the Proximity of Dedicated Infrastructure
This scoring is based on the previous one, but instead of considering the presence of dedicated infrastructure at the node itself, it assesses the proximity of the node to other nodes with dedicated infrastructure. Each node was evaluated based on whether it is possible to access other nodes with dedicated infrastructure within a straight-line distance of 200 m. This proximity indicates that the original node could be part of a transport hub.

Nearby nodes served by buses or communal taxis receive a score of 0. Nodes served by one mode requiring dedicated infrastructure receive a score of 1. Nodes serving two modes that require dedicated infrastructure are scored 2, while nodes serving three modes with dedicated infrastructure receive a score of 3. Ultimately, many nodes can be accessed from the original one, but only the maximum value is considered (Table 6).

Table 6. Scores for Present of Dedicated Infrastructure

Score	Description
3	Proximity of nodes that have 3 modes requiring Dedicated Infrastructure
2	Proximity of nodes that have 2 modes requiring Dedicated Infrastructure
1	Proximity of nodes that have 1 mode requiring Dedicated Infrastructure
0	Proximity of nodes that have 0 modes requiring Dedicated Infrastructure

3 Results

The results are based on the two complementary composite indices presented in the previous section, developed from a data-driven perspective: LoS and Coverage index, and Dedicated Infrastructure index. Figure 1 visualizes the relationship between these indices for each stop and station within the Västra Götaland Region in Sweden, presented as a heatmap.

The data reveals that the majority of stops and stations (73%) have both low infrastructure and low LoS. A small share (7%), however, benefits from high infrastructure levels. In areas with limited physical infrastructure, higher LoS or route coverage compensates for these deficiencies in 20% of cases, ensuring higher accessibility. High infrastructure and high LoS values were defined as those in the top quartile of the distribution, with the remaining stops/stations classified as having low values.

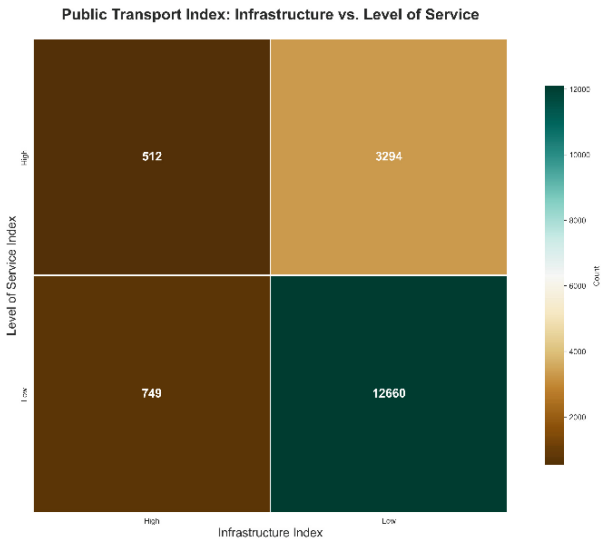

Fig. 1. Interplay between the LoS and Coverage index and the Dedicated Infrastructure index for each stop/station within the Västra Götaland Region in Sweden.

When these indices are spatially mapped, as shown in Fig. 2, a distinct pattern emerges. The map, which focuses on Gothenburg, the main city of the Västra Götaland Region, illustrates that dedicated infrastructure, such as rail, tram, and ferry facilities, is primarily concentrated in the central areas and along a few key corridors. In contrast, suburban zones generally lack this type of infrastructure and rely more heavily on frequent or extensive service coverage to ensure accessibility.

This spatial pattern reinforces the compensatory mechanism identified in Fig. 1, where lower infrastructure availability is offset by more intensive service levels. Together, these indices effectively capture the trade-off between physical infrastructure and operational service, providing a comprehensive perspective on transport accessibility across the urban region.

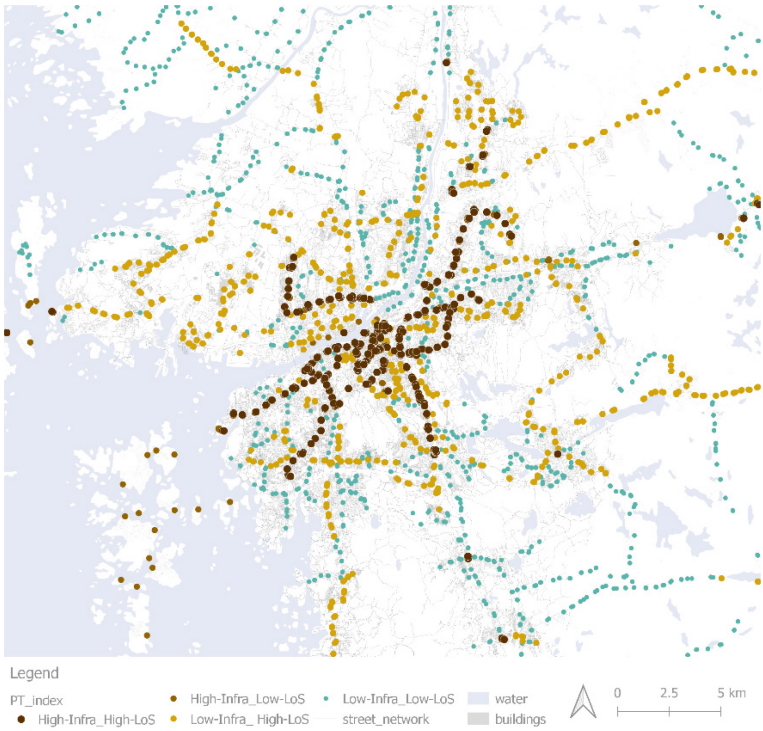

Fig. 2. Distribution of LoS and Coverage and Dedicated Infrastructure indices across the city.

