SFMTA
Municipal
Transportation
Agency

# All-Door Boarding Evaluation

# Final Report


December 2014

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# EXECUTIVE SUMMARY

For generations, the transit industry has had to balance the desire for faster service with the need to collect fares. Today, most bus systems require front-door boarding and fare verification by the operator in order to increase fare compliance. The tradeoff is that front-door boarding also extends dwell times at stops, lengthens overall travel times and uses scarce resources less efficiently.

On July 1, 2012, the San Francisco Municipal Transportation Agency (SFMTA) became the first multimodal transit operator in North America to implement All-Door Boarding systemwide. Expanding a policy already applicable to light rail vehicles, the SFMTA began permitting customers with valid proof-of-payment to enter through any door of Muni buses and streetcars. In doing so, the agency legalized an informal practice that had developed organically in response to front-door queues, crowding and slow service. Unlike other transit operators with Proof-of-Payment systems, the SFMTA allows customers to pay cash on-board vehicles at surface stops, thus avoiding the expenses of ticket vending machines.

Serving the nation's second-densest major city with crowded transit vehicles largely operating in mixed traffic, the SFMTA must make efficient use of every minute in revenue service. Two years after implementation, a comprehensive evaluation of All-Door Boarding finds that the policy has contributed to:

- Shorter Stops – Legalizing All-Door Boarding has encouraged boarding customers to distribute themselves more evenly between the front and rear doors, thereby reducing average dwell times. Pre- and post-implementation surveys at busy Muni stops found average reductions of 1.5 seconds (38%) per customer entry or exit. All-Door Boarding also has improved dwell time consistency and lowered variability, an important factor in helping reduce vehicle bunches and gaps and making service more reliable and predictable.
- Faster Trips – From FY 2010-2011 through FY 2013-2014, average bus system speeds (including stops) improved modestly from 8.41 to 8.56 mph (2%). All-Door Boarding has helped keep Muni moving during a period of rapid growth in San Francisco and increasing demand on the transportation system. All-Door Boarding is just one of many tools such as exclusive transit lanes, transit signal priority and parking management that together can help reduce travel time.
- Improved Fare Compliance – A series of four fare surveys between 2009 and 2014 indicate that fare compliance continues to improve. The fare evasion rate has decreased from 9.5% to 7.9% over five years and the estimated uncaptured revenue due to fare evasion has dropped from $19.2 million to $17.1 million.

The success of All-Door Boarding in San Francisco's operating environment demonstrates the potential benefits of this policy for other cities that are exploring cost-effective opportunities to speed up transit.

# INTRODUCTION

On July 1, 2012, the San Francisco Municipal Transportation Agency (SFMTA) became the first multimodal transit provider in North America to permit systemwide All-Door Boarding. As the operator of Muni, the eighth-largest U.S. transit system, the SFMTA manages a diverse fleet of buses (motor coaches and electric trolley coaches), light rail vehicles, historic streetcars and cable cars with an annual ridership of 226 million. This report summarizes the operational and financial results of All-Door Boarding two years after implementation.

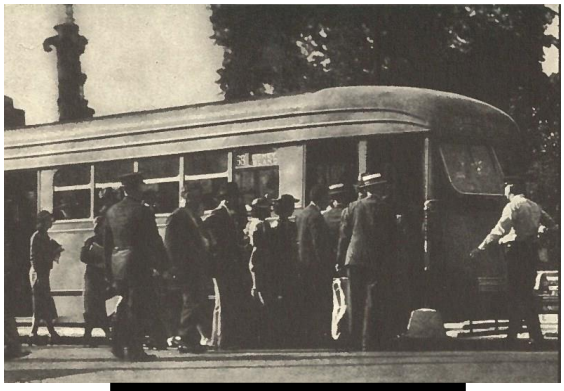
Previously available on the six Muni light rail lines only, the SFMTA expanded All-Door Boarding to encompass all vehicles. The rules are simple: customers with valid transfers/fare receipts, Clipper® Cards or other fare media may enter through any door of any vehicle at any time. Clipper® users must validate their cards by tapping readers which are adjacent to every door. The historic open-air cable cars remain a special case where conductors handle fare collection.

All-Door Boarding in San Francisco evolved from various official policies and unofficial practices over the past two decades. On light rail, a proof-of-payment policy allowing customers with pre-paid fares to enter through any door took effect in the 1990s. No such policy existed on buses, however. Instead, customers organically developed a culture of rear-door boarding at certain busy stops – with or without proof-of-payment – in response to long front-door queues, crowding, and slow service. The then-illegal practice and its inconsistent application increased perceptions of fare evasion even though it reduced delays and demonstrated the potential of sanctioned All-Door Boarding.

### Dwell Times and Fare Collection: A Historical Perspective

Shortening dwell time – when a vehicle stops for customers to board and alight – can make transit a more attractive choice and optimize scarce fiscal resources. Balancing the desire for faster service with the need to collect fares has challenged the transit industry for generations. Historically, rail rapid transit lines such as the New York Subway or Chicago 'L' evolved to have off-board ticket vending machines and faregates, thus minimizing dwell times at stations but increasing fare collection costs.

The situation has been more difficult for buses, streetcars and other "surface" transit modes due to relatively lower ridership volumes and the physical configurations of at-grade and open boarding locations. A century ago, streetcar companies employed an operator and a conductor, which enabled the vehicle to move while customers paid. Fighting for its economic survival, the industry transitioned to one-person operation. Although this change reduced deficits, it increased boarding delays since everyone now needed to file through the front door (Figure 1).



Brooklyn, NY (1937)


Akron, OH (1945)

**FIGURE 1 Historical Front-Door Boarding** (Images from the publications *Transit Hails the Modern Car* (1937) and *Trolley Coaches – Why People Like Them* (1945))

Building off successful European models, the transit industry in North America took an important step towards reducing dwell times with the first modern light rail systems in Edmonton (1978), Calgary (1981) and San Diego (1981). Under those and most subsequent "Proof-of-Payment" (POP) systems, customers may enter through any door with prepaid fare media or tickets pre-purchased from station vending machines. Fare inspectors may issue citations to those without valid proof-of-payment.

Now standard on new light rail lines, transit systems are extending the proof-of-payment model to many bus rapid transit operations such as Select Bus Service in New York, the Health Line in Cleveland and the Orange Line in Los Angeles. As of 2014, however, San Francisco remains the only large urban bus and rail transit system in North America with All-Door Boarding throughout the entire transit network.

## The Need for All-Door Boarding

San Francisco's operating environment provides an ideal testing ground for All-Door Boarding in the United States. Serving the nation's second-densest major city with crowded transit vehicles largely operating in mixed traffic, the SFMTA must make efficient use of every minute in revenue service. All-Door Boarding is part of a larger effort to improve travel times through transit priority lanes, signal preemption, stop consolidation, new vehicles and increased limited-stop service.

Service stops account for about 20% of Muni's travel time. Muni buses average approximately 70 boardings per hour, the highest in the country along with New York. This rate increases to about 100 boardings during the peak hour in the peak direction, which further hampers the ability to deliver on-time service.

Unlike systems with exclusive rights-of-way, all or part of every Muni line operates in mixed traffic. Muni buses average only 8.6 mph. Boarding delays exacerbate the difficulty of meeting demand with an insufficient fleet – at least 8% of peak-hour buses are currently full. The challenges of the recent past will only intensify in the future: San Francisco's population increased from 805,235 to 837,442 (+4.0%) between 2010 and 2013 and is projected to reach 1 million by 2032.

## A Different Implementation Approach

To implement systemwide All-Door Boarding, the SFMTA overcame two significant hurdles that historically have precluded similar policies elsewhere: (1) extending fare enforcement cost-effectively over a geographically-dispersed transit network; and (2) placing ticket vending machines at every stop with associated installation, servicing and maintenance costs.

During the past five years, the SFMTA has strengthened its Proof-of-Payment Program and incrementally improved fare compliance. In 2010, it expanded fare inspections from six light rail lines to over 60 bus lines and one historic streetcar line, representing an increase in ridership coverage from 145,000 to 680,000 weekday trips. In 2012, All-Door Boarding brought a modest increase in Transit Fare Inspectors. Active full-time equivalent positions grew from 41 to 54 over two years. With staffing constrained by the budget, the SFMTA developed new deployment strategies to protect fare revenues as Proof-of-Payment has expanded to the entire network. Rotating fare inspectors daily to different police districts has been particularly helpful in increasing geographical coverage.

(a) Pre-implementation Front-Door Boarding

(b) Post-Implementation All-Door Boarding

**FIGURE 2 Muni Boarding Procedures** (a) Queuing at the front door before implementation and (b) Entering through both doors after implementation

Muni serves about 3,500 surface rail and bus stops. Rather than installing ticket vending machines everywhere, the SFMTA allows cash-paying customers to enter through the front door, use the farebox and obtain a 90-minute transfer/fare receipt from the operator. With full-service ticket vending machines at light rail subway stations, electronic fare products on Clipper®, and an extensive Clipper® retail vendor network, surveys indicate that a little over 10% of boarding customers pay cash at busy stops. The SFMTA intends to pilot mobile ticketing to increase customer convenience and further reduce cash fares.

