BUS TRANSIT SERVICE RELIABILITY

Ehab Diab*
Robert Bertini**
Ahmed M. El-Geneidy***

* University of Toronto, ** California Polytechnic State University, *** McGill University

TRAM
Transportation Research at McGill

Understanding the impacts of overlapping bus service on headway delays and determinants of bus bunching

ABSTRACT

Transit agencies typically **operate several routes** that overlap with each other in order to offer a better **service coverage** to reach various origins destinations and to make the network more convenient.

This research investigates the impacts of bus **route overlapping** on service **headway delay** and **probability of bunching** at the stop-level of analysis.

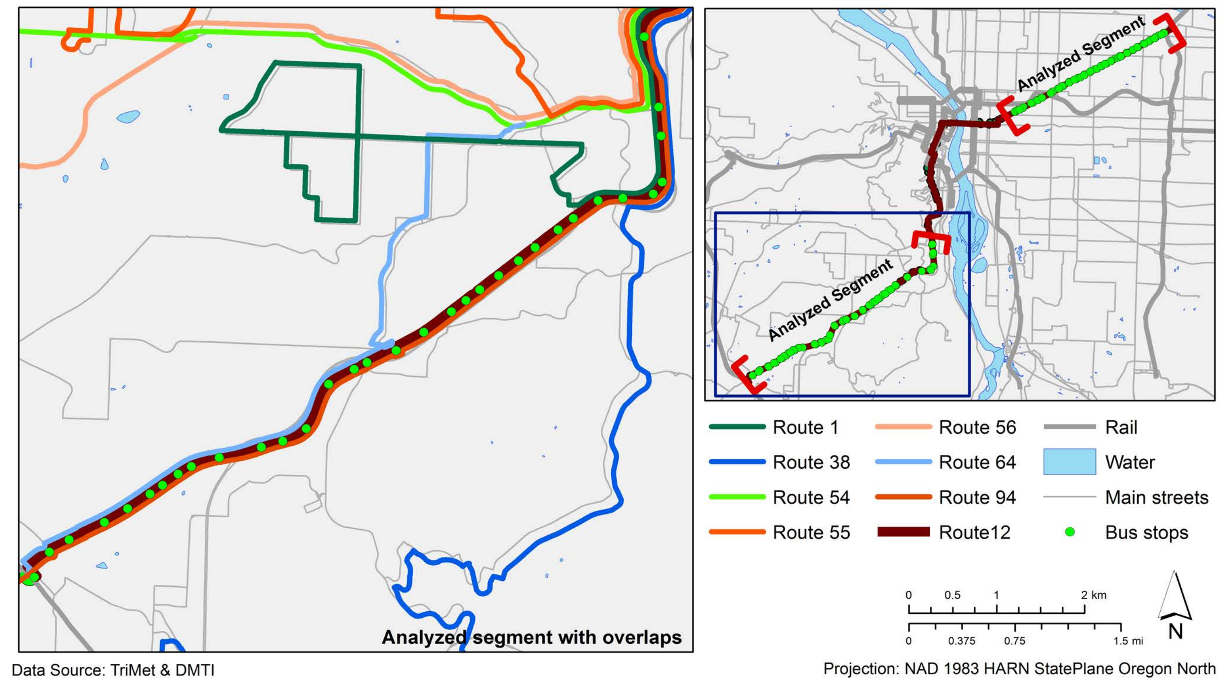
The study uses **automatic vehicle location (AVL)** and **automatic passenger count (APC)** systems data collected from TriMet, the public transit provider for Portland, Oregon, USA.

It shows that service **overlapping** can **increase** headway delay, with no impacts on service bunching. It also shows headway delay and bunching as a function of **several variables** that rarely explored in the literature.

INTRODUCTION

The data used in our analyses come from a sample of TriMet's AVL and APC archived data system for a bus-corridor, the **Barbur bus corridor, Route 12.**

Route 12 **overlaps with** several routes, including 1, 38, 54, 55, 56, 64 and 94. Since all of TriMet's buses are **outfitted with** AVL/APC, it was possible to calculate the actual headway between all buses at the stop level.



METHODOLOGY

Over **600,000 individual stop-level** records for Route 12 were collected from the TriMet's dispatch system over a **three month period** between September 1, 2014 and November 28, 2014. Another AVL/APC dataset was obtained for all abovementioned overlapping routes.

