King County Metro TSP Policies and Strategies

Updated 7/22/2021

King County

Overview and Purpose

The purpose of this document is to provide guidance to Metro project managers, consultants, and local agencies who wish to deploy Transit Signal Priority (TSP) at signalized intersections within King County (KC). The document discusses the TSP deployment requirements, guidance for where TSP benefits can be realized, TSP timing strategies to consider, and the ongoing operations and maintenance of TSP. This document will be updated as new systems and features become available and as King County gains more experience operating and evaluating TSP.

TSP Benefits & Planning

TSP is a technology to detect buses approaching a traffic signal and adjust signal timing to reduce delay to buses to improve transit service performance. The benefits of TSP can vary widely depending on the existing level of delay/congestion, presence of nearby intersections or bus stops, TSP timings/strategies allowed by the local traffic agency, and other technical limitations. Past evaluations on TSP benefits have shown bus travel time savings of up to 8% on overall corridor travel times. A reasonable planning-level estimate is that TSP on a corridor can reduce bus travel times by 5%. TSP can also improve service reliability by reducing the number of buses running late or not meeting headway thresholds. After deploying a reliability-focused corridor TSP strategy on RapidRide C & D Lines, a 30% reduction in the number of buses missing headway targets was measured during a peak period.

A VISSIM study can be used to estimate TSP savings and impacts along a corridor, however the VISSIM virtual signal controller may not perfectly simulate how actual signal controllers will provide TSP. Early discussions about TSP strategies with the local traffic agency can help inform appropriate TSP settings to include in a VISSIM model.

Synchro can be used to estimate existing signalized intersection delay, which can help develop a range of expected TSP savings. Synchro can also be used to select which intersections to include TSP based on bus movement LOS (See *LOS/Delay Criteria* below).

Where to install TSP

Corridor vs. Isolated Locations

- Corridor installations of TSP are preferred because travel time savings from many signalized intersections can add up to measurable travel time savings and improvements in reliability across individual bus trips and for transit riders.

- Single-intersection deployments should only be considered if significant travel time savings per trip are anticipated.
- Installation of TSP in isolated locations can be considered where TSP detection will be used to activate a queue jump or special bus phase.

Bus Volumes

- TSP works best at an intersection where bus volumes are in the range of 8-25 buses/hour total for all intersection approaches/directions.
- If bus volumes are greater than 25 per hour, a bus would be expected to arrive on nearly every signal cycle. In these cases, normal signal timing adjustments or other transit-supportive treatments would likely be more beneficial than TSP.
- Central business districts or downtown areas are typically not effective locations for TSP due to high bus volumes, high pedestrian volumes, and closely-spaced intersections that do not recover well from TSP.
- Exceptions to the above criteria could be made where TSP is used as a headway-management tool and only a subset of approaching buses will be requesting TSP.

LOS/Delay Criteria

- The bus movement Level of Service (LOS) should be C or worse (average delay greater than 20 seconds/vehicle) during at least one peak period (AM, PM, or mid-day) before considering TSP.
- Low-delay intersections (intersection or movement LOS A or B) are not likely to provide enough benefit to justify the time and expense involved with deployment and maintenance of TSP.
- Efficient TSP operation requires a predictable and consistent travel time between detection point and intersection; LOS F bus movements at intersections without a bus lane may not provide adequate predictability.

TSP Strategies

Corridor Strategies

Previously, when the original RapidRide A-F lines were deployed, the main TSP strategy employed was to optimize bus travel time for all trips and maximize the number of TSP requests. The goal of this strategy is to have the average travel time savings reflected in the schedule. A drawback of this strategy is that local traffic agencies may choose to employ a low level of priority for each TSP request due to concerns about general purpose traffic operations and delay to pedestrians.

In 2018, a new TSP strategy focused on reliability was deployed with the retiming of TSP along the RapidRide C & D lines. With this reliability strategy, buses request a higher level of priority when running late by a certain threshold that can be configured per intersection, direction, and time of day. In return for requesting TSP less often, Metro expects the local traffic agency to offer more beneficial TSP strategies at intersections.