With All-Door Boarding, the SFMTA hoped to achieve several operational and financial goals: (a) shorter stops, (b) faster trips and (b) maintained or improved fare compliance. In certain circumstances, faster service may permit a transit operator to assign fewer

vehicles to a route and still maintain headways. Given pre-existing crowding and schedule adherence issues, however, this was not a program objective.

## IMPLEMENTATION

At the end of 2011, the SFMTA decided to implement formal systemwide All-Door Boarding within six months. Without a peer transit system model to follow, the agency faced uncertainty about revenue losses and other risks. On the other hand, the SFMTA already had unofficial All-Door Boarding and would only be formalizing the policy across the system. To determine the program's outcome, preparations included a robust evaluation plan.

### Fare Survey

Indirect preparation actually began several years earlier, focusing on understanding systemwide fare payment patterns and identifying ways to improve the effectiveness of fare enforcement. In 2009, the SFMTA conducted its first comprehensive Proof-of-Payment Study in response to growing concerns about revenue losses from then-illegal rear-door boarding in an environment of significant budget shortfalls.

Besides reviewing the practices of the agency's Proof-of-Payment Program, the study included a comprehensive survey to determine the times, routes and locations where fare compliance issues were most prevalent. To obtain a representative sample of fare payment patterns, in-house teams of Transit Fare Inspectors and survey recorders rode the entire system for several months.

The survey employed two methodologies to determine fare payment: (a) a "spot check", where teams checked customers and then immediately exited, and (b) a "ride along", where teams remained on-board for multiple stops to check boarding customers. The "ride along" allowed the team to observe farebox payments and through which door customers entered. Examples of invalid proof-of-payment included underpaying the cash fare, showing nothing or improperly using fare media. With 41,239 customer observations, the fare survey found a fare evasion rate of 9.5%. A smaller 2010 follow-up survey of over 12,000 customers revealed a fare evasion rate of 8.6%.

### Fare Enforcement

The primary purpose of Transit Fare Inspectors is not to recover their costs through citation fines but to improve fare compliance. Rather than involving the court system, the SFMTA treats citations for adults as infractions and collects fines, which are just over one percent of fare revenues. Efforts are also underway at the state level to decriminalize youth citations at the state level. As importantly, Transit Fare Inspectors increase safety and security by providing a uniformed staff presence.

The SFMTA's fare enforcement strategy is designed to create the expectation that fare inspections can happen anywhere at any time. Informed by the 2009 Proof-of-Payment

Study, the agency has undertaken changes to improve its fare inspection program, including:

- Expanding enforcement from light rail to buses and streetcars
- Rotating Transit Fare Inspectors to a different police district everyday where they can check any Muni vehicle, rather than focusing on one specific line
- Rescheduling shifts to improve weekend coverage so that all inspectors work either Saturday or Sunday instead of only Monday to Friday
- Introducing "enhanced fare enforcement", where a large team of fare inspectors quickly checks all customers on a vehicle, sometimes accompanied by police
- Centralizing the Transit Fare Inspector reporting location at SFMTA headquarters to increase inspection time and reduce travel time to the system's core

**Six-Month Preparation Process**

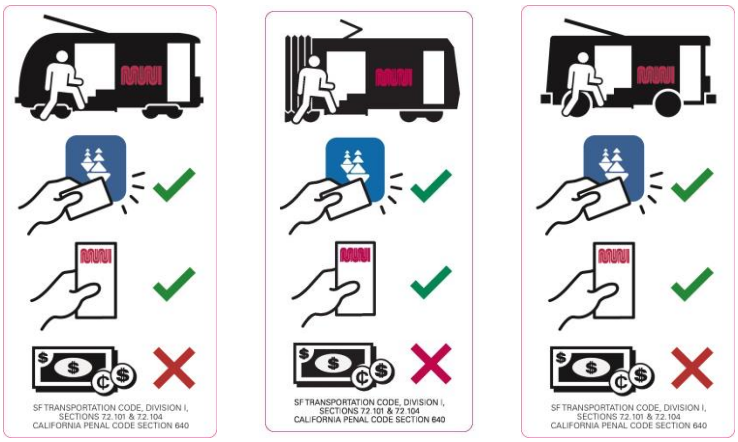
Given the multi-disciplinary nature of the implementation process, the SFMTA convened an internal working group consisting of virtually all organizational divisions: Finance & Information Technology, Transit (including Transit Management and Operations Planning & Schedules), Sustainable Streets (including Security, Investigations and Enforcement), Communications, System Safety and Taxi & Accessible Services. The group collaborated to accomplish the following:

- *Transit Fare Inspector Staffing Increase* – The working group justified the hiring of additional Transit Fare Inspectors, ultimately netting approximately 13 new full-time equivalent positions over two fiscal years. As a result, estimated inspection rates have increased from 1.1% to 1.3% of bus, streetcar and light rail customers. The budget assumed that increased citation revenue would cover a portion of the incremental salaries and benefits, but that the net labor cost would be approximately $47,000 per employee.
- *Transportation Code Amendments* – In May 2012, at the request of the SFMTA Board of Directors, the San Francisco Board of Supervisors amended the city's Transportation Code to accommodate the new policy. The updated regulations eliminated restrictions on rear-door boarding and clarified that Clipper® users must tag their cards on readers to validate their fare upon boarding.
- *Fare Survey* – Methodologically consistent with the 2009 and 2010 fare surveys, SFMTA staff conducted an abbreviated survey in spring 2012 to benchmark fare compliance prior to implementation. The survey covered all times of day and virtually every Muni route. With 9,162 customer observations, it found a systemwide 8.4% fare evasion rate.
- *Vehicle Preparation* – Staff verified the functionality of previously-installed rear-door Clipper® readers, removed signs warning "Stop: Enter Through Front Door Only" and added language-neutral decals illustrating the policy.
- *Public Outreach* – The SFMTA installed informational car cards in English, Spanish and Chinese in shelters and on bus and streetcar overhead panels. Staff outreached to community groups to explain the boarding policy and emphasize safety when boarding and exiting vehicles. SFMTA's Director of Transportation and Director of Transit held a press event four days prior to implementation. Finally, the SFMTA produced several light-hearted YouTube videos in-house

featuring “Professor Muni” explaining All-Door Boarding’s “do’s” and “don’ts”. Public outreach efforts, combined with signage on vehicles and shelters, may have contributed to a high public acceptance of the policy. In the month following implementation, the SFMTA received fewer than 50 complaints from unique individuals about All-Door Boarding.

- *Internal Communications* – With the anticipated influx of rear-door customers, the SFMTA made special efforts to communicate safety procedures internally. Operators received a bulletin containing guidelines on positioning buses to maintain visibility and activating the rear doors.


(a) Rear-Door Clipper® Card Reader




(b) All-Door Boarding Decals on Streetcars, Light Rail and Buses

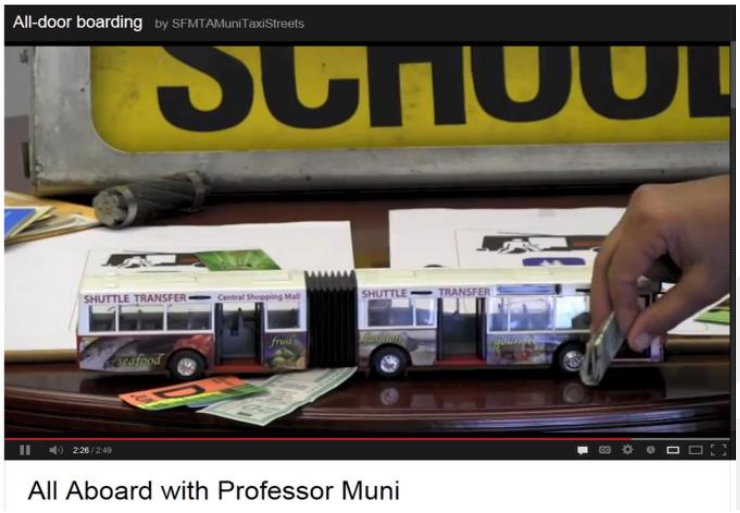

(c) Former Decals Prohibiting All-Door Boarding

(d) New Decals Authorizing All-Door Boarding

**FIGURE 3 Vehicle Preparation for All-Door Boarding** (a) Verified functionality of previously-installed rear-door Clipper® readers, (b) Designed language-neutral decals explaining that customers with Clipper® Cards and other valid fare media could enter through the rear door, but not with cash, (c) Removed signs prohibiting rear-door boarding and (d) Added the decals permitting rear-door boarding.


