Florida Department of Transportation Central Office

Transit Signal Priority Implementation Guidance

Final Report

Photo courtesy of flickr.com/photos/itdp

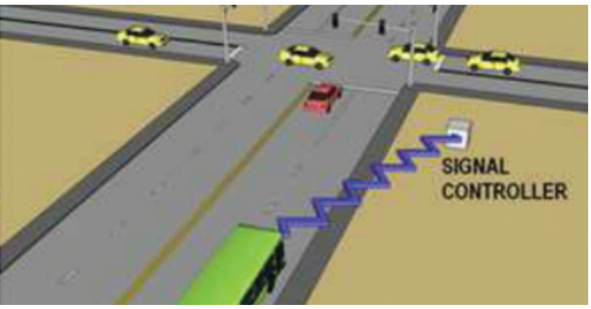

Photo courtesy of metrojacksonville.com

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION
FLP
Office of Freight, Logistics and Passenger Operations

July 2014

Transit Signal Priority Implementation Guidance

July 7, 2014

Final Report

Prepared for

Diane Quigley, Project Manager
Florida Department of Transportation
605 Suwannee Street, MS26
Tallahassee, FL 32399
(850) 414-4520
diane.quigley@dot.state.fl.us

Prepared by

Tindale-Oliver & Associates, Inc.

Table of Contents

Project Overview 1

Case Study Interviews 1

Transit Signal Priority Stakeholders 5

Implementation Guidelines 7

Appendix A – Fundamentals of Transit Signal Priority

Appendix B – Case Study Agency Interview Questions

Appendix C – Case Study Agency Stakeholders

List of Tables

Table 1: Transit Signal Priority Case Study Interviews and System Characteristics 3

Table 2: Transit Signal Priority Interagency Implementation Guidelines 9

Project Overview

Transit Signal Priority (TSP) collectively refers to various techniques used to improve service and reduce delay for transit vehicles at signalized intersections. By its nature, implementing a TSP program is a collaborative practice, requiring coordination between multiple stakeholder agencies on key elements ranging from planning to operation to system evaluation. As interest in implementing new TSP systems gains momentum throughout Florida, there is an increased need for guidance concerning interagency coordination between the transit agencies (who often champion the development of a TSP system for the benefit of their services) and local transportation, traffic, and/or public works departments (who often operate the traffic control signals). The implementation guidelines presented in this report serve to enhance interagency coordination between transit agencies and local transportation/traffic operations departments during the planning, implementation, operation, and evaluation phases of a TSP system.

To help establish such guidance, a set of national case studies in which transit and transportation/traffic agencies have worked together to successfully implement TSP systems were identified and interviews were conducted with key personnel involved in the process. These case study interviews were designed to mine a range of information concerning interagency coordination challenges, opportunities, and lessons learned. The information gathered from this effort forms the basis for the interagency guidance and strategies that local agencies can consider when exploring the implementation of TSP.

While there exists a library of substantial resources that provides detailed information regarding the technical aspects of TSP, including the technologies available and how the system components operate, the purpose of this effort is not to discuss in detail the technical aspects of TSP. Instead, the focus is to learn from actual implementing agency experiences and provide decision-making support as the TSP potential grows in Florida. To support this overall project goal, information on the fundamentals of TSP and the identification of potential stakeholders that could be involved in a TSP implementation process was prepared. This information, used to set the foundation for the implementation guidelines, is provided in Appendix A.

Case Study Interviews

During the early phases of this project, Internet research was conducted to compile a list of candidate TSP case studies to review. An initial list of 32 transit agencies that have implemented TSP systems was compiled. Characteristics such as the governance structure of

the transit agency (stand-alone agency, city/county department, etc.), mode of transit for which TSP is applied (fixed-route bus, premium bus service, light rail, etc.), age of the TSP system, and extent of system (number of intersections, miles of corridor, etc.) were evaluated. Ten candidate case studies were identified along with a list of alternates. Of the original 10 candidates identified, 6 participated in the interview process; the remaining 4 initial candidates could not be reached or were deemed not suitable to continue with the interview for a variety of reasons. Three of the remaining four case studies were selected from the list of alternates. Sun Metro in El Paso, Texas, was added as a case study to gain perspective about a TSP system that is in the final stages of development. In total, 21 transit agencies were contacted to participate in this research effort.

For each case study, the Project Team made every attempt to contact a representative of a transportation/traffic operations jurisdiction involved in the TSP system implementation to interview. This was done to gain insight from not only the perspective of the transit agency staff, but also from the local government transportation/traffic operations staff on the coordination and communications during development of the TSP system.

During this process, 20 individuals were interviewed for the 10 transit agency case studies. Prior to the interviews, a set of interview questions was prepared and sent to each interviewee. Most interview questions were the same for representatives of the transit agency and representatives of the traffic operations department(s); however, some questions were asked to reflect the particular perspective of each interviewee. The questions asked during the interviews are provided in Appendix B.

Table 1 provides an overview of the 10 case study interviews as well as characteristics of each system.

Table 1: Transit Signal Priority Case Study Interviews and System Characteristics

Transit Agency	Local/State Government	Type of Transit Agency	Transit Mode of TSP System	Year TSP Operational	Extent of TSP System (Urban/Suburban)
LYNX (Central Florida Regional Transportation Authority)	City of Orlando (FL) Transportation Engineering Division	Stand-alone agency	LYMMO, LYNX Bus Rapid Transit (BRT) downtown circulator	2007	39 intersections (urban)
Charlotte Area Transit System	City of Charlotte (NC) Department of Transportation	Department within the City of Charlotte	Fixed-route bus	2011	90 intersections (urban)
King County Metro	King County (WA) Department of Transportation/Transit; City of Seattle (WA)	Department within King County	Fixed-route bus; Rapid Ride BRT	1999	176 intersections (urban)
Lane Transit District	City of Springfield (OR) Development and Public Works Department	Stand-alone agency	EmX BRT	2007	Approximately 10.5 miles serving two routes (Springfield--suburban and Eugene-urban)
Metropolitan Transit	City of Minneapolis (MN) Traffic and Parking Services Division	Operative Division of Metropolitan Council	Fixed-route bus; light rail	2009	33 intersections (urban)
Pierce Transit	Washington State Department of Transportation (WSDOT); City of Tacoma (WA)	Stand-alone agency	Fixed-route bus	2003/04	84 intersections (Tacoma-urban and SR 7-suburban)
TriMet	City of Gresham (OR) Transportation Division	Stand-alone agency	Fixed-route bus	Initial system in Portland implemented in mid-1990s; system expanded into Gresham in 2013	Over 275 intersections in Portland are equipped with TSP; expansion of system provides TSP at 8 additional intersections in Gresham (urban)

