Trips Reliability Improvement and Performance System (TRIPS) Final Implementation Report

Recipient: Santa Clara Valley Transportation Authority

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Prepared by

Santa Clara Valley Transportation Authority

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1.0 Introduction and Project Overview

Santa Clara Valley Transportation Authority (VTA) worked closely with the local jurisdictions to plan an innovative multi-jurisdictional transit signal priority (TSP) system fully connected across the county.

> *The primary goal of this effort is to keep buses moving through intersections across different jurisdictions to make transit a faster, more reliable, and a mobility option so people, particularly those living in transit-dependent communities, have greater access to opportunities that make for a full life.*

The TRIPS project expects to provide a centralized TSP (CTSP) system with minimal infrastructure, using standardized communications protocols to connect traffic signals, taking advantage of approaches used on the Internet of Things (IoT) with remote virtualized servers monitoring and controlling traffic signals. VTA estimates TRIPS could save approximately $100 million in capital costs compared to infrastructure-based TSP that currently exists. Santa Clara County not only has eleven different signal operators throughout the county (sixteen total agencies), but these operators use four different control systems that are not compatible with each other.

The targeted improvements to VTA's Frequent Network routes, spanning 11 local jurisdictions, aim to better serve transit-dependent communities across the county. These communities face many challenges such as access to employment, education barriers, healthcare access, access to essential services, and social isolation. TRIPS seeks to address these challenges through improving transit accessibility and service reliability. Stakeholders from various communities provided input through public outreach, surveys, polls, ongoing feedback, partnerships with other local agencies, and sharing performance data.

The Stage 1 met its key outcome by having industry experts develop the Systems Engineering Management Plan (SEMP) (See Appendix A) that would allow stakeholders to be seamlessly integrated into the virtual environment which operates the CTSP system. This allows rapid deployment of CTSP service across the county with minimal installation requirements. VTA, experts, and stakeholders worked within the Project Development Team (PDT) to determine the essential, optional, and non-necessary components of the project.

Local agency stakeholder consensus was a key goal of the SEMP development, including O&M roles and responsibilities defined in a draft Memorandum of Understanding (MOU) (See Appendix B) to ensure future success. The scalability depends on having this consensus, and this would be initially tested with multiple local agencies at first. The lessons learned was used as feedback to adjust the system requirements as needed. Stakeholder input and engagement played a crucial role in gathering feedback to measure user satisfaction and identify areas of improvement.

As the Stage 1 has completed for TRIPS, the SEMP provides a technical framework to allow for a seamless deployment and operation of the proposed CTSP system with this document defining the critical user needs, potential risks with mitigation measures, and roles and responsibilities of stakeholders in the operations and maintenance (O&M) of the system. The purpose of this plan allows interoperability throughout the county no matter the agency, signal controller or operator, and even multiple different CTSP vendors. It serves as the baseline to allow the ultimate scalability of the network throughout the county.

The cities of San Jose and Santa Clara individually engaged with separate CTSP vendors for signal operations on Route 57 in each of their respective agencies. This small-scale sample was used to assess the concept that multiple agencies, signal operators, and vendors can work together to serve the transit riders efficiently along this route. Route 57 is approximately 12 miles oriented in a north-south direction and extends through the Cities of San Jose and Santa Clara. The CTSP systems have been deployed at 38 (15 in San Jose and 23 in Santa Clara) intersections along this route. The CTSP system was initially operational through the 15 intersections in San Jose, however, the intersections in Santa Clara were not operational until October 2024 and final acceptance tested certified by Santa Clara staff until April 2025. VTA conducted an assessment of the impact of both CTSP systems on this route and the viability of utilizing these systems over multiple jurisdictions, which will be described in later section of this report.

The evaluation of the TRIPS project centers on several key aspects. Firstly, data accuracy and integrity would be examined to ensure the system's reliability. The responsiveness of the system to real-time challenges would be assessed through simulations and, where feasible, pilot implementations. The scalability and adaptability to varying transit environments would be evaluated to ascertain its potential for widespread implementation of CTSP throughout the county. The CTSP system should be expandable to accommodate all traffic signals in the transit network in the future, including up to 650 transit vehicles. The goal of Stage 2 for TRIPS is to expand the TSP system to the Frequent Network which includes 20 bus routes throughout Santa Clara County. However, the SEMP will also allow the expansion to all transit bus and light rail routes throughout the county.

VTA issued a Request for Proposal (RFP) for consultant services to develop the SEMP and awarded the contract to ITERIS, Inc. All work task associated with the SEMP development by ITERIS, Inc. have been completed, including the development of a draft system verification testing plan to be carried forward in the second stage (procurement and deployment of a CTSP solution) for the effort. In addition, VTA completed the outreach to engage the community in the perception and desire for CTSP. The engagement consultant services were conducted through the expansion of other existing VTA contracts doing similar efforts.

2.0 Proof-of-Concept or Prototype Evaluation Findings

The table below describes the Stage 1 performance metrics and how they will be measured as described in the Evaluation Plan.

Evaluation Question	Performance Measure	Performance Measure Target
Can multiple signal operators and different agencies determine comprehensive technical requirements to operate a CTSP system?	Develop technical specifications to be able to operate within all agencies and all types of signals.	Complete Systems Engineering Management Plan (SEMP) that incorporates at least two agencies.
Can agencies agree on transit priority operations at signalized intersection?	Memorandum of Understanding (MOU) outlining agreed approach for priorities.	Executed MOU between VTA and local agencies
Does transit route's travel time improve with the implementation of CTSP service?	Compare the recorded real-time tracking data (travel time and speed stop to stop) .	5% to 10% change.
What is the success of a transit vehicle arriving on a green indication on the corridor?	Ratio of transit vehicles arriving on a green to total transit vehicles for peak periods. Use the recorded real-time actions by the signals over a specified period (e.g., AM, Midday, and PM peak periods).	5% to 10% change

The Route 57 proof-of-concept (See Appendix C) demonstrated the operational benefits of CTSP in improving travel time reliability and overall transit efficiency. Data collected from Santa Clara's Kimley-Horn system and San Jose's LYT platform showed that while total run times remained relatively stable, southbound trips experienced reduced dwell times, indicating improved stop-level performance. In contrast, northbound travel times saw a slight increase, primarily due to longer dwell durations at high activity stops in San Jose and Santa Clara. Segment-level analysis consistently identified Santa Clara as a delay hotspot in both directions, highlighting the need for targeted operational review. These findings support the effectiveness of CTSP in enhancing schedule adherence and reducing delays, aligning with the original goals of the project.

The analysis was based on a short-term dataset, which may not reflect seasonal trends or event-driven variability. Additionally, external factors such as traffic incidents, construction, or weather conditions were not isolated and could have influenced performance metrics. Passenger boarding and alighting patterns were inferred from dwell times rather than directly measured, limiting the precision of passenger behavior insights. Additionally, passenger boarding and alighting patterns were inferred from dwell times rather than directly measured, which may affect the precision of behavioral insights. To build on these results, further operational assessments should be conducted at high-delay locations to identify specific causes of increased dwell and run times.

Piloting enhancements to CTSP, such as refined detection zones and adaptive signal logic, along with expanded data collection and continuous monitoring, will be essential to validate improvements and support broader system-wide optimization.

Route 57 proof-of-concept has generally met the goals stated in the project proposal, which focused on improving transit efficiency through the implementation of TSP. The purpose of Route 57 proof of concept was to show that TSP could have improvements on travel time reliability and reduce delays along the corridor. The evaluation demonstrated that TSP measures contributed to more consistent run times, with notable improvements in southbound dwell times and overall operational performance. Although northbound travel times experienced a slight increase, this was primarily due to longer dwell durations in high-activity segments such as San Jose and Santa Clara, which were anticipated in the proposal as areas requiring further operational refinement. The project also aimed to identify delay hotspots and inform future signal optimization strategies, which was successfully achieved through segment-level analysis that consistently flagged Santa Clara as a key area for intervention. These findings validate the effectiveness of the TSP implementation and align with the proposal's goal of using data-driven insights to guide future enhancements. While some limitations in data scope and external influences were noted, the prototype has provided a strong foundation for continued refinement and broader deployment of TSP strategies across the network.

The following goal areas are listed with the associated demonstration of how CTSP is projected to improve them.

Safety and Reliability: As described above we expect to see an increase in speed and decrease in travel time for transit that should directly provide more reliable service.

Resiliency: The SEMP will allow the CTSP to be able to scale up or down no matter the agency or signal operator and could even be operated through multiple vendors which allow the VTA to maximize the cost savings and performance objectives.

Access: By providing a more reliable transit service and focusing on the Frequent Network that serves transit dependent communities, VTA can serve the communities that are typically the highest users of transit.

Travel Time and Delay Reduction: Decreasing the travel times and delay for transit vehicles enhances the overall system efficiency. This can encourage higher transit ridership, reduce operational costs, and support better traffic flow across the transit network.

Partnerships: The partnerships we are developing through this process will be documented through memorandums of understanding.

Integration: Once the SEMP is completed the integration of the CTSP system should be seamless and allow for quick implementation.

Workforce: The CTSP will require staff to maintain and monitor activity as well as review data obtained from reports. Leveraging this innovative approach to signal and transit operations will require education and learning on staff's part.

3.0 Anticipated Costs and Benefits of At-Scale Implementation

The table below shows the anticipated/estimated impacts of at-scale implementation for each key goal area.

Goal Areas	Anticipated/estimated impacts of at-scale implementation
Safety and Reliability	Primarily improve speed and reliability of transit vehicles. Secondary impact is the ability to serve emergency vehicles as well as bicycle and pedestrian traffic. The CTSP system can not only provide more reliable transit service but also can be scaled out to improve safety by reducing emergency vehicle response times.
Resiliency	Reduced time needed to implement CTSP compared to infrastructure-based system. Specifically, the SEMP provides the platform of the system to allow VTA to adjust service and scale as needed serving the public efficiently and quickly.
Access	Transit dependent communities will play a significant role in shaping the transit system, ensuring it better meets their needs and preference. Through the outreach component VTA will better understand the needs of transit riders in transit dependent communities and be able to provide more reliable transit service to access key destinations throughout the county.
Travel Time and Delay Reduction	Reduce delay at signalized intersections, having fewer vehicles sit and waiting for their green light. By reducing delay for transit vehicles throughout the region can improve transit efficiency. When transit vehicles experience fewer stops and shorter wait times, it enhances reliability, shortens overall trip durations, and improves coordination across the transit network.
Partnerships	Each jurisdiction will have a baseline to establish working parameters for CTSP deployment. These partnerships with local agencies are critical for VTA to achieve these goals in providing faster and more reliable transit service.
Integration	The SEMP provides the ability to adjust the CTSP system to the demands of the public and scale as needed. This not only helps with the initial implementation but also as needed modifications to the system to maximize efficiency and operations.
Work Force	VTA will create practical training and education programs to help meet workforce capacity needs for implementation, operations and maintenance of the CTSP system. In addition, local agency staff will also be needed to keep updated on the operations and maintenance of the network.

The table below illustrates the overall estimated costs of the project at its entirety. The table breaks down the cost for each activity, SEMP Development, Public Engagement, CTSP Deployment, and Traffic Signal Controller Replacement & Support.

Object Class Categories	**Grant Program, Function or Activity**				**Total**
	(Stage 1) SEMP Development	(Stage 1) Public Engagement	(Stage 2) CTSP Deployment	(Stage 2) Traffic Signal Controller Replacement & Support	
Personnel	$629,914	$789,634	$1,628,113	$4,030,088	$7,077,748
Fringe Benefits	$0	$0	$0	$0	$0
Travel	$0	$0	$0	$0	$0
Equipment	$0	$0	$0	$0	$0
Supplies	$0	$0	$0	$0	$0
Contractual	$0	$0	$0	$0	$0
Construction	$0	$0	$500,000	$39,500,000	$40,000,000
Other	$125,983	$146,798	$425,623	$8,706,018	$9,404,420
Total Direct Charges	$755,897	$936,432	$2,553,736	$52,236,106	$56,482,168
Indirect Charges	$0	$0	$0	$0	$0
TOTAL	**$755,897**	**$936,432**	**$2,553,736**	**$52,236,106**	**$56,482,168**

VTA spends roughly $900,000 annually to operate a single bus on weekdays. When considering multiple buses per route the total cost can escalate significantly. The expected deployment and operation of the at-scale CTSP implementation are anticipated to reduce these expenses by enhancing the reliability and efficiency of the transit system. With a more efficient transit network, VTA can maintain its schedule by operating fewer buses and optimizing overall cost. VTA's Frequent Network has 20 routes. By removing at least one bus from each route, VTA can save up to $11,000,000 annually.

When evaluating the feasibility of replacing traffic signal controller cabinets at scale, it is essential to consider both the deployment and operational costs alongside the long-term benefits. The initial investment includes the cost of acquiring new cabinets particularly those equipped with advanced features, labor for installation and removal, and potential expenses related to traffic disruption during implementation.

Despite these upfront costs, newer cabinets offer substantial long-term advantages. They typically require less maintenance, reducing ongoing operational expenses and minimizing the risk of failures that could lead to costly traffic delays. Additionally, modern cabinets provide improved integration with CTSP systems, enhanced real-time data collection, and superior communication capabilities, all of which contribute to more efficient traffic management.

Over the typical 15-year lifecycle of a cabinet, these benefits translate into significant savings and improved system reliability. The infrastructure upgrade also ensures compatibility with evolving traffic technologies, supporting future scalability and innovation.

While the initial costs of at-scale implementation are considerable, the long-term operational savings, enhanced performance, and reduced risk of system failures strongly support the investment. Based on this analysis, the benefits are expected to exceed the costs, making the replacement strategy both economically and operationally sound.

In Stage 1 of the evaluation for at-scale traffic signal controller cabinet replacement, baseline data were collected across multiple jurisdictions to assess transit performance and identify transit routes that need improvements. This data included cabinet inventories, traffic volumes, and speed. For mobility goals, travel time and delay data were gathered using controller event logs to establish benchmarks for vehicle progression and congestion levels. The evaluation also examined the existing TSP infrastructure, revealing significant limitations in older controller cabinets that hinder integration with modern traffic management technologies. These baseline findings provide a critical foundation for measuring the effectiveness of future upgrades and strongly support the case for at-scale implementation.

4.0 Challenges and Lessons Learned

During the initial stage of the project, the team encountered significant challenges in procuring contractors due to funding constraints as well as long lead times for contract procurement. VTA's contract team requires funds to be secured before initiating the procurement process. Unfortunately, the TRIPS team was unable to finalize funding agreements with the United States Department of Transportation (USDOT) in time to procure professional services for the spring of 2024. This delay not only set back the project timeline but also highlighted the importance of flexible funding strategies in project management.

Had the project leveraged VTA's local funding sources, such as local funds, to secure professional services earlier, the project timeline could have been advanced by 3-4 months. In response to this, VTA will adopt a more proactive financial planning approach for future projects under the SMART grant program, utilizing local funding resources for contractor procurement to ensure timely progress and avoid similar delays. This experience highlights the critical need for better alignment between funding availability and project milestones to maintain momentum and achieve on-time project delivery.