TSP is one of many different tools available to improve transit speed & reliability; more tools are described in the *Transit Speed & Reliability Guidelines & Strategies*. The NACTO *Transit Street Design Guide* outlines other active and passive signal timing strategies that can be incorporated into an overall corridor strategy.

Intersection Strategies

At an intersection level, the following TSP strategies can generally be used:

Standard TSP strategies

- **Green Extension** – A signal phase is held on the green phase longer to accommodate an approaching bus
- **Red truncation or early green** – Other signal phases are shortened to serve a waiting bus faster

Advanced TSP strategies

- **Phase skipping (aka "full priority")** – Other signal phases are omitted or rotated for one signal cycle to provide immediate service to an approaching or waiting bus
- **Near-side stop advance request** - When a near-side bus stop is located prior to the signal, the bus will initiate a TSP request prior to arriving at the bus stop. TSP timing parameters are set based on historical dwell time data for the stop and available green extension times.
- **Cascading priority** – A bus requests signal priority to multiple closely-spaced intersections simultaneously. This strategy assures that controller has adequate notice to activate a beneficial green extensions or full priority.

Experimental TSP strategies

The following strategies are theoretical in nature and have not been tested in an actual TSP deployment. These strategies may not be feasible with current signal controller technology and may have limited use depending on other intersection operational constraints.

- **Green truncation for early buses** – If a bus is running ahead of schedule or following too closely to the bus ahead, a green light could be terminated early to hold that bus back and allow other intersection users to be served.
- **Pre-ped request** – When a bus travels through an intersection to a far-side stop and the StopRequested data field is "true", the signal controller would automatically trigger a pedestrian call in anticipation that an alighting passenger would likely want to cross during the next signal phase.

Metro and the local traffic agency should collaborate to determine the appropriate TSP strategies and timings, recognizing that the local traffic agency has final approval authority. Metro has developed spreadsheets to document the agreed-upon TSP strategies and timings; these should be used and kept updated as much as possible.

TSP Systems: Legacy RapidRide vs. ngTSP

King County Metro is in the process of procuring a new centralized next-generation TSP system (ngTSP). ngTSP is expected to be available for widespread deployment in early 2022. The anticipated benefits of the ngTSP system include:

- Improved system accuracy and reliability
- Reduced capital and maintenance costs
- Rapid deployment possible since no construction is typically required
- Leverage existing communication networks and cellular communication

- Centralized management of TSP operations and improved reporting

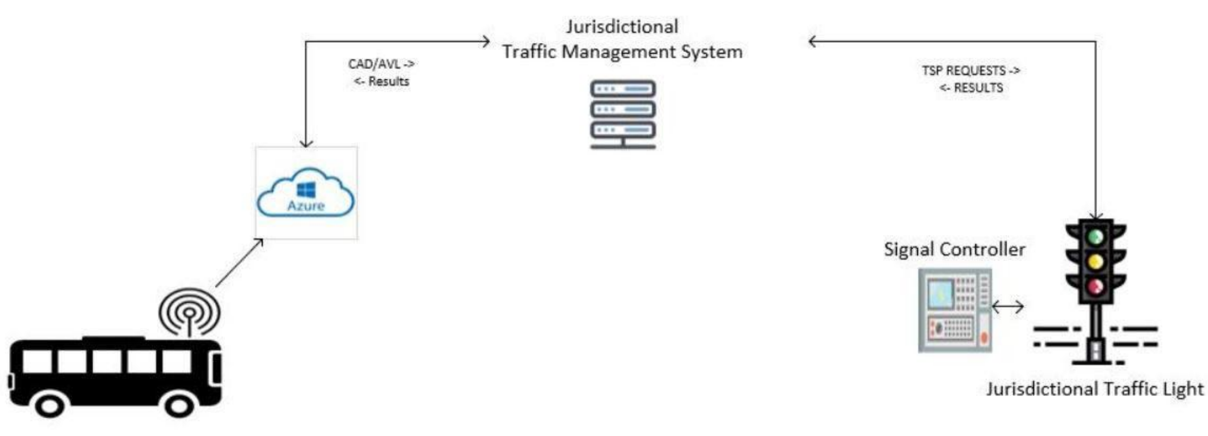
Currently, the existing RapidRide A-F lines, Route 44, and 120 corridors operate on the Legacy RapidRide TSP system. Until ngTSP is available, Metro cannot support any new TSP installations using the RapidRide Legacy TSP system due to the following factors:

- Legacy 4.9GHz Wireless Access Points are no longer manufactured and replacement parts are scarce
- The Legacy TSP system requires a dedicated county-owned cabinet connected to or adjacent to the city-owned signal cabinet at each intersection as well as fiber connections to each of those cabinets; this roadside infrastructure can be a considerable expense
- Deployment, operation, and maintenance of the Legacy system requires considerable staff time; these resources are currently being directed to develop the ngTSP system and optimize TSP timings on existing installations
- Any new Legacy system equipment purchased would become obsolete within a few years

ngTSP Architecture

ngTSP is designed to be a fully centralized TSP system that will link King County's on-vehicle and back-office systems to the various traffic signal systems used by local agencies within King County Metro's service area. KC-owned cellular communications (next-gen wireless) will be used to communicate between buses and the Metro centralized TSP server. The local agency's traffic signal central system will receive bus location data via a secure Application Programming Interface (API) through the internet, potentially routed through a dedicated peering arrangement. The data fields available through the TSP bus location feed are listed in Appendix A; some customization may be possible to meet specific jurisdiction or signal vendor needs. Note that the data feed has no information related to the location or status of traffic signals; the local agency's centralized signal system must provide this information. New KC-owned fiber or cabinets do not need to be constructed with ngTSP, instead, the local agency's traffic network will be used to relay TSP requests from the traffic central system to the signal controllers.

Metro expects to be able to receive information back from the traffic agency about TSP requests and the results of each request. This information will be used for regular reporting, fine-tuning, and troubleshooting.



ngTSP Requirements

- The local agency's traffic signal central system must have the applicable TSP modules installed and connected to King County's bus location feed. Vendor licensing fees, IT costs, and staff time may be incurred during this initial setup.

    - The initial ngTSP project plans to compete this for all jurisdictions within the existing RapidRide (A-F) lines as well as the currently funded new RapidRide lines (G, H, & I).
    - For other deployments of ngTSP beyond the RapidRide program upgrades, either the local agency or a separately-funded KC Metro capital project will need to fund the central system TSP integration.
- Each intersection planned for TSP must be connected to the local agency's central signal/traffic management system via a low-latency communication link. Typically, fiber to the cabinet provides this link, but other communication technologies such as ethernet, fixed wireless, cellular, etc. may suffice.
- Each intersection must have a signal controller and software version compatible with the centralized TSP system (specifics vary by vendor). A controller software and/or hardware upgrade may be needed to support centralized TSP. See *Signal Controller Platforms* below for more details.
- King County and the local agency need to agree on policies and procedures for operation and maintenance of TSP within that jurisdiction, including reporting TSP information back to Metro. A TSP operations and maintenance agreement is anticipated for each jurisdiction.

Signal Controller Platforms

Metro has experience operating TSP with the following traffic signal controller/software platforms:

- Siemens SEPAC running on M50/M52/M60/M62 controllers
    - Version 3.4 or higher required for Full Priority TSP
    - Version 3.56 or higher fixes some TSP bugs
    - Higher version may be needed for ngTSP integration (TBD)
    - Planned ngTSP integration with Siemens TSP Connect module
- Siemens SCOOT Adaptive Signal Control
    - TSP functions have been tested & evaluated at one intersection in the City of Seattle, showing reduction in intersection delay compared to SCOOT operation without TSP.
    - Extensive TSP feature set
    - Planned ngTSP integration with Siemens TSP Connect module
- Econolite ASC/3 and Cobalt
    - ASC/3 software requires logic programming to provide green extensions on non-coordinated phases
    - Newer EOS software has advanced TSP features, but Metro has not tested them yet
    - Planned ngTSP integration with Centrax TSP module
- SCATS Adaptive Signal Control
    - TSP is currently deployed at 13 intersections in the City of Bellevue
    - Providing Green extensions and red truncations require using one or more SCATS stages; the number of stages available at individual intersections may be limited depending on the complexity of the intersection
    - Planned ngTSP integration with SCATS via TRANSnet application
- Intelight

