ALL ABOARD AT ALL DOORS

Route selection and runtime savings estimation for multi-scenario all-door bus boarding

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ABSTRACT

Transit agencies that allow **bus boarding through all doors**, instead of just the front door, enjoy greatly **decreased boarding and running times**.

This paper studies the feasibility of all-door boarding (ADB) for Montréal's public-transit agency, STM. The benefits of this are assessed through three main steps:

- First, a **selection methodology** is developed to determine which of STM's routes would benefit most;
- Second, a **regression analysis**, using STM's AVL/APC data, is used to estimate the dwell- and running-times savings that would result; and
- Third, a **sensitivity analysis** is used to show the savings under different implementation strategies

Our findings show that ADB could yield **running-time savings of up to 15.8%** in the morning peak. Often, the savings are enough to **remove a bus** from a route while maintaining existing frequencies.

The findings from this research can be beneficial to **public-transit planners** and **operators**.

LITERATURE REVIEW

The main benefit of ADB is a reduction in **dwell time**—the time spent at stops to service passengers. It is estimated that dwell-time reductions due to ADB can lead to **running-time savings of 4.6 to 13.3%**.

These savings will be highest if **three-door buses** and **off-board payment** are used.

The greatest concern of ADB is increased **fare evasion**. However, it has been shown that the **perception** of fare evasion is much greater than actual rates. For example, **evasion rates are only 2.4% and 4.7%** in Ottawa and San Francisco, two cities that have ADB policies.

The main **costs** of ADB are those of new **fare readers** and **fare inspectors**. However, it is largely agreed upon that **these costs are outweighed by the savings** in operating costs that result from running-time reductions.

Since no literature could be found on the process of selecting bus routes for ADB, **the authors devised their own methodology**.

ROUTE SELECTION & ANALYSIS

Several **criteria** were used to identify which bus routes would excel with all-door boarding:

- **High average boardings** across all stops
- **High total boardings**
- The above criteria in both the **AM and PM peaks**, **inbound** and **outbound** directions

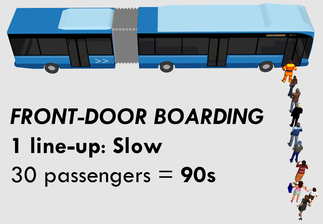
Ultimately, **seven routes** were chosen for analysis.

To determine the **running-time savings** under different ADB implementations, multi-variate **regression models** for **runtime** and **dwell-time** were generated with **AVL/APC data**.

This data included figures on each bus stop on a bus trip, such as arrival and departure time, and the number of passengers boarding ("ons") and alighting ("offs").

The models are shown in **Tables 1 and 2** below.

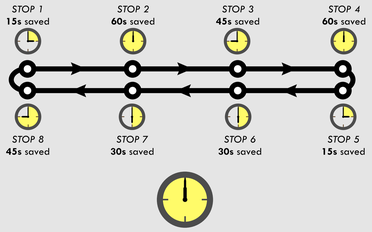
HOW ALL-DOOR BOARDING SAVES MONEY



FRONT-DOOR BOARDING
1 line-up: Slow
30 passengers = **90s**

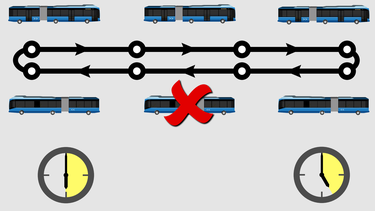
ALL-DOOR BOARDING
3 line-ups: Up to **3x faster**
30 passengers = **30s** (60s saved)

SMALL SAVINGS AT EACH STOP ADD UP



Total saved running time:
5 minutes

WITH ENOUGH SAVINGS, A BUS CAN BE REMOVED



OLD cycle, 5-min headway
6 buses required

NEW cycle, 5-min headway
5 buses required

TABLE 1: Runtime model (all times in seconds)

Variable	Mean	Std Dev	Coefficient
Runtime	2126.84	422.20	–
(Constant)	–	–	180.20***
AM_Peak[D]	.16	.37	18.26***
PM_Peak[D]	.18	.38	85.53***
AllOn	72.14	39.95	3.53***
AllOff	78.96	39.03	1.21***
PaxSq	2596.16	2884.74	-0.01***
Load	22.99	1.22	-8.29***
LoadSq	784.76	695.60	0.05***
DelayAtStart	35.18	112.46	-0.12***
RealStops	23.71	7.83	11.97***
FarSideStops	1.63	1.73	-10.31***
(weather- and route-specific variables removed)			
R^2			0.839
N			15,633

