IDENTIFYING THE BIAS:

Evaluating the effectiveness of automatic data collection methods in estimating the details of bus dwell time

Emily Grisé
Ahmed M. El-Geneidy
School of Urban Planning, McGill University

TRAM
Transportation Research at McGill

ABSTRACT

Automatic Vehicle Location (AVL), Automatic Passenger Counters (APC), and fare box payments data have been heavily used to generate dwell time models with the goal of recommending improvements in efficiency and reliability of bus transit systems.

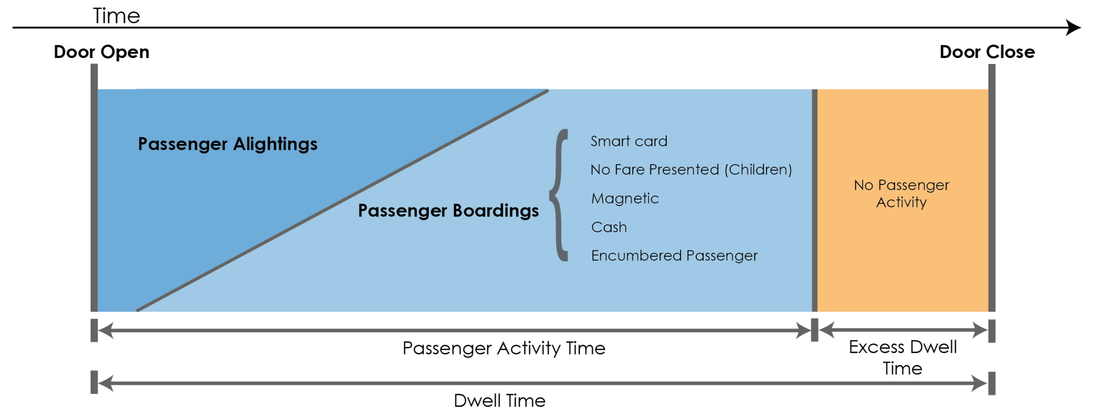
Automatic data collection methods may result in a loss of detail regarding the dynamics of passenger activity, which may bias the estimates associated with dwell or passenger activity time.

The puspose is: **to estimate how accurately AVL/APC and fare box data are capturing the time associated with passenger activity.**

The results reveal an overestimation in the passenger activity component of dwell time, which is mainly attributed to excess dwell time that AVL/APC and fare box payment generally do not capture.

CONTEXT

Elements of dwell time



Based on previous research a typical dwell time model is as follows:

Dwell time (s) = f (Boardings, alightings, total passenger activity^2, passenger load, friction, direction, time of day, lift usage, stop location, weather conditions, fare payment method)

DATA & METHODOLOGY

Manual observations of bus operations data

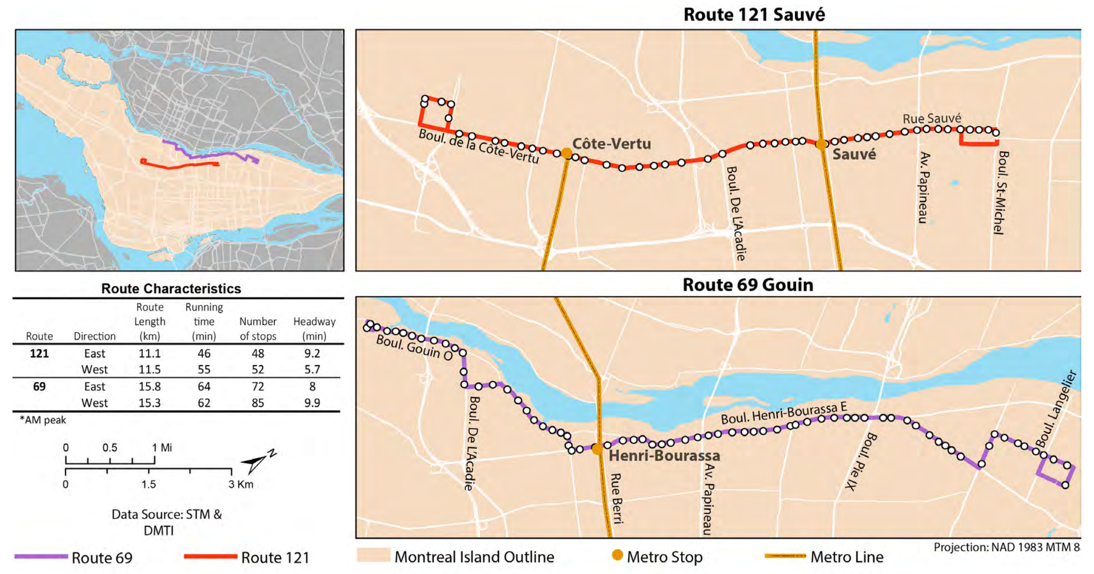
Temporal data:
- Time from doors open to door close (dwell time)
- Time after doors open to end of passenger activity (passenger activity time)
- Excess dwell time

