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Paper Title: Pace Suburban Bus Transit Signal Priority Regional Plan
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Pace Suburban Bus Transit Signal Priority Regional Plan

Background:

Pace is the premier suburban transit provider, quickly moving people to work and school safely and efficiently. The backbone of Chicago's suburbs, Pace serves of daily riders with more fixed bus routes, vanpools and Dial-a-Ride programs. Pace covers 3,500 square miles and is the one of the largest bus services in North America. Pace service Area includes DuPage, Kane, Lake, McHenry, Will and Cook Counties in Northeast IL. It serves 210 Communities with Population of 5.2 million. Total ridership in 2007 is 39.2 million. Pace operates fixed bus 240 routes with an average length of 12.5 miles. Pace also provides Paratransit, Vanpool & Carshare program.

Pace has developed a Regional Plan for deploying Transit Signal Priority (TSP) throughout its service area. The project included analyzing approximately 850 miles of roadway along 27 potential TSP corridors to allow the transit agency to identify the areas of greatest need for future TSP funding and deployment throughout its entire service area.

What is Transit Signal Priority (TSP)

TSP facilitates the movement of transit vehicles through traffic-signal controlled intersections. When buses are behind schedule, special devices on the buses send signals to detectors installed at traffic-signal controlled intersections, which automatically give the bus priority by extending a green, shortening a red or providing queue jumps. TSP is a great benefit because it ensures schedule adherence and improves travel times along busy arterial routes. The time savings, though small at each intersection, create a significant decrease in travel time over the course of our entire bus route. There is evidence of this along Cermak Road where TSP has been active for several years; there has been a 7 to 20% reduction in transit travel times along this route. Also Pace successfully tested Wi-fi Based TSP along four signalized intersection of 159th street and place 20 more signalized intersections along Halsted, US6 & 159th Street.

Goals for Regional TSP System Deployment

TSP Deployment will promote the vision presented in Pace's *Vision 2020: Blueprint for the Future*: "Pace's vision for the future is to provide a publicly acceptable level of efficient suburban mobility."[1] Three main goals identified in Pace's 5-year plan from 2007-2011 that work toward this *Vision 2020* are:

1. Improved access and mobility for the elderly and disabled throughout the region without constraints of local governmental bodies.
2. Provide access to jobs through an expansion of City to Suburban trips.
3. Reduce congestion in the suburb to suburb commute.

It is Pace's goal to provide better access to trip origins and destinations through a time-competitive, long-distance line-haul service between multiple suburban centers. As the suburban job market has grown, the demand for transit services that connect locations in the City of Chicago with widely distributed suburban employers has increased significantly. Table 1.1 displays the population and employment growth anticipated from 1990 to 2020 for each of the six counties that Pace serves. Pace's success depends on how effectively it serves this change in travel needs.

Table 1– County Population and Employment Growth Projected from 1990 to 2020[2]

County	Population Growth (1990-2020)	Employment Growth (1990-2020)
Cook	+9%	+23%
DuPage	+26%	+54%
Kane	+73%	+54%
Lake	+51%	+70%
McHenry	+85%	+47%
Will	+130%	+239%

The growth in suburban employment has in turn lead to increased congestion, longer travel times and a decline in air quality as commuters increasingly rely on single-occupancy vehicles access employment opportunities. The percentage of lane-miles congested in the Chicago region grew from 32% in 1982 to 65% in 1999. Miles traveled on congested roadways are forecast to grow by 60% between 1996 and 2020 and time spent traveling is forecast to jump 44% between 1996 and 2020.

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[1] Pace Vision 2020: Blueprint for the Future. Wilbur Smith Associates, 21 December, 2001.
[2] http://www.pacebus.com/sub/vision2020/default.asp

Vision 2020 is the blueprint for Pace's vision of developing a network of new services, infrastructure improvements and a decrease in travel times. Transit Signal Priority is one of the many tools that Pace can use to meet the needs of city-to-suburb and suburb-to-suburb transit commuters.

Regional TSP System Objectives

Improving the schedule adherence of Pace bus routes is among the goals of the HTC TSP Demonstration. TSP can work to accomplish other objectives that may be more ideal for future TSP Corridors, such as:

1. The improvement of transit travel times along an entire TSP Corridor
2. The improvement of transit operations at isolated intersections
3. The establishment of a Bus Rapid Transit line, through the application of procedures and technologies in addition to TSP

These objectives are presented here as examples of how TSP can be utilized along other Corridors to achieve the goals of Pace's *Vision 2020*. Although the main objective for the Regional TSP System will be to improve schedule adherence, other objectives may be deemed more appropriate for other TSP Corridors in the future.

Reduction of Traffic Signal Delay

While TSP is one tool that can improve transit travel times, it is limited to reducing the delays to transit vehicles caused only by traffic signals. For the signal delay data collection process (discussed in Section 3.0), signal delay was objectively defined as the sum of two time periods: 1) the time between when a transit vehicle stops at the end of a queue while waiting for a green light and when that light first turns green, and 2) the time between when the light first turns green and when the transit vehicle (waiting at the end of the queue or at the stop bar) first begins moving.

Delay can occur at that same intersection for other reasons as well. Slow-moving traffic can prevent the transit vehicle from clearing the intersection, thus causing it to be delayed through an additional red signal cycle. Delay can also be caused by other factors on the roadway, such as train crossings, which may be creating lengthy vehicle queues beyond the intersection which the transit vehicle is waiting to clear. Thus, TSP cannot be guaranteed to eliminate all of the delay that can potentially occur at a signalized intersection.

Regional Framework

This plan fits within the regional framework of key transit and transportation agencies, as displayed in Figure 1.1. This plan fulfills the vision of the Northeastern Illinois ITS Deployment Plan[3], which is to:

> *Use advanced technologies (including computer, electronic, and communications devices) to share information to improve the operation, management and use of the region's transportation system in order to provide safer, more accessible, more reliable, and more secure roadway and transit services to our customers.*

With regard to TSP, the ITS Deployment Plan recognizes the efforts of Pace to plan for a TSP Demonstration and use that as a base for "developing TSP standards and in formulating a technology oversight policy/plan for the region."

The Regional Transportation Authority (RTA) of Northeastern Illinois developed in May 2000 a Regional Transit Intelligent Transportation Systems (ITS) Plan (RTIP). This plan presented a vision for further transit ITS deployments that ensure regional ITS project coordination and integration. A key mission of the RTA is "to ensure a comprehensive and coordinated public transit system for the residents of northeastern Illinois."[4] The RTA works to ensure that the technologies deployed by transit agencies are in coordination with other transportation agencies in the Gary-Chicago-Milwaukee (GCM) Corridor, composed of 16 counties stretching across Wisconsin, Illinois, and Indiana. The Regional TSP Deployment / Implementation Plan will fulfill this vision of integration and coordination through meeting the objective of improving bus schedule adherence.