[D]Dummy variable; *p<0.1; **p<0.01; ***p<0.001

TABLE 2: Dwell-time model (all times in seconds)

Variable	Mean	Std Dev	Coefficient
DwellTime	25.94	27.009	–
(Constant)	–	–	2.710***
Inbound[D]	.484	.500	-.378***
AM_Peak[D]	.198	.399	-1.167***
PM_Peak[D]	.232	.422	-.172**
Door1_On	3.619	5.692	3.871***
Door2_On	.009	.120	3.505***
Door3_On	.006	.103	1.918***
Door1_Off	1.359	1.874	2.570***
Door2_Off	1.425	2.436	1.607***
Door3_Off	.926	2.051	1.287***
Door1_OnSq	45.500	188.651	-.024***
Door2_OnSq	.015	.706	-.103*
Door3_OnSq	.011	.992	-.098**
Door1_OffSq	5.359	16.956	-.069***
Door2_OffSq	7.964	34.763	-.064***
Door3_OffSq	5.065	27.209	-.056***
Standees	2.462	7.281	-.035***
DelayAtStart	.799	16.352	-.008***
TimingStop[D]	.053	.223	15.996***
TrafficLight[D]	.802	.399	5.674***
FarSideStop[D]	.046	.209	-4.342***
RainFall	.352	1.679	.080***
SnowFall	.136	.961	.067**
SnowOnGround	1.609	5.319	.025***
(route-specific variables removed)			
R^2			0.695
N			473,969

[D]Dummy variable; *p<0.1; **p<0.01; ***p<0.001

SENSITIVITY ANALYSIS

To estimate the **running-time savings** for each route, **sensitivity analysis** was performed using the runtime and dwell-time models. Savings were calculated for the following three ADB implementations:

- **Full route** (ADB at **all stops** on a route)
- **Major stops** (ADB only at **busy, non-first stops** on a route)
- **Layover** (ADB only at the **first stop** on a route, during drivers' scheduled breaks)

Four **savings scenarios** were simulated: **low-saving**, **high-saving**, and two similar scenarios with extra savings from **off-board** payment. **Savings** were as high as **13.9%** (see Table 3), and were often high enough to **remove a bus** from the route.

Greater savings can be achieved by **combining implementations**; for example, combining the full-route and layover implementations on Route 467 yields **savings of up to 15.8%**.

TABLE 3: Percentage savings of AM-peak running times under each scenario

	Routes	45	67	121	161	165	435	439	467
Full route	Low	6.9	7.6[1]		4.7	6.8[1]		6.2	9.2
	High	9.2	10.1[1]		7.1	9.1[1]		8.7	12.2
	Offboard low	8.9	9.8[1]		7.4	8.8[1]		7.9	11.8
	Offboard high	10.5	11.6[1]		9.1[1]	10.4[1]		9.4	13.9[1]
Major stop	Low		2.3	2.4	0.8	1.5[1]	1.9		3.2
	High		3.2	3.3	1.2	2.0[1]	2.6		4.3
	Offboard low		3.1	3.3	1.3	1.9[1]	2.5		4.1
	Offboard high		3.7	4.0	1.6	2.3[1]	3.0		5.0
Layover	Low	1.0	0.9		0.5	1.4		1.5	1.2
	High	1.3	1.2		0.7	1.9[1]		2.0	1.6
	Offboard low	1.3	1.2		0.8	1.9[1]		2.1	1.6
	Offboard high	1.5	1.4		0.9	2.2[1]		2.4	1.8

[1]A bus can be removed

CONCLUSIONS

The purpose of this research was to **assess the benefits of all-door bus boarding** (ADB) in general, and to **develop a methodology** for selecting routes for pilot testing or partial implementation of such a policy.

Montréal's transit network, run by STM, was used as a case study.

The research consisted of the following steps:

- A literature review, which found that ADB can yield enough **operating-cost savings** from reduced running times to **outweigh losses from fare evasion.**
- Selection of the routes in STM's network that would benefit most from ADB. A **new selection methodology was devised** using STM's AVL/APC data.
- Generation of runtime and dwell-time regression models for the selected routes. **These models were the first**, to our knowledge, to capture the effect of **locating stops on the far-side** of an intersection.
- Sensitivity analysis to **estimate running-time savings** under various scenarios.

The main findings were as follows:

- Running-time savings at the route level **ranged from 4.7 to 13.9%**, and were as high as **15.8%** when adding the savings from layovers.
- Bus stops on the **far side of an intersection** were found to **decrease running times** by about ten seconds each.
- It was often possible to **remove a bus** from a route while maintaining current frequencies. This represents **substantial operating-cost savings** for any transit agency.

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