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Transit Signal Priority Demonstration Project Fargo-Moorhead Metro Area Transit

Final Report

June 2008

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Fargo-Moorhead Council of Governments

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BACKGROUND

The Metro Area Transit (MAT) provides public transportation to the cities of Fargo, Moorhead, and West Fargo. The service primarily consists of a fixed-route bus system; however, a paratransit service is also available. Currently, the bus system consists of 11 Fargo routes, 6 Moorhead routes, 1 West Fargo route, and 2 NDSU campus circulator routes. In addition, most of the routes operate using 30-minute headways. The agency would like to reduce the travel time for some of its routes. If travel times are reduced, MAT may be able to combine routes and expand service to other areas.

Transit signal priority has been used in large metropolitan areas for many years. Normally these areas have moderate to high transit demand and have bus headways of 15 minutes or less. Limited information is available for determining the benefits of TSP in smaller urban areas, such as Fargo-Moorhead. However, a study was conducted in 2001 by Kiel Ova and Ayman Smadi of the Advanced Traffic Analysis Center (ATAC) to determine the potential benefits of implementing TSP in downtown Fargo, ND (*1*). The study used a traffic simulation model (VISSIM) to evaluate various TSP strategies during two peak periods. The results of the simulation study and three other field studies are provided in the following sections. It should be noted that the results are more specific to the corridor where TSP was applied.

Evaluation of Transit Signal Priority Strategies for Small-Medium Cities, Fargo (1)

- 14% reduction in bus travel time
- 38% reduction in bus stop delay
- 14% increase in side-street person delay

Cermak Road Bus Preemption Study, Illinois (2)

- 8.2 sec/veh increase in cross-street stopped delay
- 83 sec (eastbound buses) and 12 sec (westbound buses) reduction in bus travel time
- 8% (eastbound buses) and 1% (westbound buses) reduction in bus travel time

King County Demonstration Project, Washington (3)

- 13% decrease (AM peak) to a 9% increase (midday peak) in non-transit traffic delay
- 34% (AM peak) and 24% (midday peak) reduction in intersection bus delay
- 8% reduction in bus travel time
- 13% decrease (AM peak) to a 8% increase (midday peak) in person delay

St. Cloud Transit Priority Evaluation Project, Minnesota (4)

- 43% reduction in bus delay caused by signalized intersections
- 24 bus riders were required to balance the person delay

OBJECTIVES

The main objective of the TSP implementation is to reduce the travel time of Route 11 by at least one minute. Travel time savings of one to two minutes may allow Routes 11 and 12 to be combined into one route. Other objectives of the study include the following:

1. Determining and installing the required hardware/software to the traffic signals and transit vehicles
2. Evaluating the before and after transit vehicle travel time
3. Documenting the lessons learned from the demonstration that may assist future implementations

TSP OVERVIEW

Transit signal priority is a tool to help the transit system become more reliable and cost effective. Using a variety of traffic signal timing hardware and control strategies, transit vehicles can incur less delay time at signalized intersections by giving them more right-of-way (priority) over other motor vehicles. Therefore, the transit vehicle may be able to complete its route in a shorter amount of time. However, there are usually negative impacts on other traffic that must be taken into consideration.

Preemption vs. Priority

Signal priority and signal preemption are often used interchangeably; however, they refer to different processes (note Table 1). Signal preemption interrupts normal traffic signal operation to service railroad crossings and emergency vehicles. This special control mode allows opposing signal movements (phases) to be shortened or skipped until the signal transfers back to normal operations. The objectives of preemption at railroad crossings are to reduce train/vehicle crashes, while emergency vehicle preemption reduces emergency response time, improves safety of emergency vehicle personnel, and reduces emergency vehicle crashes at signalized intersections.

Signal priority provides preferential treatment within normal control operation to service transit, emergency service vehicles, and commercial fleet vehicles. This strategy allows less drastic adjustments of opposing signal movements (phases) while providing some preferential treatment to the targeted vehicles. The objectives of signal priority, specifically transit signal priority, include reduced transit travel time (i.e., to improve schedule adherence) while minimizing the impacts to normal traffic operations.

Table 1. Signal Preemption and Priority Information

Signal Strategy	**Strategy Objectives**	**Typical Applications**	**Traffic Signal Operation**
Signal Priority	• Reduce transit vehicle travel time (improve schedule adherence)	• Transit vehicle passage • Commercial vehicle passage	• Preferential treatment • Does not disrupt normal control
Signal Preemption	• Reduce train/vehicle crashes • Reduce emergency response time • Improve safety of emergency personnel • Reduce crashes at signalized intersections	• Servicing railroad crossings • Emergency vehicle passage	• Transfers control to special mode • Does affect normal control

Transit Signal Priority Components

The major components used for a TSP implementation include transit vehicle detection and a traffic signal controller capable of responding to a signal priority request (note Figure 1). Transit vehicle detection (Pd) is a location upstream of the intersection where the priority request is sent to the traffic signal controller (C). The traffic signal controller processes the priority request and determines how to serve the request based on the defined priority control strategies (based on hardware/software capabilities). When the transit vehicle clears the intersection (Pc), the controller will then revert back to the normal signal timing parameters.

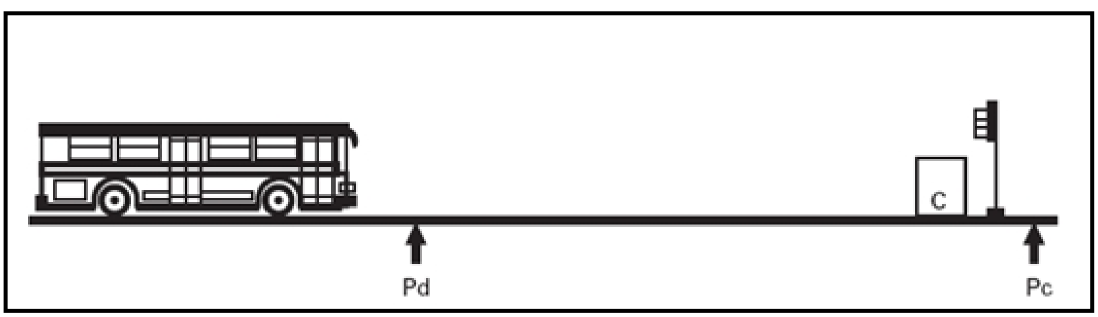

Figure 1. TSP Basic Components (*5*)

TSP Strategy Options

TSP objectives of reducing transit travel times can be met using several options, which include passive, active, and adaptive priority strategies. Passive and active strategies are the most commonly used strategies; therefore, these will be discussed further in the following sections.