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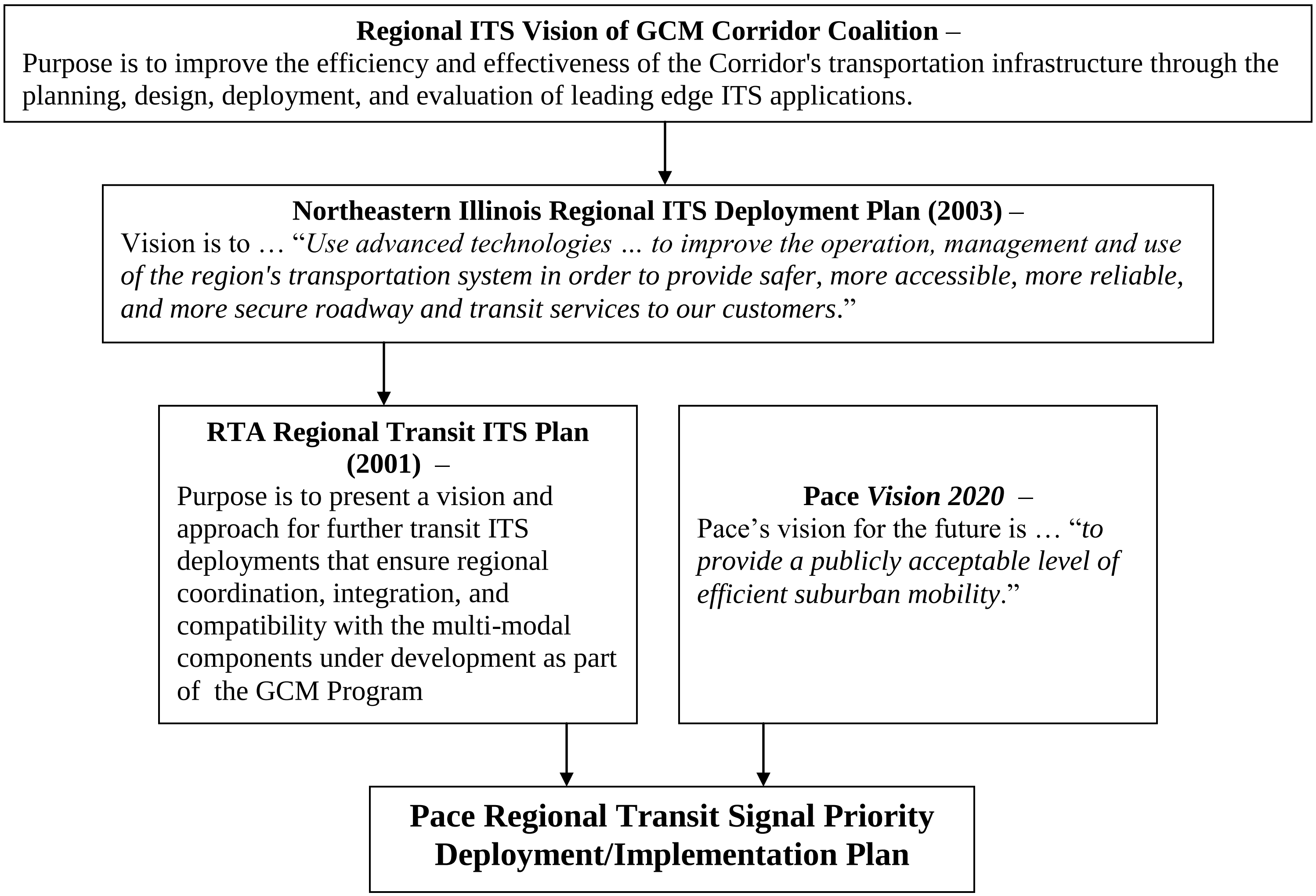
[3] Northeastern Illinois ITS Deployment Final Plan Update: Final Report, July 2005. Prepared by: Chicago Area Transportation Study Advanced Technology Task Force (ATTF), with the support of: Parsons Transportation Group, Consensus Systems Technologies, and National Engineering Technology (NET).
[4] RTA Regional Transit ITS Plan, Exec Sum., p. 1

Figure 1.1 -- Regional Framework for TSP Deployment/Implementation Plan



Regional TSP System Benefits and Costs

The benefits realized with TSP vary depending on the objectives, but the most common benefits have been an improved bus schedule adherence and reduced travel times, which, in turn, lead to a better quality of transit service.   Travel time savings lead to variable operating cost savings in the form of less fuel consumption which, in turn, cause fewer bus emissions and improve the surrounding environment. Travel time savings can also increase the satisfaction of Pace commuters and may even lead to an increase in ridership along a TSP Corridor.

The direct costs to implementing TSP vary on the technology used and the extent of TSP deployment. Traffic signal controllers may need to be upgraded or replaced in order to communicate with TSP components. Other potential costs include extensive delay for cross street traffic and a reduction in the safety of travel along the TSP Corridor. However, side street delay is minimal in most cases and does not offset the travel time savings gained on TSP Corridors. Also, TSP has not been proven to significantly decrease the safety of travel along a TSP Corridor.

The direct benefits to transit operations are realized through variable operational cost savings. Fuel savings, as a result of fewer stops and idling through traffic, are realized by transit vehicles with TSP. The direct benefit to general traffic is similar in nature and can be measured as part of the signal system optimization that is performed in conjunction with TSP. The direct benefit to Pace bus passengers is travel time savings.

Pace Network of TSP Corridors

Pace has designated 27 corridors in their service region as TSP Corridors. The Pace routes along each of the 27 TSP Corridors are listed in Table 2.1 and displayed in Figure 2.1.

The TSP Corridors overlap with Illinois state highways and main arterial roads, which provide regional connectivity of suburban areas with Chicago and other suburban areas.

