Report No:	**18-137**
Meeting Date:	**June 27, 2018**

Alameda-Contra Costa Transit District

S T A F F   R E P O R T

TO: AC Transit Board of Directors
FROM: Michael A. Hursh, General Manager
SUBJECT: Line 51 Corridor Delay Reduction and Sustainability Project Evaluation Report

BRIEFING ITEM

RECOMMENDED ACTION(S):

Consider receiving a report on Line 51 Corridor Delay Reduction and Sustainability Project.

BUDGETARY/FISCAL IMPACT:

There is no budgetary or fiscal impact associated with this report.

BACKGROUND/RATIONALE:

This report summarizes the findings of the Line 51 Corridor Delay Reduction and Sustainability Project Evaluation Report (hereafter the Line 51 Project). Lines 51A and 51B are two of the most heavily used bus routes in the East Bay, carrying a combined 19,000 passengers a day through Berkeley, Oakland, and Alameda. Service has been both slow and unreliable along the corridor due to outdated traffic signal infrastructure and growing traffic congestion. The problem of growing delay and slower operations is not confined to Lines 51A and 51B but has affected operations across the District.

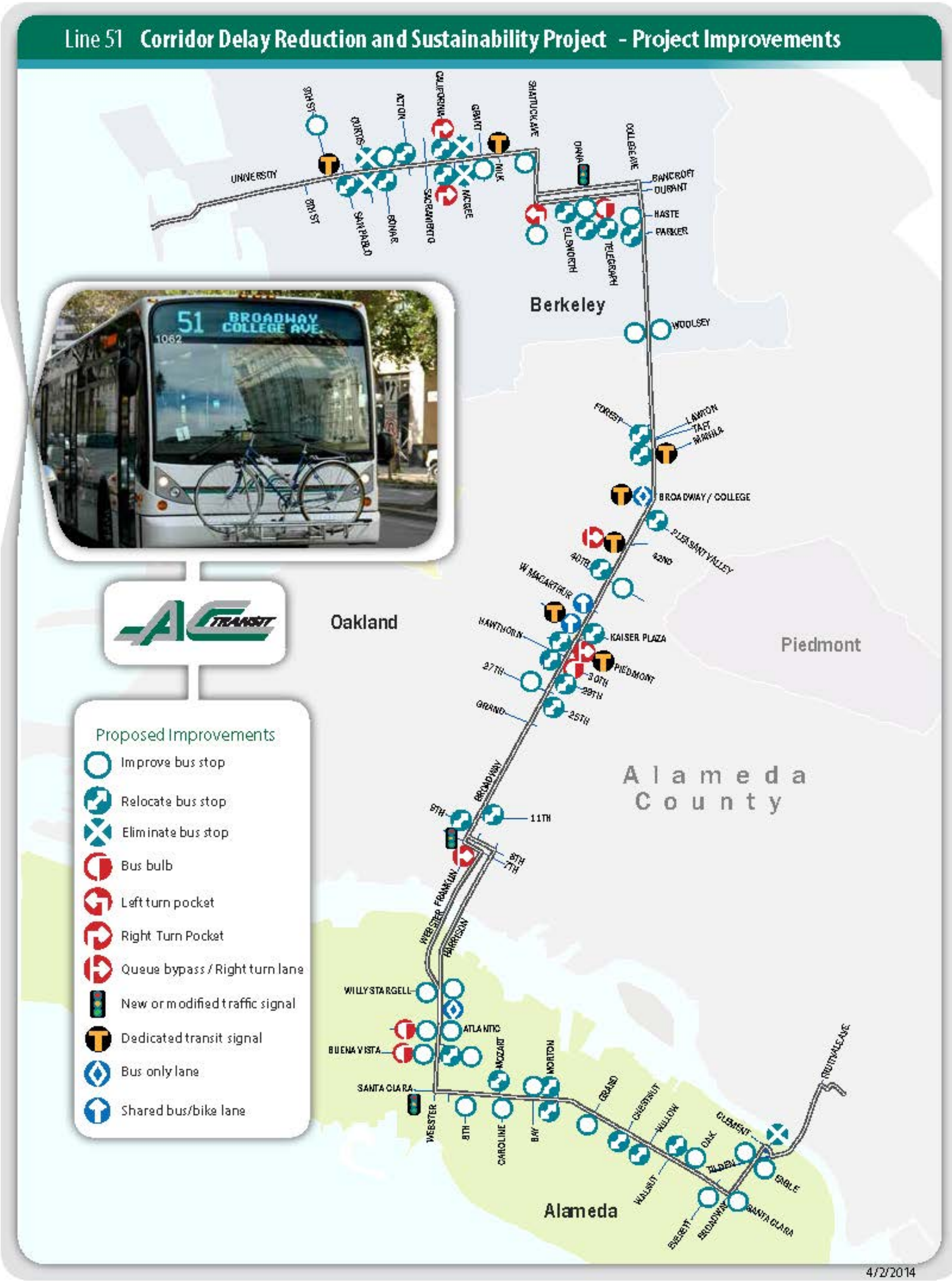
The Line 51 Project was the first project funded by the Metropolitan Transportation Commission (MTC) under their Transit Performance Initiative. The project, initiated in 2012, deployed a comprehensive technology and operations solution to help reduce passenger delay, increase travel speeds and improve on-time performance (SR 12-146). The attached report is a requirement of MTC for closing out the project.

The project included Transit Signal Priority (TSP), traffic signal modifications, signal interconnect and coordination, some of the region's first queue jump lanes and signals, bus bulbs, bus stop modifications and relocations, dedicated bus lanes and a fiber optic communications trunk line. Exhibit 1 shows the locations of project improvements.

There are broad negative trends affecting District operations. For example, growing traffic congestion adds increasing delays to bus operations reflected in falling average speeds. The District average fleet speed has fallen three percent since 2012 and for the major corridors, which operate on heavily congested streets, the average speed has fallen seven percent. The Line 51 Project, by comparison, has increased the average speeds of Lines 51A and 51B by two percent. The Line 51 Project has also contributed to better on-time performance, now exceeding the District's standard of 72 percent.

All project elements, including: signal timing and coordination, TSP and queue jumps work as designed. Together, they successfully reduced delay. Comparable lines without any improvements showed increased delay and falling average speeds.

Exhibit 1: Line 51 Project Improvements



Attachment 1 is the full report and provides a detailed evaluation of the Line 51 project.

ADVANTAGES/DISADVANTAGES:

There are no disadvantages associated with receiving this report.

ALTERNATIVES ANALYSIS:

There are no alternatives.