Passive Priority

Passive priority strategies do not require any additional hardware or software for the transit vehicles or traffic controllers. This strategy attempts to benefit transit vehicle by retiming/adjusting signal plans to reduce travel time. Reductions in transit vehicle travel time may occur by providing signal coordination that favors transit vehicles and using shorter coordination cycle lengths.

Active Priority

Active priority strategies provide preferential treatment to a transit vehicle after the traffic controller detects the approaching vehicle. The controller responds to the priority activation (call) via two main strategies: 1) green extension, and 2) early green.

<u>Green Extension</u>

This strategy extends the green time for the movement (phase) having the transit vehicle. When the movement is displaying a green indication, transit vehicle detection extends the green interval allowing the transit vehicle to clear the intersection. Green extension is one of the most effective TSP strategies since it can prevent the transit vehicle from stopping at the signalized intersection.

<u>Early Green</u>

This strategy shortens the green time of preceding (opposing) phases when the transit vehicle is detected. If the movement with the transit vehicle is displaying a red indication, the controller will shorten the red interval of that movement by shortening (truncating) the green of the cross-street movements. Typically, early green and green extension strategies are available together within TSP environments but only one can be used per signal cycle.

FARGO TSP IMPLEMENTATION

Metro Area Transit (MAT) is always looking to expand its services to more areas of the metro area while maintaining its current headway, which is typically 30 minutes. The bus headway provides sufficient time for the bus to traverse its route and return to the main ground terminal center (GTC) or other transfer points. Each route has approximately 5 minutes of slack (buffer) time to ensure the buses stay on schedule. The slack time can be consumed by boarding/alighting (stop) frequency, stop duration, and traffic congestion.

Initially, two routes were identified to incorporate TSP: Route 11 and Route 15. However, traffic controller tests revealed significant traffic impacts would occur when using TSP along a major arterial, which Route 15 traverses, without performing significant modification to the traffic controllers (these impacts will be discussed later in this document). Therefore, Route 15 was removed from this study.

Routes 11 and 12 provide service to the north side of Fargo (Figure 2). The routes run parallel to each other (two blocks apart) for approximately two miles. Route 12 remains on 4th St. until 19th Ave. N. where it traverses east to Elm St. At Elm St., the route travels north to 32nd Ave. N. where it makes a loop using Cherry Lane and 35th Ave. N. prior to traveling back to the GTC. Route 11 remains on Broadway until 32nd Ave. N. where it circles back to Broadway prior to traveling back to the GTC. The route combination may allow MAT to create another route in a different part of the metro area using one of the buses that currently serves Route 11 or 12.

