

# Understanding Transit Service Reliability in a Geographic Context Using High-Resolution Transit Data and Multi-Source Urban Data

**Xiaohuan Zeng, Ying Song, Alireza Khani and Sahas Sok**

## **ABSTRACT:**

Transit services provide a sustainable way to connect people to jobs and many other opportunities and create multimodal and vibrant areas near service corridors. Reviews of national and international transit services have proved that service reliability is often among the most demanding service improvements and plays a significant role in reducing travel costs, increasing ridership, and attracting or retaining users. Many transit agencies have collected Automatic Vehicle Location (AVL) and Automatic Passenger Count (APC) data to support transit system operations and performance evaluations at fine spatial and temporal resolutions.

Recent studies have used AVL to derive the actual arrival times and dwell times at stops and compare them to the scheduled arrival and/or departure times at stops recorded in General Transit Feed Specification (GTFS) data. The comparison results are then used to investigate on-time arrival at stops and evaluate user costs due to delays. However, the analysis of stop-level service reliability is often limited to scheduled stops (a.k.a. time points) where the vehicle strictly adheres to the specified arrival and departure times. Further, transit agencies have an increasing preference for adapting a fixed headway in operations, such as having buses leaving the terminal every ten minutes along bus rapid transit (BRT) routes. Therefore, this paper examines service reliability along route segments between stops and develops reliability metrics that are independent of GTFS and transit operation strategies. We then collect urban environment data from various sources and visually explore factors associated with transit reliability including route types (e.g., route class, traffic signal priority), segment characteristics (e.g., mixed traffic, dedicated right-of-way), and regional characteristics (e.g., new snow, precipitation). Last, we apply interpretable machine learning (IML) models to identify key factors that have the strongest association with service reliability.

To demonstrate our methods, we use AVL, APC, and multi-sourced urban data collected from March 13 2022 to April 13, 2023, in the Twin Cities metropolitan area, Minnesota, U.S. as a study case. Further exploratory analysis revealed that the calculated transit reliability indices differ across time and space. First, the daily reliability shows that transit service is more reliable on weekends than on weekdays, which may be related to reduced, traffic volume, and bus service frequency. Similarly, it is found that hourly reliability is lower during morning and evening peak periods. In addition, part of the transit routes become less reliable during bad weather, such as after fresh snowfall. In terms of spatial variability of transit reliability at the route-segment level, there are numerous unreliable segments in downtown Minneapolis. Even along the same transit route, there can be large differences in the service reliability of the consecutive segments, further illustrating the need for finer-scale reliability measurements. Spatial variability of reliability may be related to lots of factors. For example, some road sections have dedicated rights-of-way that allow buses to bypass traffic jams and help vehicles travel on time.

**KEYWORDS:** *public transit, service reliability, dedicated right-of-way, automatic vehicle location (AVL), automatic passenger count (APC), spatiotemporal analysis, interpretable machine learning (IML)*

**Xiaohuan Zeng**, Graduate Student, Department of Geography, Environment, and Society,  
University of Minnesota, Minneapolis, MN, USA

**Ying Song**, Associate Professor, Department of Geography, Environment, and Society,  
University of Minnesota, Minneapolis, MN, USA

**Alireza Khani**, Associate Professor, Department of Industrial and Systems Engineering,  
University of Minnesota, Minneapolis, MN, USA

**Sahas Sok**, Graduate Student, Department of Industrial and Systems Engineering, University of  
Minnesota, Minneapolis, MN, USA