Table 2.1 also lists the number of signalized intersections along each TSP Corridor. There are a total of 1,116 signalized intersections along the Regional TSP System at which TSP could be deployed. In addition, the length of Pace route overlap with each TSP Corridor demonstrates the extent of route coverage along each corridor. Some TSP Corridors are exposed to Pace fixed-route service for more than 30 miles, while other Corridors are only exposed to a handful of Pace fixed routes. Total number of signalized intersections along 27 regional TSP Corridors that intersect with existing Pace fixed route service 1,116. Total length of overlap between 27 regional TSP Corridors and existing Pace fixed route service is 557 miles. Total length of All 27 Regional TSP Corridors is 848.3 miles

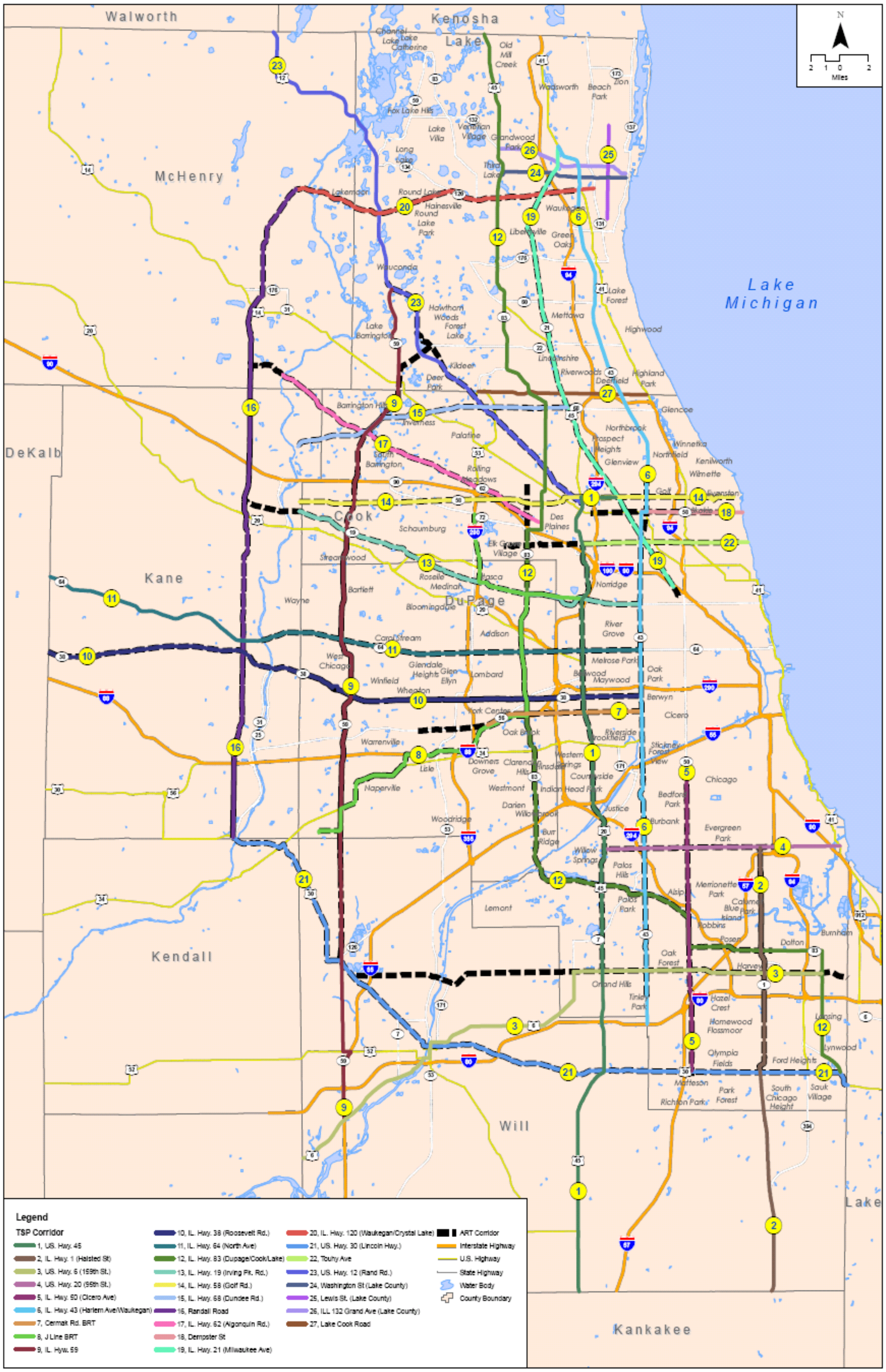


Figure 2.1

Pace Transit Signal Priority Corridor Network

Pace Transit Signal Priority Initiative

Pace Routes along TSP Corridor

Currently, 145 Pace routes overlap with the 27 TSP Corridors for a total length of 557 miles. This total length does not account for the overlap of one route with another route along a TSP Corridor. In general, Pace routes cover approximately one-half of the 850 mile-long TSP Corridor Network. Each Pace route and the numbered TSP Corridors with which they overlap are contained in the Appendix.

Traffic Signal Controllers along TSP Corridors

A key element to successful TSP operations is the ability of signal controllers to process requests for TSP from approaching Pace buses. Throughout the suburban Chicago region, signal controllers are provided by two major manufacturers -- Econolite Control Products, Inc., which manufactures Econolite signal controllers, and Siemens, which manufactures Eagle signal controllers.

As of 2005, there were approximately 120 coordinated Econolite signal systems and 50 coordinated Eagle signal systems along TSP Corridors in the region. A large majority of these systems are owned and owned and maintained by IDOT, while some systems are owned maintained by individual counties and municipalities.

The differences in how these signal controllers function complicates the technology that can be selected for TSP Deployment. Different versions of Econolite and Eagle controllers have varying capabilities for processing TSP requests and older versions require hardware and software upgrades for TSP operations.

Pace ART Corridor Network

The network of TSP Corridors overlaps closely with Pace’s Arterial Rapid Transit (ART) network. This is because TSP is one tool that achieves the goals of ART, which are to connect the region’s suburban centers, improve schedule reliability, and reduce transit travel times for commuters. The overlap of ART Corridors with TSP Corridors is displayed in Figure 2.1.

Pace's ART Corridor Network serves as the high-quality trunk-route frame for Pace's family of services. It is integrated with Pace's Express Bus Service to provide regional connectivity. It is supported by Pace's integrated community services as its feeder service.

Prioritization of TSP Corridors and Segments

This section presents the prioritization of segments of Pace's 27 TSP Corridors that will guide future TSP Deployments. Three scenarios of TSP Deployment were created to reflect changing conditions with respect to state and federal funding and transit service expansion. The following scenarios will assist Pace in the decision-making process of when and where to deploy TSP in the future:

- **Scenario One**: Prioritize all segments of all Pace TSP Corridors to assist in the decision that may need to be made in deploying TSP along an existing fixed-route and a new fixed-route in a previously un-served area along a TSP Corridor
- **Scenario Two**: Prioritize only those segments of TSP Corridors *with* current fixed-route service along them to determine where TSP can be deployed in the immediate-term.
- **Scenario Three**: Prioritize only those segments of TSP Corridors *without* fixed-route service along them to determine where TSP can be deployed in the long-term if fixed-route service is extended to those un-served areas.

