ON STREET TRANSIT PRIORITY MEASURES – PUTTING BUSES FIRST IN WINNIPEG

David Wiebe, P.Eng. Associate, Dillon Consulting Limited (presenter)
Dave Krahn, P.Eng. Partner, Dillon Consulting Limited

200-895 Waverley Street
Winnipeg, Manitoba   R3T 5P4
Tel: 204-453-2301
Fax: 204-452-4412
www.dillon.ca
dwiebe@dillon.ca, dkrahn@dillon.ca

Paper prepared for presentation at the
Transit Plans and Planning: How They Support Sustainability Session
of the 2008 Annual Conference of the Transportation Association of Canada
Toronto, Ontario

1 ABSTRACT

In February 2006, the City of Winnipeg approved a comprehensive plan of transit improvements for implementation. The improvement plan included new buses, upgraded stations, intelligent transportation system applications, transit priority measures, as well as park and ride facilities. While several of the initiatives were system-wide, others were focused on major arterial streets with high levels of transit service. These streets have been designated as "Quality Corridors".

Dillon Consulting Limited was retained to study and implement the transit priority measures. This included a study of eleven Quality Corridors, modeling the traffic and transit patterns, analyzing possible transit priority measures, and implementing the recommended measures through construction. This report presents a case study of the impacts of the transit priority measures in the first three Quality Corridors of the program: Pembina Highway; St. Mary's Road; and St. Anne's Road. This was Phase I of three phases.

Transit priority measures are one of the few strategies that can be used concurrently to attract passengers with moderate capital costs. Improvements in speed and reliability make transit travel more competitive with automobile travel and attract ridership. A decrease in bus running times due to priority measures can lead to higher operating speed and reduced delay, which can translate to more reliable service, decreased delays, fuel consumption, and emissions from idling vehicles. Increased ridership can further result in reduced emissions and congestion from the reduction in passenger cars on the roadway.

There are many ways to provide priority to on street transit over regular traffic. A variety of items in the "toolbox" are necessary to be able to address different situations. Retrofitting an existing arterial or collector street to include transit priorities usually means issues with traffic volumes, restricted right-of-way, traffic signal spacing, and adjacent parking and access. There is no "one size fits all" solution to promote transit. Measures can include dedicated bus lanes, bus-only links or "shortcuts", queue jumps, transit priority signals, and even optimization of existing signal phases for transit.

In general, transit priority measures were implemented within the Corridors without unduly impacting general traffic movements. In this way, the gap in speed between transit and other traffic was narrowed and transit can become more attractive to commuters. This reduced delay, idling, and emissions for all modes, is a benefit to the community and contributes to a more sustainable city.

2 INTRODUCTION

2.1 Background

The City of Winnipeg (Winnipeg) has had mass transit in various forms over the years. Early systems date back to 1882 when horse drawn carts on tracks moved down the major routes. This was followed by an extensive system of electric streetcars, trolleys, and finally diesel buses that service almost all areas of Winnipeg.[1] As Winnipeg has grown, so has traffic congestion, travel times, and delay for all motorists. This affects transit users as well. In light of increasing fuel costs, the environmental impact of motor vehicles, and increased congestion on the transportation infrastructure, the need for transit to be more competitive and attractive is more important than ever. By improving transit service, ridership should increase which has a positive impact on the community, environment, and a more sustainable future.

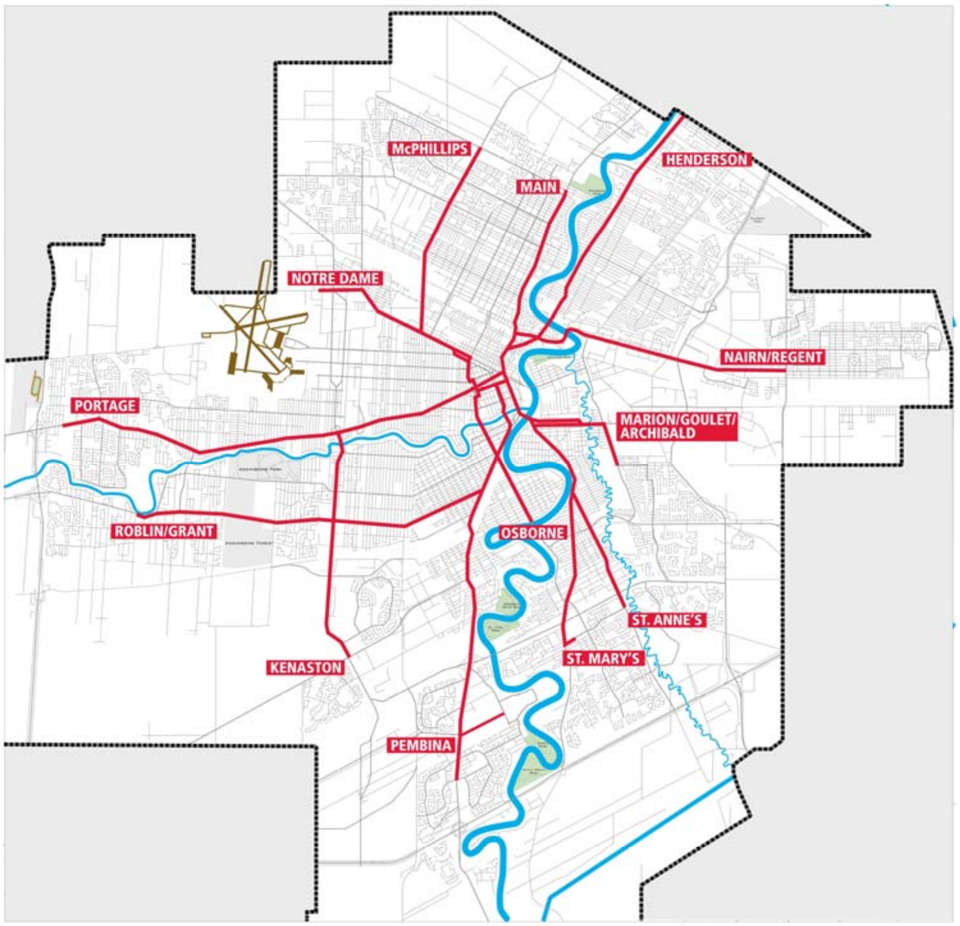
The City of Winnipeg has a long term plan for Bus Rapid Transit (BRT) including dedicated busways separate from the existing roadway network. Theses busways would greatly increase the speed and reliability of service. Portions of the BRT network have already undergone preliminary and final design.