(a) English Car Card explaining All-Door Boarding


(b) Spanish and Chinese Car Card explaining All-Door Boarding




(c) "Professor Muni" YouTube Video


(d) Transit Operator Bulletin

**FIGURE 4 External and Internal Communications** - (a) and (b) English, Spanish and Chinese car cards placed on bus and streetcar overhead panels, (c) a YouTube video featuring "Professor Muni" and (d) a Training & Instruction Bulletin for Transit Operators

## EVALUATION METHODOLOGY

During implementation, SFMTA staff developed a rigorous methodology to evaluate the All-Door Boarding's operational and financial impacts. Data included direct observations of ridership and dwell times at busy stops and along entire routes, travel speeds from approximately one-third of buses and another comprehensive fare survey.

### Stationary Dwell Time Survey

To correlate ridership volumes and dwell times, staff timed how long it took for customers to enter and exit vehicles. Recognizing that limited personnel constrained the quantity of collected samples, the SFMTA chose this approach to achieve ridership accuracy that Automatic Passenger Counter (APC) reports could not necessarily replicate. While APCs provide reliable timing and geo-locational data, crowding at doors can interfere with registering customer entries and exits by existing laterally-mounted sensors.

Stationary Dwell Time Surveys at fixed locations took place in spring 2012, just prior to implementation, and two years later in spring 2014. To control for as many variables as possible, the two sets of surveys took place on the identical day of the week. To gauge All-Door Boarding's impacts in various contexts, staff observed over 2,000 boardings and alightings at nine high-volume stops served by 29 routes of differing types (local, limited-stop and express lines) and vehicles (two-door buses, three-door buses and streetcars). Additionally, the nine locations represented four diverse types and ridership markets, including the Downtown shopping area, the commuter-oriented Financial District, neighborhood commercial intersections in Chinatown and the Mission District, and tourist destinations in Fisherman's Wharf and along the Embarcadero.

Surveying focused on the afternoon peak period to maximize the chances of observing concentrated boardings. The roughly 4-to-1 ratio of boardings to alightings helped reduce the interference effects between entering and existing customers, although most people exercise the common courtesy of allowing others to leave before boarding. Staff recorded the total boardings and alightings by door, the time duration of customer activity and farebox use. Dwell times excluded when the doors remained open but no customer activity took place, such as when the vehicle was stationary at a red light or during a wheelchair lift deployment.

### Ride-Along Dwell Time Survey

While the stationary methodology captured high-ridership stops, it did not measure the All-Door Boarding's impacts as vehicles traversed the city and served stops with varying ridership. As a supplement, the SFMTA conducted Ride-Along Dwell-Time Surveys. Consisting of riding buses for over 20 hours, these observations helped estimate a "sweet spot" for distributing boardings between doors to minimize dwell times. These surveys covered seven routes and two- and three-door buses at different times of the day. With one surveyor per door, teams observed over 840 door openings and closings. Due to staffing constraints, the SFMTA employed this methodology only post-implementation.

## Speed Analysis

The SFMTA relied on APC travel time data to measure whether All-Door Boarding could impact overall speed including stops. Installed on about one-third of motor and electric trolley coaches, APCs provide 200,000 to 500,000 trip-level samples annually, enough to draw general conclusions about potential speed impacts. Using a deployment plan approved by the Federal Transit Administration for National Transit Database reporting, the SFMTA rotates APC-equipped vehicles on different routes to ensure sufficient and weighted sampling.

## Fare Survey

Following three pre-implementation fare surveys in 2009, 2010, and 2012, the SFMTA undertook another fare survey in 2014 to determine how All-Door Boarding had affected fare compliance. All surveys included observations spread across nearly every route during all times of the day, with the 2009 and 2014 comprehensive surveys having several times more samples to provide greater statistical confidence at the route level.

Unlike the pre-implementation surveys, the SFMTA hired a market research firm to record observations for the post-implementation survey. SFMTA staff worked with the contractor to replicate the methodology and train its employees to partner with Transit Fare Inspectors. The 2014 survey also included customer observations at the nine Muni Metro subway stations, whereas the previous studies only observed those on board light rail vehicles. Figure 5 illustrates the survey's widespread geographical coverage and customer volumes at each boarding location.

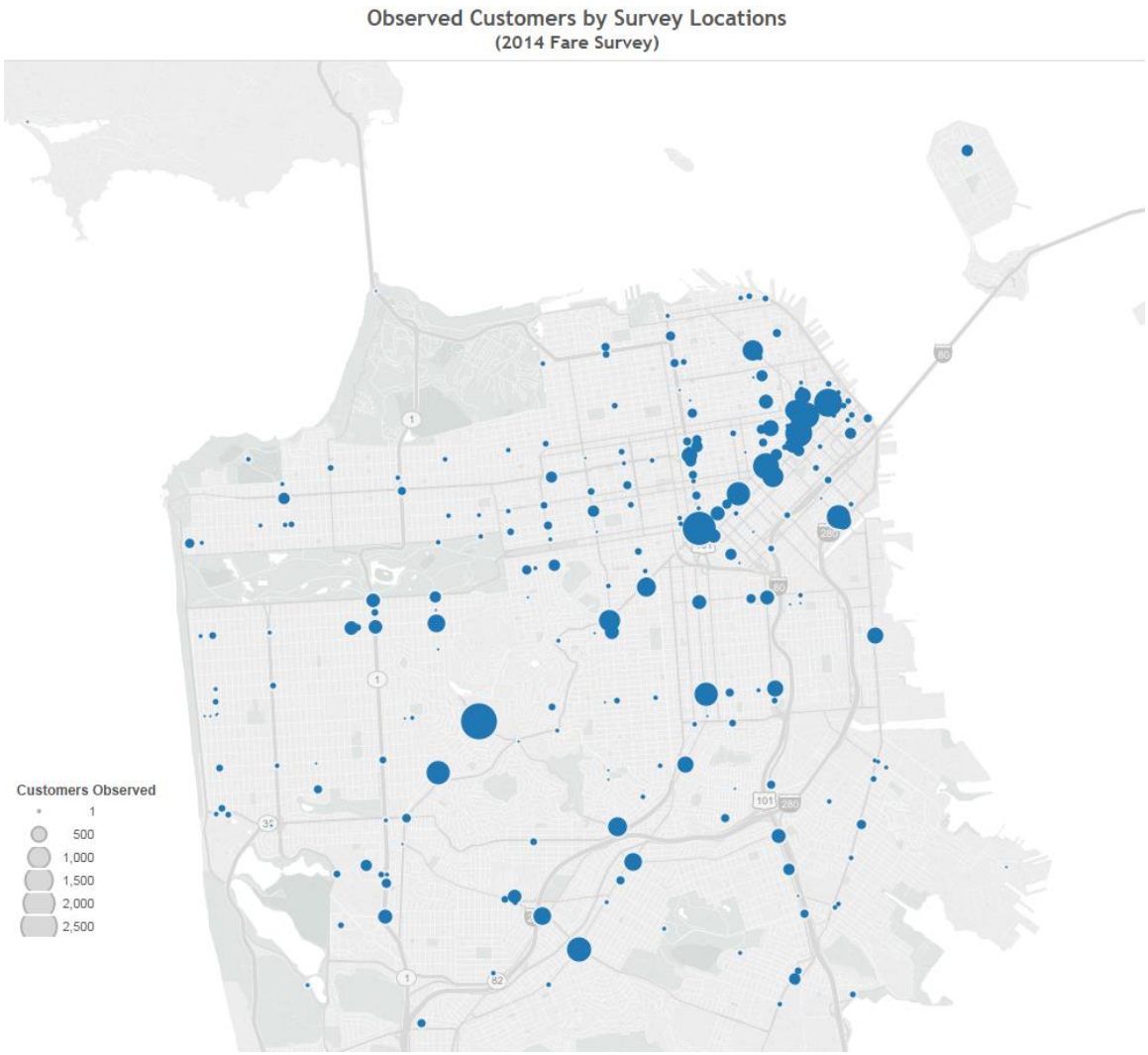



**FIGURE 5 2014 Fare Survey Observations**

## RESULTS

Two years after official All-Door Boarding began, transit operations have improved without adverse financial impacts. Table 1 highlights the principal findings:

- Boarding customers are distributing themselves between the front and rear doors more evenly than before, lowering average dwell times per entry and exit.
- Systemwide bus speeds (including stops) modestly improved despite growth in population, employment, ridership and motor vehicle registrations.
- Systemwide fare compliance slightly increased.