While it cannot be predicted when Pace transit could be extended to un-served areas of TSP Corridors, these scenarios provide Pace with the flexibility to address TSP Deployment under changing conditions in the coming years.

The remainder of this section outlines the methodology followed in prioritizing segments of the 27 TSP Corridors for system-wide TSP deployment. The methodology features three main steps:

1) The collection of traffic and transit data relevant to TSP Deployment,
2) The assembly of all data in GIS to visually display the information, and
3) The prioritization of TSP Corridors based on all transit and traffic characteristics.

The result of the prioritization of segments of TSP Corridors provides Pace with a mile-by-mile analysis of where it will be most beneficial to deploy and maintain TSP along each of the 27 TSP Corridors.

TSP Corridor Segmentation and Data Collection

Understanding the transit and traffic conditions along each TSP Corridor is critical in taking the first step to Regional TSP Deployment. Since these conditions vary along the length of a TSP Corridor, it is ideal to divide the TSP Corridors into segments, because TSP may benefit passengers in some areas of a corridor more than others. For example, the transit and traffic conditions along the north end of the Harlem Avenue TSP Corridor may indicate a greater need for TSP while different conditions along the south end of the Corridor might indicate a lesser need for TSP.

Dividing the 27 TSP Corridors into segments is also ideal for the data collection plan. Several data measures were collected to determine which segments should receive a higher priority than others for TSP Deployment. These measures are listed in Table 3.1 and discussed in greater detail below.

Table 3.1 – Data Collected for Pace TSP Corridor Segments

Criteria	Measure	Rationale
Probe Vehicle Field Data on Signal Delay	Time between stopping at end of vehicle queue at signal and first movement after light turns green	Indicates where the greatest amounts of signal delay exists in the region
Location of Coordinated Traffic Signal Systems	State-/County-/Municipal-maintained signal systems and # of signals in each system	Coordinated signal systems allow for the progression of queues of vehicles over longer distances
Volume-to-Capacity Ratios	AADT Counts / [Lane Capacity * Number of Lanes]	Could be used to indicate which segments of roadway are operating beyond capacity
Corridor Funding Situation	Source of corridor funding – SAFETA-LU, State Funding, or No Funding	Source of corridor funding determines whether or not TSP will be deployed in the field
2006 Average Weekday Ridership per Route	Average number of riders per day per route for year 2006	Ridership indicates which areas of the TSP Corridor can benefit more people
Pace IBS Travel Time Index	Index that compares the actual travel time measured by IBS to the optimal travel time	Complements field data on signal delay

Table 3.1 – Data Collected for Pace TSP Corridor Segments

Criteria	Measure	Rationale
Pace Bus Frequency along Segment during Peak Periods	Frequency of bus service during peak weekday periods (6 – 10 AM, 3 – 7 PM)	TSP could be more effective on segments with higher frequencies of service
Pace Route Length along Segment of TSP Corridor	Number of miles Pace routes travels along a segment of a TSP Corridor	TSP can better improve schedule adherence for more routes traveling along segments of TSP Corridor
Transfer Location	Transfer locations along TSP Corridor Segment	TSP could bring passengers to their transfer quicker and decrease transit travel times
Segment Overlap with ART Corridor	Whether or not the segment lies along an ART Corridor	Pace has planned to implement four ART Corridors by 2011

Probe Vehicle Field Data on Signal Delay

Since the objective of transit signal priority is to reduce time spent waiting by transit vehicles (and their passengers) at signalized intersections, identifying where extensive signal delays are occurring can highlight where the greatest need for TSP exists in the region. Field data on traffic signal delay during peak periods of travel (6 – 10 a.m. and 3 – 7 p.m.) was collected with GPS units that record the position and speed of data collection teams for every second spent collecting data. A regional map displaying signal delay measurements is contained in the appendix.

Since the field measurements were made for every second spent traveling along a TSP Corridor, these measurements can be aggregated to one-mile segments. As a result, travel times and signal delays along TSP Corridors can be analyzed at one-mile increments. This allows for an easier observation of signal delay along approximately 850 segments as opposed to observing the 1,560 traffic signals along all TSP Corridors. This process also reduces the potential of analyzing no traffic signal delay data for any one segment, in the event that data collectors always received green lights at some traffic signals.

Given the tremendous effort and expenditure associated with running probe vehicles for 8,500 to 10,200 miles of roadway, it was essential to adopt a sampling strategy. There were two (2) peak hour and two (2) off-peak hour runs along 15-20 mile segments of each TSP Corridor. The adoption of a sampling strategy is further justified by the fact that signal delay is only one of the several criteria used for determining the priority of TSP Deployment along segments of TSP Corridors, albeit arguably the most significant one. Once TSP Corridors have been selected as a result of this prioritization, detailed intersection-level analyses will need to be conducted to determine the most appropriate area along a corridor for TSP Deployment.

Location of Coordinated Traffic Signal Systems

Traffic signal systems facilitate the movement of long queues of vehicles through a series of signalized intersections. These signal systems are beneficial to TSP operations and many of them overlap with TSP Corridors. In addition, the signal timings of systems older than five years will need to be re-optimized as part of TSP Deployment. The optimization of the systems is a part of the SCAT (Signal Coordination and Timing) program that IDOT has maintained to increase the capacity of its roadways. This will require coordination with an IDOT-approved SCAT consultant.

Volume-to-Capacity Ratios

Volume-to-capacity (v/c) ratios indicate the level of congestion along a roadway, defined as the volume of traffic divided by the vehicle lane capacity of the roadway. Traffic volumes were obtained from IDOT and information on lane capacities was obtained from CATS (Chicago Area Transportation Study). Ratios above 1.0 indicate that the volume of traffic exceeds the vehicular capacity of the roadway. Measurements of v/c ratios have been made for each one-mile segment along the TSP Corridors.

The relationship of v/c ratios to TSP operations is simple – as v/c ratios escalate beyond 1.0, TSP becomes less effective in advancing through signalized intersections.[5] Other studies have recommended that the v/c ratios can impact the TSP strategy used. Generally, higher v/c ratios impact the priority that can be granted to transit vehicles.[6]

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[5] RTA Regional Transit Signal Priority Location Study—Phase II, Model Simulation, April 2003, Innovative Transportation Concepts, Inc., www.rtams.org.

[6] Effectiveness of Bus Signal Priority, January 2002, prepared by National Center for Transit Research, University of South Florida, http://www.itsbenefits.its.dot.gov/its/benecost.nsf.