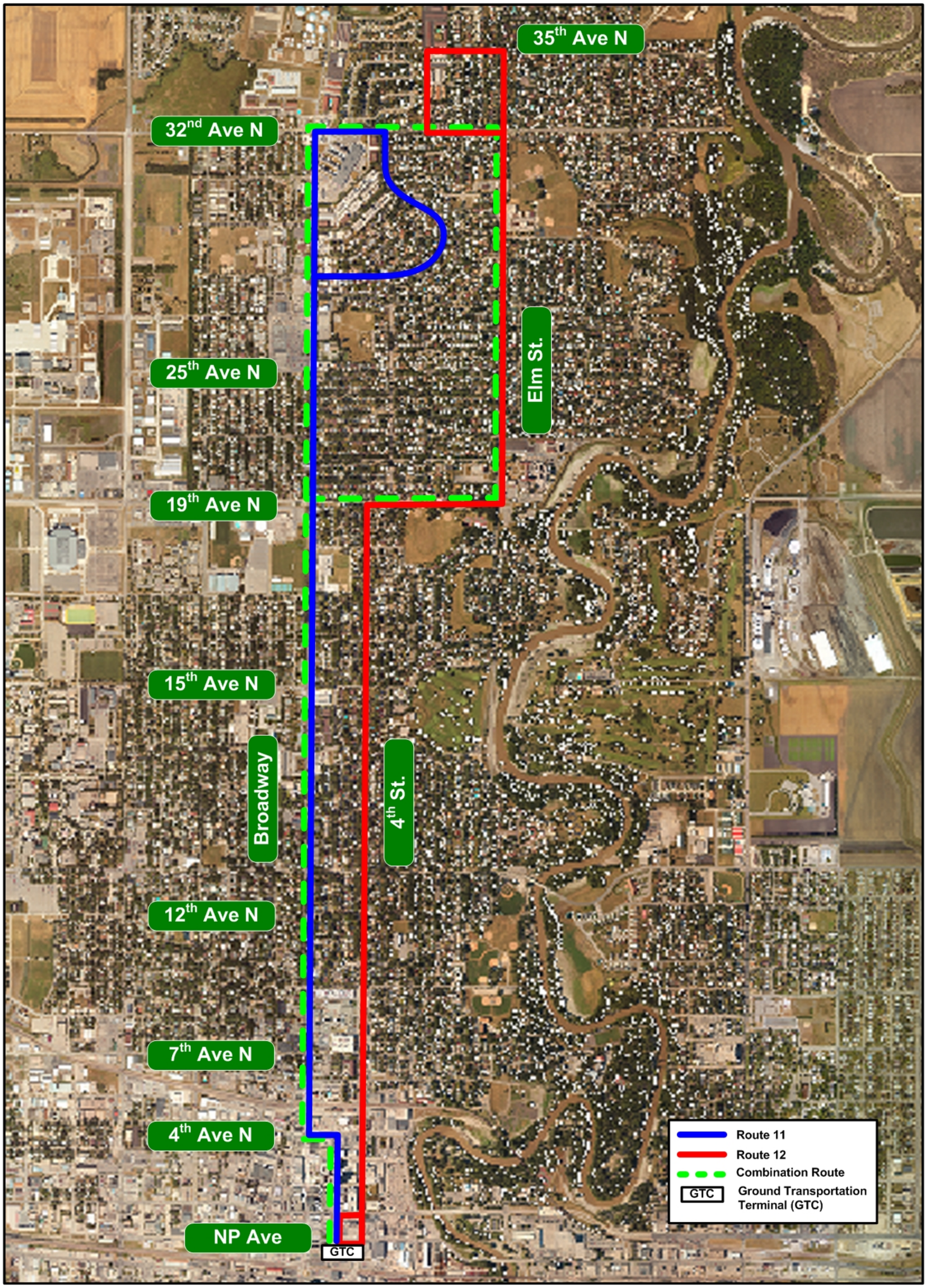

Figure 2. MAT Routes 11, 12, and potential combination route

Traffic Signal System

The City of Fargo uses Eagle traffic controllers (primarily NEMA TS 1) for the city's traffic signal system. Most of the signalized intersections incorporate vehicle loop detectors and operate as actuated-coordinated. Emergency vehicles are allowed to preempt the signalized intersection using the Opticom Infrared System. Therefore, implementing TSP would not require significant resources since the Opticom Phase Selector/Discriminator and Opticom Detector are already installed and configured. However, Opticom Detectors are currently installed for only the approaches that are relevant for the emergency route (primarily along the major streets).

Route 11 contains 13 traffic signals: 12 vehicle-actuated signals and 1 pedestrian-actuated signal. Most of these signalized intersections have some level of Opticom implementation (Figure 3). However, several of the approaches used by Route 11 do not have Opticom Detectors, which include the following:

- Broadway & 29th Ave. N. (westbound)
- Broadway & 4th Ave. N. (westbound and southbound)
- 5th St. & NP Ave. (northbound and southbound)
- 5th St. & 1st Ave. (northbound and southbound)

Implementing Opticom Detectors for these approaches should increase TSP performance. However, the city did not want to add additional hardware for the TPS demonstration.

TSP Signal Modifications

Although the Eagle EPAC300 traffic controllers do not have a specific TSP module/program, the controller handles a TSP call as a low priority call. Since TSP has not been used in the area before, the Advanced Traffic Analysis Center (ATAC) performed extensive traffic controller testing to determine the effects of implementing the system. The testing was performed using the exact signal timing parameters of two intersections: Broadway and 19th Ave. N. and 25th St. and 13th Ave. S. Using a controller interface device developed by ATAC (ATACid), low priority calls were placed during different times within the cycle length during the AM peak-hour coordination timing plan. The results of the signal controller tests are shown in Appendix A.

When TSP calls were placed during the green extension strategy, the previous signal phases would be skipped if the call was active too long (a constant call could hold the green indefinitely). Therefore, it was decided to use the max call parameter. A value of 10 seconds was selected based on a literature review and judgment by City of Fargo traffic engineering staff. When incorporating the max call time of 10 seconds, the preceding phase after the TSP call was only skipped if its phase split (green time, clearance interval, and change interval) was less than 20 seconds. An Eagle EPAC controller needs to have a phase split time of at least 10 seconds to serve that phase. Therefore, phase 3 is skipped for the intersection of 25th St. and 13th Ave., since only 9 seconds is available when the max call time is used.

In addition, the early green extension TSP strategy may also create some problems, especially with left-turn phases by providing short green time for non-TSP phases. When a TSP call is received while its phase is displaying a red indication, the signal cycles through the preceding phases by only providing the phase minimum time (vehicle or pedestrian). Therefore, the left-turn phases of 25th St. and 13th Ave. S. would terminate after one or three seconds even when demand for the phase exists. Due to the adverse effects to the left-turn phases of the major signalized intersections, Route 15 was removed from the TSP demonstration since this route has several major intersections having left-turn phases.

Based on the controller testing, data were entered for only two low priority parameters, which include max call and dwell phase. The low priority data used for the implementation included the following:

- Max Call = 10 seconds
- Dwell Phase(s) = 2 and 6 (main street approaches)