PRIOR RELEVANT BOARD ACTION/POLICIES:

SR 14-156: Award a contract to West Bay Builders, Inc. for the Line 51 Corridor Delay Reduction and Sustainability Project

SR 12-146: Report on the Line 51A/B Corridor Delay Reduction and Sustainability Project

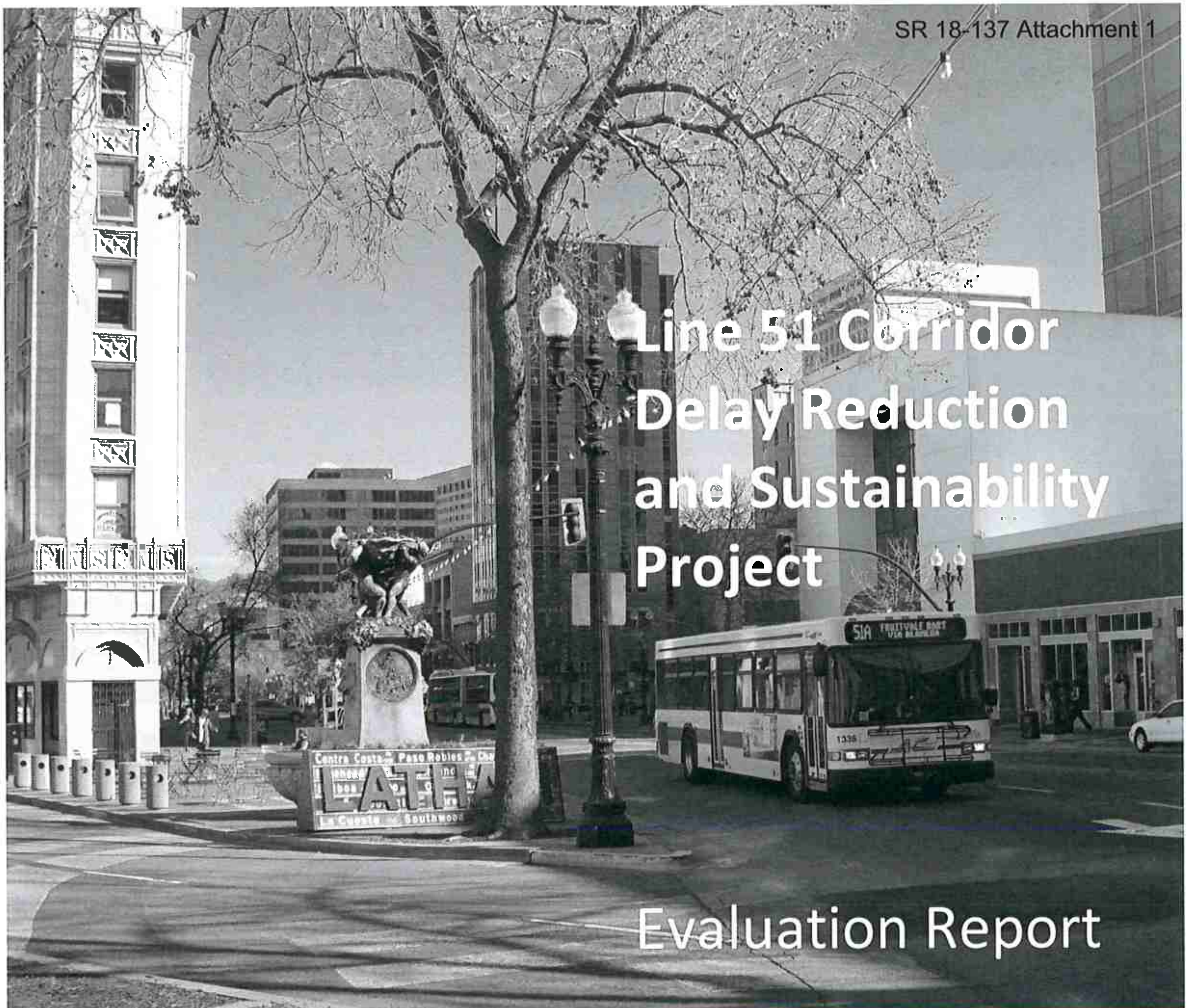
ATTACHMENTS:

Attachment 1: Line 51 Corridor Delay Reduction and Sustainability Project Evaluation Report

Approved by: Ramakrishna Pochiraju, Executive Director of Planning and Engineering

Reviewed by: Robert del Rosario, Director of Service Development and Planning

Prepared by: Jim Cunradi, Transportation Planning Manager



Line 51 Corridor Delay Reduction and Sustainability Project

Evaluation Report

April 2018

AC TRANSIT

Summary & Findings

Roadway congestion has been increasing throughout the AC Transit service area, slowing bus service and reducing on-time performance. AC Transit's major corridors have seen a 7 percent decline in operating speed since 2012. The Line 51 Corridor Delay Reduction and Sustainability Project, initiated in 2012, was intended to deploy a comprehensive technology and operations solution to help increase travel speeds and improve on-time performance (SR 12-146). Exhibit 1 shows the project limits of the Line 51 project. This was the first project funded by the Metropolitan Transportation Commission (MTC) under their Transit Performance Initiative. The project included Transit Signal Priority (TSP), traffic signal modifications, signal interconnect and coordination, queue jump lanes and signals, bus bulbs and bus stop modifications and relocations, dedicated bus lanes and a communications trunk line. Exhibit 2 shows the locations of project improvements.

The Project has increased the average speeds of Lines 51A and 51B by two percent. On-time performance has been improved, now exceeding the District's standard of 72 percent. Each project element: Signal timing and coordination TSP and queue jumps independently and together work as designed and successfully reduce bus travel time while comparable lines showed marked declines.