Key challenges identified at community engagement events (See Appendix D - Engagement Report) to scale the project include concerns about CTSP's effectiveness in highly congested corridors, potential negative impacts on other road users, and the risk of uneven implementation that favors high-profile areas over transit-dependent communities. Riders have expressed skepticism about whether CTSP can meaningfully reduce delays in gridlocked areas and raise safety concerns for pedestrians and cyclists at busy intersections. Additionally, missed connections between VTA buses, light rail, and regional transit systems, such as Caltrain and BART, highlight the need for improved schedule coordination and real-time information sharing. Uncertainties remain around system integration, user experience, and equitable access. Risk mitigation strategies should include piloting CTSP in varied traffic conditions, enhancing real-time communication tools, improving transfer coordination, and ensuring transparent, data-driven decision-making to guide fair and effective deployment.

Additionally, the proof-of-concept evaluation found that CTSP routes performed significantly better on segments with signal-coordinated intersections compared to those without. Future implementations should consider prioritizing corridors with existing signal coordination or implementing coordination along transit routes to further improve reliability.

5.0 Deployment Readiness

The evaluation of the proposed CTSP system deployment utilized a database maintained by VTA for its planning and programming purposes called the Intelligent Transportation Systems (ITS) database. This ITS database contains information on the traffic signal controller type, traffic signal controller cabinet type, TSP functionality, and others. This first phase of the TRIPS project to develop a SEMP for the proposed countywide CTSP system updated the ITS database for its development of this plan and aided VTA to determine a potential deployment pathway for the countywide CTSP system.

The Centralized Transit Signal Priority Technical Deployment Evaluation Report (See Appendix E) provides a high-level overview of the signals along VTA's frequent and rapid routes, focusing on CTSP functionality and speed analysis to determine a suggested deployment path. Both community engagement and the technical evaluation came to the same conclusion on the routes to move forward with CTSP deployment, but the outreach identified a different deployment prioritization.

Based on community engagement, the preferred priority order for future CTSP deployment is based on priority and need (highest to lowest) are Routes 22, 522, 66, 25, 68, 568, 523, 23, and selected Santa Clara County intersections such as Route 70 and 71. *These priority orders are subject to change based on community support, available funding, and political support.*

To ensure CTSP system is functional and effective after full-scale implementation, it is vital to define staffing needs, technical training programs, and system monitoring protocols. CTSP technologies require ongoing support from skilled technicians to handle daily operations, troubleshooting issues, and perform routine maintenance. This ensures long-term sustainability of the system and prepares for future upgrades and building in-house expertise to prevent system failures.

At-scale implementation of CTSP will create new technical and support roles, many of which provide opportunities for stable and well-paying careers. With targeted workforce development strategies such as training and certification programs, transit agencies can ensure staff are equipped to manage evolving technologies. These roles should be structured to support a free and fair choice to join a union, helping to maintain labor standards and promote sustainable job growth. Mitigating potential challenges requires transparent hiring practices, equitable access to job opportunities, and continued collaboration with labor organizations to align technological advancement with workforce protections.

6.0 Wrap-Up

Reflecting on the current progress of the project, CTSP has shown that it can be a promising solution to improve transit reliability, community engagement has highlighted a strong need for dependable transit service. While the solution is still in progress and not fully implemented, it aligns well with initial expectations. At this point, no major changes are recommended, but flexibility should be maintained to adapt based on future findings. For other agencies pursuing similar efforts, early and ongoing stakeholder engagement is essential to ensure clear planning and full cooperation from local agencies. Addressing local transit challenges early will help ensure smoother implementation and long-term impact.

Appendix A – System Engineering Management Plan

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Transit Reliability Improvement and Performance System (TRIPS)

System Engineering Management Plan

Final

May 22, 2025

Prepared for:

Valley Transportation Authority

iteris

DOCUMENT VERSION CONTROL

DOCUMENT NAME	SUBMITTAL DATE	VERSION NO.
Draft SEMP – Internal Review	12/2/2024	1.0
Draft SEMP – Administrative Review	12/5/2024	1.1
Draft SEMP – Stakeholder Review	4/7/2025	1.1
Final SEMP	5/22/2025	1.2

Iteris Project 12610

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1.0 PURPOSE OF DOCUMENT

The Systems Engineering Management Plan (SEMP) for this project provides a high-level plan for the management of the Systems Engineering process in compliance with the Federal Highway Administration (FHWA) Federal Rule 23 CFR 940.11. This document has been prepared as part of the Santa Clara Valley Transportation Authority (VTA) Transit Reliability Improvement and Performance System (TRIPS) project for the deployment of a muti-jurisdictional centralized transit signal priority (TSP) system across Santa Clara County.

The SEMP is intended to serve as a guide for the project team and System Vendor(s) through the entire project, following a systems engineering approach. The SEMP will enable the project team to manage the project using systems engineering principles and methods to maximize the quality of the system being implemented while minimizing the risks to the budget and schedule. The System Engineering (SE) documents are living documents, so as information is gathered through the life of the project, some plans may be updated to reflect the most current data.

Key information delivered in the SEMP includes:

- Identify the major tasks to be completed;
- Identify the schedule of major tasks;
- Identify the stakeholders and their roles/responsibilities;
- Document the process to be followed in developing, installing, verifying, operating and maintaining the system;
- Specify the documentation requirements for the system; and
- Document the management controls that will be used to manage the project.

2.0 SCOPE OF PROJECT

2.1 Project Background

VTA has secured federal funds under the Strengthening Mobility and Revolutionizing Transportation (SMART) grant program to improve transit performance and reliability by applying advanced technologies to provide priority treatment to its transit vehicles as they approach signalized intersections throughout Santa Clara County. The vision of the project is to deploy and utilize the technology in transit vehicles, at the central signal system of local agencies managing traffic signals, through a centralized TSP application platform, and at the roadside at traffic signals. This approach leverages the existing equipment on the transit vehicles (the existing CAD/AVL and communications equipment) and the existing traffic signal system infrastructure (existing communications between central traffic signal systems and traffic signal controllers at intersections) operated and maintained by the various municipal agencies throughout Santa Clara County. The envisioned system will allow VTA to expand TSP functionality to local cities throughout Santa Clara County where VTA provides transit service.

VTA will deploy the system initially on the Rapid and Frequent bus routes throughout Santa Clara County. VTA has plans to scale up the system(s) in the future to include local routes. An illustration of a VTA's route map showing the Rapid and Frequent bus network in the vicinity of the cities of Cupertino and Santa Clara is shown in **Figure 1**, with the full system map included in **Appendix A.** Throughout Santa Clara County, the Rapid and Frequent bus routes collectively cross through approximately 12 jurisdictions and a total of 871 signalized intersections. A summary of intersections on the Rapid and Frequent routes by jurisdiction is shown in **Table 1**.

Figure 1 – VTA Bus Route Map Sample

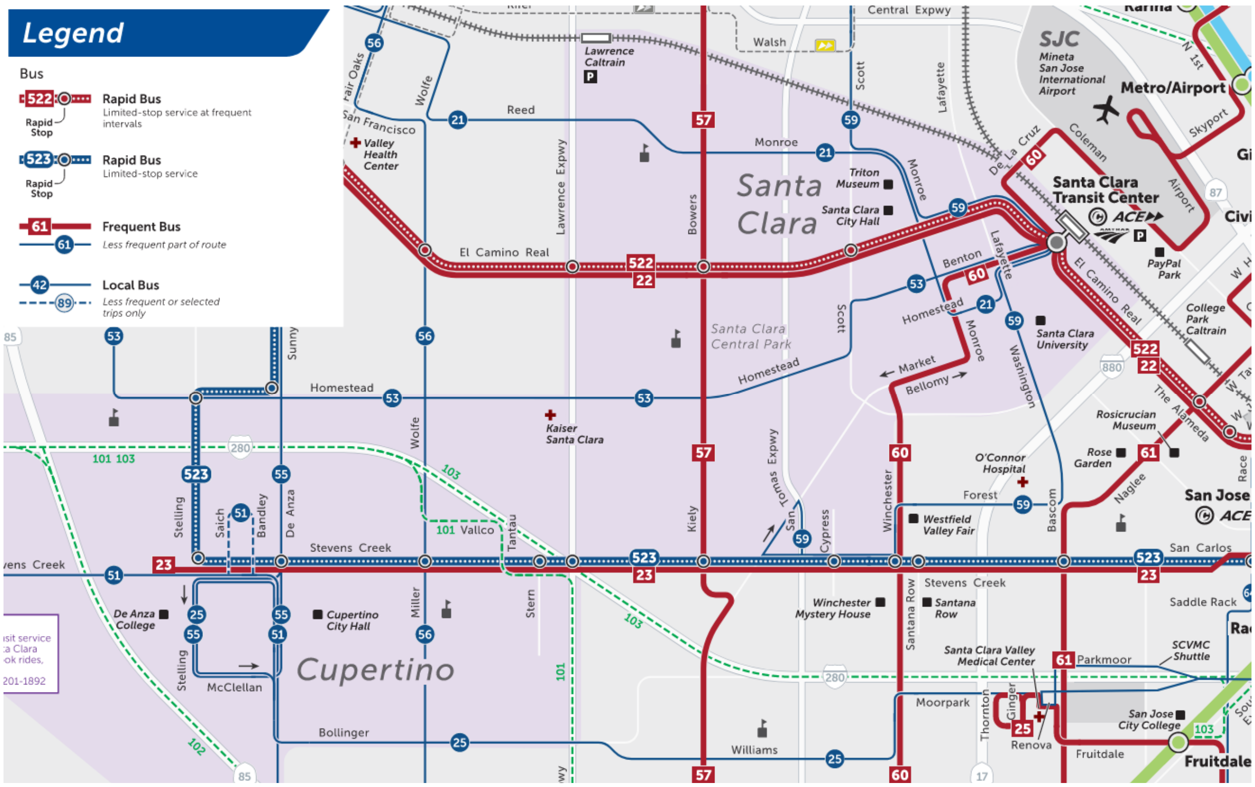


Table 1 – Project Stakeholder Signals on VTA Rapid and Frequent Routes

Stakeholder Agency	Number of Agency Signals on Rapid and Frequent Routes
Caltrans	68
Campbell	26
County of Santa Clara	54
Cupertino	19
Gilroy	10
Milpitas	20
Morgan Hill	20
Palo Alto	1
San Jose	568
Santa Clara (City)	48
Saratoga	7
Sunnyvale	30
Total Signals	**871**

2.2 Project Objectives

The goal of this project is to deploy TSP to keep VTA transit vehicles moving through intersections across multiple jurisdictions to make transit faster, more reliable, and an equitable mobility option so people have greater access to opportunities and to contribute to thriving communities.

The objectives for this project are to:

- Deploy a centralized TSP system(s) initially focused on the Rapid and Fast network, and that is easily scalable to the rest of VTA's transit network.
- Improve transit reliability and travel time along all VTA's service routes.
- Increase transit mode share (i.e., ridership and person throughput) and improve mobility for residents, employers, retailers and regional commuters.
- Reduce fuel consumption related to transit vehicle operations.

This project will deploy a centralized transit signal priority (TSP) system(s) throughout Santa Clara County and is expected to transform the efficiencies and innovation in Santa Clara County's various transportation systems by improving transit performance metrics (e.g., travel time, reliability, etc.). This project builds upon a previous pilot project that tested a centralized TSP system that leveraged existing infrastructure resulting in minimal new infrastructure, using standardized communications protocols to connect to traffic signals, and taking advantage of modern-day broadband communications and edge-computing capabilities. The project will deploy a centralized application that provides TSP for VTA transit vehicles through integration between the existing transit system infrastructure and the local agency traffic signal system infrastructure. The goal is to provide TSP capabilities throughout Santa Clara County at all traffic signals that transit vehicles operate through, which are managed by multiple disparate traffic signal control systems and controllers.

The details of TSP operation (i.e., business rules) will be determined with the agency Stakeholders as part of the project, but in general the benefit to transit travel time will be dependent on: 1) the thresholds that will be established to allow a TSP request to be generated by the transit vehicle, and 2) the extent of priority that will be provided by parameters programmed in the traffic signal controller to either extend or provide an early green indication for the transit vehicle. It is also important to note that more than a single TSP system may need to be present to achieve the goals of the project.

2.3 Stakeholder Roles

This project requires the cooperation and participation of many jurisdictions in which VTA buses travel. The stakeholders and their roles in this project are summarized in **Table 2**.

Table 2 – Project Stakeholders and Roles

Stakeholder	Role(s)
VTA	Current Role: Operates and maintains transit service in the project area. Project sponsor and initial recipient of SMART grant funds. Funding agency, program manager, systems engineering contract manager, and overall systems engineering project oversight. Future Role: Lead, and/or support, the procurement and deployment of the centralized TSP system(s)and associated improvements for use on its network.
Cities/Towns of San Jose, Campbell, Milpitas, Santa Clara, Sunnyvale, Cupertino, Mountain View, Palo Alto, Los Gatos, Gilroy, Morgan Hill, Saratoga, Los Altos, Los Altos Hills, Monte Sereno; County of Santa Clara; and Caltrans	Current Role: Owns, operates, and maintains the traffic signals in their respective jurisdictions that are travelled by VTA's transit routes. Responsible for review and acceptance of the proposed TSP system concept and requirements. Future Role: Support and/or lead the procurement and deployment of the centralized TSP system and associated improvements for use within its agency. Will own, operate, and maintain any TSP-related roadside hardware implemented by this project (e.g., controllers) within their jurisdiction. Lead and/or support the procurement and deployment of traffic signal hardware or infrastructure improvements (as needed), and for any City-owned systems which may integrate with the centralized TSP system. Procurement and deployment responsibility and funding will vary by project and available funding sources and would be documented in a Memorandum of Understanding between VTA and stakeholder agency(ies).
System Engineer (Iteris)	Perform system engineering tasks and provide support during TSP system selection and deployment.
System Vendor(s)	Furnish, install, and deploy the centralized TSP system. More than one TSP system may be utilized, which may require more than one TSP system vendor.
Design Engineer(s)	Perform design (PS&E) for physical improvements (i.e., traffic signal communication upgrades) in support of one or more project elements, if needed.
Construction Contractor(s)	Construct and install field elements such as communications, controllers, and TSP devices, if needed.
Construction Manager(s)	Provide construction administration and oversight of all field elements, if needed.
System Evaluation Consultant(s)	Develop the validation and evaluation plan for the deployed TSP system including performance of a before and after study, if needed.

2.4 Technical Challenges

Since VTA's bus routes traverse multiple jurisdictions and most routes are not isolated to a single agency where traffic signals are under the control of that single agency, the technical challenges that come with a multi-jurisdictional project will be present in this project.