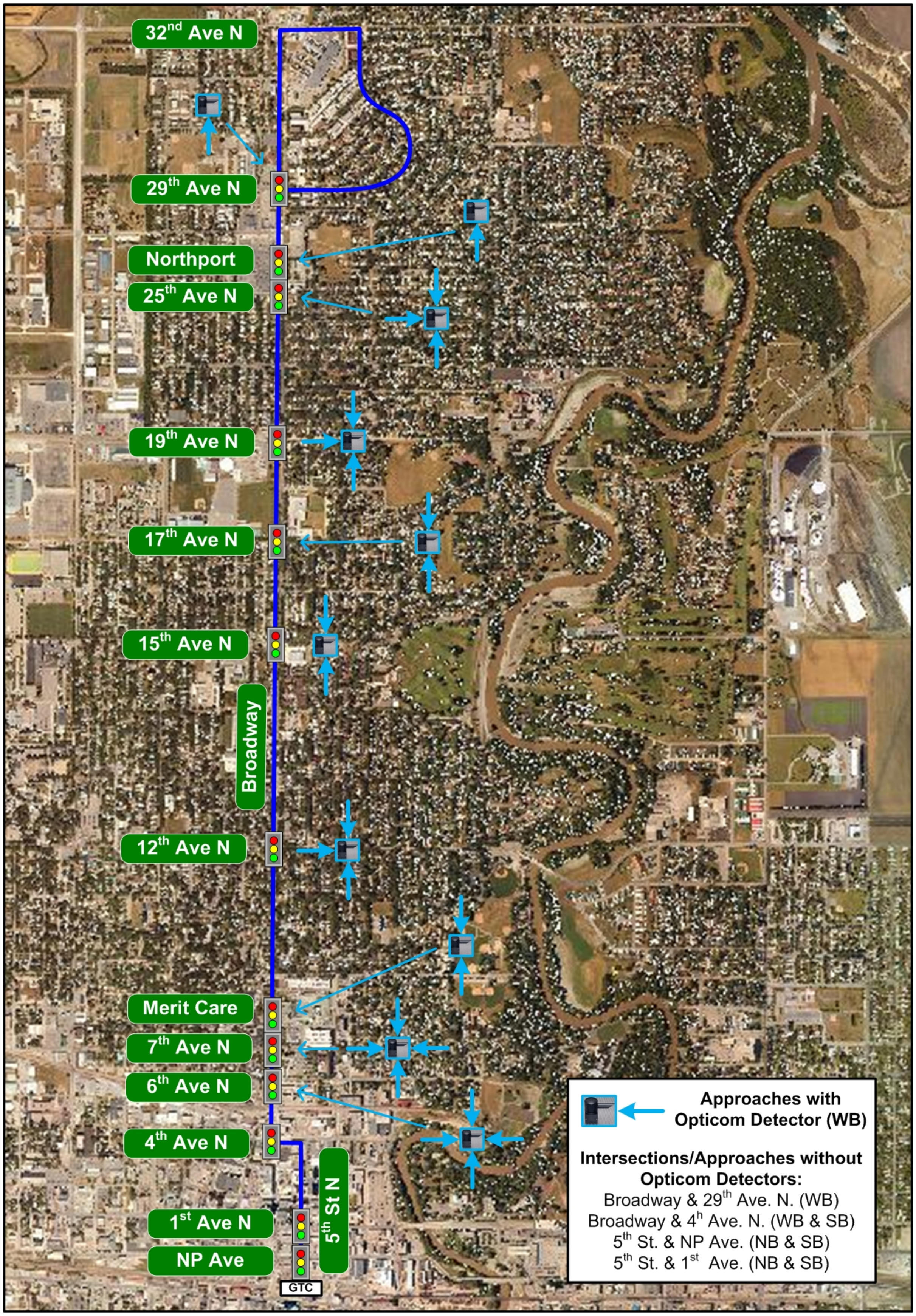

Figure 3. Preemption/priority detection equipment on Route 11

The max call parameter is critical to minimizing the impacts of the TSP call. If a non-zero value is not entered, the dwell phases could receive and maintain the green indication indefinitely. Although the threat of this occurrence is low, entering the appropriate max call time will ensure that the signal phases will not be skipped and coordination will be maintained. The dwell phase setting is used to establish which phase(s) receive the green time for the TSP call.

When using the max call time of 10 seconds, the controller of Broadway and 19th Ave. N. operated as expected by providing a green extension of up to 10 seconds and an early green of up to 3.4 seconds. An additional 6 seconds of early green could be realized if the controller didn't operate as dual coordinated, providing 10.4 seconds of early green. After the controller tests were completed, the TSP signal parameters were entered into the Eagle controller supervisor software (MARC NX) and downloaded to the required signal controllers from the traffic signal shop.

Bus Modifications

The buses that operate on Route 11 were installed with the required TSP hardware. Each day, two buses rotate among Routes 11, 12, and 17 (which has a 60-minute headway). These two buses and two additional buses had low priority emitters (Opticom Model 792T) mounted on the top of the bus and a switch (Opticom 793B Switch) mounted in the dash for activating the emitter (Figures 4 and 5). It should also be noted that the low priority emitter incorporated a visible light filter.

Figure 4. Bus equipped with Opticom emitter

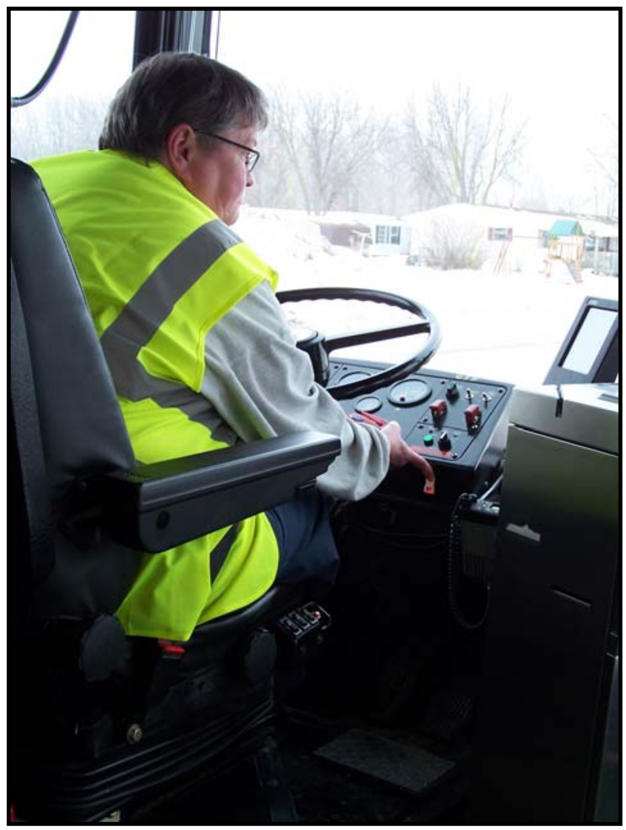
Figure 5. Operator using the emitter switch

TSP Range Setting

Setting the range for detecting the TSP call was performed by traffic engineering staff. An emitter (Opticom Model 792T) was installed on a service vehicle along with the range setting switch (Opticom 793R Switch). Using a speed limit of 25 mph, a max call of 10 seconds, and assuming an equipment response time of 1 second, the range was calculated and set at 405 feet from the approach stop line. The range was set by stopping the TSP equipped service vehicle in the travel lane 405 upstream from the stop line (which was already measured and marked by lathe) and turning on the low priority emitter. While this was being performed, another signal technician was at the signal cabinet to verify the call was correctly received.

TSP Field Test

After the appropriate hardware and parameters were installed/entered, a TSP equipped bus performed a test run. The test run incorporated staff from MAT, Fargo Traffic Engineering, and ATAC. The goal of the test run was to demonstrate how to properly use the TSP hardware and determine if any traffic signal issues would occur. The test went without incident; however, two unexpected issues were observed. First, the confirmation light at the TSP detector was illuminated when the emitter was turned on. This was not expected since TSP doesn't take control of the signal. The Eagle signal controller cannot disable the confirmation light directly, but the controller vender provided information on how to modify the signal cabinet to do so. Engineering staff decided not to modify the cabinet, which will assist the bus drivers in determining if the TSP call is received by the controller.

The second issue observed during the test run related to the delay between turning on the emitter and seeing the confirmation light illuminate. A more significant equipment delay time was observed than was initially anticipated. During the laboratory testing, a delay time of approximately a half second was observed; however, the field test determined a delay of approximately four seconds. Therefore, approximately three and a half seconds of delay/response time occurs between the Opticom Detector receiving the emitter signal and the priority call being placed to the traffic signal. Based on field tests, approximately one and a half seconds were required to verify/discriminate the TSP call by the Opticom Phase Selector. The remaining response time (two seconds) relates to the Opticom Phase Selector activating its output to the traffic controller as a low priority call. It should be pointed out that the discrimination component occurs when the emitter signal is initially received, but it doesn't activate the TSP output until the appropriate range has been achieved. For example if the emitter is turned on at 405 feet upstream from the approach, the signal controller will activate the TSP call 4 seconds later, which would be approximately 260 feet from the stop line (if traveling at free-flow speed). This would equate to seven seconds of green extension for the bus.

