Title: **Harvey Transit Signal Priority Demonstration Project Evaluation**

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Harvey Area TSP Demonstration Project Evaluation Results

ABSTRACT

The Harvey Area TSP Demonstration Project (Phase 1) was successfully implemented and tested in 2010 along Pace bus routes 350, 352 and 364, operating on Sibley Boulevard, Halsted Street, and 159th Street, respectively in South Suburban Cook County, realized significant benefits as detailed below. Not only did Pace reduce its costs by reducing delays, but Pace riders saw a reduction in travel time and were more often on time. Pace equipped **20 intersections** and 55 **buses with TSP equipment**, and a TSP **Central Management System** was established at Pace Suburban Service Headquarters in Arlington Heights, IL.

The following are some key benefits found during the Harvey TSP Demonstration Project Deployment:

- **Bus Travel times were reduced up to 15% (by a range of 25 seconds to 3.3 minutes).**
- **Cumulative Daily Delay for buses was reduced by 27 minutes at TSP- equipped intersections during AM and PM Peak Periods.**
- **Average travel time for all traffic was reduced by as much as 6 minutes during peak hours.**
- **The number of stops made by buses at signalized intersections with TSP at a corridor level was reduced by a range of 3 to a maximum of 13 on a directional basis by route.**

In conclusion, Harvey TSP Demonstration Project was successful both in terms of benefits to Pace riders and technology implementation. Pace plans to start Phase 2 deployment of the project by mid-year 2012 and begin subsequent region wide TSP deployment along major Arterial Rapid Transit (ART) corridors.

Background:

Identified in the "Vision 2020" plan, Pace's blueprint for the future of suburban transit, as one of several key service improvements intended to help enhance bus speed and thus improve travel times and on-time performance, TSP is envisioned as an integral part of Pace's Intelligent Bus System (IBS) and a key component of future Arterial Rapid Transit (ART) service as Pace reshapes it system by using new methods and technologies.

It is anticipated that implementing TSP throughout the Pace service area at strategically-selected signalized intersections along Pace bus routes will improve bus mobility and reliability, and therefore, as a result, will help Pace provide enhanced transit services to better meet current and future demands, attract additional ridership, and increase the satisfaction of transit users.

In order to investigate how to best implement a region-wide TSP program, determine where TSP should be deployed, and assess how TSP would benefit Pace transit operations, Pace began work on the planning, design, demonstration, testing, and evaluation of a TSP system through the Pace TSP Initiative. The Pace TSP Initiative included the development of a comprehensive Regional TSP Deployment Plan and the execution of a TSP demonstration project.

- Regional TSP Deployment Plan – This plan is being used by Pace to help guide the future deployment of TSP throughout Pace's service area. The Regional TSP Deployment Plan, completed in June 2008, identified and prioritized corridors in Pace's service area that could benefit from the deployment of TSP in short-, medium-, and long-term timeframes.

- Harvey Area TSP Demonstration Project – **The purpose of the Harvey Area TSP Demonstration Project learn following:**
  - how to best implement a TSP program
  - the benefits that can be realized from the deployment of TSP in coordination with other transit technologies
  - to provide a roadmap for future TSP deployments

Goals and Objectives

Quantitative Goals and Objectives:

The quantitative goals and objectives were identified to assess the potential improvements in mobility and reliability for buses and general traffic after TSP implementation.

Goal 1: Improve Transit Mobility – TSP implementation will improve mobility for Pace buses.

Objective 1-1: To reduce bus travel time
Objective 1-2: To reduce bus delay at TSP intersections
Objective 1-3: To reduce bus delay at the corridor level (i.e. to reduce bus delay for each bus within the segment of the bus route where TSP is deployed)

Goal 2: Improve Transit Reliability – TSP implementation will improve schedule adherence for Pace buses.

Objective 2-1: To reduce bus travel time variance
Objective 2-2: To reduce the amount of time that arrival/departure times deviate from the schedule

Goal 3: Improve General Traffic Mobility – Signal optimization and TSP implementation will improve mobility for general traffic.

Objective 3-1: To reduce general traffic travel time (i.e. all other traffic besides Pace buses)

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<u>Qualitative Goals and Objectives</u>:

While not Pace's first foray into TSP, the Harvey Area TSP Demonstration Project represents a considerable advancement in project scope, the capabilities of the available TSP technology and related equipment, and the project's goals and objectives when compared to the Cermak Road Bus Preemption Study and demonstration project completed in 1998.