The primary technical challenge for this project relates to multiple stakeholders who may have differing operational strategies for TSP, as well as differing infrastructure. As a result, the technical challenges may include the following:

- The TSP system(s) need to be compatible with the signal infrastructure in each jurisdiction. The main technical challenge will lie with stakeholders' controllers and whether there is communication at the intersection. Additionally, depending on each agency, the robustness of the existing traffic signal infrastructure to support the TSP deployment varies.
- Any given stakeholder agency may have a TSP operating strategy (i.e., business rules that define the level or extent of priority parameters) that differs from another. Given that the same TSP system (or systems) will be utilized by all agencies, the TSP system must be able to accommodate varying TSP operating strategies, or the stakeholders must agree upon a common approach.
- The conditional aspect of the TSP operation may require integration of the TSP system with VTA's existing central CAD/AVL system (CleverCAD) or on-board Clever Devices' Intelligent Vehicle Network (IVN) system.
- Stakeholder agencies' signal system infrastructure will need to support applicable NTCIP protocols, which may be a challenge for some with older or legacy signal systems and controllers.
- VTA's central and/or onboard devices (i.e., CleverCAD CAD/AVL, IVN, and mobile routers) will need to meet bus polling rate requirements to provide accurate and timely bus location status updates in order to ensure appropriate transmission for TSP request messages.
- The TSP system needs to support various communications and integration requirements based on each local jurisdiction's signal system infrastructure. This includes the ability to communicate directly with the traffic signal controller, communicate to the traffic signal controller through an intermediary central signal system, and/or where the traffic signal controller has no communications.
- The TSP system needs to support and implement applicable NTCIP protocols (i.e., NTCIP 1202 and 1211) to send and receive priority request messages and signal status messages to and from a traffic signal controller.
- The TSP system will need to comply with current cybersecurity standards, including IT security policies of the stakeholder agencies.
- Providing agency staff with the necessary skill set for continued operations and maintenance of the TSP system including field infrastructure and on-board equipment.

3.0 TECHNICAL PLANNING AND CONTROL

The purpose of this section is to describe the activities and plans that will act as controls on the project's systems engineering activities.

3.1 Work Breakdown Structure (WBS)

The WBS identified in this section and detailed in other sections of this document are intended to be guidelines. Many of the tasks and work plans are dependent on the TSP system(s) that will be selected and will have to be developed once the TSP Vendor(s) has been selected. The major activities to select, deploy, and operate the TSP system along VTA's bus routes are described as follows:

- **WBS-1 | Select System Engineer:** VTA, through a competitive RFP process, selected Iteris, Inc. as the System Engineer to lead the systems engineering process for this project. Work by the System Engineer commenced in September 2024.

- **WBS-2 | Prepare Systems Engineering Management Plan:** The System Engineer will prepare and maintain the Systems Engineering Management Plan (SEMP) to address the overall systems engineering management approach. The SEMP will identify what items are to be developed, delivered, installed, verified, and supported. It will also identify roles and responsibilities of all stakeholders involved in the project along with when critical tasks will be completed, who will complete them, and how the products will be accepted and managed.

- **WBS-3 | Prepare Concept of Operations:** The System Engineer will work with VTA and the public agency stakeholders to assess user needs. The needs will be driven by answers to questions on the operational objectives and strategies, desired operational features, and the centralized TSP concept that VTA and stakeholders plan to implement. The System Engineer will document these findings highlighting all stakeholders' critical, essential, and desired needs. Following identification of user needs, the System Engineer will lead the effort to develop the Concept of Operations (ConOps), a document describing the characteristics of the proposed system from the perspective of the system operator(s). The ConOps is a key document and provides a model of the activities the centralized TSP systems under consideration will ultimately support.

- **WBS-4 | Prepare System Requirements:** The System Engineer will lead the effort to identify and develop a list of technical requirements and functionalities that are essential and/or desirable to be included in the new centralized TSP system(s) software. These requirements will be based on the ConOps developed in the prior task and through discussions and meetings with project stakeholders.

- **WBS-5 | Prepare Verification Plan:** The System Engineer will lead the effort to develop a verification plan. Details of this plan are described in **Section 3.4.2** of this document.

- **WBS-6 | Select System Vendors:** VTA, in consultation with the public agency stakeholders, will initiate the effort to evaluate and select the TSP system(s) that best fulfills the system requirements of the project and participating stakeholders' needs. VTA will procure the selected TSP system(s). The System Engineer will provide support to VTA staff during this process.

    - *WBS-6.1 | Develop Request for Proposal:* VTA will lead the preparation of the Request for Proposal (RFP) for the procurement of the TSP system(s) which VTA will own. The RFP will incorporate and/or reference the ConOps, System Requirements, and Verification/Acceptance Plan. VTA will release and advertise the RFP.

      For Stakeholder agencies wishing to lead the procurement, the agency may coordinate with VTA and their system documentation (as noted previously) in the development and release of their own RFP.

    - *WBS-6.2 | Select System Vendors:* There are multiple ways the system(s) may be selected:

        1. **VTA Selection**: For agencies who are agnostic on the system selection, VTA will lead the TSP System vendor selection process. The System Engineer will assist VTA in responding to questions from

proposers, review submitted proposals and provide comments, help address specific issues raised by proposers, help prepare requests for clarification from proposers if needed, help prepare questions during interviews, participate in interviews, and help evaluate further information provided during interviews. Based on the proposals and interviews, VTA, in consultation with the applicable public agency stakeholders, will select the system vendor(s) to implement the centralized TSP system.

2. **Stakeholder Agency Selection**: Stakeholder agencies may also lead their own selection process. As needed, VTA and the System Engineer may provide support for the selection by providing basic system requirements for integration with VTA buses and system(s). Following their individual selection process, the Stakeholder agency or agencies will select the system vendor(s) to implement the TSP software and inform VTA of its selection or preference.

3. **Existing System Integration**: For agencies who already have a cloud-based or centralized TSP solution or solutions in place, no procurement or selection will be necessary.

  - *WBS-6.3 | Identify Field Elements Needs for the Selected Systems:* Once the TSP system has been selected, VTA will coordinate with the System Vendor(s) to identify the field elements that will be required to allow for the proper operation of the TSP system.

- **WBS-7 | Prepare Agreement(s):** The public agency stakeholders will determine the need to prepare and enter into various agreements that may be required as part of the project delivery process and on-going operations and maintenance (O&M). It is anticipated that a Memorandum of Understanding (MOU) will be needed between VTA and participating agencies, with the lead agency being that which owns the TSP system. The agreement should also include funding support, especially ongoing O&M costs following the initial implementation. The System Engineer will advise VTA in determining what may be needed based on the selected TSP system.

- **WBS-8 | Develop Plans, Specifications, and Estimate (PS&E) for Project Field Elements and Select Contractor to Construct Field Elements:** If needed to accommodate the selected TSP system(s), either VTA or the affected stakeholder agency where improvements are needed will lead the development of project PS&E. The PS&E will detail the project elements, any new equipment or infrastructure that is required, the existing equipment and infrastructure to be utilized, and the preliminary cost estimate to procure, construct, and deploy the field equipment needed to provide full functionality of the new TSP system. As applicable, individual public agency stakeholders will be responsible for plan review and approval for improvements which may modify infrastructure within their jurisdiction.

- **WBS-9 | Deploy TSP System and Integrate Project Field Elements:** The System Vendor(s) will be responsible for deploying the TSP system. In parallel, the field elements Contractor will deploy and/or construct the necessary field equipment (i.e. controllers, communications, TSP field equipment, etc.) to allow for the proper operation of the TSP system. Stakeholder agencies will each lead construction administration for construction activity within their jurisdiction, as well as provide any construction inspection and approval of improvements.

- **WBS-10 | System Testing and Acceptance:** VTA will work with all public agency stakeholders during the acceptance testing to verify that each element of the TSP system and field elements deployed are performing as required, and that the intended TSP operation is performing per the System Requirements document and as specified by the System Vendor(s). The System Vendor(s) will develop verification testing procedures based on the Verification/Acceptance Plan. The testing will evaluate each functional and detailed specification criteria identified in the verification testing procedure and it will be the responsibility of the System Vendor(s) to make sure all system requirements are met.

- **WBS-11 | Project Evaluation:** VTA or stakeholder agencies may lead the effort to evaluate the effectiveness of the deployed TSP system. The evaluation would assess the effectiveness of the project, including measurable performance metrics, benefits and costs, lessons learned, and identifying technical and non-technical challenges.

3.2 Task Decision Gates and Deliverables

Task decision gates represent critical activities that must be satisfactorily completed before a task is considered complete. **Table 3** provides a list of those activities and which stakeholder should provide its approval.

Table 3 – Task Decision Gates

Critical Activity	Deliverable	Completed By	Approval By	Prerequisite
Select System Engineer	System Engineer	VTA	VTA	None
Prepare SEMP	Draft & Final SEMP	SE	All Public Agency Stakeholders	Select SE
Prepare Concept of Operations	Draft & Final Report	SE	All Public Agency Stakeholders	Meet with Stakeholders
Prepare System Requirements	Draft & Final System Requirements	SE	All Public Agency Stakeholders	Concept of Operations
Prepare Verification/ Acceptance Plan	Draft & Final Verification/ Acceptance Plan	SE	All Public Agency Stakeholders	System Requirements
Select System Vendors	Final TSP System RFP	VTA/SE	All Public Agency Stakeholders	Verification Plan
	Advertise TSP System RFP	VTA	VTA	Final RFP
	Award TSP System Vendor Contract	VTA	VTA	Selection Process
Prepare Stakeholder Agreement(s)	Various Agreements	Public Agency Stakeholders/SE	Public Agency Stakeholders	Varies
Select Construction Contractors	PS&E Design Consultant(s)	Public Agency Stakeholders	Public Agency Stakeholders	None
	Final PS&E Package(s)	Public Agency Stakeholders	Public Agency Stakeholders	Select System Vendors
	Construction Management Consultant(s)	Public Agency Stakeholders	Public Agency Stakeholders	None
	Advertise PS&E	Public Agency Stakeholders	Public Agency Stakeholders	Final PS&E
	Award Construction Contract(s)	Public Agency Stakeholders	Public Agency Stakeholders	Responsive Bids
Deploy TSP System and Construct Field Elements	TSP system software	System Vendor	All Public Agency Stakeholders	Select System Vendor
	TSP field elements	Contractor	Public Agency Stakeholders	Select Contractor
	TSP on-board equipment	Contractor	VTA	Select Contractor
System Testing and Acceptance	Completed TSP System	System Vendors	All Public Agency Stakeholders	System Deployment
Project Evaluation	Evaluation Plan, Before & After Study	VTA	VTA	System Acceptance

3.3 Schedule

This project will be completed in a staged approach. The first stage consists of the Systems Engineering analysis that includes preparation of this SEMP, ConOps, System Requirements, Verification Plan, and the TSP system procurement documents. The first phase is led by VTA and its System Engineering consultant, Iteris. The second stage will consist of procurement and deployment of the TSP system, detailed design, and construction of field elements. VTA will lead the procurement and deployment of the TSP system, while each of the public agency stakeholders will lead the detailed design, and construction of necessary field elements within their jurisdictions. **Figure 2** illustrates a high-level schedule of the tasks included in each stage, as well as a general timeline for completion. A detailed project schedule is provided in **Appendix B**.

Figure 2 – High- Level Systems Engineering Schedule

	2024				2025												2026	
Project Task	*Sep*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb+*
Project Planning Phase																		
Develop SEMP	■	■	■	■														
Develop ConOps			■	■	■	■	■	■										
System Requirements Phase																		
Develop System Requirements									■	■								
Develop Verification Plan										■	■							
Draft MOUs with Stakeholders										■	■	■	■					
Design Phase (Anticipated)																		
Develop Procurement Docs												■	■	■				
Develop Deployment Plan										■	■							
Finalize MOUs with Stakeholders														■	■			
Deployment Phase																		
Advertising & Procurement	To Be Determined																	
Deployment	To Be Determined																	

3.4 Project Specific Technical Plans

The transit signal priority system deployed as part of this project will likely be comprised of an existing commercial-off-the-shelf centralized TSP system. It is also possible that some customized software application development may be needed to modify or build upon the solution's existing application(s) for this project. As part of the initial steps of this project, the System Engineer will develop a set of functional requirements and a verification plan that will guide the selection of the TSP system and software.

3.4.1 Technical Review Plan

The deployment of the TSP system will require the review of a number of technical documents. **Table 3**, in **Section 3.2,** provides a summary of the deliverables and the entity responsible for conducting the review. The System Engineer will develop the systems engineering documents, and the public agency stakeholders will provide comments. The System Engineer will be responsible for responding to those comments on the following technical submittals:

- SEMP
- ConOps
- System Requirements
- Verification Plan
- RFP for the procurement of the system

The System Vendor(s) will be selected by VTA. If needed, resources for field-related improvements such as the Design Engineer, the Construction Contractor, and the Construction Manager will be selected by the applicable stakeholder public agencies for work within their jurisdictions. The stakeholder agencies will be responsible for developing and responding to comments on the following technical documents:

- TSP system hardware needs for implementation provided by the System Vendor(s)
- Construction PS&E package, as applicable
- Deployment Plan – TSP system and Construction Field Elements

If applicable, VTA and/or Stakeholder agencies (or their respective consultant) will be responsible for the following submittals:

- Evaluation Plan
- Before/After Study

3.4.2 Verification/Acceptance Plan

The System Engineer will develop a verification plan to establish the framework for review and acceptance of the new system such as inspection, demonstration, analysis or testing. Based on the verification plan, the System Vendor(s) will be responsible for developing the verification test procedures for verification (acceptance testing) of each system requirement. This will include the verification and acceptance of the new field equipment (if any is deployed), software application(s), other required hardware, and the new system. Test cases will be identified based on the verification plan.

Acceptance testing for the system and required components may consist of a variety of tests ranging from tests at the factory on the proposed hardware and software through system acceptance testing at individual public agency stakeholder facilities. Acceptance testing will be based on a matrix that is a function of the requirements, specifications, implementation, and the procedures to ensure that all requirements are tested. The following are various types of tests that may be needed depending on the system selection and hardware or infrastructure needs of the system:

- **Factory Tests** – As part of the Project, a variety of equipment/material may be required. To ensure this equipment/material is suitable for this project and meets the specifications, it will be necessary that tests be performed at the factory where the equipment/material is manufactured. Certification of such testing will be provided with the equipment as it is shipped.

- **Delivery Tests –** Upon delivery of any material to the selected project site, inspection of the received hardware will need to be performed. As a minimum, these tests will be to compare what was ordered with what was delivered and what was specified.
- **Bench Tests** – Following delivery testing, it is imperative that additional testing be performed at one or more public agency stakeholder's designated facility (such as a maintenance center) before placement of the components in the field and implementation of any software application(s). This testing will range from simply powering up the component to establishing a mini-network in the agency's designated facility to demonstrate receipt and transmission of messages, compatibility of the various components, and proper operation of software application(s).
- **Unit Tests** – Unit testing will involve installations at one or more agency's TMC and in the field. Components will need to be connected to the equipment in the cabinet/equipment room at their respective locations and tests performed ranging from powering up to receipt/transmission of messages from the connected equipment.
- **Subsystem Tests** - Potential subsystems to be tested include communications and TSP. However, to perform subsystem testing, it will be necessary to first verify the existing communications is in place with a connection provided between the various locations. With the verification that the communication links are operational (i.e., able to transmit a signal in both directions), testing of the TSP subsystem can occur. This will involve sending messages from the vehicle to the traffic signal and in the reverse direction. The installed subsystems shall be inspected and tested to validate orderly cable placement, cable markings and unit installation in accordance with manufacturer's installation recommendations.
- **System Tests** - Once the various subsystems have been tested individually, a system acceptance test will need to be performed to ensure that all components and software application(s) (existing and proposed) work together. This will involve end-to-end testing of all linkages. The testing initially consists of testing the functionality of the components by comparing it to the requirements. A requirements traceability matrix will be developed to aid in this process.