Transit Agency	Local/State Government	Type of Transit Agency	Transit Mode of TSP System	Year TSP Operational	Extent of TSP System (Urban/Suburban)
Utah Transit Authority	City of Salt Lake City (UT) Transportation Division	Stand-alone agency	MAX BRT line	2008	10-mile corridor (urban)
Sun Metro	City of El Paso (TX) Department of Transportation	Department within the City of El Paso	Brio Rapid Transit System (RTS)	First Brio line (Mesa) will be operational in late 2014; second Brio line (Alameda) is in final design and should be operational by February 2016	Mesa line has 36 intersections; Alameda line will have 49 intersections (urban)
Pace Suburban Bus	Illinois DOT	Stand-Alone agency	Existing system includes fixed-route bus on arterial routes; expanded system will include TSP along fixed routes and Arterial Rapid Transit (ART) routes (described by Pace as a rapid transit route operating in mixed-traffic)	2011	30 intersections currently in operation; planning to implement TSP at 300 signals over next five years (suburban)

Notes: The above table is based on information provided by persons interviewed at each agency and Internet research. A total of 32 initial case studies were initially researched to identify the 10 case studies included in the above table. The 10 case studies were selected based on the initial information available, the length of time the TSP system has been operational, the type of transit agency, and the type of mode in which the TSP system applies so as to examine a range of different factors that may influence the TSP implementation process. The information from these 10 case study interviews form the basis for the guidance included in this document.

Transit Signal Priority Stakeholders

During the interview process, most case study agencies cited the decision of which stakeholders to involve at different stages of the TSP implementation process as the most difficult decision. The specific circumstances of each case study strongly influenced the transit agency and traffic operations personnel involved, as well as other external stakeholders.

Based on the interviews conducted, the following factors were cited as being the most influential in determining the appropriateness of which stakeholders to involve:

- **Geography** – the scale of the geographic boundaries of the initial TSP system as well as any potential future geographic expansions. Involving potential future stakeholders in the initial process may be appropriate and lessen the learning curve of new stakeholders during subsequent expansions, especially those that are more near-term.

- **Jurisdictional Responsibility** – the number of agencies that have jurisdictional/ maintenance responsibility of the roadway segments affected by the implementation of TSP.

- **Type of Transit Agency** – the organizational characteristics of the transit agency, which strongly influence the specific stakeholders involved, the overall communication process, and existing relationships. The case study agencies included transit agencies with varying organizational characteristics, including those that operate as a city/county department and as an independent, stand-alone agency.

- **Funding** – the source of funding for the TSP system, which may require the involvement of state agencies, metropolitan planning organizations, or other regional oversight agencies.

- **Technology** – new traffic signal technology will likely broaden the involvement of traffic operations personnel, as opposed to a TSP system integrated into an existing traffic signal system.

- **Extent of the Project** – if implementation of a TSP system is concurrent with or a part of other transportation facility, operations, or technological improvements (e.g., the implementation of premium transit service), then the group of stakeholders involved

during the planning and implementation phases likely will be broader than the stakeholders involved solely for the implementation of TSP.

- **Extent of Institutional Knowledge** – as TSP is implemented locally or regionally, stakeholders become more knowledgeable about what TSP is, its capabilities, and the implementation process, even if they are not directly involved. This can lessen the extent and expanse of stakeholder involvement considerably when the TSP system expands elsewhere in the region. One example of this occurring is in Portland, Oregon. TriMet, the Portland-Metro area's public transportation provider, worked with the City of Portland to implement one of the nation's earliest TSP systems approximately 20 years ago. Given the history of TSP in the region and the familiarity of regional stakeholders, when the system was expanded outside of Portland into neighboring Gresham, there were considerably fewer stakeholders involved than observed from the other case study agencies. In fact, there was a single point of contact between TriMet and the City of Gresham via the Traffic Engineer. This was, in part, due to the minimal impact of the relatively small TSP system expansion, as well as the exceptional knowledge about TSP by agencies throughout the Portland-Metro region.

Key Findings from Case Study Agency Interviews

During the interviews, there was general consensus that a core group of stakeholders should be developed and include a lead person (or project manager) from the transit agency and a counterpart lead person from the appropriate traffic operations department. A range of stakeholders should be included throughout the planning, implementation, and operational/evaluation phases of developing a TSP system, and there was general consensus that all parties should be involved, to some degree, during the initial planning and project development stages to ensure that project goals, approach, and timeline are clear.

In most cases, early outreach or education provided the opportunity for this larger group of stakeholders to be involved. Subsequently, the group would then be distilled into a core implementation team. This also sets the stage for discussing the point at which specific stakeholders become more involved in the process based on their specific role.

From the transit agency perspective, almost all departments are touched in some way during development of a TSP system, whether developing a stand-alone TSP system or as part of premium transit service. Planning, scheduling, technology, and finance/budget staff were noted

as being the core transit staff involved during the initial planning stages and throughout the duration of TSP system development. However, at key points, staff from other departments also must become involved, depending on the specific needs of the agency. For example, as decisions about technology purchases are made, the transit agency's procurement department must become involved. As the system nears implementation, public affairs and marketing staff must become involved (although several persons interviewed cited early involvement by outreach/marketing staff as being very helpful in the overall implementation process). At the policy-making level, the transit agency board (if a stand-alone agency) provides the direction to pursue TSP and typically is updated at key points throughout the process.

From the traffic operations perspective, a key point of contact often was identified to serve as the agency representative during development of the TSP system. In most instances, this was a traffic or signal operations engineer or equivalent for the traffic operations agency. As implementation of the TSP system approached, field technicians and other traffic operations staff who would be responsible for helping to maintain the signal control boxes became involved. Education of signal operators was cited as being important, as they are the first line between the system and any issues that may be encountered.

In some cases, elected officials from the local government were actively involved; this was more typical if the TSP system was being implemented as part of a larger project, such as bus rapid transit or light rail. In some cases, policy direction was set by the policy-makers and decisions were then executed at the staff level. In some other instances, a formal Project Advisory Committee of high-level agency leaders and elected officials was established to provide policy guidance to staff involved in the project.