In addition to BRT, Winnipeg is in the midst of implementing city-wide "Quality Corridors". These Quality Corridors are major arterial routes with significant transit presence. Upgrading transit facilities and service along these routes also increases the viability and attractiveness of transit. These Quality Corridors were reviewed to determine whether any of the following potential improvements could be implemented:

- A combination of dedicated transit lanes, diamond lanes, transit signal priority, and other transit priority measures to enhance operating efficiency, improve schedule adherence, and increase transit operating speeds;
- Enhanced passenger facilities with off-vehicle fare collection and real-time schedule information; and,
- State-of-the-art vehicle technology.

Dillon Consulting Limited (Dillon) was retained by Winnipeg to study the Quality Corridors, model the traffic patterns, analyze possible transit priority measures, and implement the recommended measures through construction. This report presents a case study of the impacts of the transit priority measures in the first three Quality Corridors of the program: Pembina Highway; St. Mary's Road; and St. Anne's Road. This was Phase I of III phases.

Figure 1: City of Winnipeg Transit Quality Corridors



2.2 Project Rationale

Transit priority measures are one of the few strategies that can be used concurrently to attract passengers with moderate capital costs. Improvements in speed and reliability make transit travel more competitive with automobile travel and attract ridership. A decrease in bus running times due to priority measures can lead to higher operating speed, which can translate to fewer buses providing the same frequency of service, and decreased delays and emissions from idling vehicles. Alternately, the same number of buses can be used to provide more frequent service in travel Corridors, which can allow and translate into increased ridership demand. Increased ridership also results in reduced emissions and congestion from the reduction in passenger cars on the roadway.

It is recognized that transit can carry person-trips more efficiently than regular traffic from a street capacity point of view and should therefore be given priority. For example, one regular bus has the ability to carry over 40 passengers, while two passenger cars take up the same space on the roadway, but likely only have one passenger each. Priority to the bus reflects the much higher passenger trips possible from this mode. It is a more efficient use of resources. [2]

Optimizing the use of existing infrastructure through transit priority measures creates an affordable option for a rapid transit concept to meet performance objectives. The objectives of the Transit Priority Measure implementation were:

1. To make the speed of transit service more competitive with the speed of automobile traffic in the same travel Corridor. Where the average speed of transit is significantly lower than that of adjacent automobile traffic, diamond lanes, queue jumps, and transit priority signals can make transit service more attractive.
2. To reduce variability in bus running times. If transit service along a street segment is highly susceptible to delays created by traffic congestion and other causes, running time variations make the service less reliable. For passengers, this results in unpredictable waiting times at downstream stops and longer travel times and missed transfer connections for those already on board.

Increasing speed, reducing variability, and reducing delay has the added benefit of reducing greenhouse gas emissions and fuel consumption for the transit fleet. It was also found that by optimizing the traffic signal timing for transit along the Quality Corridor, that signal timing was also reduced for non-transit motorists, furthering the benefits to the community.

3 TRANSIT PRIORITY MEASURES TOOLBOX

There are many ways to provide priority to on-street transit over regular traffic. A variety of items in the "toolbox" are necessary to be able to address various situations. Retrofitting an existing arterial or collector street to include transit priorities usually means issues with traffic volumes, restricted right-of-way, traffic signal spacing, and adjacent parking and access. There is no "one size fits all" solution to promote transit. The following section outlines measures that are being considered on the various Corridors in Winnipeg. [3]

3.1 Bus Lanes

Affectionately called "diamond lanes" due to the diamond symbol used on signage and paint markings, these lanes are reserved for transit operations, and sometimes also designated for cyclists and high occupancy vehicles. The bus lane can be located on a paved shoulder, in the curb lane, median, or even as a contraflow lane. In the Quality Corridors in Winnipeg, restricted right-of-way and median width limited the analysis of bus lanes to conversion of existing curb lanes. Issues to consider for this measure include heavy right turning traffic which may limit the effectiveness, loss of capacity for regular traffic if converting a lane, and parking restrictions.

3.2 Bus-Only Link

To avoid areas of congestion or facilitate access to transit only facilities, such as a station, short bus-only lanes can be constructed. These may allow a transit vehicle to shortcut and bypass regular traffic through an area. Issues to consider for this measure are signage and pavement markings to prevent unauthorized use, and driver education and enforcement.

3.3 Queue Jumps

A queue jump is a short transit only lane, usually at a congestion point such as an intersection. It allows a bus to bypass the queue of traffic and re-enter the mixed use lane in advance of vehicular traffic. Typical applications for this study included using an existing right turn deceleration lane to bypass the through movement queue, then "cutting back" a pedestrian island to create a queue jump at the intersection. Buses then proceed and merge through the intersection, or have a dedicated Transit Priority Signal Phase so they proceed ahead of the through queue. Issues to consider for this measure include increasing pedestrian crossing distances by cutting back islands, congestion in the right turn lane that negates the benefit, and property acquisition to lengthen turn lanes to adequately bypass queues.