3.4.3 Systems Integration Plan (SIP)

The System Vendor(s) for the TSP system will each create a detailed System Integration Plan that complies with FHWA guidelines and, more importantly, clearly explains the roles and responsibilities of each participant on a per task basis. The System Integration Plan will be divided into the sections listed below:

- **Purpose of the Document** – A brief statement of the Integration Plan's purpose.
- **Scope of Project** – A brief description of the planned project.
- **Integration Strategy** – This section will explain the high-level plan for integration and why the plan is structured the way it is. A project of this nature is bound to have several constraints or conditions that must be met to be deployed successfully. These constraints can take the form of technical capabilities or preconditions, production/development schedule of other systems that are needed to support the TSP system, and contractual limitations placed on other stakeholders. These will all be discussed and explained in detail at the outset so all parties fully understand the overall strategy.

- **Phased Integration** – A separate section will be provided for each integration phase. This section will define and explain each step in the integration process. Each step will identify:
    - The activity location.
    - The hardware, software and firmware to be integrated, including quantities and part numbers/model numbers.
    - Support equipment (special software, test hardware) needed for this step.
    - All integration activities to be completed before, during and after installation, including integration with on-site and external systems at other sites. Examples of activities performed prior to installation include hardware configuration and stand-alone testing.
    - A description of the verification activities that occur after this integration step.
    - The responsible parties for each activity in the integration step.
    - The schedule for each activity.

3.4.4 Deployment Plan

It is envisioned that the deployment of the TSP system and any field elements will occur simultaneously. As mentioned previously, the details of the deployment, including who will deploy, scheduling, training, etc., will be developed based on the specific needs of the TSP system. The deployment plan will be developed by the System Vendor(s) and approved by the public agency stakeholders. Stakeholder agencies may each bid out a separate contract for the construction of various field elements that will support the TSP system.

VTA, in cooperation with the public agency stakeholders, will select the TSP System Vendor(s), who will be responsible for deploying, configuring, testing, and fine-tuning the system. Improvements to the existing traffic signal infrastructure and on-board equipment needed to support the TSP will be bid out as part of the construction contract to meet the TSP system needs.

3.4.5 Training Plan

During construction of the new TSP system, each System Vendor must understand the requirements that the system must have in order to satisfy the public agency stakeholder's needs. These requirements must be fully communicated to each System Vendor to ensure that the project continues to completion on-budget and on-time.

Although it is envisioned that the TSP system(s) will ultimately operate with minimal user inputs, it will require significant effort from the system users to monitor, manage, and maintain the system. Thus, when the acceptance testing of the new TSP system is complete, the regular system users should be trained to operate, maintain, and troubleshoot the system. Training system users to operate and troubleshoot the system is necessary to successfully operate the new TSP system at the desired levels. The users should be aware of the system capabilities, the necessary initial and regular inputs necessary to maintain optimal operations, as well as the "quick fixes" should minor issues occur during the life of the systems. It will be the responsibility of each System Vendor to develop the Training Plan and provide the appropriate training to the public agency stakeholder's staff.

Potential additional field elements required to operate the TSP will include controller upgrades and communications equipment. Additional training may be necessary for new equipment that replaces any of the public agency stakeholder's existing equipment.

3.4.6 Risk Management Plan

The risk of the project is directly related to the type of deployment that is selected. A selection of multiple systems to meet the multiple stakeholder's needs may introduce some technical risks with system compatibility and integration. This can be mitigated by ensuring that system requirements are specific and clear about integration requirements, especially with respect to VTA's and Stakeholder agencies' existing systems.

System selection, whether one or more, may also present some institutional risks. To mitigate institutional risks of one or more systems operating across multiple jurisdictions, agreements (i.e., MOU and/or Cooperative Agreement) can be executed to address system access, ownership, maintenance, cost sharing, etc.

There are no safety risks foreseen with the installation of the TSP system. The TSP system is meant to enhance the operation of transit vehicles. To minimize risks with a new TSP system deployment, warranties for the new system (including software and hardware) should be included.

There are some inherent operational risks associated with any project. Specifically, these might include the malfunctioning or breakdown of the communications equipment, malfunctioning or breakdown of new controllers (if new controllers are deployed), and the use and operation of the new software (controller software or TSP software). However, these can be mitigated by bench testing of equipment prior to deployment, testing of the new software features, providing redundant and spare equipment, and obtaining proper training in the use and maintenance of the new system.

Critical to mitigate any safety risks, all new hardware and software must be tested for failure in a test bed environment. This includes tests of failure of each component of the new system such as:

- Application failure
- Communication failure
- Local controller failure

A clear definition of the delivery responsibilities of each party (vendor, agency, or integrator, as appropriate) would also be defined as part the procurement to ensure that it is clear what each party is responsible for providing with respect to testing, installation, and integration.

3.5 Documentation

Project documentation control includes the processes to ensure that the Project is administered in conformance with the contract requirements. A solid and efficient document control system to administer Project records will ensure that the work is constructed in accordance with the contract requirements.

Documents shall be developed that describe the responsibilities and requirements for the identification, preparation, and maintenance of records that furnish documentary evidence of the process undertaken, the design of the system, the implementation of the system, and the operation and maintenance of the system. The term "records" used throughout this section refers to records attesting to the achievement of the requirements that are generated during the various phases of this project.

Records will be legible, identifiable, and retrievable. These records will be protected against damage, deterioration, or loss. Requirements and responsibilities for record transmittal, distribution, retention, maintenance, disposition, and organizational responsibilities will be identified. A record is defined as a completed document that furnishes evidence of the quality of items and/or activities affecting quality.

The scope of the records retention and distribution system will be described in instructions and procedures. Records will be indexed and the indexing system will include, as a minimum, record retention times and the location of the record within the record system. The records and/or indexing system will provide sufficient information to permit prompt retrieval, and identification between the record and the items or activities to which it applies.

Corrections to records will be controlled. Controls will provide for appropriate review or approval by the originating organization. All corrections will include the date and the identification of the person authorized to issue the correction. Previously developed records shall be updated when major changes are made and accepted in related documentation.

4.0 SYSTEM ENGINEERING PROCESS

The System Engineering Process (SEP) will be applied to the TSP system selection and deployment portion of the project. The most significant objective of the SEP is to ensure that the resulting design fulfills the technical performance requirements of the TSP system and field elements throughout the project life-cycle as well as meeting the needs of the project stakeholders. To achieve this objective, the systems engineering process is utilized to minimize changes to the detailed design once it has been completed. This goal is accomplished by ensuring that all relevant concerns have been included in the overall design process and at the right time.

The approach to the application of the SEP is to identify TSP deployment stakeholders, determine their needs, and follow a logical process in defining a system architecture and functional design that can be reviewed and verified to meet stakeholder needs. The key concept in this approach is to identify system requirements, track the requirements to ensure they link to the stakeholder needs, and then verify that the requirements have been satisfied by the installed system.

4.1 Systems Engineering Planning Process

The systems engineering planning process is an interdisciplinary approach that helps to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements and proceeding with design synthesis and system validation while considering the complete problem. The systems engineering process includes:

- Operations
- Performance
- Test
- Manufacturing
- Cost and Schedule
- Training and Support
- Disposal

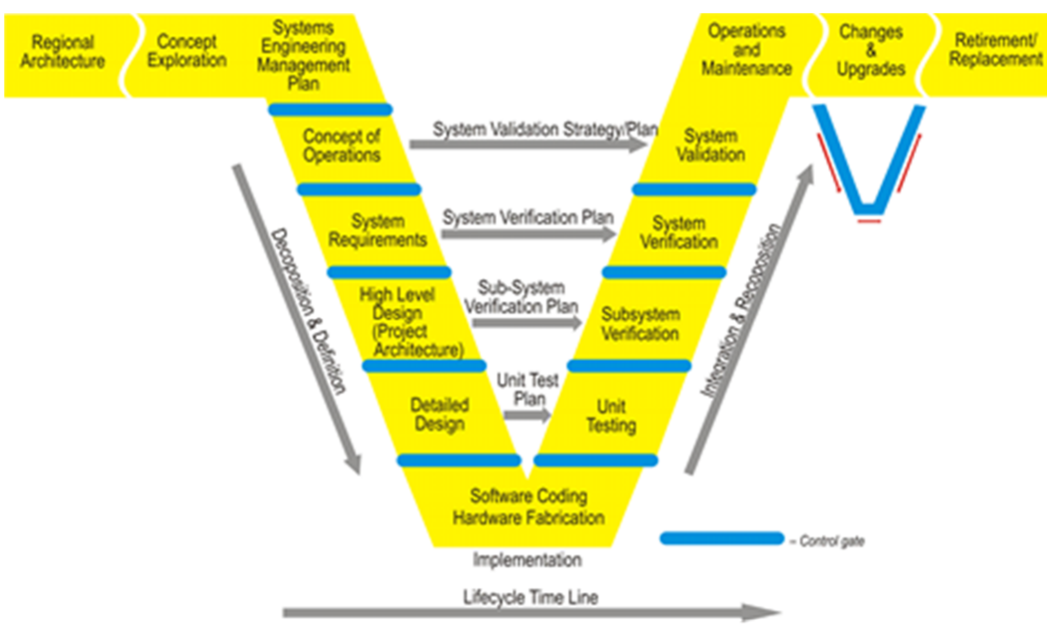
Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs.

The SEP is used to identify the project's needs and constraints and lay out the activities, resources, budget, and timeline for the project. A critical part of the process is to build consensus among the stakeholders of the project. The process should be applicable at all stages of a project, from initial system planning through final operations and maintenance of the system.

FHWA Federal Rule 940, Intelligent Transportation Systems Architecture and Standards, which implements Section 5206 (e) of the Transportation Equity Act of the 21st Century (TEA-21), requires agencies implementing projects with ITS elements utilizing federal funds to develop regional architectures and adopt an SEP for project deployments in order to qualify for ITS grants. This project's systems engineering documents were prepared using the guidelines in the "Systems Engineering Guidebook for ITS", Version 3.0 dated November 2009 published by the Federal Highway Administration (California Division).

The process can be summarized in a "V" diagram as shown in **Figure 3**. The first phase of the process involves concept exploration and identification of regional architecture requirements. The next phase includes developing a SEMP (this document) and a ConOps for the proposed system. Once those are completed, the system requirements (both functional and performance) are able to be determined, and a matrix is developed that ties all requirements to their origin in the ConOps. This matrix will later be used as the framework for the System Verification plan. The next phase is detailed design (if needed), which draws from all the previous documents to identify each piece of the system and produce plans for construction. During each stage of construction and installation, the systems engineering process is used to test, validate, and accept systems and subsystems to ensure that the final product will meet or exceed the expectations written out during the planning and design phases.

Figure 3 – Systems Engineering "V" Diagram



4.2 Regional System Architecture

The Bay Area ITS Architecture is the regional ITS architecture that provides a structures framework for planning, deployment, and integration of ITS across the Region. It was last updated in 2019 and continues to be maintained and updated by MTC and the region's stakeholders. VTA will deploy one or more projects to implement the centralized TSP system and stakeholder agencies may deploy additional projects based on the infrastructure needs of the TSP system or other required infrastructure.

The TSP project is compatible with the Bay Area Regional Architecture Component titled "VTA Transit Signal Priority." This project is associated with the PT09: Transit Signal Priority – VTA Transit Signal Priority service package. This includes the stakeholders for VTA and all stakeholder agencies as mentioned in the Stakeholders Roles section of this document.

4.3 Requirements Documentation

Requirements mining will be used to develop the functional and performance requirements for the TSP system. Stakeholder needs and operational goals are translated into a set of requirements that define what the system must do and how well it must perform. Requirements developed must be understandable, unambiguous, comprehensive, complete, and concise. The requirements analysis must clarify and define functional requirements and design constraints. The performance requirements define quantity (how many), quality (how good), coverage (how far or where), timelines (when and how long), and availability (how often). Design constraints define those factors that limit design flexibility.

The requirements of the TSP system to be deployed must relate directly to the performance characteristics required by the owner and project stakeholders for the operation of the project corridors, including the stated life-cycle customer needs and objectives for the TSP system, and the relation of these needs and objectives to how well the systems will work in its intended environment.

The functional requirements:

- Will be based on identification of the functionality of the proposed system (to include communications and traffic signal systems)
- Shall be traced to the ConOps, where possible
- Will be further detailed in the System Requirements document
- Will each have a method of verification

The high-level requirements will be based on the following:

- Functional requirements developed previously
- System requirements of the following types:
    - Functional in nature (what the system shall do)
    - Performance (how well the system and its components will perform)
    - Interface (definition of the interfaces to other systems or components or users)
    - Data (data elements)
    - Non-functional (safety, reliability, environmental)
    - Enabling requirements (production, development, testing, training, support, deployment, etc.)
    - Constraints imposed by existing system(s) or infrastructure

The detailed design requirements will be based on the following:

- High-level requirements previously developed
- Identification of the system architecture and its associated subsystems (this will include notation of its integration with the Regional Architecture)
- Identification of the logical architecture
- Further definition of the data, performance measures and interface requirements
- Tracing the detailed design requirements to the high-level requirements to the functional requirements and the ConOps

The systems engineering process is critical because the primary purpose of the process will be to transform the requirements of the TSP system into design documents to procure and implement the systems. The process develops these design documents with consideration of defined constraints, such as minimizing the construction of new infrastructure. They eventually must be verified by the System Vendor(s) to ensure the system is fulfilling traffic operations, and objectives.

5.0 TRANSITIONING CRITICAL TECHNOLOGIES

There are risks associated with the critical technology transitioning process in any project. Critical technologies are those technologies which could prevent the system from meeting its goals/objectives and providing the functionality required. For any software application procurement, questions related to usage, access, and ownership will need to be detailed out. The System Requirements and RFP documents will communicate the project stakeholder's requirements in these areas. The project stakeholders will need to provide approval rights for the technology transfer process and for the technology that is chosen by the vendor. The Systems Engineer will be involved in this process and will provide technology recommendations to the project stakeholders.

6.0 INTEGRATION OF THE SYSTEM

The System Vendor RFP will clearly describe the various system integration requirements. The System Vendor(s) shall explain very clearly in the Integration Plan the various methods that they will use to ensure successful integration of the developed components into a fully functioning system that meets the requirements from the RFP and the other Contract documents. The various SEP steps shall be adhered to by the System Vendor(s) during the design, integration, verification/testing, deployment and training phases required to support the operation and maintenance of the new TSP system. The System Vendor(s) shall provide documentation that confirms that they will adhere to each of these engineering steps. The Systems Engineer may monitor the integration process to ensure that it is being performed correctly.

