

TRANSIT PREFERENTIAL STREETS PROGRAM

FINAL REPORT



CITY of PORTLAND, OREGON
OFFICE of TRANSPORTATION

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As part of this project, a separate document with the title “Transit Preferential Streets Program Sourcebook” was prepared to complement the Transit Preferential Streets Program Final Report.

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1. EXECUTIVE SUMMARY

The City of Portland's Transportation Element of the Comprehensive Plan adopted June 21, 1996 recommends developing a Transit Preferential Streets Program as a means of dealing with congestion and air quality problems within the metropolitan area. It is the goal of the Transit Preferential Streets Program to improve transit travel times and service by giving priority to transit vehicles where conflicts with autos occur.

A team of City of Portland staff in association with a Technical Advisory Committee (TAC) selected the following five corridors for analysis of the effect of transit preferential strategies:

- NE Martin Luther King, Jr. Blvd. (Hawthorne Bridge to N. Lombard Street)
- NE Sandy Blvd. (Burnside Bridge to SE 82nd Avenue)
- SE Hawthorne Blvd./Foster Road (Hawthorne Bridge to I-205)
- SE Division Street (Martin Luther King, Jr. Blvd. to SE 82nd Avenue)
- SW Beaverton-Hillsdale Highway/Barbur Blvd. (I-405 to Oleson Road)

This report summarizes the findings of a detailed operations analysis of these corridors, and the solutions that were developed to improve transit travel time and the potential impacts associated with their implementation. In addition, the report discusses the results of an international inventory of previously applied treatment solutions, the solutions that were developed for problem locations identified on the five corridors. Furthermore, the report recommends one of the developed solutions for a demonstration project of transit preferential streets measures.

Findings

The operations analysis reveals that only 31% to 39% of the total bus travel time along the selected corridors is necessary for driving. The remaining 60% to 70% of the total estimated travel time consists of the time buses spend at traffic signals, bus stops, and in traffic; with delays at traffic signals (27% of total travel time) representing the most significant source of delay.

The team's research into viable transit preferential treatment solutions developed and implemented in other cities in the United States, Canada, and abroad, identified the following solutions:

- Signal Priority for Buses
- Signal Timing Changes
- Bus Stop Consolidation
- Bus Stop Relocation
- Queue Bypass Lanes for Buses

- Fare Collection Changes
- Curb Extensions at Bus Stops
- Boarding Islands at Bus Stops
- Low-floor Bus Equipment Technology
- Parking Restrictions Within Bus Corridors
- Exclusive Bus Lanes
- Queue Jump Lanes for Buses
- Exempting Buses from Turning Restrictions

A separate source book containing the individual transit preferential streets solutions together with recommendations for their application has been prepared in addition to this report.

The corridor level assessment identified corridor issues that generate the greatest bus transit delay on the five studied corridors, and ranked them according to their travel time savings potential. Corridor wide implementation of bus signal priority and bus stop consolidation demonstrated the highest potential for travel time reductions on the five corridors.

Transit preferential streets improvement strategies were developed for a total of twelve intersections within the five study corridors that were found to experience high transit delays at certain locations. These strategies were developed for each individual location with the objective of reducing bus transit delay while minimizing negative impacts on land use and other modes of transportation.

Impacts

The impact analysis evaluated the effect of introducing the developed transit preferential streets strategies on transit travel time, as well as their corresponding impacts on the following systems and features:

- Traffic Circulation
- Transit Patrons
- Bicycle Circulation
- Pedestrian Circulation
- Overall Traffic Safety
- Urban Design
- Existing and Future Land Use
- On-Street Parking Supply

Transit preferential streets strategies were simulated using the microscopic traffic/transit simulation model VISSIM, which documented transit and general traffic travel times, speeds, level of service measurements for general traffic, and travel delays.

Analyses of the impact of these strategies to parking supply, businesses and other land uses, pedestrians and bicyclists, were then made based on field survey information, and previously completed transportation planning plans, policies and studies completed by the City of Portland.

Implementation of the proposed transit preferential streets strategies would significantly improve transit travel time and general operations at the specific locations, as well as along each of the respective entire corridors. With one exception, transit travel time savings are estimated to range between 22% and 62%. The most significant travel time savings are anticipated to occur at:

- Hawthorne Blvd. EB at 39th Avenue = savings of 91.5 seconds/bus during the PM peak hour
- Division Street EB, 37th-39th Avenues = savings of 88.6 seconds/bus during the PM peak hour
- Grand Avenue NB, SE Oak-Burnside Street = savings of 74.5 seconds/bus during the PM peak hour
- Division Street WB, 39th-37th Avenues = savings of 52.6 seconds/bus during the AM peak hour

Recommended Demonstration Project

The project team recommends that the segment of SE Division Street between SE 39th and SE 37th avenues be selected for demonstration of design, operation, and anticipated benefits of transit preferential streets measures because of the relatively high level of transit delay experienced at the location. This location also accommodates relatively high ridership levels and frequent peak hour (and off-peak hour) service. Furthermore, it incorporates a variety of transit preferential streets measures (physical as well as operational) that are expected to effectively reduce previously documented transit travel time delays. The measures proposed for this location also include exclusive transit lanes which are of particular importance because of their high visibility and the resulting psychological affect on motorists when being passed by a bus.

2. INTRODUCTION

2.1 GENERAL

The City of Portland's Transportation Element of the Comprehensive Plan adopted October 23, 1992 recommends developing a Transit Preferential Streets Program as a means of dealing with congestion and air quality problems within the metropolitan area. It is the goal of the Transit Preferential Streets Program to improve transit travel times and service by giving priority to transit vehicles where conflicts with autos occur.

A team of City of Portland staff in association with a Technical Advisory Committee (TAC) selected the following five corridors for analysis of transit preferential strategies (see Figure 1):

- NE Martin Luther King, Jr. Blvd. (Hawthorne Bridge to N. Lombard Street)
- NE Sandy Blvd. (Burnside Bridge to SE 82nd Avenue)
- SE Hawthorne Blvd./Foster Road (Hawthorne Bridge to I-205)
- SE Division Street (Martin Luther King, Jr. Blvd. to SE 82nd Avenue)
- SW Beaverton-Hillsdale Highway/Barbur Blvd. (I-405 to Oleson Road)

2.2 DESCRIPTION OF CORRIDOR TRANSIT OPERATIONS

2.2.1 Martin Luther King, Jr. Blvd./Grand Ave. Corridor, North Lombard Street to Hawthorne Bridge

This north/south corridor accommodates the No. 6 bus between Columbia Blvd. and the Hawthorne Bridge, and the No. 63 bus between NE Multnomah Street and the Hawthorne Bridge. Several bus routes as well as MAX intersect with the corridor, providing bus transfer opportunities to and from east and west destinations.

2.2.2 Sandy Blvd. Corridor, Burnside Bridge to SE 82nd Avenue

This corridor, which is oriented in a northeasterly/southwesterly direction, accommodates the No. 12 bus, and intersects with several bus routes along its entire length. Transfer opportunities are provided throughout the corridor, with significant transfers occurring at the Hollywood Transit Center between the No. 12, No. 75, No. 77, No. 83 lines, and MAX. Park-and-ride facilities are located adjacent to Sandy Blvd. at NE 70th Avenue, and just beyond the corridor's eastern terminus, at NE 95th Avenue.

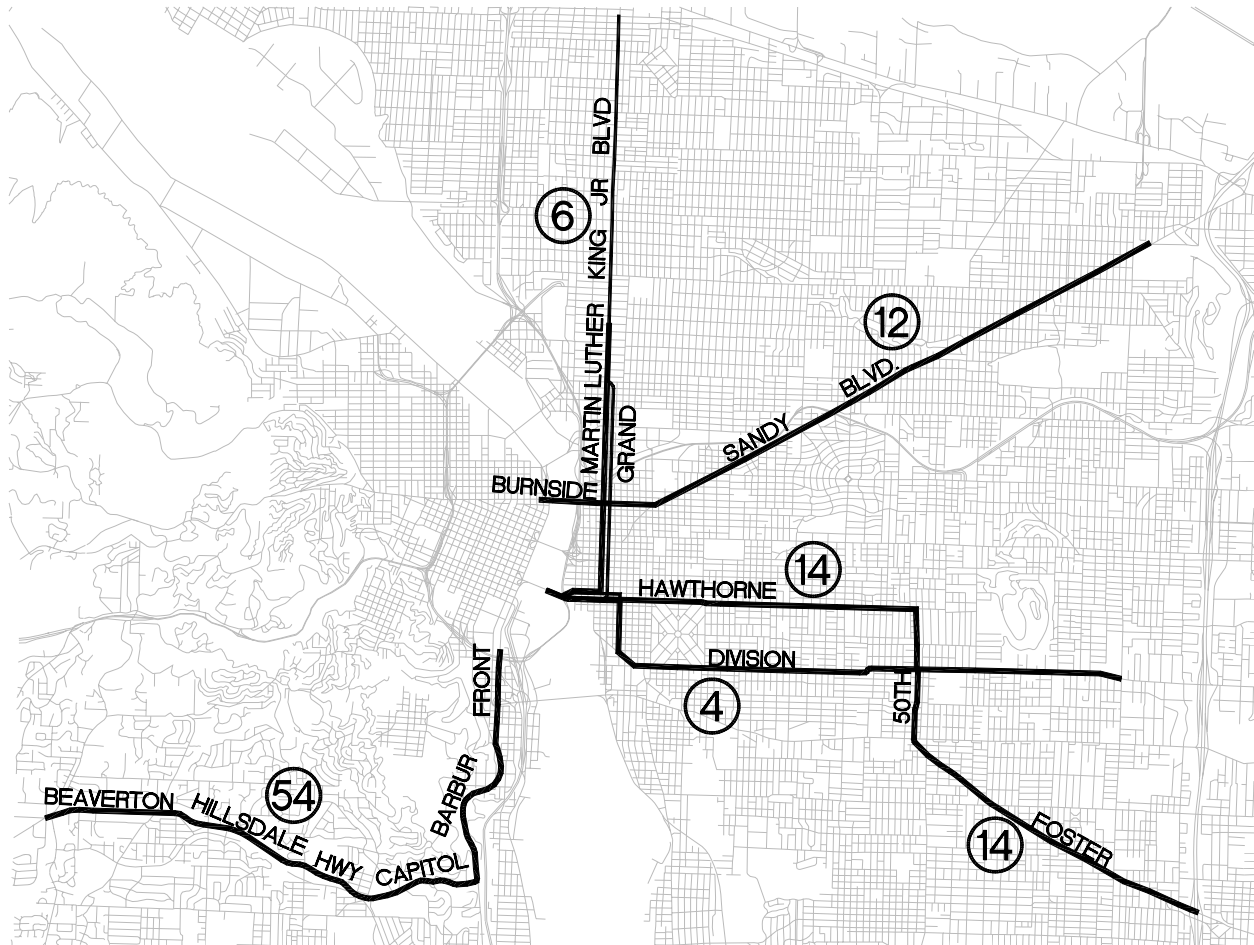


Figure 1: Overview of Studied Corridors

2.2.3 Hawthorne Blvd./Foster Street Corridor, Hawthorne Bridge to I-205

Bus travel along this corridor follows an east-west path west of SE 50th Avenue, before running north/south along SE 50th Avenue, and in a northwest/southeast direction east of the Foster Street/Powell Street/SE 50th Avenue intersection. The No. 14 bus traverses the entire corridor, and is joined by the No. 4 and No. 10 bus routes in the extreme western segment of the corridor, and the No. 71 bus near the eastern end of the corridor. A park-and-ride facility is located along the corridor at Foster Street and SE 68th Avenue.

2.2.4 Division Street Corridor, Martin Luther King, Jr. Blvd. to SE 82nd Avenue

This east-west corridor accommodates the No. 4 bus, and provides numerous opportunities for transfer to and from other bus routes.

2.2.5 Barbur Blvd./Beaverton-Hillsdale Hwy. Corridor, I-405 to Oleson Rd.

This corridor consists of Barbur Boulevard running north-south and Beaverton-Hillsdale Highway running east-west. Multiple bus routes share this corridor with the No. 54 bus route covering it in its entire length.

3. OPERATIONS ANALYSIS

3.1 DATA COLLECTION

3.1.1 Critical Time Period Determination and Schedule

Three different time periods representing morning, mid-day, and afternoon peak periods were selected for the travel time data collection. The selection was made in coordination with City of Portland Department of Transportation (PDOT) staff. Data collection for the morning peak period was determined to occur between 7:00 AM and 8:30 AM, data collection for the mid-day period between 11:00 AM and 1:00 PM, and data collection for the afternoon peak period between 4:00 and 5:30 PM (see Table 1).

Table 1: Critical Time Periods

TIME PERIOD	TIME INTERVAL
Morning Peak	7:00 AM - 8:30 AM
Mid-day	11:00 AM - 1:00 PM
Afternoon Peak	4:00 PM - 5:30 PM

The data collection process was completed before the end of the Portland school year. Five data collectors equipped for bus transit data collection worked concurrently on one corridor per day. One crew from PDOT simultaneously collected auto travel time data while the schedule presented in Table 2 was maintained.

Table 2: Data Collection Schedule

CORRIDOR	LIMITS	ROUTE	DATE
Martin-Luther-King Boulevard	Hawthorne Bridge to N. Lombard Street	6	Monday, June 3, 1996
Sandy Boulevard	Burnside Bridge to SE 82 nd Avenue	12	Tuesday, June 4, 1996
Division Street	Martin Luther King Blvd. To SE 82 nd Avenue	4	Wednesday, June 5, 1996
Hawthorne Blvd./50th Ave./Foster Rd.	Hawthorne Bridge to I-205	14	Thursday, June 6, 1996
Barbur Blvd./Beaverton Hillsdale Hwy.	I-405 to Oleson Road	54	Monday, June 10, 1996

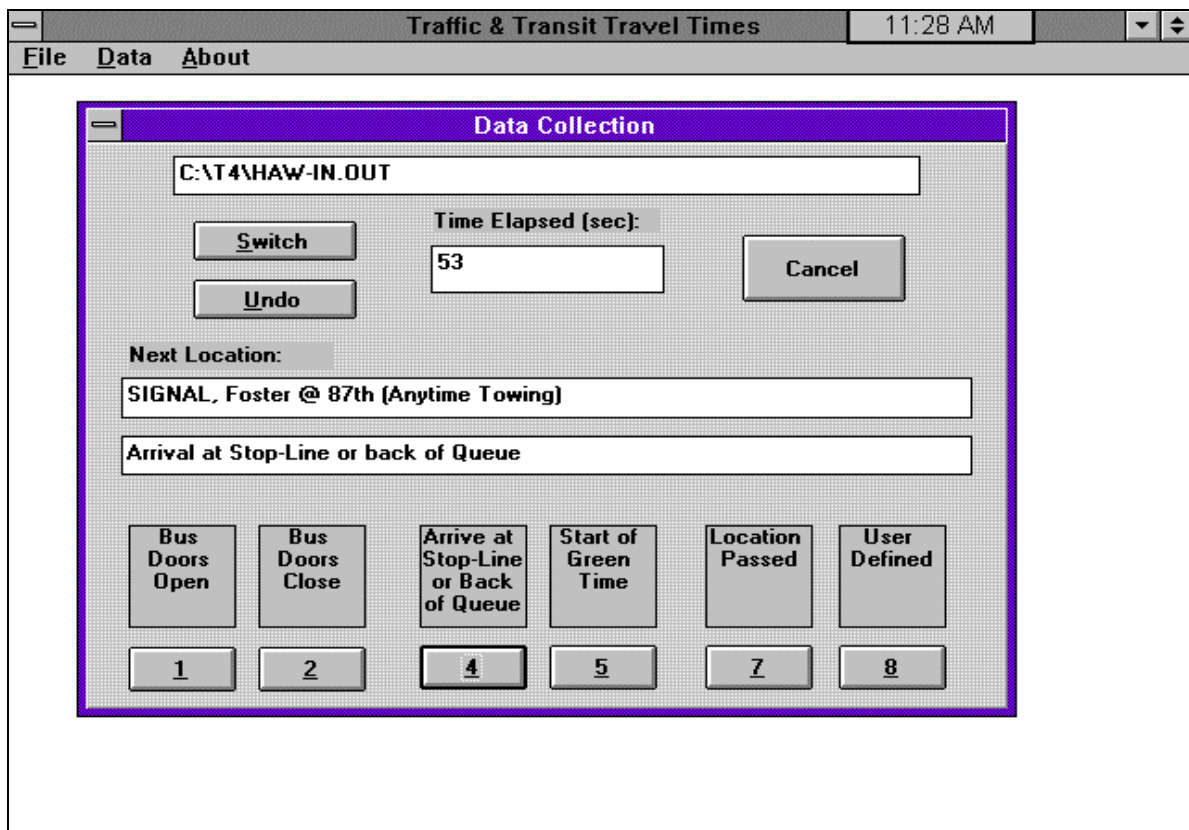
3.1.2 Methodology

Bus travel time data was manually entered into a notebook computer by data collectors traveling on the bus. In order to reduce the work load for data collectors and therefore improve the accuracy of the collected data, Access Engineering has developed the data collection software program "T⁴". T⁴ is designed to allow data collectors to log the following common bus travel events by pressing a single button:

- arrival at bus stop,
- doors closed,
- departure from bus stop,
- arrival at back of traffic queue at a signalized intersection,
- start of green time, and
- passing of stop line.

In addition, the program allows the data collector to log any uncommon events using a separate button. Figure 2 below shows a typical user interface input screen for T⁴.

Figure 2: T⁴ User Interface Input Screen



Input files for T⁴ containing all bus stop and traffic signal locations were prepared and field verified prior to the start of the data collection process.

T⁴ generates output files that include the time and date of the data collection run as well as all logged events together with the exact time of their occurrence.

Figure 3: T⁴ Output File Sample

```
----- BEGINNING OF ROUTE -----06/05/96, 07:39:21

Hawthorne Bridge~Location passed~6
SIGNAL, (FS STOP follows), Hawthorne @ Grand~Arrival at Queue/Stop-Line~59
SIGNAL, (FS STOP follows), Hawthorne @ Grand~Start of Green Phase~60
SIGNAL, (FS STOP follows), Hawthorne @ Grand~Location passed~68
FS STOP, Hawthorne @ Grand~Doors open~82
FS STOP, Hawthorne @ Grand~Doors close~89
FS STOP, Hawthorne @ Grand~Location passed~92
SIGNAL @ Hawthorne @ 7th~Arrival at Queue/Stop-Line~105
SIGNAL @ Hawthorne @ 7th~Location passed~124
NS/SIGNAL, 7th @ Clay~Location passed~135
NS STOP, 7th @ Mill~Location passed~146
FS STOP, 7th @ Harrison~Doors open~169
FS STOP, 7th @ Harrison~Doors close~175
FS STOP, 7th @ Harrison~Location passed~181
NS STOP, 7th @ Grant~Location passed~199
SIGNAL, Division @ 8th~Location passed~294
MB STOP, BZ, Division Opposite 10th (pullout on corner)~Doors open~311
MB STOP, BZ, Division Opposite 10th (pullout on corner)~Doors close~317
MB STOP, BZ, Division Opposite 10th (pullout on corner)~Location passed~320
```

The configuration of the output file is designed to allow for an easy import into any spreadsheet program such as EXCEL, QUATTRO PRO, etc. for data reduction and analysis purposes.

3.2 TRANSIT DELAY IDENTIFICATION

3.2.1 Methodology

The analysis of the collected bus travel time data focuses on delay type, delay location, and actual speed for each individual route discriminating between the following types of delay:

- *passenger service* - delay caused by passengers entering and leaving the bus including wheel chair or bike boardings,
- *dwell time delay* - delay caused by bus waiting to merge into traffic flow after servicing a bus stop (measured from “doors closed” to “bus leaving stop”),
- *signal timing delay*¹ - delay caused by bus waiting for a traffic signal to turn green,
- *queue delay* - caused by bus waiting behind traffic queued at a traffic signal after it turned green at least once, and
- *roughness delay* - delay caused by anything else but stops or traffic signals (on-street parking, delivery trucks, congested streets, etc.).

Passenger service time, dwell delay, signal timing delay, and queue delay is derived directly from the T⁴ output file. Driving time is defined as the time the bus actually drives between two locations (travel time without specific delays). The ideal driving time is defined as the minimum driving time between two locations measured during any run of the day. Therefore, roughness delay is computed as the difference between actual driving time and ideal driving time.

Results of the data collection are presented in tabular format as well as in graphical format. Three different charts were selected for graphical presentation of the travel time analysis:

- *Travel Time Composition* - depicts the total travel time of each route broken down into its composites,
- *Speed Analysis* - shows the measured speed profiles of each segment of the analyzed routes, and
- *Delay Type and Location Identification* - visualizes delay type, amount and location along each route.

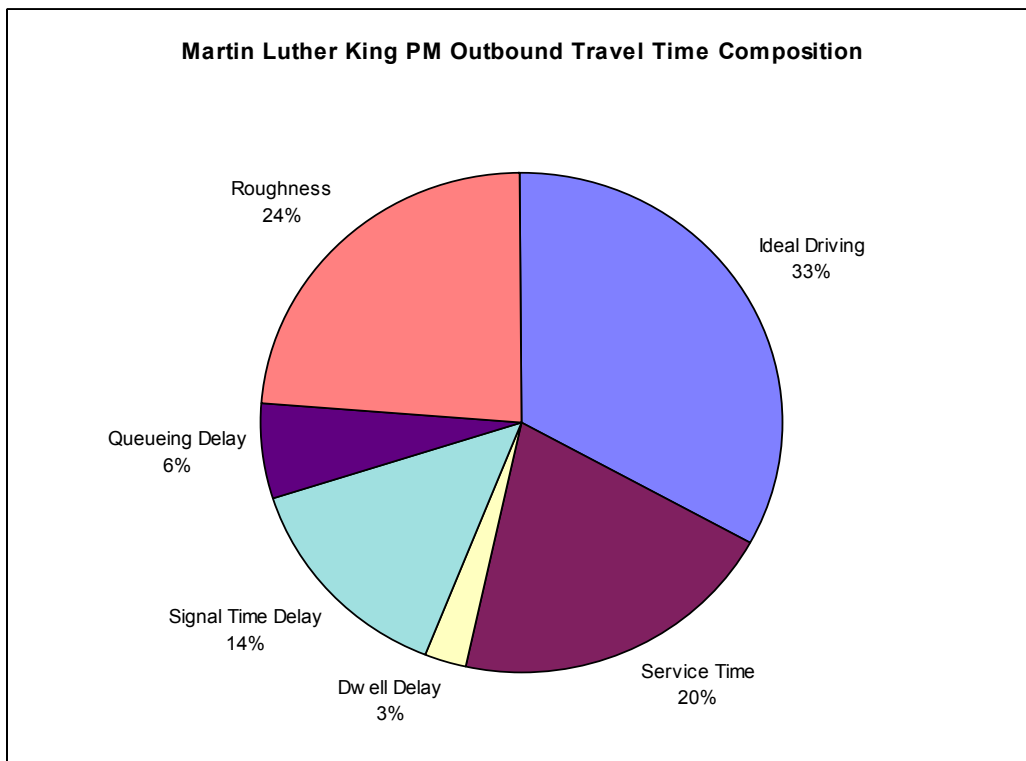
¹ The total of signal timing delay and queue delay is comparable to signal delay as defined by the Highway Capacity Manual and used for level of service calculation.

3.2.2 Statistical Results

3.2.2.1 Martin Luther King Boulevard (Route #6)

The bus travel time analysis reveals that buses traveling along Martin Luther King Boulevard have an average speed of 12.0 mph in inbound direction during the AM peak period and 10.1 mph in outbound direction during the PM peak period. During the peak periods (AM inbound / PM outbound), buses spend only 39%/33% of the total travel time driving. Bus stops (which include service time plus dwell time) account for 23%/23% of the total travel time. Traffic signals (which includes queue time) account for 17%/20%, and roughness or street friction for 21%/24% of the time. With an average bus stop spacing of 613 feet inbound and 584 feet outbound, actual passenger service time accounts for 20%/20% of the total travel time. Traffic signal timing (red time) delay accounts for 12%/14% of the total average bus travel time during the peak direction along Martin Luther King Boulevard, while delays caused by traffic queues at signalized intersections accounted for 5%/6% (see Figure 4 below).

Figure 4: Martin Luther King Boulevard PM Peak Travel Time Composition

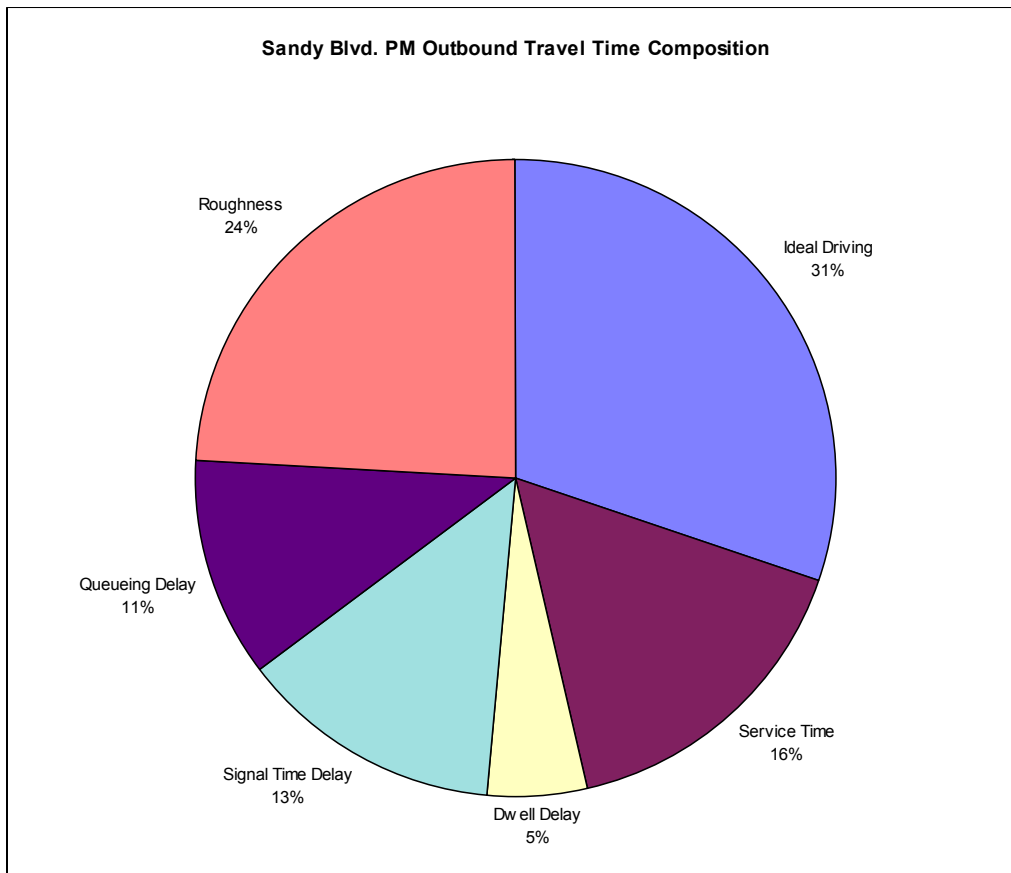


Generally, the Martin Luther King Boulevard route has the highest number of stops per 1,000 feet. In the outbound direction, there are three signalized intersections which caused major delays in all time periods: Weidler, Alberta, and Killingsworth. Ankeny causes significant delays to outbound buses during the PM peak period.

3.2.2.2 Sandy Boulevard (Route #12)

The bus travel time analysis reveals that buses traveling along Sandy Boulevard have an average speed of 10.5 mph in inbound direction during the AM peak period and 9.5 mph in outbound direction during the PM peak period. During the peak periods (AM inbound / PM outbound), buses spend only 40%/30% of the total travel time driving. Bus stops (which include service time plus dwell time) account for 19%/21% of the total travel time. Traffic signals (which includes queue time) account for 16%/24%, and roughness or street friction for 24%/24% of the time. With an average bus stop spacing of 796 feet inbound and 747 feet outbound, actual passenger service time accounts for 17%/16% of the total travel time. Traffic signal timing (red time) delay accounts for 13%/13% of the total average bus travel time during the peak direction along Sandy Boulevard, while delays caused by traffic queues at signalized intersections accounted for 3%/11% (see Figure 5 below in the Attachment).