## TABLE 1 Principal Findings

| Evaluation Metrics | Data Source | Pre-Implementation | Post-Implementation |
|---|---|---|---|
| **Operational Impacts** | | | |
| Dwell Times Per Boarding and Alighting | Stationary Dwell Time Survey (major stops) | Average 3.9 s<br>Std. Dev. 3.5 s<br><br>2-door vehicles[1]:<br>Average 4.3 s<br>Std. Dev. 3.6 s<br><br>3-door vehicles[1]:<br>Average 1.6 s<br>Std. Dev. 0.9 s | Average 2.5 s<br>Std. Dev. 2.0 s<br><br>2-door vehicles[1]:<br>Average 2.7 s<br>Std. Dev. 2.1 s<br><br>3-door vehicles[1]:<br>Average 1.3 s<br>Std. Dev. 0.5 s |
| Rear-Door Boarding | Stationary Dwell Time Survey (major stops) | 28.5%<br>2-door vehicles[1]: 21.5%<br>3-door vehicles[1]: 55.0% | 54.1%<br>2-door vehicles[1]: 48.3%<br>3-door vehicles[1]: 77.7% |
| Rear-Door Boarding | Ride-Along Dwell Time Survey (all stops) | N/A | 51.5%<br>2-door vehicles[3]: 42.1%<br>3-door vehicles[1]: 61.1% |
| Bus System Speed | Automatic Passenger Counter Data | FY 2011: 8.41 mph<br>FY 2012: 8.48 mph | FY 2013: 8.52 mph<br>FY 2014: 8.56 mph |
| Farebox Usage | Stationary Dwell Time Survey (major stops) | 13.7% | 10.4% |
| **Financial Impacts** | | | |
| Fare Evasion | Fare Surveys | 2009: 9.5% ±0.3%[2]<br>(41,239 customers)<br>2010: 8.6% ±0.5%[2]<br>(11,939 customers)<br>2012: 8.4% ±0.6%[2]<br>(9,162 customers) | 2014: 7.9% ±0.2%[2]<br>(52,635 customers) |
| Fare Revenue (excluding cable cars) | Operating Budget | FY 2010-11: $164.3 m<br>FY 2011-12: $171.6 m | FY 2012-13: $179.1 m[4]<br>FY 2013-14: $178.1 m[4] |
| Proof-of-Payment Program Expenses | Operating Budget | FY 2010-11: $5.2 m<br>FY 2011-12: $5.3 m | FY 2012-13: $6.1 m<br>FY 2013-14: $7.0 m |
| Fare Inspections | Proof-of-Payment Program Records | FY 2011-12: 2,375,101 | FY 2012-13: 2,817,740<br>FY 2013-14: 2,801,061 |
| Fare Citations Issued | Proof-of-Payment Program Records | FY 2011-12: 42,867 | FY 2012-13: 71,028<br>FY 2013-14: 72,426 |
| Fare Citation Revenue | Operating Budget | FY 2010-11: $927,681<br>FY 2011-12: $1,488,615 | FY 2012-13: $2,423,514<br>FY 2013-14: $2,556,779 |
| **Background Statistics** | | | |
| Population | U.S. Census Bureau | 2010: 805,235<br>2011: 814,233 | 2012: 827,420<br>2013: 837,442 |
| Employment | Bureau of Labor Statistics | 2010 Q4: 555,742<br>2011 Q4: 570,094 | 2012 Q4: 601,101<br>2013 Q4: 626,230 |
| Weekday Bus and Streetcar Ridership | SFMTA Estimates | FY 2010-11: 500,213<br>FY 2011-12: 513,964 | FY 2012-13: 518,747<br>FY 2013-14: 526,781 |
| Motor Vehicle Registrations | California Department Of Motor Vehicles | 2010: 470,481<br>2011: 466,448 | 2012: 471,298<br>2013: 485,471 |

Notes: [1]High-floor buses and streetcars. Low-floor buses excluded due to limited sampling.
[2]Margin of error at a 95% confidence level.
[3]Low-floor buses.
[4]Excludes $2.2 million ($0.75 million pro-rated for FY 2012-13) in funding to offset Free Muni for Youth fare revenue impacts, as estimated by the SF Board of Supervisors Budget and Legislative Analyst's Office

## Dwell Times

The Stationary Dwell Time Survey showed significant shifts to rear-door boardings and corresponding decreases in dwell times. Most observations were of high-floor vehicles but also covered some of SFMTA's growing fleet of low-floor buses, which pre-implementation comprised less than 10% of vehicles. Due to the small sample size of low-floor buses at that time and the desire to compare identical vehicle types, the Stationary Dwell Time Survey results focus on high-floor models.

Rear-door boardings increased from 29% to 54% at nine of Muni's busiest stops. Correspondingly, the average dwell time per boarding and alighting decreased 38% from 3.93 to 2.45 seconds. While seemingly small, these incremental savings can accumulate and be the difference between making a green light and waiting for another traffic signal cycle.

Two-door buses and streetcars showed greater reductions in dwell times per boarding and alighting (1.6 seconds) than three-door articulated buses (0.3 seconds). With an extra door providing 50% greater throughput and high levels of pre-existing All-Door Boarding, articulated buses already had relatively short dwell times.

Focusing on two-door buses, Figure 6 illustrates several key points:

- *The boarding distribution through each door affects dwell times*. A more "even" boarding distribution (arbitrarily defined as 25% to 75% rear-door usage) is significantly faster than an "uneven" one (less than 25% or more than 75% rear-door usage). This was a consistent finding both before and after implementation. "Even" boarding distributions resulted in per-person dwell times around two seconds; "uneven" boarding distributions averaged four to five seconds.
- *Legalizing All-Door Boarding shifted more customers to the rear doors, thereby reducing average dwell times*. "Even" boarding distributions are now occurring much more frequently than before and more customers are using the rear doors on two-door buses (48% instead of 22%). Correspondingly, per-person dwell times have dropped from 4.3 to 2.7 seconds.
- *Legalizing All-Door Boarding also increased dwell time consistency and reduced variability.* As measured by their standard deviation, post-implementation dwell times across observations became more consistent and less variable than before. This can help reduce vehicle bunches and gaps and is an important factor in making service more reliable and predictable.

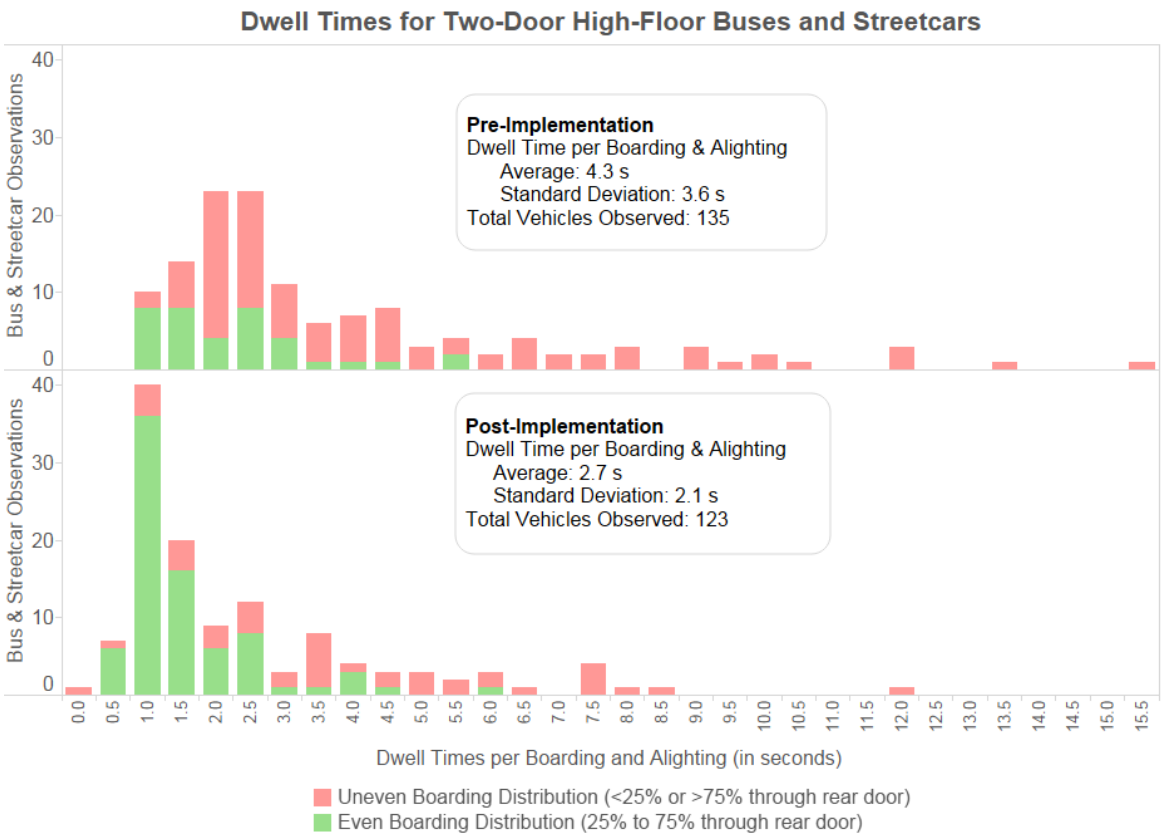



**FIGURE 6 Distribution of Dwell Times per Boarding and Alighting on Two-Door High-Floor Buses and Historic Streetcars**

*Findings by Stop Type*

The SFMTA serves many ridership markets, ranging from first-time visitors to seasoned commuters. As shown in Figures 7 and 8 and Table 2, the policy's impacts have varied based on stop type with the most pronounced impacts occurring where pre-existing All-Door Boarding was less prevalent.