As indicated in the previous section, the Harvey Area TSP Demonstration Project aims to help Pace learn how to best implement and reap the benefits from TSP, which will provide invaluable experience for upcoming TSP deployments. The qualitative goals and objectives were developed to assess the areas of the project that cannot be measured in hard numbers.

Goal 1: Address Institutional Concerns – Address institutional concerns related to deploying TSP in the demonstration project area and throughout the Pace service area

Objective 1-1: **Coordinate with local jurisdictions**, such as Illinois DOT, City of Harvey, and Village of Riverdale.

Goal 2: Address Needs for Deploying TSP on Buses

Objective 2-1: **Integrate TSP system with Pace's IBS,** the existing Automated Vehicle Location (AVL) system
Objective 2-2: Implement **conditional priority** where the buses **only request TSP when behind schedule**
Objective 2-3: **Cancel TSP calls** when **entrance/exit doors are open** and when the **next stop pull cords are activated**

Objective 2-4: **Distinguish** the locations of **near-side and far-side bus stops** at TSP intersections

Goal 3: Address Needs for Deploying TSP at Intersections

Objective 3-1: Implement **"green extension"** and **"red truncation"** TSP strategies
Objective 3-2: Implement TSP on the various **locally-approved traffic signal controllers**, mainly the Econolite ASC/2 and ASC/3 controllers and Siemens EAGLE EPAC300 M40 and M50 controllers.
Objective 3-3: Maintain **coordination** for traffic signals that are part of interconnected signal systems
Objective 3-4: Maintain **pedestrian clearance intervals**
Objective 3-5: Maintain functionality of **existing Emergency Vehicle Preemption (EVP)** systems

Goal 4: Address Requirements for Deploying TSP Central Management System

Objective 3-6: **Remotely monitor, collect data from, and configure the TSP system** from Pace Headquarters in Arlington Heights.

Pace TSP Initiative and the Harvey Area TSP Demonstration

The following section describes how the TSP Initiative and the Harvey Area TSP Demonstration Project align with, and help to achieve, the goals and objectives of other efforts to improve transit service and regional mobility by Pace and its sister agencies.

CMAP is the federally designated Metropolitan Planning Organization (MPO) for the northeastern Illinois counties of Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will. CMAP developed and now guides the implementation of GO TO 2040, metropolitan Chicago's first comprehensive regional plan in more than 100 years. To address anticipated population growth of more than 2 million new residents, GO TO 2040 establishes coordinated strategies that help the region's 284 communities address transportation, housing, economic development, open space, the environment, and other quality-of-life issues. GO TO 2040 includes specific recommendations on improvements related to public transit, Intelligent Transportation Systems (ITS), and TSP. The following two paragraphs are direct quotes from the GO TO 2040 plan.

"GO TO 2040 recommends that the region prioritize investments toward strategic enhancements and modernization of the transportation system. If carefully targeted, these types of projects will improve access, mobility, and the overall experience for all users.[1]"

"Improvements related to Intelligent Transportation Systems (ITS) are also considered strategic enhancements and modernization. These include the use of real-time traveler information for both highway and transit, signal improvements such as interconnects or Transit Signal Priority (TSP) systems, traffic management centers, and many others. (…) GO TO 2040 supports continuing to advance ITS projects of all types, and recommends a continued role for CMAP in coordinating these efforts regionally.[2]"

Pace's Vision 2020 Plan

Unveiled in 2002, Pace continues to use its Vision 2020 plan as a guide into the future. The Pace TSP Initiative and the Harvey Area TSP Demonstration Project will help Pace realize many of the expected benefits of implementing the Vision 2020 plan, which are as follows[3]. (A check mark indicates an identified benefit of implementing the Vision 2020 plan that TSP can have a positive influence on.)