TSP Corridor Funding

TSP Corridor funding was addressed in Section 2 and is vital to TSP Deployment. Whether or not a corridor has received funding may not determine the need for TSP, but obtaining a source of funding is the first and most critical obstacle to deployment. Therefore, those corridors with a funding source will receive a measure of priority over those corridors without funding. In addition, corridors with SAFETEA-LU funding will receive priority over those corridors with an FY 2007 Appropriated source of funding.

2006 Average Weekday Ridership per Route

The measure of average weekday passengers per route could be used to determine where TSP could directly serve the most passengers. The HTC TSP Demonstration centered on heavily traveled routes around the HTC. Route 352 currently serves an average of more than 6,000 passengers per day, which is the most passengers of any Pace route and nearly twice the amount of the second most heavily traveled Pace route. Future deployments of TSP can be planned around other heavily traveled routes along TSP Corridor.

Pace IBS Travel Time Index

Using three months of IBS data from September to December of 2006, an IBS Travel Time Index (TTI) was calculated to compare the actual travel time along a segment to the optimal travel time. Higher values of TTI indicate higher travel times along a segment and thus, better candidate locations for TSP Deployment.

Pace Bus Frequency along Segment during Peak Periods

Based on the three months of IBS data collected, the peak period frequency of Pace transit service along each segment was calculated. The frequency of Pace bus service along segments can impact the number of TSP calls that are made. Higher frequencies of bus travel will lead to more frequent calls for TSP at the intersection level and serve greater amounts of Pace commuters. There are 145 Pace routes that overlap with the 27 TSP Corridors with a mix of high and low frequency routes.

Pace Route Length along Segment of TSP Corridor

The length of Pace routes along a segment of a TSP Corridor impacts the number of TSP calls that can be made. Multiple routes traveling along a one-mile segment affect the amount of TSP service provided. For example, three bus routes traveling the entire length of a one-mile segment equates to three miles of TSP service that could potentially be provided.

Transfer Locations

Deploying TSP near transfer locations can increase the reliability of transfers made by passengers between Pace routes and other forms of public transportation. Transfer locations are identified from the RTA Transfer Location Study.[7] These are locations where Pace, CTA, and Metra public transportation services meet to provide for an enhanced regional connectivity of Chicago with surrounding suburban areas. These are also locations where a majority of Pace routes transfer to other Pace routes. TSP Deployment along a Pace route connecting to any of these transfer locations can reduce the transit travel times and increase Pace transit reliability.

ART and TSP Corridor Overlap

TSP is one component of the ART Corridor Network that will work to improve schedule adherence, transit travel times, and customer service. Pace has planned to implement four ART Corridors operating over approximately 12 miles of service each by 2011, and many of them overlap with TSP Corridors. A regional map displaying the overlap of ART Corridors with TSP Corridors is displayed in the appendix.

Transit and Traffic Data Assembly

With the criteria in Table 3.1 collected for the 27 TSP Corridors, the second step involves the assembly of the criteria into a database that can be used to prioritize the TSP Corridors. The assembly of a GIS database assists primarily in the graphical representation of the criteria along TSP Corridors. The database also allows for the approximate definitions of one-mile segments with specific intersections along a TSP Corridors. GIS was also utilized in the field data collection process for signal delay along the TSP Corridors and in the measurements of v/c ratios

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[7] Regional Transit Coordination Plan: Location Study. July 2001, prepared by Booz-Allen & Hamilton, Inc. in association with Welsh Planning.

for each one-mile segment. The data assembled in GIS was transferred into a Microsoft Excel database for further analysis in the prioritization of the 27 TSP Corridors.

Scenarios of TSP Deployment

The prioritization of segments of TSP Corridors is the final step in the methodology. It is presented in three different scenarios that account for changing conditions with respect to funding and levels of transit service. Each of the scenarios are discussed below along with the criteria used to prioritize the segments of TSP Corridors. Section 3.4 describes in more detail the methodology for how and where TSP can be deployed along each TSP Corridor.

Scenario One: Deploying TSP on New/Restructured Routes vs. Existing Fixed-Route Service Segments

This scenario accounts for future route restructuring initiatives that might result in new or restructured lines of fixed-route service along a TSP Corridor where no transit service previously existed. At that time, Pace may want to determine if the route would be a good candidate for TSP deployment.

Nearly half of Pace's network of 27 regional TSP Corridors is covered with fixed-route service while the remaining half currently has no fixed-route service. Given this fact, all potential TSP deployment areas considered under this scenario will need to be evaluated using comparable criteria to make an objective determination. The criteria that are used to evaluate these potential TSP deployment areas are:

- Vehicle Probe Signal Delay Data
- Presence of coordinated signal systems
- Volume-to-Capacity Ratio of segment
- Segment overlap with Pace Arterial Rapid Transit (ART) Corridor
- RTA Transfer Location(s) along segment

Scenario Two: Deploying TSP on Existing Fixed-Route Service Segments

The second scenario considers only those areas of the regional TSP corridors with existing fixed-route service. Given the potential for TSP deployment along other routes based on the success of the HTC TSP Demonstration and the current funding situation, it is important to understand where TSP could benefit areas with existing fixed-route service in the near term. The following criteria listed below include all five of the measures described in Scenario One and five additional criteria:

- 2006 Average Weekday Ridership per Route
- Pace IBS Travel Time Index
- Bus Frequency along Segments of TSP Corridor
- Corridor Funding Situation
- Route exposure to TSP Corridor

Scenario Three: Deploying TSP on Segments without Existing Fixed-Route Service

Scenario Three considers only the segments without existing fixed-route service. In the event that new fixed-route transit service is extended to currently un-served areas, this scenario depicts the value of TSP to segments without Pace transit service. Similar to Scenario One, it will assist in the decision on whether or not to deploy TSP along new or restructured lines of fixed-route service. The criteria used to prioritize segments without fixed-route service are:

- Vehicle Probe Signal Delay Data
- Presence of coordinated signal systems
- Volume-to-Capacity Ratio of segment
- Segment overlap with Pace Arterial Rapid Transit (ART) Corridor
- RTA Transfer Location(s) along segment

This prioritization is simply a subset of Scenario One and will require minimal effort to determine. While these segments currently have no fixed-route service, a prioritization of the segments may help Pace determine whether or not they would be good candidates for TSP deployment in the event of new routes and/or route restructuring.

Prioritizing Segments for TSP Deployment

Three considerations were made in how the criteria in Table 3.1 were used to prioritize segments for TSP Deployment under each of the three scenarios.