3.4 Transit Priority Signals

Intersections are the primary source of delay for all vehicles on street. Providing a dedicated signal phase for transit movements can provide a significant reduction in delay and travel times. Other options include signal pre-emption, advance detection of buses, or extending a green phase when a bus is detected. Some of these options require specialized detection or GPS equipment to communicate with the signal controller. Providing a queue jump lane allows for traditional detection methods such as induction detector loops, or other vehicle sensors that do not have to be aware of the type of vehicle. A Transit Priority Signal Indicator (TPSI) is used on the signal head to indicate a transit only phase. Issues to consider for this measure are pedestrian crossing times and their impact on altering phasing, reduced capacity for other movements when green time is assigned to transit, and detector and controller technology.

3.5 Traffic Signal Optimization

In addition to specific transit priority signals, general optimization of the signalized intersections on a Corridor can provide benefit to transit as well as regular traffic. Maintaining timing plans that account for current traffic volumes and splits, progression through the Corridor, and allowances for peak period alterations is crucial to reducing unnecessary delay and idling of vehicles. Priority can be given to transit vehicles by favoring green time to the movements with a high number of transit vehicles. Higher density passenger movement with transit is given priority over vehicle movement. Priority can also be given by shifting the location of queues or traffic jams from one intersection to another if it allows buses to bypass a queued area. Issues to consider for this measure are the continual need to review and account for changing traffic patterns by updating timing plans and controller phasing.

3.6 Other Measures

There are various other measures, or iterations of measures presented above. These include relocated stop bars to allow buses to "jump" and merge through an intersection faster, removal of bus bays so buses do not have to merge after boarding and alighting, moving bus stops, lifting turn restrictions for transit vehicle, or a combinations of measures.

4 METHODOLOGY

4.1 General Approach

Planning for transit priorities requires knowledge of existing conditions and issues, site specific limitations, and an ability to test potential measures. An overall project methodology was established for the analysis of potential measures in the designated Quality Corridors.

For each of the three Corridors that were studied in the Phase I work program, characteristics were defined and documented, transit priority opportunities identified and analyzed, and final recommendations made. On-going meetings were held with City of Winnipeg staff to discuss analysis assumptions and to review the technical feasibility of alternatives.

The following tasks were included as part of the program:

- Analysis of current transit operations (passenger loads, service levels, average speeds, variability of bus running times, areas of delay).
- Analysis of traffic operations (traffic and pedestrian volumes, intersection capacity, link capacity, average speeds, traffic signal operations, turning movements, parking/stopping/turning regulations).
- Computer modeling of both transit and traffic operations using Synchro and VISSIM modeling software. Models were built to simulate existing conditions, and the impacts of all transit priority alternatives considered.
- As part of the analysis, an identification of areas within the Corridors with delay or reliability issues. A steering committee provided input and reviewed priority alternatives.
- Generation of transit priority alternatives to improve transit speeds and reliability (such as bus-only lanes, queue jumps, priority signals).
- Analysis of alternatives including impact on transit operations, impact on traffic modes, capital costs and impact on adjacent properties.

- Preparation of preliminary design, property requirements, capital cost estimate, operating cost impacts and implementation plan.
- Following approval of the preliminary design, final design of the recommended measures, preparation of construction drawings, technical specifications, and construction bid packages.
- Construction and implementation of the recommended transit priority measures.

4.2 Analysis of Transit and Traffic Operations

The existing transit characteristics along the Corridors were established in terms of passenger activity, service frequency, travel speed, reliability and delay. To accomplish this, information was requested from Winnipeg Transit which included:

- Automatic Passenger Counting (APC) data to assess transit travel time and variability (including average travel speed and areas of delay);
- Route scheduling information; and,
- Service stop characteristics (e.g. near side versus far side, stop amenities).

Anecdotal reports of operating issues were given during the Steering Committee Workshop (e.g. lane drops or bulb outs, traffic queuing, merging issues, sources and locations of transit delays). This gave the study team better insight about potential transit priority improvements.

Roadway characteristics were established in order to gain an appreciation for the existing conditions, as well as any constraints or issues that could affect implementation of transit priority measures. Site inspections were carried out and observations were documented; particular issues or constraints relating to diamond lanes and queue jumps were noted. Information used included:

- Electronic Air Photos, legal plans, and GIS information to establish current conditions, underground utility location, signal locations, etc.
- A detailed photographic inventory documenting the existing conditions along each Corridor.
- Existing traffic and pedestrian counts within each Corridor, average travel speeds, on-street parking, stopping regulations, etc.
- Existing signal timing information.

4.3 Computer Model Simulations

Much of the information gathered for the transit and traffic operations was used in computer simulations of the Corridors. These simulations were necessary to be able to review the impact of individual, and the combined effect, of priority alternatives on the Corridor and passenger movement.

Two parallel analyses were carried out for each Corridor: transit analysis and traffic analysis. Once sufficient transit data, traffic and pedestrians counts, roadway geometry and signal timing data was gathered, it was input into the appropriate software package. Trafficware's Synchro 6/SimTraffic traffic modeling software was used for operational analysis of traffic volumes, which is consistent with City of Winnipeg practice.

Roadway operating characteristics and transit schedule data were also input into PTV's VISSIM software which, unlike Synchro software, considers transit operations within its analysis. VISSIM was used to model transit conditions within the Corridor.

For both AM and PM peak hours, current operating conditions were assessed for all signalized intersections and at grade pedestrian crossings within each of the three Corridors. A number of measures of effectiveness were assessed including:

- Delay – based on "non-moving" time (e.g. signal delay and queuing delay) at intersections overall and for individual turning movements and is calculated in seconds.
- Volume to Capacity ratio (V/C) – indicates the amount of congestion for each lane group/movement and intersection as a whole. As the v/c approaches 1.0 it means that the approach or intersection is at, or is approaching, its theoretical capacity. Ratios greater than or equal to one indicate that a movement or intersection is operating above capacity and delays can be expected.
- Intersection Capacity Utilization (ICU) – is a measure of how well an intersection is functioning and gives an indication of the amount of extra capacity available to handle traffic fluctuations and incidents.
- Corridor Travel Time – comprised of moving time between stopped points (e.g. between intersections and/or bus stops) and "non-moving" time (e.g. intersection signal delay, queuing delay, passenger boarding/alighting time). "Non-moving" time has been estimated in other cities to comprise 20 to 40% of overall Corridor travel time for transit. This is higher for transit than for general traffic given passenger activity at bus stops along the Corridor. Bearing this in mind, reducing lost time or delay at intersections effectively reduces overall Corridor travel time.