The key reasons to implement Vision 2020 are:

Customers
- ✓ Higher level of suburban mobility
- ✓ Faster service
- ✓ More flexible service
- ○ Pedestrian and bicycle access
- ○ Improved passenger facilities
- ○ Greater public safety
- ✓ Improved connections
- ○ Better access to jobs and community facilities
- ✓ Reduced reliance on the automobile

Region
- ○ Positive effect on new development
- ✓ Less congestion
- ✓ Infrastructure improvements
- ○ Strong economic development
- ✓ Strong regional public transportation system

Environment
- ✓ Improved Air Quality
- ✓ Better connected communities

Serves Everyone
- ✓ Transit dependent
- ✓ Work commuters
- ✓ Riders with strollers
- ✓ People with disabilities
- ✓ Seniors

Full Suburban Access
- ✓ Convenient
- ○ Affordable
- ○ Easy to use
- ✓ Faster
- ○ Direct

Pace is meeting the goals of Vision 2020 in a variety of ways, including through several continued efforts aimed at increasing network speed as noted in the 2012 Pace Budget[4]. Those network speed enhancements include the following strategies:

- implementing TSP on designated corridors as part of the 5-year *Traffic Corridor Optimization and Traffic Signal Priority Program*

- improving on-time performance of Pace fixed routes
- converting routes from "flag stop" service to "posted stop" service

The Harvey Area TSP Demonstration project included two (2) bus routes that were converted from flag stop service to posted stop service during the course of the project, and Pace Service Planning is currently using data from the Harvey Area TSP Demonstration project system to help improve on-time performance as part of its ongoing program to make transit work better for existing riders and to encourage non-users to try public transit.

Description of Harvey Area TSP Demonstration Project:

The Harvey Area TSP Demonstration project included the following activities:

- Pace equipped **20 signalized intersections** in the area surrounding the Harvey Transportation Center (HTC) with TSP equipment (PRS units)
- Three diverse and strategically-selected Pace bus routes that serve the HTC, **Route 350 (Sibley), Route 352 (Halsted), and Route 364 (159th Street)**, travel through the TSP-equipped intersections.
- Pace outfitted **55 buses** that operate out of the South Division Garage with TSP equipment (PRG units).
- Pace installed a **TSP Central Management System** at the Arlington Heights headquarters so that Pace could monitor, evaluate, and configure the TSP system remotely.
- Pace installed a **robust communications system** that connects the various elements of the TSP system, from the wayside (on-street) equipment to the bus-mounted equipment to the Central Management System at Pace Headquarters.

The TSP system provides Pace buses with the technology to either extend green lights (green extension) or shorten red lights (red truncation) in the direction that the bus is traveling at the 20 TSP-equipped intersections **when the buses are running behind schedule by more than one (1) minute**. The TSP system can be managed from anywhere with access to the internet by anyone that has the required security clearance for the Central Management System's servers that reside at Pace Headquarters.

A key objective of the Pace TSP system is to **improve the schedule adherence** of Pace fixed-route service. This is aided by **integrating the TSP System with the bus Automated Vehicle Location (AVL) system, Pace's on-board Intelligent Bus System (IBS)**. When the Pace IBS determines that a bus is more than one minute behind schedule, the bus will request TSP until the deviation from the route's schedule has been corrected. Improving the schedule adherence will indirectly lead to operational cost savings through a decrease in fuel consumption, emissions, and wear-and-tear on the buses as a result of fewer stops and starts at red lights afforded by TSP. Customer satisfaction with Pace transit can also be improved as passengers notice an increase in

on-time performance and a decrease in transit travel times, which could potentially increase ridership along TSP Corridors.