Figure 5: Sandy Boulevard PM Peak Travel Time Composition

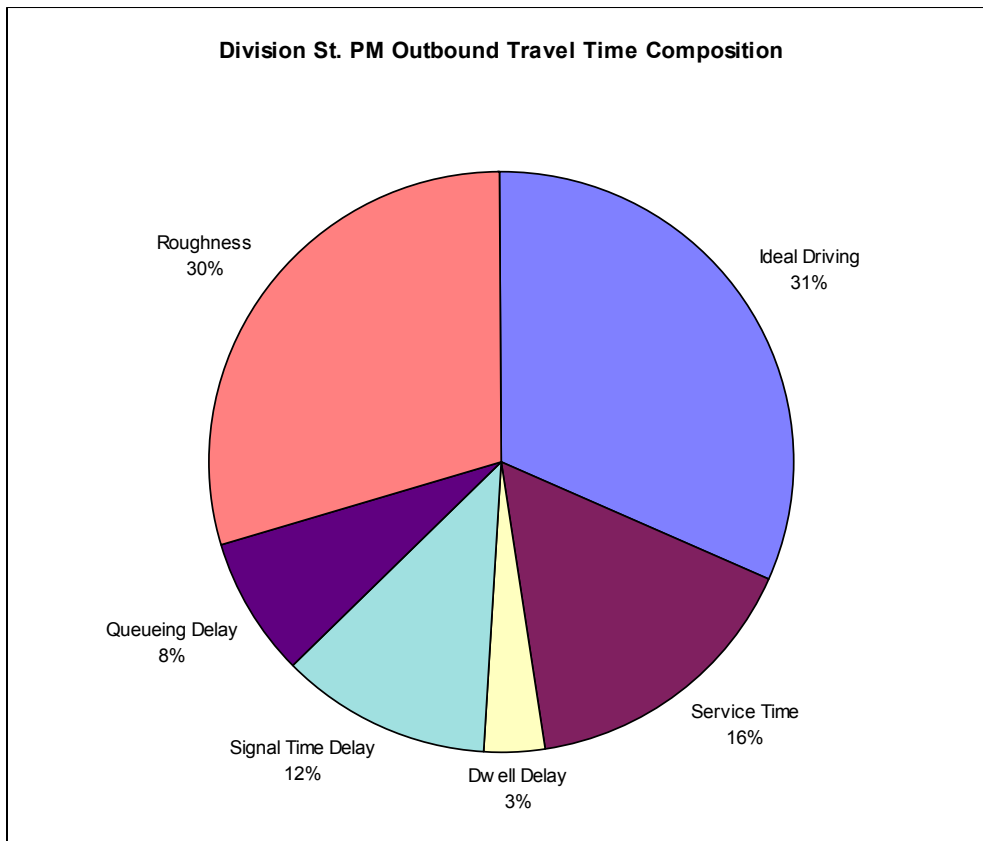


The intersection of Sandy Boulevard at 57th causes delays during all time periods and directions. The intersection of Sandy Boulevard at 72nd is regularly a problem for outbound buses particularly in the PM peak period.

3.2.2.3 Division Street (Route #4)

The bus travel time analysis reveals that buses traveling along Division Street have an average speed of 12.3 mph in inbound direction during the AM peak period and 10.3 mph in outbound direction during the PM peak period. During the peak periods (AM inbound / PM outbound), buses spend only 40%/32% of the total travel time driving. Bus stops (which include service time plus dwell time) account for 18%/19% of the total travel time. Traffic signals (which includes queue time) account for 22%/20%, and roughness or street friction for 20%/30% of the time. With an average bus stop spacing of 597 feet inbound and 604 feet outbound, actual passenger service time accounts for 16%/16% of the total travel time. Traffic signal timing (red time) delay accounts for 15%/12% of the total average bus travel time during the peak direction along Division Street, while delays caused by traffic queues at signalized intersections accounted for 7%/8% (see Figure 6 below).

Figure 6: Division Street PM Peak Travel Time Composition



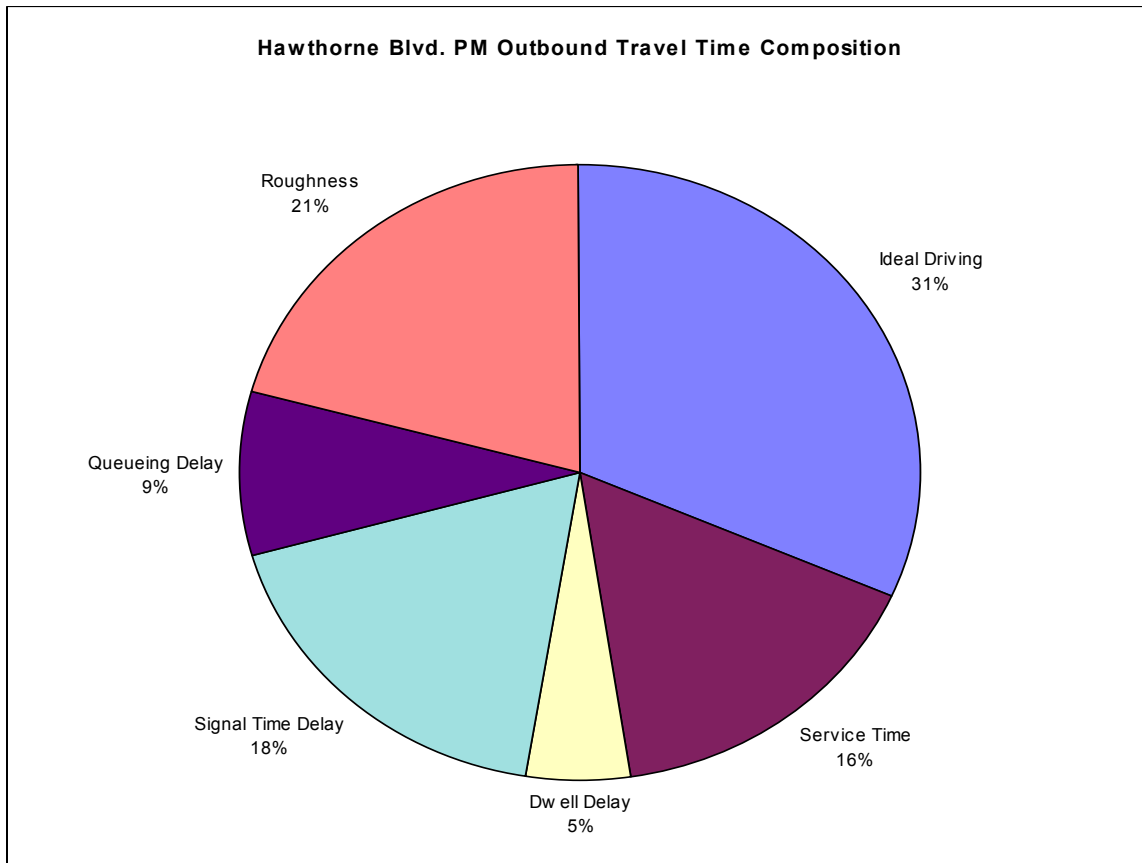
Inbound buses experience significant delay at the intersection of 7th Street and Madison; left turning buses must move on a permissive phase across an over-saturated through movement. Vehicles can only complete this turn at the end of the clearance phase (so called sneakers). In addition to the signal delay, buses experience a significant amount

of queue delay at this intersection. Division Street at 39th causes signal delay for all time periods and all directions.

3.2.2.4 Hawthorne Boulevard/50th Street/Foster Road (Route #14)

The bus travel time analysis reveals that buses traveling along Hawthorne Boulevard/50th Street/Foster Road have an average speed of 11.7 mph in inbound direction during the AM peak period and 10.4 mph in outbound direction during the PM peak period. During the peak periods (AM inbound / PM outbound), buses spend only 38%/32% of the total travel time driving. Bus stops (which include service time plus dwell time) account for 22%/21% of the total travel time. Traffic signals (which includes queue time) account for 18%/27%, and roughness or street friction for 22%/21% of the time. With an average bus stop spacing of 688 feet inbound and 685 feet outbound, actual passenger service time accounts for 19%/16% of the total travel time. Traffic signal timing (red time) delay accounts for 14%/18% of the total average bus travel time during the peak direction along Hawthorne Boulevard/50th Street/Foster Road while delays caused by traffic queues at signalized intersections accounted for 4%/9% (see Figure 7 below).

Figure 7: Hawthorne Boulevard PM Peak Travel Time Composition

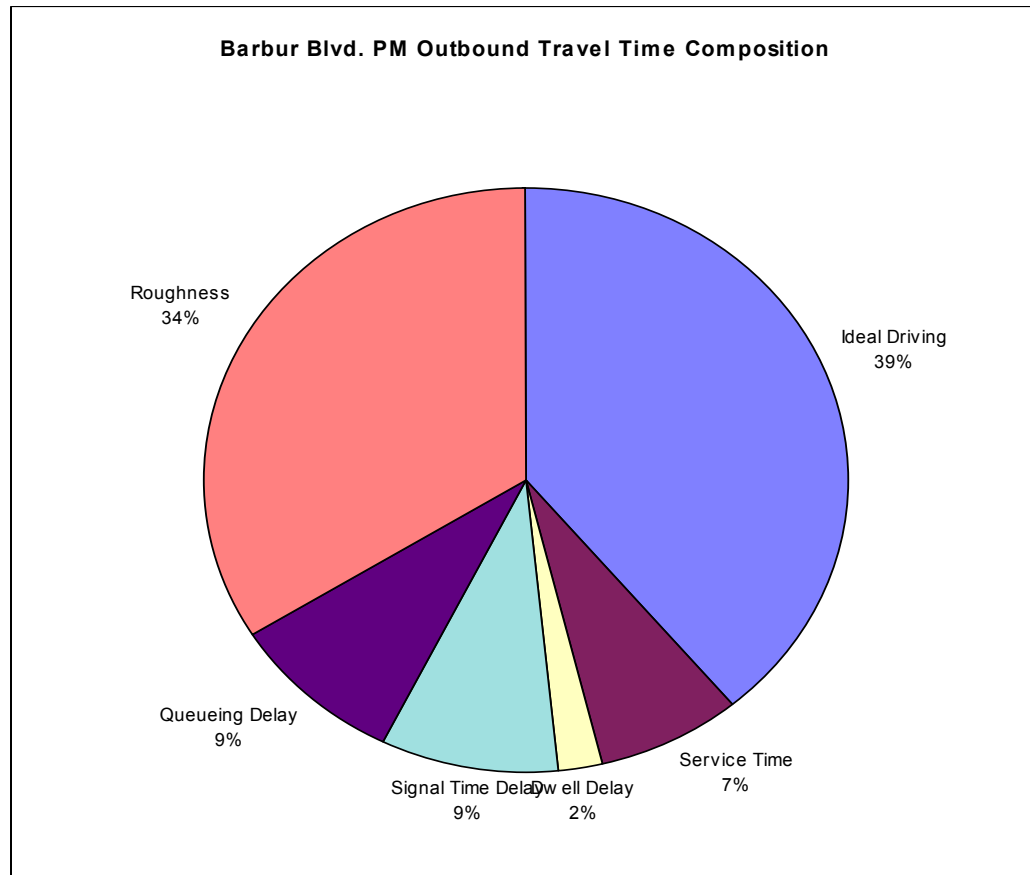


The intersections of Foster at 82nd and Hawthorne at 39th cause delays during all time periods and directions. Foster at 82nd has the longest signal timing and queuing delay of all intersections studied.

3.2.2.5 Barbur Boulevard/Beaverton-Hillsdale Highway (Route #54)

The bus travel time analysis revealed that buses traveling along the corridor have an average speed of 20.9 mph in the inbound direction during the AM peak period and 16.1 mph in outbound direction during the PM peak period. During the peak periods (AM inbound / PM outbound), buses spend only 48%/39% of the total travel time driving. Bus stops (which include service time plus dwell time) account for 14%/9% of the total travel time. Traffic signals (which includes queue time) account for 12%/18%, and roughness or street friction for 27%/34% of the time. With an average bus stop spacing of 1,209 feet inbound and 1,177 feet outbound, actual passenger service time accounts for 11%/7% of the total travel time. Traffic signal timing (red time) delay accounts for 7%/9% of the total average bus travel time during the peak direction along Barbur Boulevard while delays from traffic queues at signalized intersections accounted for 5%/9% (see Figure 8 below).

Figure 8: Barbur Blvd./Beaverton-Hillsdale Hwy. PM Peak Travel Time Composition



Barbur Boulevard has the fewest stops per 1,000 feet and the fewest traffic signals of any corridor. It also has the highest average speeds during peak times. Scholls Ferry Road caused delay inbound during all time periods and Olesen Road caused delays outbound for all time periods.

3.2.2.6 System Wide Statistics

The bus travel time analysis reveals that there are 11 approaches to signalized intersections along the five selected corridors that cause more than 30 seconds in signal timing delay. The analysis further reveals that 7 intersection approaches cause more than 25 seconds in queuing delay with 5 of these approaches also causing more than 30 seconds of signal timing delay. Table 3 and Table 4 below present the intersections with the highest signal timing and queuing delay.

Table 3: Intersections with Highest Bus Signal Timing Delay (> 30 sec.)

LOCATION	NEARSIDE STOP	ROUTE	DIRECTION	DELAY [sec]
Hawthorne @ 39 th	YES	Hawthorne (14)	Outbound	54
Beaverton-Hillsdale Hwy. @ Oleson	YES	Barbur (54)	Outbound	52
Foster @ 82 nd	YES	Hawthorne (14)	Outbound	51
50 th @ Powell	NO	Hawthorne (14)	Outbound	48
Hawthorne @ 39 th	YES	Hawthorne (14)	Inbound	38
Division @ 39 th	YES	Division (4)	Inbound	38
Sandy @ 57 th /Alameda	YES	Sandy (12)	Inbound	37
Beaverton-Hillsdale Hwy. @ Oleson	YES	Barbur (54)	Inbound	36
Division @ 39 th	YES	Division (4)	Outbound	35
Sandy @ Fremont/72 nd	YES	Sandy (12)	Outbound	35
7 th @ Madison	NO	Division (4)	Inbound	31

Table 4: Intersections with Highest Bus Queuing Delay (> 25 sec.)

LOCATION	NEARSIDE STOP	ROUTE	DIRECTION	DELAY [sec]
Foster @ 82 nd	YES	Hawthorne (14)	Outbound	61
Beaverton-Hillsdale Hwy. @ Oleson	YES	Barbur (54)	Outbound	53
Sandy @ Fremont/72 nd	YES	Sandy (12)	Outbound	52
Division @ 39 th	YES	Division (4)	Outbound	52
7th @ Madison	NO	Division (4)	Inbound	32
Grand @ Ankeny	YES	Martin Luther King (6)	Outbound	30
Sandy @ 70 th	NO	Sandy (12)	Outbound	27

The travel time analysis indicates that buses on the five studied corridors spend between 20% and 34% of their peak hour travel time on delays caused by other sources than stations and traffic signals. Table 5 below summarizes the impact of roughness on bus travel times on the five studied corridors.

Table 5: Roughness Experienced by Each Corridor

CORRIDOR	TIME PERIOD	ROUGHNESS
Martin Luther King (#6)	AM Inbound	272 sec./21%
Martin Luther King (#6)	PM Outbound	385 sec./24%
Sandy (#12)	AM Inbound	415 sec./24%
Sandy (#12)	PM Outbound	443 sec./24%
Division (#4)	AM Inbound	263 sec./20%
Division (#4)	PM Outbound	462 sec./30%
Hawthorne (#14)	AM Inbound	389 sec./22%
Hawthorne (#14)	PM Outbound	430 sec./21%
Barbur (#54)	AM Inbound	241 sec./27%
Barbur (#54)	PM Outbound	407 sec./34%

Roughness accounts for 407 seconds and an equivalent of 34% of the PM peak travel time on the Barbur Boulevard/Beaverton-Hillsdale Highway corridor. Most of the roughness delay buses experience on the Beaverton-Hillsdale Highway section between

Shattuck Road and Oleson Road is caused by traffic congestion due to the oversaturated signalized intersections of Beaverton-Hillsdale Highway at Oleson Rd./Scholls Fy. Rd.².

Roughness on Division Street accounts for 462 seconds and an equivalent of 30% of the PM peak travel time and 263 seconds and an equivalent of 20% of the AM peak travel time. Roughness on the Hawthorne Boulevard corridor accounts for 430 seconds and an equivalent of 21% of the PM peak travel time and 389 seconds and an equivalent of 22% of the AM peak travel time. Table 6 below presents the locations with the highest roughness on Division Street and the Hawthorne Boulevard corridor.

Table 6: Locations following Segments with Highest Roughness Delay (> 20 sec.)

LOCATION	ROUTE	DIRECTION	DELAY [sec]	CAUSE
Bus Stop at 37 th	Division (4)	Outbound	81	Congestion
Signal Division @ 8 th	Division (4)	Outbound	29	STOP Sign 7 th @ Division
Bus Stop opposite 35 th Pl.	Division (4)	Outbound	24	Congestion
Bus Stop at 41 st	Hawthorne (14)	Outbound	22	Congestion
Signal Division @ 39 th	Division (4)	Outbound	20	Congestion
Bus Stop at 37 th	Hawthorne (14)	Outbound	20	Congestion

3.2.3 Summary

The transit travel time analysis reveals that only 31% to 39% of the total travel time is necessary for driving. The remaining 60% to 70% of the total travel time buses spend at traffic signals, bus stops, and in traffic.

The most significant single source of delay identified by the data collection are traffic signals which take up to 27% of the total travel time. Buses experience two different, but correlated types of delay at traffic signals. The first type of delay is the bus waiting for the signal to change from red to green (signal timing delay). The second type of delay is the bus waiting behind other vehicles after the signal has changed to green at least once (queue delay). Signal timing delay takes up to 18% of the total travel time, while queue delay takes up to 11%.

Serving of bus stops takes up to 23% of the total travel time. Buses spend up to 20% of their travel time just on serving passengers (service time) which includes time spend on wheelchair and bicycle boardings. Up to 5% of the total travel time buses spend on waiting to merge back into traffic flow after serving a bus stop (dwell delay).

² The signalized intersections of Beaverton-Hillsdale Highway at Oleson Road/Scholls Fy. Rd. are under the jurisdiction of Washington County which is currently in the process of studying improvement options.

While buses spend between 52% and 73% on traveling between locations, only 31% to 39% of this time is actually necessary for driving. Traffic congestion, interference with driveway traffic, parking vehicles, delivery trucks, bicyclists, and pedestrians takes up to 34% of the total driving time.

3.3 TRANSIT/TRAFFIC OPERATIONS INVESTIGATION

The auto travel time analysis reveals that there are 8 approaches to signalized intersections along the five selected corridors that cause more than 30 seconds in signal timing delay. The analysis further reveals that 6 intersection approaches cause more than 25 seconds in queuing delay with three of these approaches also causing more than 30 seconds of signal timing delay. Table 7 and

Table 8 below present the intersections with the highest signal timing and queuing delay.

Table 7: Intersections with Highest Auto Signal Timing Delay (> 30 sec.)

LOCATION	DIRECTION	DELAY [sec]
Division @ 82 nd	Outbound	64
50 th @ Powell	Outbound	51
50 th @ Powell	Inbound	42
Hawthorne @ 39 th	Outbound	41
Hawthorne @ 12 th	Inbound	35
Sandy @ 12 th	Outbound	34
Division @ 39 th	Outbound	39
Division @ 39 th	Inbound	38

Buses experience the lowest average travel speeds on the Martin Luther King and Sandy corridors in outbound direction with average speeds of 10.1/9.5 mph. The highest average travel speeds achieved by buses were measured on the Barbur corridor with speeds of 20.9/16.1 mph during the AM and PM peak period.

Table 8: Intersections with Highest Auto Queuing Delay (> 25 sec.)

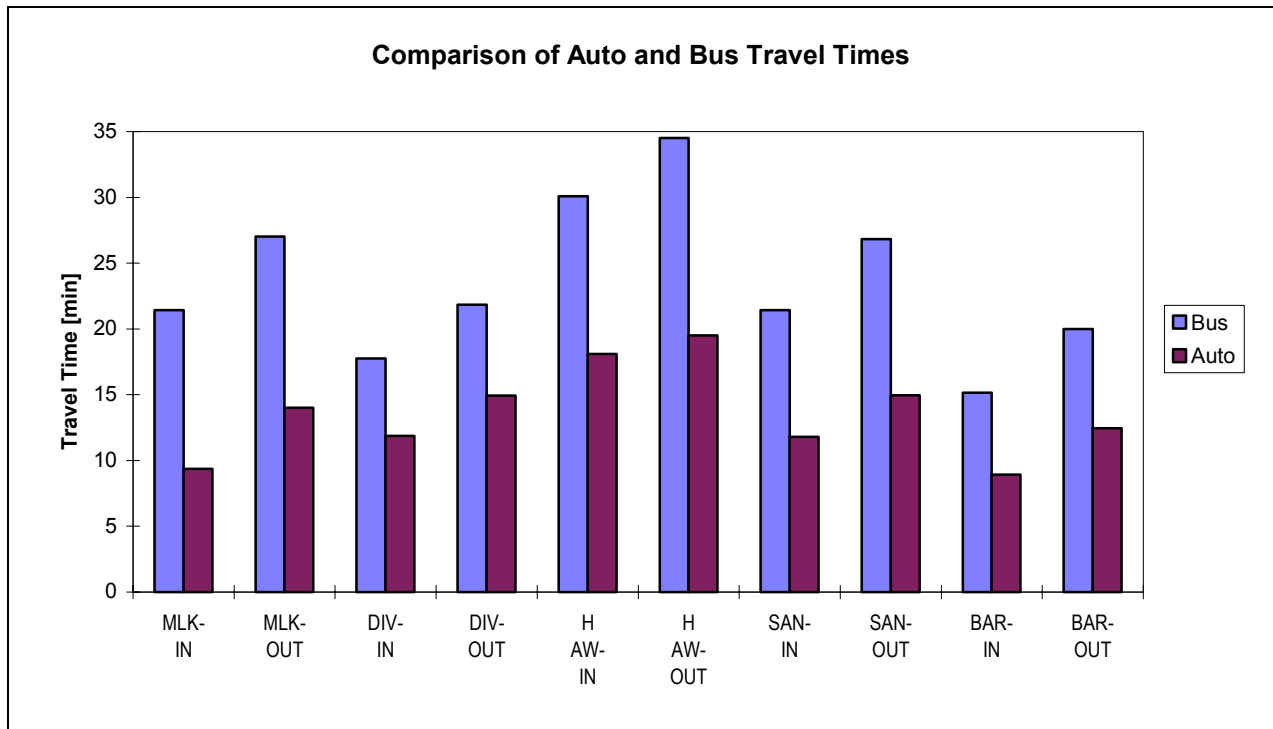
LOCATION	DIRECTION	DELAY [sec]
Beaverton-Hillsdale Hwy. @ Oleson	Outbound	119
Sandy @ Fremont/72nd	Outbound	54
50 th @ Powell	Outbound	52
Division @ 39 th	Inbound	40
Division @ 39 th	Outbound	35
Capitol @ Sunset	Inbound	31
Sandy @ Fremont/72nd	Inbound	30
Sandy @ 57 th	Outbound	29

The greatest speed contrast (15 mph) between auto and bus transit occurs on Martin Luther King Boulevard during AM peak period in inbound direction. The delay on this corridor is spread throughout with a peak in the area between Lombard and Prescott. The second largest (11 mph) speed contrast is observed on Barbur Blvd. On this corridor the majority of contrast occurs between 25th Court and Shattuck Road, approximately half of the route. This holds true for both the AM and PM peak periods and can be explained by buses having to serve bus stops while cars can maintain an uninterrupted speed of up to 50 mph. The following Table 9 summarizes comparisons of automobile traffic and bus transit speeds, while Figure 9 depicts a comparison of traffic and transit travel times for the PM peak period.

Table 9: Summary of Auto/Bus Speed Comparison [mph]

ROUTE	AVG. SPEED CARS	AVG. SPEED BUSES	DIFF.	GREATEST DIFFERENCE	AREAS WITH TRANSIT SPEEDS OF 5 MPH OR LESS
Barbur AM Inbound	30	19	11	Between 30th and Shattuck	Oleson/Scholls Ferry Road Traffic Signal
Barbur PM Outbound	22	14	8	Between Sunset and Shattuck	Between Shattuck and Oleson/Scholls Ferry Road
Division AM Inbound	19	12	7	Between 60th and 82nd	Traffic Signal at 12th
Division PM Outbound	16	11	5	Between 60th and 76th	Between 34th and 39th
Hawthorne AM Inbound	19	12	7	Between 34th and 16th	Traffic Signal at 39th
Hawthorne PM Outbound	18	11	8	Between 64th and 67th	Traffic Signal at 12th and between 37th and 39th
Martin Luther King AM Inbound	27	12	15	Between Portland and Lloyd	Traffic Signal at Couch
Martin Luther King PM Outbound	19	10	9	Between Killingsworth and Lombard	Traffic Signals at Weidler and Couch
Sandy AM Inbound	22	12	10	Between 67 th and 62nd	--
Sandy PM Outbound	17	10	7	Between 33rd and 37 th , and 52nd and 54th	Traffic Signal at 42nd and between 70th and 72nd

Figure 9: Comparison of Auto and Bus Travel Times (AM Inbound/PM Outbound)



4. INVENTORY OF APPLIED TREATMENT SOLUTIONS

4.1 INTRODUCTION

The objective of this inventory of applied treatment solutions is to identify viable transit preferential treatment solutions that have been developed and implemented in other cities in the United States, Canada, and abroad. The purpose of this investigation is to learn from the experiences of other communities.

The inventory collected information about bus transit preferential treatment measures in general with particular emphasis on comprehensive programs such as the Transit Preferential Streets Program in San Francisco.

4.2 TRANSIT PREFERENTIAL STREETS PROGRAM, SAN FRANCISCO

4.2.1 Background

San Francisco's Transit Preferential Streets Program (TPS) is designed to make streets more transit friendly through an inter-departmental effort to address the problems of moving high volumes of people via surface public transit. Furthermore, it is an attempt to give public transit priority in moving people rather than vehicles.

The TPS program was started in the mid-1970s, following adoption of a Transit First policy by the Board of Supervisors stating that public transit vehicles will be given priority over automobiles on city streets through the development of a transit preferential streets plan which would include such elements as:

- Exclusive right-of-way for transit vehicles,
- Signal priority treatment,
- Automobile turn restrictions,
- Construction of curb extensions at bus stops (bus bulbs), and
- Targeted enforcement.

4.2.2 Funding

Proposition B, approved by the voters of San Francisco in 1989, provided the City with funding for transportation projects through a 20-year sales tax. Approximately \$3 million was set aside for the Transit Preferential Streets program, primarily for funding of TPS staff in three city departments; the Municipal Railway (Muni), Parking & Traffic (DPT), and City Planning (DCP). Since funds available through Proposition B are limited, the Strategic Plan developed for TPS projects envisages mainly using the funds as match for regional, state, and federal funds.

4.2.3 TPS Projects

4.2.3.1 Problem Analysis

At the beginning of the TPS program, the City of San Francisco conducted a detailed and comprehensive transit travel time data collection to determine the reasons and locations of transit delays. The data collection was performed manually using stop watches and delay charts. Data collectors logged the delay amount, location and reason along the traveled route. Data collected through this process became instrumental in selecting appropriate improvement measures.

4.2.3.2 Signal Priority

Currently, light rail vehicles as well as electric trolley buses receive priority treatment at 16 intersections in San Francisco. Transit vehicles approaching an intersection are detected by triggering a contact installed in the overhead catenary. Upon receiving a priority call from a transit vehicle, the traffic signal controller either starts the pedestrian clearance interval for the cross street (“early green”) or extends the current green phase (“green extension”).

Initial analysis showed a reduction in signal timing delay of between 14% and 25%. This is achieved even though the mechanical transit vehicle detection device has a failure rate of 10% to 40%, thus prompting the City of San Francisco to test other technologies such as Opticom.

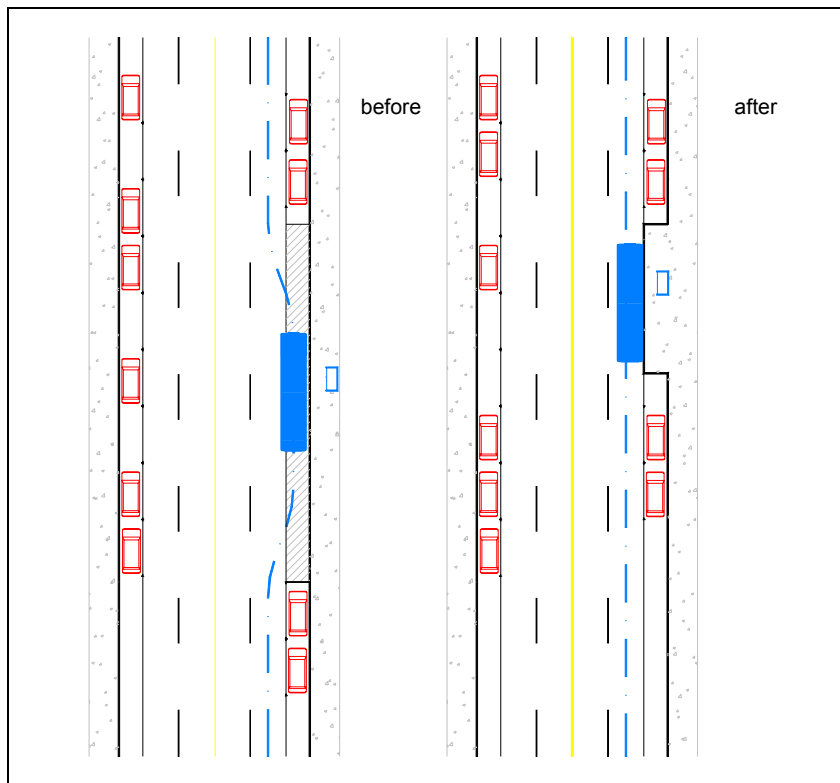
4.2.3.3 Transit Lanes

San Francisco has an extensive network of curbside transit lanes; 10.4 miles of transit lanes on 11 streets, mainly in the downtown area. While one of the goals of the TPS program was to increase the number of transit lanes within the city, another major effort of the TPS program has been to increase the effectiveness of transit lanes through consistent, standardized signing and pavement markings. Furthermore, the TPS program improved the effectiveness of exclusive transit lanes by imposing peak hour parking restrictions with a tow-away enforcement between transit lanes and sidewalks.