For reference, Appendix C provides more detailed information concerning the specific stakeholders involved specific to each case study interview.

Implementation Guidelines

The input provided from the case study agency interviews was reviewed and synthesized to discern key topics and themes as well as similarities and differences among the different experiences and perspectives. Not surprising was the fact that the circumstances surrounding each case study agency's experience in planning for, implementing, and evaluating a new or expanded TSP system were different. No two case studies were alike or described the same experiences. Also, as expected, many of the previously-noted factors that influenced the

involvement of particular stakeholders also influenced the overall TSP implementation experience.

Based on the information received during the case study agency interviews, the implementation guidelines for enhancing interagency communication and coordination during the planning phase of a TSP system are wide-ranging and extensive. One of the challenges in this effort was distilling very case-specific information and bringing it back to a level of broader application to develop guidelines that ultimately will provide the most benefit to a range of interested agencies.

One key take-away from this effort is that, based on the experience of the case study agencies, a well-laid foundation during the early planning stages of the TSP system will enhance the overall communication and coordination of stakeholders. As a result, the majority of the implementation guidelines should be considered during the initial planning phase to set the framework for the successful subsequent phases in which the communication protocols have been well-established and carry through the remainder of the project. Another key finding is that the extent of the overall communication and coordination process is greatly influenced not only by personal relationships, but also the organizational relationship between the transit agency and traffic operations department. In instances where both fall under the same organization (i.e., both being city departments, as in the case of Charlotte, NC and El Paso, TX), communication and coordination protocols seem to be more standardized as both departments operate under the same leadership and are working towards a common goal established for the agency. In instances where the transit agency is a separate entity, communication and coordination processes may differ between the different organizations or end-goals may not align, as is the possibility with any major project, which can present additional challenges in the overall process.

The key topics and themes garnered from the case study interviews have been developed into a set of implementation guidelines that are presented in Table 2. For each implementation guideline identified, key findings and “lessons learned” or recommendations for carrying-out the application of the implementation guideline are provided, based on the case study interviews and research conducted as part of this effort.

Table 2: Transit Signal Priority Interagency Implementation Guidelines

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Leverage Existing Relationships (establish during planning phase; continuously strengthen and develop throughout all project phases)	• **The benefit of existing relationships was cited as the most important element to successful communication** between the transit agency and traffic operations personnel.	• Consider the strength of existing working relationships as a key asset when identifying key stakeholders and core project team. • Hold in-person meetings to continue/strengthen relationships of TSP project team. • Ensure that the transit agency project manager has a good working relationship with the traffic engineer(s).
Identify Core Stakeholders/ Project Team (establish during planning phase)	• While the involvement of various stakeholders will fluctuate throughout the TSP system process, **a core project team should remain constant through planning, implementation, and operation phases**.	• Identify core project team members, organizational structure, and roles/responsibilities early in the planning process. • Include a primary contact/project lead from both the transit agency and traffic agency/operations department(s). • When possible, include a transit agency staff person with an engineering background on the core project team who can "speak the same language" as traffic operations personnel.
Identify and Leverage TSP "Champions" (establish during planning phase)	• As with most projects, **leveraging the enthusiasm and support of one or more project champions is critical to the successful outcome** of TSP system.	• Identify and engage TSP champions early on who are well-respected by both the transit agency and traffic operations personnel.

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Hold Regular Communication/Meetings (establish during planning phase; carry-on throughout project)	• **No case study agencies set any formal communication policies or procedures specific to the TSP project** outside of regular coordination meetings and identifying a project team organization/project lead(s). • Most of the case study agencies cited the **occurrence of regularly-scheduled meetings as very important to the communication process** of the core stakeholder group.	• Hold regular project team meetings to establish a predictable meeting schedule and to maintain continuity of process, strengthen project team relationships, and ensure open communication. • Adjust the frequency of project team meetings based on the specific phase of the project. • Although less frequent once the system is implemented, hold regular "touch base" meetings between the transit agency and traffic operations staff to discuss system performance, ongoing protocols, and other issues, as appropriate.
Establish a Bottom-Up Process for Information Flow (establish during planning phase; carry-on throughout project)	• Based on the experience of the case study agencies**, the core project team will likely consist of staff-level transit agency and traffic operations representatives.**	• Encourage frequent communication at the staff level, then bring this information to the director and policy leader levels at key-decision points during the planning process.
Provide Early Fundamental Education (establish during planning phase; carry-on throughout project)	• For areas where TSP is a brand new concept, it will be **important to provide a more broad-based fundamental educational component very early in the project process**, often when TSP is initially being considered or explored. • **Conduct a solid analysis (such as a simulation) to demonstrate the benefits of TSP and include in educational process.** Demonstrable planning evidence for operations will help illustrate the quantifiable benefits of TSP to all parties.	• Hold an educational summit where outside experts from both the transit agency and traffic operation perspectives speak to the group of stakeholders. This can be done for broader regional forums as well as for smaller, more specific stakeholder groups. • For region-wide interest in TSP, explore the possibility of hosting an FTA-sponsored workshop. This was done by Lane Transit District and found to be a very informative forum. • Include an interactive component between transit and traffic operations professionals to gain insight into the difference of perspectives from the two sides.

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Balance Existing and Future Stakeholders in the Education and Planning Process (establish during planning phase; carry-on throughout project)	• **Consider the extent to which potential TSP stakeholders (those likely to become active stakeholders upon system expansion) should be involved in the early education and planning processes**, especially if expansion plans are more near term.	• In addition to current stakeholders, identify potential stakeholders based on future TSP expansion plans. Evaluate the appropriateness of their involvement in the process, especially during the early discussions of TSP and educational components to provide general agreement and knowledge about the approach and identify compatibility issues up front. This will more easily allow the system to be expanded when the time is right, as the goal is to avoid having "pockets" of separate systems.
Educate from All Perspectives (establish during planning phase)	• **Touting only the benefits of TSP is unrealistic.** Ensure that the education does not *feel* one-sided (i.e., discusses only the benefits to transit).	• Include both transit agency and traffic operations professionals as part of the educational process to give a realistic expectation of what to expect from both viewpoints.
Leverage Peer Experiences and Exchanges of Information (establish during planning phase; carry-on throughout project)	• One of the most successful educational tools cited by case study agencies was **leveraging the prior experiences of peer agencies through a peer exchange of information**.	• Conduct on-site visits or tours of peer agency systems. • Hold conference calls with peer agencies when in-person visits are not possible. • Attend peer exchange working groups where TSP is discussed. • Include funding for peer agency visits as part of the TSP budget. Lane Transit District used FTA funds to fund a scanning tour where transit agency and city traffic engineers went to see first-hand how Chicago's TSP system was developed and functioned.