    - Several WSDOT intersections run TSP using MAXTIME software, they have not been fully evaluated by Metro
    - ngTSP integration with MAXVIEW central system currently TBD

TSP Monitoring & Optimization

Similar to regular traffic signal timings, TSP timings need to be reviewed and adjusted periodically. Metro recommends that TSP timings be reviewed along each corridor every 4-6 years or in conjunction with any significant changes to the corridor such as signal retiming or channelization changes. The optimization process is an opportunity to perform the following activities:

- Review system reliability and locations of transit delays
- Discuss potential new TSP strategies with the local traffic agency(s)
- Upgrade controller or TSP software to enable new features
- Replace any failing or unreliable equipment
- Implement other low-cost improvements such as regular signal timing or phasing adjustments
- Develop and implement new TSP timings and settings
- After optimization, conduct an evaluation of TSP effectiveness

Operational Readiness

Implementation of TSP requires an ongoing operations and maintenance budget; these resources must be secured before a TSP deployment is completed and enters the O&M phase. Outside of the regular optimization process described above, Metro may need to provide technical support for efforts led by a local agency that affect TSP operation, such as the addition of a left turn phase or implementation of adaptive signal control systems. IT resources at both Metro and local agency are needed to maintain and make periodic changes to the central servers on both ends.

Planning-Level Cost Estimates

The following are planning-level estimates for the costs involved with deploying and operating TSP, including costs borne by both Metro and the local jurisdiction. These costs are the additional costs of TSP on top of regular traffic signal capital and operating costs and assume that communication is available to the signal cabinet. Funding for these items can come the budgets of either agency, transferred via interagency agreement if needed.

- Central System Integration: $50,000 per jurisdiction
  (ongoing licensing/maintenance fees may also apply)
- Controller upgrade, if required, including hardware & labor: $6,000 per intersection
- Staff time to develop, deploy, monitor, and fine-tune TSP timings: $10,000 per intersection
- Ongoing TSP operation, maintenance, & periodic re-timing: $500 per year per intersection

Metro has not yet completed a full deployment of the ngTSP system, so actual costs are not yet known, and these estimates are subject to change.

Appendix A: TSP Bus Location Data Feed Specification

Telegram	Data	Type	Current Description	Format
Head	SystemID	Integer	=1	=1
Head	Timestamp	Integer	Time message sent (sync'ed to GPS)	
Head	AgencyID	Integer	Operating agency	1 = King County Metro 2 = Community Transit 3 = Pierce Transit 4 = Sound Transit
Head	VehicleID	Integer	Coach number	Integer ID
OBS Data	Route	Integer	Block route	Integer ID
OBS Data	Run	Integer	Block run	Integer ID
OBS Data	Trip	Integer	Block trip	Integer ID
OBS Data	Lateness	Float	Time delay from scheduled time of arrival	Minutes [mm.s]
OBS Data	Ridership	Integer	Real-time passenger load; actual load value	Integer
OBS Data	DoorOpen	Integer	Flag indicating if the door is open at the time of message	0=False 1=True 2=unknown
OBS Data	StopRequested	Integer	Flag indicating that the next stop is requested for alighting Coach (if signal connected to COPILOTpc)	0=False 1=True 2=unknown
OBS Data	LastStopID	Integer	Current or last stop, pattern associated	Integer ID
OBS Data	NextStopID	Integer	Next stop, pattern associated	Integer ID
OBS Data	Distance	Integer	remaining distance to next stop	
OBS Data	Schedule	?	?	?
GPS	UTC	Integer	Fix taken at 12:35:19	123519
GPS	Status		Status A=active or V=Void.	A

GPS	Latitude		Decimal degrees <10ft (approx. 3cm) resolution, WGS'84 projection, North direction.	DDMM.MMMMMM 4807.038,N
GPS	Longitude		Decimal degrees <10ft (approx. 3cm) resolution, WGS'84 projection, Easting direction.	DDDMM.MMMMM 01131.000,E
GPS	Speed		Speed over the ground in knots	22.4
GPS	Track		Track angle in degrees True	84.4
GPS	PDOP		PDOP (dilution of precision)	2.5
GPS	HDOP		HDOP (horizontal)	1.3
GPS	VDOP		VDOP (vertical)	2.1