The first consideration is how to treat the different criteria in a similar manner. Six of the measures in Table 3.1 (signal delay, bus frequency, ridership, IBS TTI, route length along segment, and v/c ratios) are continuous variables, in that they can take on any numerical value. The other four measures are nominal variables, and can only be one of a finite number of values. For example, there either *is* or *is not* a transfer location along a one-mile segment. In order to objectively compare the need for TSP on one segment with another, the continuous variables need to be converted into nominal variables by creating categories of values.

The second consideration is an assignment of points that indicate the need for, and feasibility of, TSP Deployment. A point scale from 1 to 5 objectively assimilates the different characteristics into a single prioritization scheme for prioritizing segments for TSP deployment. A value of 1 indicates either a low need for TSP or low amount of feasibility for deployment based on the segment criterion. A value of 5 indicates a great need for TSP or high amount of feasibility for TSP Deployment along that segment. Since higher measures of signal delay will indicate a greater need for TSP, those segments are assigned higher point values for having that characteristic.

The points assigned for each continuous variable were *proportional* to its position within each defined range. For example, one segment with an average daily ridership of 3,500 could have been assigned the same score as another segment with an average daily ridership of 5,000 (between the range 3,000 and 5,500). A score that is *proportional* to the variable's place within the specified range (i.e., 4.2 for the former segment and 4.8 for the latter) assigns more priority to the segment with 5,000 passengers and provides a more accurate set of final rankings.

The last consideration is how to weight the different criteria for TSP Deployment. Assigning weights to all criteria reflects the importance of that measure in determining where TSP should be deployed. For example, field data on signal delay relates directly to the objectives of TSP and, therefore, could account for a larger part of the decision on where to deploy TSP throughout the region. Likewise, the frequency of bus service indicates that TSP will impact more passengers along that segment than other segments.

The weights are represented by percentages that account for a part of the decision on where to deploy TSP. Given the value of field data on signal delay, it will account for at least 20% of the decision on segment prioritization in each of the three scenarios. The point values that each one-mile segment receives for having a desirable characteristic are then multiplied by each respective weight to arrive at a final score for each one-mile segment that determines the order of prioritization.

Scenario One: Prioritization of All Segments of All TSP Corridors

Table 3.2 displays how all segments of all TSP Corridors are prioritized to identify where priority for TSP deployment exists along the entire network of TSP Corridors. Field data on signal delay accounts for 40% of the prioritization while the remaining five variables account for mostly even amounts of the remaining 60%. A regional map of prioritized segments for Scenario One and the prioritized listing of all 867 segments are presented in the appendix.

Scenario Two: Prioritization of Segments with Fixed-Route Service

Table 3.3 displays how one-mile segments of TSP Corridors *with* fixed-route service are prioritized to identify where the need for TSP deployment exists in the near term. This scenario features more criteria than the first scenario and signal delay accounts for one-fourth, or 25%, of the decision on where to deploy TSP. Six criteria account for 10% of the decision and the remaining three criteria account for 5% of the decision. A regional map of prioritized segments for Scenario One and the prioritized listing of all 464 one-mile segments with Pace service is presented in the appendix.

Table 3.2 – Scenario One Prioritization of All One-Mile Segments of All 27 TSP Corridors

Criteria	Categories	Range of Values	Points	Weights
Probe Vehicle Field Data on Signal Delay	High	> 50 sec.	5	40%
	Moderate/High	30 - 50 sec.	4	
	Moderate	15 - 30 sec.	3	
	Moderate/Low	5 - 15 sec.	2	
	Low	0 - 5 sec.	1	
	No Delay	0 sec.	0	
Coordinated Signal Systems	Yes	Yes	3	20%
	No	No	1	
Volume-to-Capacity Ratios	High	>1.00	3	15%
	Moderate	0.80 – 1.00	4	
	Low	< .80	5	
Segment Overlap with	Yes	Yes	3	15%

ART Corridor	No	No	1	
Transfer Locations	Yes	Yes	5	10%
	No	No	3	

Table 3.3 – Scenario Two Prioritization of One Mile Segments with Existing Pace Fixed-Route Service

Criteria	Categories	Range of Values	Points	Weights
Probe Vehicle Field Data on Signal Delay	High	> 50 sec.	5	25%
	Moderate/High	30 - 50 sec.	4	
	Moderate	15 - 30 sec.	3	
	Moderate/Low	5 - 15 sec.	2	
	Low	0 - 5 sec.	1	
	No Delay	0 sec.	0	
Corridor Funding Situation	SAFETEA-LU	SAFETEA-LU	5	5%
	FY06 Authorization	FY06 Authorization	3	
	FY07 Appropriations	FY07 Appropriations	3	
	No funding	No funding	1	
2006 Average Weekday Ridership per Route	High	> 5,500 Passengers	5	10%
	Moderate/High	3,000-5,500 passengers	4	
	Moderate	2,000-3,000 passengers	3	
	Moderate/Low	550-2,000 passengers	2	
	Low	< 550 passengers	1	
IBS Travel Time Index	High	> 2.85	5	10%
	Moderate/High	2.5 – 2.85	4	
	Moderate	2.1 – 2.5	3	
	Moderate/Low	1.75 – 2.1	2	
	Low	< 1.75	1	
Bus Frequency along Segment During Peak Periods	High	> 30 buses	5	10%
	Moderate/High	16-29 buses	4	
	Moderate	7-15 buses	3	
	Moderate/Low	3-7 buses	2	
	Low	1-2 buses	1	
Pace Route Length along	High	> 4 miles	5	5%
	Moderate/High	2-4 miles	4	

Table 3.3 – Scenario Two Prioritization of One Mile Segments with Existing Pace Fixed-Route Service

Criteria	Categories	Range of Values	Points	Weights
Segment of TSP Corridor	Moderate	1-2 miles	3	
	Moderate/Low	0.5-1 miles	2	
	Low	< 0.5 miles	1	
Volume-to-Capacity Ratios	High	>1.00	3	10%
	Moderate	0.80 – 1.00	4	
	Low	< .80	5	
Coordinated Signal Systems	Yes	Yes	3	10%
	No	No	1	
Transfer Locations	Yes	Yes	5	10%
	No	No	3	
Overlap with ART Corridor	Yes	Yes	3	5%
	No	No	1	

Scenario Three: Prioritization of Segments without Fixed-Route Service

Lastly, Table 3.4 displays how one-mile segments of TSP Corridors *without* fixed-route service are prioritized to identify where TSP could be deployed if fixed-route service is provided to those areas in the future. As in Scenario One, field data on signal delay accounts for 40% of the prioritization while the remaining five variables account for mostly even amounts of the remaining 60%. The prioritized list of all 403 segments is presented in the appendix.