In particular, the greatest absolute and percentage reduction in dwell times per boarding and alighting (3.3 seconds, or 49%) occurred at tourist-oriented stops. Despite less familiarity with riding Muni, it appears visitors readily adapted to All-Door Boarding. At Financial District commuter express bus stops, the pre-implementation boarding process was already efficient with a relatively low dwell time of 2.4 seconds per person even with 85% front-door entries. Afterwards, commuters also nearly evenly distributed themselves through each door, decreasing average dwell times by 1.0 second (44%). The least change came at neighborhood commercial intersections in the Mission District and Chinatown, where unofficial rear-door boarding was already commonplace.

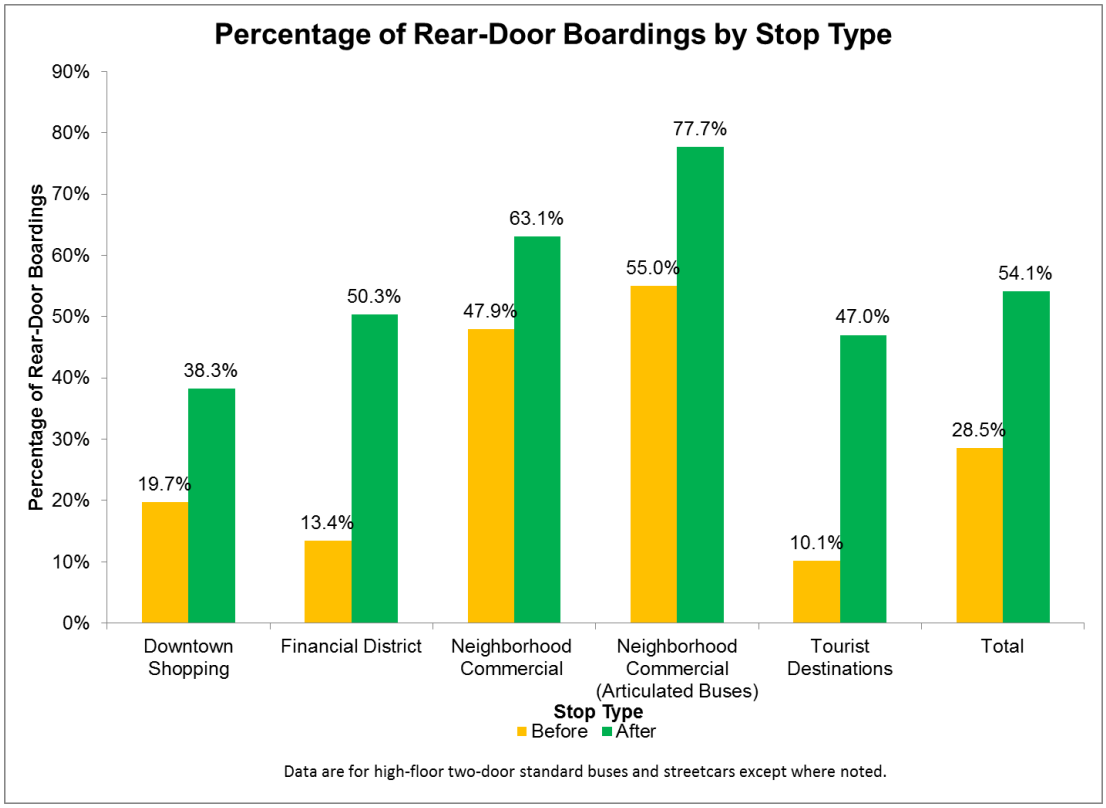



**FIGURE 7 Percentage of Rear-Door Boardings by Stop Type**

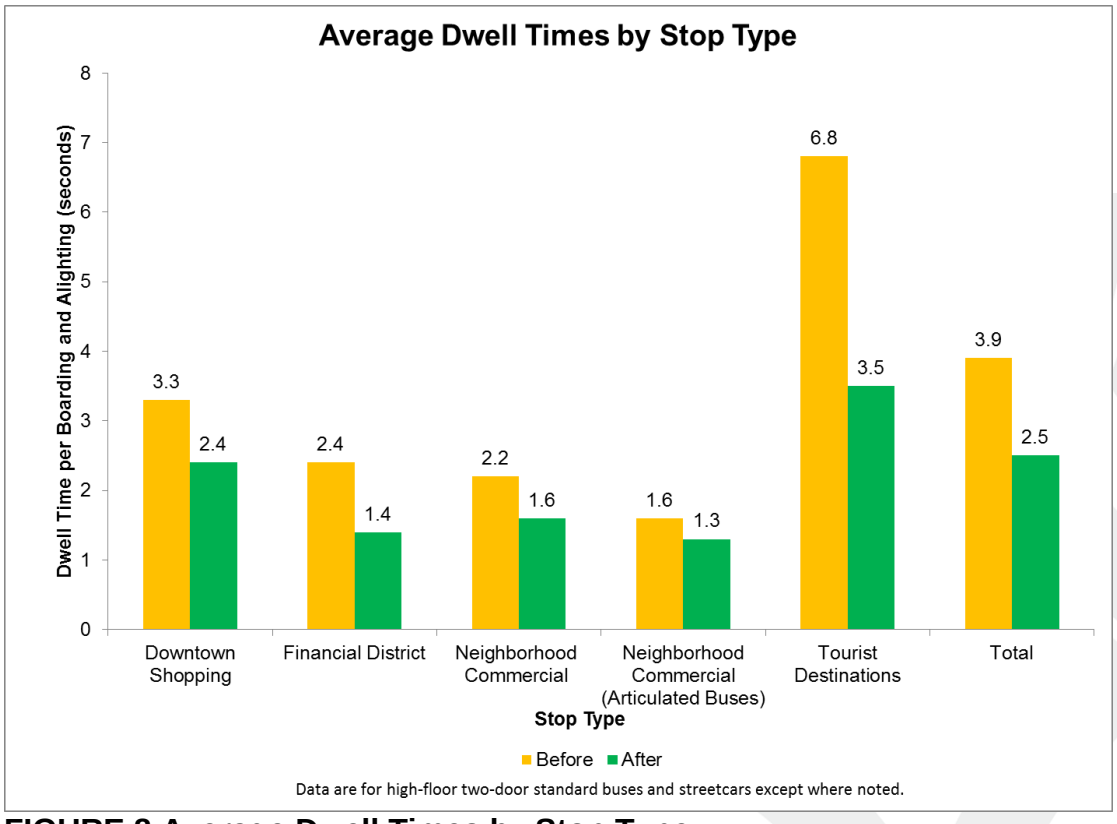



**FIGURE 8 Average Dwell Times by Stop Type**

**TABLE 2 Pre- and Post-Implementation Stationary Dwell Time Survey Results**

| Stop Type | Survey Period | Vehicle Observations | Boardings | Alightings | Rear-Door Boarding Percentage | Dwell Time per Boarding & Alighting |
|---|---|---|---|---|---|---|
| Central Business District | Before | 49 | 547 | 115 | 19.7% | 3.3 s |
| Central Business District | After | 26 | 324 | 98 | 38.3% | 2.4 s |
| Financial District | Before | 17 | 314 | 0 | 13.4% | 2.4 s |
| Financial District | After | 16 | 298 | 3 | 50.3% | 1.4 s |
| Neighborhood Commercial (2-Door Buses) | Before | 21 | 280 | 180 | 47.9% | 2.2 s |
| Neighborhood Commercial (2-Door Buses) | After | 20 | 225 | 119 | 63.1% | 1.6 s |
| Neighborhood Commercial (3-Door Buses) | Before | 19 | 389 | 125 | 55.0% | 1.6 s |
| Neighborhood Commercial (3-Door Buses) | After | 22 | 336 | 157 | 77.7% | 1.3 s |
| Tourist Destinations | Before | 48 | 335 | 63 | 10.1% | 6.8 s |
| Tourist Destinations | After | 61 | 515 | 95 | 47.0% | 3.5 s |
| Subtotal, 2-Door Vehicles | Before | 135 | 1,476 | 358 | 21.5% | 4.3 s |
| Subtotal, 2-Door Vehicles | After | 123 | 1,362 | 315 | 48.3% | 2.7 s |
| Subtotal, 3-Door Vehicles | Before | 19 | 389 | 125 | 55.0% | 1.6 s |
| Subtotal, 3-Door Vehicles | After | 22 | 336 | 157 | 77.7% | 1.3 s |
| Grand Total | Before | 154 | 1,865 | 483 | 28.5% | 3.9 s |
| Grand Total | After | 145 | 1,698 | 472 | 54.1% | 2.5 s |

Stops and Routes for each Stop Type include: Central Business District – Market & Powell and Market & 5th (Muni Lines F, 5, 6, 9, 9L, 21, 31, 71L); Tourist Destinations – Ferry Building, Fisherman's Wharf and Market & Drumm (Muni Lines F, 2, 6, 21, 31); Neighborhood Commercial – 16th & Mission and Stockton & Jackson (Muni Lines: 8AX, 8BX, 8X, 14, 14L, 22, 30, 33, 45, 49); Commuter – Pine & Davis and Sacramento & Davis (Muni Lines: 1, 1AX, 1BX, 30X, 31AX, 31BX, 38AX, 38BX, 41)

*Optimal Distribution of Customers*

The Ride-Along Dwell Time Survey found that dwell times over entire routes could be minimized when approximately 60-70% and 80-90% of customers entered through the rear on two-door and three-door buses, respectively.