Exhibit 1 – Project Limits

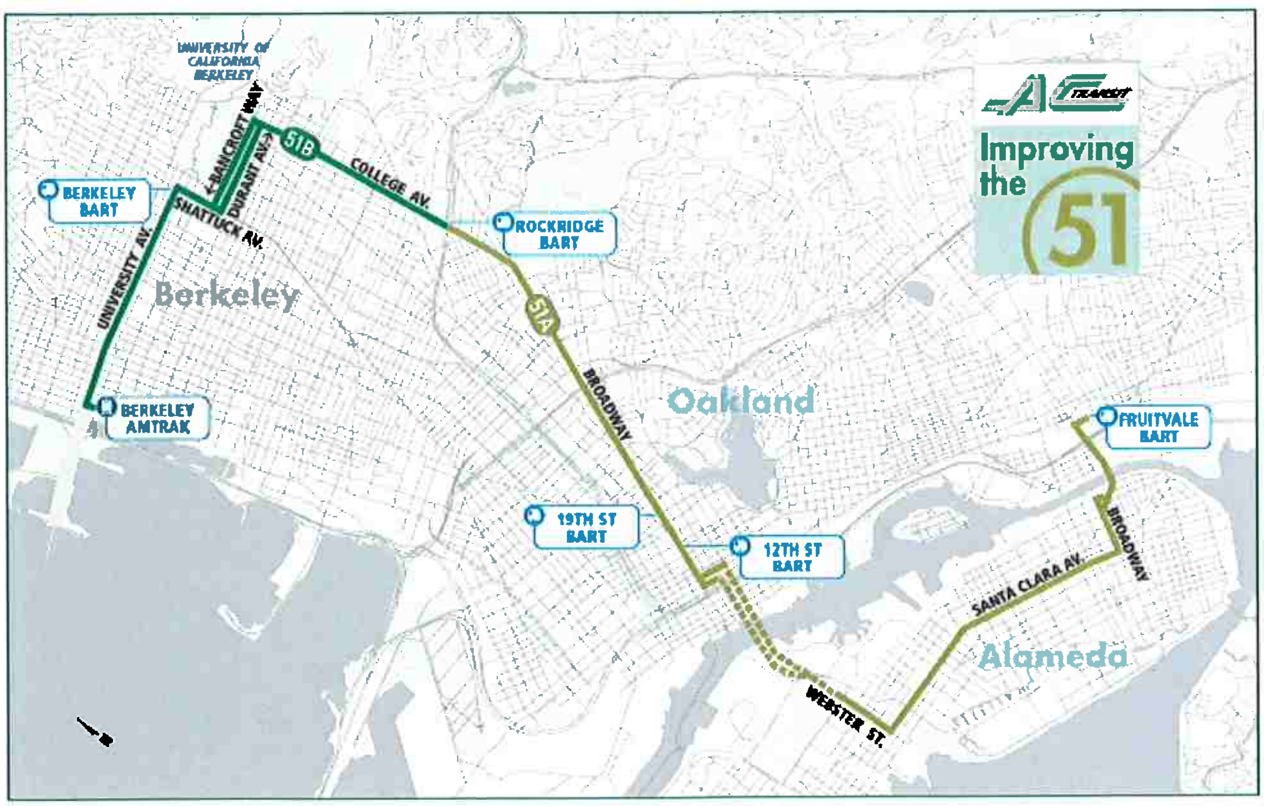
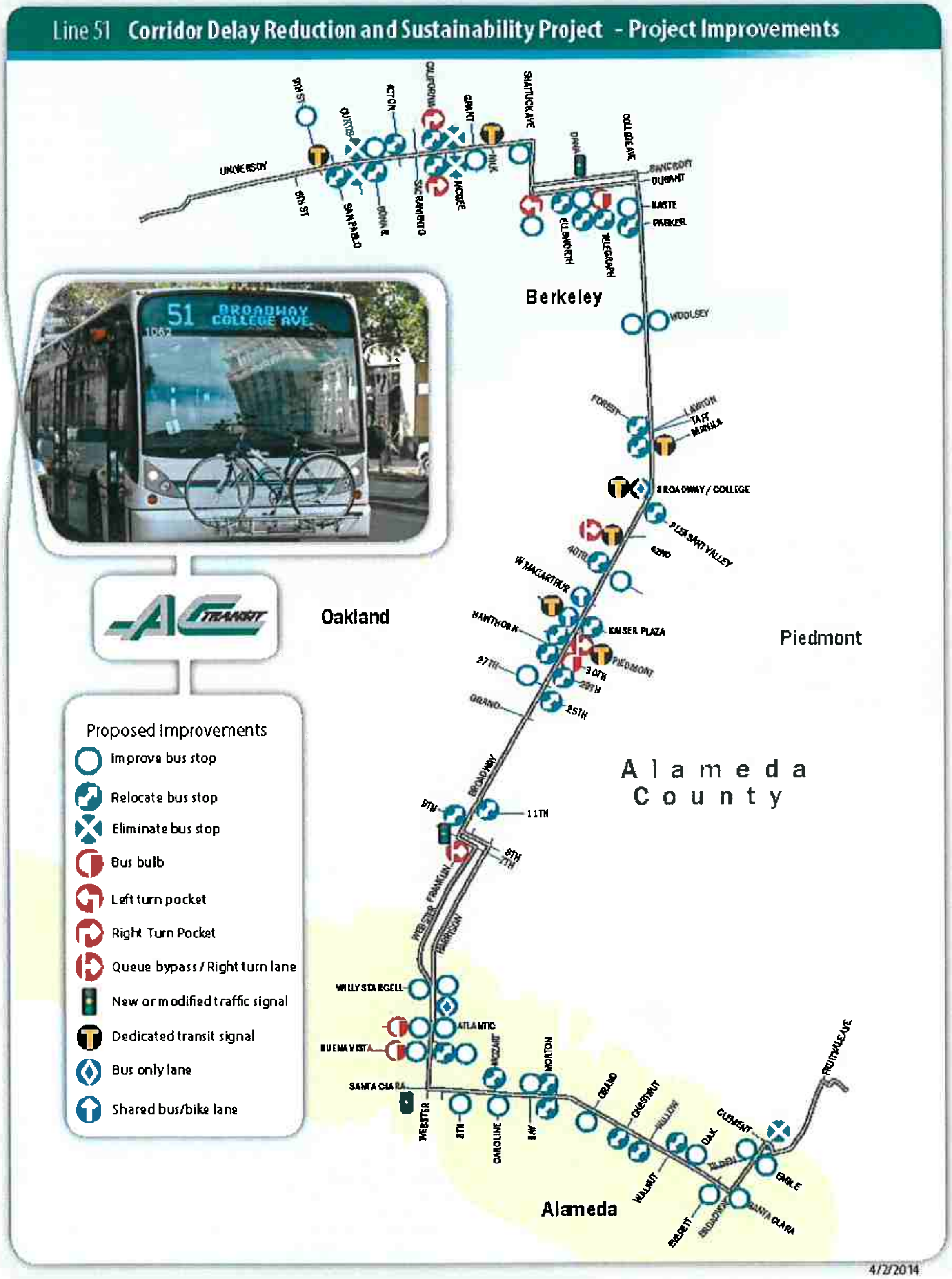


Exhibit 2 – Project Improvements



The final project was not what was originally proposed and the performance of Line 51 reflects local restrictions on what could have been built and how it could have operated. In some locations, cities would not permit the needed changes to traffic signals, sometimes due to local opposition. At other locations, cities permitted upgrading their signals but forbade or restricted the activation of TSP. Where no investments were made, Line 51 performed similar to the District as a whole – slower during the "after" study – due to worsening traffic conditions. Conversely, where a full project was built – signals upgraded and TSP installed – the largest travel time benefits were observed. The overall performance of the project could be improved by working with local officials to ensure a more comprehensive implementation of improvements.

Background & Introduction

Traffic congestion has been having a growing and deleterious effect on bus operations. The economic recovery and low gas prices have driven up VMT nationally to 3.1 trillion miles by late 2015, an all-time record. The local traffic impacts have been pronounced. According to the Metropolitan Transportation Commission, freeway delays due to congestion have increased nine percent since 2015, averaging an additional 3.5 additional minutes per commuter. Notably, regional traffic congestion is significantly worse compared to previous economic booms. Since 2000, congested delay per-commuter has risen 64 percent, while the population has grown by only 13 percent and jobs have grown by eight percent. This trend is particularly noticeable on Bay Area roads given that nearly all of the growth in gridlock has occurred during the last four years.

The immediate effect on bus operations is falling average speed. Since 2012, the average fleet speed has dropped three percent District-wide. The Major Corridors, which operate mainly on arterial streets, have shown an even more precipitous decline in operating speed, slowing by over seven percent. Against the backdrop, the Line 51 Project has helped Lines 51A and 51B to buck this trend, increasing average speeds by two percent. On-time performance has also improved, now exceeding the District's standard of 72 percent.

Lines 51A and 51B are two of the most heavily used bus routes in the East Bay, carrying a combined 19,000 passengers a day through Berkeley, Oakland, and Alameda. Service has been unreliable along the Line 51 corridor due to outdated traffic signal infrastructure and increased congestion resulting in bus bunching, late vehicle arrivals and overcrowded buses.

This report summarizes the performance of the Line 51 Corridor Delay Reduction and Sustainability Project (hereafter the Line 51 Project). It includes the improvements to average speed and on-time performance as well as the performance of individual project elements like traffic signal timing, transit signal priority (TSP) coupled with bus stop relocations, queue jump lanes, and bus-only signals.