4.2.3.4 Curb Extensions

Curb extensions (bus bulbs) at bus stops have been constructed in San Francisco in different environments ranging from low volume residential streets to high volume commercial corridors. Curb extensions have proven to provide a number of advantages for transit riders, transit operator, and transit authority. They allow buses to load and unload passengers in the travel lane, thus reducing delays and safety problems associated with pulling in and out of traffic lanes to serve bus stops at the curb or at pullouts. Furthermore, curb extensions improve the riding comfort for people on the bus as well as increase sidewalk space to allow for unrestricted pedestrian flow. Figure 10 below illustrates a bus stop designed as a curb extension.

Figure 10: Curb Extension



4.2.3.5 Bus Stop Consolidation and Relocation

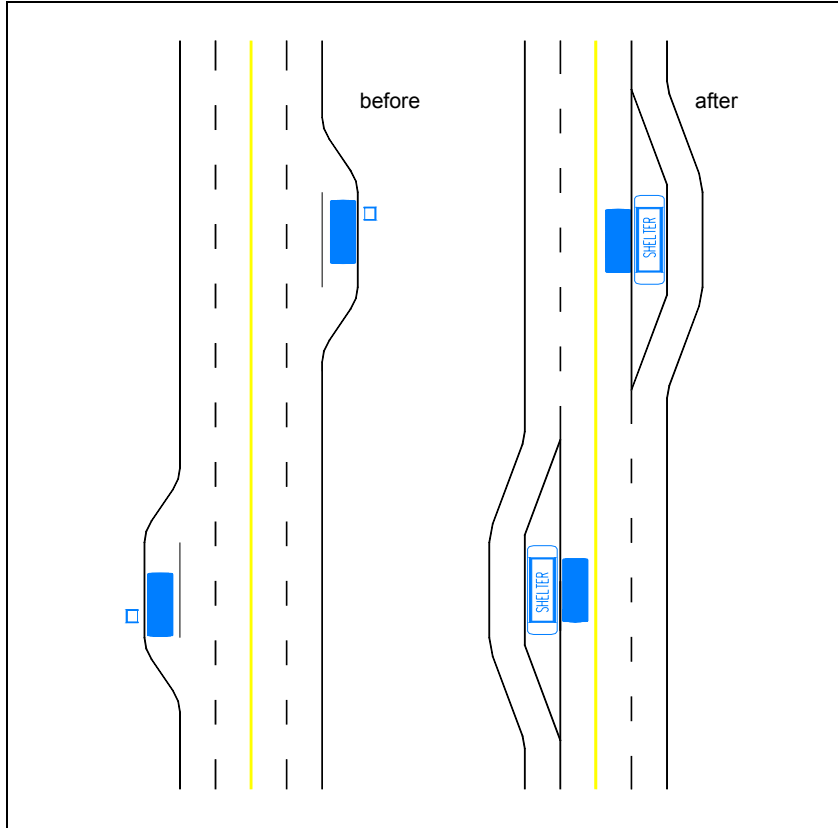
In contrast to the standard bus stop spacing of North American transit systems of 400-800 feet, San Francisco has adopted a standard of spacing bus stops at an average of 800-1,000 feet. Muni estimates that the elimination of each bus stop results in an average travel time reduction of 10 seconds. Bus stop consolidations have been performed on all major trunk and cross-town lines resulting in an elimination of up to 40% of all bus stops on some street segments and an overall reduction of 10-15% per route. Initial analysis of some of the bus stop consolidation measures showed an average travel speed increase of 4-14% that could be achieved with a bus stop reduction of approximately 33%. The analysis also showed that ridership did not suffer as a result of this measure.

4.2.3.6 Boarding Islands

Center-lane boarding islands are commonly used in North America for light rail or street car operation. In San Francisco, boarding islands are also used for buses, in conjunction with center-lane operation. Center-lane boarding islands allow buses to travel in the left lane rather than in the curb lane resulting in less conflicts with automobiles. Side-friction with parked automobiles, problems caused by double-

parking, and delays caused by autos queuing to right turn at intersections with heavy pedestrian flows are eliminated. Figure 11 below depicts a typical boarding island.

Figure 11: Center Boarding Island



4.3 GUIDEBOOK ON TRANSIT PREFERENTIAL TREATMENT, GERMANY

The transit authorities of Krefeld, Wuppertal, and Bochum/Gelsenkirchen (all in Germany) together with the consulting firm SNV Studiengesellschaft Nahverkehr mbH, Bergisch Gladbach, Germany have developed the “Leitfaden zur ÖPNV-Beschleunigung” (Guidebook on Transit Preferential Treatment). The development of this guidebook was funded by the German Department of Research and Technology and is used all over Germany as a reference for transit authorities, municipal jurisdictions, and consulting firms. Its primary objective is to visualize the advantages of transit preferential treatment in its various forms to an audience of politicians, planners, and operators. Furthermore, it describes in detail the process of planning, implementation, and funding of transit preferential treatment solutions as well as potential problems associated with them.

The recommended procedure for developing transit preferential treatment solutions starts with a detailed traffic and transit operations analysis identifying type and location of delay both modes experience. Depending on the problems identified by the

operations analysis, the guidebook offers a variety of treatment solutions as listed below:

External Measures (Outside the Authority of Transit Operator):

- Changes to lane configuration and signal phasing at signalized intersections,
- Protected left-turn phasing,
- Turning prohibitions,
- Access management techniques such as driveway consolidation,
- Traffic signal installation,
- Installation of exclusive left-turn lanes,
- Change of right-of-way designation at unsignalized intersection in favor of transit route,
- Rerouting of through traffic,
- Metering of traffic accessing sensitive areas such as Central Business Districts,
- Parking restrictions,
- Regulation of delivery traffic, and
- Widening of curves to eliminate sharp turns.

Internal Measures (Within the Authority of Transit Operator):

- Accurate scheduling to eliminate unnecessary waiting times or low speed driving,
- Constant vehicle headways for equal distribution of passengers,
- Removal of bus turnouts,
- Installation of curb extensions,
- Relocation of bus stops in relation to traffic signals,
- Consolidation of bus stops,
- Replacement of driver ticket sale by vending machines in conjunction with honor system or proximity card system,
- Use of low-floor technology, and
- Improved passenger information system including on-line transfer information to reduce drivers' workload.

As the next step of the development of a transit preferential treatment program the guidebook presents an evaluation procedure based on the concept of benefit/cost analysis. This procedure is designed for comparison of various competing measures

under the premise of a limited budget. However, it also helpful for the purpose of convincing a non-technical audience of the benefits of transit preferential treatment measures.

The last part of the guidebook contains a description of successful implementations of transit preferential treatment solutions including transit signal priority measures, advanced passenger information systems, etc. The guidebook documents the implementation of the various measures as well as their results.

4.4 TRANSIT PRIORITY MEASURES IN THE PORTLAND AREA

4.4.1 Background

Tri-Met as the transit authority serving the Portland metropolitan area enjoys a nationwide reputation for its innovative approach to improving transit operation. It has gained extensive experience by experimenting and implementing various forms of transit priority measures. For example, the traffic signal priority used by the MAX light rail system is a nationwide showcase for the effective use of traffic signal priority for transit vehicles. Tri-Met's experience with preferential treatment solutions for bus transit have included measures such as queue bypass lanes, queue jumps, curb extensions, and traffic signal priority as explained below.

4.4.2 Bus Transit Priority Measures

4.4.2.1 Queue Bypass and Queue Jump

Queue bypass lanes allow buses to bypass a queue of automobiles waiting at a traffic signal. In the Portland metropolitan area, queue bypass lanes using the right-turn lane have been used effectively together with queue jump signalization at the following locations:

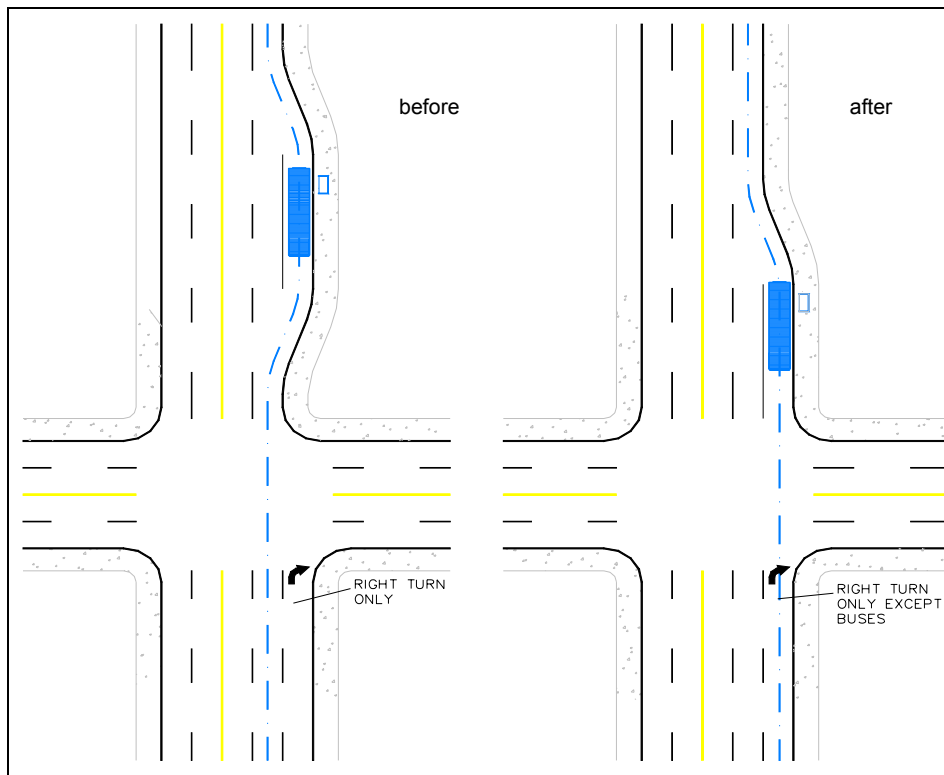
- Capitol Highway at Terwilliger Boulevard (Inbound)
- SE Powell Boulevard at SE 26th Street (Outbound)
- SE 39th Avenue at SE Belmont Street (Outbound)
- SE 39th Avenue at SE Belmont Street (Inbound)

Examples for queue bypass lanes without queue jump are:

- Division Street at 82nd Avenue (Inbound)
- Division Street at 82nd Avenue (Outbound)

Queue bypass lanes are currently in design for the intersections of Barbur Boulevard at Capitol Highway and Baseline at 10th Street in the City of Cornelius. Figure 12 below depicts the layout of a typical queue bypass in conjunction with a farside bus stop.

Figure 12: Queue Bypass



4.4.2.2 Traffic Signal Priority

Tri-Met has undertaken several pilot projects to determine the applicability and effectiveness of bus signal priority treatment allowing buses to call for an early green phase or a green phase extension depending on the time of the call within the signal controller's cycle time.

The latest study of bus signal priority on Tualatin Valley Highway (T.V. Highway) from SW Murray Boulevard through SW 234th Street shows bus travel time savings ranging from 1.4% to 6.4% for one direction and 6.4% for both directions combined. These travel time savings correspond to traffic signal delay reductions ranging from 19.6% to 20.3% for one direction and a two-way average of 20.0%.

4.4.2.3 Curb Extensions

Curb extensions create a "bulb" at an intersection, usually the width of the parking lane. Curb extensions can reduce pedestrian crossing distances, create additional parking (compared to typical bus zones), mitigate conflicts between autos and buses merging back into the traffic stream, and create space for additional pedestrian and transit rider amenities. Examples for curb extensions in the Portland area are on Main Street in Gresham, "A" Street in Lake Oswego, and NW 23rd Avenue in Portland.

4.4.2.4 Fare Collection Change

Tri-Met currently operates two different fare collection systems for its light rail (MAX) and bus system. While MAX operates under a self-service fare collection (SSFC) or honor system allowing passengers to board the train without proof of paid fare, buses operate under the traditional proof-of-payment system requiring patrons to either show their valid ticket or purchase the ticket at the driver.

In 1980, Tri-Met received grants from the Urban Mass Transit Administration (predecessor to Federal Transit Administration - FTA) to implement SSFC on its bus system. The SSFC was implemented by Tri-Met in September 1982 and replaced with the traditional proof-of-payment system in April 1984. Tri-Met terminated the use of the self-service fare collection system because of problems with fare evasion, high enforcement costs, unreliable fare collection equipment, low surcharge/fine collections, overburdened courts, and increased vandalism while not resulting in measurable productivity improvements.

4.5 APPLICABILITY OF APPLIED TREATMENT SOLUTIONS

4.5.1 Signal Priority

Signal priority has been used successfully around the country and is appropriate for the Portland metropolitan area as Tri-Met has demonstrated during various pilot studies (see Section 4.4.2.2). Priority systems can reduce bus travel time by granting buses preferential treatment at traffic signals.

One of the most significant factors in signal priority is choosing an appropriate communication system between vehicle and wayside controller. Several priority systems have been studied by Tri-Met, with a goal of finding a superior system. For a variety of reasons most studies were inconclusive. Many systems such as Opticom, Tote, LoopComm are available of which all are third party systems. In addition, there are other, radio based systems which have not been extensively tested in this country. These systems can relay information from buses equipped with an AVL system ("smart buses") directly to the signal controller.

Since Tri-Met's area covers many jurisdictions, signal priority would have greatest ongoing success with was coordination and agreement by all parties to have a single priority treatment system. In addition, transit signal priority requires continued inter-jurisdictional and inter-departmental communication to ensure its success.

Signal priority should be considered in case of existing signal delay. Reliable communication between buses and traffic signal controllers is a necessary requirement without an increase of work load for bus drivers.

4.5.2 Curb Extensions

Curb extensions allow buses to board and de-board buses in the travel lane, thus reducing delays and safety problems associated with pulling in and out of traffic lanes to serve bus stops. Furthermore, curb extensions improve riding comfort for people on the bus as well as increase sidewalk space to allow for unrestricted pedestrian flow and to locate station improvements such as benches and shelters. Curb extensions can reduce parking loss since they eliminate tapering for bus acceleration and deceleration.

Curb extensions should be considered in case of existing dwell delay or inadequate pedestrian space.

4.5.3 Bus Stop Consolidation

Experience from other cities shows that bus stop consolidation can be a strategy for reducing bus travel times. However, the reality of reducing the number of bus stops is complicated. Tri-met has established a history with its customers regarding bus routes and stops, and for some customers even small increases in walking distance to the bus stop can incur hardship. Therefore, the consolidation of bus stops has to balance the needs of some patrons with the benefit of a reduced travel time for all passengers.

Bus stop consolidation is applicable for sections with a low average bus stop spacing. However, a detailed land use and passenger flow analysis should be undertaken before attempting to eliminate or relocate bus stops.

4.5.4 Boarding Islands

Boarding islands allow buses to operate in the left travel lane and therefore to avoid delays caused by parking maneuvers, delivery trucks, and right-turn vehicles waiting for pedestrians to cross. Boarding Islands should be given careful consideration when being installed. Issues such as passenger comfort, safety, ADA requirements as well as all bus and car movements should be considered.

Boarding islands are applicable for areas with high side friction, but require at least two travel lanes per direction with a significant difference in travel speed.

4.5.5 Queue Bypass

A queue bypass is a short lane used by buses to bypass traffic queues at signalized intersections. The bypass is usually a right turn lane, which will be used as a through lane for buses to cross the street to a far side stop. However, in conjunction with traffic signal priority treatment, bypasses can also be created with left-turn lanes. In order for the bypass to function properly, it has to be longer than the back of the queue. Queue bypasses are often used in conjunction with queue jumps at signalized intersections.

Queue bypasses are applicable for intersection approaches with high queue delay. The existence or possible construction of a less congested turn lane is required.

4.5.6 Queue Jump

Queue jumps allow buses to call for an early green phase which starts 6-8 seconds ahead of the normal green phase. This exclusive early green allows buses to merge back into a mixed-flow traffic lane at the end of a queue bypass lane.

Accordingly, queue jumps are only applicable in conjunction with queue bypass lanes. Queue jumps should only be used without a far side bus stop following the intersection.

4.5.7 Exclusive Bus Lane

Exclusive bus lanes are travel lanes reserved for the use by transit or high occupancy vehicles (HOV) and can be operated during peak periods only or throughout the whole day. Exclusive bus lanes can be very effective in reducing conflicts with parking cars, side friction, general congestion, and queues at traffic signals. Furthermore, exclusive lanes give transit vehicles recognition and improve on-time performance.

Optimal placement of exclusive lanes is an important issue. In case of a curbside lane, buses encounter conflicts with right turning vehicles, driveways, delivery trucks, and illegally parked vehicles requiring strict enforcement. If placed in the center or median, exclusive lanes will require boarding islands to accommodate passenger boardings. Roadway space for exclusive lanes can be taken from general traffic lanes, parking areas, or additional right-of-way. On multiple lane arterials, exclusive bus lanes can also be installed as contra-flow lanes using a traffic lane of the off-peak direction.

All of these alternatives are politically difficult to implement, making this solution only desirable with a high volume of transit vehicles. An exclusive bus lane as a measure of transit preferential treatment is applicable for roughness, dwell delay, and queue delay.

4.5.8 Parking Restriction

Parking restrictions reduce delay by decreasing side friction caused by parking maneuvers, and removing the need for buses to pull in and out of the travel lane for boardings. They can be permanent or for specified peak hours only. As with exclusive bus lanes, parking restrictions require continuous enforcement.

Roughness delay is the primary application for the use of parking restrictions.

4.5.9 Signal Timing or Phasing Change

Signal timing or phasing change are appropriate for isolated intersections as well as coordinated intersections. Signal timing changes could include increasing of green time for a particular movement or the modification of a coordination scheme for bus oriented signal progression. Phasing changes could include changing a permissive left-turn to a protected left-turn.

Signal timing or phasing change as a measure to reduce signal timing delay for transit vehicles is applicable to any signalized intersection with that type of delay.

4.5.10 Bus Stop Relocation

The relocation of a bus stop from the near side to the far side of an intersection or vice versa is a valuable tool to reduce traffic signal timing delay for buses in a coordinated traffic signal environment. The alternation of near side and far side bus stops allows buses to use two consecutive dwell times to fall back into signal progression.

Bus stop relocation as a measure to reduce bus travel times is applicable for corridors with good signal progression designed for automobile traffic and low queue delay.

4.5.11 Low-floor Bus Technology

Low-floor technology on buses eliminates the need for passengers to manage steps for boarding and de-boarding. The result is enhanced comfort especially for senior passengers or passengers with physical disabilities such as passengers in wheelchairs. Furthermore, low-floor technology increases passenger flow thus reducing the time required for passenger service. However, the most significant passenger service time saving is accomplished by eliminating the need for a wheelchair lift. According to the Ann Arbor Transportation Authority, an average passenger service time reduction of 15 percent can be achieved with low-floor technology.

The use of low-floor buses as a measure to reduce passenger service times is applicable for all bus routes in the Portland metropolitan area. However, low-floor bus technology can only successfully be used as a measure to reduce passenger service times if implemented on entire bus routes.

4.5.12 Fare Collection Change

Changing the existing proof-of-payment fare collection system to a self-service fare collection (SSFC) or honor system thus eliminating the need to wait to pay the driver and allowing passengers to board both the front and the back door is a potential measure to reduce the time required for passenger service. New fare collection systems using state of the art technology such as smart cards or proximity cards combine the benefits of a self-service fare collection system with the enforceability and control of the traditional proof-of-payment system.

In general, the implementation of a self-service fare collection or honor system as a measure to reduce passenger service times is applicable to Tri-Met's bus system. However, problems such as enforcement issues, overburdening of the courts, etc. as experienced during the 1982 test need to be resolved.

4.5.13 Exemption from Turning Restriction

Exempting buses from turning restrictions for automobile traffic designed to improve overall traffic flow. These exemptions eliminate the need for buses to detour through side streets in order to make an indirect left-turn.

The use of turning restriction exemptions as a measure to reduce bus travel times is applicable for all bus routes in the Portland metropolitan area.

4.5.14 Summary

Table 10 below summarizes the different treatment solutions, their application, responsible jurisdiction, and implementation time frame.

A separate source book containing the individual transit preferential streets solutions together with recommendations for their application has been prepared in addition to this report.

Table 10: Summary of Transit Preferential Streets Treatment Solutions

TREATMENT SOLUTION	TYPE	APPLICATION	JURISDICTION	RANGE	TIME FRAME
Signal Priority	Operational	Signal Timing Delay (Queue Delay)	Public Works/ Tri-Met	Corridor Wide	Short Term
Signal Timing Changes	Operational	Signal Timing Delay (Queue Delay)	Public Works	Point Specific	Short Term
Bus Stop Consolidation	Operational/ Physical	Roughness	Tri-Met/PDOT	Point Specific	Short Term
Bus Stop Relocation	Operational/ Physical	Signal Timing Delay	Tri-Met/PDOT	Point Specific	Short Term
Queue Bypass	Physical	Queue Delay	Public Works	Point Specific	Short Term
Fare Collection Change	Operational	Passenger Service Delay	Tri-Met	System Wide	Long Term
Curb Extension	Physical	Dwell Delay	Public Works	Point Specific	Medium Term
Boarding Islands	Physical	Roughness Queue Delay	Public Works	Point Specific	Medium Term
Low-floor Technology	Operational	Passenger Service Delay	Tri-Met	System Wide	Long Term
Parking Restriction	Physical	Roughness	Public Works	Point Specific	Short Term
Exclusive Bus Lanes	Physical	Roughness (Queue Delay)	Public Works	Corridor Wide	Medium Term
Queue Jump	Operational	Queue Delay	Public Works	Point Specific	Short Term
Exemption from Turning Restriction	Operational	Detour Delay	Public Works	Point Specific	Short Term

5. POTENTIAL TREATMENT SOLUTIONS DEVELOPMENT AND EVALUATION

5.1 CORRIDOR LEVEL ASSESSMENT

5.1.1 Corridor Issues Identification

5.1.1.1 Introduction

The corridor issues identification distinguishes the main factors contributing to bus transit delay for each of the five studied corridors as they have been quantified by the preceding travel time study. Furthermore, the identified issues are analyzed on a macroscopic level for potential for travel time reduction and then ranked according to travel time savings potential.

The estimated potential of travel time reduction for signal timing delay is based on the result of Tri-Met's bus priority study on Tualatin Valley Highway (see Section 4.4.2.2). The 20% reduction of signal timing delay measured in that study is applied to all signal timing delay along the five analyzed corridors.

The potential for travel time savings due to the reduction of passenger service time is based on a study of the transit authority of Ann Arbor, Michigan stating that a 15% passenger service time reduction can be achieved through the use of low floor technology. The potential for travel time savings is then computed by applying this number to all passenger service time delay measured on the five studied corridors.

The potential delay reduction for roughness delay is based on an estimate from the City of San Francisco for travel time savings to be achieved through bus stop consolidation. Delay caused by acceleration and deceleration at bus stops is included in the roughness delay category. As a consequence, consolidating bus stops will reduce roughness rather than passenger service time. The amount of possible reduction for roughness by bus stop consolidation is then computed by multiplying the theoretical reduction of bus stops based on average spacing of 800 feet by an average saving of 10 seconds per eliminated stop.

5.1.1.2 Martin Luther King Boulevard (Route #6)

The bus travel time analysis shows that roughness, passenger service, and signal timing delay are the main corridor wide issues for the Martin Luther King (Route #6) corridor. Table 11 depicts the corridor wide issues ranked by the amount of time saving that can be expected from experiences of other communities, while Table 12 shows the major point specific delay locations for Route #6.

Table 11: Corridor Wide Issues for Martin Luther King Boulevard (#6)

RANK	ISSUE	DELAY [sec]	POT. TRAV. TIME REDUCTION		CONCEPTUAL SOLUTION
A	ROUGHNESS				Bus Stop Consolidation
	Inbound	272	90 ³ sec	7%	
	Outbound	385	110 ³ sec	7%	
B	PASSENGER SERVICE				Low Floor Technology Fare Collection Change
	Inbound	252	38 sec	3%	
	Outbound	326	49 sec	3%	
C	SIGNAL TIMING DELAY				Signal Timing Change, Bus Stop Relocation, Signal Priority
	Inbound	155	31 sec	2%	
	Outbound	229	46 sec	3%	

Table 12: Point Specific Issues for Martin Luther King Boulevard (#6)

ISSUE	DELAY [sec]	DIRECTION
QUEUE DELAY Grand @ Ankeny	30	Outbound
SIGNAL TIMING DELAY Martin Luther King @ Burnside	24	Inbound
Martin Luther King @ Fremont	24	Outbound

5.1.1.3 Sandy Boulevard (Route #12)

The bus travel time analysis shows that signal timing delay, passenger service, and roughness are the main corridor wide issues for the Sandy (Route #12) corridor. Table 13 depicts the corridor wide issues ranked by the amount of time saving that can be expected from experiences of other communities, while Table 14 shows the major point specific delay locations for Route #12.

³ Through bus stop consolidation only.

Table 13: Corridor Wide Issues for Sandy Boulevard (#12)

RANK	ISSUE	DELAY [sec]	POT. TRAV. TIME REDUCTION		CONCEPTUAL SOLUTION
A	SIGNAL TIMING DELAY				Signal Timing Change, Bus Stop Relocation, Signal Priority
	Inbound	221	44 sec	3%	
	Outbound	242	48 sec	3%	
B	PASSENGER SERVICE				Low Floor Technology Fare Collection Change
	Inbound	285	43 sec	3%	
	Outbound	291	44 sec	2%	
C	ROUGHNESS				Bus Stop Consolidation, Exclusive Bus Lanes
	Inbound	415	0 ⁴ sec	-	
	Outbound	443	20 ⁴ sec	1%	

Table 14: Point Specific Issues for Sandy Boulevard (#12)

ISSUE	DELAY [sec]	DIRECTION
QUEUE DELAY		
Sandy @ Fremont/72 nd	52	Outbound
Sandy @ 70 th	27	Outbound
SIGNAL TIMING DELAY		
Sandy @ Alameda/57 th	37	Inbound
	30	Outbound
Sandy @ Fremont/72 nd	28	Inbound
	35	Outbound

5.1.1.4 Division Street (Route #4)

The bus travel time analysis shows that roughness, signal timing delay, and passenger service are the main corridor wide issues for the Division (Route #4) corridor. Table 15 depicts the corridor wide issues ranked by the amount of time saving that can be expected from experiences of other communities, while Table 16 shows the major point specific delay locations for Route #4.

⁴ Through bus stop consolidation only.

Table 15: Corridor Wide Issues for Division Street (#4)

RANK	ISSUE	DELAY [sec]	POT. TRAV. TIME REDUCTION		CONCEPTUAL SOLUTION
A	ROUGHNESS				Bus Stop Consolidation, Exclusive Bus Lanes
	Inbound	263	100 ⁵ sec	8%	
	Outbound	462	100 ⁵ sec	6%	
B	SIGNAL TIMING DELAY				Signal Timing Change, Bus Stop Relocation, Signal Priority
	Inbound	188	38 sec	3%	
	Outbound	184	37 sec	2%	
C	PASSENGER SERVICE				Low Floor Technology Fare Collection Change
	Inbound	204	31 sec	2%	
	Outbound	245	37 sec	2%	

Table 16: Point Specific Issues for Division Street (#4)

ISSUE	DELAY [sec]	DIRECTION
ROUGHNESS		
Before Bus Stop at 37 th ⁶	81	Outbound
Before Signal Division @ 8 th	29	Outbound
Before Bus Stop op. 35 th Pl. ⁶	24	Outbound
Before Signal Division @ 39 th ⁶	20	Outbound
QUEUE DELAY		
7 th @ Madison ⁷	32	Inbound
Division @ 39 th	52	Outbound
SIGNAL TIMING DELAY		
Division @ 39 th	38	Inbound
	35	Outbound
7 th @ Madison ⁷	30	Inbound

5.1.1.5 Hawthorne Boulevard/50th Street/Foster Road (Route #14)

The bus travel time analysis shows that roughness, signal timing delay, and passenger service are the main corridor wide issues for the Hawthorne (Route #14) corridor.

Table 17 depicts the corridor wide issues ranked by the amount of time saving that can

⁵ Through bus stop consolidation only.

⁶ Caused by Signal at 39th and Division.

⁷ Signal timing changes have been implemented after data collection.

be expected from experiences of other communities, while Table 18 shows the major point specific delay locations for Route #14.

Table 17: Corridor Wide Issues for Hawthorne Blvd./50th St./Foster Rd. (#14)

RANK	ISSUE	DELAY [sec]	POT. TRAV. TIME REDUCTION		CONCEPTUAL SOLUTION
A	ROUGHNESS				Bus Stop Consolidation, Exclusive Bus Lanes
	Inbound	389	60 ⁸ sec	3%	
	Outbound	430	70 ⁸ sec	3%	
B	SIGNAL TIMING DELAY				Signal Timing Change, Bus Stop Relocation, Signal Priority
	Inbound	258	52 sec	3%	
	Outbound	374	75 sec	4%	
C	PASSENGER SERVICE				Low Floor Technology Fare Collection Change
	Inbound	336	50 sec	3%	
	Outbound	330	50 sec	2%	

Table 18: Point Specific Issues for Hawthorne Blvd./50th St./Foster Rd. (#14)

ISSUE	DELAY [sec]	DIRECTION
ROUGHNESS		
Before Bus Stop at 37 th	20	Outbound
Before Bus Stop at 41 st	22	Outbound
QUEUE DELAY		
Foster @ 82 nd	61	Outbound
SIGNAL TIMING DELAY		
Hawthorne @ Grand	30	Outbound
Hawthorne @ 12 th	25	Outbound
Hawthorne @ 39 th	38	Inbound
	54	Outbound
50 th @ Division	29	Inbound
50 th @ Powell	48	Outbound
Foster @ 82 nd	27	Inbound
	51	Inbound

⁸ Through bus stop consolidation only.