Figure 9 shows that a completely even boarding distribution (one-half through two doors or one-third through three doors) did not minimize dwell times. One reason may be that the front door has lower throughput than the rear door(s). The front door accommodates customers who may require extra time, such as those with limited mobility or who pay cash. As indicated by the mark sizes, higher boarding volumes are occurring near the optimal dwell time points, suggesting that customers are naturally distributing themselves at each door to shorten their travel times.

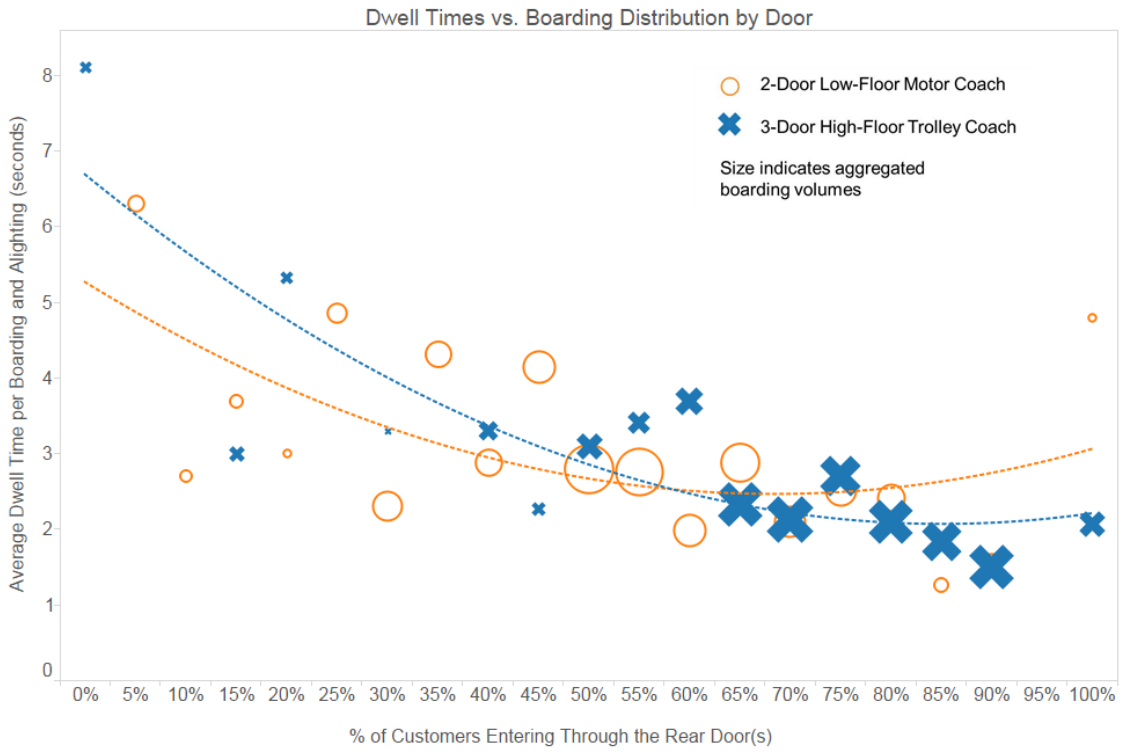



**FIGURE 9 Dwell Times vs. Boarding Distribution by Door**

## Trip Speeds

From FY 2010-2011 through FY 2013-2014, the average APC-measured bus system speed (including stops) increased slightly from 8.41 to 8.56 mph, or 2%. Several factors may have limited overall speed gains despite significant time savings at a stop level:

- *Population* – According to the U.S. Census Bureau, San Francisco's population grew by over 32,000 (+4.0%) between April 2010 and July 2013, increasing demand on the transportation system and adding to traffic congestion.
- *Employment* – According to the Bureau of Labor Statistics, employment within San Francisco increased by over 70,000 (+12.6%), one of the largest job gains of any city in the United States.
- *Ridership* – Between FY 2010-2011 and FY 2013-2014, average weekday bus and streetcar ridership grew by over 26,000 (+5.3%).
- *Motor Vehicle Registrations* – According to the California Department of Motor Vehicles, vehicles registered in San Francisco increased by approximately 15,000 (+3.2%).

Muni vehicles spend four-fifths of their time traveling between stops, waiting at traffic lights or being stuck in traffic. Thus, a combination of exclusive transit lanes, transit signal priority, parking management and other strategies that supplement All-Door Boarding can contribute to significant travel time reductions. With even modest speed improvements, All-Door Boarding appears to have helped keep Muni moving during a period of increasing demand on the city's transportation system.

## Fare Compliance

The 2014 post-implementation fare survey countered concerns that All-Door Boarding would spike fare evasion. Of the 52,635 customer observations, 42,539 occurred on buses, light rail and streetcars and were factored into the overall fare evasion rate, which was weighted by weekly line ridership. The remaining 10,096 observations took place at the nine Muni Metro underground light rail stations. To maintain methodological consistency across surveys and to avoid double-counting with light rail vehicle observations, the weighted fare evasion rate excludes these station surveys.

**TABLE 3 Comparison of 2009 and 2014 Comprehensive Fare Surveys**

| Fare Analysis Category | 2009 Customers Surveyed | 2009 Fare Evasion Rate (%) | 2014 Customers Surveyed | 2014 Fare Evasion Rate (%) |
|---|---|---|---|---|
| ***Systemwide*** | 38,672[1] | 9.5 | 52,635 | 7.9 |
| *Transit Mode* | | | | |
| Bus & Historic Streetcar | 32,648 | 10.5 | 37,201 | 8.0 |
| Light Rail | 6,024 | 4.7 | 5,338 | 7.5 |
| Muni Metro Underground Stations | N/A | N/A | 10,096[2] | 3.5 |
| ***Route (top 10 bus corridors and all rail lines)*** | | | | |
| 1 California (TC) | 893 | 4.5 | 638 | 4.4 |
| 5 Fulton & 5L Fulton Ltd (TC) | 740 | 9.7 | 738 | 7.3 |
| 6 Parnassus & 71 Haight-Noriega (MC/TC) | 1,760 | 9.0 | 1,564 | 9.3 |
| 8X, 8AX, 8BX Bayshore Exp (MC) | 1,882 | 14.0 | 1,682 | 8.5 |
| 14 Mission & 14L Mission Ltd (MC/TC) | 1,760 | 19.9 | 2,230 | 11.3 |
| 22 Fillmore (TC) | 1,074 | 9.7 | 751 | 9.3 |
| 29 Sunset (MC) | 750 | 9.2 | 1,166 | 9.4 |
| 30 Stockton (TC) | 1,316 | 8.4 | 1,295 | 4.0 |
| 38 Geary & 38L Geary Ltd (MC) | 2,739 | 9.5 | 1,361 | 6.9 |
| 49 Van Ness-Mission (TC) | 1,258 | 12.2 | 1,299 | 8.5 |
| F Market and Wharves (HS) | 1,546 | 12.0 | 887 | 6.4 |
| J Church (LR) | 734 | 5.6 | 456 | 7.9 |
| K Ingleside (LR) | 870 | 3.8 | 785 | 6.1 |
| L Taraval (LR) | 1,023 | 2.4 | 830 | 5.2 |
| M Ocean View (LR) | 1,216 | 3.8 | 1,107 | 5.1 |
| N Judah (LR) | 1,469 | 2.5 | 1,031 | 8.1 |
| T Third (LR) | 666 | 15.2 | 1,129 | 15.1 |
| ***Time Period*** | | | | |
| Weekday AM peak (7-9 a.m.) | 9,056 | 6.2 | 8,286 | 5.6 |
| Weekday Midday (9 a.m.-2 p.m.) | 7,655 | 9.5 | 10,599 | 6.5 |
| Weekday School (2-4 p.m.) | 7,170 | 9.8 | 3,244 | 9.8 |
| Weekday PM peak (4-7 p.m.) | 9,249 | 10.5 | 9,987 | 8.9 |
| Weekday Evening (7-10 p.m.) | 2,923 | 14.5 | 4,525 | 11.3 |
| Weekend (all day) | 2,619 | 12.3 | 5,898 | 7.2 |
| ***Successful or Attempted Rear-Door Entries (Buses and Streetcars)*** | 857 | 55.3 | 4,451 | 11.2 |

NOTES: HS = historic streetcar; LR = light rail; MC = motor coach; TC = electric trolley coach.
[1]Consists of base survey data prior to the July 1, 2009, fare increase, and excludes 2,567 supplementary observations afterwards.
[2]To maintain methodological consistency between the 2009 and 2014 surveys and to avoid double-counting with light rail vehicle observations, Muni Metro subway station observations are excluded when calculating the weighted fare evasion rate systemwide and by time period.