Project Description

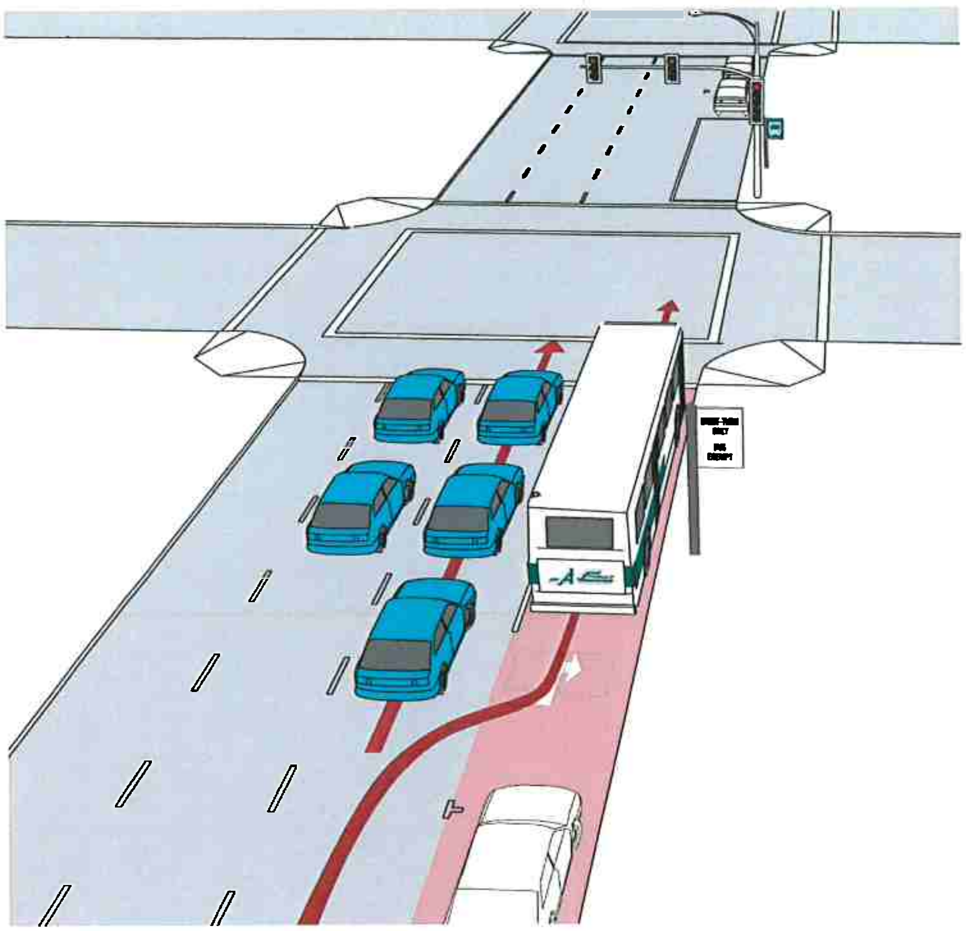
The Line 51 Project, initiated in 2012, deploys a technology and operations solution to increase travel speeds and improve on-time performance (SR 12-146). This is the first project funded by the

Metropolitan Transportation Commission (MTC) under their Transit Performance Initiative (TPI). The approach was informed by an earlier Service and Reliability study presented to the Board in 2011 (SR 10-233a) which highlighted the intractable problems of slow operating speeds and poor schedule adherence. This report aims to give a comprehensive picture of the impact of the project on operations of Lines 51A and 51B. Line 51B operates along University, the Bancroft/Durant couplet, and College Avenue to Rockridge BART in Oakland. Line 51A operates from Rockridge BART along College Avenue and Broadway in Oakland, Webster Street and Santa Clara Avenue in Alameda, and back to Fruitvale BART in Oakland. The lines serve three Jurisdictions: Alameda, Berkeley, and Oakland and carry approximately 20,000 passenger trips per typical weekday.

Generally, improvements along the corridor include the following:

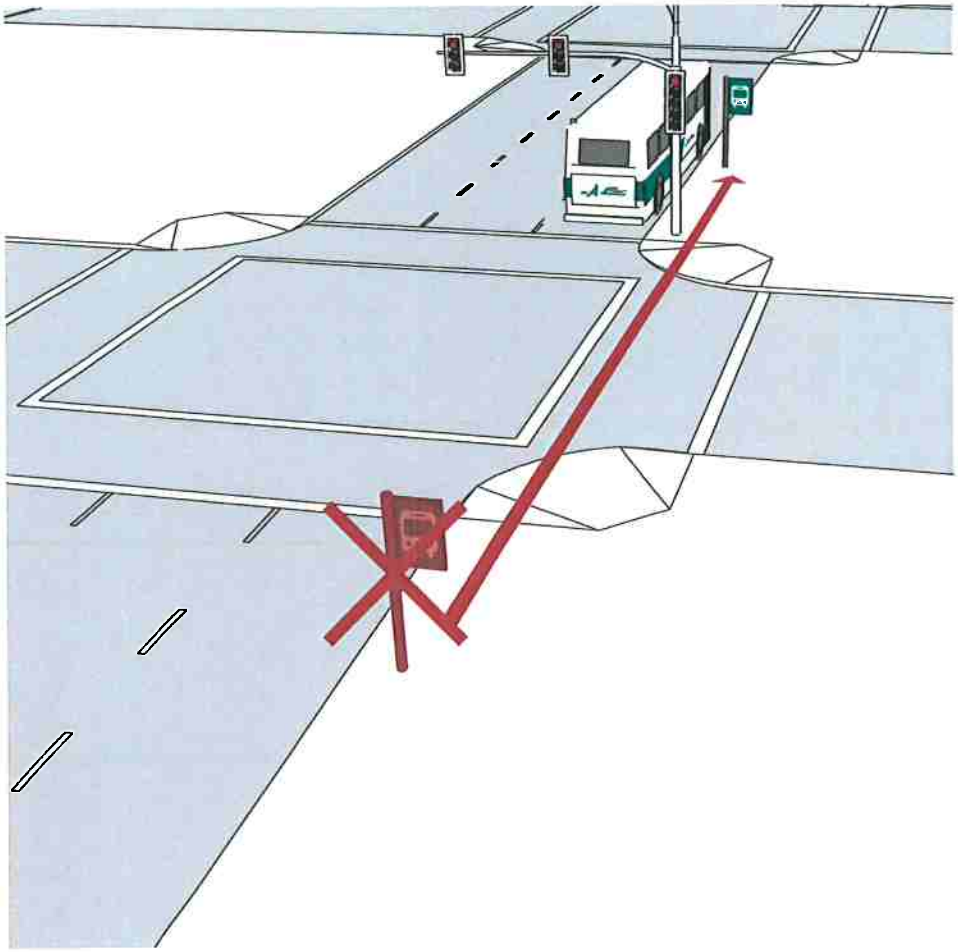
- Transit Signal Priority – TSP, a type of "active priority", provides an advantage to a bus at a signalized intersection by detecting a bus in advance and then either extending the green phase time at the beginning or end of the signal cycle. The added advantage is cumulative when implemented along a corridor with a high number of intersections and with bus stop relocations. The goal of transit signal priority (TSP) is to improve transit travel times by providing Line 51 buses an extended green or an early green. Priority calls are placed by the transit vehicles using an on-board radio unit that utilizes a Global Positioning Sensor to determine the location, speed, and direction of the bus, and communicates to a compatible receiving unit inside the traffic signal cabinet at the intersection. When a call is received at the intersection, the transit vehicle may obtain priority by receiving additional green time at the end of the priority phase or early green to the priority phase. This allows the transit vehicle to proceed through the intersection when it would have otherwise been required to stop.
- Signal Modifications –Signal modifications included side street vehicle detection and pedestrian actuation to improve overall efficiency in signal operations.
- Signal Interconnect Management & Coordination – A traffic responsive coordination system provides the level of sophistication needed to help reduce congestion and bus delay along the corridor. Signal coordination is a type of "passive priority" that improves bus travel times by smoothing traffic flow along the direction of travel of the bus.
- Intersection Reconfigurations (left and right turn movements) – Additional turn pockets or protected turn signal phases were added to reduce congestion by removing vehicles waiting to turn out of the through lanes. A separate turn signal phase also reduces delays caused by left-turning cars having to yield to oncoming traffic.
- Bus Queue Jump Lanes & Signals – Installed at near-side locations where there is roadway congestion but where far-side bus stops are not feasible. A queue jump provides buses a bypass and head-start (usually three to seven seconds) ahead of stopped vehicles. Exhibit 3 illustrates typical queue jump signal operation.