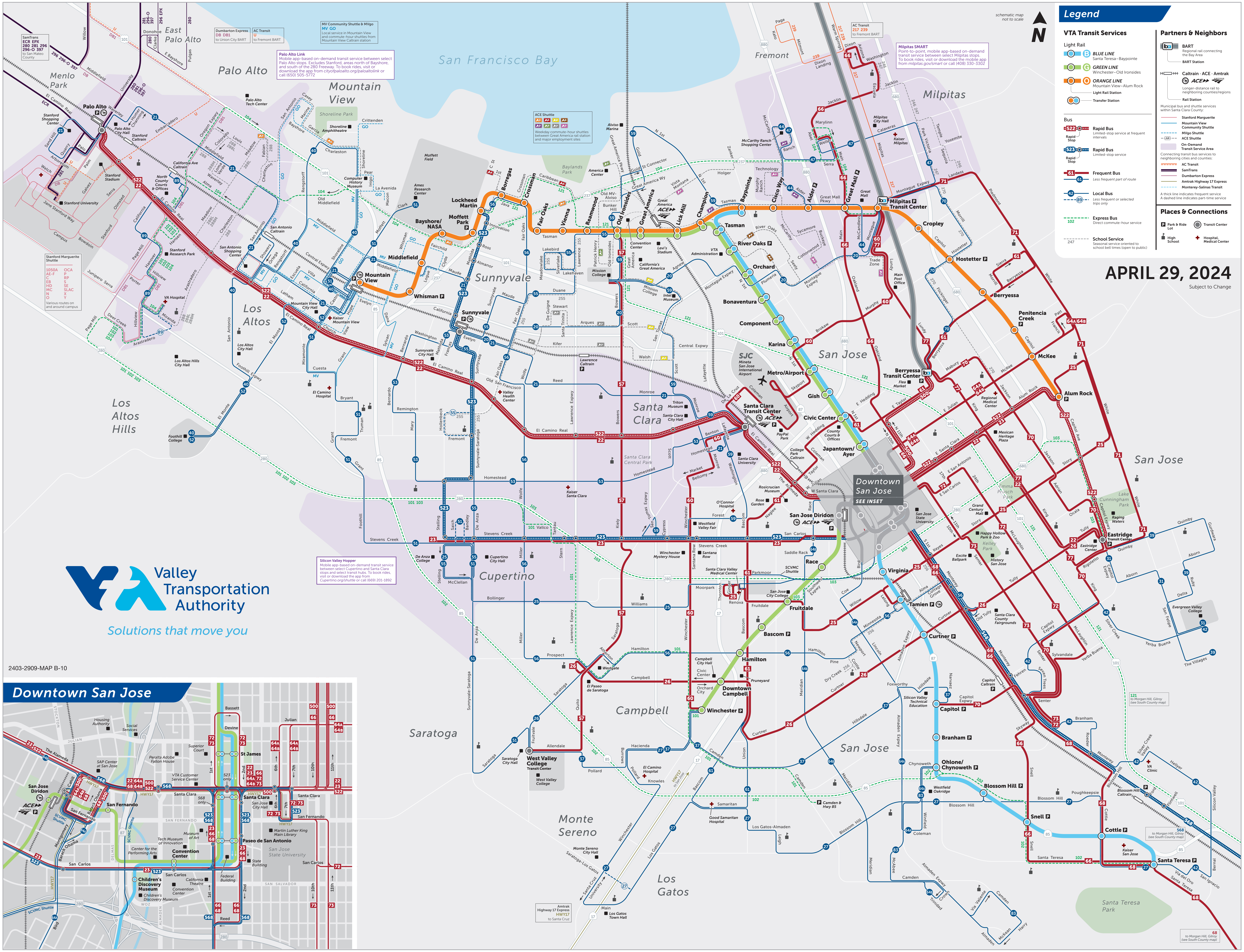
For the TSP system, integration is anticipated to be required with the traffic signal controllers either at all identified stakeholder intersections along the Rapid and Frequent routes or via the stakeholder's ATMS to receive the priority request and then execute the priority operation.

7.0 APPLICABLE DOCUMENTS

The following documents have been used in the preparation of this SEMP document. Some of these documents provide policy guidance for traffic signal design and operations in this area and some are standards with which the system must comply.

- "Systems Engineering Guidebook for ITS", California Department of Transportation, Division of Research & Innovation, Version 3.0, November 2009.
- "Systems Engineering Processes for Developing Traffic Signal Systems", National Cooperative Highway Research Program (NCHRP) Synthesis 307, Transportation Research Board, 2003.
- "Intelligent Transportation System Architecture and Standards; Final Rule, 23 CFR Parts 655 and 940", Department of Transportation, Federal Highway Administration, Federal Register, Vol. 66, No. 5, Monday, January 8, 2001.
- "Executive Summary of the Bay Area ITS Architecture", Metropolitan Transportation Commission, Updated April 2021.

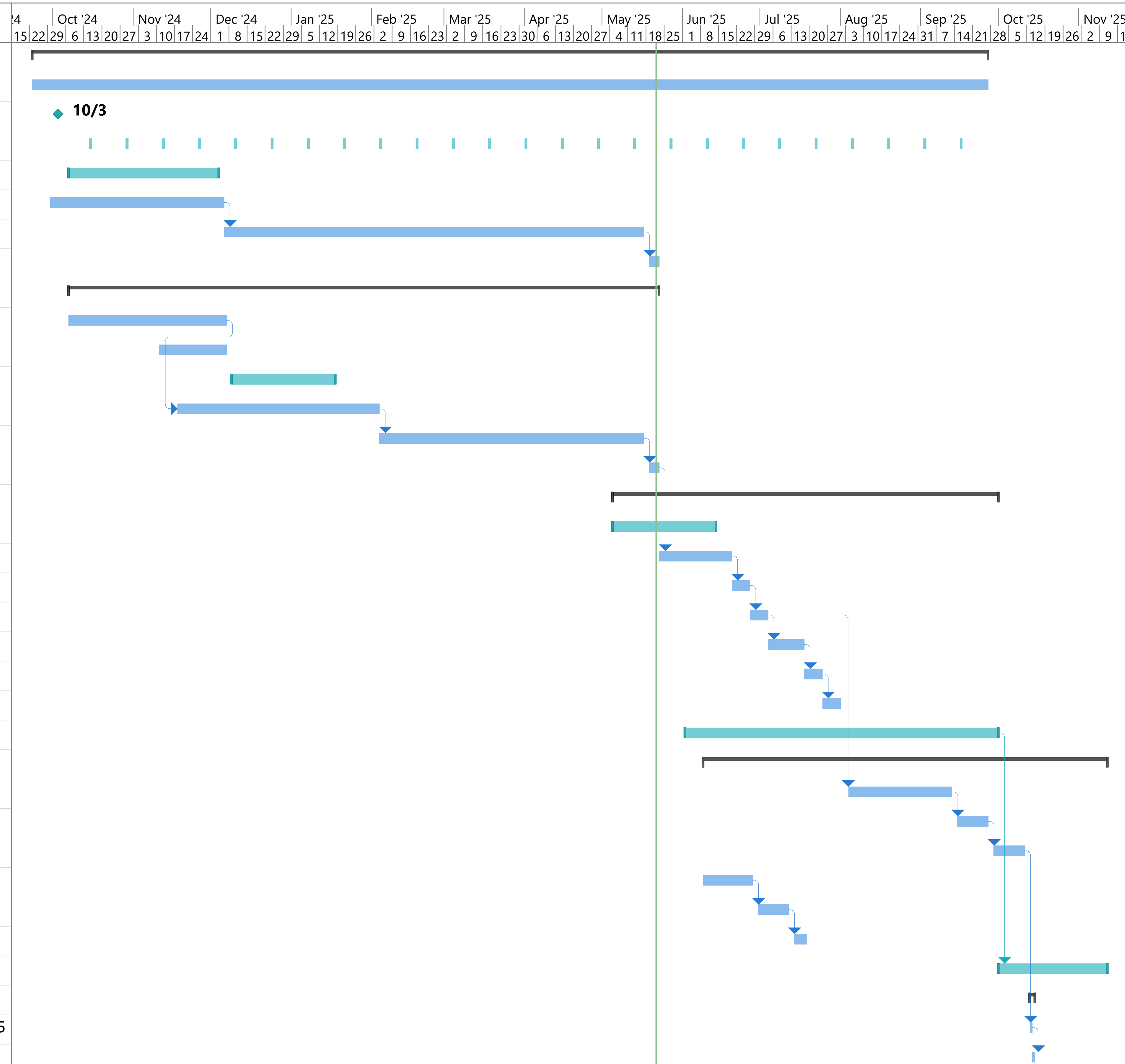
APPENDIX A – VTA TRANSIT ROUTE MAPS


APRIL 29, 2024
Subject to Change
Valley Transportation Authority
Solutions that move you
Legend
VTA Transit Services
Light Rail
BLUE LINE Santa Teresa–Baypoint
GREEN LINE Winchester–Old Ironsides
ORANGE LINE Mountain View–Alum Rock
Light Rail Station
Transfer Station
Bus
Rapid Bus Limited-stop service at frequent intervals
Rapid Bus Limited-stop service
Frequent Bus Less frequent part of route
Local Bus Less frequent or selected trips only
Express Bus Direct commute-hour service
School Service Seasonal service oriented to school bell times (open to public)
Partners & Neighbors
BART Regional rail connecting the Bay Area
BART Station
Caltrain · ACE · Amtrak
Rail Station
Places & Connections
Park & Ride Lot
Transit Center
High School
Hospital, Medical Center
Downtown San Jose
SEE INSET
San Francisco Bay
Palo Alto
East Palo Alto
Menlo Park
Mountain View
Sunnyvale
Los Altos
Los Altos Hills
Santa Clara
Cupertino
Saratoga
Campbell
Monte Sereno
Los Gatos
San Jose
Milpitas
Fremont
2403-2909-MAP B-10


OCTOBER 30, 2023
Subject to change
121 to Lockheed Martin
568 to Diridon Station
Freeway Vista
Burnett
Peebles
87
Monterey
De Paul Health Center
Cochrane
Mission View
Half
Elm
Butterfield
121
101
Main
287
MoGo Morgan Hill
Citywide point-to-point, mobile app-based on-demand transit service between select Morgan Hill stops.
To book rides, visit or download the mobile app from mogomh.com or call (408) 330-3302
Morgan Hill
Hale
68 to San Jose
68
568
Main
3rd
Morgan Hill Caltrain P
Peak
Dewitt
Alkire
Morgan Hill City Hall
Dunne
Butterfield
Tennant
San Martin
San Martin Caltrain P
San Martin
South County Offices
Monterey
No Name Uno
85
84
St Louise Hospital
Las Animas
San Ysidro
Gilroy Outlets
Cohansey
Mantelli
Church
Leavesley
Welburn
Arroyo Cir
Howson
1st
Kaiser Gilroy
Valley Health Center
Camino Arroyo
Montebello
Wren
Santa Barbara
3rd
6th
Gilroy City Hall
Gilroy
P
Pacheco Pass
Gilroy Crossing
Holloway
10th
86
Princevalle
59
Gilroy
Luchessa
Thomas
Santa Teresa
Gavilan College
Monterey-Salinas Transit 59 to Monterey County
San Benito County Express to San Benito County
N
schematic map not to scale
Legend
VTA Transit Services
568 Rapid Bus
68 Frequent Bus
87 Local Bus
287 School Service
See main map legend for more info
Partners & Neighbors
Caltrain
Rail Station
121 Gilroy-Lockheed Martin Transit
59 Monterey-Salinas Transit
On-Demand Transit Service Area
A dashed line indicates part-time service
P Park & Ride Lot
Transit Center
High School
Hospital, Medical Center
2309-2763-MAP G - 26

APPENDIX B – PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Project Management**	**265 days**	**Mon 9/23/24**	**Fri 9/26/25**
2	Project Administration	265 days	Mon 9/23/24	Fri 9/26/25
3	Kick-Off Meeting (Tentative)	0 days	Thu 10/3/24	Thu 10/3/24
4	Project Status Meetings	241 days	Tue 10/15/24	Tue 9/16/25
30	Stakeholder Outreach/Meetings	42 days	Mon 10/7/24	Tue 12/3/24
31	Draft SEMP	49 days	Mon 9/30/24	Thu 12/5/24
32	Draft SEMP Review	116 days	Fri 12/6/24	Fri 5/16/25
33	Final SEMP	4 days	Mon 5/19/25	Thu 5/22/25
34	**Project Planning Phase**	**164 days**	**Mon 10/7/24**	**Thu 5/22/25**
35	Existing Conditions	45 days	Mon 10/7/24	Fri 12/6/24
36	ITS Architecture	20 days	Mon 11/11/24	Fri 12/6/24
37	Stakeholder Outreach/Meetings	30 days	Mon 12/9/24	Fri 1/17/25
38	Draft ConOps	56 days	Mon 11/18/24	Mon 2/3/25
39	Draft ConOps Review	74 days	Tue 2/4/25	Fri 5/16/25
40	Final ConOps	4 days	Mon 5/19/25	Thu 5/22/25
41	**System Requirements Phase**	**107 days**	**Mon 5/5/25**	**Tue 9/30/25**
42	Stakeholder Meetings	30 days	Mon 5/5/25	Fri 6/13/25
43	Draft SysReq	20 days	Fri 5/23/25	Thu 6/19/25
44	Draft SysReq Review	5 days	Fri 6/20/25	Thu 6/26/25
45	Final SysReq	5 days	Fri 6/27/25	Thu 7/3/25
46	Draft Verification Plan	10 days	Fri 7/4/25	Thu 7/17/25
47	Draft Ver Plan Review	5 days	Fri 7/18/25	Thu 7/24/25
48	Final Verification Plan	5 days	Fri 7/25/25	Thu 7/31/25
49	Draft MOU	87 days	Mon 6/2/25	Tue 9/30/25
50	**Design Phase (Estimated)**	**112 days**	**Mon 6/9/25**	**Tue 11/11/25**
51	Draft Procurement Docs (Estimated)	30 days	Mon 8/4/25	Fri 9/12/25
52	Review Draft Proc. Docs (Estimated)	10 days	Mon 9/15/25	Fri 9/26/25
53	Final Procurement Docs (Estimated)	10 days	Mon 9/29/25	Fri 10/10/25
54	Draft Deployment Plan (Estimated)	15 days	Mon 6/9/25	Fri 6/27/25
55	Review Deployment Plan (Estimated)	10 days	Mon 6/30/25	Fri 7/11/25
56	Final Deployment Plan (Estimated)	5 days	Mon 7/14/25	Fri 7/18/25
57	Final MOU (Estimated)	30 days	Wed 10/1/25	Tue 11/11/25
58	**Deployment Phase**	**2 days**	**Mon 10/13/25**	**Tue 10/14/25**
59	Procurement Support (# of days TBD)	1 day	Mon 10/13/25	Mon 10/13/25
60	Deployment Support (# of days TBD)	1 day	Tue 10/14/25	Tue 10/14/25



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Innovating Through Informatics™

Transit Reliability Improvement and Performance System (TRIPS)

System Engineering Management Plan

Verification Plan

Draft

July 3, 2025

Prepared for:

Valley Transportation Authority

iteris ALMAVIVA GROUP

DOCUMENT VERSION CONTROL

DOCUMENT NAME	SUBMITTAL DATE	VERSION NO.
Draft Verification Plan – Internal Review	6/30/2025	1.0
Draft Verification Plan – Released to VTA	7/3/2025	1.1

Iteris Project 12610

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FIGURES

1.0 SCOPE OF THE SYSTEM

1.1 Document Purpose

This document presents the proposed verification plan for the TSP system(s) which will be deployed within Santa Clara County. This document describes the scope of the project, the documents referenced in the preparation of the verification plan, and details on the methods of verifications. This document also includes the verification cases and corresponding system requirements which will be tested. This document will guide stakeholder staff and the System Vendor during the deployment in the installation, integration, and testing of the TSP system(s).