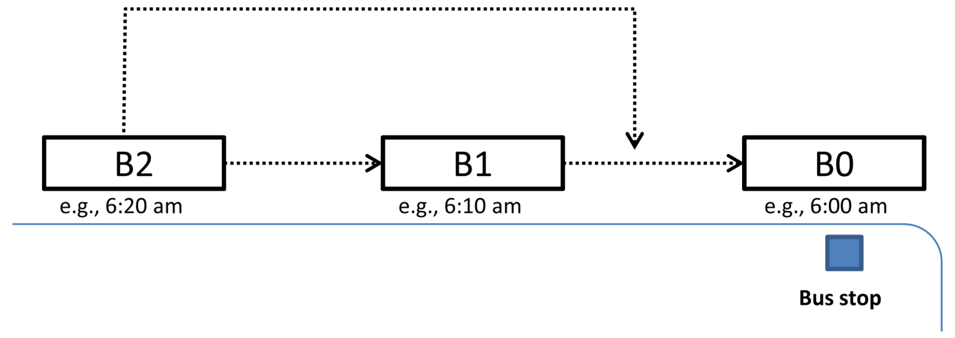
In this research, we will focus on developing **two statistical** models to capture the effects of the service overlapping:

1

The first model is a **headway delay model** used to estimate the effects of bus service overlapping at the stop-level of analysis. Headway delay is the **difference** between **actual and scheduled** headway. **Actual headway** is calculated based on departure times from each bus stop.

2

We also developed a **bus bunching model** to reveal the potential causes of bus bunching and the impacts of service overlapping. The model focuses on the **first locations** where **bunching began to occur**, as well as one stop that was randomly selected from each trip (i.e., one stop per trip) where no bunching occurred, to serve as controls.



The figure **illustrates bus bunching**, when the bus in question (B2) moves in front of the bus ahead of it (B1). Thus, for each observation, data from the **previous scheduled trip (B1)** and from the **one prior (B0)** are used to better understand the bus bunching phenomenon.

ANALYSIS

1 Headway Delay Model

Variable	Coefficients	*t*-stat	95% Conf. Interval Lower Bound	95% Conf. Interval Upper Bound
Constant	**14.06*** **	**4.05**	**7.26**	**20.85**
Direction	**-7.55*** **	**-9.72**	**-9.07**	**-6.03**
Barbur Blvd	**-2.87*** **	**-3.45**	**-4.49**	**-1.24**
AM peak	-0.15	-0.13	-2.53	2.23
PM peak	**-2.06***	**-1.69**	**-4.44**	**0.33**
Night	**5.36*** **	**5.37**	**3.41**	**7.32**
Midnight and early morning	**8.98*** **	**5.60**	**5.84**	**12.12**
Actual stops made	**12.45*** **	**12.62**	**10.52**	**14.39**
Lift	**47.15*** **	**10.13**	**38.02**	**56.27**
Total passenger activity	**14.41*** **	**47.22**	**13.81**	**15.01**
Total passenger activity^2	**-0.05*** **	**-14.97**	**-0.05**	**-0.04**
Passenger load	**2.86*** **	**60.74**	**2.76**	**2.95**
Friction	**0.54*** **	**7.91**	**0.40**	**0.67**
Headway Delay at the start (s)	**0.72*** **	**434.35**	**0.72**	**0.73**
Distance	**-0.01*** **	**-10.24**	**-0.01**	**0.00**
Stop sequence	**0.15*** **	**10.27**	**0.12**	**0.18**
Stop at Time point	**-43.44*** **	**-25.20**	**-46.82**	**-40.06**
After unscheduled stop	**15.73*** **	**15.53**	**13.75**	**17.72**
Near-side stop	**3.53*** **	**3.71**	**1.66**	**5.40**
Midblock stop	**10.13** **	**9.60**	**8.06**	**12.20**
Signalized intersection	**-4.67*** **	**-4.84**	**-6.56**	**-2.78**
Reserved lanes in operation	**-16.66*** **	**-7.96**	**-20.76**	**-12.56**
Overlapping trips	**3.81** **	**1.81**	**-0.31**	**7.93**
Scheduled headway (s)	**-0.11*** **	**-22.16**	**-0.12**	**-0.10**
Scheduled headway^2	**0.001*** **	**25.00**	**0.000**	**0.001**
N	445,316			
R2	0.32			
F statistics	(24, 445291.0) 8,661			
F significance (Prob > F)	0.00			