Exhibit 3 – Queue Jump Lane and Signal



- Bus Bulbs – These position the bus in the travel lane at stops to reduce delays caused by buses waiting to merge back into traffic after loading and unloading of passengers.
- Dedicated Bus Lanes – Bus-only lanes avoid travel time delays caused by constant interaction with congested traffic and provide a bypass for long vehicle queues.
- Communications Trunk – Modern traffic signals, better signal timing and transit signal priority can contribute to improved bus travel times and produce better schedule reliability. To maintain peak performance, there is a need to monitor these technologies and make adjustments on a periodic basis. This requires a communications backbone capable of collecting information on traffic conditions, signal timing and TSP functionality. This communications trunk can be built using fiber optic cables or by using copper wire.
- Bus Stop Modifications & Relocations – Currently the district attempts to generally locate bus stops on the far side of intersections wherever feasible. Locating far side of signalized intersections can reduce travel time by avoiding being stopped at a signal for multiple cycles due to loading and unloading of passengers. Far-side stops also allow buses to take better advantage of TSP improvements. Exhibit 4 illustrates a near-side bus stop relocated to the far-side of an intersection.

Exhibit 4 – Far-side Bus Stop Relocation



Results

The results of the evaluation are organized into four parts:

1) General observations.
2) An evaluation of the effect of the project on average speed and on-time performance. These data are routinely collected by the District and are the simplest measure of the project's overall effectiveness.
3) A summary report on the performance of the signal timing improvements was prepared by the Kimley-Horn consultant team. Signal timing effectiveness is ultimately more important to bus operations than TSP. These data were collected using "floating car runs."
4) Staff and interns prepared a report on the functioning of queue jump signals. The report also contains a "lessons learned" section to guide future queue jump installations.

General Observations

The following section includes general observations about the project and recommends steps that could be taken to further improve operations or ease the implementation of new projects.

Exhibit 5 shows an overview of the project construction and evaluation schedule beginning in August 2014 and finishing in February 2018.

Exhibit 5 – Project Construction Schedule

Item	Start Date	Completion Date
Overall Project Construction Schedule	August 2014	February 2018
Bus Stop Relocations	August 2014	December 2015
Bus Bulb Installations	September 2015	October 2015
Shattuck Median Left Turn	September 2015	October 2015
Alameda Bus Lane (Atlantic to Stargell)	May 2015	September 2015
Signal Re-coordination	June 2015	September 2015
TSP Activation	March 2016	September 2016
After Study Diagnostics Report (draft w/o queue jumps)	April 2017	May 2017
Willie Stargell Queue Jump Upgrade	July 2017	September 2017
Queue Jump Installation, Programming and Activation	March 2016	November 2017
Queue Jump Evaluation	November 2017	February 2018
Final Line 51 Assessment	December 2017	February 2018

<u>Design and Policy Compromises</u>

The final project was not what was originally proposed and the performance of Line 51 reflects local restrictions on what could have been built and how it could have operated. In some locations, cities would not permit the needed changes to traffic signals, sometimes due to local opposition. In other locations, cities permitted upgrading their signals but forbade or restricted the activation of TSP. The results are not surprising. In general, on these segments where no investments were made, Line 51 performed similar to the District as a whole – slower during the "after" study period due to worsening traffic conditions. Notably, in the segments where a full project was built – signals upgraded and TSP installed – the largest travel time benefits were observed. The overall performance of the project could be improved through more comprehensive implementation of improvements. Examples include:

- Minimal signal improvements or TSP were installed along 7th and 8th Streets in Oakland.
- TSP was only permitted every 5 or 7 signal cycles within Berkeley.
- Bus bulbs at 30th and Broadway and at 40th and Broadway were not built.
- Many far side relocations were not implemented due to business objections.
- Queue jump signal at University and Martin Luther King Jr. was not activated.
- No signal installations along College Avenue in Berkeley (e.g. Russell Street)

There is a pressing need to educate stakeholders about the importance of various project elements, particularly controversial ones, in delivering public benefits. If investments appear to be in jeopardy, discussions should be elevated within partner jurisdictions to ensure those specific features of future projects are supported and their benefits to transit service are acknowledged. Compromises should be identified early to reduce budget impacts later. If the local jurisdictions want high-quality transit at a policy maker level, accommodations for transit priority projects must be granted.

Vehicle Assignment

Because AC Transit has not equipped all buses in the fleet with TSP emitters and does not have a dedicated fleet assigned to Lines 51A & 51B, dispatch relies heavily on having a high spare ratio to ensure all buses deployed onto the route are equipped with TSP technology. Staff successfully worked though this issue to ensure that most buses assigned to Line 51 routes are properly equipped. As of this writing, 70-80 percent of Line 51 buses were deployed that had TSP equipment on board. Ideally, all 40-foot, 60-foot and Transbay coaches should be outfitted with TSP to simplify dispatch, maximize the benefits of TSP, and reduce the need for sub-fleets.

Time Points and Schedules

The District should consider eliminating time points to improve travel time and system performance. Often, the time savings of the project were diminished when operators followed current rules and dwelled at time points or intermediate stops when running ahead of schedule. The resulting travel time savings from time point elimination could then be used to reduce operating costs or improve frequency. In addition, time savings could be used to create reliable layover and recovery times. This is a legitimate outcome because it contributes to on-time performance and improves adherence to allotted break times required by the bus operator collective bargaining agreement. Elimination of time points may itself cause a decline in on-time performance.

Communication Trunks

To date, the District has enjoyed mixed success in incorporating communication trunk lines into projects – the primary hurdle being the cost of the infrastructure and the lack of existing interconnecting signals throughout the service area. For example, early TSP projects like the 72R (San Pablo) or 1R (Telegraph, International) did not include a continuous communications trunk. Line 51 has a short communications trunk along Broadway extending from 5th Street to Pleasant Valley Boulevard in Oakland. This was partially built by Oakland and partially by the project. By comparison, BRT and Line 97 will have complete communications networks. BRT had to build the communications trunk while Line 97 was able to primarily use existing conduits and communications trunks built by the cities.

Currently, the District has no connection to the Broadway communications trunk or to the Oakland Traffic Management Center (TMC). After the BRT communications link is complete, the District's Operations Control Center (OCC) will be able to communicate with the Oakland TMC.

Due to the high cost of communications infrastructure, future projects or updates to the Line 51 Project will need to place a greater emphasis on inter-agency cooperation to build the communications backbone. For instance, MacArthur Boulevard will receive a high speed communications trunk line, funded by the County's Capital Improvement Program, and built by the City of Oakland. This could serve future TSP improvements for Line 57 and NL. Alternatively, lower cost options such as wireless networks could be used to close communication gaps along the Line 51 corridor or as the basis for future projects' communications infrastructure.

New Development Projects

Development in Oakland has accelerated since the end of the Great Recession. The Line 51 corridor has seen a series of development projects built over the course of the before-and-after study period. These projects often disrupted bus operations during their construction and affected data collection efforts. Unfortunately, in some cases the projects resulted in an ongoing degradation of bus service such as at the new signals at Kaiser Hospital and at Latham Square (Oakland). The Line 51 Project was not able to fully mitigate the impacts of these projects when measured by average speed. Exhibit 6 lists the projects that were under construction during the "before" or "after" periods of the evaluation or during construction or that may permanently affect bus operations.