A detailed examination of Gothenburg's central areas reveals that both indices effectively capture the key variations in service levels and the presence of dedicated infrastructure. As shown in Fig. 3, the area around Central Station stands out as the busiest and most complex transport hub in the city. Within this hub, several nodes with distinct profiles are observed, highlighting the diverse roles these locations play in the overall transport network.

While these nodes are part of the same broader hub, the indices reveal clear hierarchies in terms of service and function. For example, Centralstationen, Nordstan, Brunnsparken, and Lilla Bommen show high service levels but mainly cater to local connections. In contrast, Göteborg Central and Nils Ericson Terminal serve intermunicipal routes, offering broader coverage but lower frequency. Interestingly, Åkareplatsen, despite its proximity to the hub, does not match the service levels or infrastructure presence of the other nodes. This distinction underscores the indices' ability to highlight nuanced differences in transport accessibility within a single, centralized area.

These findings demonstrate the indices' ability to uncover both local and global variations in transport accessibility, revealing areas with significant movement potential as well as those with opportunities for future consolidation. By identifying these patterns, the indices provide valuable insights that can inform decision-making, enabling planners to target interventions in overcrowded areas while also highlighting underutilized locations with the potential for development. This approach not only supports more efficient



Fig. 3. Map1: distribution of the LoS and coverage in the central area of Gothenburg. Map 2: distribution of public transport infrastructure in the central area of Gothenburg.

use of urban space but also contributes to a more balanced and sustainable distribution of resources and services across the city.

4 Discussion and Conclusion

This study introduces two complementary composite indices developed through a data-driven approach to assess public transport performance. Together, they offer a comprehensive framework for evaluating both the operational and structural dimensions of transport systems. The first index measures the Level of Service and Coverage, capturing how effectively the public transport network serves different areas. The second index focuses on the presence and proximity of Dedicated Infrastructure, such as rail tracks, tram lines, and ferry docks, emphasizing the physical elements that can drive urban development.

The findings demonstrate that these indices effectively capture spatial patterns at both macro and micro scales. At the city-wide level, they reveal the concentration of dedicated transport infrastructure in central areas and along key corridors, while also highlighting disparities in suburban regions that are often underserved by fixed infrastructure. This imbalance is partially mitigated by a compensatory mechanism; whereby some suburban areas rely more heavily on high-frequency or extensive coverage services to maintain accessibility.

At a finer scale, particularly within Gothenburg's central transport hub, the indices uncover substantial variation between nodes within the same broader node cluster. While some nodes prioritize local connectivity through frequent services, others serve inter-municipal routes, offering wider coverage but lower service frequencies. In constructing the indices, the model proposed by Lopes et al. (2023, 2024) [30, 31] was employed, retaining information at the platform level. This detailed level of analysis enhances the understanding of how each individual platform contributes to the movement potential of the adjacent street segments.

From a methodological perspective, the development of these composite indices represents a significant step toward establishing quantitative, reproducible, and scalable tools for evaluating movement potential and understanding the role of public transport in supporting the formation of consolidated local centers. By integrating both service quality and infrastructure resilience, the indices provide valuable insights into how public transport networks can contribute to the spatial structure and performance of urban areas.

The creation of these indices serves as a foundational step toward a broader methodology that incorporates population distribution and street network data. The next step in the methodology will integrate these indices with the street network, weighted by centrality, and surrounding population data to assess the potential use of urban spaces. This approach aims to identify areas with a high potential for activity, as well as gaps in the system. For instance, it can reveal well-connected streets with high centrality but lacking public transport and population, highlighting areas that may benefit from increased public transport investment or residential development. Conversely, it can also identify areas with strong public transport networks but low centrality and population, indicating underutilized infrastructure. This comprehensive assessment will help prioritize interventions that can transform emerging areas into vibrant local centers, potentially serving as the backbone of the "X-minute city" concept.

Ultimately, this work contributes to the development of more efficient, inclusive, and sustainable urban environments, supporting the broader objective of enhancing quality of life through integrated urban and transport planning.

Acknowledgements. EMC2: Evolutive Meshed Compact City Model project. The EMC2 project is funded by ANR (France), FFG (Austria), MUR (Italy) and Vinnova (Sweden) under the Driving Urban Transition Partnership, which has been co-funded by the European Commission.

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