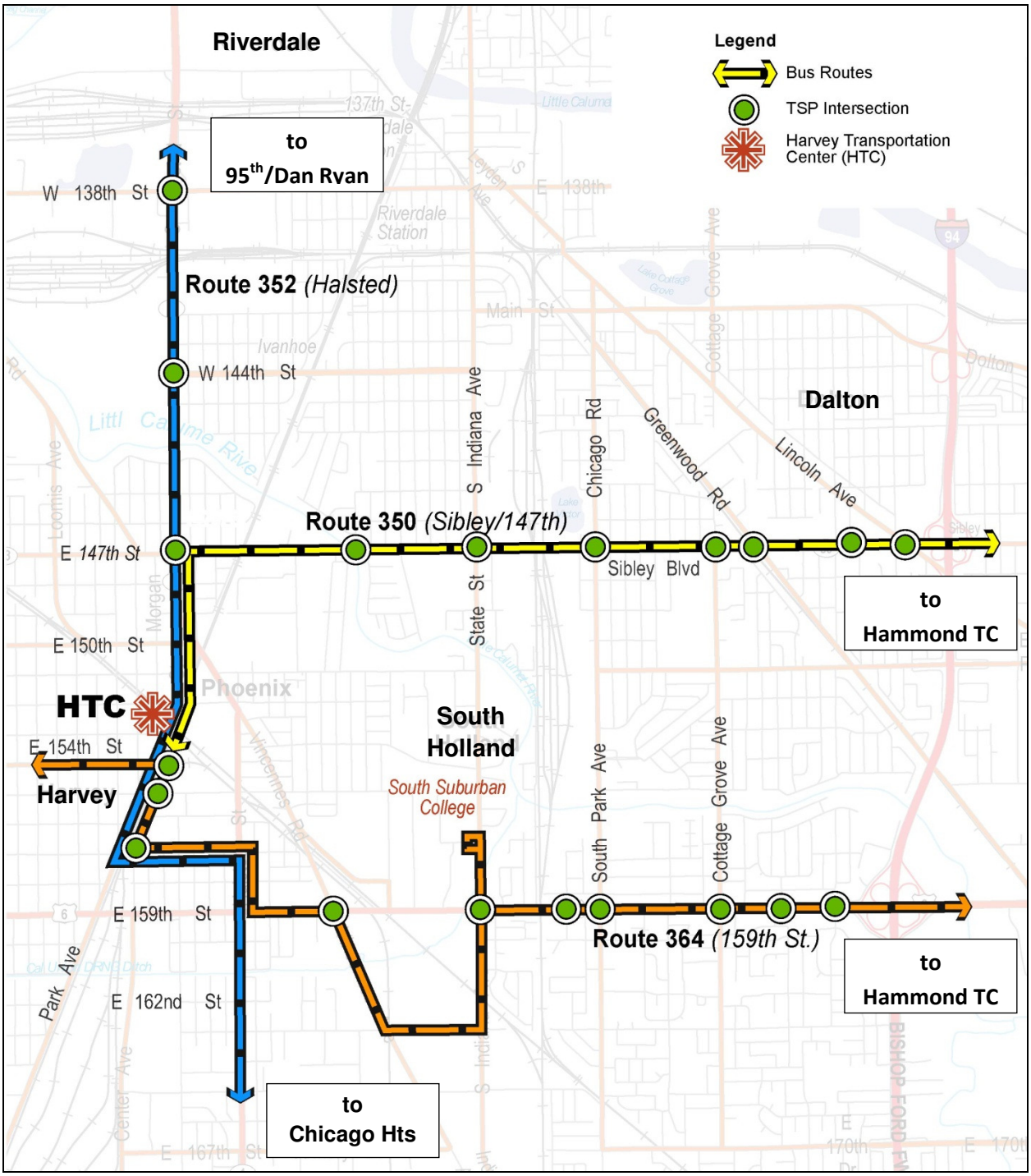
Table ES-1 provides a table listing of the 20 signalized intersections that were equipped with TSP equipment.

Table ES-1: Pace Harvey Area TSP Demonstration Project – TSP Intersections

147th St Corridor (7 Signals)	159th St Corridor (7 Signals)
147th St @ LaSalle St	159th St @ Vincennes Rd
147th St @ Indiana Ave/State St	159th St @ Indiana Ave/State St
147th St @ Chicago Rd/South Park Ave	159th St @ Wausau Ave
147th St @ Cottage Grove Ave	159th St @ Chicago Rd/South Park Ave
147th St @ Greenwood Rd	159th St @ Cottage Grove Ave
147th St @ Woodlawn Ave	159th St @ Ellis Ave
147th St @ Lincoln Ave/Michigan City Rd	159th St @ Woodlawn Ave
Halsted St Corridor (3 Signals)	**Park Ave Corridor (3 Signals)**
Halsted St @ 138th St	Park Ave @ 154th St
Halsted St @ 144th St	Park Ave @ 155th St
Halsted St @ 147th St	Park Ave @ 157th St

Figure ES-2 on the following page provides a graphic of the project area featuring the three Pace bus routes and the 20 TSP-equipped intersections in the project area.