Exhibit 6 – Projects by Others

Location or Project	**Start**	**Finish**
Kaiser Garage	Before 2012	Prior to Project Initiation
Lower Sproul Transit Center	Summer 2013	Summer 2016
Safeway (College Avenue)	August 2013	January 2015
Upper Broadway Roadway Striping	November 2014	November 2014
Sprouts (Broadway)	February 2015	January 2016
Latham Square	Spring 2015	July 2016
23rd Street/29th Street Overpasses	April 2015	Present
Safeway (Rockridge)	Spring 2016	Present
3093 Broadway (Hawthorne)	Spring 2016	Present
Downtown Berkeley BART	Fall 2016	Present
New Traffic Signal (Coronado Avenue)	February 2017	Complete

Project Performance

This section documents the performance of the project for the following measures and features:

- Average Transit Speed & On-Time Performance
- Signal Timing & Coordination
- Transit Signal Priority Test Results
- Queue Jump Lanes & Signals

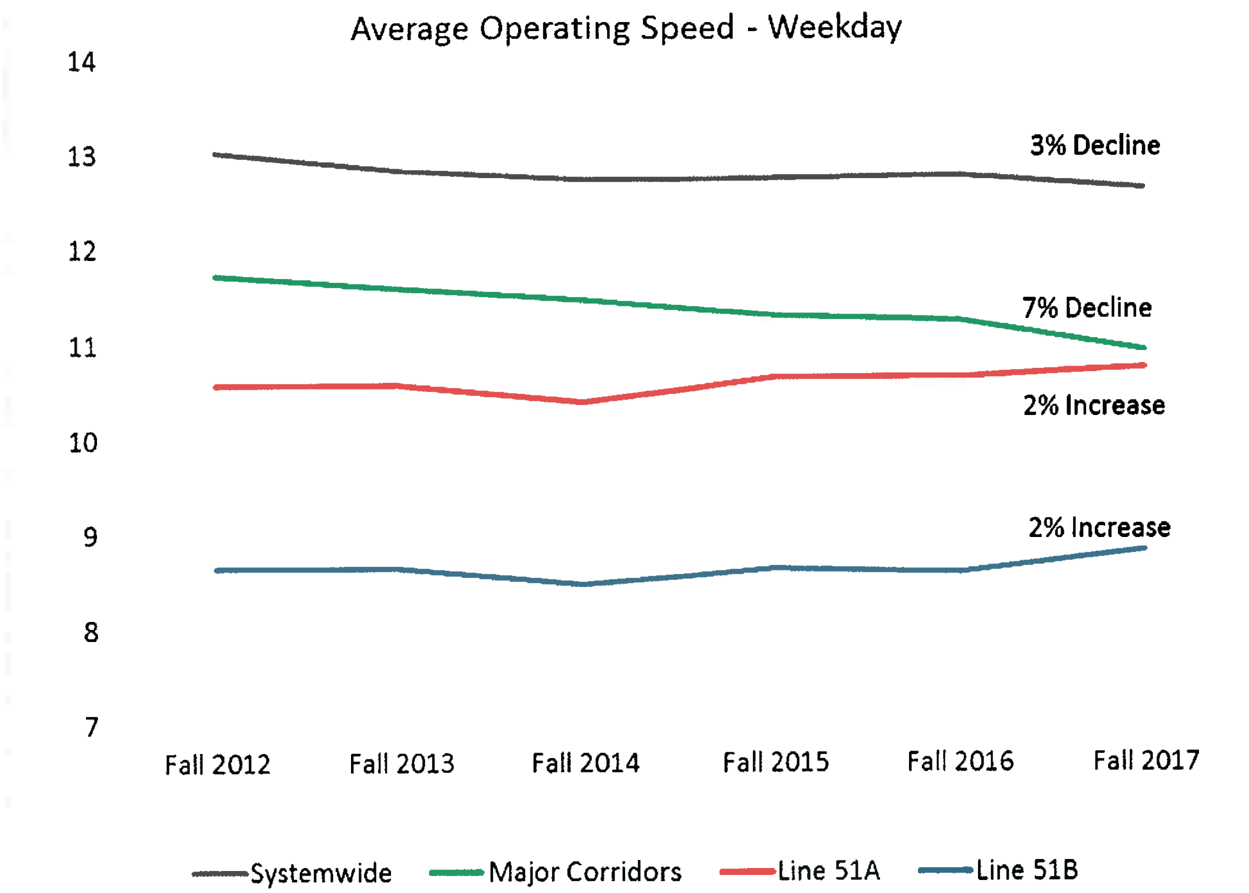
Average Transit Speed & On-Time Performance

The average speed of the bus is the simplest measure of the project's effect on operations. These data are constantly collected by the Automatic Vehicle Location (AVL) system and present a low-cost way to capture a statistically significant sample of trips.

Exhibit 7 shows the average speed of all bus lines operated by the District between 2011 and the end of 2017 compared with Lines 51A and 51B. The average speed of District service has been falling as traffic congestion worsens. The average speed District-wide has fallen from 13.02 miles per hour in 2012 to 12.64 miles per hour in 2017, a decline of three percent. The major corridors as a group have seen an even greater decline in operating speed falling from 11.72 mph in 2012 to 10.95 mph in 2017, a seven-percent decline. The District-wide data for the major corridors excludes Line 1 along International Boulevard which is undergoing construction and has highly variable and non-representative travel times.

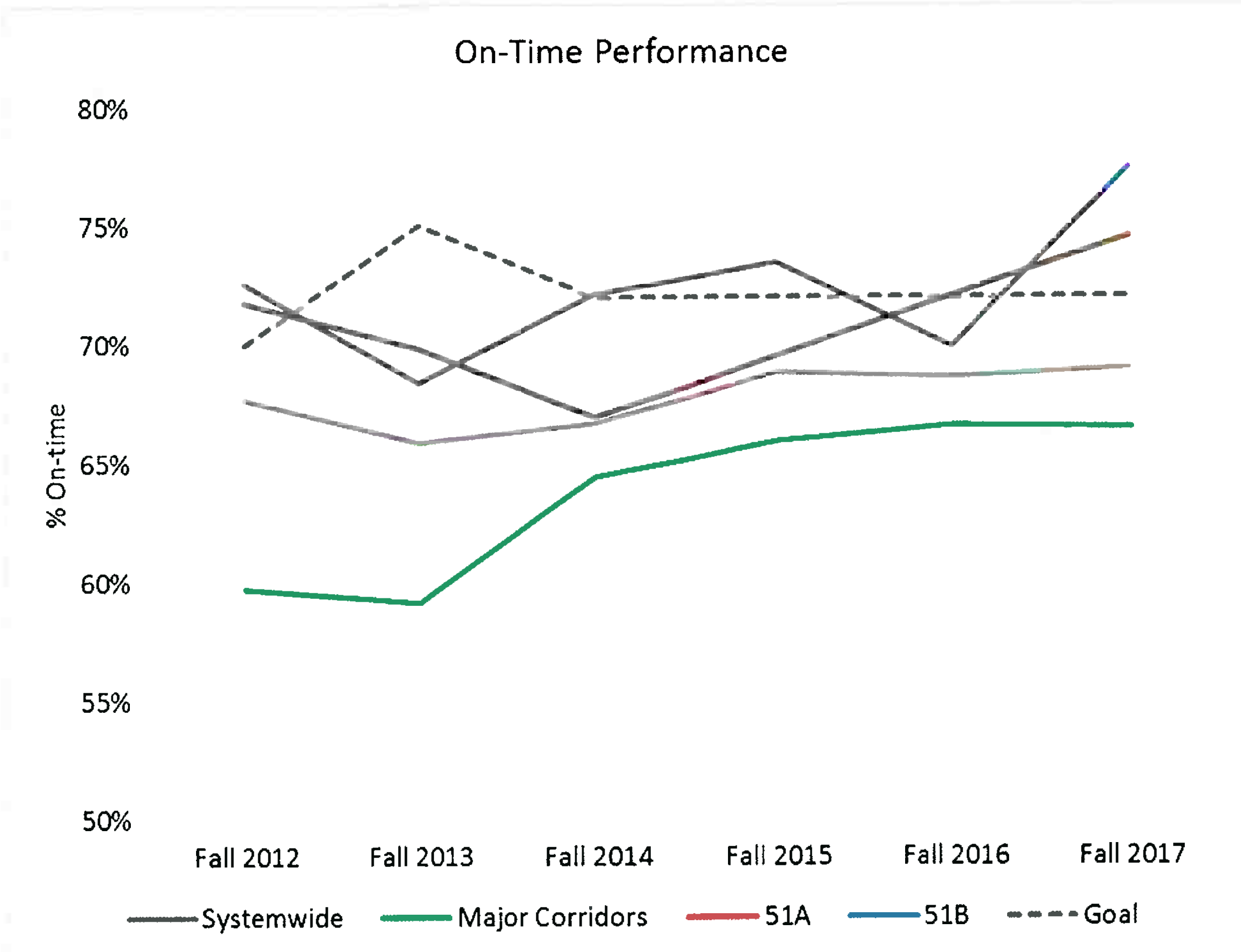
By contrast, the average speeds of Line 51A and 51B have increased by two percent over the same time period. The average speed of the Line 51A and 51B both began rising in 2015 as improvements were brought online. Between 2012 and 2017, the speed of Line 51A increased slightly from 10.57 mph to 10.75 mph. Similarly the speed of Line 51B increased from 8.65 mph to 8.84 mph. However, speeds remain significantly slower than the District average.