The intended audience of this document includes technical staff, system operators, system designers, and vendors. Project stakeholders include the stakeholders defined in the SEMP and ConOps, summarized as VTA and the various agencies throughout Santa Clara County.

1.2 Project Background

VTA has secured federal funds under the Strengthening Mobility and Revolutionizing Transportation (SMART) grant program to improve transit performance and reliability by applying advanced technologies to provide priority treatment to its transit vehicles as they approach signalized intersections throughout Santa Clara County. The vision of the project is to deploy and utilize the technology in transit vehicles, at the central signal system of local agencies managing traffic signals, through a centralized TSP application platform, and at the roadside at traffic signals. This approach leverages the existing equipment on the transit vehicles (the existing CAD/AVL and communications equipment) and the existing traffic signal system infrastructure (existing communications between central traffic signal systems and traffic signal controllers at intersections) operated and maintained by the various municipal agencies throughout Santa Clara County. The envisioned system will allow VTA to expand TSP functionality to local cities throughout Santa Clara County where VTA provides transit service.

VTA will deploy the system initially on the Rapid and Frequent bus routes throughout Santa Clara County. VTA has plans to scale up the system(s) in the future to include local routes. An illustration of a VTA's route map showing the Rapid and Frequent bus network in the vicinity of the cities of Cupertino and Santa Clara is shown in **Figure 1**, with the full system map included in the Concept of Operations document. Throughout Santa Clara County, the Rapid and Frequent bus routes collectively cross through approximately 12 jurisdictions and a total of 871 signalized intersections. A summary of intersections on the Rapid and Frequent routes by jurisdiction is shown in **Table 1**.

Figure 1 – VTA Route Map Sample

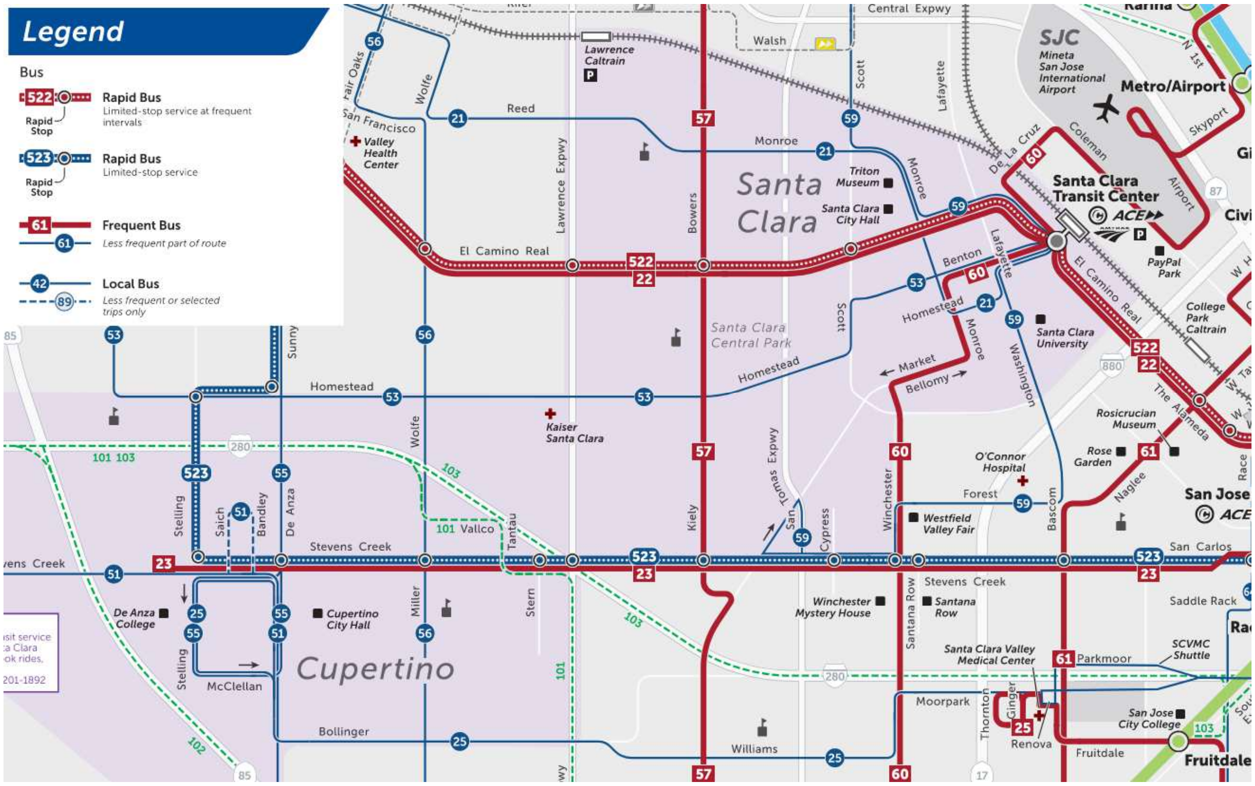

Table 1 – Project Stakeholder Signals on VTA Rapid and Frequent Routes

Stakeholder Agency	Number of Agency Signals on Rapid and Frequent Routes
Caltrans	68
Campbell	26
County of Santa Clara	54
Cupertino	19
Gilroy	10
Milpitas	20
Morgan Hill	20
Palo Alto	1
San Jose	568
Santa Clara (City)	48
Saratoga	7
Sunnyvale	30
Total Signals	**871**

1.3 Project Objectives

The goal of this project is to deploy TSP to keep VTA transit vehicles moving through intersections across multiple jurisdictions to make transit faster, more reliable, and an equitable mobility option so people have greater access to opportunities and to contribute to thriving communities.

The overall objectives for this project are to:

- Deploy a centralized TSP system(s) initially focused on the Rapid and Fast network, and that is easily scalable to the rest of VTA's transit network.
- Improve transit reliability and travel time along all VTA's service routes.
- Increase transit mode share (i.e., ridership and person throughput) and improve mobility for residents, employers, retailers and regional commuters.
- Reduce fuel consumption related to transit vehicle operations.

This project will deploy a centralized transit signal priority (TSP) system throughout Santa Clara County and is expected to transform the efficiencies and innovation in Santa Clara County's various transportation systems by improving transit performance metrics (e.g., travel time, reliability, etc.). This project builds upon a previous pilot project that tested a centralized TSP system that leveraged existing infrastructure resulting in minimal new infrastructure, using standardized communications protocols to connect to traffic signals, and taking advantage of modern-day broadband communications and edge-computing capabilities. The project will deploy a centralized application that provides TSP for VTA transit vehicles through integration between the existing transit system infrastructure and the local agency traffic signal system infrastructure. The goal is to provide TSP capabilities throughout Santa Clara County at all traffic signals that transit vehicles operate through, which are managed by multiple disparate traffic signal control systems and controllers.

2.0 CONDUCTING VERIFICATION

The verification will be conducted by the System Vendor in the presence of VTA's project manager, public agency stakeholder's staff, and the System Engineer. Prior to conducting the verification test, the System Vendor will develop the verification procedures to be reviewed and approved by VTA. All verification shall be conducted in the presence of VTA's Project Manager and the public agency stakeholder's staff. Oversight of the verification process and system acceptance will be supported by the System Engineer. Final verification and formal system acceptance will be provided by VTA's Project Manager. The VTA Project Manager will control the plan and tests, but will also work with the System Engineer to clarify the verification procedure and acceptance tests.

The System Vendor will be responsible for providing all materials, equipment and staff to complete the testing. A list of all hardware, software, and any special equipment utilized in the testing shall be provided at a future date. The proposed date and time of all acceptance testing will be planned in advance and coordinated with the VTA Project Manager. The System Vendor shall produce and maintain a schedule for the VTA Project Manager that details all proposed dates and time of all acceptance testing activities. The VTA Project Manager, in coordination with the applicable stakeholder agency(ies) and the System Engineer, will review and approve the schedule.

The System Vendor shall conduct the verification tests in two steps. In the first step, the Vendor shall bench test the system against the system requirements at a VTA facility, or another location to be determined by VTA. This "bench test" shall serve to test conditions that would otherwise be unsafe or unwanted in the field with actual traffic conditions. In the second step, the System Vendor shall conduct the verification tests with the field-deployed hardware and software. The verification table indicates where the test should be conducted. The Vendor shall coordinate with the VTA Project Manager to schedule the testing time periods consistent with the test schedule.

Verification testing will be a critical part of implementation. The acceptance test is expected to consist of a multiple day test of the field components. This testing will take place in the field at selected locations and at each public agency stakeholder's office for complete end-to-end system performance verification. If there are verification tests that result in failure, then the verification could take longer. If hardware will be deployed to support the system, a 30-day reliability test for each component installed as part of the project will also be documented. The 30-day test is expected to document the verification of daily operation.

Any failure or lack of performance to meet the stated system requirements shall be immediately recorded as a system variance and the System Vendor shall prepare a report stating why the system requirement was not met. It will be the responsibility of the System Vendor to complete, track, and resolve each variance to the satisfaction of the VTA Project Manager. The variance form shall include a proposed solution to resolve the deficiency and shall be submitted to the Project Manager within seven days of the failure if discovered. Upon any failed verification, the VTA Project Manager, in consultation with the System Engineer and stakeholder agencies, will decide if all testing should stop until the correction is made. A failure with a key system requirement such as upload/download data to the system will likely cause all testing to halt. Other functional requirement failures such as a report layout may not necessitate a halt to system verification.

If the System Vendor is not able to meet a system requirement that was included in the contract, the System Vendor shall prepare a report documenting the failure and develop a plan to provide similar performance operation or correction to the failure. Upon completion of all required verification testing, the System Vendor shall prepare a final Verification Report which will contain all critical information regarding testing conducted, including both failures and successes for all system requirements. Resolution of the cause of failures will also be detailed.

Note that in the event that more than one TSP system will be deployed, testing and verification will be performed independently for each system on an individual basis. Testing and verification may also be performed by each stakeholder agency if necessary to confirm performance requirements by jurisdiction.

3.0 VERIFICATION IDENTIFICATION

This section identifies specific verification cases to be performed. A verification case is a logical grouping of functions and performance criteria that are to be verified together. Each case should contain the following:

- Name and reference number
- Need (from Requirements)
- List of requirements to be verified or traced
- Data to be recorded or noted during verification as well as expected results
- Statement of requirements met, partially met, or not met.
- Comments on how requirements are met, and proposed action if only partially met or not met.

The following verification cases have been identified to correspond with the primary verification methods as outlined in the verification and test case matrix in **Appendix A**. More specific test case instructions will be developed by the System Vendor, after a specific system has been procured so that all necessary software demonstration procedures are adjusted accordingly.

Verification Case 1: Product Submittal Review

As the System Vendor selects final system components for procurement, the System Vendor will provide the VTA Project Manager with product specifications and/or engineering drawings for requirements verification and acceptance. Once accepted, the Vendor may complete procurement of components for installation and integration.

Verification Case 2: Product Demonstration

After the System Vendor has procured the system hardware (if necessary) and integrated an initial group of intersections with the system, a series of detailed software demonstration tests will be conducted. The demonstration will take place on-site at the designated facility to be determined by VTA. The system shall be activated and observed for requirements verification and acceptance.

Verification Case 3: Field Observations

After the System Vendor has integrated the system components and completed the software demonstration test case, a visual inspection of system performance and/or functionality in the field will be conducted. This visual confirmation will document how the system satisfies requirements associated with field-observed operations and/or functions.

4.0 REFERENCED DOCUMENTS

The following documents have been used in the preparation of this Systems Requirements document.

- "Systems Engineering Guidebook for ITS", California Department of Transportation, Division of Research & Innovation, Version 3.0, November 2009.
- "Systems Engineering Processes for Developing Traffic Signal Systems", National Cooperative Highway Research Program (NCHRP) Synthesis 307, Transportation Research Board, 2003.
- "Intelligent Transportation System Architecture and Standards; Final Rule, 23 CFR Parts 655 and 940", Department of Transportation, Federal Highway Administration, Federal Register, Vol. 66, No. 5, Monday, January 8, 2001.
- "Executive Summary of the Bay Area ITS Architecture", Metropolitan Transportation Commission, Updated April 2021.
- "Transit Reliability Improvement and Performance System (TRIPS) Systems Engineering Management Plan (SEMP) - Final", VTA, May 22, 2025
- "Transit Reliability Improvement and Performance System (TRIPS) Concept of Operations (ConOps) - Final", VTA, May 22, 2025
- "Transit Reliability Improvement and Performance System (TRIPS) System Requirements - Draft", VTA, June 6, 2025

APPENDIX A – Verification Test Case Matrix

System Requirement ID	Description	Mandatory (M)/ Desirable (D)	Verification Method	Test Location	Verification Case (See Section 3.0 of Verification Plan)			Met	Partially Met	Not Met	Describe how requirements are met and proposed action if not met or only partially met.
					1	2	3				
TSP System Requirements											
1.0 Applicable Standards											
1.1	The transit signal priority (TSP) system shall, at a minimum, conform to the following standards:	M	Demonstration of software	Bench	✓	✓					
1.1.1	NTCIP 1202 v03 - Object Definitions for Actuated Traffic Signal Controller	M	Demonstration of software	Bench	✓	✓					
1.1.2	NTCIP 1211 v02 - Object Definitions for Signal Control and Prioritization	M	Demonstration of software	Bench	✓	✓					
2.0 External Interfaces											
2.1	The TSP system shall interface with the stakeholder agencies' traffic signal controllers of various types. The agency controllers will utilize the NTCIP 1202 and 1211 standards for actuated signal, preemption, and priority message exchange.	M	Demonstration of software	Bench		✓	✓				
2.1.1	The TSP system shall receive traffic signal data from the traffic signal controllers utilizing the NTCIP 1202 standard protocol.	M	Demonstration of software	Bench		✓	✓				
2.1.2	The TSP system shall receive signal control and priority data from the traffic signal controllers utilizing the NTCIP 1211 standard protocol.	M	Demonstration of software	Bench		✓	✓				
2.1.3	The TSP system shall receive preemption data from the traffic signal controllers utilizing the NTCIP 1202 and 1211 standard protocols.	D	Demonstration of software	Bench		✓	✓				
2.1.4	The TSP system shall receive an updated data set from the traffic signal controllers on a schedule to be defined by NTCIP 1202, but at a minimum the entire set of NTCIP objects shall be received each time there is a state change in the controller.	D	Demonstration of software	Bench		✓	✓				
2.1.5	The TSP system shall send a transit signal priority request to the traffic signal controller utilizing the NTCIP 1211 standard protocol.	M	Demonstration of software	Bench		✓	✓				
2.1.6	The TSP system shall send a preemption request to the traffic signal controller utilizing the NTCIP 1202 and 1211 standard protocols.	D	Demonstration of software	Bench		✓	✓				
2.2	The TSP system shall interface and communicate with the traffic signal controller using one or more of the following methods:	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
2.2.1	The TSP system will communicate directly with the traffic signal controller using an agency's existing ethernet-based network (i.e., existing central office switch, existing field cabinet switch, and existing ethernet port on the controller).	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
2.2.1.1	The TSP system may utilize a communications server, installed at each agency's office, to communicate with the existing traffic signal controller, if needed.	D	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
2.2.2	The TSP system will communicate with the traffic signal controller through an agency's existing central traffic signal management system (ATMS) using an agency's existing communications network.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
2.2.3	The TSP system will communicate with the traffic signal controller through a field interface unit equipped with a cellular modem installed within the intersection cabinet.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
2.3	The TSP system shall interface with VTA's existing GTFS (static and real-time) and/or Swiftly real-time transit information data feeds, hereafter referred to as "real-time data feeds."	M	Demonstration of software	Bench		✓					
2.4	The TSP system shall obtain all required transit system and transit vehicle information from the real-time data feeds.	M	Demonstration of software	Bench		✓					
2.4.1	The TSP system shall obtain bus operational status (e.g., in service or out of service) from the real-time data feeds.	M	Demonstration of software	Bench		✓					
2.4.2	The TSP system shall obtain bus schedule information from the real-time data feeds as frequently as the system provides.	M	Demonstration of software	Bench		✓					
2.4.3	The TSP system shall obtain bus location information (i.e., time stamp, vehicle ID, latitude, longitude, speed, heading) from the real-time data feeds. The TSP system shall obtain bus location updates as frequently as the system provides or once every five (5) seconds, whichever is more frequent.	M	Demonstration of software	Bench		✓					
3.0 System Architecture											
3.1	The TSP system shall be centralized cloud-based (hosted off the agency's premise by the system vendor).	M	Demonstration of software	Bench		✓					
3.2	The TSP system's server hosting location(s) shall have geographic redundancy and automatic failover in the event of an outage to maintain at least a 99% daily system uptime.	M	Demonstration of software	Bench		✓					
3.3	The TSP system shall function as the priority request generator (PRG) for each transit vehicle.	M	Demonstration of software	Bench		✓					
3.4	The TSP system shall function as the priority request server (PRS) for each traffic signal controller.	M	Demonstration of software	Bench		✓					
3.5	The TSP system shall determine if a priority request is generated for the transit vehicle based on user-defined parameters.	M	Demonstration of software	Bench		✓					
3.6	The TSP system shall send the priority request message, that conforms to the NTCIP 1211 standard format, by one of the following methods:	M	Demonstration of software	Bench		✓	✓				
3.6.1	The TSP system shall send the priority request message directly to the traffic signal controller(s).	M	Demonstration of software	Bench		✓	✓				
3.6.2	The TSP system shall send the priority request message to an agency's central traffic management system directly to be relayed to the traffic signal controller(s).	M	Demonstration of software	Bench		✓	✓				
3.7	The TSP system shall track the transit vehicle, determine if a priority request message is to be generated, and shall generate and send the priority request message to the traffic signal controller(s) based on one or both of the following conditions:	M	Demonstration of software	Bench		✓					