Fare payment type:
- Cash
- Smart card
- Magnetic fare card
- No fare presented (children under 6)

Passenger activity:
- Boardings and alightings
- Stop arrival time
- Passenger load
- Passengers boarding with an encumberment or mobility restriction

Stop characteristics:
- Direction of trip
- Time of day
- Passenger load
- Stop location (e.g. near-side)
- Reserved bus lane
- Bus shelter

Context map of routes studied



Route Characteristics

Route	Direction	Route Length (km)	Running time (min)	Number of stops	Headway (min)
121	East	11.1	46	48	9.2
	West	11.5	55	52	5.7
69	East	15.8	64	72	8
	West	15.3	62	85	9.9

*AM peak

Dwell time models

Six models are employed to compare estimates of manual observations of dwell time to estimates generated from models using data similar to what AVL/APC and fare box reports. Models 1-3 report total boardings, and Models 4-6 report boardings by fare payment type.

Models 1 & 4: typical AVL/APC data

Models 2 & 5: controls for amount of excess dwell time

Models 3 & 6: considers encumbered passengers boarding

DWELL TIME MODELS

	Traditional Dwell Time (Model 1)			Expanded Model (Model 2)			Expanded Model (Model 3)		
Variable	Coef.	2.5%	97.5%	Coef.	2.5%	97.5%	Coef.	2.5%	97.5%
Constant	4.82^{b}	0.84	0.98	3.33^{a}	2.09	4.57	3.26^{a}	2.05	4.46
Total Boardings	4.33^{a}	3.73	8.81	1.84^{a}	1.65	2.03	1.74^{a}	1.55	1.93
Total Alightings	2.14^{a}	1.47	4.93	0.78^{a}	0.57	0.99	0.76^{a}	0.56	0.97
Total Passenger Activity ^2	-0.011^{a}	-0.02	2.82	-0.010^{a}	-0.01	-0.01	-0.0096^{a}	-0.01	-0.01
Excess Dwell	NA	NA	NA	0.96^{a}	0.94	0.98	0.96^{a}	0.94	0.98
Friction	-0.66^{b}	-1.19	-0.14	0.32^{a}	0.16	0.49	0.32^{a}	0.16	0.48
Eastbound Trip	-1.19	-3.96	1.58	-0.76^{b}	-1.62	0.10	-0.83^{b}	-1.67	0.00
AM	-4.55^{a}	-7.81	-1.29	-0.70	-1.72	0.31	-0.76^{c}	-1.74	0.23
PM *(ref= midday)*	-0.49	-4.19	3.20	0.17	-0.98	1.32	0.14	-0.97	1.25
Metro Station	26.54^{a}	18.46	34.62	-3.82^{a}	-6.41	-1.23	-3.23^{b}	-5.74	-0.71
Encumbered Passenger	NA	NA	NA	NA	NA	NA	9.19^{a}	6.84	11.54
Signalized intersection	5.52^{a}	2.50	8.54	1.67^{a}	0.72	2.61	1.42^{a}	0.51	2.34
Route 121	-1.43	-4.96	2.10	0.45	-0.65	1.54	0.65	-0.42	1.71
	R-Squared 0.52			R-Squared 0.95			R-Squared 0.96		

Signif. codes: a=p<0.01, b=p<0.05, c=p<0.1

Model 1
- On average each passenger **boarding** adds **4.3 seconds** to the total dwell time.
- Each passenger **alighting** adds **2.1 seconds** to the total dwell time.

Model 2
- By controling for **excess dwell** the model reports lower time estimates of boardings (**1.8 seconds per boarding** and **0.8 seconds per alighting**).

Model 3
- **Encumbered passenger boardings** add **9.2 seconds** to the total dwell time.