Figure ES-6: Pace Harvey Area TSP Demonstration Project Area



KEY FINDINGS:

Harvey Area TSP Demonstration Project

The evaluation results are presented in this document are in quantitative terms. Quantitative results are presented at a high level in Tables in following pages. Transit and traffic data have been collected from three major sources, including the Pace Intelligent Bus System (IBS data) as well as more detailed data collected by URS staff traveling through the TSP project area on Pace buses (Bus Ride Along Data) and in passenger vehicles (Floating Car Data).

Transit and traffic data collection was conducted for AM and PM peak periods over the course of the demonstration project to study the conditions at specific stages of the project.

- Before (Existing) Conditions – Data collected during this stage of the project represents Pace operations before any work was done on the project.
- Optimized (TSP Off) – Data collected during this stage of the project represents Pace operations after traffic signal timings were optimized to best accommodate current traffic patterns and conditions but before TSP was deployed.
- After (TSP On) – Data collected during this stage of the project, the final configuration of the demonstration project, represents Pace operations after the traffic signal timings were optimized and the TSP System was deployed.
- At least one TSP intersection (159th & South Park) was not operational due to an accident during the evaluation study period.

The evaluation focused on transit mobility and reliability and was performed by comparing the Measures of Effectiveness (MOEs) for travel time, delay, time deviated from schedule, and number of delayed buses before and after TSP implementation. Direct value change and percentage change were both used to quantify the improvements for these MOEs.

The tables and figures summarize the major MOEs (travel time and travel time variation) discussed in this document for Pace Routes 350, 352, and 364 respectively. The improvements to Pace transit operations for the AM and PM peak periods are displayed by comparing the Existing state (Before) vs. the TSP state (After). Improvements are all highlighted in blue in the tables.

In general, there were many improvements to Pace transit operations when comparing the Before and After states. Overall, the travel time was reduced by a range from 2% (25 sec) to 15% (3.3 min). The travel time variation was reduced by a range of 14% (12 sec) to 66% (4 min). Route 364 WB received the most improvements during the PM peak period.

There were some instances where the TSP system did not improve transit operations as expected. Some reasons for this include various changes made to transit operations between the rounds of data collection. In addition, different traffic levels during the before and after phases when the evaluation data was collected may also impact the evaluation results. If more travel runs were collected during the peak hour out of the three-hour peak periods, the higher likelihood is to obtain higher travel time and delay which may cause the results to vary.

While TSP can improve schedule adherence and transit travel times, TSP alone can only reduce the delays to transit vehicles caused by traffic signals, specifically the delay from red lights. For the TSP Demonstration evaluation, signal delay was objectively defined as the time between when a transit vehicle stops at the end of a queue at a red light while waiting for a green light and when that light first turns green.

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, the green extension or red truncation of TSP cannot be guaranteed to eliminate all of the delay that can potentially occur at a signalized intersection. TSP can only reduce the amount of time that a transit vehicle is stopped at a red light.

Table ES-2: Comparison of Total Daily Travel Time (hh:mm:ss) for Each Route and All Routes Combined During AM and PM Peak Periods

Route	Route Direction	From	To	Before (Existing)	After (TSP On)	Change	% Change
350	EB	HTC	147th St (Sibley Blvd) @ I-94	5:52:32	5:32:36	-0:19:56	-5.7%
	WB	147th St (Sibley Blvd) @ I-94	HTC	5:29:27	5:49:24	0:19:56	6.1%
352	NB	HTC	Halsted St @ Blue Island-Riverdale Rd.	5:17:06	5:03:03	-0:14:03	-4.4%
	SB	Halsted St @ Blue Island-Riverdale Rd.	HTC	4:55:32	4:09:00	-0:46:32	-15.7%
364	EB	HTC	159th St(US 6) @ I-94	4:03:25	4:20:36	0:17:10	7.1%
	WB	159th St(US 6) @ I-94	HTC	4:19:10	3:53:00	-0:26:10	-10.1%
All Routes	**All**	-	-	**29:57:13**	**28:47:39**	**-1:09:34**	**-3.9%**

Note: AM Peak Period: 6:00 am – 9:00 am; PM Peak Period: 3:30 pm – 6:30 pm

Figure ES-7: Percentage Change in Daily Travel Time Between Before and After Conditions