System Requirement ID	Description	Mandatory (M)/ Desirable (D)	Verification Method	Test Location	Verification Case (See Section 3.0 of Verification Plan)			Met	Partially Met	Not Met	Describe how requirements are met and proposed action if not met or only partially met.
					1	2	3				
3.7.1	The transit vehicle is within a configured distance to the traffic signal.	M	Demonstration of software	Bench		✓					
3.7.2	The transit vehicle's estimated time of arrival (ETA) to the traffic signal is within a configured threshold.	M	Demonstration of software	Bench		✓					
3.8	The TSP system shall track the transit vehicle, generate and send the priority request message cancellation (check-out) immediately once the transit vehicle traverses past the far side of the intersection.	M	Demonstration of software	Bench		✓					
3.9	The TSP system shall manage receipt of conflicting priority request messages.	M	Demonstration of software	Bench		✓					
3.10	The TSP system shall include a function to prioritize priority request messages received from multiple equipped vehicles based on one or more configurable parameters, as follows: vehicle class, ETA, distance from signal/intersection, route, direction, or a combination of multiple.	D	Demonstration of software	Bench		✓					
3.11	The TSP system shall allow the user to disable and enable the prioritization function.	M	Demonstration of software	Bench		✓					
3.12	The TSP system shall function with allowable system latency of up to 3 seconds.	M	Demonstration of software	Bench		✓					
4.0 System Configuration											
4.1	The TSP system shall include a graphical user interface for users to manage the system and its data.	M	Demonstration of software	Bench		✓					
4.1.1	The user interface shall be browser-based application that provides access to authorized users for all management, configuration, monitoring, and support functionality of the system.	M	Demonstration of software	Bench		✓					
4.1.2	The user interface shall be accessible via any workstation and laptop computer with internet access.	M	Demonstration of software	Bench		✓					
4.1.3	The user interface shall display information on the system's operation, status, configuration, and diagnostics.	M	Demonstration of software	Bench		✓					
4.1.4	The user interface shall display information in text and graphical formats as appropriate.	M	Demonstration of software	Bench		✓					
4.2	The TSP system shall provide digital mapping to geographically view the system and manage data.	M	Demonstration of software	Bench		✓					
4.3	The TSP system shall include functionality to create geofence zones at each approach to an intersection.	D	Demonstration of software	Bench		✓					
4.3.1	The TSP system shall include functionality to graphically display the location and layout of each geofence zone.	D	Demonstration of software	Bench		✓					
4.3.2	The TSP system shall include functionality for the user to create geofence zones within the interface.	D	Demonstration of software	Bench		✓					
4.3.3	The TSP system shall include functionality to name, copy, modify, and delete geofence zones.	D	Demonstration of software	Bench		✓					
4.4	The TSP system shall provide the functionality to remotely make program changes and configure system parameters.	M	Demonstration of software	Bench		✓					
4.5	The TSP system interface shall include a live (real-time) system map showing the location of all transit vehicles, transit routes, transit stops, and traffic signals that are monitored and managed by the system.	M	Demonstration of software	Bench		✓					
4.5.1	The system map shall be dynamic allowing for the user to zoom in, zoom out, and pan in all directions to navigate to different areas of the map.	M	Demonstration of software	Bench		✓					
4.5.2	The system map shall allow the user to select and filter the items that are shown on the map.	M	Demonstration of software	Bench		✓					
4.5.2.1	The system map shall allow the user to select and filter transit routes to be shown by the transit route names and/or numbers.	M	Demonstration of software	Bench		✓					
4.5.2.2	The system map shall allow the user to select and filter transit stops to be shown by the transit route names and/or numbers.	M	Demonstration of software	Bench		✓					
4.5.2.3	The system map shall allow the user to select and filter transit vehicles to be shown by the transit route names and/or numbers.	M	Demonstration of software	Bench		✓					
4.5.2.4	The system map shall allow the user to select and filter traffic signals to be shown by the transit route names and/or numbers.	M	Demonstration of software	Bench		✓					
4.6	The live system map shall provide the status of all transit vehicles that include:	M	Demonstration of software	Bench		✓					
4.6.1	Each transit vehicle shall be represented by an icon with status to be continuously updated (no less than every 5 seconds).	M	Demonstration of software	Bench		✓					
4.6.2	Each transit vehicle icon shall be continuously updated to show the current location of the transit vehicle on the system map.	M	Demonstration of software	Bench		✓					
4.6.3	Each transit vehicle icon shall be continuously updated to show the transit vehicle information including vehicle ID, route number, and in/out of service status.	M	Demonstration of software	Bench		✓					
4.6.4	Each transit vehicle icon shall be continuously updated to show transit signal priority request status (requesting/not requesting TSP).	M	Demonstration of software	Bench		✓					
4.7	The live system map shall provide the status of all traffic signals that include:	M	Demonstration of software	Bench		✓					
4.7.1	Each traffic signal shall be represented by an icon with status to be continuously updated (no less than every 5 seconds).	M	Demonstration of software	Bench		✓					
4.7.2	Each traffic signal icon shall show the traffic signal information including intersection location, city, agency, and signal ID.	M	Demonstration of software	Bench		✓					
4.7.3	Each traffic signal icon shall be continuously updated to show the traffic signal controller status (online or off-line).	M	Demonstration of software	Bench		✓					
4.7.4	Each traffic signal icon, when on-line, shall be continuously updated to show the traffic signal phase status.	D	Demonstration of software	Bench		✓					
4.7.5	Each traffic signal icon, when on-line, shall be continuously updated to show signal operational status (i.e., Free, Coordinated, Preempt, Priority, Flash).	D	Demonstration of software	Bench		✓					

System Requirement ID	Description	Mandatory (M)/ Desirable (D)	Verification Method	Test Location	Verification Case (See Section 3.0 of Verification Plan)			Met	Partially Met	Not Met	Describe how requirements are met and proposed action if not met or only partially met.
					1	2	3				
4.7.6	Each traffic signal icon, when on-line, shall be continuously updated to show the priority status (providing/not providing TSP).	M	Demonstration of software	Bench		✓					
4.8	The TSP system shall support at least five (5) vehicle class types (i.e., transit vehicle, light rail vehicle, fire vehicle, police vehicle, commercial fleet, etc.) and levels in which priority request levels can be assigned.	M	Demonstration of software	Bench		✓					
	5.0 Operations										
5.1	The TSP system shall track each VTA transit vehicle along its route and as it approaches signalized intersection.	M	Demonstration of software	Bench		✓	✓				
5.2	The TSP system shall determine signal priority eligibility for each tracked transit vehicle.	M	Demonstration of software	Bench		✓					
5.3	The TSP system shall determine the desired level of signal priority for each tracked transit vehicle.	M	Demonstration of software	Bench		✓					
5.4	The TSP system shall acquire data for a tracked transit vehicle including time stamp, vehicle ID, vehicle type, location (lat/long/elev), speed, and heading.	M	Demonstration of software	Bench		✓					
5.5	The TSP system shall generate transit vehicle priority request message data including time-stamp, vehicle ID, vehicle type, priority request, and expected time of arrival at the intersection.	M	Demonstration of software	Bench		✓					
5.6	The TSP system shall estimate the expected time of arrival of the transit vehicle at each signalized intersection along the transit route.	M	Demonstration of software	Bench		✓					
5.7	The TSP system shall not generate a priority request message when the transit vehicle door status is open.	D	Demonstration of software	Bench		✓	✓				
5.7.1	The TSP system shall resume generation of a priority request message when the transit vehicle door status is closed and the transit vehicle has not traversed the intersection. This may be the case for a near-side bus stop where a transit vehicle will stop to pick-up or drop-off passengers prior to proceeding through the intersection.	D	Demonstration of software	Bench		✓	✓				
5.8	The TSP system shall process priority request messages from one or more transit vehicle at each signalized intersection.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
5.9	The TSP system shall determine the appropriate traffic signal phase(s) to serve a transit vehicle's priority request on approach to each signalized intersection.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
5.10	The TSP system shall generate an NTCIP 1211 priority request to the traffic signal controller at each signalized intersection.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
5.11	The TSP system shall obtain status data from the traffic signal controller.	M	Demonstration of software	Bench/Field		✓	✓				
5.11.1	The TSP system shall obtain signal phasing and timing status data.	M	Demonstration of software	Bench/Field		✓	✓				
5.11.2	The TSP system shall obtain priority status data.	M	Demonstration of software	Bench/Field		✓	✓				
5.12	The TSP system shall receive priority status message information from each signalized intersection.	D	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
5.13	When the transit vehicle has traveled past the far side of the signalized intersection, the TSP system shall generate and process the priority request cancellation (check-out) immediately to the traffic signal controller.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
5.14	The TSP system shall not interrupt traffic signal coordinated operation.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
5.15	The TSP system shall be capable of running concurrently with all available adaptive control systems and shall not interrupt the adaptive system operation.	M	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
5.16	The TSP system shall be capable of implementing reservice inhibitions to lockout TSP calls within a user configurable time duration following a previously granted priority.	D	Demonstration of software/Visual Inspection	Bench/Field		✓	✓				
	6.0 Security and Access										
6.1	The TSP system shall comply with each agency's IT security policy when accessing or communicating with each agency's existing systems.	M	Demonstration of software	Bench		✓					
6.2	The TSP system shall include security features to limit unauthorized user access.	M	Demonstration of software	Bench		✓					
6.2.1	The TSP system shall include security features for an administrator to configure user access such that different class of users (i.e., admin, user, guests, etc.) are limited to different levels of functionalities (full access, limited write access, read access only, etc.).	M	Demonstration of software	Bench		✓					
6.2.2	The TSP system shall support authentication of individual users via individual user names and passwords.	M	Demonstration of software	Bench		✓					
6.2.3	The TSP system shall not limit the number of user accounts that can be created to allow and grant access.	M	Demonstration of software	Bench		✓					
6.2.4	The TSP system shall provide varied levels of data access and analytic functionality that are tiered by multiple user types.	D	Demonstration of software	Bench		✓					
6.2.5	The TSP system shall provide full access to the administrator.	M	Demonstration of software	Bench		✓					
6.2.6	The TSP system shall allow the administrator to determine which user has rights to change system parameters related to conditional priority settings.	M	Demonstration of software	Bench		✓					
6.3	The TSP system shall show users who are logged in to the system at a given time.	D	Demonstration of software	Bench		✓					
6.4	The TSP system shall utilize industry standard security methods for data storage and access.	M	Demonstration of software	Bench		✓					
6.5	The TSP system shall employ industry standard encryption to ensure user login names and passwords are secure.	M	Demonstration of software	Bench		✓					
6.6	The system shall allow the system administrator to configure and implement authorized users, password rules, and password change requirements.	M	Demonstration of software	Bench		✓					