Exhibit 7 – Weekday Average Speed



On-time performance (OTP) has been improving District-wide due to the efforts to adjust schedules to reflect real-world travel times and by monitoring and supervision by the Operations. The project supports efforts to boost OTP by providing faster and more consistent travel times. Exhibit 8 shows the trends in on-time performance measured for the District as a whole, the major corridors and for Lines 51A and 51B. The dashed line shows the District's OTP goal of 72 percent. The OTP gains plateaued in 2015 but have held steady for the District as a whole and for the major corridors. After the project began in 2014, OTP improved and by 2016 both lines surpassed the District's OTP goal. Line 51A achieved 74.57 percent on-time performance rate and Line 51B achieved 77 percent. This represents operations for an entire weekday. Peak period OTP would likely be lower due to heavier traffic and larger numbers of passengers.

Exhibit 8 – On-time Performance



Signal Timing & Travel Time Evaluation

Improved signal timing and signal coordination, or "passive priority," is the single most important element to improve bus speeds. To evaluate the performance of the traffic signal timing and the effectiveness of signal coordination, the consultant conducted "floating car runs." This technique measures travel time with a test vehicle, while elapsed time is recorded manually at predefined checkpoints by a passenger in the test vehicle. This information is then converted to travel time, speed, and delay for each segment along the survey route. For this project, observations were collected in private cars. Exhibit 9 shows the segment-by-segment travel time summaries and key observations. All observations were taken before activation of the queue jump lanes and signals. In most segments, improvements to average vehicle speeds were observed. Only three segments showed worse travel times: Broadway between 27th and College; Bancroft between Telegraph and Shattuck; and Durant between Shattuck and College. These three segments were heavily affected by construction projects. The table below shows the change in average speed for each roadway segment. The Notes and Exceptions column shows instances when the average speed declined for particular directions or times of day.

College Avenue, a critical segment of the corridor, was not included because it has widely-spaced traffic signals that couldn't be coordinated by the project. Similar conditions exist on Santa Clara Avenue in Alameda. On this segment, investments were concluded to have a relatively small benefit. Faced with budget constraints, investments along Santa Clara were reduced through the value engineering process.

Exhibit 9 – Average Speed by Segment

Route Segment	Change in Average Speed (%)	Notes and Exceptions
Webster Street – Santa Clara to Willie Stargell	12.8	Slight decline in off-peak direction (SB AM and NB PM) speed. Traffic volumes have grown but signal timing favors peak, not off-peak direction.
Broadway – 8th to 27th	13.2	Major decline in SB PM speed. New signal at Telegraph/Latham Square.
Broadway – 27th to College	-3.1	Decline in NB midday and PM speed. New Kaiser Hospital parking entrance adds 50 seconds of delay. New signal at Broadway & Coronado. Construction at 51st Street and new signal timing adds over 100 seconds of delay.
College – Dwight to Durant	41.0	No exceptions.
Bancroft – Telegraph to Shattuck & Durant – Shattuck to College	-3.0	Decline in NB and SB midday speeds. Affected by construction activity at UCB and new pedestrian signal at Sather Lane
Shattuck – Bancroft/Durant to University	13.0	Slight decline in SB PM speed. Most delay recorded at left turn from Shattuck to Durant.
University – Shattuck to 6th	7.1	Slight decline in NB midday speed. Operation of traffic signal at 6th Street contributes to queues extending back past 7th Street. No other incidents or causes identified.

The data collection efforts reflect multiple construction projects occurring during the "before and after" periods. Local construction activity resulted in traffic delays, particularly during the midday period. This affected the observed travel times. In some cases, projects contributed to increase delay to buses even after construction was completed.

Transit Signal Priority Test Results

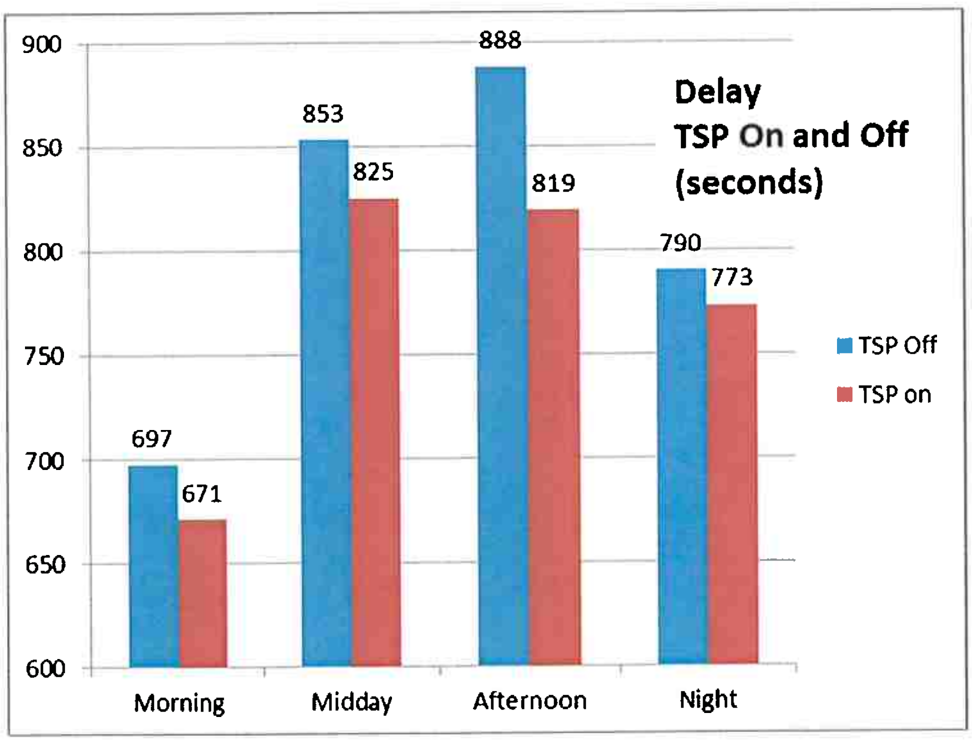
A test was conducted with the TSP system off and on to measure the effectiveness of TSP and the ability of this "active priority" system to reduce travel time. During all test periods, bus travel times were reduced with the system turned on. Exhibits 10 and 11 summarize the travel time savings attributed to TSP by time period. Data were collected along a small portion of the project corridor between Broadway & 40th Street and Broadway & 25th Street. TSP was turned on and off for only a small portion of the total project corridor length to avoid unnecessary disruptions to service. Enough signals were included to infer TSP performance on the route as a whole. The test was conducted by Global Traffic Technologies (GTT), the vendor for the TSP equipment.