These factors, especially delay, were used to establish baseline existing conditions against which the effects of transit priority measures alternatives were simulated and measured.

4.4 Identification of Problem Areas

Analysis of transit and traffic operations was undertaken at workshops with the Steering Committee. Comments made during the workshops were noted and highlighted such as areas of transit delay and/or low travel speed, opportunities for transit priority measures, traffic operations constraints (e.g. heavy queuing, poor level of service) and geometric issues or opportunities.

Additional ideas were brought forth at other points in the study. The study team developed alternatives as operational constraints became clearer. The process was somewhat iterative as alternatives were discarded or built upon to achieve better results.

4.5 Analysis of Transit Priority Measures Alternatives

The suite of proposed transit priority measures, mainly in the problem areas identified during the workshop, were modeled in Synchro and VISSIM to determine their effects. Given the inter-dependence between transit and traffic, transit priority measures were evaluated to select the optimum solutions for both transit riders and motorists.

At the intersection level, a transit priority measure was considered favorable if it reduced the amount of delay time and if it did not substantially increase lost time for other modes. Improvements were also considered on an overall Corridor level to determine the impact on transit travel time for the suite of recommended transit priority measures. Corridor impacts for traffic were also assessed.

For transit priority improvements considered at localized intersections, delay was summed for all significant intersection approaches and traffic movements (e.g. northbound left, northbound through, and northbound right) and expressed as total passenger hours of delay for each peak hour.

The general approach used to calculate the intersection delay index was:

Delay Change (s) = [Delay (s)] $_{\textit{Priority Measure}}$ *– [Delay (s)]* $_{\textit{Existing Condition}}$

A bus is assumed to hold 40 passengers.

A vehicle is assumed to hold 1.2 passengers.

*Total Person Delay (passenger hours) = sum for all critical movements [Delay Change (s) * [peak hour volume (vehicles)] * [Vehicle Load (passengers/vehicle)] / [3600 s/hr]*

This provides the total change in delay for all intersection users due to a particular improvement considered.

Example: A transit measure alternative for southbound left turning buses reduced delay from 150 seconds per bus in the existing condition to 50 seconds per bus in the AM peak hour, but increased all northbound traffic delay by 10 seconds. There are seven southbound left turning buses per hour and 1,000 northbound vehicles. The following would be calculated:

Delay Change (s) $_{\textit{Transit}}$ *= 50 s – 150 s = -100 s*
Delay Change (s) $_{\textit{Traffic}}$ *= +10 s*

*Total Person Delay (passenger hours) = {-100 s * 7 buses * 40 (passengers/bus)*
*+10 s * 1000 vehicles * 1.2 passengers/vehicle} / [3600 s/hr]*
= -4.4 passenger hours

There would be 4.4 passenger hours of time saved at this intersection by implementing the changes assuming no other movements are affected.

When alternatives were analyzed and refined, the competing goals included decreasing transit travel time and delays while having minimal to no impact on delays and travel time for general traffic. Some increases in delay for traffic were deemed justifiable to encourage the use of transit within the Quality Corridors. However, delay was measured in "passenger-hours" to reflect the more sustainable transit operations rather than simple vehicle movement.

Other quantifiable and qualitative factors besides delay, travel time, and level of service were reviewed. This included capital cost for construction, visual impact, local aesthetics, acceptance by the public, environmental considerations, time of implementation, ease of implementation and/or enforcement, and property requirements.

All factors were considered to create a final list of recommended transit priority measures for the three Corridors. Both computer simulation models (Synchro and VISSIM) were then re-run to reflect overall traffic signal optimization as well as all recommended transit priority measures. The Corridors were then assessed in terms of overall travel time and delay to determine the benefit as compared to existing conditions.

4.6 Preliminary and Final Design

Some preliminary design of alternatives was necessary to adequately analyze for cost, property requirements, and impact to utilities. After final recommendations were made, final design in preparation for construction occurred.

4.7 Construction of Recommended Transit Priority Measures

Construction of the recommended queue jump lanes, transit priority signals, bus-only lanes, and other measures occurred within one year of the inception of the study. Most of the physical infrastructure improvements were complete in November of 2007 before the end of the construction season for winter.

5 SELECTED MEASURES AND ANTICIPATED RESULTS

5.1 Recommended Transit Priority Measures

After all alternatives were considered, the following measures were recommended for implementation, and were carried forward to construction:

Table 1: Recommended Transit Priority Measures			
	Pembina Highway	***St. Mary's Road***	***St. Anne's Road***
Corridor Characteristics			
Length (km)	8.4	6.3	3.7
Lanes (two way)	6	4	4
AADT	67,000	42,000	30,000
Signalized intersections (#)	17	11	8
Transit Priority Measures			
Bus Lanes	2 (240 metres)	1 (130 metres)	1 (340 metres)
Bus-Only Links	1 (120 metres)	--	--
Queue Jumps	1	1	1
Transit Priority Signals	5	4	3
Traffic Signal Optimization	Throughout Corridor	Throughout Corridor	Throughout Corridor
Other	Reconstruct existing Bus Lanes	--	--

It is noted that the bus lanes are relatively short. On these Corridors, right-of-way for an additional bus lane was not available, and conversion of long stretches of the Corridors to bus lanes was not possible due to an unreasonable drop in the level of service for other vehicles. The bus lanes that were converted are generally at intersections where the right turn deceleration lanes were extended to the far side of the intersection. This allows the buses to bypass queues at congested intersections. Many of the bus lanes and queue jumps that are exclusively for transit use were constructed with red-tinted concrete. This is used to further identify to other motorists that the lane is for transit only.