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Identify Appropriate Professional Resources (identify during planning phase; carry-on throughout project)	• **Considerably underestimating the required time commitment by the core project team, especially the Project Manager(s) in the planning and implementation of the TSP system, was cited as a barrier** to the overall project process. • **The use of consultants/outside experts was cited as a frequent resource in the educational process** during initial implementation of new TSP programs.	• Universities and research centers can be a good source of information concerning TSP and often at less cost than a private consultant. A university/research center also may provide a more neutral perspective on technology than a consultant who is invested in a particular type of technology.

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Understand Technology Goals and Limitations (establish during planning phase)	• **Identify and agree on technology goals up front** in terms of leveraging the capabilities of the existing signal system(s) or pursuing new infrastructure. Education about technology/systems should be conducted according to this goal. • **Ensure that education about technology options is thorough and wide-ranging.** Once you select a vendor, you are essentially selecting the technology that they provide. • For multi-jurisdictional TSP systems, it is very important to **understand the differences in technology and capabilities of the different signal systems** to determine what technology will work or what system upgrades are needed to develop a multi-jurisdictional or regionally-compatible system. • A **cost/benefit analysis** of how much money will be spent for new/upgraded equipment versus how much time and money (fuel, etc.) will be saved once the TSP system is operational should be conducted.	• Invite TSP vendors for discussions and demonstrations with the stakeholders to provide valuable insight into how complex TSP could be, as well as to discuss potential issues with existing system compatibility. • Consider the geography/terrain when evaluating hardware and technology. For Sun Tran, a GPS-based system would have solved many issues that the agency encountered with the TSP system for its Mesa Line due to hills and uneven terrain. • Bring all parties to the table during the RFP process to select a technology. • Know how the project will be placed out for bid ahead of time so it is clear how the project will be categorized (i.e., do not have a TSP project bid as a construction contract).

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Maximize Financial Benefit for All Parties (establish during planning phase; carry-on throughout project)	• Implementing a TSP system can provide the **opportunity for complementary capital improvements to antiquated traffic control systems**. • **Design of traffic signal cabinets that allow transit agency access to their equipment** can reduce the in-field time requirement of traffic operations staff to address in-field issues and complications. • **The ability to make remote field adjustments through a central traffic management center provides a great benefit**, as opposed to in the field, which can become cumbersome and time consuming depending on the jurisdictional policies for accessing controller cabinets. • **A lack of reliable information available about existing equipment or infrastructure in the field** (e.g., fiber optic cables) can cause significant cost increases and time delays.	• If enough capital dollars are available, the transit agency should consider including projects that traffic engineers would like but do not have the resources for, so long as it benefits the system (e.g., upgrading antiquated traffic signals). • Include costs of providing extended warranties (where available) on new technology purchases to help mitigate costs associated with the long-term maintenance. • During signal system replacement, explore the feasibility/policy for providing localized cabinet access by transit system personnel to their equipment. • If not already available, use the development of the TSP system as an opportunity to update the local infrastructure inventory and make it available to both transit agency and traffic operations staff.

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Develop the Public "Message" and Outreach Plan (develop during planning phase; execute throughout project)	• The project team, consisting of both transit agency and traffic operations personnel, should work together to **develop a clear and consistent message for TSP and an accompanying outreach plan.**	• Develop a specific message about what TSP is (and is not) to help prevent misinformation from being published (i.e., TSP will cause renegade buses running through green lights). • Leverage consultant or other external resources (e.g., MPO planning liaisons) to conduct outreach if such effort exceeds the capabilities of the internal project team. • Engage and educate the press, as needed and appropriate, to control the message concerning TSP.
Educate Internally within the Transit Agency and Traffic Operations Departments (conduct during planning phase)	• **Include high-level transit agency personnel/policy leaders in the education process to manage expectations.**	• A policy leader educational session where transit agency and local jurisdiction policy leaders come together with the core project team, including transit agency and traffic operations representatives, can not only serve as an educational session, but also provide a unified front as to the goals and expectations of the TSP system.
Begin the Interagency Agreement Process Early On (establish during planning phase; carry-on throughout project)	• **Formalizing the interagency agreement process and content was frequently cited by those case study agencies involved in initial TSP system implementations as being a significant hurdle.** Several case study agencies indicated that it took several years to get agreements in place, often after the system was operating. • **Ensure that the responsibility for operation and maintenance of the equipment after the system is implemented is clearly stipulated in the agreement** very early in the process so that there is no confusion.	• Begin formulating interagency agreement language very early in the process. Use existing agency service and maintenance agreements, where available, as a starting point. • Review copies of other agency's TSP interagency agreements to identify core areas and topics to consider and address. • Establish and implement the framework for the core agreement early on and then adjust later as necessary.

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Establish Communication Protocol for Reconciling System Issues and Efficiencies (establish during planning phase; carry-on throughout project)	• Once the TSP system is operational, a **process for addressing in-field system issues must be established.** • **Consider the appropriate financial responsibility for pre-planning signal timing optimizations** needed for future TSP corridors if outside of the regularly scheduled optimization schedule.	• The process for addressing system issues and funding agreements should be formalized as part of the interagency agreement. • Involve different stakeholders in the development of the interagency agreement(s) to consider all aspects/scenarios, such as stipulating the fiscal responsibility for unscheduled signal optimization on TSP corridors.
Identify and Agree Upon Parameters for Giving Priority (identify during planning phase; carry-on throughout project)	• **Low allocations of signal "green" time that allows for priority can be very challenging** when planning for TSP, especially in very urban areas.	• Include discussions among the stakeholders early on to agree upon what the parameters are for giving priority.
Establish Performance Measures (establish during planning phase; evaluate periodically once system is operational)	• Several case study agencies indicated that an area lacking in the planning process was the **establishment of performance measures to evaluate how the system is functioning once operational.**	• Establish performance measures to evaluate how the TSP system is functioning in relation to established goals. • During the technology selection process, understand the capabilities of the potential system in regard to providing the necessary data to monitor identified performance measures.
Establish Pre-Implementation Testing Process (establish during planning phase; carry-on throughout project)	• **Several case study agencies cited technological glitches or difficulties as adversely impacting the success (or perceived success) of the system.** Transit agency personnel indicated that unnecessary technology issues should be avoided at any cost, as they can taint the perception of TSP to the public and traffic agency personnel.	• Have a robust testing process on the software before it goes into the field and then retest again in the field. This provides assurances to all parties (transit agencies and traffic operations personnel) that system has been tested and will perform as expected when "live."