5.1.1.6 Barbur Boulevard/Beaverton-Hillsdale Highway (Route #54)

The bus travel time analysis shows that signal timing delay and passenger service are the main corridor wide issues for the Barbur (Route #54) corridor. Table 19 depicts the corridor wide issues ranked by the amount of time saving that can be expected from experiences of other communities, while Table 20 shows the major point specific delay locations for Route #54.

Table 19: Corridor Wide Issues for Barbur Blvd./Beaverton-Hillsdale Hwy. (#54)

RANK	ISSUE	DELAY [sec]	POT. TRAV. TIME REDUCTION		CONCEPTUAL SOLUTION
A	SIGNAL TIMING DELAY				Signal Timing Change, Bus Stop Relocation, Signal Priority
	Inbound	61	12 sec	1%	
	Outbound	107	21 sec	2%	
B	PASSENGER SERVICE				Low Floor Technology Fare Collection Change
	Inbound	101	15 sec	2%	
	Outbound	87	13 sec	1%	

Table 20: Point Specific Issues for Barbur Blvd./Beaverton-Hillsdale Hwy. (#54)

ISSUE	DELAY [sec]	DIRECTION
QUEUE DELAY Beaverton-Hillsdale @ Oleson ⁹	53	Outbound
SIGNAL TIMING DELAY Beaverton-Hillsdale @ Oleson ⁹	36	Inbound
	52	Outbound
Beaverton-Hillsd. @ Scholls Fy.	28	Inbound

5.1.2 Potential Project Locations

In addition to corridor wide issues, the corridor level assessment also identifies isolated problem areas that would lend themselves for potential project locations. Table 21 below presents a summary of all intersections (except Beaverton-Hillsdale Highway at Oleson and Scholls Ferry Road) that result in more than 25 seconds of signal timing or queue delay. Figure 13 shows the location of the potential projects along the studied corridors.

⁹ Intersections of are under the jurisdiction of Washington County which is currently studying options for improvement.

Table 21: Potential Project Locations and Improvement Strategies

LOCATION	ROUTE	DELAY	PROBLEM	POTENTIAL SOLUTIONS
Grand @ Ankeny	6	Queuing PM 30 sec	congestion	NB by-pass lane (peak hour parking removal)
MLK @ Burnside	6	Signal Timing AM 24 sec	nearside bus stop	SB bus stop relocation
MLK @ Fremont	6	Signal Timing PM 24 sec	nearside bus stops	NB/SB bus stop relocation, signal priority
Sandy @ Fremont/72 nd	12	Signal Timing, Queuing AM 28 sec PM 87 sec	signal timing, congestion, nearside bus stop	signal timing change, EB by-pass lane (parking removal), EB bus stop relocation, Signal Priority
Sandy @ Alameda/57 th	12	Signal Timing AM 37 sec PM 30 sec	signal timing, nearside bus stops	signal timing change, EB/WB bus stop relocation, signal priority
Division @ 39 th	4	Signal Timing, Queuing, Roughness AM 38 sec PM 212 sec	oversaturated intersection, nearside bus stops that are blocked by traffic queue	signal timing change, EB by-pass lane to beginning of left-turn lane (parking removal), WB bus stop relocation, signal priority
7 th @ Division	4	STOP Sign PM 29 sec	bus on minor approach	install traffic signal
Foster @ 82 nd	14	Signal Timing, Queuing AM 27 sec PM 112 sec	nearside bus stops, long cycle length	EB/WB bus stop relocation, signal priority
Hawthorne @ 39 th	14	Signal Timing AM 38 sec PM 54 sec	nearside bus stops, long PM signal cycle	EB/WB bus stop relocation, signal priority
50 th @ Powell	14	Signal Timing PM 48 sec	bus on minor approach	signal priority
50 th @ Division	14	Signal Timing AM 29 sec	bus on minor approach, nearside bus stops	signal priority
Hawthorne @ 12 th	14	Signal Timing PM 25 sec	nearside bus stop	EB bus stop relocation

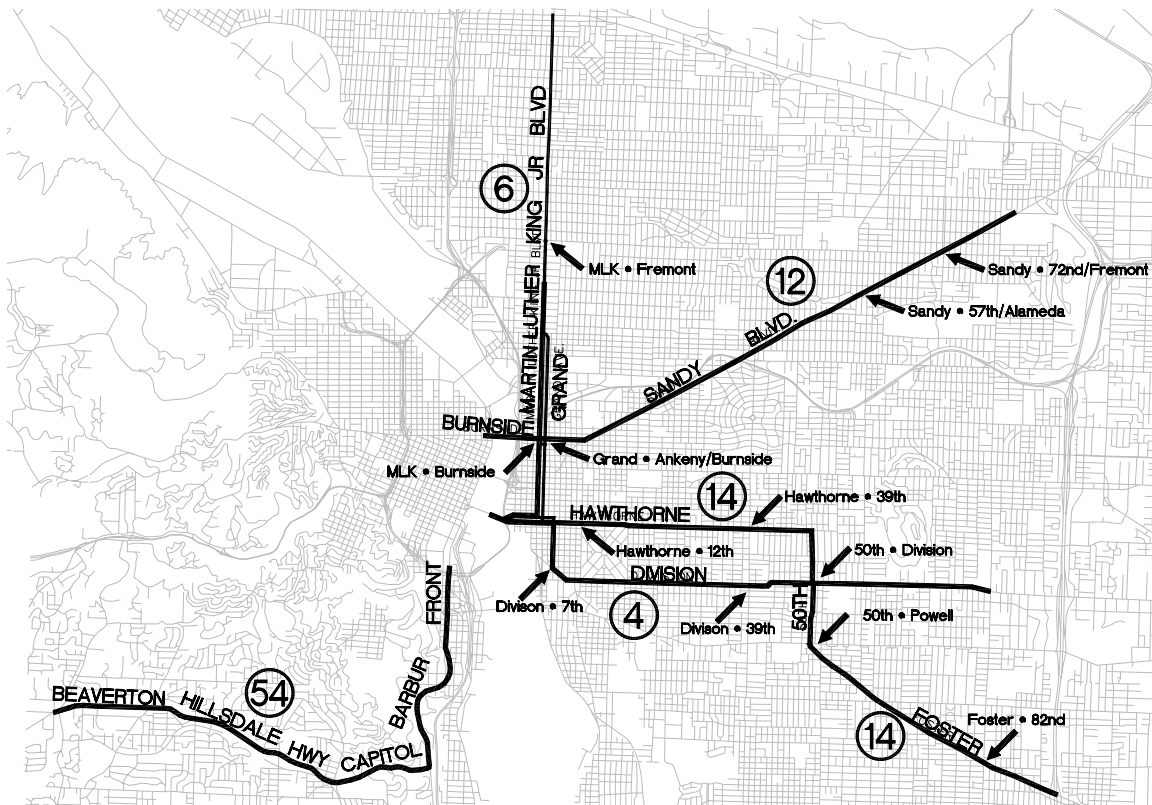


Figure 13: Potential Project Locations

5.2 IMPROVEMENTS STRATEGY AND PLAN DEVELOPMENT

5.2.1 Characteristics of the Corridors

Each of the four corridors are busy commercial through streets which accommodate relatively heavy traffic flows and bus headways ranging from 7 minutes (#4 on Division Street) to 15 minutes (#6 on Grand Street) during peak hour periods. As shown in Table 5, of the 18 bus stop locations under review, 15 are located at the nearside of the intersection, and traffic movements are controlled by traffic signals at all locations except Division Street at SE 7th Avenue, where a STOP sign controls southbound SE 7th Avenue traffic.

On-street parking is prohibited along 11 of the 21 curb space areas where strategies are proposed. Where parking is permitted, the regulations allow parking for one-hour intervals only. At one location, the westside curb lane of Grand Street between SE Ash and SE Ankeny Streets, there are approximately six designated truck loading spaces that would be affected by the transit preferential street strategy proposed at that location.

Where intersections are signalized, all corners contain crosswalks, curb ramps, and fully connected sidewalk systems. Further, in most cases where pedestrian movements are

permitted, traffic signals are equipped with pedestrian indications which can be activated by pedestrians.

Segments of the Martin Luther King, Jr. Blvd./Grand Ave., Hawthorne Blvd. and Sandy Blvd. corridors are designated City Bikeways, though there are no marked bicycle lanes nor posted Bikeway signs present at this time. The City Bikeway designation indicates that striped lanes and posted signs will be installed at a future date.

5.2.2 Proposed Transit Preferential Streets Treatments

5.2.2.1 SE Grand Avenue at Ankeny Street

Buses experience excessive delay on Grand Avenue between Oak Street and Burnside Street because of a high level of traffic congestion during the afternoon peak period.

The recommended improvements for SE Grand Avenue at Ankeny Street include the creation of a northbound bus-only by-pass lane on Grand Avenue between Oak Street to Burnside Street. The right-hand curbside bus-only lane is created by re-striping the existing roadway to accommodate four 10 foot travel lanes, a 4 foot bicycle lane, and a 12 foot bus lane. Right-turn vehicles are allowed to use the bus lane as indicated by a "Right-Turn Only Except Bus" striping. It is further recommended to allow off-peak parking in both the bus-only lane as well as the left-hand curb lane (see Figure 14).

5.2.2.2 SE Martin Luther King Boulevard at Burnside Street

Buses traveling southbound on Martin Luther King Boulevard experience high signal timing delay at the traffic signal at Burnside Street because of the nearside bus stop. The nearside bus stop at Burnside causes buses to miss the green phase at the traffic signal at Burnside which is coordinated with the upstream traffic signal at Couch.

The recommended improvements for SE Martin Luther King Boulevard at Burnside Street include the relocation of the bus stop to the south of Burnside (farside). It is recommended to create a no parking/bus zone from the intersection at Burnside to the bus stop in accordance to Tri-Met's design guidelines (see Figure 14).



Figure 14: Proposed Measures for Grand at Ankeny and Martin Luther King at Burnside

5.2.2.3 NE Martin Luther King Boulevard at NE Fremont Street

The intersection of NE Martin Luther King Boulevard at NE Fremont Street is a major delay point for buses on Martin Luther King Boulevard because of its nearside bus stops. Buses usually wait in a traffic queue until the signal turns green. After the queue in front of them disperses they are able to proceed to their bus stop. The signal then turns red before or just when they get ready to leave the stop.

The recommended improvements for NE Martin Luther King Boulevard at NE Fremont Street include the relocation of the northbound and southbound bus stop to farside. Furthermore, it is recommended to equip this traffic signal for bus signal priority treatment to grant buses an early green or green extension of 10 seconds (see Figure 15).

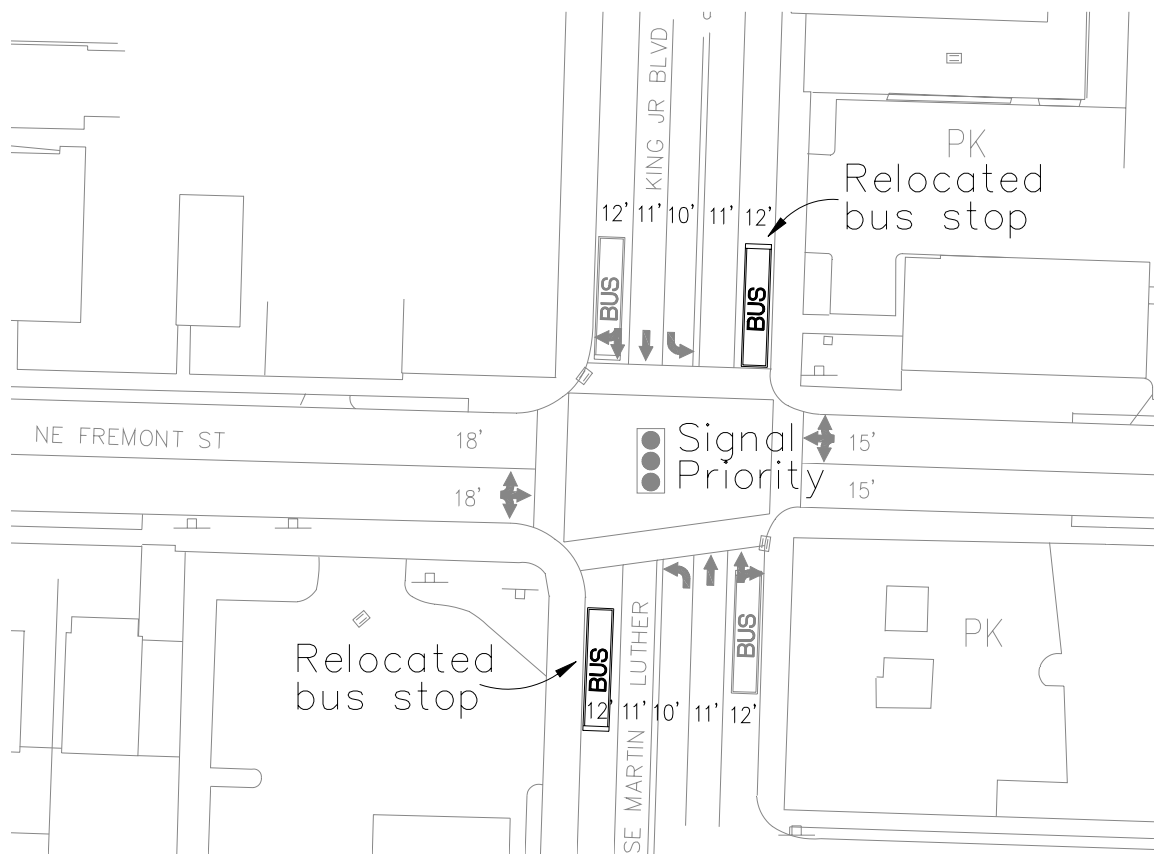


Figure 15: Proposed Measures for Martin Luther King at Fremont

5.2.2.4 NE Sandy Boulevard at NE 57th Avenue/NE Alameda Street

Several factors contribute to the intersection of NE Sandy Boulevard at NE 57th Avenue/NE Alameda Street being a major delay point for buses on Sandy Boulevard. First of all, the intersection currently operates under an inefficient signal timing plan. In addition, currently bus stops for both the eastbound and westbound direction are located nearside the intersection causing additional signal delay as outlined above.

Recommended bus transit improvements at this intersection include the development of AM/PM peak hour timing plans, the relocation of both bus stops to farside, and the provision of signal priority for buses (10 seconds early green/green extension) (see Figure 16).

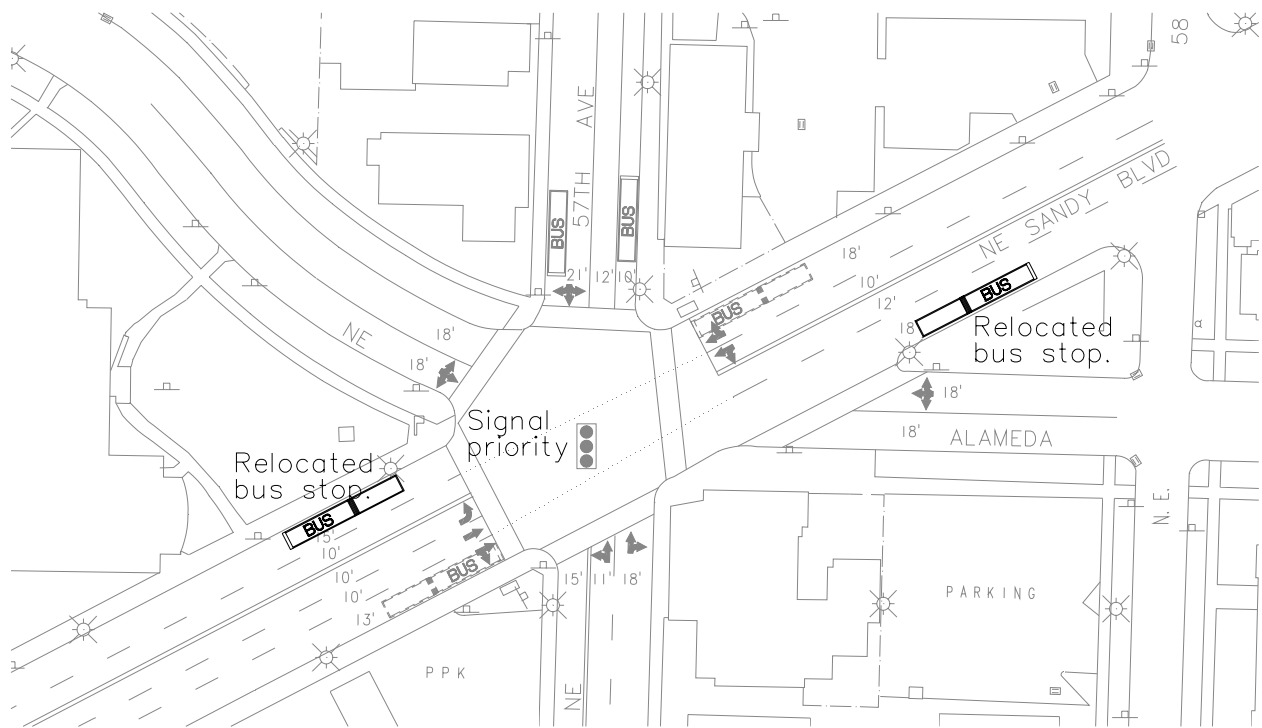


Figure 16: Proposed Measures for Sandy at 57th/Alameda

5.2.2.5 NE Sandy Boulevard at NE Fremont Street/NE 72nd Avenue

Another major delay point for Buses on Sandy Boulevard is the intersection of NE Sandy Boulevard at NE Fremont Street/NE 72nd Avenue. As with the intersection of Sandy Boulevard at 57th/Alameda Street, this intersection currently operates under an inefficient signal timing plan causing long queue lengths during the afternoon peak period. Furthermore, the nearside bus stop located directly at the stop bar causes additional delay for eastbound buses causes.

Bus preferential streets elements recommended for the intersection of NE Sandy Boulevard at NE Fremont Street/NE 72nd Avenue include updated signal timing, an eastbound bus-only (except right-turns) lane between 70th Avenue and 72nd Avenue, the relocation of the eastbound bus stop into a farside bus zone, and the provision of signal priority for buses (10 seconds early green/green extension) (see Figure 17).

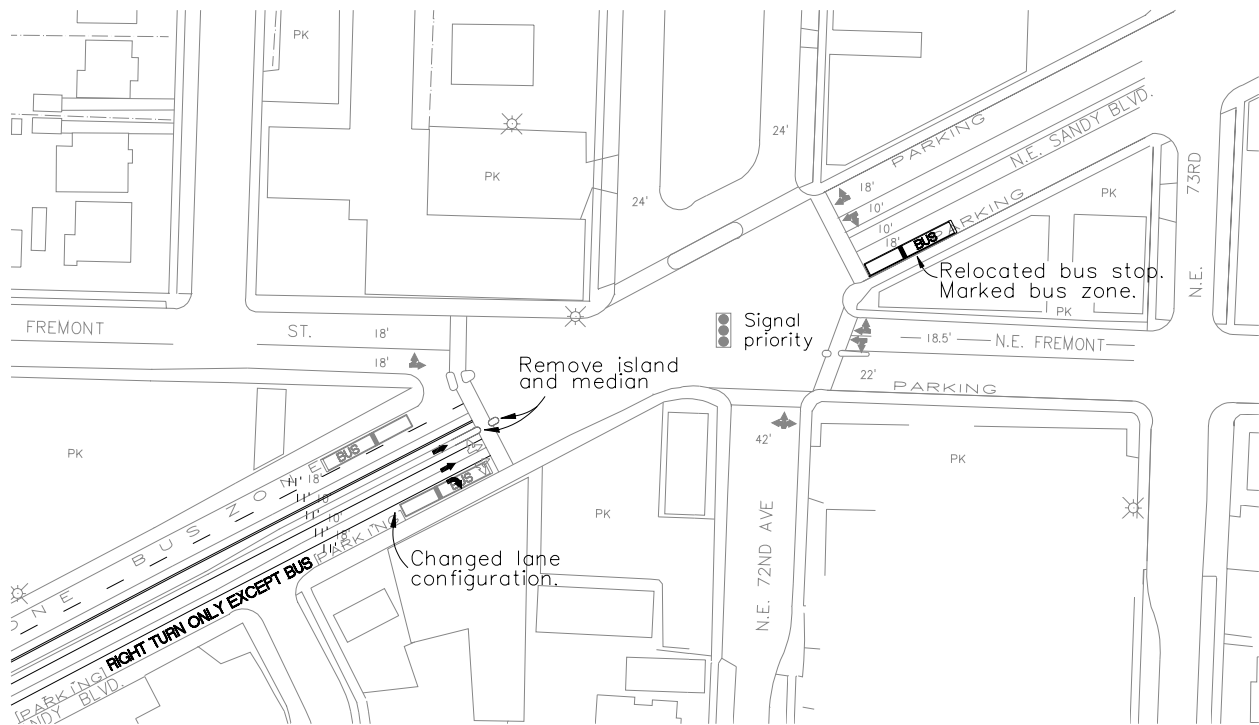


Figure 17: Proposed Measures for Sandy at Fremont/72nd

5.2.2.6 SE 7th Avenue at SE Division Place

Eastbound buses experience long delays at the intersection of SE 7th Avenue at SE Division Place when turning left onto Division Place. The intersection is stop sign controlled and operates at an unsatisfactory level of service.

Recommended improvements for the intersection of SE 7th Avenue at SE Division Place include the installation of a traffic signal (see Figure 18).

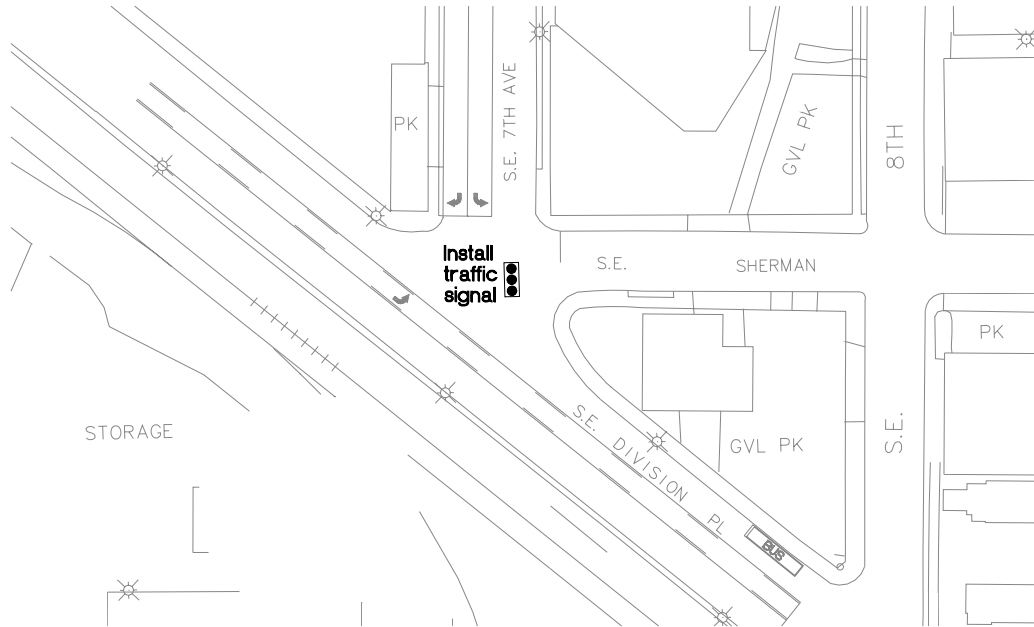


Figure 18: Proposed Measures for 7th at Division Place

5.2.2.7 SE Division Street at SE 39th Avenue

The intersection of SE Division Street at SE 39th Avenue currently operates under a 70 second cycle timing plan which causes substantial delays and queue lengths for the eastbound approach during the afternoon peak period. In addition, both eastbound and westbound bus stops are currently located nearside causing additional delay for buses and motorists.

Transit preferential streets recommendations for the intersection of SE Division Street at SE 39th Avenue include updated signal timing, the creation of an eastbound bus-only (except right-turns) lane from 37th Avenue to the beginning of the eastbound left-turn pocket, the relocation of the eastbound bus stop into the bus-only lane, the relocation of the westbound bus stop to the east of the intersection (farside), as well as the provision of bus signal priority (10 seconds early green/green extension). The bus-only lane will be available for on-street parking outside the afternoon peak period (see Figure 19).

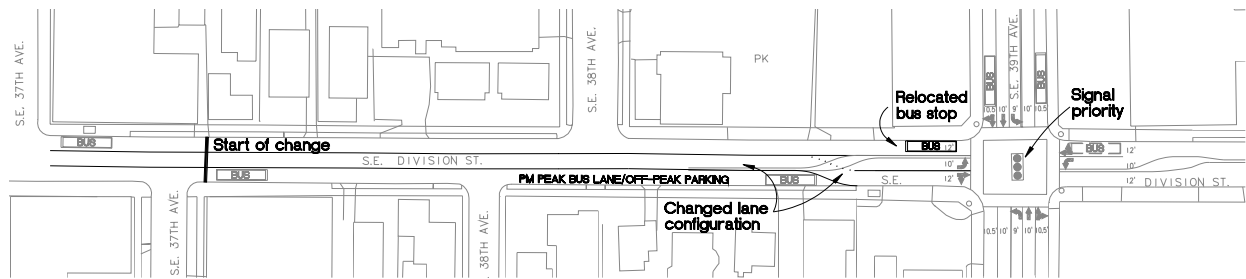


Figure 19: Proposed Measures for Division at 39th

5.2.2.8 SE Hawthorne Boulevard at SE 12th Avenue

The intersection of SE Hawthorne Boulevard at SE 12th Avenue is the last signal of a closely spaced coordinated system in eastbound direction on Hawthorne Boulevard. Currently, buses experience a high amount of signal timing delay by missing the coordinated green band because of a bus stop just west of 12th Avenue.

The recommended improvement measure for the intersection of SE Hawthorne Boulevard at SE 12th Avenue consists of relocating the bus stop to a newly created bus zone to the east side of the intersection (see Figure 20).

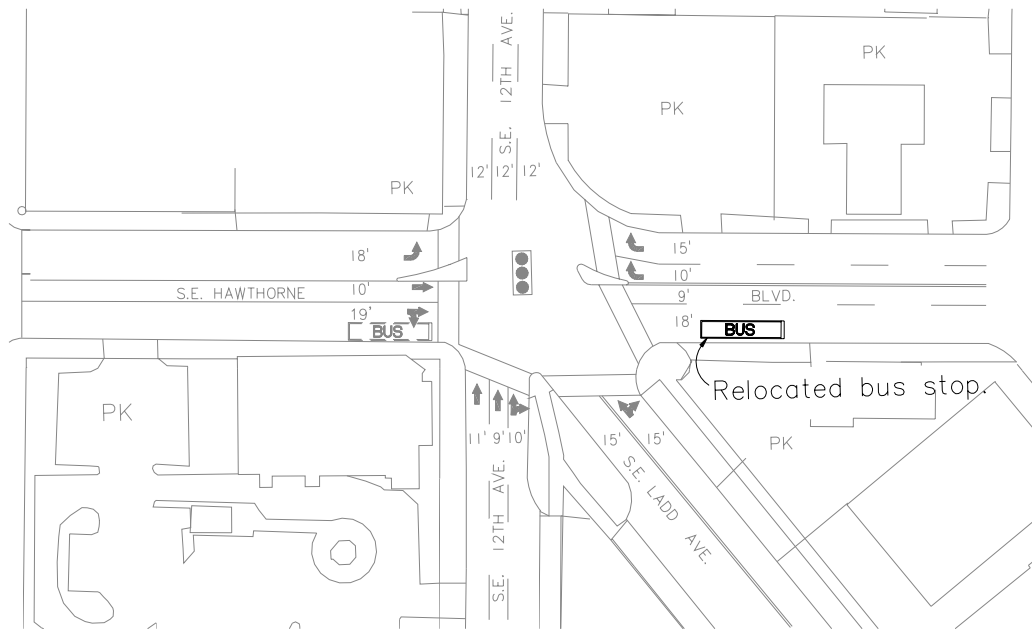


Figure 20: Proposed Measures for Hawthorne at 12th

5.2.2.9 SE Hawthorne Boulevard at SE 39th Avenue

The intersection of SE Hawthorne Boulevard at SE 39th Avenue is a major delay point for buses on Hawthorne Boulevard. The combination of long cycle lengths and nearside bus stops causes substantial signal timing delay for bus transit.

Improvement recommendations for the intersection of SE Hawthorne Boulevard at SE 39th Avenue include the relocation of eastbound and westbound bus stops to farside as well as the provision of transit signal priority (10 seconds early green/green extension) (see Figure 21).