Transit priority signals that were installed occurred where new queue jumps were installed, as well as at existing queue jump locations.

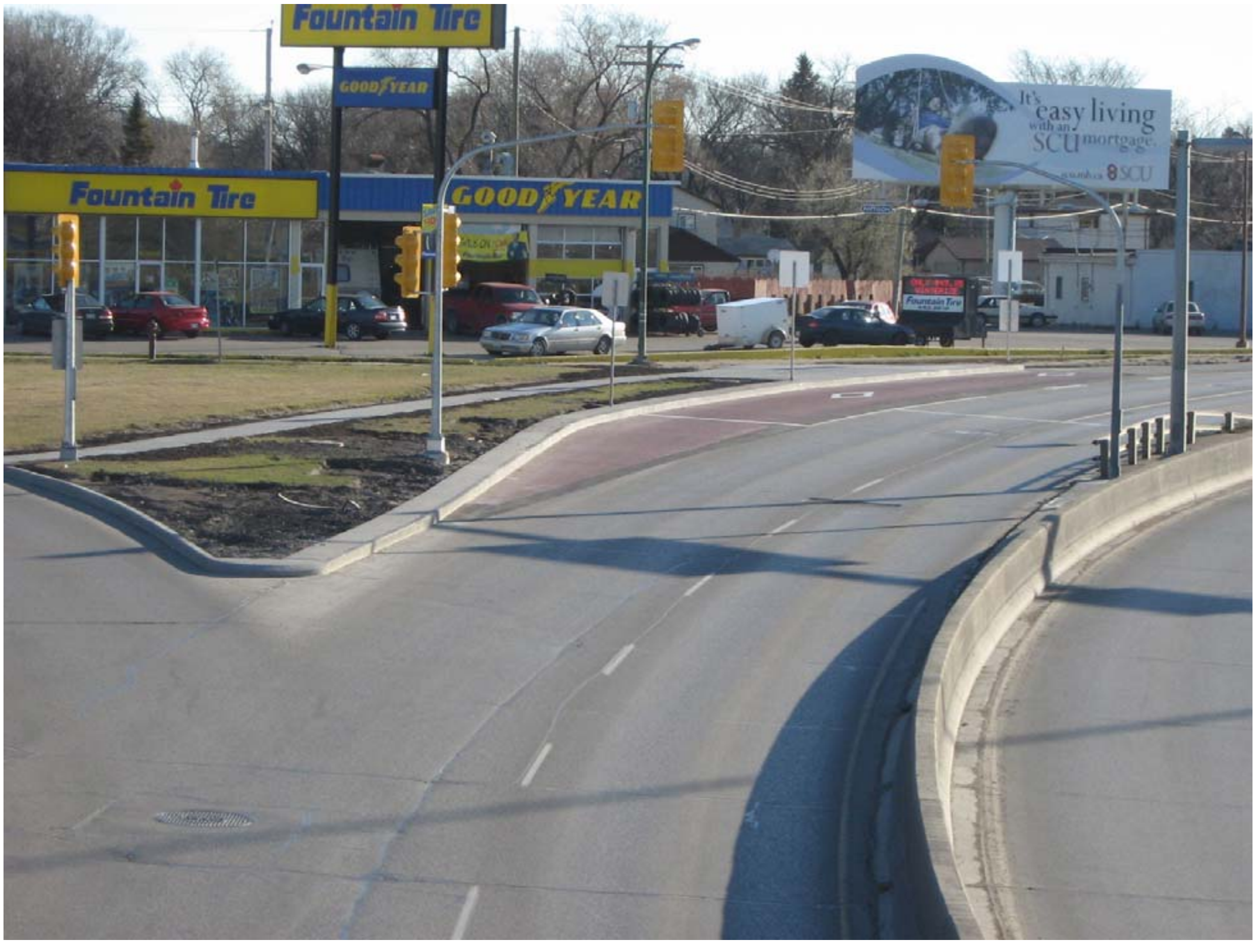
5.2 Selected Measures

Pembina Highway Corridor - The bus-only link on the Pembina Corridor allows buses using the eastbound Bishop Grandin off ramp to Pembina to completely bypass the Chancellor intersection, and access the existing "jug handle" queue jump and bus station. Note the red concrete used to construct this bus-only bypass lane.