IMPLEMENTATION GUIDELINE (Applicable Phase of TSP System Development)	KEY FINDINGS	"LESSONS LEARNED" OR RECOMMENDATIONS FROM OTHER AGENCIES
Conduct Periodic Monitoring and Maintenance Review (conduct during operation/evaluation phase)	• Once the TSP system is operational, it is necessary to **conduct periodic monitoring of the system operations and establish a formal protocol for monitoring and periodic maintenance needs**.	• Establish a protocol for monitoring and making sure that ongoing maintenance is being performed. • Conduct a maintenance review 10 years after the original TSP system was implemented to determine what adjustments were needed to ensure that the system would provide benefit long into the future. • Include a continuous quality control process in the interagency agreement. • Understand who the "client" is for the traffic signal equipment vendor to determine the appropriate process that the transit agency will need to use to have any issues addressed by the vendor.

Appendix A – Fundamentals of Transit Signal Priority

TSP is an operational strategy that facilitates the movement of transit vehicles more expediently through signalized traffic intersections by temporarily adjusting traffic signal timings. This signal timing adjustment gives priority to transit vehicles operating in mixed traffic or in an exclusive transit lane. The use of TSP is popular in urbanized areas because it reduces the time that transit vehicles spend delayed at intersection queues, thereby improving efficiency and schedule adherence, which influence increased transit usage. A TSP system is typically used on corridors with high ridership, moderate frequencies, and significant corridor congestion. Upon approach to a signalized intersection, the TSP system automatically detects the transit vehicle, and the signal timing and phasing are adjusted to provide the transit vehicle with clear passage through the intersection, reducing potential delay at the signal. Benefits of TSP include a reduction in travel time for the transit vehicle and improved reliability and schedule adherence, providing significant cumulative time benefits to transit users and help to attract ridership.

TSP attempts to provide benefit to transit users through minimum impact to cross-traffic, bicyclists, and pedestrians by only temporarily modifying the signal timing to accommodate the transit vehicle. TSP is not the same as signal pre-emption, which is commonly used for emergency vehicles or train crossings and where the signal cycle is completely interrupted; when a traffic signal is preempted, the existing signal timing plan is not maintained as it is with TSP.

Transit Signal Priority System Implementation Types

There are two different approaches for implementing TSP: local intersection TSP and network-based TSP.

- **Local intersection TSP systems** – In its more simplistic form, TSP is provided at the intersection level when the traffic signal controller first detects a transit vehicle upon approach and subsequently upon departure when moving through the intersection. The point at which the transit vehicle is detected within the intersection approach and exit zones relative to the traffic signal cycle will determine whether the TSP treatment is triggered. Under this system, the transit vehicle communicates directly with the traffic signal controller and, if certain criteria are met, the transit vehicle is granted priority. Many TSP systems use this more simplified approach, especially when first

implementing TSP, as local intersection TSP systems cost significantly less than their network-based counterparts.

- **Network-based TSP systems** – Technological advancements have enabled more sophisticated TSP systems that operate continuously at the network level rather than localized to a specific intersection. Network-based TSP systems use Automatic Vehicle Location (AVL) technology to locate the vehicle en route. The real-time travel information determines the actual arrival time of the transit vehicle to the intersection prior to communicating with the traffic signal controller to request signal priority.

Transit Signal Priority System Components

There are three major components to a TSP system: the transit vehicle detection system, the communication system, and the traffic signal control system. Collectively, these systems are responsible for providing communication between the transit vehicle and the traffic signal control system.

- **Transit Vehicle Detection System** – initiates requests for priority, which can be automatic for all buses on certain routes or variable based on certain operational criteria. A number of technologies can detect transit vehicles along the transit route. Local intersection detection occurs using an on-board transmitter and receiver at the traffic signal control; network-based detection uses an on-board transmitter that communicates directly with a management center.

- **Communications System** – provides a connection among the TSP system components. The reliability of the TSP system is completely dependent on this component. The communications system detects information from the transit vehicle to the traffic signal control system via the local intersection or centralized management center.

- **Traffic Signal Control System** – receives the priority request from the transit vehicle detections system via the communications system and makes the necessary changes to the signal via the local traffic signal controller.

Traffic signal control systems at intersections can be categorized by the following:

- **Fixed-time signal control** – operate with a constant signal cycle length and phase sequence, relying on the same amount of green time for each movement during every cycle regardless of traffic demand.

- **Actuated signal control** – collect information about the current traffic demand at the intersection and reallocate green time within each phase in response to the demand.

- **Adaptive/real time signal control** – assess the status of the network and forecast traffic flows to adjust signal timings to more efficiently accommodate traffic demand. Adaptive/real time traffic signal control requires more enhanced detection, communication, and processing capability than actuated signal control.

Signal Priority Treatments

There are two categories of signal priority treatments for TSP systems: passive priority and active priority.

- **Passive Signal Priority** – provides some level of transit priority through the use of pre-timed modifications to the signal system that occur whether or not a bus is present. Therefore, no transit detection system is needed with passive priority, as this strategy relies on simply improving traffic for all vehicles along the transit route. Passive priority TSP systems can be efficient when transit operations are predictable, transit frequencies are high, and traffic volumes are low. However, since traffic signals are coordinated to account for the unique flow of transit vehicles (based on consistent dwell times at transit stops), transit vehicles will benefit but other traffic may experience unnecessary delays.

- **Active Signal Priority**

  – **Early Green/Red Truncation** – truncates the amount of time a TSP-equipped vehicle waits at a red light by shortening the green time of preceding phases. This strategy only applies when the signal is red for the approaching TSP-equipped vehicle; such truncations would respect any minimum green times governed by pedestrian crossing constraints in effect. It should be noted that this technology has been tested in FDOT District 4 and a lesson learned is that is needs to be applied in

conjunction with intersection improvements that provide turn lanes that allow for separate TSP traffic.