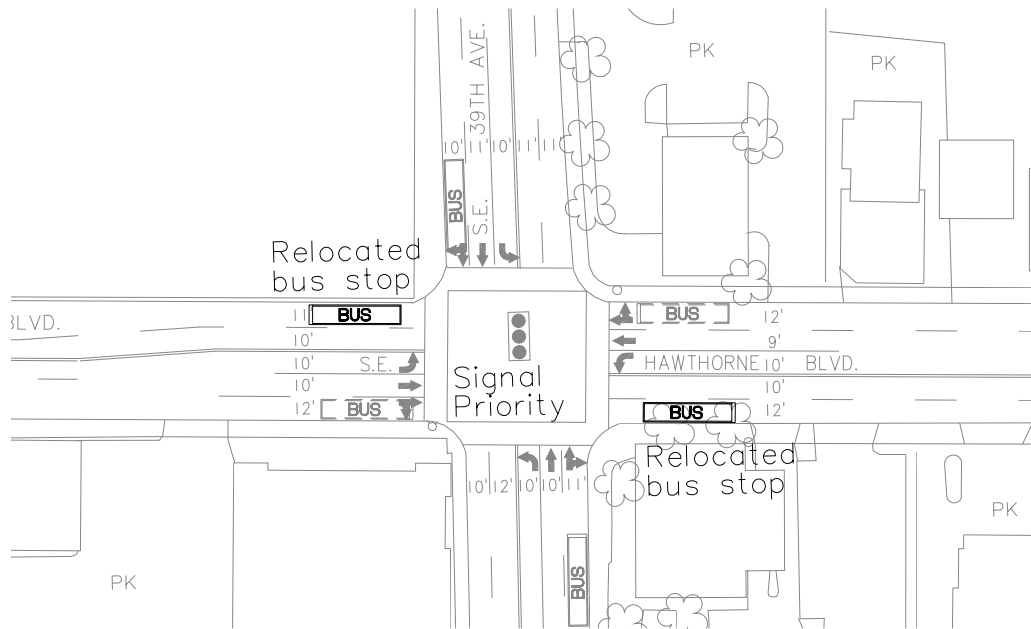


Figure 21: Proposed Measures for Hawthorne at 39th

5.2.2.10 SE 50th Avenue at SE Division Street

The intersection of SE 50th Avenue at SE Division Street is a major delay point for buses on 50th Avenue (Route 14). The signal operates under a 70 second timing plan with the majority of green time allocated to Division Street.

Recommended improvements for the intersection of SE 50th Avenue at SE Division Street include the provision of transit signal priority allowing for a 10 second green extension as well as a skipping of the leading opposing left-turn phase (9 seconds) (see Figure 22).

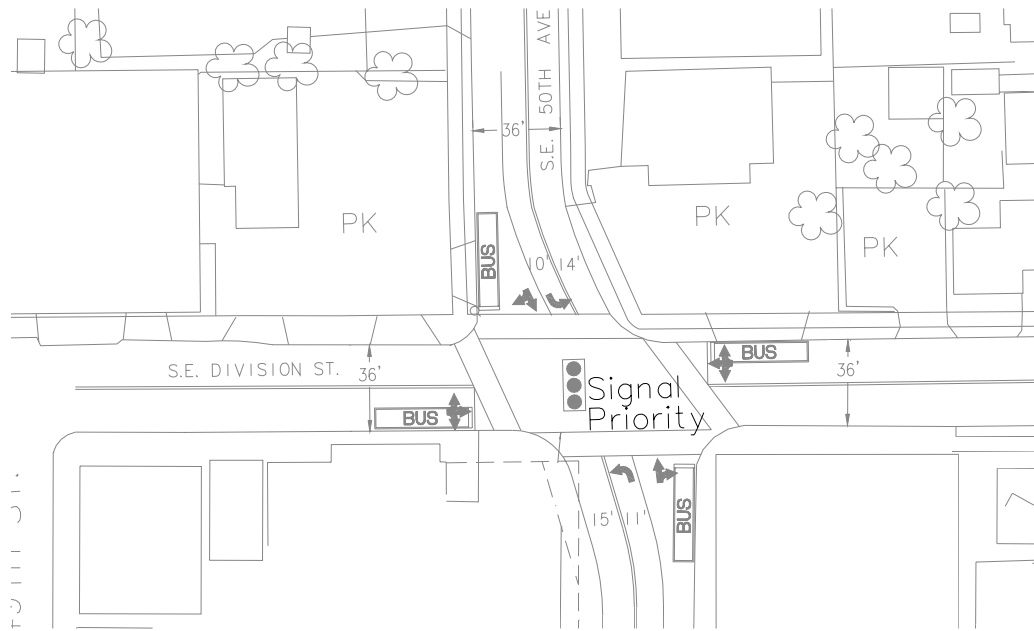


Figure 22: Proposed Measures for 50th at Division

5.2.2.11 SE 50th Avenue/SE Foster Road at SE Powell Boulevard

The intersection of SE 50th Avenue/SE Foster Road at SE Powell Boulevard causes major delay for buses on SE 50th Avenue during the PM peak period. The delay is caused by signal timing rather than queuing since buses approaching this intersection from the north are provided with a bus-only lane (except right-turns).

The recommended improvement measure for the intersection of SE 50th Avenue/SE Foster Road at SE Powell Boulevard consists of bus signal priority allowing for 10 seconds early green/green extension (see Figure 23).

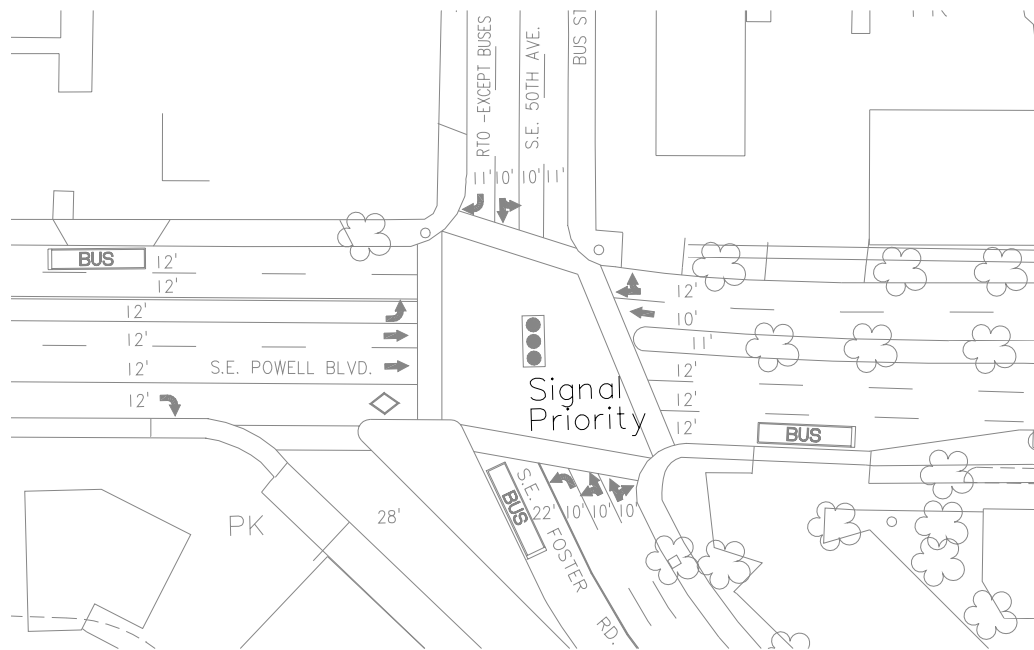


Figure 23: Proposed Measures for 50th/Foster at Powell

5.2.2.12 SE Foster Road at SE 82nd Avenue

Eastbound and westbound buses on SE Foster Road experience long delays at the intersection of Foster Road with SE 82nd Avenue because of the combination of nearside bus stops with long signal cycles.

Improvement measures recommended for the intersection of SE Foster Road at SE 82nd Avenue include the relocation of both the eastbound and westbound bus stop to farside as well as the provision of transit signal priority (10 seconds early green/green extension) (see Figure 24).

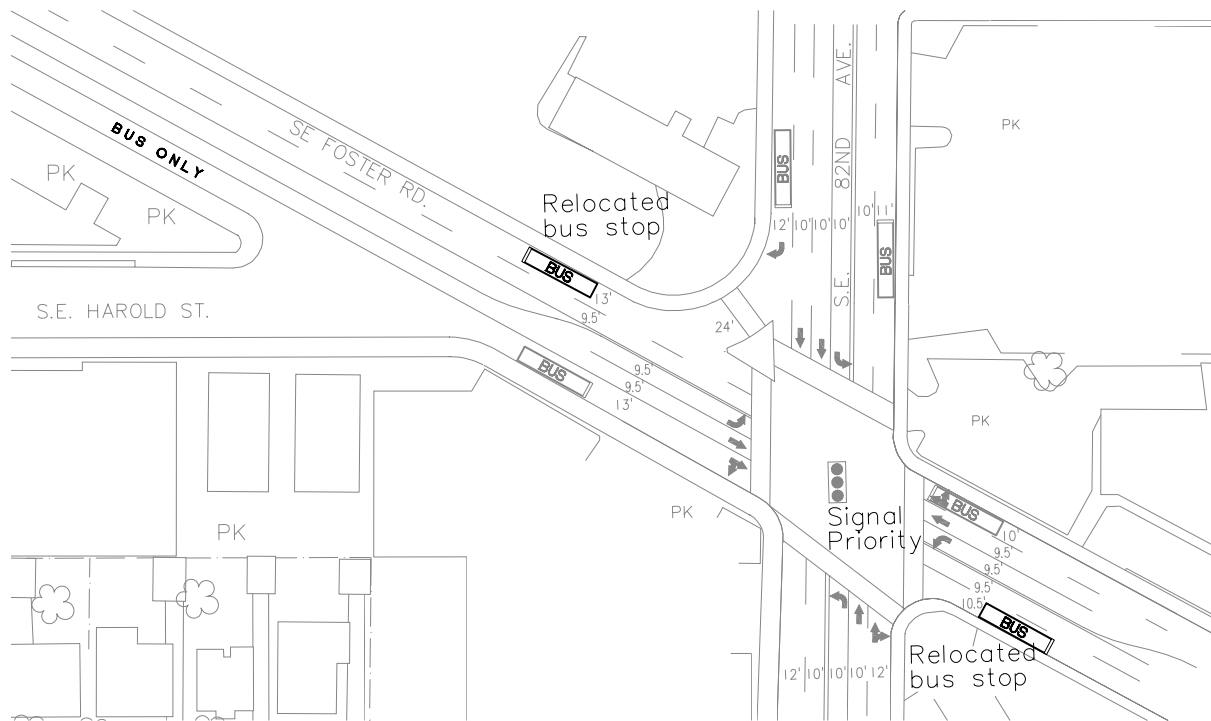


Figure 24: Proposed Measures for Foster at 82nd

6. IMPACT EVALUATION

6.1 INTRODUCTION

6.1.1 Purpose of Impact Evaluation

The objective of the Impact Evaluation is to generally identify the effect of introducing transit preferential streets strategies on transit travel time, as well as their impact on the following systems and features:

- Traffic Circulation
- Transit Patrons
- Bicycle Circulation
- Pedestrian Circulation
- Overall Traffic Safety
- Urban Design
- Existing and Future Land Use
- On-Street Parking Supply

6.1.2 Methodology for Technical Analysis

As discussed in Section 3, the analyses of transit preferential streets strategies were built from a rigorous two-day field survey of existing bus travel time and delay. These data were then input to the microscopic traffic/transit simulation model VISSIM, which produced existing conditions transit and general traffic travel times and delay. Finally, field surveys were conducted to collect information about the bicycle and pedestrian networks, urban design, land uses, and on- and off- street parking characteristics of the corridor locations.

Transit preferential streets strategies were simulated for these sites using the VISSIM model, which documented transit and general traffic travel times, speeds, level of service measurements for general traffic, and travel delays. Analyses of the impact of these strategies to parking supply, businesses and other land uses, pedestrians and bicyclists were then made based on the field survey information, and previously completed transportation planning plans, policies and studies completed by the City of Portland.

6.2 CONSISTENCY WITH TRANSPORTATION POLICY

According to the *Transportation Element*¹⁰, each of the four corridors share the following designations:

- “Major City Transit Street”
- “City Walkways”, and
- “Major or Minor Truck Streets”

All of the corridor segments of Hawthorne Blvd., Sandy Blvd., Martin Luther King, Jr. Blvd., and Grand Street are designated “City Bikeways”. Division Street, Foster Street, and SE 50th Avenue do not accommodate designated bicycle routes.

According to the *Transportation Element*, Major City Transit Streets should “employ preferential transit service, including transit priority treatment (such as signal preemption or exclusive lanes), which may involve removing on-street parking or acquiring additional right-of-way” (page 29). The *Transportation Element* does not describe any recommended relationships between City Walkways, City Bikeways, and Major and Minor Truck Routes and Major City Transit Streets.

The proposed transit preferential streets strategies are consistent with these policies, and are supportive of the types of treatments envisioned in the policy.

6.3 IMPACTS TO TRANSIT OPERATIONS

6.3.1 Martin Luther King, Jr. Blvd./Grand Avenue Corridor

Two of the three locations under review in this corridor were found to benefit from relocation of bus stops from nearside locations to far side locations, with a queue bus lane proposed for Grand Avenue between SE Ankeny and Burnside Streets and signal priority for buses proposed for Martin Luther King, Jr. Blvd. at Fremont.

6.3.1.1 Martin Luther King, Jr. Blvd. at Burnside Street

The current transit travel time delay of 49.6 seconds/bus occurs because SB buses pickup and discharge passengers at the nearside bus stop, which causes them to miss the coordinated “green” portion of the signal cycle. It is proposed that the bus stop be relocated to the far side of the MLK Blvd./Burnside Street intersection. This relocation will allow buses to flow through the intersection during the coordinated green times of the signal, thus reducing transit travel time by a total 28.0 seconds.

¹⁰ *Transportation Element: City of Portland Comprehensive Plan*, City of Portland Office of Transportation, Ordinance No. 170136, June 21, 1996

6.3.1.2 Grand Avenue between SE Oak and Burnside Street

At this location, general traffic flow including buses, moves very slowly, often sitting through more than one signal cycle to clear each blockface because of: very high traffic levels; significant cross-traffic on Burnside requiring ample green time; high turning movements which are interrupted by legal pedestrian crossings; and movements into an out of driveways and on-street parking spaces. Simulations of existing conditions show that queuing and signal delay results in a 192.8 seconds average delay/bus at this location during the PM peak hour. Proposed treatments for reducing transit travel time include designating the eastside curb lane for buses and right turning vehicles only, and moving the nearside bus stop to the farside of the Grand Avenue/Burnside Street intersection. These treatments together would reduce transit travel time delays by 39%, to an average delay of 118.3 seconds/bus.

In order to maintain reasonable general traffic conditions, it is proposed that during the PM peak hour, curbside parking on the westside of Grand Avenue also be removed to maintain the current four lanes of moving traffic through this segment of the corridor. In total, the designation of street space for the queue bus lane would require the removal of approximately 39 on-street parking spaces and eight loading zone spaces in the PM peak hour.

6.3.1.3 Martin Luther King, Jr. Blvd. at Fremont Street

As mentioned above, an appropriate means to reduce bus travel time during the PM peak hour would be to relocate bus stops - both NB and SB - from nearside to farside locations. In combination with signal priority for NB buses during the PM peak hour, these strategies would reduce bus travel time from 21.8 seconds/bus to 11.3 seconds/bus in the NB direction.

6.3.2 Sandy Blvd. Corridor

Both locations under review in this corridor accommodate six approach legs to the intersection, and were found to benefit substantially with the introduction of optimization to current intersection signal timing, relocation of bus stops, and signal priority by bus, for the peak direction flow during respective peak hour periods.

6.3.2.1 Sandy Blvd. at Alameda/57th Avenue

For both peak hour periods, a set of incremental strategies were tested for the peak direction of flow for No. 12 buses on Sandy Blvd. Beginning with optimization of signal timing, per bus delays were reduced from 92.0 seconds and 79.5 seconds to 84.0 seconds and 69.2 seconds for EB PM peak hour buses and WB AM peak hour buses, respectively. Relocating bus stops from nearside to farside further reduced EB bus travel time to 58.9 seconds/bus (from 84.0 seconds) in the PM peak hour, and WB bus travel time to 47.6 seconds/bus (from 69.2 seconds) in the AM peak hour.

Finally, signal priority for buses was found to further decrease EB bus travel time in the PM peak hour from 58.9 seconds/bus to 43.3 seconds/bus, and would reduce WB bus travel time in the AM peak hour from 47.6 seconds/bus to 34.2 second/bus. In total, the combination of the four strategies (signal timing, queue bus lane, bus stop relocation, and signal priority for buses) would improve bus travel time by 53% for EB buses during the PM peak hour and 41% for WB buses during the AM peak hour.

The relocated bus stops would require the removal of between three and four on-street parking spaces in the westbound direction.

6.3.2.2 Sandy Blvd. at Fremont/72nd Avenue

The same incremental process and set of improvements used to test the improvements to bus travel time at the above location was used at the intersection of Sandy Blvd. at Fremont/72nd Avenue. In the EB direction during the PM peak hour, bus travel time was reduced from 112.2 seconds/bus under existing conditions to 81.4 seconds/bus (with signal timing changes) to 71.2 seconds/bus (with a queue bus lane and bus stop relocation added), to 66.5 seconds/bus (with signal priority for buses added to the previous strategies). In summary, EB bus travel time would be reduced by 41% or by 71.2 seconds/bus.

In the WB direction during the AM peak hour, the same set of incremental strategies would improve bus travel time from 44.5 seconds to 43.0 seconds to 40.8 seconds and to 35.3 seconds for each set of improvements. In total, WB bus travel time is estimated to decrease by 21% or 9.2 seconds/bus with introduction of the entire set of proposed strategies.

The queue bus lane would require the removal of between five and six parking spaces in the EB direction only.

6.3.3 Hawthorne Blvd./Foster Road Corridor

The seven locations evaluated in this corridor would benefit from the introduction of bus stop relocations and signal priority by bus treatments. Other strategies would not provide substantial benefit and would result in significant impacts to other modes.

6.3.3.1 Hawthorne Blvd. EB at Ladd Avenue/12th Avenue

At this location, relocating the EB bus stop from the nearside to the farside corner of the intersection would reduce the bus travel time for the No 14 bus by 50%, from an average of 53.5 seconds of delay/bus to 27.0 seconds/bus. Relocating the bus stop will allow buses coming from the signal at 11th Avenue to proceed through the intersection during the coordinated green times of the signal, thus reducing transit travel time.

6.3.3.2 Hawthorne Blvd. EB and WB at SE 39th Avenue

In both directions, bus travel time can be reduced by relocating bus stops from nearside to farside locations, and by introducing signal priority for buses. During the PM peak hour in the EB direction, bus stop relocation would reduce bus travel time from 146.7 seconds/bus to 75.8 seconds/bus, and adding signal priority for buses would further reduce travel time to 55.2 seconds/bus. For WB buses during the AM peak hour, bus stop relocation would reduce travel time from 50.9 seconds to 24.5 seconds, and signal priority for buses would reduce travel time to 21.9 seconds.

6.3.3.3 Foster Road EB at Powell Street/50th Avenue

Implementing signal priority for buses alone at this location for EB buses during the PM peak hour would reduce bus travel time from 26.2 seconds/bus to 20.2 seconds/bus; a 23% decrease.

6.3.3.4 Foster Road EB and WB at SE 82nd Avenue

At this location, relocating bus stops to farside and introducing signal priority for buses would reduce EB bus travel time by 51% and WB bus travel time by 31% during the PM and AM peak hour periods, respectively. In the EB direction, bus stop relocation would reduce bus travel time from 87.3 seconds/bus to 69.0 seconds/bus, and signal priority would further reduce bus travel time to 42.5 seconds/bus. Buses traveling WB during the AM peak hour would experience a reduction in bus travel time from 79.1 seconds/bus to 57.9 seconds/bus with bus stop relocation, and to 54.5 seconds/bus with the added strategy of signal priority for buses.

6.3.4 Division Street Corridor

Proposed improvements along this corridor range from the introduction of a traffic signal at SE 7th Avenue to a set of bus right-of-way and stop improvements at SE 39th Avenue.

6.3.4.1 Division Street at SE 7th Avenue

At the “T-intersection” where Division Street and SE 7th Avenue meet, the addition of a traffic signal in place of the existing southbound STOP sign control, would reduce bus travel time delay from 51.6 seconds/bus to 20.3 seconds/bus in the PM peak hour¹¹.

6.3.4.2 Division Street between SE 37th and SE 39th Avenues

Presently, EB buses experience 216.3 average seconds of delay/bus in the PM peak hour and WB buses experience 100.2 seconds of delay/bus in the AM peak hour. As with

¹¹ Based on field delay measurements and Highway Capacity Manual calculations.

locations along Sandy Blvd. and Grand Avenue, a set of incremental improvements would significantly improve travel time at these locations.

In the EB direction during the PM peak hour, the combination of signal timing modifications (i.e., signal timing optimization) and queue bypass bus lane would improve bus travel time from 216.3 seconds of delay/bus to 131.2 seconds/bus. Signal priority for buses would further decrease bus travel time to 127.7 seconds/bus. Buses traveling WB during the AM peak hour would experience bus travel time delay reductions from 100.2 seconds/bus to 61.6 seconds/bus with signal timing changes, a queue bus lane and farside bus stops, and to 47.6 seconds/bus with the added strategy of signal priority for buses.

The queue bus lane would require the removal of 31 parking spaces and one truck loading zone space in the eastbound and westbound directions.

6.3.5 Summary

Implementation of the proposed transit preferential streets strategies would significantly improve transit travel time and general operations at the specific locations, as well as along each of the four respective entire corridors. As shown in Table 22, transit travel time savings range between 22% and 62%, except for SE 50th Avenue at Division Street which would only experience a 6% reduction in travel time. In terms of actual reduced transit travel time, these strategies would result in a savings of at least 25 seconds/bus at nine of the 17 bus stops studied. The most significant travel time savings are anticipated to occur at:

- Hawthorne Blvd. EB at 39th Avenue = savings of 91.5 seconds/bus during the PM peak hour
- Division Street EB, 37th-39th Avenues = savings of 88.6 seconds/bus during the PM peak hour
- Grand Avenue NB, SE Oak-Burnside Street = savings of 74.5 seconds/bus during the PM peak hour
- Division Street WB, 39th-37th Avenues = savings of 52.6 seconds/bus during the AM peak hour

Table 22: Resulting Transit Delay on Corridor Routes-- Existing Versus Proposed Transit Preferential Streets Treatments

CORRIDOR LOCATION	ROUTE(S)	TRANSIT DELAY IN SECONDS PER BUS											
		AM PEAK HOUR					PM PEAK HOUR						
		DIR.	EXISTING	PROJECTED	% DIFF.	DIR.	EXISTING	PROJECTED	% DIFF.				
Grand Ave., Oak-Burnside	6, 63					NB	192.8	118.3	-39%				
MLK Blvd. @ Burnside	6, 63	SB	49.6	28.0	-44%	NB	21.8	11.3	-48%				
MLK Blvd. @ Fremont	6					EB	92.0	43.3	-53%				
Sandy Blvd. @ Alameda/57 th	12	WB	79.5	34.2	-57%	EB	112.2	66.5	-41%				
Sandy Blvd. @ Fremont/72 nd	12	WB	44.5	35.3	-21%	EB	53.5	27.0	-50%				
Hawthorne Blvd. @ 12 th /Ladd	14					EB	146.7	55.2	-62%				
Hawthorne Blvd. @ 39 th	14	WB	50.9	21.9	-57%	EB	26.2	20.2	-23%				
Foster Road @ 50 th /Powell	14					EB	87.3	42.5	-51%				
50 th Avenue @ Division	14	NB	62.3	58.4	-6%	All	51.6 ¹²	20.3	-61.2 ¹²				
Foster Road @ 82 nd	14	WB	79.1	54.5	-31%	EB	216.3	127.7	-41%				
Division Street @ 7 th	4	All				EB							
Division Street, 37 th -39 th	4	WB	100.2	47.6	-52%	EB							

¹² Based on field delay measurements and Highway Capacity Manual calculations, not VISSIM simulation.

6.4 IMPACTS TO TRAFFIC CIRCULATION

As shown in Table 23, the proposed transit preferential streets strategies would have more modest travel time benefits for general traffic flow (i.e., between 2% and 19% reductions in travel time; or between 0.3 seconds/vehicle to 39.5 seconds/vehicle), and in five instances (of a total 16 instances) would result in slight increases in general traffic delay (between 1% and 6%; or between 0.1 seconds to 1.5 seconds).

The transit preferential streets strategies would include signal optimization treatments at the Sandy Blvd. locations and Division Street at SE 39th Avenue, and would include a new traffic signal at Division Street at SE 7th Avenue. Bus stop relocations to farside locations would result in some improvements for right turning vehicles, and removal of on-street parking would eliminate conflicts between through traffic and vehicles moving into and out of parking spaces.

Table 23: Resulting Traffic Delay on Corridor Routes-- Existing Versus Proposed Transit Preferential Streets Treatments

CORRIDOR LOCATION	TRAFFIC DELAY IN SECONDS PER VEHICLE									
	AM PEAK HOUR					PM PEAK HOUR				
	DIR.	EXISTING	PROJECTED	% DIFF.	DIR.	EXISTING	PROJECTED	% DIFF.		
Grand Ave., Oak-Burnside	SB	9.8	9.5	-3%	NB	207.6	168.1	-19%		
MLK Blvd. @ Burnside										
MLK Blvd. @ Fremont	WB	26.7	23.0	-14%	NB	22.6	23.0	+2%		
Sandy Blvd. @ Alameda/57 th	WB	25.3	23.7	-6%	EB	42.6	34.9	-18%		
Sandy Blvd. @ Fremont/72 nd	EB	24.8	26.3	+6%	EB	35.3	32.9	-7%		
Hawthorne Blvd. @ 12 th /Ladd	WB	18.9	18.3	-3%	EB	17.0	17.1	+1%		
Hawthorne Blvd. @ 39 th	EB	33.3	33.6	+1%	EB	55.4	45.3	-18%		
Foster Road @ 50 th /Powell	NB	35.8	29.6	-17%	EB	33.4	33.6	+1%		
50 th Avenue @ Division	WB				NB	58.0	56.8	-2%		
Foster Road @ 82 nd	All				All	NA	NA	NA ¹³		
Division Street @ 7 th	WB				EB	57.6	52.5	-8%		
Division Street @ 37 th -39 th										

¹³ Intersection meets signal warrants.

6.5 IMPACTS TO TRANSIT PATRONS

For transit patrons, one of the more significant results of the proposed strategies is that they can begin to improve the service and schedule reliability of buses. Since schedule adherence and reliability can be important factors for persons making travel behavior decisions, eliminating significant travel time bottlenecks can lead to better on-time performance, and potentially, to increased ridership. As shown in Table 24, the transit travel time reductions would benefit thousands of transit riders currently using these routes.

Table 24: Bus Transit Riders Benefiting From Projected Transit Travel Time Improvements

ROUTE	AM PEAK HOUR				PM PEAK HOUR			
	DIR.	EST. RIDER-SHIP ¹⁴	CORR. TRAVEL TIME CHANGE ¹⁵	PERSON DELAY SAVINGS	DIR.	EST. RIDER-SHIP ¹⁴	CORR. TRAVEL TIME CHANGE ¹⁵	PERSON DELAY SAVINGS [PERS.-H.]
No. 4	WB	552	-1.7% -52 sec.	8.1 Pers-h	EB	566	-2.7% -89 sec.	13.9 Pers-h
No. 6	SB	406	-1.0% -22 sec.	2.5 Pers-h	NB	417	-4.0% -85 sec.	9.8 Pers-h
No. 12	WB	325	-2.0% -54 sec.	4.9 Pers-h	EB	333	-3.3% -93 sec.	8.6 Pers-h
No. 14	WB	911	-2.4% -57 sec.	14.4 Pers-h	EB	937	-6.7% -168 sec.	43.7 Pers-h

There are a large number of factors, including travel time and reliability improvements, which can influence travelers to use transit. Specific market studies have not been completed for this project to test the impact of these factors.

6.6 IMPACTS TO BICYCLE CIRCULATION

The proposed strategies are not anticipated to have any noticeable impact on bicycle circulation and/or safety. Bicycle movements would continue to be permitted in all

¹⁴ Tri-Met 1990 Bus Passenger Census and 1996 Bus Boarding Ride Counts, data provided by Nancy Jarigese, Tri-Met, 5/19/97. Peak hour distributions based on system-wide ratio of 54% PM Peak Hour and 46% AM Peak Hour. Peak direction distributions is based on the ratios that occur on MAX.

¹⁵ Effect of all proposed site specific travel time reductions over the entire corridor.

corridors where queue bus lanes, bus stop relocations, and other transit preferential streets treatments are proposed. The general benefits to vehicular traffic travel time may extend to bicycle travel, but no such analysis has been made to confirm such a statement.

6.7 IMPACTS TO PEDESTRIAN CIRCULATION

While the proposed transit strategies would not modify the existing pedestrian system at any of these locations, they would result in the relocation of certain bus stops, and would modify and add traffic control equipment that would affect pedestrian circulation patterns. A study of pedestrian origins and destinations has not been completed for this project, therefore, it is not possible to definitively describe impacts to pedestrian circulation such as the number of pedestrians that would experience increased walking distance and/or pedestrian travel time.