Bus Driver Training

Since the TSP call is performed manually by bus drivers operating Route 11, training was required to ensure proper use of the system. If the system is not used properly, the bus travel time for the route can actually increase. This occurrence is explained when a TSP call is placed during the green indication at an intersection approach having a near-side bus stop and a passenger waiting to be served. The traffic signal will extend the green time unnecessarily while the bus stops to pick up the passenger and will display a red indication by the time the bus finally approaches the stop line. Since the TSP call can only be served once per cycle, a second TSP call for the bus will be disregarded and the opposing movement will be served. The opposing movement's green time may be longer since these vehicles had up to 10 seconds longer to queue.

Bus drivers for Route 11 were given training by ATAC and MAT staff. Operating instructions were prepared by ATAC to illustrate how and when to place a TSP call and notes the signalized intersection approaches that are not equipped with TSP devices (Appendix B). ATAC staff presented the information to the drivers and discussed the capabilities and limitations of the system. MAT staff reinforced the operating instructions through both verbal and written methods. To assist drivers in determining the 405 ft distance to activate the emitter, traffic engineering staff placed cones adjacent to the travel lanes approaching a TSP equipped signal.

TSP Evaluation

The purpose of evaluating the TSP implementation is to quantify the impacts on both transit and traffic operations and document the lessons learned from this demonstration. This information will assist in determining the feasibility of future TSP implementations. Since traffic data were not collected during this study, it will only focus on the impact to the bus operation. It is assumed that TSP operation will negatively affect vehicular traffic for the opposing approaches. However, since this study occurred in a corridor with relatively low traffic volume, the side-street impact should not be significant. The tasks associated with the evaluation include the following:

- Analyze bus travel time information provided by MAT (before and after TSP)
- Analyze traffic controller reports related to priority calls (frequency)
- Document the findings

Bus Travel Time

Originally, the bus travel time comparisons were going to use the information collected by MAT. One of roles of the dispatchers at the GTC is to report the bus arrival time as they enter the bus stanchion. The main reason for this observation was to track how often the buses arrived late and those that were late enough to miss its transfer. It should be noted that the arrival time reported is not an exact measurement. The dispatchers report the arrival time in minutes and are rounded down to the nearest minute unless the next minute is within five seconds. In addition, the actual bus departure time is not reported. To obtain a more accurate bus travel time, the departure time for the routes used the larger of the scheduled departure time or arrival time of the previous interlining bus if it arrived late.

Due to some potential inaccuracies with the GTC arrival time information, ATAC staff obtained travel time information from a portable GPS device. Originally, the GPS data were going to be used for determining the potential improvements of TSP at the signalized intersections. However, it was also used to obtain bus travel time information. The antenna and recording unit were installed by MAT service technicians on a bus used for Route 11 (#1141). ATAC staff would go to the MAT garage in the evening to set up the travel time study and download the data, which were based on five-minute intervals. Due to several issues, which include GPS device technical problems, bus technical problems (electrical problems), and snow storms, usable bus travel time information was obtained from three days. The GPS unit was installed in a Route 15 bus and 5 days of data were collected. However, these data were not analyzed since the route was removed from the TSP deployment.

GTC Travel Time Results

Although the GTC arrival time is not as accurate as the GPS data, this information was compared due to the large sample sizes between strategies. The statistical tests for these data are to determine if the pre-TSP deployment travel times are statistically different than the TSP deployment travel times. The average travel time for the pre-TSP deployment (549 runs) and TSP deployment (587 runs) were 27:57 and 27:16, respectively. It was determined that the TSP deployment reduces travel time on Route 11. At a 95% confidence interval, travel time reductions using TSP will range from 21 seconds to 61 seconds (Table 2). Due to the lower fidelity in GTC travel time data, it was primarily used to determine that the TSP deployment provides travel time savings that are statistically significant.

Table 2. Route 11 Travel Time Results Using GTC.

	Pre-TSP Deployment (December 2007)	**TSP Deployment (February 2008)**
Avg. Travel Time	27:57	27:16
Standard Deviation	3:05	2:40
# of Samples	549	587
Difference in Means	:41	
Confidence Interval	95%	
Lower Bound	:21	
Upper Bound	1:01	

Using Large Sample Confidence Interval for (μ_1-μ_2): Independent Sample
Note: Recorded GTC time does not include seconds.

GPS Travel Time Results

Compared to the GTC travel time, GPS travel time provides a much higher level of accuracy but at a much lower sample size. Based on the GPS data, TSP deployment produced significantly lower travel times. The average travel time for the pre-TSP deployment (23 runs) and the TSP deployment (43 runs) was 27:22 and 25:13, respectively (Table 3). The difference between the means was 2:09. At a 95% confidence interval, travel time reductions using the TSP ranged from 1:16 to 3:02. This range exceeds the goal of a one minute travel time reduction using TSP.

Table 3. Route 11 Travel Time Results Using GPS

	Pre-TSP Deployment (December 2007)	TSP Deployment (February 2008)
Avg. Travel Time	27:22	25:13
Standard Deviation	2:08	1:28
# of Samples	23	43
Difference in Means	2:09	
Confidence Interval	95%	
Lower Bound	1:16	
Upper Bound	3:02	

Using Small Sample Confidence Interval for (μ_1-μ_2): Independent Sample

TSP Usage

Since the TSP system requires the bus driver to activate the Opticom emitter, the system's success is dependent on the proper emitter activation. A review of the traffic signal log files was performed on three occasions to get an idea of how often the emitter was used at the intersection of Broadway and 19th Ave. N. Since this intersection incorporates far-side bus stops, the driver should activate the emitter every time they approach the intersection from the south (outbound) and north (inbound). Typically, the controller's event log (Local Status Report) can retain several days of data before it is overwritten. However, the controller event log for the Broadway and 19th Ave. N. intersection contained unexplained gaps of as many as 10 days. Therefore, the last download only obtained a partial day of February 29th. Typically, the northbound approach had the highest level of usage, ranging from 71% to 100% (Table 4). The southbound approach had level of usage ranging from 54% to 88%. Overall level of usage for the five days ranged from 63% to 90%.