Table 3.4 – Scenario Three Prioritization of One Mile Segments without Existing Pace Fixed-Route Service

Criteria	Categories	Range of Values	Points	Weights
Probe Vehicle Field Data Signal Delay	High	> 50 sec.	5	40%
	Moderate/High	30 - 50 sec.	4	
	Moderate	15 - 30 sec.	3	
	Moderate/Low	5 - 15 sec.	2	
	Low	0 - 5 sec.	1	
	No Delay	0 sec.	0	
Coordinated Signal Systems	Yes	Yes	3	20%
	No	No	1	
Volume-to-Capacity Ratios	High	>1.00	3	15%
	Moderate	0.80 – 1.00	4	
	Low	< .80	5	

Segment Overlap with ART Corridor	Yes	Yes	3	15%
	No	No	1	
Transfer Locations	Yes	Yes	5	10%
	No	No	3	

Segment and Corridor Prioritization

The prioritization of segments of each TSP Corridor revealed areas along each corridor that appeared to have a greater need for TSP than others. These areas were defined based on the presence of Pace routes consistently traveling along contiguous segments. This is because TSP will have a greater impact on Pace routes that could receive TSP at multiple traffic signals along a corridor, thus improving the route's overall travel time from its origin to its final destination. The average score of the contiguous segments is used to sort these areas and understand where TSP could potentially have the greatest impact on Pace routes.

Segments are differentiated by five levels of need for TSP Deployment. In the maps for each Scenario of TSP Deployment presented in the appendix, these levels of need range from low to high and depicted with colors ranging from green to red. Given the assembly of all segment scores GIS, the levels of need were defined by examining the distribution of segment scores and where those scores were clustered around a general point value. Therefore, the definition of each level of need varies with each Scenario of TSP Deployment. Table 3.5 presents the definition of need for segments with and without Pace transit service under Scenarios 1 and 2.

Table 3.5 – Determination of Need for TSP Deployment

Segments *with* Pace Transit Service (Scenario 2)	Segments *without* Pace Transit Service (Scenario 1)	Level of Need for TSP Deployment
4.09 – 4.83	4.33 – 5.00	"High"
3.62 – 4.08	3.83 – 4.32	"Moderately High"
3.10 – 3.61	3.27 – 3.82	"Moderate"
2.42 – 3.09	2.52 – 3.26	"Moderately Low"
1.44 – 2.41	1.80 – 2.51	"Low"

Table 3.6 displays segments along TSP Corridors with "high" and "moderately high" needs for TSP Deployment. These are segments where TSP could serve Pace routes in the immediate-term. For example, a group 11 one-mile segments along TSP Corridor #6 – Harlem

Ave./Waukegan Road – ranked the highest among all areas of segments in Scenario Two. Pace Route 307 travels along this entire stretch of segments from Old Harlem Ave. to Altgeld St. There are also 41 traffic signals that could potentially serve passengers on Route 307 with TSP. The characteristics which make this group of segments a high priority candidate for receiving TSP include the high average amount of signal delay and high amount of Pace transit ridership.

Table 3.7 displays segments along TSP Corridors with a "moderate" need for TSP Deployment. These are segments where TSP could be deployed to serve current Pace transit service in the long term. Lastly, Table 3.8 contains prioritized segments along TSP Corridors without Pace transit service. These segments received higher scores in Scenario One than segments on the same corridor with Pace transit service. In the event that transit service is extended to those areas in the future, consideration should be given to the application of TSP in those areas provided that funding becomes available for those corridors. A map displaying the location of these areas is contained in the appendix.

Conclusion: Pace plans to utilize below results in deployment of TSP in the six county suburban region.

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Table 3.6 -- Immediate-Term Potential TSP Deployment Areas with Pace Transit Service: Segments with "High" to "Moderately High" Need for TSP Deployment

TSP Corridor	From:	To:	Approx. Distance in Miles	Pace Routes	Number of Signals	Transfer Locations (Number)	ART Corridor Overlap	**Average Segment Score**
"High" Need for TSP Deployment								
Harlem Ave. / Waukegan Rd.*	S Harlem Ave and Old Harlem	N Harlem Ave and W Altgeld St	11	307	41	Yes (6)	Yes	**4.390**
Cicero Ave.*	S Cicero Ave and W 101st St	S Cicero Ave and W 53rd St	6	379, 383, 385	23	Yes (3)	Yes	**4.269**
US Hwy. 20 / 95th St.*	E 95th St and S Avalon Ave	W 95th St and S Kean Ave	13	381, 395	46	Yes (9)	Yes	**4.263**
Touhy Ave.	W Touhy Ave and N Rogers Ave	W Touhy Ave and N Clifton Ave	8	290	35	Yes (3)	Yes	**4.257**
"Moderately High" Need for TSP Deployment								
Cermak Rd.*	W Cermak Rd and S Harlem Ave	E Butterfield Rd and S Highland Ave	11	322, 877, 888	31	Yes (1)	Yes	**4.033**
Roosevelt Rd.	Roosevelt Rd and Elgin Ave	W Roosevelt Rd and S Wolf Rd	5	301	9	None	Yes	**4.00**
Dempster St.	Dempster St and Sheridan Rd	Dempster St and Oconto Ave	8	250	32	Yes (2)	Yes	**3.964**
Harlem Ave. / Waukegan Rd.*	N Harlem Ave and W Ainslie St	N Waukegan Rd and Voltz Rd	8	423	27	Yes (1)	Yes	**3.930**
Milwaukee Ave.	N Milwaukee Ave and W Veteran St	N Milwaukee Ave and Gregory Dr	10	270, 272, 411	31	Yes (1)	Yes	**3.920**

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Table 3.6 -- Immediate-Term Potential TSP Deployment Areas with Pace Transit Service: Segments with "High" to "Moderately High" Need for TSP Deployment

TSP Corridor	From:	To:	Approx. Distance in Miles	Pace Routes	Number of Signals	Transfer Locations (Number)	ART Corridor Overlap	**Average Segment Score**
North Ave.	W North Ave and N Harlem Ave	W North Ave and N Wolf Rd	5	318	17	Yes (1)	Yes	**3.853**
Lake Cook Road	Lake Cook Rd and US 41	Lake Cook Rd and Northbrook Ct	5	626, 628, 629	18	None	No	**3.828**
US Hwy. 6 / 159th St.*	E 159th St and S Ashland Ave.	W 159th St and S 94th Ave	10	354, 364	18	None	Yes	**3.762**
Algonquin Rd.	W Algonquin Rd and S Elmhurst Rd	W Algonquin Rd and Weber Dr	4	606	12	None	Yes	**3.72**
Golf Rd.	E Golf Rd and S Radcliffe Ave	Golf Rd and Keystone Ave	10	208	22	Yes	Yes	**3.71**
Lincoln Highway	E Cass St and N Bissel St/N Henderson Ave	N Plainfield Rd and I-55	7	505, 507	18	None	Yes	**3.688**
US Hwy. 45	N La Grange Rd and Preston St	Mannheim Rd and W Higgens Rd	9	330	28	Yes (1)	Yes	**3.63**
Rand Road*	E Rand Rd and N 3rd Ave	W Rand Rd and E Winslowe Dr	8	691**	23	None	Yes	**---**

* Corridor has identified source of funding for TSP Deployment.