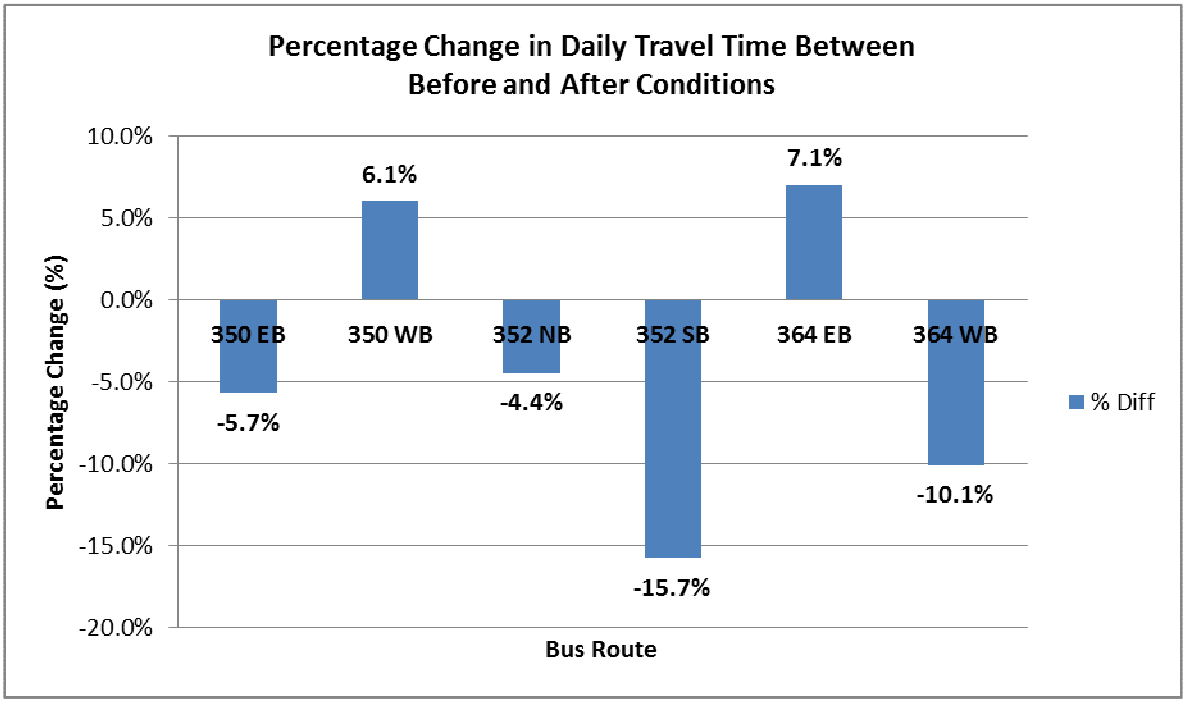


Table ES-3: Comparison of Daily Travel Time Variation (mm:ss) for Each Route and All Routes Combined During AM and PM Peak Periods

Route	Route Direction	From	To	Before (Existing)	After (TSP On)	Change	% Change
350	EB	HTC	147th St (Sibley Blvd) @ I-94	03:43	01:59	-01:43	-46%
	WB	147th St (Sibley Blvd) @ I-94	HTC	01:31	01:26	-00:05	-6%
352	NB	HTC	Halsted St @ Blue Island-Riverdale Rd.	01:40	02:06	00:26	26%
	SB	Halsted St @ Blue Island-Riverdale Rd.	HTC	01:40	00:59	-00:40	-41%
364	EB	HTC	159th St(US 6) @ I-94	04:10	01:26	-02:43	-65%
	WB	159th St(US 6) @ I-94	HTC	05:21	02:25	-02:55	-55%
All Routes	**All**	**Average Travel Time Variations**		**03:01**	**01:44**	**-01:17**	**-43%**

Note: AM Peak Period: 6:00 am – 9:00 am; PM Peak Period: 3:30 pm – 6:30 pm

Figure ES-8: Percentage of Daily Travel Time Variation Between Before and After Conditions