The bus stop relocations would result in moving bus stops from nearside locations to the farside of an intersection. For some pedestrians this would result in a shorter walk distance, for others a longer walk trip, and for still others there would be no change in walk distance at all. Similarly, the proposed changes to signal timing may increase wait times for some pedestrian crossing maneuvers, and may decrease them for others. The length of time for completing a pedestrian crossing may also have converse impacts for different crossings.

The proposed introduction of a traffic signal at the intersection of Division Street at SE 7th Avenue would be expected to improve safety for pedestrians when crossing SE 7th Avenue, but may not represent any improvement to pedestrian circulation.

Without the benefit of a pedestrian origin-destination survey, only summary statements can be made about the impact of the strategies to pedestrian circulation. In general, the strategies would appear to benefit as many pedestrians as they may penalize in terms of walk distance and travel time; and those adversely impacted would appear to be only minimally affected by the minor increases in walk distance and travel time.

6.8 IMPACTS TO OVERALL TRAFFIC SAFETY

The proposed transit preferential streets strategies are generally expected to have little or no effect on general traffic safety, and in certain instances, would represent some improvement to traffic safety. For example, while optimizing signal timing will improve traffic operations, by itself it is not anticipated to result in any traffic safety benefits. Similarly, bus priority for buses should have little impact on traffic safety.

The introduction of a traffic signal at Division Street and SE 7th Avenue, and queue bus bypass lanes on Grand Avenue, Sandy Blvd., and Division Street, are expected to result in traffic safety benefits as traffic and transit operations would become better controlled, organized and understandable to motorists, bus drivers, bus patrons, pedestrians and bicyclists.

There is some debate about the traffic safety benefits associated with moving bus stops from nearside locations to the farside of an intersection. Farside stops encourage pedestrians to walk behind buses when they're at bus stops, and potential sight distance problems are minimized at approaches to intersections with farside stops¹⁶. However, there is some speculation that farside stops may increase the number of rear-end accidents since drivers do not normally expect buses to stop again after stopping at a red light¹⁷. On the other hand, buses at nearside stops can obscure one's vision and understanding of curbside traffic control devices and crossing pedestrians, and they increase sight distance problems for pedestrians¹⁸. With proper equipment and advisory signage, far side bus stops can result in improved safety for vehicular and pedestrian traffic.

Without enforcement of the proposed new regulations and controls these traffic safety benefits would not be realized.

6.9 IMPACTS TO URBAN DESIGN

The proposed strategies will not change any existing right-of-way configurations, nor will they add, eliminate, modify, or disturb any streetscape amenities or features of the environment, with the exception of certain bus stop locations and their corresponding amenities

6.10 IMPACTS TO EXISTING AND FUTURE LAND USE

For this set of treatments, only the proposed queue bus lanes and the bus stop relocations would be anticipated to potentially impact existing and future land uses at the locations under review. The changes to signal timing, signal priority for buses, and introduction of a new traffic signal would not be expected to measurably affect land use.

The queue bus lanes proposed for Grand Avenue (between SE Oak and Burnside Streets), Sandy Blvd. (between NE 70th and NE 72nd Avenues), and Division Street (between SE 37th and SE 39th Avenues) would result in the removal of on-street parking spaces and on-street commercial loading zones which could have a direct affect on businesses and residences that rely on those spaces. In the case of Grand Street, there is limited available on-street space to relocate these spaces, and adjacent off-street facilities do not appear to have available room to accommodate the passenger and freight vehicles that currently use those spaces. Similarly, there is limited room to

¹⁶ *Transit Cooperative Research Program Project A-10: Location and Design of Bus Stops on Major Streets and Highways*, Texas Transportation Institute, Quarterly Progress Report from January 1, 1995 to March 31, 1995, Table A-4, page A-15.

¹⁷ *Ibid.*

¹⁸ *Ibid.*

replace the lost on-street parking spaces on the southside curb lane of Division Street, though in brief field surveys there appear to be some available spaces along cross streets. Finally, there is a surplus of on-street parking spaces along adjacent cross streets to the two Sandy Blvd. locations, as well as ample off-street parking capacity that is free of charge within commercial facilities along Sandy Blvd.

With respect to the impact of these treatments on long range re-development opportunities at these locations, the proposed strategies are relatively unobtrusive and common in the streetscape, and on their own would not be expected to adversely affect such opportunities.

As described in Section 6.2, the proposed strategies are consistent with the transportation policies identified in the City of Portland's Comprehensive Plan.

6.11 IMPACTS TO ON-STREET PARKING SUPPLY

As described in the previous section, the proposed projects would reduce the number of on-street parking and commercial loading zone spaces at some of the locations where a queue bus lane and/or a bus stop relocation are proposed (see Table 25). These strategies may produce site specific adverse impacts to on-street parking supply, and a corresponding impact to local businesses and residents that rely on curbside parking areas.

The most significant impacts to on-street parking supply would occur at the queue bus lane along Grand Avenue between SE Oak and Burnside Streets during the PM peak hour, which would eliminate approximately 39 on-street parking spaces and eight truck loading zone spaces. At this location, the eastside parking lane would be used by buses and right-turning vehicles only, and parking would also be removed from the westside parking lane to maintain the current four moving travel lanes along this segment. While there are a number of on-street parking spaces along adjacent cross streets as well as at some off-street parking facilities in this area, limited PM period surveys indicate that there may not be enough spaces to accommodate the existing parking and truck loading demand within a two block radius of this segment of Grand Street.

Table 25: Impact of Proposed Transit Preferential Streets Measures to On-Street Parking Supply

CORRIDOR LOCATION	PROPOSED TRANSIT PREFERENTIAL STRATEGIES	PARKING (TRUCK) SPACES REMOVED ¹⁹
Grand Ave. NB, Oak-Burnside	Queue Bypass Lane	39 (8)
MLK Blvd. SB @ Burnside	Bus Stop Relocation	0 (0)
MLK Blvd. NB/SB @ Fremont	Bus Stop Relocation Signal Priority by Bus	0 (0)
Sandy Blvd. EB/WB @ Alameda/57 th	Signal Modifications Bus Stop Relocation Signal Priority by Bus	4 (0)
Sandy Blvd. EB/WB @ Fremont/72 nd	Signal Modifications Queue Bypass Lane Bus Stop Relocation Signal Priority by Bus	4 (0)
Hawthorne Blvd. EB @ 12 th /Ladd	Bus Stop Relocation	0 (0)
Hawthorne Blvd. EB/WB @ 39 th	Bus Stop Relocation Signal Priority by Bus	0 (0)
Foster Road EB @ 50 th /Powell	Signal Priority by Bus	0 (0)
50 th Avenue NB @ Division	Signal Priority by Bus	0 (0)
Foster Road EB/WB @ 82 nd	Bus Stop Relocation Signal Priority by Bus	0 (0)
Division Street @ 7 th	Install Traffic Signal	0 (0)
Division Street EB/WB, 37 th -39 th	Signal Modifications EB Queue Bypass Lane Bus Stop Relocation Signal Priority by Bus	31 (1)

The queue bus lane proposed for the southside curb lane of Division Street between SE 37th and SE 39th Avenues during the PM peak hour would require the removal of approximately 31 parking spaces and one truck loading zone space in the northside and southside curb lanes. Limited field surveys identified about half of all on-street parking spaces on Division Street and adjacent cross streets to be in use, and a large number of empty spaces at off-street facilities.

On Sandy Blvd. at NE Alameda/57th Avenue, the relocation of the nearside bus stop to the farside location would require the removal of approximately three to four on-street parking spaces on the southside curb lane between NE 57th and NE 58th Avenues.

¹⁹ Based on either number of marked spaces or 25.0 feet per parking space.

Limited field surveys indicated that there are available on-street parking spaces available around the corner of the northside of NE Alameda between NE 57th and NE 58th Avenues to replace this loss.

Similarly, on Sandy Blvd. between NE 70th Avenue and the NE Fremont/72nd Avenue intersection, the queue bus lane and bus stop relocation combined would require the removal of approximately five to six parking spaces on the southside curb lane. Limited field surveys indicate that there is a surplus of available parking spaces in off-street facilities at the Safeway Shopping complex on the northside of the street, at the Subway Sandwich shop, and along curb spaces on adjacent cross streets.

6.12 POTENTIAL MITIGATION MEASURES

As described earlier, the proposed strategies would result in unavoidable adverse impacts to on-street parking supply at Grand Avenue between SE Oak and Burnside Streets, and along Division Street between NE 37th and NE 39th Avenues. A more detailed field survey and needs analysis should be completed to confirm these projected PM peak period impacts, and to document the level of impact more thoroughly. It may be possible to replace these spaces at a nearby location.

Transit preferential streets strategies that have not been discussed in this memorandum, but which could also reduce bus travel times and improve reliability, include such system wide measures as the use of low floor buses, consolidation of bus stops, communication systems between bus drivers and bus stops, and additional street space dedicated exclusively for bus operations within these corridors.

6.13 OPERATING COST SAVINGS

Tri-Met has calculated that one hour of bus operation costs the agency an average of \$52.00²⁰. Therefore, travel time savings as a result of transit preferential streets measures translate into operating cost savings. Table 26 depicts the estimated bus operating cost savings resulting from the accumulated travel time savings of the analyzed transit preferential streets measures.

Table 26: Estimated Bus Operating Cost Savings

ROUTE	AM PEAK HOUR				PM PEAK HOUR			
	DIR.	NUMBER OF BUSES	CORR. TRAVEL TIME CHANGE ²¹	ANNUAL OP. COST SAVINGS ²²	DIR.	NUMBER OF BUSES	CORR. TRAVEL TIME CHANGE ²¹	ANNUAL OP. COST SAVINGS ²²
No. 4	WB	12	-52 sec.	\$2,704	EB	6	-89 sec.	\$2,314
No. 6	SB	6	-22 sec.	\$572	NB	5	-85 sec.	\$1,842
No. 12	WB	6	-54 sec.	\$1,404	EB	6	-93 sec.	\$2,418
No. 14	WB	12	-57 sec.	\$2,964	EB	9	-168 sec.	\$6,552

²⁰ Source: Tri-Met

²¹ Effect of all proposed site specific travel time reductions over the entire corridor.

²² Annual Operating Cost Savings = No. of buses per peak period * hourly operating cost * time savings per bus (* 1/3600) * 300 days per year

6.14 CONSTRUCTION COST ESTIMATE

Cost estimates to construct the improvements recommended for the analyzed intersections have been prepared by the Portland Office of Transportation. The estimates include a 40% contingency to cover unanticipated project variables, to account for inflation prior to project construction, and to allow for some changes in the scope of work.

Table 27: Cost Estimate to Construct Recommended Improvements

CORRIDOR LOCATION	PRELIMINARY ENGINEERING	CONTRACT	CONSTRUCTION ENGINEERING	40% CONTINGENCY	TOTAL
Grand Ave, Oak-Burnside	\$3,951	\$13,169	\$3,292	\$8,165	\$28,577
MLK Blvd. @ Burnside	\$612	\$2,041	\$510	\$1,265	\$4,429
MLK Blvd. @ NE Fremont	\$4,116	\$13,720	\$3,430	\$8,506	\$29,772
Sandy Blvd. @ Alameda/57 th	\$6,265	\$20,884	\$5,221	\$12,948	\$45,318
Sandy Blvd. @ Fremont/72 nd	\$9,031	\$30,103	\$7,526	\$18,664	\$65,324
SE 7 th @ Division Place	\$30,000	\$130,000	\$15,000	\$25,000	\$200,000
Division Street, 37 th -39 th	\$6,550	\$21,834	\$5,459	\$13,843	\$47,381
Hawthorne Blvd. @ 12 th	\$88	\$294	\$73	\$182	\$637
Hawthorne Blvd. @ 39 th	\$4,914	\$16,381	\$4,095	\$10,156	\$35,547
SE 50 th Avenue @ Division	\$4,295	\$14,318	\$3,580	\$8,877	\$31,070
Foster Road @ 50 th /Powell	\$4,295	\$14,318	\$3,580	\$8,877	\$31,070
Foster Road @ 82 nd	\$3,539	\$15,388	\$3,847	\$9,110	\$31,885

6.15 SUMMARY OF FINDINGS

As shown in Table 22, the proposed transit preferential streets strategies are expected to result in significant transit travel time savings, expressed as percent decreases, for all corridor locations. Travel time savings range between 22% and 62%, except for SE 50th Avenue at Division Street which would only experience a 6% reduction in travel time. In terms of actual reduced transit travel time, these strategies would result in a savings of at least 25 seconds/bus at nine of the 17 bus stops studied. The most significant travel time savings are anticipated to occur at:

- Hawthorne Blvd. EB at 39th Avenue = savings of 91.5 seconds/bus during the PM peak hour
- Division Street EB, 37th -39th Avenues = savings of 88.6 seconds/bus during the PM peak hour
- Grand Ave. NB, Oak-Burnside Street = savings of 74.5 seconds/bus during the PM peak hour
- Division Street WB, 39th -37th Avenues = savings of 52.6 seconds/bus during the AM peak hour

At most of the corridor locations, these strategies are also anticipated to improve the operations of general traffic circulation (see Table 23). In other words, in most instances these treatments do not reduce roadway capacity, and they help to reduce the impact of bus operations (buses pulling and out of bus stops) on general traffic circulation. Along one segment, Grand Ave. NB between SE Oak and Burnside Street, general traffic travel times are estimated to decline by 38.9 seconds during the PM peak hour.

In three of a total 18 instances, general traffic delays would experience extremely minor changes with the introduction of the proposed transit preferential streets strategies (i.e., between 0.1 second to 1.5 seconds per vehicle).

Due to the transit travel time reductions and expected improvements in travel time reliability, these strategies would result in travel benefits to current users, and would be expected to have a modest positive impact in generating increased ridership levels.

6.16 EXPECTED ADVERSE IMPACTS

The proposed projects would reduce parking supply at some of the locations where a queue bus lane and/or a bus stop relocation are proposed (see Table 25), which may produce site specific adverse impacts to on-street parking supply, and a corresponding impact to local businesses that rely on curbside parking areas.

The most significant impacts to on-street parking supply would occur at the queue bus lane along Grand Ave. between SE Oak and Burnside Streets during the PM peak hour. At this location, the eastside parking lane would be used by buses and right-turning vehicles only, and parking would also be removed from the westside parking lane to maintain the current four moving travel lanes along this segment. While there are a number of on-street parking spaces along adjacent cross streets as well as some off-street parking facilities in this area, limited PM period surveys indicate that there may not be enough spaces to accommodate the existing parking and truck loading zone demand within a two block radius of this segment of Grand Street.

In addition, the queue bus lane and bus stop relocation proposed along SE Division Street between 37th-39th Avenues would remove as many as 31 parking spaces and one truck loading space from the northside and southside curb lanes. Similarly, the queue bus lane and bus stop relocations proposed for Sandy Blvd. between 56th-57th Avenues, and between 70th-72nd Avenues would remove approximately four parking spaces from each location during the PM peak hour.

With respect to other modes of travel, such as the impact to bicycle and pedestrian circulation and traffic safety, the project would have a negligible effect on existing operations. Further, the strategies would be generally consistent with adopted transportation policy and urban design programs.

7. IMPLEMENTATION

7.1 DEMONSTRATION PROJECT

The project team has formulated a recommended corridor for implementation of a project which demonstrates the design, operation, and anticipated benefits of transit preferential streets measures. This demonstration project would also serve as a local test site for before and after studies of transit preferential streets strategies. Ideally, this demonstration project will incorporate a variety of transit preferential streets measures (physical as well as operational) that can effectively improve previously documented transit travel time delays. Exclusive transit lanes are of particular importance because of their high visibility and the resulting psychological affect on motorists when being passed by a bus.

The team recommends that the segment of SE Division Street between SE 39th and SE 37th avenues be selected for demonstration of transit preferential streets measures because of the relatively high level of transit delay experienced at the location. This location also accommodates relatively high ridership levels and frequent peak hour (and off-peak hour) service. As shown in the table below, bus transit today experiences average delays of 216.3 seconds in the eastbound direction during the PM peak period, and 100.2 seconds in the westbound direction during the AM peak period.

Recommended transit preferential streets measures for this location (see Section 5.2.2.7) include:

- signal timing modification,
- an eastbound queue bypass lane,
- the relocation of the westbound bus stop from nearside to the farside intersection location, and
- the transit signal priority.

In combination, these measures are projected to significantly reduce bus transit delays (i.e., reductions of 88.6 seconds - 41% - for the eastbound direction in the PM peak, and 52.6 seconds - 52% - for the westbound direction in the AM peak). These delay reductions will benefit about 566 PM peak hour passengers and 552 AM peak hour passengers, resulting in a total transit passenger delay savings of 13.9 person-hours during the PM peak hour and 8.1 person-hours during the AM peak hour. The recommended measures are also expected to provide benefits to general purpose traffic through a reduction in average vehicle delay by 5.1 seconds per vehicle (8%) during the PM peak period and 6.2 seconds per vehicle (17%) during the AM peak period.

The implementation of the recommended transit preferential streets measures is estimated to cost \$47,381, compared to an estimated annual savings of \$5,039²³ in bus operating costs.

The project team also recommends that a series of detailed analyses be undertaken before actually implementing the recommended transit preferential streets measures at this location. These studies should include:

- a bus boarding and transfer study,
- a pedestrian circulation study, and
- a thorough before and after study quantifying impacts on all modes of transportation including on-street parking supply.

7.2 PROJECT DEVELOPMENT

Transit Preferential Streets measures can be applied to improve transit operations at isolated locations or along whole corridors. While it is beneficial for demonstration purposes to implement TPS measures at an isolated location that has been identified as a high transit delay point (see Section 7.1), it is recommended to use a corridor-wide approach for the full-scale TPS implementation. First of all, a corridor-based approach allows for the application of corridor-wide measures such as bus stop consolidation. Second, the transit agency as well as the bus rider actually notices the time benefits of TPS measures through the accumulative benefit of a number of small increments of time savings.

7.3 PROJECT UNDERTAKING

Transit Preferential Streets measures are for the most part specific modifications to automobile and bus transit operations. As a consequence, their implementation requires the coordination and consensus of a number of jurisdictions. This requirement and the fact that TPS measures affect virtually every project undertaken within the public right of way mandates continuous communication between all agencies involved. The success of the San Francisco Transit Preferential Streets Program which is driven by an inter-departmental project team demonstrates that TPS measures can be successfully implemented if undertaken as a concerted effort of all departments involved. Therefore, it is recommended to form a TPS project steering group consisting of representatives from Tri-Met, the City of Portland's Department of Transportation, Metro, and the Oregon Department of Transportation to meet on a regular basis and direct the further development and implementation of the Portland Transit Preferential Streets Program.

²³ Annual Operating Cost Savings = No. of buses per peak period * hourly operating cost * time savings per bus (* 1/3600) * 300 days per year

7.4 FINANCING

Various funding sources are available and should be considered for the implementation of Transit Preferential Streets measures. These sources include the general funds as well as capital improvement funds of both the transit agency (Tri-Met) and the local authorities (City of Portland) and regional Transportation System Management (TSM) funds for intersection improvement projects. Furthermore, federal funding is available through grants such as the existing federal Section 3 funding for wayside improvements.

For the selection of the appropriate funding source for the implementation of specific TSP measures, it is important to consider its impacts as well as its beneficiaries. It is recommended that the agencies affected by Transit Preferential Streets measures develop an appropriate funding strategy.

TRANSIT PREFERENTIAL STREETS PROGRAM SOURCEBOOK

Guidelines for Implementing Transit Preferential Streets Measures



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This document was prepared to complement the Transit Preferential Streets Program Final Report.

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Compatibility Matrix

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

The following Compatibility Matrix summarizes all of the Transit Preferential Streets measures illustrated in this document. The matrix also characterizes each measure's relationship to other measures described in the sourcebook. Certain measures are designed to work well together (e.g., *Queue Bypass* and *Queue Jump*) while other measures are mutually exclusive (e.g., *Curb Extensions* and *Exclusive Bus Lane*).

Compatibility Matrix

	Signal Priority	Curb Extensions	Boarding Islands	Queue Bypass	Queue Jump	Bus Stop Consolid.	Bus Stop Relocation	Exclusive Bus Lane	Parking Restriction	Timing or Phasing Change	Low-floor Techn.	Fare Collection Change	Turning Restriction Exemption
Signal Priority	✓	-	-	-	✗	-	✓	-	-	-	-	-	-
Curb Extensions	-	∩	✗	✗	✗	-	-	✗	✗	-	-	-	-
Boarding Islands	-	✗	∩	✗	✗	-	-	-	-	-	-	-	-
Queue Bypass	-	✗	✗	∩	✓	-	-	-	-	-	-	-	-
Queue Jump	✗	✗	✗	✓	∩	-	✗	-	-	✓	-	-	-
Bus Stop Consolid.	-	-	-	-	-	-	-	-	-	-	-	-	-
Bus Stop Relocation	✓	-	-	-	✗	-	-	-	-	-	-	-	-
Exclusive Bus Lane	-	✗	-	-	-	-	-	∩	✓	-	-	-	-
Parking Restriction	-	✗	-	-	-	-	-	✓	∩	-	-	-	-
Timing or Phasing Change	-	-	-	-	✓	-	-	-	-	∩	-	-	-
Low-floor Techn.	-	-	-	-	-	-	-	-	-	-	∩	-	-
Fare Collection Change	-	-	-	-	-	-	-	-	-	-	-	∩	-
Turning Restriction Exemption	-	-	-	-	-	-	-	-	-	-	-	-	∩

Legend: ✓ best if coupled with; - unrelated; ✗ non compatible

Traffic Signal Priority

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Operational

Range:

Local to System-wide

Applicability:

- Intersections where buses experience extensive signal timing delay.

Benefits:

- Increases transit operating speed by reducing signal timing delay.
- Improves on-time performance.

Conditions:

The controlled intersection should be operating at less than saturation capacity, where occasional timing or phasing changes will not significantly degrade the level of service.

Reliable communication between buses and traffic signal controllers - without increasing bus drivers' work loads - is a necessity. Therefore, an appropriate communication system between vehicle and way-side controller is essential. Several priority systems have been studied by Tri-Met, but for a variety of reasons most studies were inconclusive. Many third party systems are available, including systems that can relay information from buses equipped with an automatic vehicle location (AVL) system directly to the signal controller.

Experience/Results:

Initial analysis of installations in San Francisco showed a reduction in signal timing delay of between 14% and 25%, even with a mechanical transit vehicle detection device failure rate ranging from 10% to 40%.

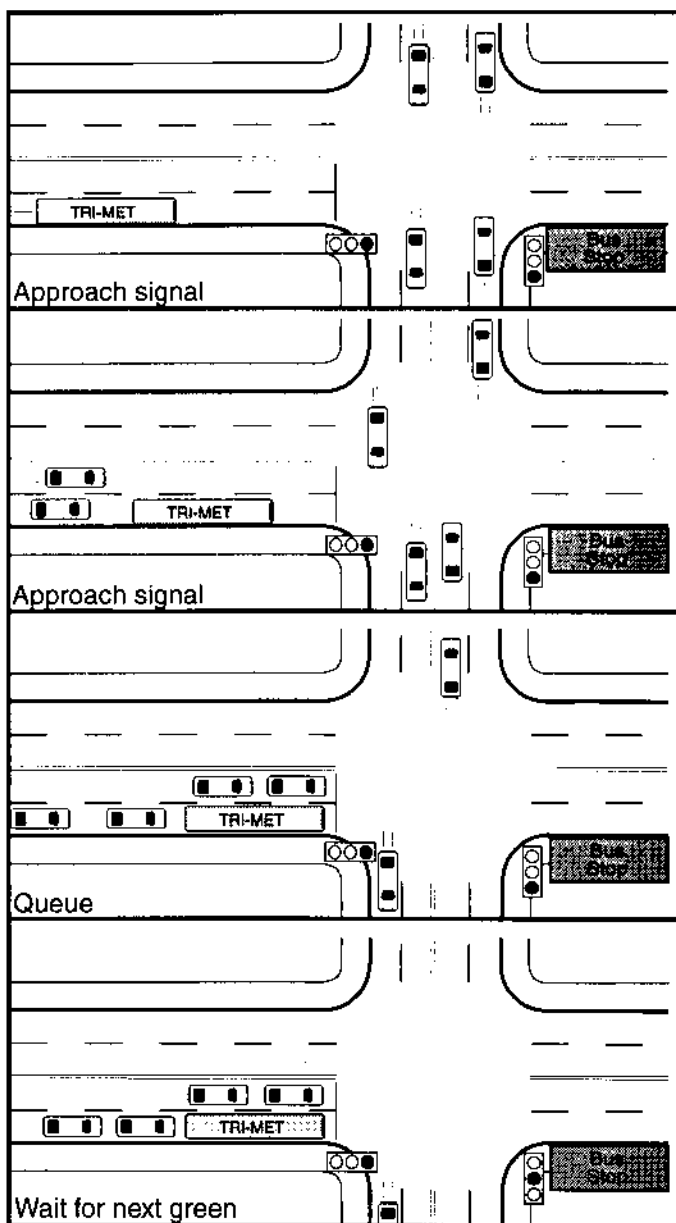
In the Portland area, Tri-Met's latest study of a bus signal priority pilot project on Tualatin Valley Highway (T.V. Highway) from S.W. Murray Boulevard through S.W. 234th Street shows bus travel time savings ranging from 1.4% to 6.4% for one direction, and 6.4% for both directions combined. These travel time savings correspond to traffic signal delay reductions ranging from 19.6% to 20.3% for one direction, and a two-way average of 20.0%.

Caveats:

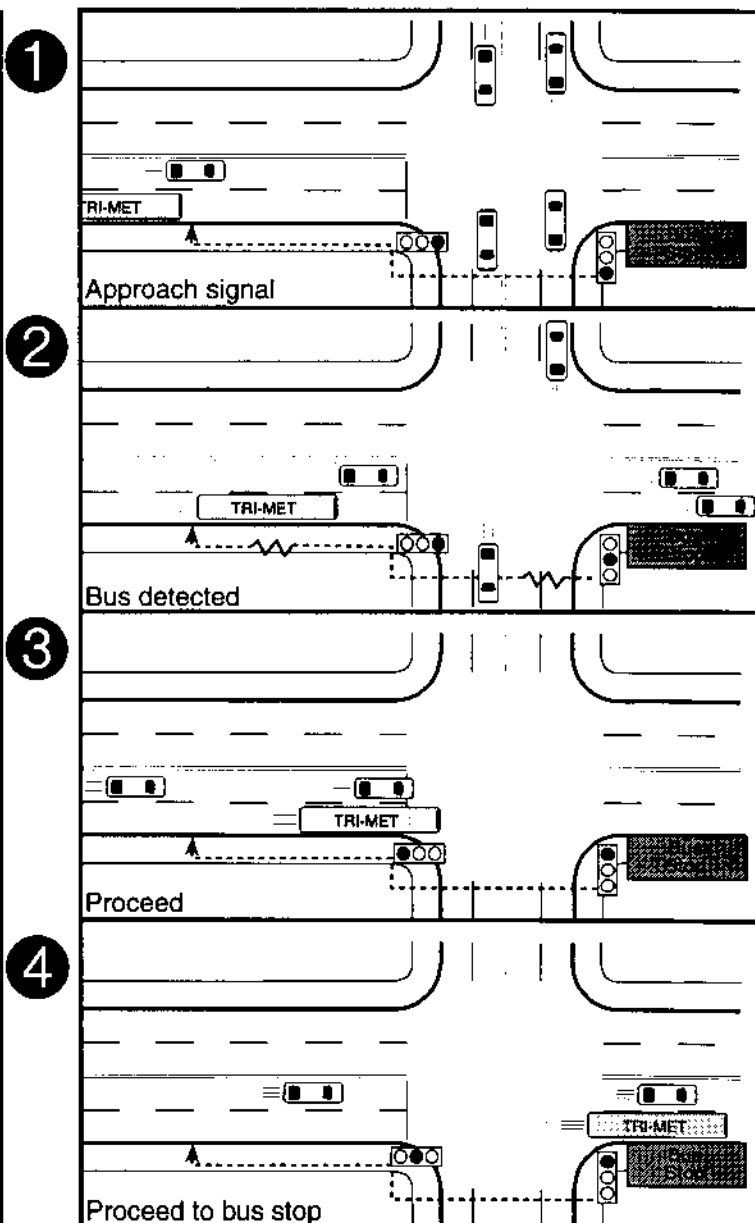
- Risk of interrupting coordinated traffic signal operation.
- Potential degrading of traffic signal level of service (especially if affected intersection is saturated).
- Requires continued inter-jurisdictional and inter-agency coordination and agreement on priority treatment system and strategy.

Description: Transit vehicles are detected as they approach an intersection. Upon receiving a priority call from a transit vehicle, the traffic signal controller either terminates conflicting phases early without violating pedestrian clearance intervals (“early green”) or extends the current green phase (“green extension”).

Before



After



Curb Extensions (Bus Bulbs)

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Physical

Range:

Local

Applicability:

- Locations where buses experience high dwell delay when merging back into the travel lane after servicing the bus stop.
- Locations with inadequate pedestrian space.

Benefits:

- Increases transit operating speed by eliminating the need for merging into traffic.
- Increases boarding comfort.
- Increases riding comfort by eliminating the need for the bus to turn in and out of the stop.

- Increases available on-street parking by eliminating the need for the taper typically required for pullouts and bus zones.
- Increases space for additional pedestrian and transit rider amenities.
- Reduces street crossing distances for pedestrians.