	Traditional Fare Payment (Model 4)			Expanded Fare Payment (Model 5)			Expanded Fare Payment (Model 6)		
	Coef.	2.5%	97.5%	Coef.	2.5%	97.5%	Coef.	2.5%	97.5%
Constant	3.30^{c}	-0.62	7.21	2.53^{a}	1.41	3.66	2.50^{a}	1.40	3.60
Fare payment type									
Smart card	4.71^{a}	3.96	5.46	2.50^{a}	2.28	2.71	2.42^{a}	2.20	2.64
Magnetic card	21.77^{a}	16.23	27.31	0.42	-1.23	2.06	0.19	-1.42	1.79
No fare presented	4.23*	-0.83	9.28	4.17^{a}	2.72	5.62	2.50^{a}	1.00	4.01
Cash	8.66^{a}	2.56	14.76	7.07^{a}	5.32	8.82	6.93^{a}	5.22	8.65
Total Alightings	1.73^{a}	1.05	2.40	0.64^{a}	0.45	0.84	0.64^{a}	0.45	0.83
Total Rear Door Boardings	1.48^{b}	0.30	2.67	0.03	-0.31	0.37	0.054	-0.28	0.39
Total Passenger Activity ^2	-0.0047^{b}	-0.01	0.00	-0.0047^{a}	-0.01	0.00	-0.0047^{a}	-0.01	0.00
Friction	-0.51^{b}	-1.03	0.01	0.27^{a}	0.12	0.42	0.28^{a}	0.13	0.42
Eastbound Trip	-0.87	-3.58	1.83	-0.79^{a}	-1.57	-0.02	-0.84^{b}	-1.60	-0.08
AM	-3.49^{b}	-6.69	-0.30	-0.66	-1.57	0.26	-0.70	-1.60	0.20
PM (ref= midday)	0.21	-3.41	3.83	0.51	-0.53	1.55	0.53	-0.49	1.54
Metro Station	27.55^{a}	19.53	35.57	-1.12	-3.49	1.25	-0.74	-3.06	1.58
Encumbered Passenger	NA	NA	NA	NA	NA	NA	7.58^{a}	5.32	9.85
Signalized intersection	5.48^{a}	2.53	8.43	1.46^{a}	0.61	2.31	1.29^{a}	0.46	2.12
Route 121	-1.04	-4.50	2.41	0.60	-0.39	1.60	0.70	-0.27	1.67
Excess Dwell	NA	NA	NA	0.97^{a}	0.95	0.99	0.97^{a}	0.95	0.99
	R-squared 0.54			R-squared 0.96			R-squared 0.96		

Signif. codes: a=p<0.01, b=p<0.05, c=p<0.1

Model 4

Boarding times by payment type are as follows:
- **Smart card** boardings add **4.7 seconds.**
- **Children** boarding add **4.2 seconds.**
- **Cash** boardings require **8.7 seconds.**
- **Magnetic cards** require **21.8 seconds.**

Model 5

Including the amount of **excess dwell** the model reports **lower** time estimates of boardings:
- **Smart card** boardings add **2.5 seconds.**
- **Children** boarding add **4.2 seconds.**
- **Cash** boardings require **7.1 seconds.**

Model 6

Accounting for **encumbered boardings** and **excess dwell,** boarding times are reduced to:
- **2.4 seconds** per **Smart card.**
- **2.5 seconds** per **children.**
- **6.7 seconds** per **cash.**

DISCUSSION

Main Findings

- The traditional model using data similar to what **AVL/APC reports** overestimated the additional time of the first passenger boarding by approximately **2.5 times.**
- **Overestimation** of time required for passenger activity was a result of **excess dwell time** likely captured by AVL/APC data.
- The **manual data collection** process employed in this study allowed us to capture details regarding the **dynamics of passenger activity**, details that are not currently well captured by AVL/APC and fare box data.

Recommendations

- To improve AVL/APC data collection, the **time stamp** of the last passenger boarding recorded by the **APC system** can be used to identify the end of passenger activity. This information, when combined with the door closing time, can enable transit agencies to identify the amount of excess dwell at every stop and adjust schedules accordingly.
- Knowledge of the **composition of patronage** along a bus route, such as a route serving a high proportion of elderly passengers, can inform schedulers with the required **modifications to the schedule.**

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