Figure 2: Bishop Grandin to Pembina Bus-Only Link

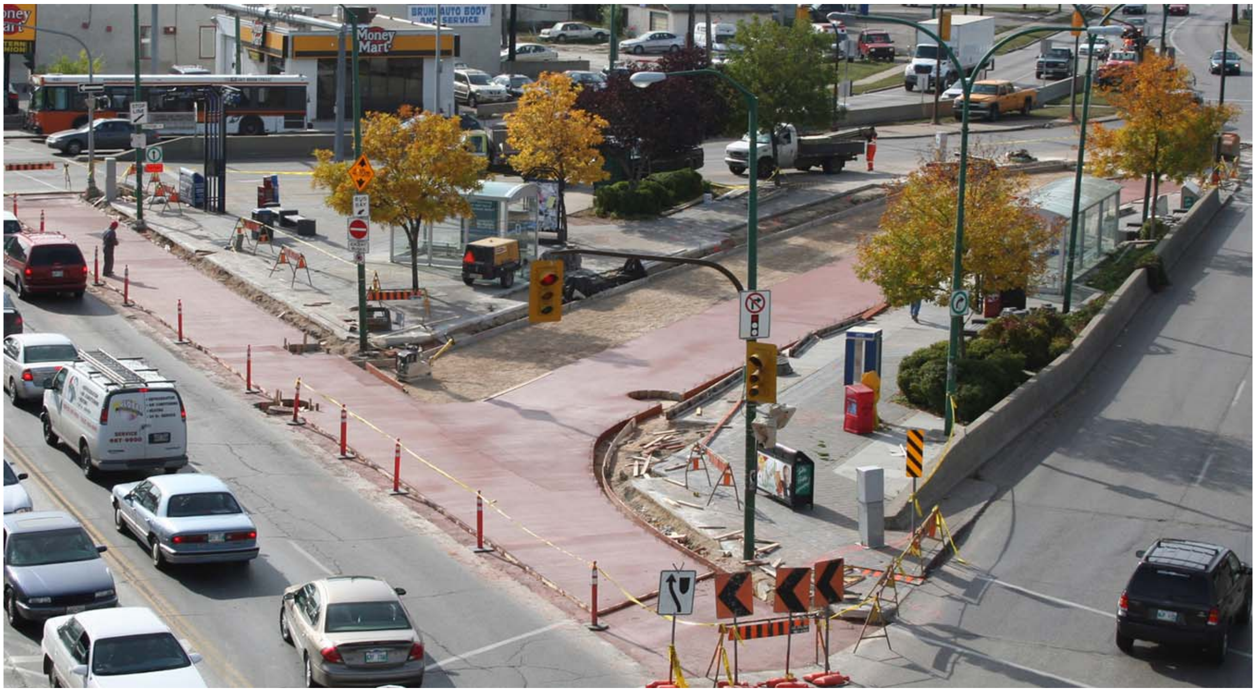
***Pembina Highway Corridor* -** As with many of the other queue jumps and transit priority signals installed, the northbound Pembina at Jubilee measure occurs at a constriction point. Here, the northbound lanes constrict from three to two, and allow buses to remain in the curb lane and bypass the regular traffic queue with a transit priority signal.

Figure 3: Pembina at Jubilee Northbound Queue Jump and Transit Priority Signal



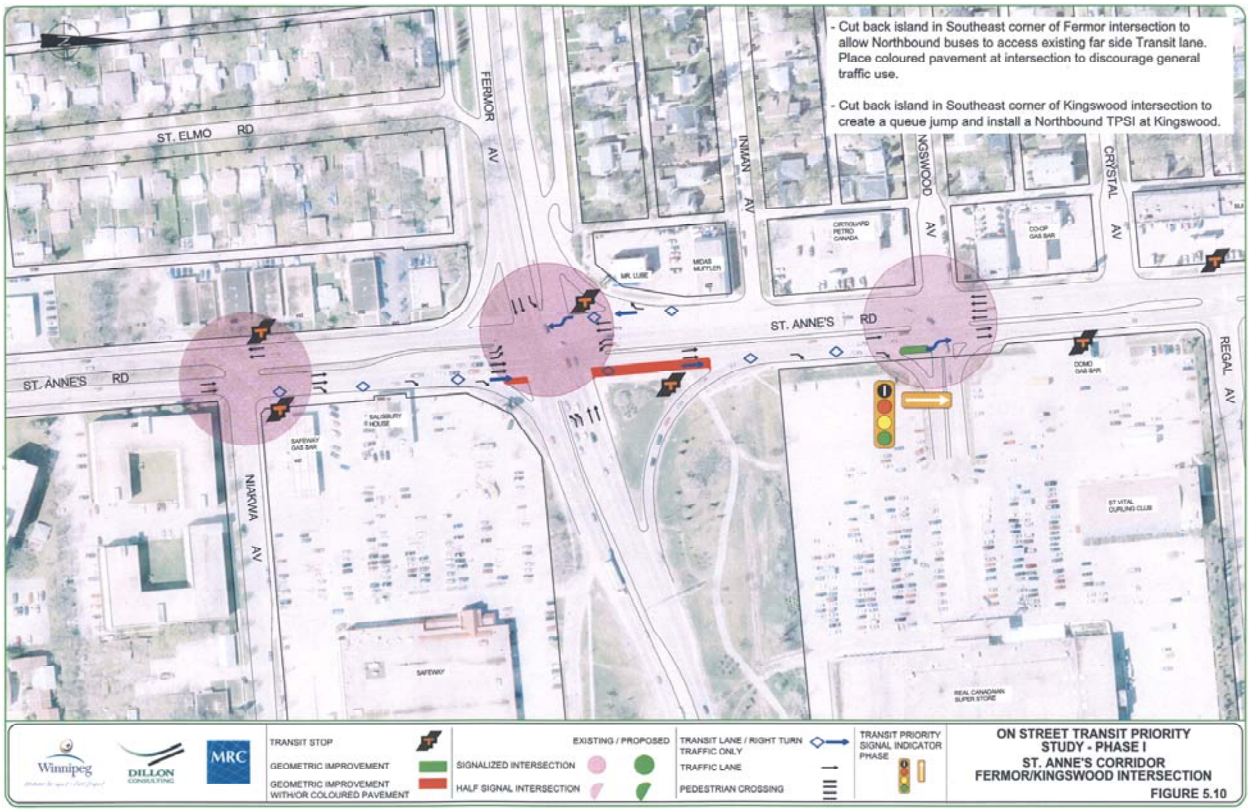
Pembina Highway Corridor **-** Various existing bus lanes were reconstructed at the "Osborne Exchange" at the north end of the Pembina Corridor. This is the confluence of five major arterial roadways. Transit priority signals were added at the terminus of each of the bus lanes to maximize their benefit.

Figure 4: Osborne Exchange Transit Lane Reconstruction



St. Anne's Road Corridor **-** By cutting back the northbound near side island at Fermor Avenue, a bus lane could be created between Niakwa and Kingswood Avenue. The bus lane can be shared by right turning traffic, but does allow transit to proceed through, bypassing the northbound queues. At the north terminus at Kingswood, a queue jump and Transit Priority Signal was installed so buses can merge back into the shared lane. The bus lane is not long, but is effective as it gets buses through the congested Fermor intersection.