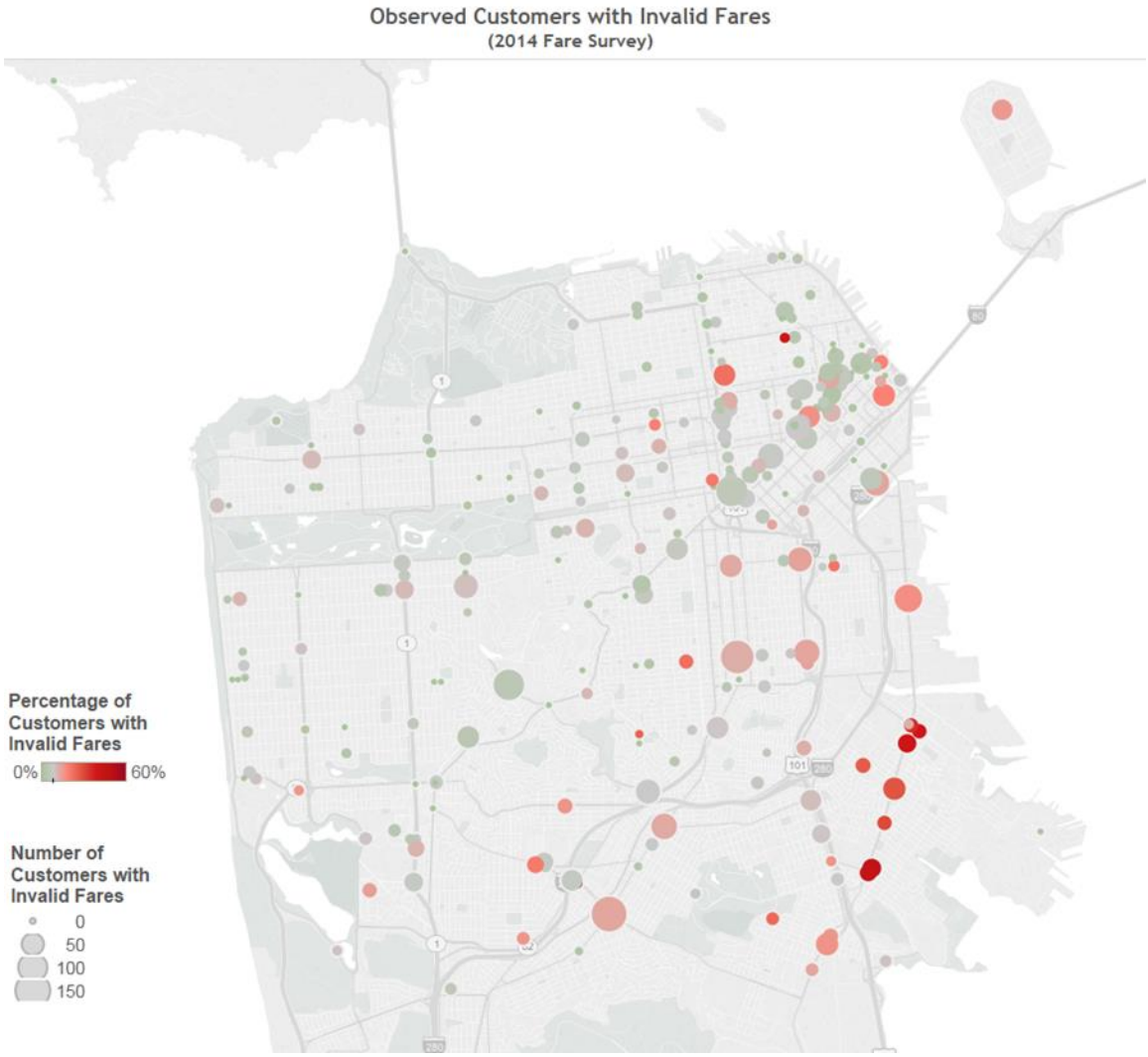



**FIGURE 10 Proof-of-Payment Patterns, 2014 Fare Survey**

As shown in Table 3, the 2014 survey found that fare evasion has declined 1.6 percentage points over five years to 7.9%. Specifically,

- Expanding fare enforcement to buses and historic streetcars has increased compliance by 2.4 percentage points on these modes. Perhaps due to this coverage shift, fare evasion appears to have increased on light rail vehicles, although it remains low at underground stations.
- Legalizing All-Door Boarding has encouraged more fare payers to enter through the rear. At 11.2%, rear-door fare evasion was higher than the 7.9% systemwide average, but significantly lower than the 55.3% found in 2009.

Figure 10 illustrates the percentage and absolute number of customers observed without valid proof-of-payment at each survey location.

## Fare Revenues

Fare revenue data suggest that All-Door Boarding has not impacted SFMTA's finances negatively. Preliminary figures for SFMTA's FY 2013-2014 operating budget indicate that transit fare revenue totaled $206.2 million. Bus, streetcar and light rail revenue comprised approximately $178.1 million of this amount and cable car cash fares account for the remainder.

In the unlikely scenario that every bus, streetcar and light rail customer had a valid fare, the SFMTA might be able to capture about $17.1 million annually based on spring 2014 fares and the methodology outlined in Table 4. Since some customers would probably continue to avoiding fare payment, it is unrealistic to expect that the SFMTA could recuperate all $17.1 million even with greatly expanded enforcement resources.

Reflecting the decline in the overall fare evasion rate from 9.5 to 7.9 percent, the $17.1 million estimate is also down from the $19.2 million figure from the original 2009 study. The uncaptured revenue decline has not been proportional to the decrease in the fare evasion rate, however, largely because inflation-indexed fare increases have occurred in the intervening years per SFMTA Board policy.

**TABLE 4 Estimated Uncaptured Fare Revenue**

| **Major Types of Fare Violations**<br>Methodology Estimating Uncaptured Revenues | **Uncaptured Revenue*** |
|---|---|
| **No Ticket, Transfer or Pass, Invalid Transfers/Fare Receipts, Walk Away**<br>Of customers without a pre-paid pass, 83% paid cash and displayed a transfer/fare receipt while the remaining 17% lacked any proof-of-payment, showed an invalid transfer/fare receipt, had an invalid Clipper® Card or walked away upon seeing a Transit Fare Inspector. Assumption: These customers would have paid the applicable cash fare, and therefore total cash fare revenues would increase proportionately**.** | $14.1 million |
| **Underpayment**<br>When watching farebox payments, the survey team observed that 6.8% of customers did not pay the appropriate fare. Assumption: Customers paid only half the applicable base fare. | $2.8 million |
| **Misused Youth Pass**<br>Compared to the total number of youths with a valid Youth Pass on Clipper®, 5% of customers surveyed had an invalid Paid Youth Pass and 5% had a Free Muni for Youth Pass that belonged to someone else. Assumption: These customers would otherwise purchase a Muni-Only Pass, resulting in an additional $43 and $66, respectively, in revenue per month per pass. | $0.2 million |
| **Total** | $17.1 million |

* Estimated uncaptured revenue is based on fare rates during the survey (Spring 2014)

While uncaptured fare revenue estimates have declined, actual fare revenues collected have increased. Between FY 2011-2012 and FY 2012-2013, immediately before and after implementation, non-cable car fare revenues grew by $7.5 million (+4.4%). During the last four months of FY 2012-2013, the SFMTA also launched the Free Muni for Youth Program to provide students from low- and moderate-income households with complimentary transit passes. Adjusting for funding received to defray the cost of these passes, the fare revenue change would be $8.2 million (+4.8%) based on Budget and

Legislative Analyst's Office estimates. Non-cable car fare revenues have increased faster than the combination of inflation-indexed fare increases and ridership changes. Cash fares stayed the same, adult monthly passes increased by 3.1% and ridership grew by 0.6%.