The following sections compare the results of running buses with TSP always turned off against buses with TSP always turned on. The detailed results are shown in the table below and the following charts.

Exhibit 10 – TSP Testing Results

	Morning – 6 – 10 AM	Midday – 10 – 2 PM	Afternoon – 2 – 6 PM	Night – 6 PM – 6 AM
Number of trips	263	220	226	226
Number of buses	31	31	30	32
Average duration (seconds) – TSP off	697	853	888	790
Average duration (seconds) – TSP on	671	825	819	773
Net savings (seconds)	26	28	68	17
Net savings (percentage)	4%	3%	8%	2%

Exhibit 11 – TSP Testing Results – Delays in Seconds



Every time category (morning, midday, afternoon, and night) showed a reduction in travel time. The time savings ranged from two to eight percent or from between 17 to 68 seconds. The greatest savings in travel time are in the afternoon, correlating to heavier traffic conditions during that time. The smallest savings in travel time are during the midday and at night as a result of lighter traffic conditions.

It may be possible to achieve even greater time savings through TSP. For example, while conducting the initial verification trips, significant time savings were recorded when testing the TSP. Although the number of data points is small (8 total trips), travel time gains were observed that exceeded those conducted during normal operations. The District should work with local jurisdictions to ensure that the TSP is properly maintained and that the maximum priority is given to buses. Additionally, effort should be undertaken to ensure that run times are accurate and do not require excessive idling at time points.

Exhibit 12 – TSP Travel Time Savings during Verification

Inbound trips with TSP on	33 minutes (average)
Inbound trips with TSP off	41 minutes (average)

<u>Queue Jump Lanes & Signals</u>

Queue jump lanes combine short, dedicated transit lanes with either a leading bus signal phase interval or active signal priority to allow buses to easily enter traffic flow in a priority position. Applied thoughtfully, queue jump treatments can reduce delay considerably, resulting in run-time savings and increased reliability (National Association of City Transportation Officials or NACTO). For this project, all queue jumps include a short bus-only lane with a signal activated by the TSP equipment.

The procedure to activate a signal is as follows: an operator will drop off or pick up passengers at a designated location and then move the bus up closer to the signal. The queue jump signal will then give the operator an advanced green light to pull the bus into traffic ahead of queueing cars. Eight queue jump signals and bus lanes were installed as part of the Line 51 Project. These locations were selected to minimize delays to buses and in one instance, at College and Manila, as a safety measure requested by the City of Oakland.

Due to restrictions imposed by Berkeley and Oakland, the queue jump locations did not also have conventional TSP installed for instances when the bus was not pulled to the curb. The implication for operations is that buses not stopping for passengers or otherwise positioned in the queue jump lane will not receive priority. Listed below are the locations of queue jump lanes and signals.

1. Webster and Willie Stargell.
2. Broadway and Kaiser Hospital.
3. 42nd and Broadway.
4. Piedmont and Broadway.
5. College and Broadway.
6. College and Manila.
7. University and Martin Luther King.
8. University and 9th.

All active queue jumps are performing as designed. The queue jump signal at University and Martin Luther King was installed but not activated due to disagreements with the City of Berkeley on the use of the signal during congested times of the day. Currently, the City only permits use of this queue jump during uncongested times of the day such as mid-day and late night. The most frequent cause for a failure of the queue jump signal to activate was caused by buses assigned to the corridor that were not outfitted with TSP emitters. The largest travel time savings were observed at Willie Stargell and Webster where the long bus-only lane combined with large vehicle queues bound for Oakland resulted in over one minute of time savings. This queue jump lane was installed prior to the project but the queue jump signal was upgraded to current standards by the project.

Exhibit 13 summarizes the results of the queue jump evaluation.

Exhibit 13 – Queue Jump Results

Intersection	Performance/Status	Travel Time Savings (sec./bus)
Webster and Willie Stargell	Works as designed	68
Broadway and Kaiser Hospital/Mosswood Park	Works as designed	12
42nd and Broadway	Works as designed. May benefit further by adjusting detection zone.	15
Piedmont and Broadway	Works as designed	15
College and Broadway	Works as designed. Does not provide clear advantages.	7
College and Manila	Works as designed	25
University and MLK	Not activated	None
University and 9th	Works as designed	11

<u>Queue Jump Recommendations</u>

1. All 40-foot and 60-foot coaches should be outfitted with TSP emitters to permit all buses to activate the signals and to eliminate the need for specialized sub-fleets. Despite receiving funds to outfit 100 buses with TSP equipment, assigning TSP-equipped buses to the corridor was a challenge. Once 70-80 percent of the coaches had TSP, the operation of the queue jump signals was fine-tuned with support from city staff and the consultants.
2. Based on observations and operator feedback, queue jump operations could be improved with further training of operators.
3. Conventional TSP should be added to all future queue jump locations to give priority to buses that are not stopping for passengers as well as for those that are. This would not require revised operator training on queue jump operations.
4. Conversations with Berkeley should be elevated within stakeholder organizations to consider permitting peak-hour queue jump operations at University and Martin Luther King.
5. Conduct more systematic evaluation of proposed queue jump locations. There may be fewer benefits realized for queue jump signals at the following types of locations:
    a. Stops with low passenger volumes,
    b. No significant traffic congestion,
    c. T-intersections with low side-street traffic, or

d. Locations with high right-turn volumes.

In order to maximize the return on investment, local jurisdictions should be educated on their importance where traffic queues and ridership are relatively high.

6. Consider modifications or repairs at Broadway and Kaiser Hospital/Mosswood Park queue jump. Determine if equipment problems are the source of poorer than expected performance. Alternatively, confirm location of detection zone. Move back bus stop ≈10 feet to separate bus stop from detection zone for triggering the queue jump signal.

Next Steps

The following additional actions are recommended to improve operations of Lines 51A and 51B, increase on-time performance, and reduce bunching:

1. Activate queue jump at University and Martin Luther King.
2. Install TSP and provide bus-only lanes along 7th and 8th Streets.
3. Negotiate increased TSP activation rates in Berkeley which currently only permits TSP every five to seven signal cycles.
4. Install Bus bulbs at 30th and Broadway and at 40th and Broadway.
5. Review bus stop locations and reconsider far-side relocations not implemented due to business objections.
6. Develop regional or county-wide policy for TSP. Avoid overly restrictive or location-specific ad hoc policies.
7. Investigate hybrid rapid stop spacing (every 1/3 mile or four blocks).
8. Implement all-door boarding or proof of payment pilot as recommended in Major Corridors Study.
9. Expedite deployment of passive wheelchair restraints.
10. Work with GTT to develop TSP diagnostics. Create a web-based interface to visually show where the system is operating successfully and locations where there may be technical issues yet to be resolved.
11. Equip more buses with TSP equipment including all 40-foot, 60-foot and Transbay buses.