Variations in the levels of usage may be explained by a couple of reasons. First, bus drivers may use the emitter more northbound compared to southbound since it is a lot earlier in the route (approximately 1/3 of the route). If drivers feel they are ahead of schedule when they return to the intersection (inbound or southbound), they may not use the emitter. Second, variability in TSP usage may be a result of having several drivers assigned to the route. Continued driver reinforcement and training should assist in level of usage.

It should be pointed out that the level of usage at the intersection of Broadway and 19th Ave. N. does not necessarily mean that the emitter is activated appropriately at the remaining intersections along Route 11. While not related to this project, ATAC staff has witnessed the emitter switch left on while they rode a portion of Route 11. Since these occurrences were reported, a timer was implemented into the emitter switch. Power will be terminated to the emitter after 15 seconds after it is turned ON. To reactivate the emitter, power must be cycled OFF and then ON.

Table 4. TSP (priority) Calls from Signal Controller Log.

Date	Start Time	End Time	Max TSP Calls (NB)	Actual TSP Calls (NB)	Level of Usage (NB)	Max TSP Calls (SB)	Actual TSP Calls (SB)	Level of Usage (SB)	Overall Level of Usage
Feb. 4, 2008	615	1845	24	18	75%	24	16	67%	71%
Feb. 5, 2008	615	1845	24	17	71%	24	13	54%	63%
Feb. 16, 2008	615	1845	24	21	88%	24	21	88%	88%
Feb. 18, 2008	615	1845	24	19	79%	24	13	54%	67%
Feb. 29, 2008	1015	2115	20	20	100%	20	16	80%	90%

LESSONS LEARNED

As with any system implementation, several issues/problems arise throughout the process. The goal is to minimize and overcome these issues in a timely manner or change the course of action. The biggest issue that was identified during the TSP implementation related to how the traffic signal controller responded to the TSP call. Initially, the TSP was going to evaluate Routes 11 and 15. However, controller testing provided valuable insight related to the impacts of non-TSP phases at critical intersections along Route 15, which disqualified it from having TSP. Several other lessons were learned during this study, which are listed below:

- Traffic Signal Controllers (Eagle EPAC300) Operation with TSP call
  - Phases less than 10 seconds will be skipped if they follow a TSP phase
  - Phase (non-TSP) will only receive minimum green during the early green strategy

- Traffic Signals with Preemption but without TSP
  - Program Opticom Phase Selector to disregard TSP call (otherwise acts as high-priority call)
    - (14 controllers in Fargo had to be adjusted to eliminate the preemption possibility)

- Equipment Response/Delay Time
  - 4 seconds (verify/discriminate call, phase selector output, and traffic controller output)

- TSP Hardware
  - Range setting distance should account for equipment response/delay time
  - Incorporate a timer to deactivate an emitter that was left ON.

- Agency Notification
  - Inform local police department about TSP (citizen concerns)
  - Inform police, fire departments, and ambulance services about TSP (staff concerns)

RECOMMENDATIONS

Although the TSP evaluation has shown to provide statistically significant benefits to Route 11, several factors will continue to play a role in maintaining the travel time reductions. Factors that MAT and Fargo's Traffic Engineering Department can control relate to equipment and bus drivers. TSP audits can determine if equipment and/or driver issues are evident. Recommended tasks for assisting in continued benefits from TSP include the following:

- Equipment Maintenance
  - Clean emitter lens daily
  - Clean detector annually
  - Replace emitter bulbs every three years

- Driver Training
  - Provide quarterly education to current bus drivers and adequate training for new drivers

- TPS Audits
  - Perform travel time measurements annually – incorporate bus GPS
  - Download traffic signal log files annually – determine driver level of usage

This study illustrated that the TSP demonstration on Route 11 was successful in reducing bus travel time. According to the GPS data, travel time savings could be realized by 1:16 to 3:02 at a 95% confident interval. Additional benefits may be realized if Opticom detectors are installed at the previously identified intersections. Signal timing adjustments for the intersections of 5th St. and NP Ave. and 5th St. and 1st Ave. N. may provide additional benefits to the Route 11 travel time. It should also be pointed out that higher gas prices have caused an increase in ridership. A continued increase in ridership may result in more frequent and longer stops, causing longer route travel times.

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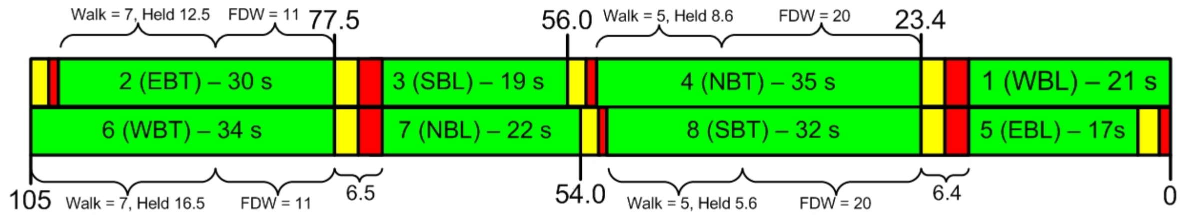
Appendix A: TSP Traffic Controller Tests
25th St. and 13th Ave. S and Broadway and 19th Ave. N.

TSP Impacts at 25th St. and 13th Ave. S.

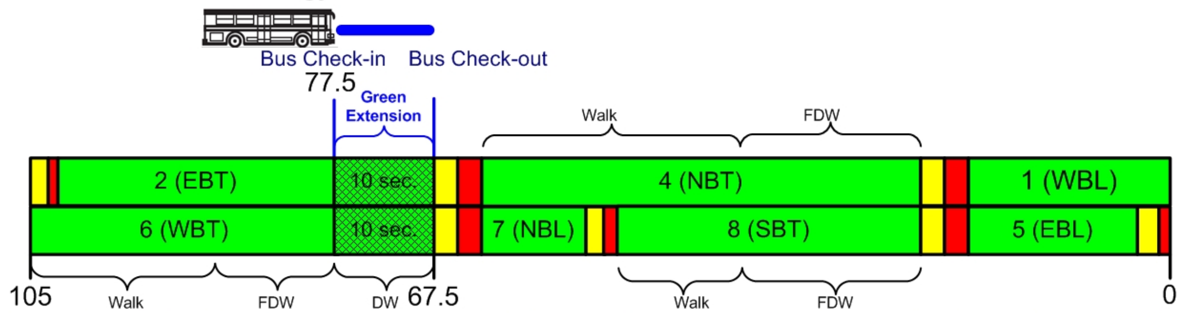
Bus Phases: Phases 2 and 6 (east and west)

Timing Plan: AM Coordination Plan (1/1/1), Dual Coordination, TSP functions (Dwell in 2 & 6, Max Call of 10 sec.)