- **Green Extension** – extends the amount of time a light is green when a TSP-equipped vehicle is approaching and only applies when the signal is green for the approaching TSP-equipped vehicle. Green extension is one of the most effective forms of TSP since it simply extends the time the signal is green. This strategy can be paired with the early green/red truncation system to maximize the eligibility of the transit vehicle for priority within the signal cycle. A TSP-capable signal controller providing an early green or green extension will not negatively affect coordination.[1]

- **Early Red** – if a transit vehicle is approaching the intersection during a green interval but is too far away and the signal would otherwise change to red by the time the vehicle reaches the intersection, the green interval is ended early and the remaining signal cycle is served. This strategy allows the signal to return to green for the transit vehicle sooner than it otherwise would have. Unlike the green extension strategy, early red is not common practice.

- **Actuated Transit Phases** – used only when a transit vehicle is present and provides for allowed movements by the transit vehicle that are prohibited by general traffic (e.g., "No Left Turn Except Buses").

- **Phase Rotation/Insertion** – allows the order of the signal phases to be shuffled to allow transit vehicles to more quickly proceed through the intersection. For example, if the signal detects that a left-turning bus will arrive at an intersection after the "leading" left turn phase (where the protected left turn phase is followed by the adjacent through phase) will occur, the timing of the left-turn phase changes so that it occurs after the through phases and becomes a "lagging" left turn. Phase insertion allows the signal controller to return to a signal phase more than once in the same cycle if a transit vehicle that uses that phase to proceed through the intersection is detected. For example, if a left-turning transit vehicle arrives at an intersection after the left-turn phase has occurred, the signal can insert a second left turn phase to accommodate the transit vehicle before the signal phase is complete.

- **Adaptive/Real-Time TSP** – "adapt" to the current situation, providing priority to the transit vehicle while at the same time optimizing other performance criteria, such as person delay, transit delay, vehicle delay, or a combination thereof. Early detection

[1] NTCIP 1211 Definition of Priority.

of the transit vehicle is critical to provide the necessary time needed to adjust traffic signals and provide priority while minimizing traffic impacts based on arrival time data for the transit vehicle.

Table A-1 provides a summary of the different types of signal priority treatments discussed.

Table A-1: TSP Signal Priority Treatment Types

Priority Treatment Type	Transit Detection Required?	Type of Traffic Control System	TSP System Extent
Passive Priority	No	Fixed Time	Corridor, Network
Early Green/Red Truncation	Yes	Actuated	Intersection
Green Extension	Yes	Actuated	Intersection
Early Red	Yes	Actuated	Intersection
Actuated Transit Phases	Yes	Actuated	Intersection
Phase Insertion	Yes	Actuated	Intersection
Phase Rotation	Yes	Actuated	Intersection
Adaptive	Yes	Adaptive	Intersection, Corridor, Network

Transit Signal Priority Planning and Implementation Steps

The complexity of TSP systems can vary significantly due to the range of available technologies, specific application, and the extent to which field equipment must be established or upgraded. Irrespective of the size and complexity of the TSP system, it is important to use a systematic approach to the planning and implementation process. The *2005 TSP Planning and Implementation Handbook* recommends using an approach that is consistent with good systems engineering and is required by the U.S. Department of Transportation (USDOT) for any federally-funded ITS project.[2] The following steps for planning and implementing a TSP system have been adapted from the handbook.

- Planning
  - Why TSP? (needs assessment)
  - Who will be involved? (stakeholders and their roles/responsibilities)
  - What will TSP do? (concept of operations and requirements)
  - Where will TSP be implemented? (corridors and intersections)

[2] *Transit Signal Priority (TSP): A Planning and Implementation Handbook*. Prepared for the U.S. Department of Transportation (May 2005).

  - How will TSP work? (technology alternatives analysis and system architecture)
- Design
  - Detailed data collection and inventory of traffic control system
  - Detailed design and engineering for central control and communications
  - System components
  - Detailed design and engineering by intersection
  - Detailed design and engineering of on-board equipment
  - Optimization and preparation of timing plans
  - Use of micro-simulation model to design TSP control strategy (in special cases)
- Implementation
  - Procurement
  - Installation
  - Verification and validation
- Operations and Maintenance
  - Ongoing performance monitoring and management
  - Procedures to ensure system is operating
  - Maintenance
- Evaluation, Verification, Validation, and Building on TSP
  - Evaluation study
  - Ongoing data collection
  - Building on TSP benefits through transit scheduling

Stakeholder Involvement

Many different stakeholders can be involved in the planning, implementation, operation, and evaluation of a TSP system. The specific stakeholders involved and the extent of their involvement depends on a variety of factors, including:

- the geographic boundaries of the TSP system and the jurisdictional/maintenance responsibility of the roadway segments affected by the implementation of TSP
- the type of technology selected
- whether or not emergency services will be integrated into the TSP system
- whether the TSP system will be implemented concurrent with other transportation facility, operations, or technological improvements
- whether TSP has been implemented in the area before or if this is a brand new concept to the agencies and the public

By definition, TSP involves integrating transit vehicle detection and the traffic control system. Therefore, there are two core groups of stakeholders internal to the process of planning, design, and implementing a new TSP system: the transit agency (or agencies, if this is a regional initiative), which typically champions the new TSP system to enhance operational efficiencies and improve service; and the local public agency (or agencies) responsible for operating the affected traffic control signals. In addition to the transit agency and traffic operations personnel, if TSP is being considered at signalized intersections along or that affect a State road, then the Florida Department of Transportation (FDOT) will also be a primary stakeholder in the process.

Although the transit agencies and those responsible for traffic operations are typically at the core of the process, it is imperative to consider other external agencies and decision-making entities involved or affected by the development of a TSP system. These external stakeholders may include emergency services, metropolitan planning organizations, federal agencies, State agencies, public officials, and the public. The extent of the stakeholder involvement will depend on the scale and jurisdictional reach of the TSP project and the agencies necessary to ensure the funding, implementation, and maintenance of the TSP system.