Conditions:

- Suitable for roadways with on-street parking.

Experience/Results:

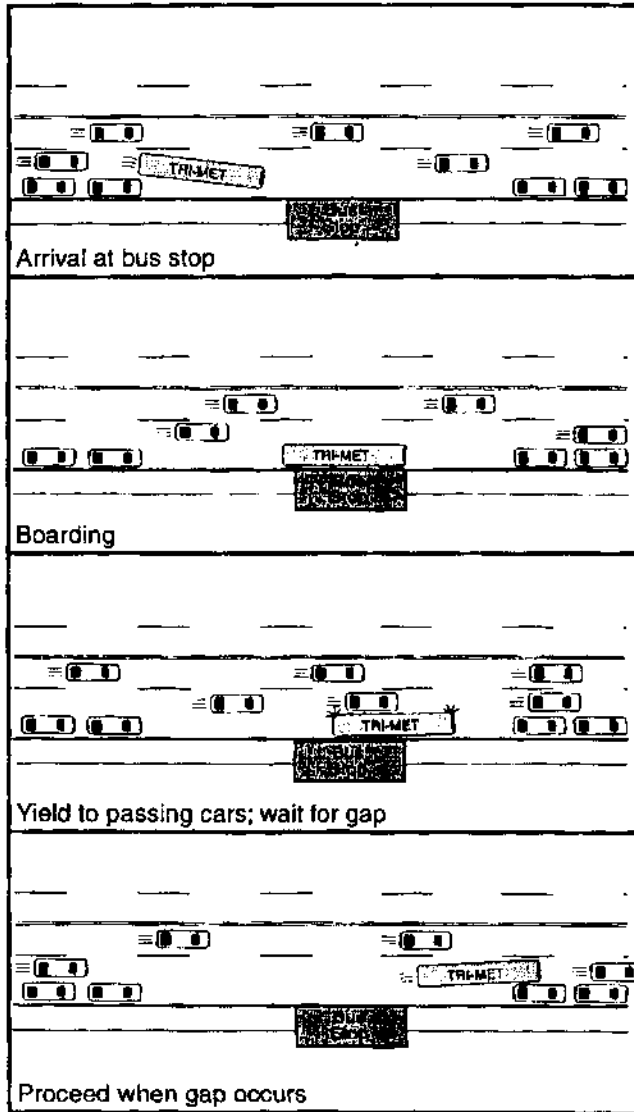
- Positive experience in Portland and other areas.

Caveats:

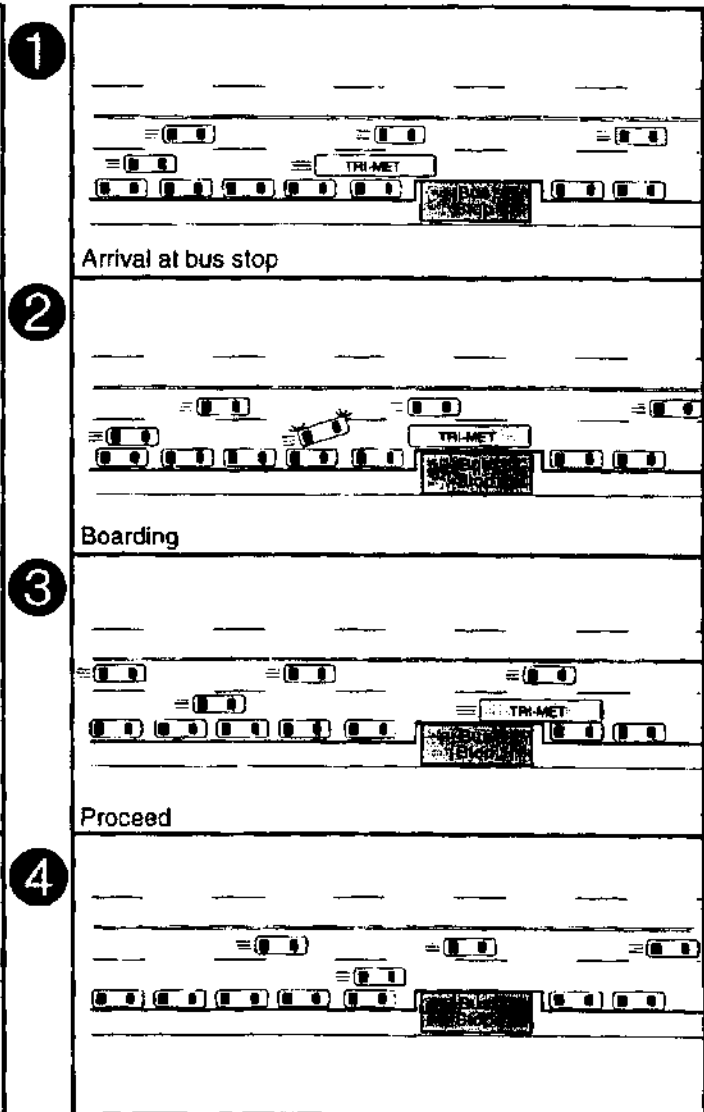
- Requires at least two travel lanes in the bus's direction of travel to allow other vehicles to pass the bus while it is stopped in the rightmost travel lane.

Description: Curb extensions create a "bulb" at a bus stop, usually the width of the parking lane, bringing the curb to the edge of the travel lane for passenger boarding and de-boarding.

Before



After



Boarding Islands

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Physical

Range:

Local

Applicability:

- Areas with high side friction caused by right-turning vehicles waiting at a crosswalk, delivery vehicles, parking maneuvers, etc.

Benefits:

- Increases transit operating speed by allowing buses to use the faster-moving left lane.

Conditions:

- The roadway must have at least two travel lanes in each direction, with a significant difference between left- and right-lane travel speed.
- There must be sufficient right-of-way to accommodate the introduction of the boarding island.

Experience/Results:

- Positive experience in San Francisco.

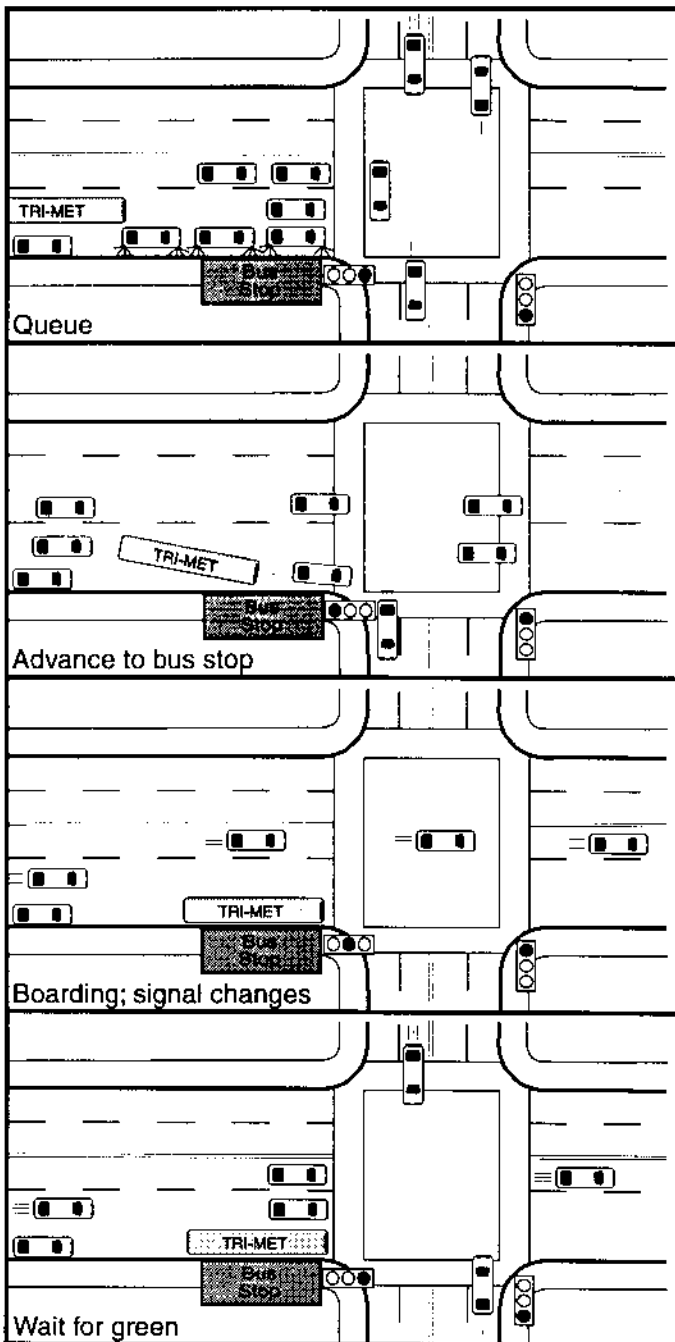
Caveats:

The following should be carefully examined before installation of boarding islands:

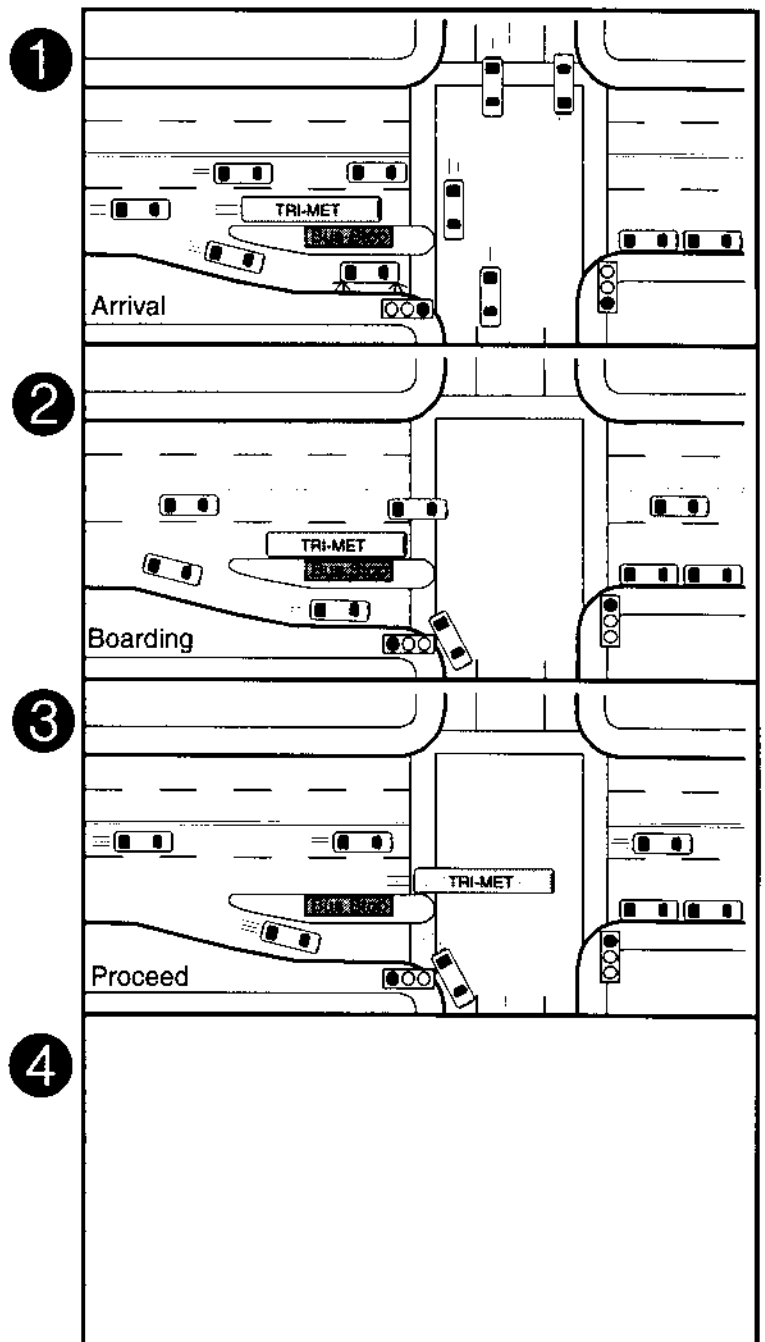
- Passenger accessibility and ADA requirements.
- Passenger comfort.
- Passenger safety.
- Effects on all bus and car movements.

Description: Boarding islands allow buses to operate in a non-curb travel lane without having to merge to the right lane to pick up or drop off passengers at the curb.

Before



After



Queue Bypass

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Physical

Range:

Local

Applicability:

- Intersection approaches with high through lane queue delay.

Benefits:

- Increases transit operating speed by reducing queue delay on the approach to the intersection.

Conditions:

The turn lane must be less congested than through lanes, and longer than the back of the queue.

Experience/Results:

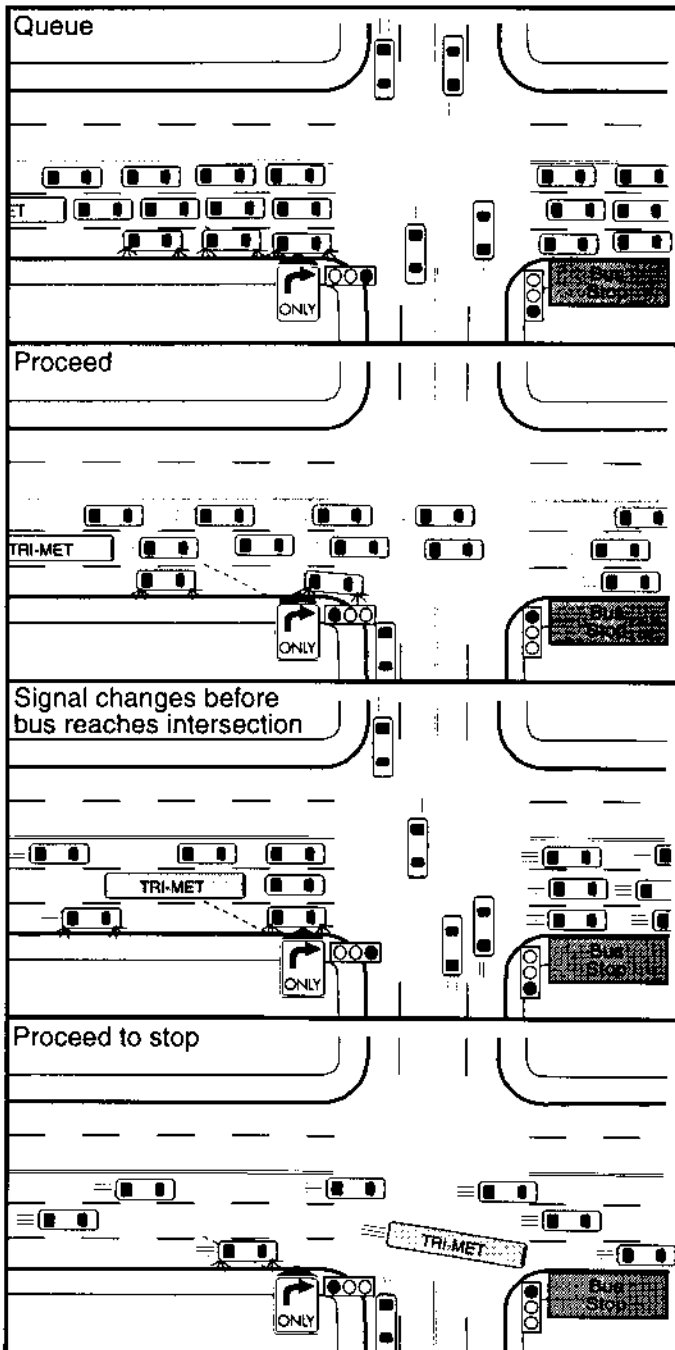
- Positive experience in Portland and other areas.

Caveats:

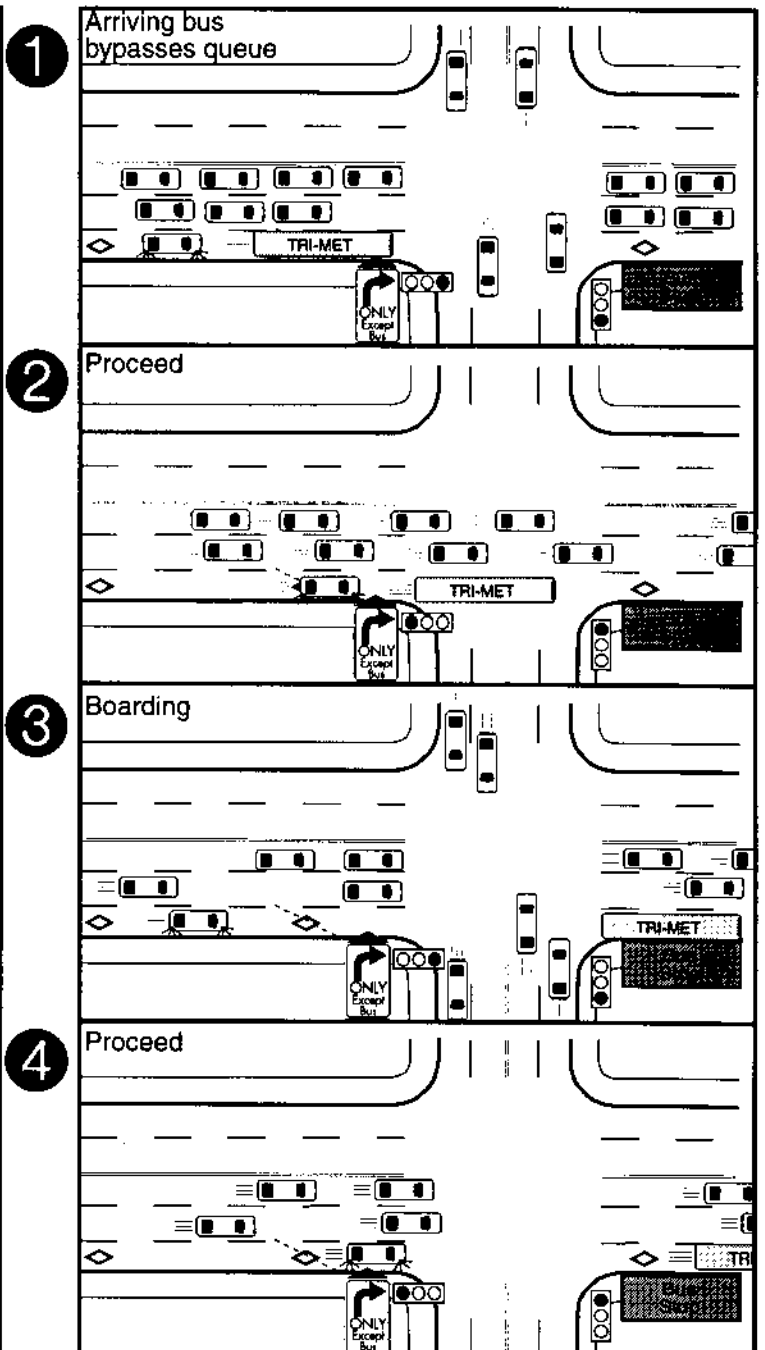
- Either a far-side refuge for the bus or Queue Jump is required.

Description: A queue bypass is a short lane used by buses to bypass traffic queues at signalized intersections. The bypass is usually a right-turn lane that allows through travel for buses only. In conjunction with Traffic Signal Priority, however, bypasses can also be created with left-turn lanes.

Before



After



Queue Jump

Type:

Operational

Range:

Local

Applicability:

- Where there is a Queue Bypass without a corresponding lane for the bus to enter on the far side of the intersection.

Benefits:

- Allows buses to merge into traffic at the end of a Queue Bypass.

Conditions:

- Applicable only in conjunction with Queue Bypass.
- Bus stop must be located on the near side of the intersection.

Experience/Results:

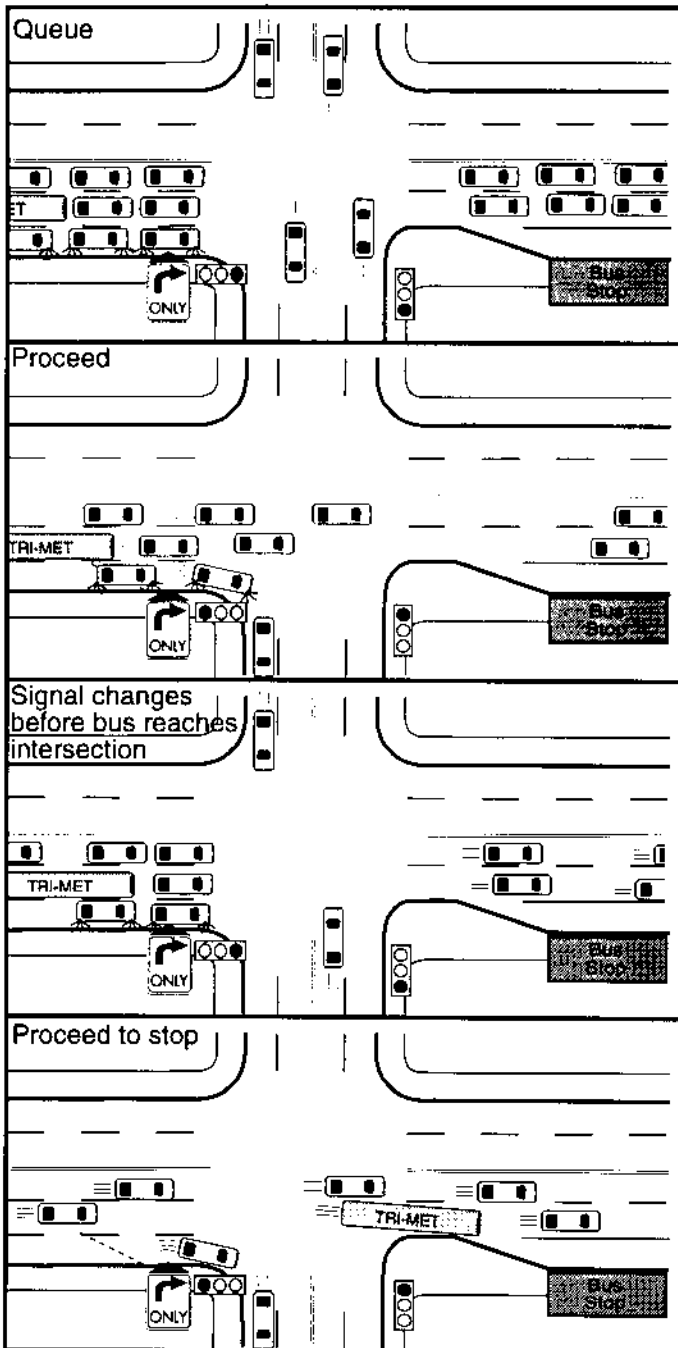
- Positive experience in Portland and other areas.

Caveats:

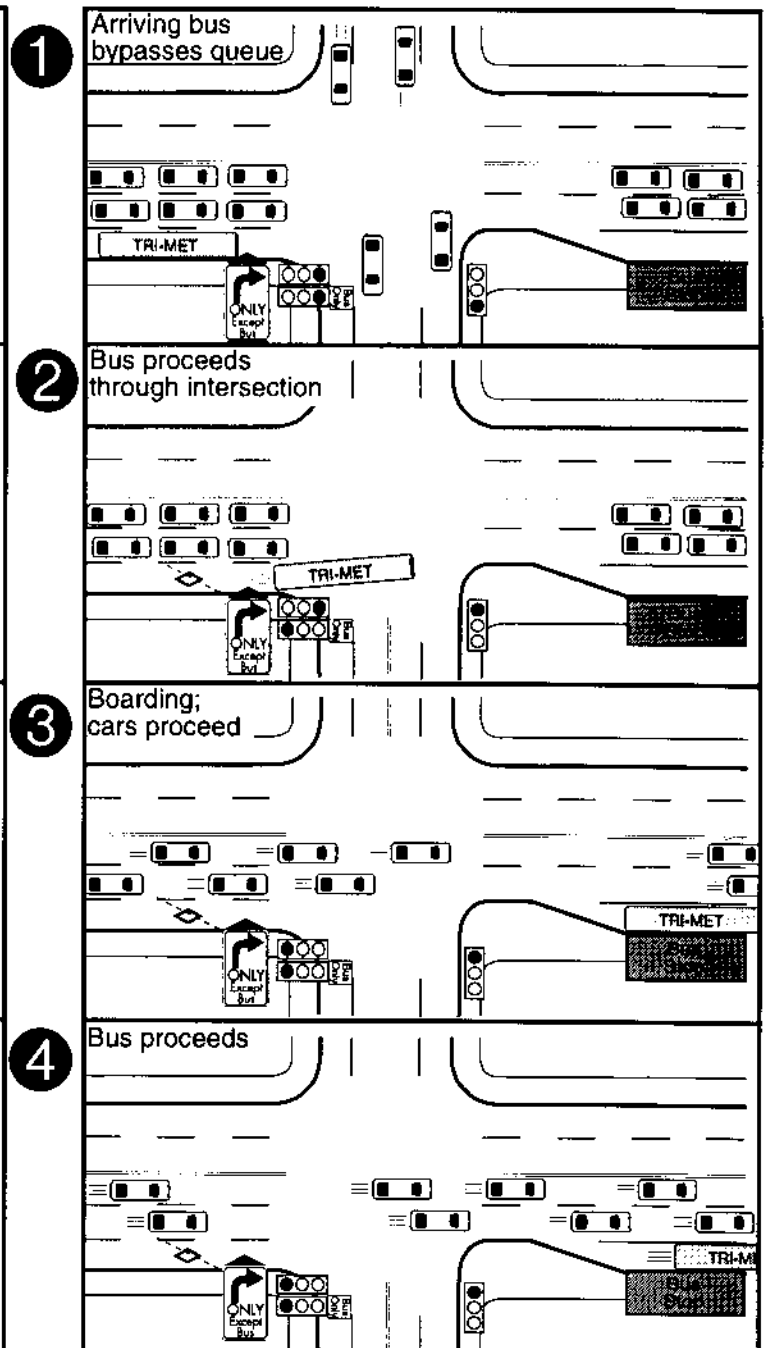
- Effective green time reduction may result in an unacceptable level of service at saturated intersections.
- Increased work load for bus drivers, who must watch the traffic signal closely to avoid missing their short period of green time.

Description: Used in conjunction with a Queue Bypass at the intersection approach, a queue jump allows buses to call for an early green phase that starts 2-3 seconds ahead of the normal green phase. This exclusive early green allows buses to proceed into the intersection and merge back into a mixed-flow traffic lane in front of regular traffic.

Before



After



Bus Stop Consolidation

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Operational/Physical

Range:

Corridor-wide

Applicability:

- Portions of bus routes with low average bus stop spacing.

Benefits:

- Increases transit operating speed by reducing the number of service stops.

Conditions:

A detailed land use and passenger flow analysis should be undertaken before attempting to eliminate or relocate bus stops to avoid creating hardships for passengers (especially senior citizens and people with disabilities).

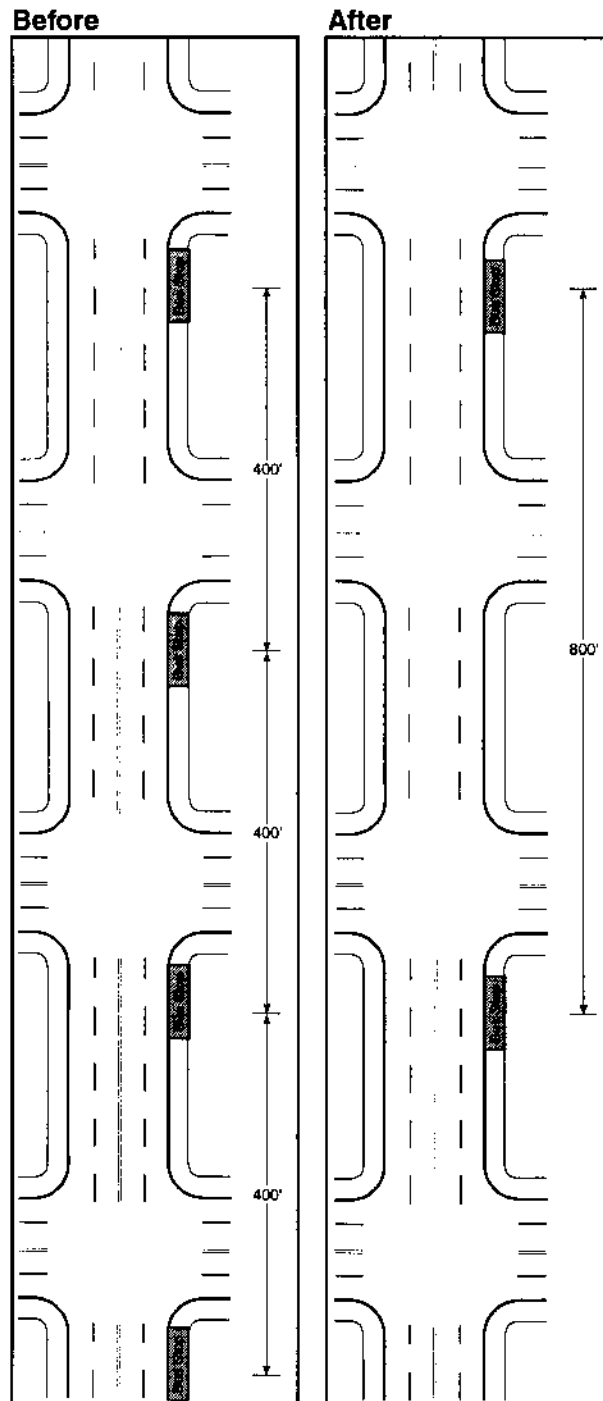
Experience/Results:

In San Francisco, analysis showed that consolidations on all major trunk and cross-town lines could eliminate up to 40% of all bus stops on some street segments, with an overall reduction of 10% to 15% per route. Initial analysis of some of the bus stop consolidation measures showed that an average travel speed increase of 4% to 14% could be achieved with a bus stop reduction of approximately 33%. The analysis also showed that ridership did not suffer as a result of this measure.