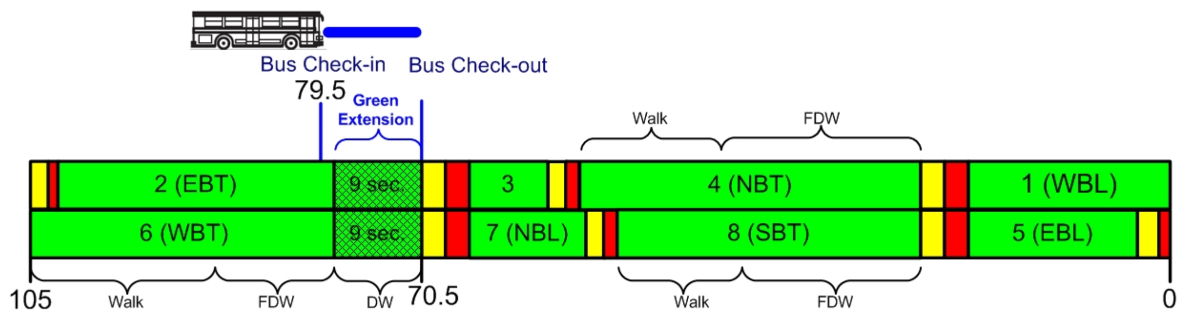
Minimum Green
Phases 1, 3, and 5 = 1 sec
Phases 2, 4, 6, and 8 = 15 sec
Phase 7 = 5 sec



Green Extension Strategy

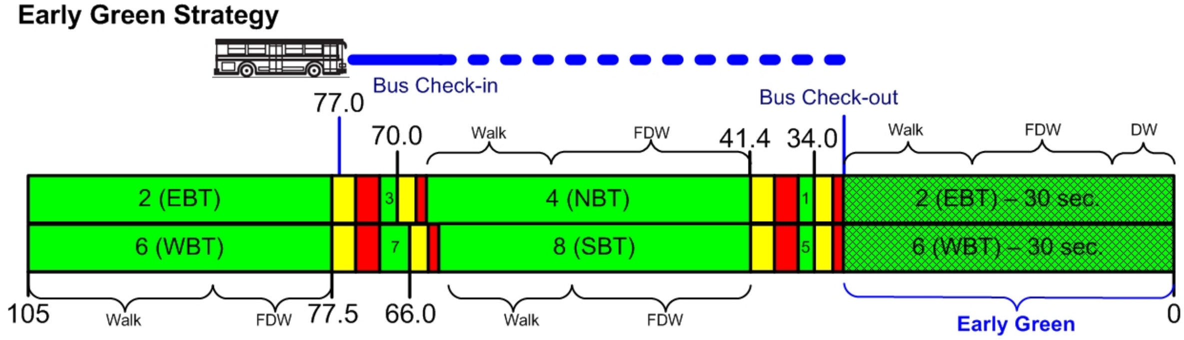


Result: TSP call will extend phases 2 & 6 up to 10 seconds (by borrowing from phases 3 & 7), then proceed to phases 4 & 7. Phase 3 is skipped since the split time remaining after TSP phases is less than 10 sec. The remaining phases follow their assigned force offs.



Result: TSP call will extend phases 2 & 6 up to 10 seconds (by borrowing from phases 3 & 7), then proceed to phases 3 & 7. The remaining phases follow their assigned force offs.

Early Green Strategy

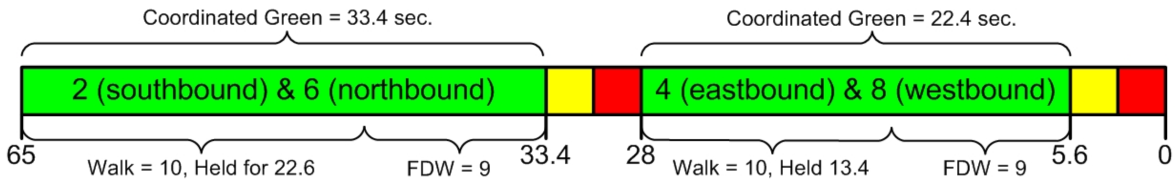


Result: TSP call will provide an early green of 30 sec. to phases 2 & 6 by giving the minimum time (greater of vehicle or pedestrian time) to non-TSP phases.

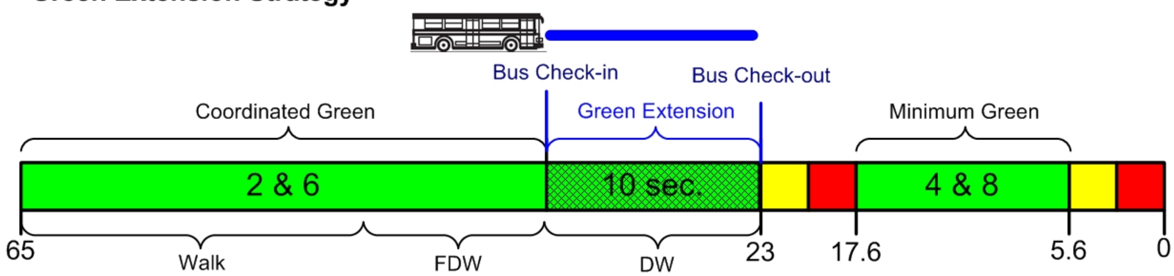
TSP Impacts at Broadway and 19th Ave. N.
Bus Phases: Phases 2 and 6 (north and south)

Minimum Green
Phases 2, 4, 6, and 8 = 12 sec

Timing Plan: AM Coordination Plan (1/2/1), Dual Coordination, TSP functions (Dwell in 2 & 6, Max Call of 10 sec.)