In many instances, transit agencies introduce or champion the development of a TSP system to improve service and reduce delay for transit vehicles. TSP especially has become more widely considered as part of the package of elements that transit agencies often propose in the development of more premium bus-based transit services, such as Bus Rapid Transit (BRT). Planning and implementing a TSP system requires involvement of transit agency personnel in any department or division that may be impacted by the project or involved in its procurement.

The benefits of TSP have been widely reported, and the fact that the number of TSP systems implemented nationally continues to grow seems to substantiate the benefits that TSP brings to operating public transportation. However, one of the primary concerns from traffic operators is whether implementing a TSP system will inadvertently cause problems for and disruptions to the traffic system. To adequately address these concerns, it is critical that representatives of all local transportation/traffic operations departments impacted by the TSP system be involved during the entire planning and implementation process, and even beyond during the monitoring and evaluation process.

The role that the traffic operations personnel play in this process typically includes:

- Communicating interests, issues, and concerns from the perspective of the traffic signal operators.
- Determining when and how frequently TSP is granted and how much time is given to provide TSP.
- Connecting the communications system with the signal controller.
- Ensuring the functionality of the signal controller.
- Maintaining the roadside TSP equipment.
- Assisting in aspects of monitoring and evaluating the performance of the system.

The level of involvement of traffic operations personnel will be influenced by the scope of the TSP system implemented. For example, if a local intersection TSP system that uses passive signal priority is being considered, then the decision-making structure and equipment requirements are less complex from a traffic operations perspective than if a network-based system using adaptive priority treatment types is considered.

While transit agencies typically are responsible for the vehicle detection component, traffic operations personnel are responsible for the traffic controller system. However, for these two components to work, they must be considered in tandem with the communications system. Therefore, it is critical that the appropriate transit agency and traffic operations personnel each be part of the internal project team from start to finish. The *2005 TSP Planning and Implementation Handbook* includes a survey of transit agency and traffic engineering personnel involved in the implementation of existing TSP systems. According to the results of this survey, many transit agencies attributed the success of their TSP programs to early and continuous coordination with local traffic engineers. Some agencies reported the use of interagency agreements or memorandums to aid in building consensus among stakeholders and to clearly identify and define the roles and responsibilities of various agencies. This type of coordination is particularly important when TSP is implemented along corridors crossing several jurisdictions, with several different groups of traffic engineers responsible for the signalized intersections.

Resources

Accessing Transit: Design Handbook for Florida Bus Passenger Facilities (Version III). Prepared for the Florida Department of Transportation (June 2013).

An Overview of Transit Signal Priority. Prepared by the Advanced Traffic Management Systems Committee and Advanced Public Transportation Systems Committee of the Intelligent Transportation Society of America (April 2002).

Transit Signal Priority (TSP): A Planning and Implementation Handbook. Prepared for the U.S. Department of Transportation (May 2005).

Appendix B – Case Study Agency Interview Questions

Transit Agency Interview Questions

1. What was your specific role in the development of the TSP system?
2. Who were the various groups of stakeholders involved in the TSP system development and what was the extent of their involvement? Were there certain stakeholder groups that should have been more involved? Less involved? Were there any stakeholders that were missed/not included that in hindsight would have helped facilitate the process in some fashion?
3. Were any policies or agreements put into place at the beginning of the TSP system development to encourage participation by or open communication among various stakeholders? If not, do you believe that such policies would have provided a benefit?
4. How did you identify the need for TSP? What data and analysis where prepared and presented to implementing agencies to illustrate the benefits of TSP.
5. How extensive was the research you conducted or were provided on TSP to become better educated with the technology before beginning the implementation process? Was it sufficient or was more information needed, whether as a whole or in regard to specific elements of the technology or aspects of the implementation process? Did all stakeholders receive and/or benefit from the information that was collected?
6. How many different levels of traffic operations personnel (e.g., city, county, state, etc.) has your agency needed to coordinate with on various TSP projects? *If more than one, ask italicized follow-up questions.*
7. Were there any specific actions, policies, procedures, or aspects of the TSP project team's organizational structure that made communicating or interacting with the traffic operations personnel a challenge or that enhanced the process? *If there are any differences or changes to your answer depending on the specific traffic operations agency you were working with, please elaborate.*
8. What actions, policies, procedures, etc., do you believe that the traffic operations personnel could have undertaken/implemented to improve communication and cooperation with the transit agency personnel? *If there are any differences or changes to your answer depending on the specific traffic operations agency you were working with, please elaborate.*
9. Were there any aspects of the system (technology, design, location, etc.) that you believe provided additional challenges to the communication and coordination with the

traffic operations personnel? Were there any aspects that you believe made this communication and coordination easier?

10. What actions, policies, procedures, etc., do you believe that the transit agency personnel could have undertaken/implemented to improve communication and cooperation with the traffic operations personnel? *If there are any differences or changes to your answer depending on the specific traffic operations agency you were working with, please elaborate.*
11. What overall advice, related to this topic, would you give to other transit agency personnel exploring the implementation of TSP? What overall advice would you give to traffic operations personnel?
12. If you were to be involved in implementing the same TSP system all over again, what policies, procedures, tools, etc., for interagency coordination would you use again? What would you do differently?
13. What one aspect or issue provided the greatest barrier to your coordination with traffic operations as you moved through the implementation process for TSP?
14. What was the one best/greatest technique, policy, process, strategy, etc. that you believe helped the transit agency and traffic operations personnel effectively communicate and collaborate to get the process done successfully?
15. Have you established any protocol/procedures for ongoing coordination/ communication with traffic operations personnel regarding the implemented TSP system? How do you reconcile technical problems, issues, or system failures that arise with TSP system?
16. Any other thoughts or comments you would like to provide?

Traffic Operations Interview Questions

1. What was your specific role in the development of the TSP system?
2. Who were the various groups of stakeholders involved in the TSP system development and what was the extent of their involvement? Were there certain stakeholder groups that should have been more involved? Less involved? Were there any stakeholders that were missed/not included that in hindsight would have helped facilitate the process in some fashion?
3. Were any policies put into place at the beginning of the TSP system development to encourage participation by or open communication among various stakeholders? If not, do you believe that such policies would have provided a benefit?