Figure 5: St. Anne's Northbound Bus Lane at Fermor Avenue



All Corridors **-** One overarching improvement throughout the Corridors was optimization of the traffic signals at each of the intersections. At certain intersections signal timing was found to not reflect existing traffic volumes. Given the number of traffic signals within Winnipeg, it is not always possible to carry out traffic signal timing updates as often as desired. Other priorities (e.g. new signal installation, regular maintenance, construction projects) and changing traffic patterns due to adjacent development make these updates difficult to undertake. As such, the analysis of traffic operations identified a number of locations where changes to traffic controller settings would be beneficial to transit and non-transit users.

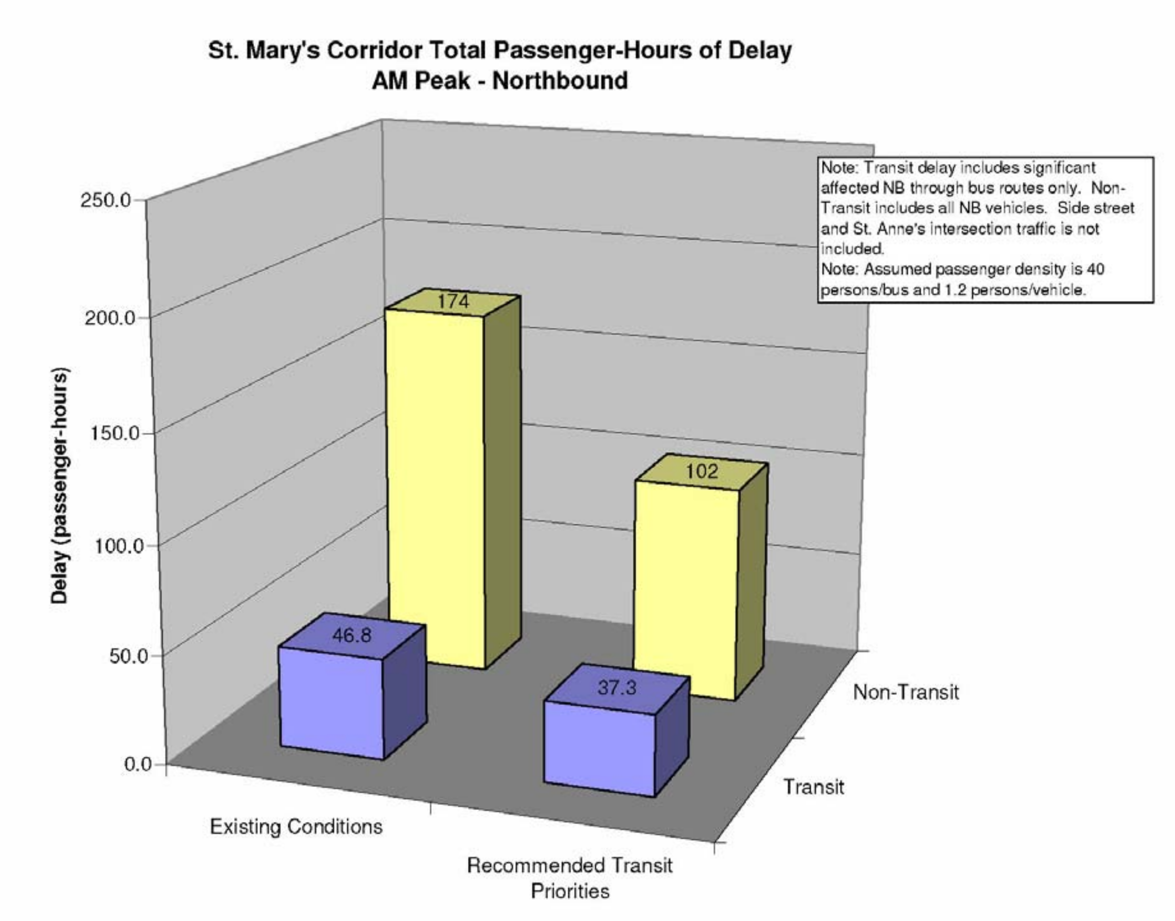
In many cases, the optimization of signals for volumes, splits, and progression was used to offset any negative impact to regular traffic from implementing transit priority signals or other measures. This was important as it made the improvements easier to accept by the public.

5.3 Anticipated Results

Overall Corridor travel time and delay reduction projections were made using the computer model simulations. In general, transit priority measures could be implemented within the Corridors without unduly impacting general traffic movements. The potential benefits from traffic signal optimization alone were sufficient to offset the impacts on traffic of most transit priority measures. It could be argued that the traffic signal optimization should not take place so as not to improve the level of service to traffic. In this way, the gap in speed between transit and other traffic is narrowed further and transit becomes more attractive to commuters. However, in some locations, the signal optimization was necessary to maintain an adequate level of service, and reduces delay, idling, and emissions for all modes, which is a benefit to the community as a whole.