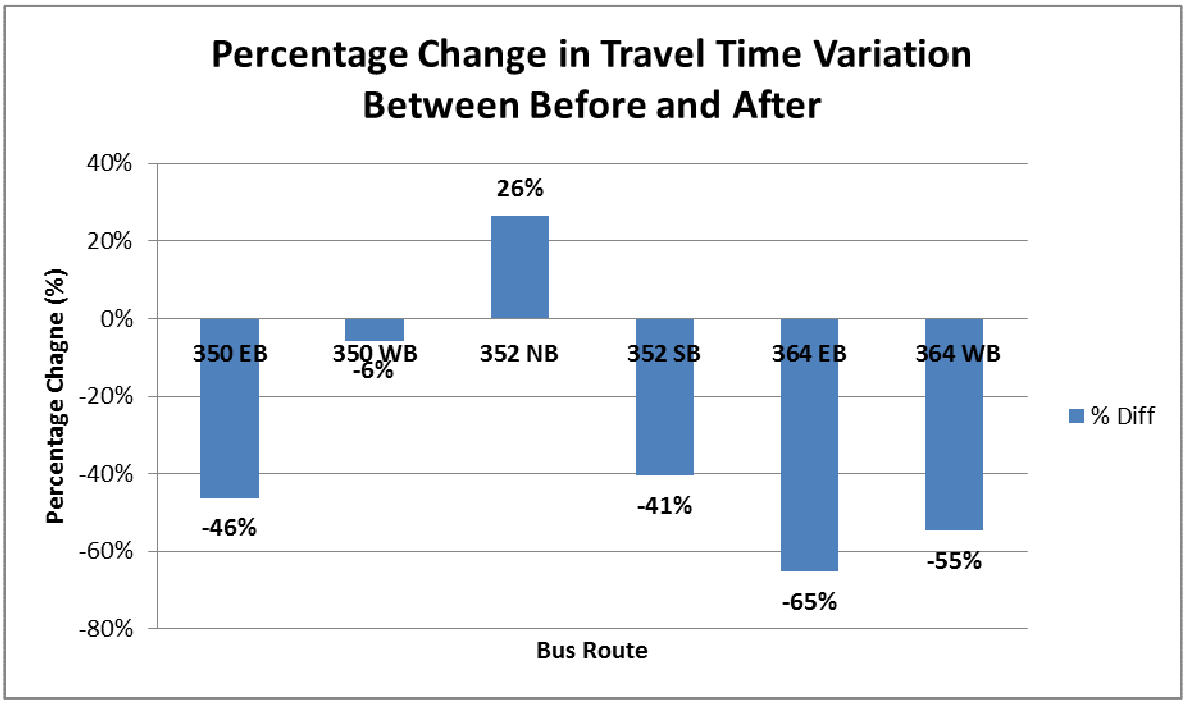


Table ES-4: Comparison of Daily TSP Intersection Delay (mm:ss) for each TSP Intersection and All TSP Intersections Combined During AM and PM Peak Periods

TSP Intersection	Optimized (TSP Off)	After (TSP On)	Change
147th St @ Halsted St	26:26	16:42	-09:44
147th St @ LaSalle St	00:08	00:23	00:15
147th St @ Indiana Ave/State St	04:05	00:37	-03:28
147th St @ Chicago Rd/South Park Ave	05:00	03:41	-01:19
147th St @ Cottage Grove Ave	00:48	00:18	-00:30
147th St @ Greenwood Rd	01:50	03:29	01:39
147th St @ Woodlawn Ave	01:53	01:47	-00:06
147th St @ Lincoln Ave/Michigan City Rd	02:42	03:57	01:15
Halsted St @ 144th St	02:35	01:22	-01:13
Halsted St @ 138th St	03:24	02:04	-01:20
Park Ave @ 154th St	01:44	01:41	-00:03
Park Ave @ 155th St	08:22	08:21	-00:01
Park Ave @ 157th St	06:24	03:32	-02:52
159th St @ Vincennes Rd	12:55	06:24	-06:31
159th St @ Indiana Ave/State St	22:21	19:58	-02:23
159th St @ Wausau Ave	01:07	02:14	01:07
159th St @ Chicago Rd/South Park Ave	03:34	03:01	-00:33
159th St @ Cottage Grove Ave	01:38	01:32	-00:06
159th St @ Ellis Ave	03:07	02:08	-00:59
159th St @ Woodlawn Ave	02:01	01:19	-00:42
All Intersections	**1:52:04**	**1:24:30**	**-27:34**