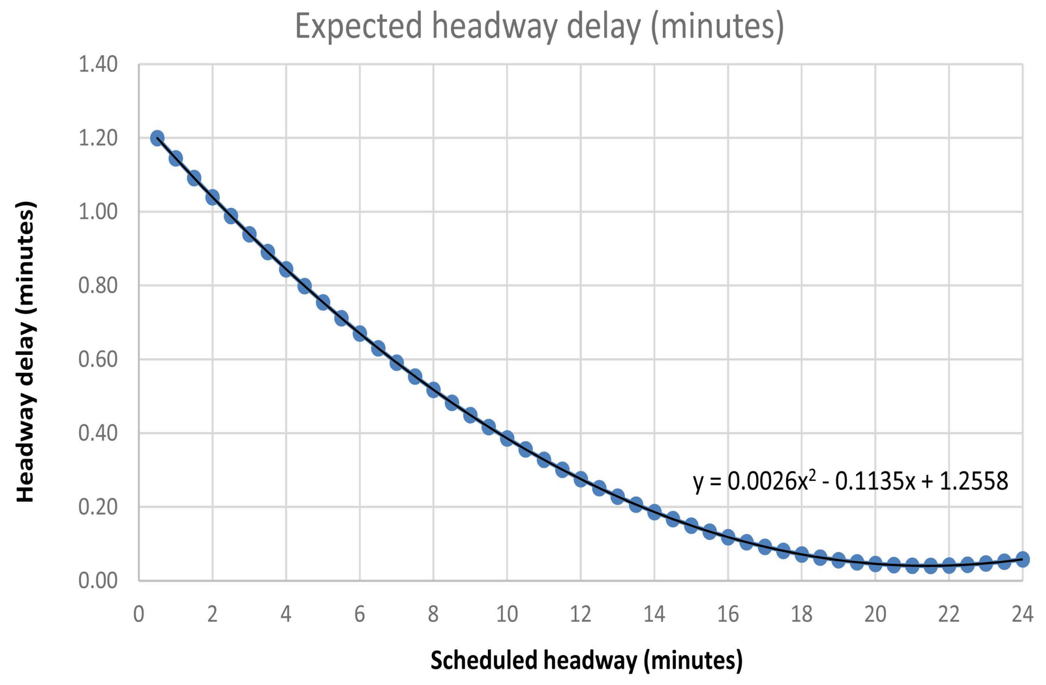
Bold indicates statistical significance
*** Significant at 99% ** Significant at 95% * Significant at 90%

2 Bus Bunching Model

Variable	Coefficient	Z	Odds ratio	95% Conf. Interval Lower Bound	95% Conf. Interval Upper Bound
Constant	**-3.795**	**149.73*** **	**0.022**		
Direction	**1.004**	**40.16*** **	**2.730**	**2.001**	**3.725**
Barbur Blvd	**-1.036**	**40.93*** **	**0.355**	**0.258**	**0.488**
AM peak	-0.044	0.06	0.957	0.683	1.341
PM peak	-0.027	0.03	0.973	0.713	1.329
Night	**-0.444**	**8.77*** **	**0.642**	**0.478**	**0.861**
Early morning	**-1.933**	**8.78*** **	**0.145**	**0.040**	**0.520**
Cumulative passenger activity	**-0.029**	**48.11*** **	**0.971**	**0.963**	**0.979**
Cumulative passenger activity^2	**0.000**	**26.61*** **	**1.001**	**1.000**	**1.001**
Delay at the start (s)	**-0.003**	**110.77*** **	**0.997**	**0.996**	**0.998**
Stop sequence	**0.035**	**85.77*** **	**1.035**	**1.028**	**1.043**
Overlapping trips	0.519	2.00	1.681	0.819	3.451
Scheduled headway (s)	**-0.001**	**38.36*** **	**0.999**	**0.998**	**0.999**
B1 delay at the start (s)	**0.005**	**386.59*** **	**1.005**	**1.004**	**1.005**
B1 cumulative passenger activity	**0.020**	**27.30*** **	**1.020**	**1.013**	**1.028**
B1 cumulative passenger activity ^2	0.000	1.43	1.000	1.000	1.000
B0 delay at the start (s)	0.000	2.38	1.000	1.000	1.001
B0 cumulative passenger activity	**-0.010**	**6.03** **	**0.991**	**0.983**	**0.998**
B0 cumulative passenger activity^2	**0.000**	**9.07*** **	**1.000**	**1.000**	**1.001**
N	8913.00				
Nagelkerke R Square	0.41				
Log likelihood	2653.15				

Bold indicates statistical significance
*** Significant at 99% ** Significant at 95% * Significant at 90%

3 Sensitivity Analysis



Headway delay in relation to scheduled headway

Overlapping trips

The models indicate that **service overlapping** increases the headway delay by **3.8 seconds**, and accordingly, contributes to passengers' waiting times. This may be understood due to a few reasons.

Scheduled headway

Headway delay is also a function of **scheduled headway** between trips. Increasing it would decrease the headway delay to a certain extent. The minimum headway delay occurs at a scheduled headway of **20 minutes** at a given bus stop.

Other variables

Other variables have **a positive effect** in terms of decreasing headway delay, i.e. bus stop placement, reserved lanes, TSP and time points. E.g., **moving bus stops** from near-side to far-side stops will decrease headway delay by 3.5 seconds.

Bus bunching

The models indicate that if the **leader bus (B1)** started late that will increase the odds of bunching for the **current bus (B2)** more than its delay. Thus, agencies should **track delays** at the beginnings of routes to decrease the odds of being bunched for the following trip when it is prevented.

CONCLUSION

This study aims at evaluating the impact of **overlapping services** on headway delay. It analyzes archived data obtained from TriMet's AVL and APC systems using two statistical models.

The paper shows that service overlapping increases headway delay by **3.8 seconds**, with no impacts on service bunching. Headway delay is also a function of **scheduled headway** between trips. Trips **starting late** increase the odds of bunching for the following trip on schedule more than their delay.

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CAL POLY SAN LUIS OBISPO
UNIVERSITY OF TORONTO
CIRRELT
McGill