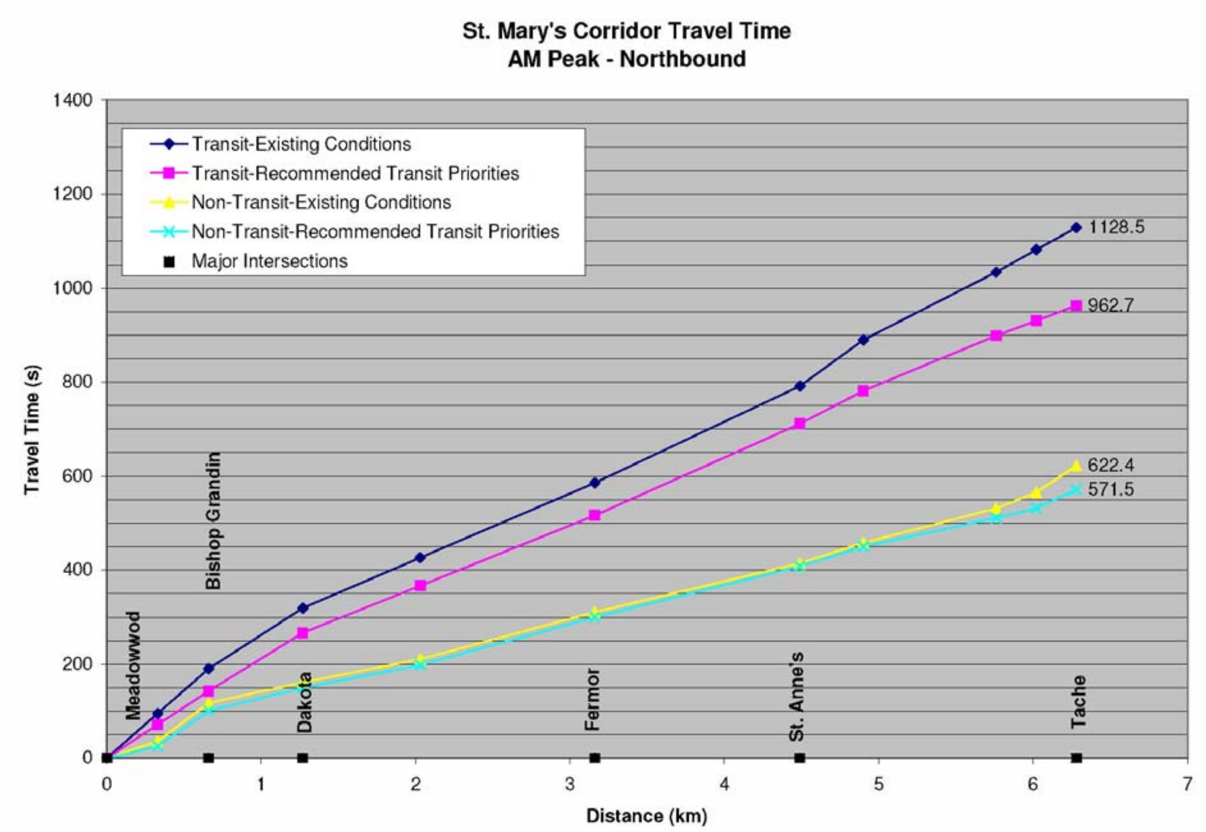
The overall Corridor delay and travel time was completed for each Corridor, in each direction, for each of the AM and PM peak hours. A sample from the St. Mary's Corridor, for the northbound direction in the AM peak hour is shown in the following figures.

Figure 6: Example Corridor Delay Reduction



Total passenger delay is the sum of signal and/or queuing delay at individual intersections along the Corridor. Passenger volumes of 40 persons/bus and 1.2 persons/car were assumed. This chart shows that delay for transit vehicles in the northbound direction in the peak hour dropped from 46.8 to 37.3 passenger hours. Delay reduction for non-transit vehicles (typical commuters) was even more significant because of the much higher volume. Delay reduction is due to the transit priority measures, and to signal optimization which benefits transit and non-transit vehicles.

Figure 7: Example Corridor Travel Time Reduction



Total travel time is the time for an average bus or car to travel from one end of the Corridor to the other. This chart shows that a typical bus would reduce their travel time from 18.8 to 16.0 minutes. The impact of the northbound bus lane through the Bishop Grandin intersection is especially noticeable. Typical car travel time also sees a slight reduction through signal optimization. This time reduction is still significant as seen in the delay chart due to the much higher volume of persons using cars versus transit.

The impact of implementing these measures was significant. Not only were commuters using transit benefited with reduced delay and travel time, but the following other benefits are realized:

- Reduced delay and travel time for non-transit through signal optimization.
- Reduced fuel consumption for transit and non-transit, resulting in lower operating costs and improved efficiency.
- Reduced greenhouse gas emissions for transit and non-transit.
- Transit is more attractive to commuters, possibly resulting in a higher mode split in the future, further reducing overall fuel consumption and emissions.

Summing the delay and travel time for the Corridors for the Phase I Study resulted in a reduction of 104 passenger hours for transit and 402 passenger hours for non-transit. This is the combination of all three Corridors, in both peak hours (1 hour in AM, 1 hour in PM), in both directions. This value is much higher if extrapolated over the entire day, and subsequently entire year.

Most of the transit priority measures were installed in the fall of 2007. At the time of this writing, not all transit priority signals had been installed, and some of the signal optimization was not yet complete. Hence, field testing with travel time surveys had not been undertaken to confirm the model results. Anecdotal reports from transit drivers and site observations do seem to indicate that a benefit is being realized.

6 CONCLUSION

As cities grow, so does the need for reliable, efficient transportation. The City of Winnipeg's program to improve speed and reliability for transit operations on key Corridors is a step to meet that need. Transit priority measures on street are an effective way to narrow the gap between transit and non-transit travel time, making transit a more attractive mode. By using transit priority measures in areas of congestion, it also makes transit more reliable, which in turn makes it more attractive. Further improvements to transit service could be achieved by separate busways as part of a Bus Rapid Transit system.

Transit is recognized as a more sustainable mode than vehicular traffic. Passenger density is much higher for transit, resulting in increased fuel efficiency per capita, and reduced greenhouse gas emissions. Providing priority to transit on-street maximizes these benefits for the community.

7 REFERENCES

1. Winnipeg Free Press. "Winnipeg Transit – Celebrating 125 Years of Service – Supplement", June 2007.
2. City of Winnipeg Transit Department. "Busway Planning and Design Manual", September 13, 2004.
3. City of Winnipeg Transit Department. "Busway Planning and Design Manual", September 13, 2004.