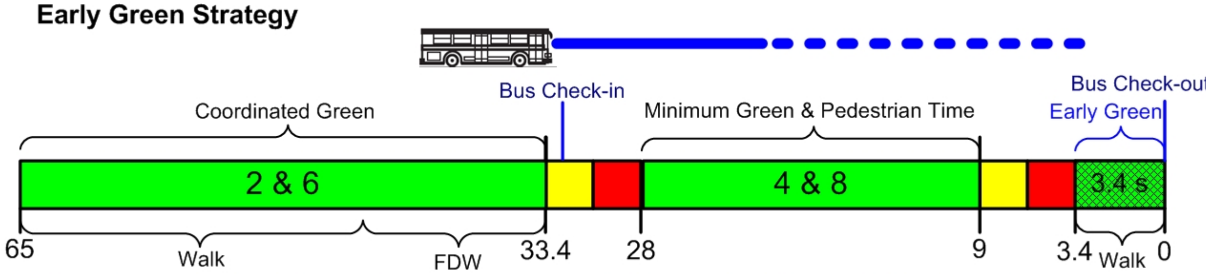


Green Extension Strategy



Result: TSP call will skip pedestrian phases 4 & 8. If TSP call occurs prior to a cycle time of 40 sec., pedestrian phases will not be skipped (since pedestrian time can be satisfied).

Early Green Strategy



Result: TSP call will provide an early green of 3.4 sec. to phases 2 & 6 by giving the minimum time (greater of vehicle or pedestrian time) to non-TSP phases. If dual coordination wasn't used, phases 2 & 6 would receive 10.4 sec. of early green (skip pedestrian phases).

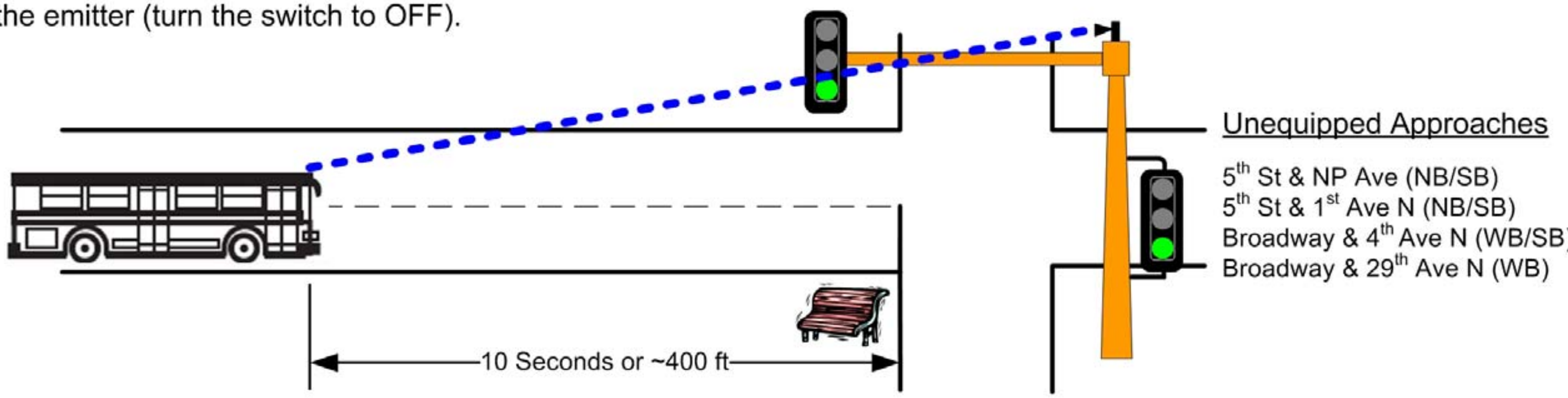
Appendix B: Operating Instructions for Transit Signal Priority

Transit Signal Priority – Operating Instructions

Fargo Route 11

Case 1: Bus Approaches Green Signal Indication

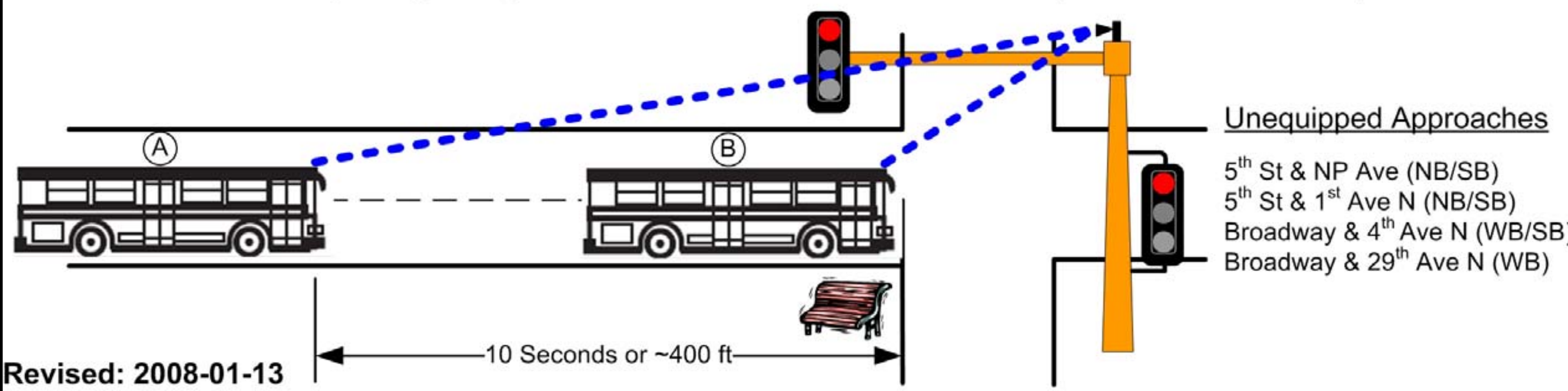
When the bus is 10 seconds away (~400 ft) from the intersection and passengers are not present at the near side shelter/stop, activate the emitter (turn switch to ON position). After passing through the intersection, deactivate the emitter (turn the switch to OFF).



Case 2: Bus Approaches a Red Signal Indication / Stopped at a Red Indication

A) When the bus is 10 seconds away (~400 ft) from the intersection and passengers are not present at the near side shelter/stop, activate the emitter (turn switch to ON position).

B) If passengers are present at the location, activate the emitter (turn switch to ON position) after they have boarded the bus. After passing through the intersection, deactivate the emitter (turn the switch to OFF).



Revised: 2008-01-13