4. How extensive was the research you conducted or were provided on TSP to become better educated with the technology before beginning the implementation process? Was it sufficient or was more information needed, whether as a whole or in regard to specific elements of the technology or aspects of the implementation process? Did all stakeholders receive and/or benefit from the information that was collected?
5. Were there any specific actions, policies, procedures, or aspects of the TSP project team organizational structure that made communicating or interacting with the transit agency personnel a challenge or that enhanced the process?
6. What actions, policies, procedures, etc. do you believe that the transit agency personnel could have undertaken/implemented to improve communication and cooperation with traffic operations personnel throughout the planning process, the implementation process, and the evaluation process?
7. Were there any aspects of the system (technology, design, location, etc.) that you believe provided additional challenges related to the communication and coordination with the transit agency personnel? Were there any aspects that you believe made this communication and coordination easier?
8. What actions, policies, procedures, etc., do you believe that the traffic operations personnel could have undertaken/implemented to improve communication and cooperation with the transit agency personnel?
9. What overall advice, related to this topic, would you give to other traffic operations personnel that will become involved in the implementation of TSP? What overall advice would you give to transit agency personnel?
10. If you were to be involved in implementing the same TSP system all over again, what policies, procedures, tools etc., for interagency coordination would you use again? What would you do differently?
11. What one aspect or issue provided the greatest barrier to your coordination with transit agency as you moved through the implementation process for TSP?
12. What was the one best/greatest technique, policy, process, strategy, etc. that you believe helped the transit agency and traffic operations personnel effectively communicate and collaborate to get the process done successfully?
13. Have you established any protocol/procedures for ongoing coordination/ communication with the transit agency regarding the implemented TSP system?
14. Are there any other thoughts or comments you would like to provide?

Appendix C – Case Study Agency Stakeholders

Case Study	Summary of Key Findings: Stakeholders Involved
LYNX	• LYNX (planning, marketing, communications staff) • City of Orlando Transportation Engineering Division • City of Orlando Transportation Planning Department • Florida Department of Transportation (FDOT) Traffic Operations • Federal Transit Administration (FTA) (as LYMMO was a federally-funded project)
Charlotte Area Transit	• City of Charlotte Department of Transportation (CDOT) • City of Charlotte Public Transit Department • City of Charlotte Fire Department • This case study was unique in that it was decided early on that CDOT would be the lead for the project. CDOT had the resources to manage the project/funding/team since, ultimately, so much of the implementation focused around the central traffic operations systems. The transit staff indicated that they found this very helpful, whereas CDOT staff indicated that it would have been more appropriate for the transit agency to lead. The overall success of this process and this specific approach was likely made easier as both departments are part of the City.
King County Metro	• The initial development of the TSP system involved the entire Puget Sound region, which included 27 different traffic jurisdictions. It was expressed that this included too many parties and overcomplicated the process, as most of these cities were smaller and not looking to implement TSP in the near future. • During the second development of the TSP system, the number of stakeholders was pared down to include only those who have a direct interest and this worked much better. • King County Metro scheduling group are critical stakeholders; they ultimately put in the system to save buses time but if the schedulers do not take time out of schedule, they will not see a result. The scheduling group must be very involved. • For Seattle TSP projects, the Seattle Department of Transportation operations group and transit programmers were heavily involved. • It is useful to involve the transit service operators for feedback loop (to get better feedback from operators if something is not working). • Involving transportation planners was very helpful, as they are often allies for using transit to reduce congestion and can help provide internal pressure to the traffic engineering staff to keep the project moving.

Case Study	Summary of Key Findings: Stakeholders Involved
Lane Transit District	• Lane Transit District • City of Springfield Traffic Engineer and Traffic Operations staff • Oregon Department of Transportation (ODOT) (a portion of the pilot route ran along an ODOT facility; responsibility for this road was transitioned to the City of Eugene prior to TSP being operational, but it was a State-maintained facility during planning stages so ODOT was involved). • The Springfield Fire Department was involved in the initial stages to ensure that changes would not compromise emergency services preemption. • The City of Eugene's Traffic Engineer was very progressive. They leveraged him as a champion to get ODOT on board. • A broader stakeholder group meets regularly regarding transit, and TSP is only one topic discussed – the MPO and the University of Oregon are examples of other stakeholders that are a part of this broader stakeholder group.
Metropolitan Transit	• Should the initial implementation of TSP be successful, the regional transit vision would likely expand the TSP system and eventually involve additional stakeholders. Knowing this, Metropolitan Transit tried to be inclusive and involve not only agencies directly involved during the initial phase but also involve potential future partners so that the discussion of TSP occurred up front on a regional level. • Stakeholders involved during the first implementation (Central Avenue bus route) include: ◊ City of Minneapolis ◊ Metro Transit ◊ Columbia Heights (small extent) ◊ Minnesota Department of Transportation (MinnDOT) • Stakeholders involved during the most recent implementation (Green Line LRT connecting Minneapolis and St. Paul) include: ◊ Metro Transit ◊ City of Minneapolis (west side) ◊ Hennepin County (west side) ◊ University of Minnesota (west side-bulk of line goes through heart of campus) ◊ City of St. Paul (east side) ◊ MinnDOT (east side-small role where train came thru freeway ramp) • A Project Advisory Committee was formed and met separately. It included government leaders and policy-makers to give stakeholders direction. From the perspective of staff, it seemed that the decisions took considerable time to make and were not resolved in a timely fashion.
Pierce Transit	• Pierce Transit Planning Department • City of Tacoma Public Works Department for the downtown Tacoma implementation • WSDOT Signal Operations for the SR 7 implementation • City of Tacoma and Pierce County emergency services staff were involved initially, but they did not stay involved once system parameters were understood.

Case Study	Summary of Key Findings: Stakeholders Involved
TriMet	• TriMet Operating Projects Department • City of Gresham Traffic Operations • There was a single point of contact between project managers for Tri Met and the City of Gresham, as TSP had been implemented for a number of years in Portland and the expansion into Gresham was a small system with minimal impact.
Utah Transit Authority	• Utah Transit Authority • Utah Department of Transportation • City of Salt Lake City • Salt Lake County • South Salt Lake
Sun Metro	• Sun Metro • City of El Paso Department of Transportation • City of El Paso Fire Department
Pace Suburban Bus	• IDOT District 1 Division of Traffic. Note: IDOT owns most traffic signals in the six-county region with the exception of Chicago (so two major traffic operations stakeholders); IDOT has interlocals with local jurisdictions to maintain signals. • Chicago Metropolitan Agency for Planning (MPO) • Illinois Fire Chief's Association • Communication stakeholders (internal to agencies, press)