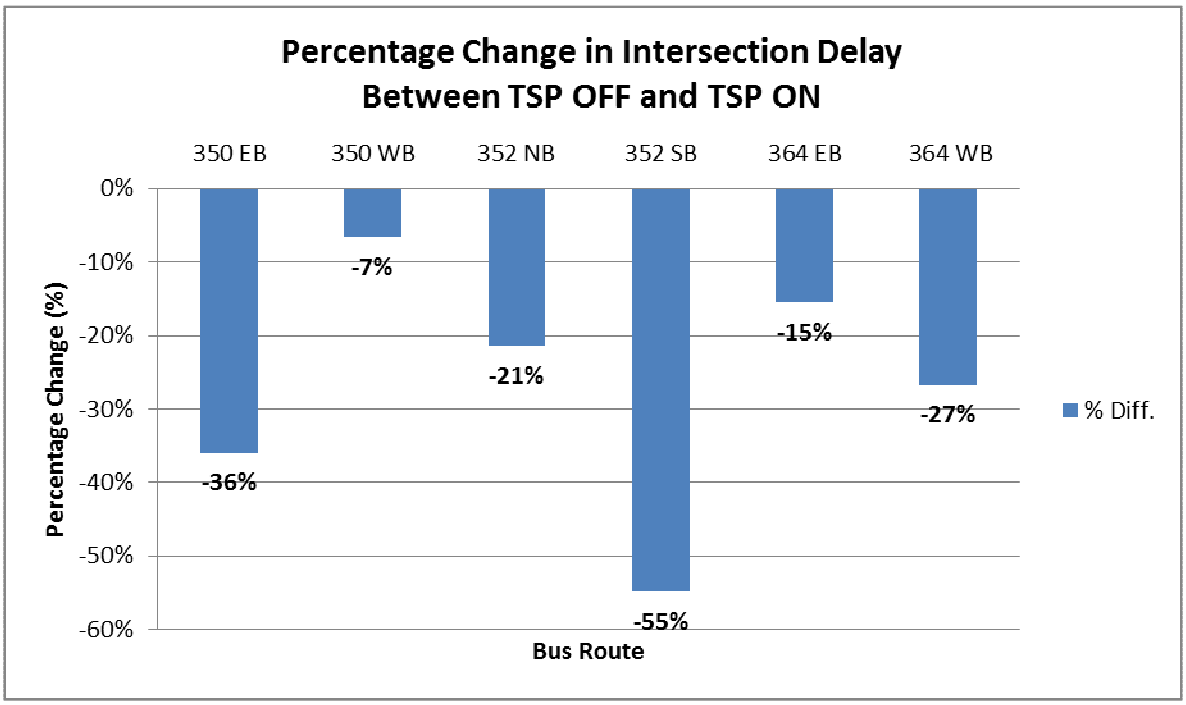
Note: AM Peak Period: 6:00 am – 9:00 am; PM Peak Period: 3:30 pm – 6:30 pm

Table ES-5: Comparison of Daily TSP Intersection Delay (mm:ss) for Each Route and for All Routes Combined

Route	Number Of TSP Intersections	Optimized (TSP Off)	After (TSP On)	Change	% Change
350EB	8	16:23	10:29	-05:54	-36%
350WB	8	11:06	10:22	-00:44	-7%
352NB	3	11:30	09:02	-02:28	-21%
352SB	3	09:52	04:27	-05:25	-55%
364EB	10	34:13	28:55	-05:18	-15%
364WB	10	29:00	21:15	-07:45	-27%
All Routes	**Total Delay for All Intersections***	**1:52:04**	**1:24:30**	**-27:34**	**-25%**

* Note: The total number of intersections is 20. Routes 350 and 352 both travel through the TSP intersection at 147th St at Halsted St.

Figure ES-12: Percentage Change in Intersection Delay Between TSP Off and TSP On Conditions



Conclusion:

Harvey TSP Demonstration Project was successful both in terms of benefits to Pace riders and technology implementation. Pace plans to start Phase 2 deployment of the project by mid-year 2012 and begin subsequent region wide TSP deployment along major Arterial Rapid Transit (ART) corridors.

References:

[1] GOTO 2040 Comprehensive Regional Plan, Chicago Metropolitan Agency for Planning (CMAP), 2010, pg 272.
[2] Ibid
[3] Vision 2020: Blueprint for the Future, Pace, 2002.
[4] Pace 2012 Proposed Budget, Pace, 2011, Appendix E, Planning Initiatives.