## CONCLUSION

With a growing interest in sustainability and urban living, many metropolitan areas are looking for innovative ways to improve transit. Since most transit lines in the United States operate in mixed traffic and require front-door boarding, minimizing excess dwell times is a widespread challenge. San Francisco's experience with systemwide All-Door Boarding can inform other cities as they explore cost-effective strategies to speed up service while preserving fare revenue.

Although the SFMTA already had accrued some benefits under unofficial All-Door Boarding, the agency has experienced incremental operational and financial improvements once the policy became legal. Muni customers are taking less time to board, buses are moving a bit faster and fare compliance continues to improve. All-Door Boarding is just one piece of a multi-faceted approach to make transit faster and more reliable. Other strategies such as exclusive transit lanes, transit signal priority and parking management can together make more significant reductions in transit travel times.

Given that transit systems contemplating All-Door Boarding are not starting in the same place as the SFMTA, they may encounter additional challenges if they elect to transition to this model. As each region has unique transportation needs, the SFMTA acknowledges that All-Door Boarding may not be appropriate everywhere but believes others may find it to be a worthwhile investment.

# APPENDIX

## 2014 Detailed Fare Survey Results

### Bus and Rail Lines

| Line | Name | Transit Mode | Weekday Ridership | Customers Surveyed | Fare Evasion Rate | Margin of Error |
|---|---|---|---|---|---|---|
| 1 | California | TC | 25,653 | 638 | 4.4% | ±1.6% |
| 1AX | California A Exp | MC | 1,048 | 539 | 6.9% | ±1.5% |
| 1BX | California B Exp | MC | 1,601 | 616 | 5.7% | ±1.4% |
| 2 | Clement | MC | 5,425 | 373 | 3.2% | ±1.7% |
| 3 | Jackson | TC | 4,136 | 373 | 4.0% | ±1.9% |
| 5/5L | Fulton | TC/MC | 21,278 | 738 | 7.3% | ±1.8% |
| 6 | Parnassus | TC | 7,693 | 586 | 9.4% | ±2.3% |
| 8X/8AX/8BX | Bayshore Exp | MC | 33,485 | 1,682 | 8.5% | ±1.3% |
| 9/9L | San Bruno | MC | 19,560 | 1,568 | 11.1% | ±1.5% |
| 10 | Townsend | MC | 5,907 | 618 | 6.5% | ±1.8% |
| 12 | Folsom-Pacific | MC | 5,328 | 536 | 5.6% | ±1.8% |
| 14/14L | Mission | TC/MC | 44,668 | 2,230 | 11.3% | ±1.3% |
| 14X | Mission Exp | MC | 2,727 | 713 | 5.2% | ±1.4% |
| 16X | Noriega Exp | MC | 1,438 | 526 | 1.7% | ±0.9% |
| 17 | Parkmerced | MC | 1,252 | 237 | 8.9% | ±3.3% |
| 18 | 46$^{th}$ Av | MC | 4,120 | 851 | 6.6% | ±1.5% |
| 19 | Polk | MC | 8,244 | 635 | 16.1% | ±2.7% |
| 21 | Hayes | TC | 7,512 | 471 | 7.6% | ±2.3% |
| 22 | Fillmore | TC | 17,150 | 751 | 9.3% | ±2.0% |
| 23 | Monterey | MC | 4,308 | 586 | 10.2% | ±2.3% |
| 24 | Divisadero | TC | 11,556 | 945 | 6.9% | ±1.5% |
| 27 | Bryant | MC | 6,808 | 498 | 5.2% | ±1.9% |
| 28/28L | 19$^{th}$ Av | MC | 15,329 | 720 | 8.7% | ±2.0% |
| 29 | Sunset | MC | 19,922 | 1,166 | 9.4% | ±1.6% |
| 30 | Stockton | TC | 26,413 | 1,295 | 4.0% | ±1.0% |
| 30X | Marina Exp | MC | 2,738 | 508 | 1.2% | ±0.8% |
| 31 | Balboa | TC | 10,138 | 861 | 9.6% | ±1.9% |
| 31AX | Balboa A Exp | MC | 960 | 143 | 2.1% | ±2.2% |
| 31BX | Balboa B Exp | MC | 900 | 192 | 4.7% | ±2.7% |
| 33 | Stanyan | TC | 6,790 | 439 | 11.2% | ±2.8% |
| 35 | Eureka | MC | 827 | 160 | 3.1% | ±2.4% |
| 36 | Teresita | MC | 1,626 | 370 | 6.2% | ±2.2% |
| 37 | Corbett | MC | 2,355 | 524 | 2.9% | ±1.3% |
| 38/38L | Geary | MC | 51,653 | 1,361 | 6.9% | ±1.3% |
| 38AX | Geary A Exp | MC | 986 | 399 | 4.3% | ±1.5% |
| 38BX | Geary B Exp | MC | 1,057 | 355 | 0.8% | ±0.8% |
| 39 | Coit | MC | 565 | 207 | 1.4% | ±1.3% |
| 41 | Union | TC | 3,395 | 391 | 2.0% | ±1.3% |
| 43 | Masonic | MC | 13,219 | 1,207 | 5.1% | ±1.2% |

| Line | Name | Transit Mode | Weekday Ridership | Customers Surveyed | Fare Evasion Rate | Margin of Error |
|---|---|---|---|---|---|---|
| 44 | O'Shaughnessy | MC | 16,208 | 1,331 | 8.0% | ±1.4% |
| 45 | Union-Stockton | TC | 11,489 | 928 | 2.7% | ±1.0% |
| 47 | Van Ness | MC | 12,533 | 592 | 11.3% | ±2.5% |
| 48 | Quintara-24th St | MC | 8,520 | 835 | 11.5% | ±2.1% |
| 49 | Van Ness-Mission | TC | 23,504 | 1,299 | 8.5% | ±1.5% |
| 52 | Excelsior | MC | 2,217 | 482 | 6.4% | ±1.9% |
| 54 | Felton | MC | 6,820 | 664 | 13.4% | ±2.5% |
| 56 | Rutland | MC | 479 | 161 | 21.7% | ±5.2% |
| 66 | Quintara | MC | 843 | 272 | 2.6% | ±1.5% |
| 67 | Bernal Heights | MC | 1,655 | 329 | 7.9% | ±2.6% |
| 71/71L | Haight-Noriega | MC | 12,077 | 978 | 9.2% | ±1.7% |
| 76X | Marin Headlands Exp | MC | Weekends | 155 | 0.0% | ±0.0% |
| 81X | Caltrain Exp | MC | 169 | 57 | 3.5% | ±3.9% |
| 82X | Levi Plaza Exp | MC | 710 | 107 | 7.5% | ±4.6% |
| 83X | Mid-Market Exp | MC | 514 | 114 | 1.8% | ±2.1% |
| 88 | BART Shuttle | MC | 455 | 120 | 5.8% | ±3.6% |
| 108 | Treasure Island | MC | 3,229 | 488 | 16.6% | ±3.0% |
| NX | Judah Exp | MC | 1,502 | 394 | 10.4% | ±2.6% |
| F | Market & Wharves | SC | 23,208 | 887 | 6.4% | ±1.6% |
| J | Church | LR | 14,767 | 456 | 7.9% | ±2.4% |
| K | Ingleside | LR | 16,876 | 785 | 6.1% | ±1.6% |
| L | Taraval | LR | 28,816 | 830 | 5.2% | ±1.5% |
| M | Ocean View | LR | 26,920 | 1,107 | 5.1% | ±1.3% |
| N | Judah | LR | 41,439 | 1,031 | 8.1% | ±1.6% |
| T | Third | LR | 16,876 | 1,129 | 15.1% | ±2.0% |
|  | Grand Total | All | 671,596 | 42,539 | 7.9%* | ±0.2% |

LR = Light Rail; MC = Motor Coach; SC = Streetcar; TC = Electric Trolley Coach
Cable Cars are not included in the fare survey. Margin of error is at the 95% confidence level.
* Weighted by Line Ridership

## Muni Metro Light Rail Subway Stations

| Station | Weekday Faregate Entries | Customers Surveyed | Fare Evasion Rate | Margin of Error |
|---|---|---|---|---|
| Castro | 4,822 | 521 | 2.1% | ±1.2% |
| Church | 3,155 | 722 | 5.8% | ±1.5% |
| Civic Center | 6,746 | 977 | 6.8% | ±1.5% |
| Embarcadero | 11,297 | 1,678 | 2.1% | ±0.6% |
| Forest Hill | 2,388 | 852 | 2.7% | ±0.9% |
| Montgomery | 8,498 | 1,727 | 1.5% | ±0.5% |
| Powell | 12,200 | 1,613 | 3.0% | ±0.8% |
| Van Ness | 7,085 | 1,325 | 6.0% | ±1.2% |
| West Portal | 3,848 | 681 | 3.7% | ±1.3% |
| Grand Total | 60,038 | 10,096 | 3.5%* | ±0.3% |

* Weighted by Station Ridership