** Transit service is planned for Rand Road.

Table 3.7 -- Long-Term Potential TSP Deployment Areas with Pace Transit Service: Segments with a "Moderate" Need for TSP Deployment

TSP Corridor	From:	To:	Approx. Distance in Miles	Pace Routes	Number of Signals	Transfer Locations (Number)	ART Corridor Overlap	Average Segment Score
Touhy Ave.	W Touhy Ave and N Clifton Ave	E Touhy Ave and Mannheim Rd	3	221, 241	5	None	Yes	**3.561**
IL Hwy. 83	Robert Kingery Hwy and W Belmont Ave	S Elmhurst Rd and W Montgomery St	8	223, 757	15	None	Segments 49-55	**3.553**
Lincoln Highway	E Lincoln Hwy and Lexington Ave	W Lincoln Hwy and Central Ave/Ridgeland Ave	8	357, 753	23	Yes (1)	Yes	**3.543**
US Hwy. 6 / 159th St.	Maple Rd and N Parkwood Dr	St Ottowa St and W McDonough St	4	501, 502	12	None	No	**3.492**
IL Hwy. 83	Torrence Ave and Michigan City Rd	Cicero Ave and Sibley Blvd./147th Ave	10	350, 354	28	Yes (2)	Segments 13-18	**3.478**
Cicero Ave.*	Cicero Ave and 163rd St	S Cicero Ave and W 101st St	8	383	22	None	Yes	**3.456**
Randall Rd.	Randall Rd and Hopps Rd	S Randall Rd and Brookside Dr	3	549	6	None	Yes	**3.44**
Lewis Street	Lewis Ave and MLK Jr Dr	Lewis Ave and 14th St	6	569	13	None	No	**3.436**
Grand Ave.	Grand Ave and N Genesee St	Grand Ave and Pine St	8	565	21	None	No	**3.431**
Milwaukee Ave.	S Milwaukee Ave and Hollister Dr	N Milwaukee Ave and W Buckley Rd	4	572	14	None	Yes	**3.411**
IL Hwy. 83	Glenwood-Dyer Rd and S Burnham Ave	Torrence Ave and Michigan City Rd	6	358	16	None	None	**3.390**
Harlem Ave.*	S Harlem Ave and W 131st St	S Harlem Ave and Old Harlem	8	386	21	None	Yes	**3.389**
Irving Park Road	W Irving Park Rd and Spruce Ave	W Irving Park Rd and N Harlem Ave	9	326, 332	14	Yes (2)	Yes	**3.356**

Table 3.7 -- Long-Term Potential TSP Deployment Areas with Pace Transit Service: Segments with a "Moderate" Need for TSP Deployment

TSP Corridor	From:	To:	Approx. Distance in Miles	Pace Routes	Number of Signals	Transfer Locations (Number)	ART Corridor Overlap	**Average Segment Score**
Dundee Rd.	E Dundee Rd and N Milwaukee Ave	W Dundee Rd and Golfview Ter	3	234	7	None	Yes	**3.28**
Milwaukee Ave.	N Milwaukee Ave and Winkelman Rd	S Milwaukee Ave and Hollister Dr	11	272	28	None	Yes	**3.260**
IL Hwy. 83	S Main St and E Milburn Ave	N Elmhurst Rd and Maureen Dr	5	234	12	None	No	**3.215**
Irving Park Road	E Chicago St and N Liberty St	Irving Park Rd and Gromer Ln	3	554, 556	6	None	Yes	**3.210**
Washington St.	Washington St and Maple Ave	W Washington St and Old Walnut Cir	8	572	22	None	No	**3.197**
North Ave.	W North Ave and N Wolf Rd	W North Ave and Kramer Ave	5	394	17	None	Yes	**3.185**

Table 3.8 -- Long-Term TSP Deployment Areas for Segments without Pace Transit Service

TSP Corridor	From:	To:	Approx. Distance in Miles	Number of Signals	Interconnect Signal System	ART Corridor Overlap	**Average Segment Score**
"High" to "Moderately High" Need for TSP Deployment							
IL Hwy. 59	IL Route 59 and N Aurora Rd	IL Route 59 and Prairie Ave	3	7	Yes	Yes	**4.350**
IL Hwy. 83	Calumet Sag Rd and S Austin Ave	Calumet Sag Rd and S Highwood Dr	3	5	No	Yes	**4.095**
IL Hwy. 83	Robert Kingery Hwy and Honeysuckle Rose Ln	Robert Kingery Hwy and Knoll Wood Rd	4	7	Yes	Yes	**4.079**
North Ave.	W North Ave and Kramer Ave	W North Ave and Goodrich Ave	3	7	Yes	Yes	**4.021**
J Line BRT	Robert Kingery Hwy and E Van Buren St	Frontage Rd and Fay Ave	3	3	Yes	Yes	**3.997**
Irving Park Rd.	W Irving Park Rd and Oak Ridge Rd	W Irving Park Rd and Albion Ave	5	15	Yes	Yes	**3.891**
"Moderate Need" for TSP Deployment							
IL Hwy. 83	N Elmhurst Rd and Maureen Dr	Mc Henry Rd and Farrington Dr	3	7	Yes	None	**3.820**
Lincoln Highway	N Plainfield Rd and I-55	Lincoln Hwy and Burdick Rd	6	8	Yes	Yes	**3.818**
Randall Road	S Randall Rd and Bunker Hill Dr	McHenry Ave and Dartmoor Dr	3	5	Yes	Yes	**3.817**
US Hwy. 20 / 95th St.	E 95th St and S Ewing Ave	E 95th St and S Avalon Ave	3	7	No	None	**3.772**
IL Hwy. 120	E Belvidere Rd and Westerfield Pl	IL Route 120 and N Almond Rd	3	4	No	Yes	**3.496**
Cicero Ave.	Cicero Ave and Morning Glory Dr	Cicero Ave and 163rd St	5	6	No	Yes	**3.472**