Caveats:

- Requires weighing of the needs of some patrons against the benefit of an overall reduced travel time for all passengers.

Description: Bus stops are consolidated to achieve an 800- to 1,000-foot spacing, rather than the standard 400- to 800-foot bus stop spacing of transit systems in the U.S.



Bus Stop Relocation

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Operational/Physical

Range:

Local

Applicability:

- Isolated intersections where proceeding through the intersection before stopping will eliminate missing the green after boarding or de-boarding passengers.
- Intersections with Traffic Signal Priority for transit vehicles.
- Corridors with good signal progression designed for automobile traffic.

Benefits:

- Increases transit operating speed.

Conditions:

- Adequate space for waiting passengers and station equipment (e.g., shelter).

Experience/Results:

- Positive experience in Portland and other areas.

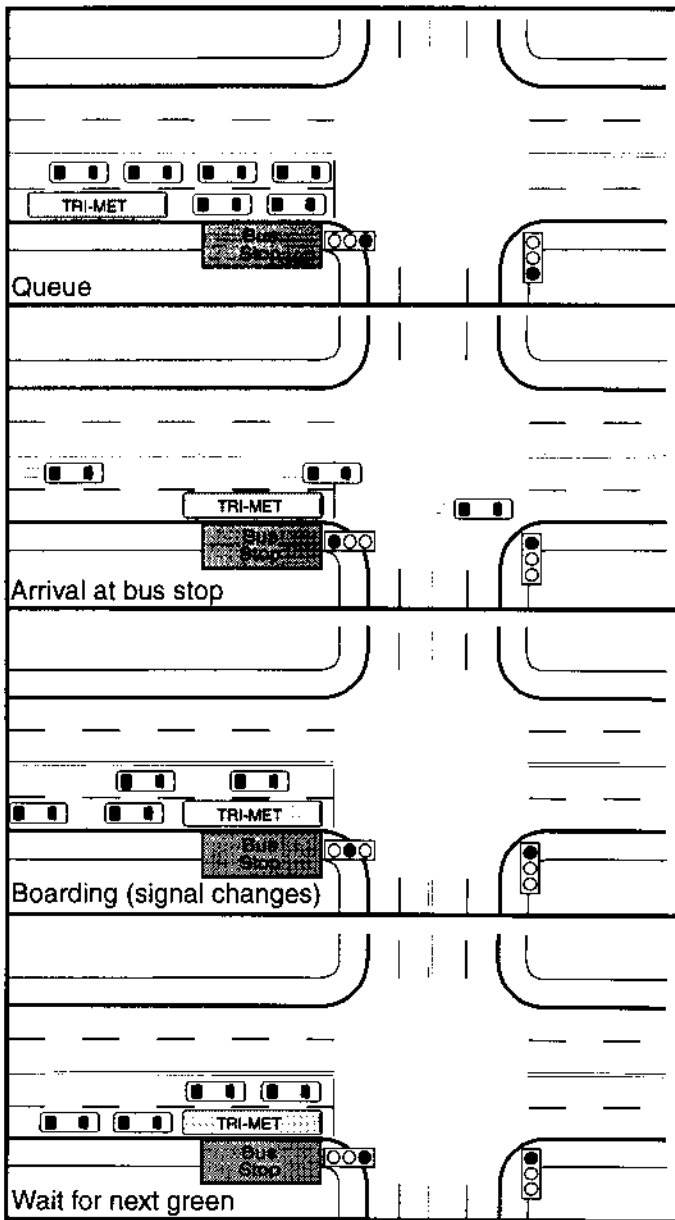
Caveats:

- Potential increase of walking distance for passengers transferring to a cross-street bus.

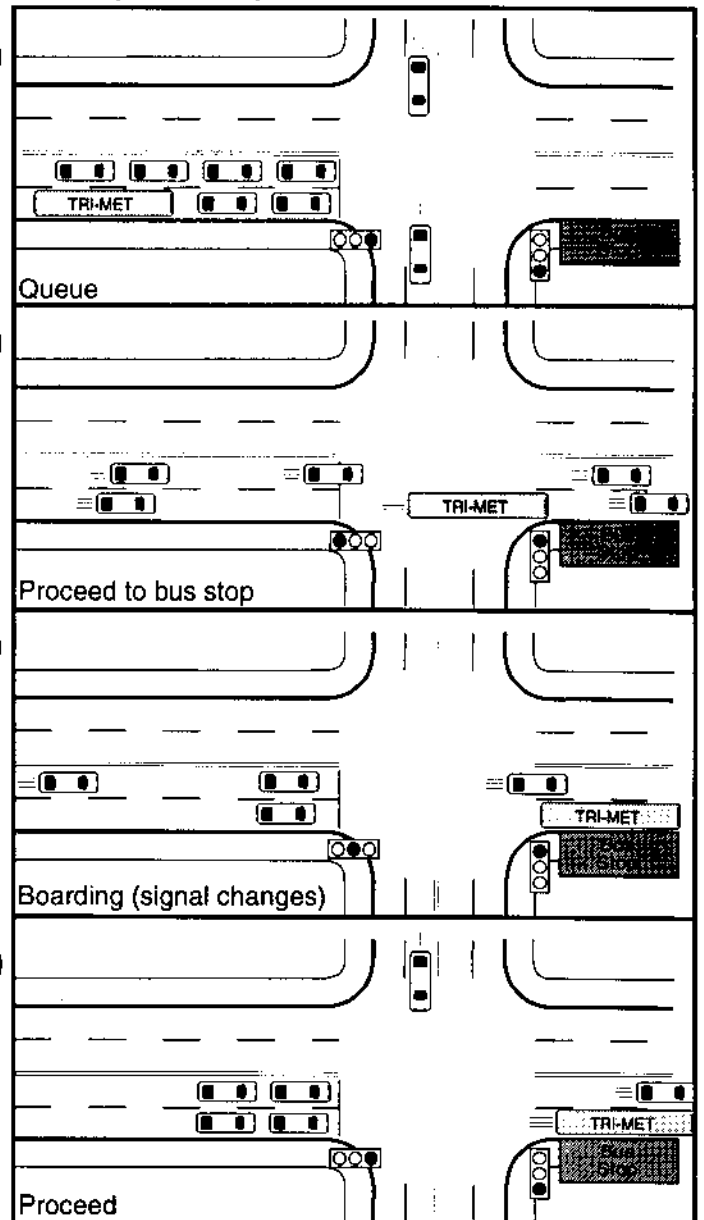
Description: The bus stop is relocated from the near side to the far side of an intersection, or vice-versa. With far side stops, traffic signal timing delay for buses is reduced because the bus proceeds through the intersection after the signal changes to green, then stops for boarding, and proceeds when ready. At near-side stops, buses arrive at the back of a traffic queue, proceed to the bus stop with the start of green and then stop for boarding. During

the boarding interval, the signal changes to red and the bus must wait for the next signal cycle. In a coordinated traffic signal environment, the alternation of near-side and far-side bus stops allows buses to use two consecutive dwell times to fall back into signal progression.

Before (near-side)



After (far-side)



Exclusive Bus Lane

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Physical

Range:

Local

Applicability:

- Areas with high congestion or side friction (delay caused by parking maneuvers, delivery trucks, etc.).

Benefits:

- Increases transit operating speed by reducing conflicts with parking cars, side friction, general congestion, and queues at traffic signals.
- Improves on-time performance.
- Increases transit visibility and recognition (marketing).

Conditions:

- Availability of a travel lane for exclusive use by transit vehicles. This may be an existing travel lane, or a lane created by eliminating on-street parking or new construction.

Experience/Results:

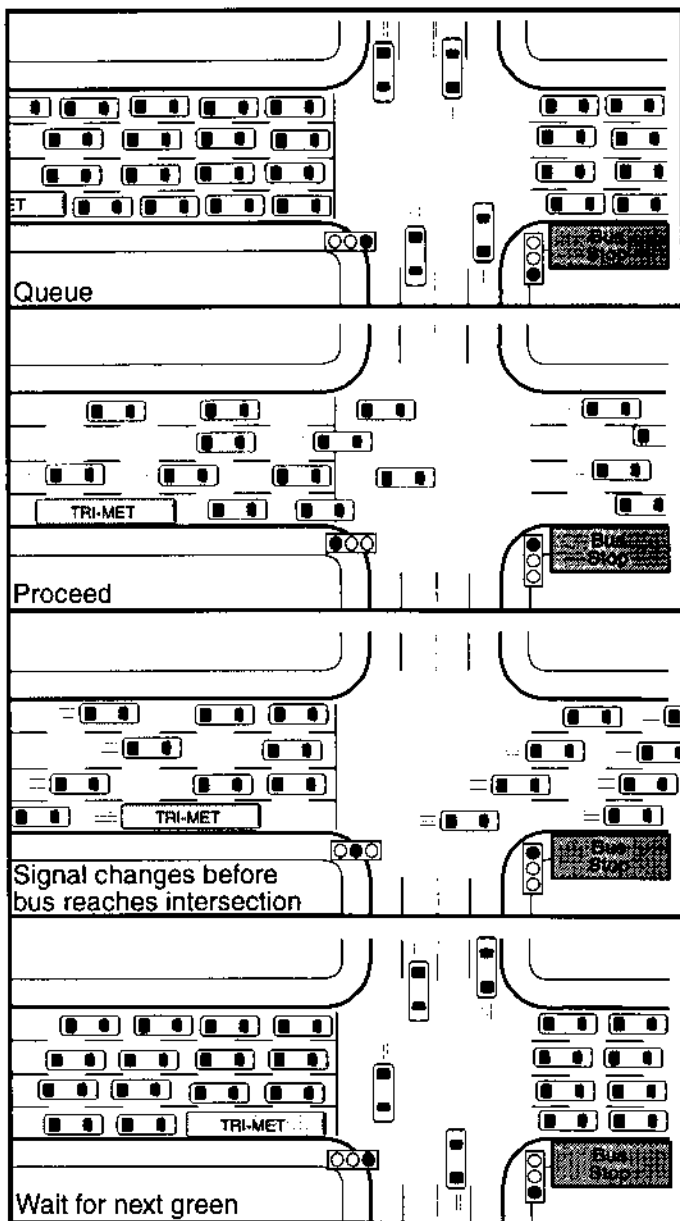
- Positive experience in San Francisco and other areas.

Caveats:

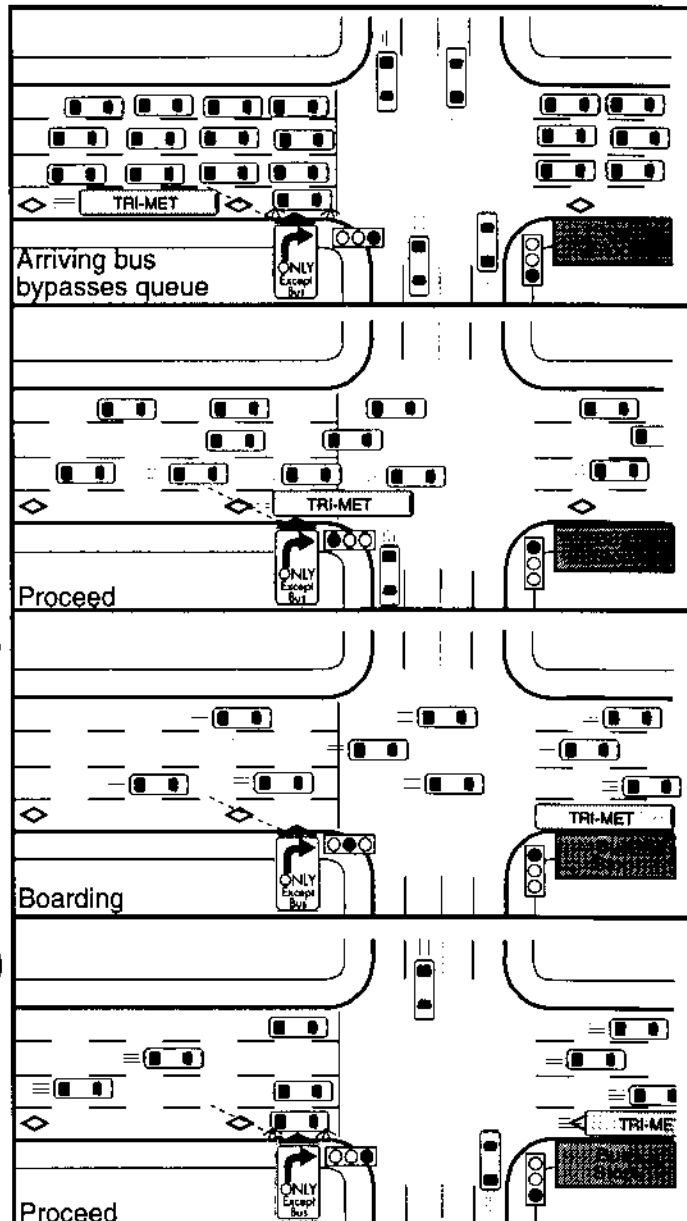
- Enforcement of exclusive bus lanes is difficult, in particular at curbside locations.
- Elimination of an existing travel lane or on-street parking may cause substantial impacts on nearby properties, particularly for uses that require on-street parking.

Description: Exclusive bus lanes are travel lanes reserved for use by transit or high occupancy vehicles (HOV) to bypass congested travel lanes. They can be operated during peak periods only, or throughout the day.

Before



After



Parking Restriction

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Physical

Range:

Local

Applicability:

- Areas with high side friction caused by parking maneuvers or delivery vehicles.
- To create right-of-way either for an Exclusive Bus Lane or a Queue Bypass.

Benefits:

- Increases transit operating speed by decreasing side friction caused by parking maneuvers.
- Increases riding comfort by eliminating the need for buses to pull in and out of the travel lane for boardings.

Conditions:

- Availability of a continuous curbside parking lane.

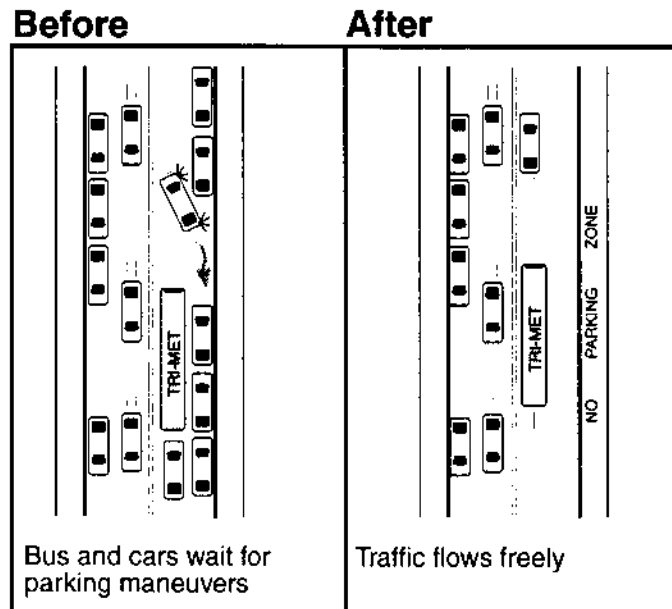
Experience/Results:

- Positive experience in San Francisco and other areas.

Caveats:

- Requires continuous enforcement.
- Potentially high impact on surrounding land uses (business or residential).

Description: Parking is restricted or eliminated along a segment of a bus route, either permanently or only for specified peak hours.



Low-floor Bus Technology

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Operational

Range:

System-wide

Applicability:

- Preferable on all bus routes.

Benefits:

- Increases transit operating speed by increasing passenger flow, thus reducing passenger service time.
- Increases transit operating speed by eliminating the need for a wheelchair lift.
- Enhances comfort, especially for senior passengers or passengers with physical disabilities.

Conditions:

- As a measure to reduce passenger service times, this strategy is only successful if implemented on entire bus routes.

Experience/Results:

- An average passenger service time reduction of 15 percent has been observed (according to the Ann Arbor Transportation Authority).
- Positive experience in other areas, and especially in Europe.

Caveats:

- The transit vehicle maintenance department may need to make major changes in order to accommodate the service needs of low-floor technology buses.

Description: *Low-floor technology on buses eliminates the need for passengers to negotiate steps for boarding and de-boarding.*



Photo provided by Tri-Met

Fare Collection Change

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Operational

Range:

System-wide

Applicability:

- Generally applicable to all transit systems.

Benefits:

- Increases transit operating speed by eliminating the requirement to pay the driver, thus reducing passenger service time.
- Increases transit operating speed by increasing passenger flow through boarding at both the front and rear doors, thus reducing passenger service time.

Conditions:

- As a measure to reduce passenger service times, the strategy is successful only if implemented on parts of a system, such as all express routes, rather than on isolated buses.

Experience/Results:

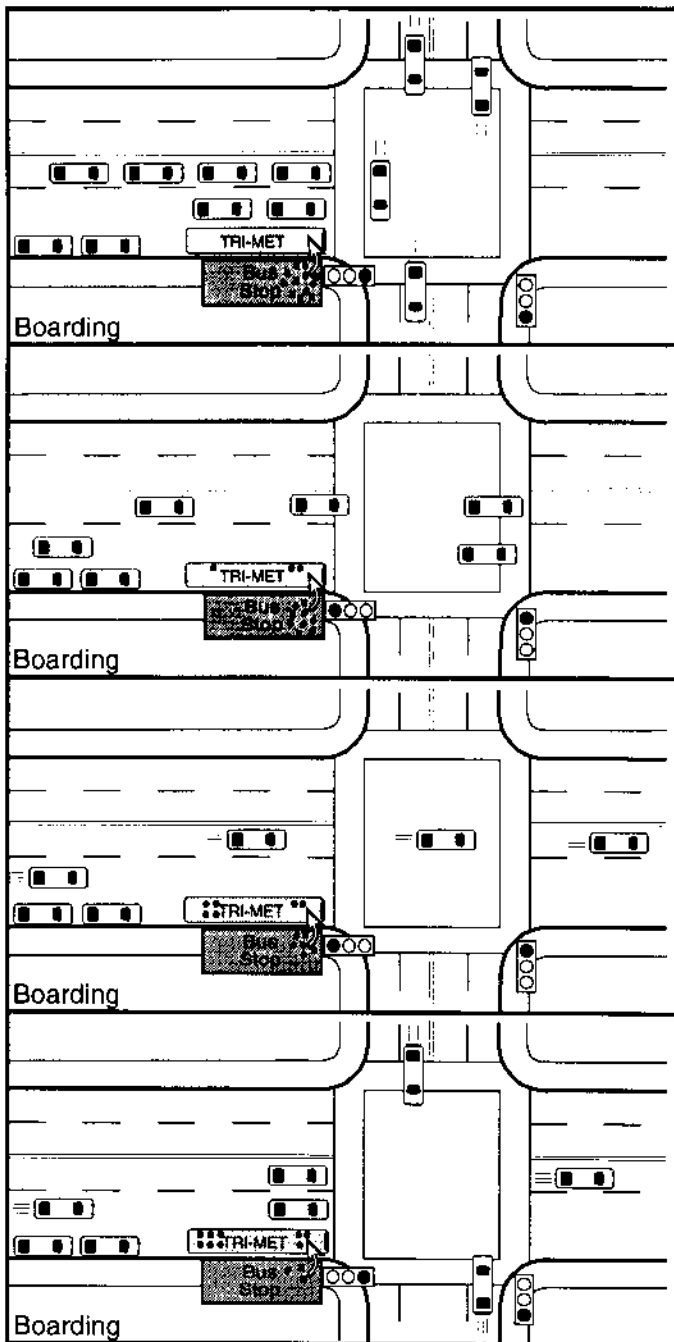
- Positive experience in other areas, especially in Europe.
- Negative experience with a Tri-Met test in the early 1980's (see Caveats).

Caveats:

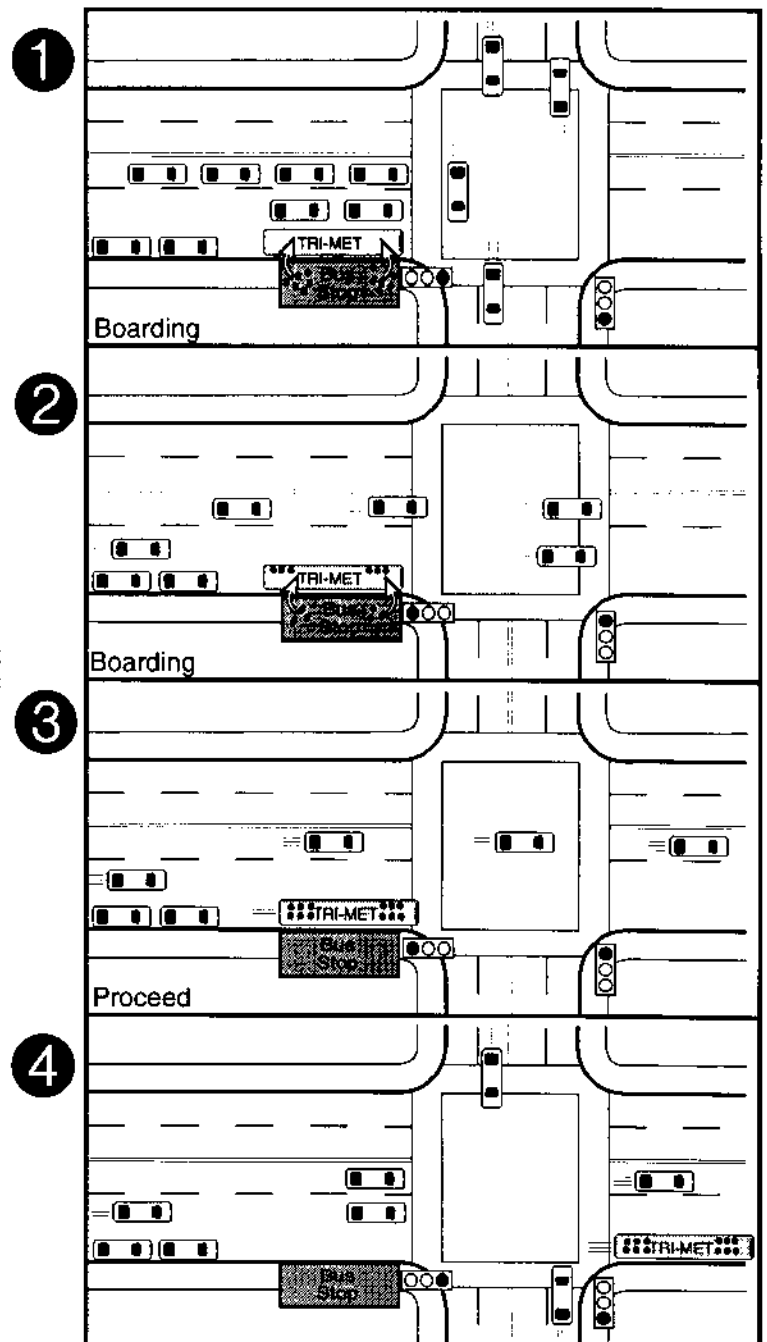
In 1980, Tri-Met received grants from the Urban Mass Transit Administration (predecessor to Federal Transit Administration [FTA]) to implement SSFC on its bus system. The SSFC system was implemented by Tri-Met in September 1982 and replaced with the traditional proof-of-payment system in April 1984. Tri-Met terminated the use of SSFC because of problems with fare evasion, high enforcement costs, unreliable fare collection equipment, low surcharge/fine collections, overburdened courts, and increased vandalism without measurable productivity improvements. State-of-the-art communication technology developed since that time, such as smart cards or proximity cards, has the potential to address most of these problems.

Description: A self-service fare collection (SSFC), or “honor” system, allows passengers to board buses or trains without proof of paid fare, in contrast to the traditional proof-of-payment system requiring patrons to either show their valid ticket or purchase one from the driver. New fare collection systems, using state of the art technology such as smart cards or proximity cards, combine the benefits of a self-service fare collection system with the enforceability and control of the traditional proof-of-payment system.

Before



After



Exemption from Turning Restriction

City of Portland Bureau of Transportation • Transit Preferential Streets Program Sourcebook

Type:

Operational

Range:

Local

Applicability:

- Intersections with turning restrictions.

Benefits:

- Increases transit operating speed by eliminating the need for detours.

Conditions:

- Appropriate for intersections where automobile traffic turning restrictions are warranted by congestion rather than as a result of traffic safety problems.

Experience/Results:

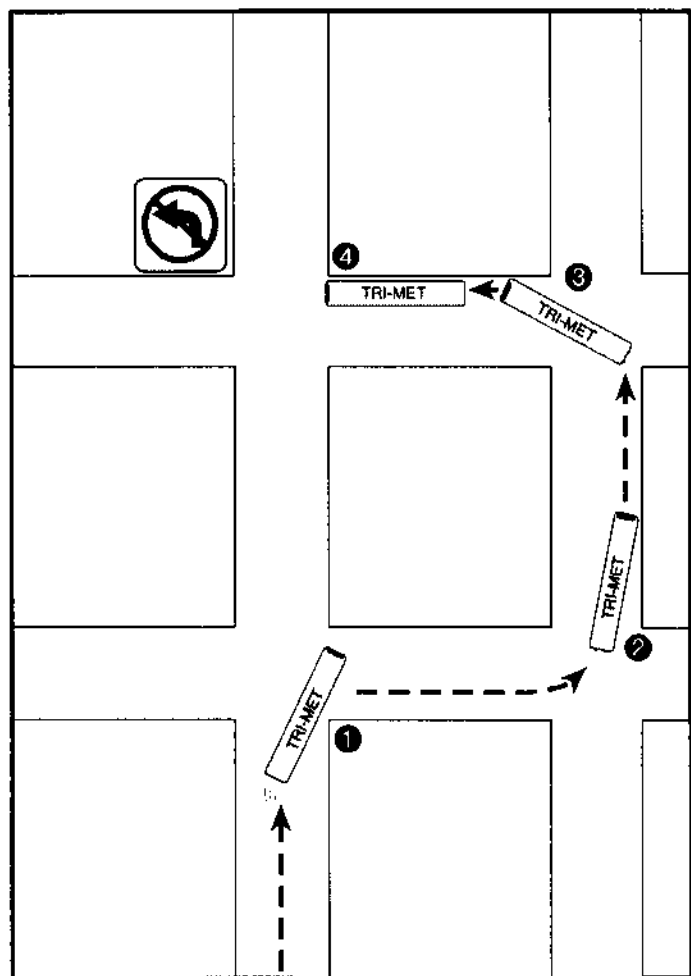
- Positive experience in San Francisco and other areas.

Caveats:

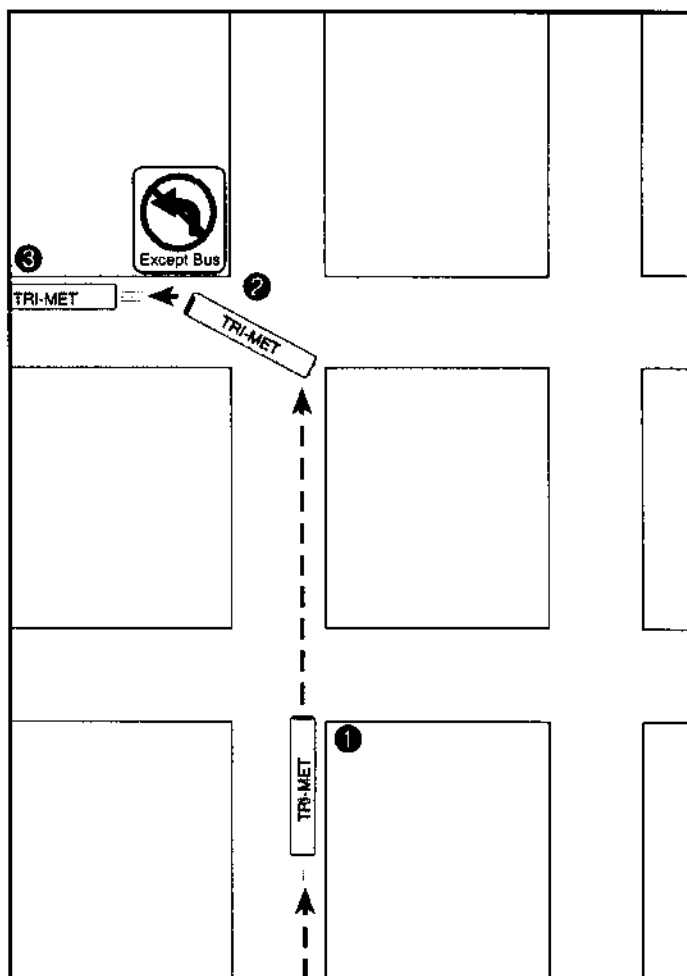
- Potential for traffic safety problems.
- Special bus-actuated turning phases may degrade intersection level of service.

Description: Buses are exempted from turning restrictions designed to improve overall traffic flow, such as left-turn restrictions on arterial streets without turning pockets. At signalized intersections, special bus-actuated turning phases may be warranted to exempt buses from turning restrictions.

Before



After





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