System Requirement ID	Description	Mandatory (M)/ Desirable (D)	Verification Method	Test Location	Verification Case (See Section 3.0 of Verification Plan)			Met	Partially Met	Not Met	Describe how requirements are met and proposed action if not met or only partially met.
					1	2	3				
6.7	The system shall support the option for two-factor authentication for user access and log-in to the TSP system.	D	Demonstration of software	Bench		✓					
7.0 Monitoring, Reporting, and Alerts											
7.1	The TSP system shall have a function for creating, storing, managing, and retrieving logs of system activity.	M	Demonstration of software	Bench		✓					
7.1.1	The system shall log and store the messages created by the system, including the content, time of generation, and time of broadcast.	M	Demonstration of software	Bench		✓					
7.1.2	The system logs shall cover a duration of at least three years.	M	Demonstration of software	Bench		✓					
7.1.3	The system logs shall be able to be exported as a CSV file format.	D	Demonstration of software	Bench		✓					
7.1.4	The system shall log and store each TSP request message generated by the system. The log shall include:	M	Demonstration of software	Bench		✓					
7.1.4.1	The start and end time of each TSP request.	M	Demonstration of software	Bench		✓					
7.1.4.2	The bus ID and route number associated with the request.	M	Demonstration of software	Bench		✓					
7.1.4.3	The traffic signal ID, location, and approach direction associated with the request.	M	Demonstration of software	Bench		✓					
7.1.5	The system shall log and store each TSP request message received by the traffic signal controller. The log shall include:	M	Demonstration of software	Bench		✓					
7.1.5.1	The start and end time of each TSP request received.	M	Demonstration of software	Bench		✓					
7.1.5.2	The bus ID and route number associated with the request.	M	Demonstration of software	Bench		✓					
7.1.5.3	The approach direction associated with the request.	M	Demonstration of software	Bench		✓					
7.1.5.4	The traffic signal controller's action taken as a result of the request including: No Action, TSP Granted, TSP Not Granted.	M	Demonstration of software	Bench		✓					
7.1.6	The system shall log and store the average duration of priority requests, by approach, for each intersection.	M	Demonstration of software	Bench		✓					
7.1.7	The system shall log and store the location of origin for all stored data such as the intersection for each message.	M	Demonstration of software	Bench		✓					
7.1.8	The system shall log and store user-initiated changes in the system setup, configuration, and parameters and shall include user name, data and time, and the change made.	M	Demonstration of software	Bench		✓					
7.1.9	The system shall log and store system errors and alerts, such as loss of power, loss of communications, and failure to generate/broadcast/receive messages.	M	Demonstration of software	Bench		✓					
7.1.10	The system shall log and store the status taken by the traffic signal controller in response to each priority request received. The log shall include:	M	Demonstration of software	Bench		✓					
7.1.10.1	The date/time stamp of the start and end time of each TSP request received by the controller.	M	Demonstration of software	Bench		✓					
7.1.10.2	The bus ID, route number, and travel direction associated with the request.	M	Demonstration of software	Bench		✓					
7.1.10.3	The traffic signal controller's action taken as a result of the request including: No Action, TSP Granted, TSP Not Granted.	M	Demonstration of software	Bench		✓					
7.1.10.4	The traffic signal controller's action taken if the TSP request was granted including: Early Green, Green Extension.	M	Demonstration of software	Bench		✓					
7.1.10.5	The traffic signal controller's operational state (i.e., Normal, Transition, Preempt, Comm Fail, etc.) at the time of the priority request.	M	Demonstration of software	Bench		✓					
7.1.11	The system shall log when the system became active and any time it is deactivated or reactivated at an intersection.	D	Demonstration of software	Bench		✓					
7.2	The TSP system shall provide a user interface for generating and managing various reports.	M	Demonstration of software	Bench		✓					
7.2.1	The system shall have a user interface for users to query system logs for report generation including time periods, routes, locations, vehicles, and type of logs.	M	Demonstration of software	Bench		✓					
7.2.2	The system shall display reports using graphs and charts on a dashboard, and produce the reports in standard file formats including CSV, Excel, and PDF.	M	Demonstration of software	Bench		✓					
7.2.3	The system shall be capable of creating customized reports by selecting available data sets as desired.	D	Demonstration of software	Bench		✓					
7.2.4	The system shall be capable of saving customized reports by user for reuse.	D	Demonstration of software	Bench		✓					
7.3	The system shall provide performance metrics reports which are sortable and queried individually or by any combination of the following: route name/number, vehicle ID, intersection location, bus stop location, direction of travel, and date/time interval as follows:	M	Demonstration of software	Bench		✓					
7.3.1	The system shall generate and display reports for the following transit route performance and travel time metrics:	M	Demonstration of software	Bench		✓					
7.3.1.1	Comparison of actual trip duration vs. scheduled trip duration.	M	Demonstration of software	Bench		✓					
7.3.1.2	Travel time and average travel time.	M	Demonstration of software	Bench		✓					
7.3.1.3	Headway between intersections.	M	Demonstration of software	Bench		✓					
7.3.1.4	Bus stop dwell time.	M	Demonstration of software	Bench		✓					
7.3.1.5	Average bus speed.	M	Demonstration of software	Bench		✓					
7.3.1.6	On-time pick up performance.	M	Demonstration of software	Bench		✓					
7.3.2	The system shall generate and display reports for the following TSP effectiveness measures:	M	Demonstration of software	Bench		✓					
7.3.2.1	TSP request generated volume (incoming TSP requests).	M	Demonstration of software	Bench		✓					
7.3.2.2	TSP request traffic signal response volume.	M	Demonstration of software	Bench		✓					
7.3.2.3	TSP request success rate.	M	Demonstration of software	Bench		✓					
7.3.2.4	Average red light delay.	M	Demonstration of software	Bench		✓					
7.3.2.5	Average green light success.	M	Demonstration of software	Bench		✓					
7.3.3	The system shall aggregate all data and produce a report summarizing: transit travel time savings and estimated fuel consumption savings.	D	Demonstration of software	Bench		✓					
7.3.3.1	The system shall allow the user to input and modify average vehicle gas mileage and fuel consumption reports.	D	Demonstration of software	Bench		✓					

System Requirement ID	Description	Mandatory (M)/ Desirable (D)	Verification Method	Test Location	Verification Case (See Section 3.0 of Verification Plan) 1	2	3	Met	Partially Met	Not Met	Describe how requirements are met and proposed action if not met or only partially met.
7.3.4	The system shall generate a report which summarizes the TSP business rules in place at each intersection.	D	Demonstration of software	Bench		✓					
7.4	The TSP system shall have a function for managing system alerts.	M	Demonstration of software	Bench		✓					
7.4.1	The system shall alert users for various system failures and operating issues including loss of power, loss of communications, hardware failure, message broadcast and receipt loss/failure, and functional failures.	M	Demonstration of software	Bench		✓					
7.4.2	The system shall have a function that allows the user to configure the threshold values for when an alert is generated by the system.	D	Demonstration of software	Bench		✓					
7.4.3	The system shall alert users by email and text message.	D	Demonstration of software	Bench		✓					
7.4.4	The system shall allow the user to configure which user(s) are alerted and by the type of alert.	D	Demonstration of software	Bench		✓					
7.5	The TSP system shall provide system health and diagnostic information related to the connectivity to the transit system and traffic signal system.	M	Demonstration of software	Bench		✓					
7.5.1	The system shall monitor and report on the health and performance of the traffic signal system as it pertains to the following:	M	Demonstration of software	Bench		✓					
7.5.1.1	Loss of communication to the traffic signal controllers.	M	Demonstration of software	Bench		✓					
7.5.1.2	Average latency time (polling rate) to the traffic signal controllers.	M	Demonstration of software	Bench		✓					
7.5.1.3	Communications connectivity to traffic signal controllers over time.	M	Demonstration of software	Bench		✓					
7.5.1.4	Instances of high latency time to the traffic signal controllers.	M	Demonstration of software	Bench		✓					
7.5.2	The system shall monitor and report on the health and performance of the transit system as it pertains to the following:	M	Demonstration of software	Bench		✓					
7.5.2.1	Average transit vehicle location (AVL) status interval (polling rate).	M	Demonstration of software	Bench		✓					
7.5.2.2	Vehicle update messages.	M	Demonstration of software	Bench		✓					
7.5.3	The system shall receive and display the messages that are broadcasted and received for each transit vehicle.	M	Demonstration of software	Bench		✓					
7.6	The TSP system shall provide a web-based user interface to manage and monitor system activity, logs, reports, alerts, and diagnostic information.	M	Demonstration of software	Bench		✓					
8.0 Training and Documentation											
8.1	The vendor shall provide training on all operations of the system. Training sessions shall be recorded for future reference.	M	Contract scope requirement	n/a							
8.2	The vendor shall provide training on troubleshooting the system.	M	Contract scope requirement	n/a							
8.3	The vendor shall provide training on system configuration.	M	Contract scope requirement	n/a							
8.4	The vendor shall provide training on administration of the system. Administration training shall include cybersecurity of the system and cover topics such as education on hacking via social engineering and password security and management.	M	Contract scope requirement	n/a							
8.5	The vendor shall provide training on the operations of the system.	M	Contract scope requirement	n/a							
8.6	The vendor's training delivery shall include: printed and electronic copies of course materials, presentations and references.	M	Contract scope requirement	n/a							
8.7	The vendor's training shall be delivered on-site (if conditions permit) at owner's facility. Exact location to be determined.	M	Contract scope requirement	n/a							
8.8	The vendor shall provide a minimum of 3 days training for all participating agencies' staff.	M	Contract scope requirement	n/a							
8.9	The vendor shall provide all hardcopy and electronic copies of manuals for the system and all other hardware equipment and software program(s) provided as part of the system.	M	Contract scope requirement	n/a							
9.0 Maintenance, Support and Warranty											
9.1	The vendor shall provide support and maintenance on the TSP system. That maintenance work should identify repairs necessary to preserve requirements fulfillment, responsiveness in effecting those repairs, and all requirements on the maintenance provider while performing the repairs.	M	Contract requirement	n/a							
9.2	The vendor shall provide all updates to the software and software environment necessary to preserve the fulfillment of requirements for the entire duration of the contract. Preservation of requirements fulfillment especially includes all IT management requirements as previously identified.	M	Contract requirement	n/a							
9.3	The vendor shall warrant the system to be free of defects in materials and workmanship for the entire duration of the contract. *Warranty* is defined as correcting defects in materials and workmanship (subject to other language included in the purchase documents). *Defect* is defined as any circumstance in which the material does not perform according to its specification.	M	Contract requirement	n/a							
9.4	The vendor shall provide "bug" fixes and security patches for the duration of the contract.	M	Contract requirement	n/a							
9.5	The vendor shall provide a warranty for any vendor-furnished hardware components for the duration of the contract.	M	Contract requirement	n/a							
9.6	The vendor shall provide software updates, including new features for the duration of the contract.	M	Contract requirement	n/a							

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Appendix B – Draft Memorandum of Understanding

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Memorandum of Understanding (MOU) between the Santa Clara Valley Transportation Authority (VTA) and the [AGENCY] For Centralized Transit Signal Priority Program

This Memorandum of Understanding (MOU) constitutes solely a guide to the intentions and policies of the parties involved. It is not intended to authorize funding or project effort, nor is it a legally binding contract. Funding commitments or specific work phases or project efforts should be covered by one or more separate cooperative agreements, if necessary.

RECITALS

A. AGENCY and VTA, in cooperation with other local and regional agencies, desire to implement a centralized Transit Signal Priority (TSP) system throughout the Santa Clara County.
B. VTA represents that it has federal funds committed and available for the implementation of a countywide centralized TSP system.
C. VTA represents that it's ready and able to provide the staff time required to implement the system.
D. VTA represents that will implement the countywide centralized TSP system unless otherwise noted.
E. This MOU is a compilation of the policies and procedures intended to be followed by the above-named parties working in a coordinated manner to accomplish a mutual goal jointly established while performing their statutory and functional duties.
F. TSP has been recognized as a cost-effective strategy to enhance transit network operations and overall mobility in Santa Clara County.

Both parties have agreed to implement a countywide centralized TSP system, as detailed below:

CLAUSES

A. To ensure consistent and predictable travel times while minimizing overall delays for transit vehicles through the management of traffic signal controllers at intersections.

1.0 Roles and Responsibilities

1.1 VTA is the Transit Agency and is responsible for ensuring the successful integration of TSP into transit operations.

1.2 VTA shall also provide necessary data to support the implementation and the optimization of TSP, including but not limited to bus schedule, vehicle location data, and route information.

1.3 VTA shall operate and maintain onboard equipment to ensure proper communication between transit vehicles and traffic signal controllers. This includes Automatic Vehicle Location (AVL) systems, onboard TSP request transmitters, and any related hardware.

1.4 VTA shall establish key performance metrics (e.g., reduction in transit delay, impacts on cross-street traffic) and regularly evaluate system effectiveness

1.5 VTA shall monitor and evaluate TSP performance by collecting operational data, tracking transit delay reductions, and coordinating with the AGENCY to optimize system performance.

1.6 AGENCY is the Traffic Management Agency responsible for the configuration, operation, and maintenance of traffic signals to support the centralized TSP system.

1.7 AGENCY shall implement signal timing adjustments and configuration to ensure TSP strategies are applied effectively while balancing overall traffic flow.

1.8 AGENCY shall maintain and operate traffic signal controllers and related roadside equipment, ensuring they are properly calibrated and functioning as intended.

1.9 AGENCY shall ensure coordination with other traffic management systems, including emergency vehicle preemption, and connected vehicles technologies, to prevent conflicts and improve operation efficiency.

2.0 Operating Principles for [Agency] and VTA

2.1 Ensure that TSP reduces transit delays at signalized intersections and improve transit vehicle schedule adherence without causing disruption to traffic.

2.2 TSP strategies will be used to provide priority to transit vehicles are:

- Green Extension – Extending the green light duration.
- Red Truncation – Shortening red light phase duration.

2.3 Ensure the TSP system prioritizes transit vehicle requests in the following order:

1. Light Rail Trains
2. Rapid Routes
3. Frequent Routes
4. Local Routes (*To be determined if TSP will be applied to Local Routes, check in planners)*

2.4 Ensure TSP operation should be coordinated with traffic signal timing plans and minimize adverse impacts on cross street traffic, nearby intersections, and overall corridor performance.

2.5 Ensure transit vehicles communicate with traffic signal controllers using *(Whatever technologies the SEMP provides).*

2.6 Ensure communication between transit vehicles and signal controllers have low latency and are reliable to ensure timely response to priority requests.

2.7 Ensure that signal timing modifications maintain pedestrian safety, preserve Leading Pedestrian Intervals (LPI), and do not disrupt bicyclist signal phasing.

2.8 Ensure TSP systems are equipped with override capabilities for emergency signal preemption, special events, and instances of excessive congestion.

2.9 Ensure VTA has dedicated TSP technicians available to diagnose and resolve system issues efficiently.

3.0 Future Implementation

3.1 Potential bus routes for TSP implementation may be identified in VTA's Transportation Technology Strategic Plan (TTSP). The TTSP serves as a regional framework, providing strategic recommendations for advancing mobility solutions throughout Santa Clara County.

4.0 Capital Improvements

7.1 AGENCY and VTA will evaluate the centralized TSP system using performance metrics established by VTA. If TSP is found to be insufficient in addressing transit delays, both parties will collaborate to identify and implement necessary capital improvements.

5.0 Monitoring and Maintenance

5.1 Meetings regarding TSP operations in Santa Clara County with the ITSWG shall be held as requested by ITSWG. At these meetings, VTA staff shall provide a status report on the operations of TSP system in Santa Clara County. The status report will include a list of operational issues that were reported by VTA and/or local agencies and how operational issues were resolved.

5.2 A review of the program will be provided to the VTA Board of Directors by VTA staff if requested by the VTA TAC or VTA Board of Directors.

5.3 VTA will conduct "before" and "after" monitoring to evaluate the impacts of TSP operations on local roadways at selected intersections and corridors. This assessment will be performed at no additional cost to local agencies. The ITSWG will determine the monitoring scope, including the level of effort and specific locations for evaluation.

5.4 The ITSWG will continuously review monitoring data and recommend solutions for issues related to TSP operations, as identified by the cities and towns of the County, the County of Santa Clara, Caltrans, and VTA.

5.5 VTA, through the ITSWG, will develop performance measures consistent with the above goal and principles (see sections 1.0 and 2.0) to assess the effectiveness of TSP.

5.6 VTA, through the ITSWG, will define a monitoring plan to periodically measure and calculate performance measures travel time reduction, delay at intersection, schedule adherence, dwell time at intersection, cross street delay, and cycle failure rate.

5.7 VTA, through the ITSWG, will work together to fine-tune TSP operation and monitor the system.

_______________________________ 	_______________________________

Carolyn M. Gonot, General Manager/CEO
Santa Clara Valley Transportation Authority

AGENCY PERSONNEL
AGENCY

____

Date

____

Date

Approval as to form:

____

Judith Propp, VTA Counsel
Santa Clara Valley Transportation Authority

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Appendix C – Proof of Concept Route 57 Report

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Proof-of-Concept – Route 57 Centralize TSP System

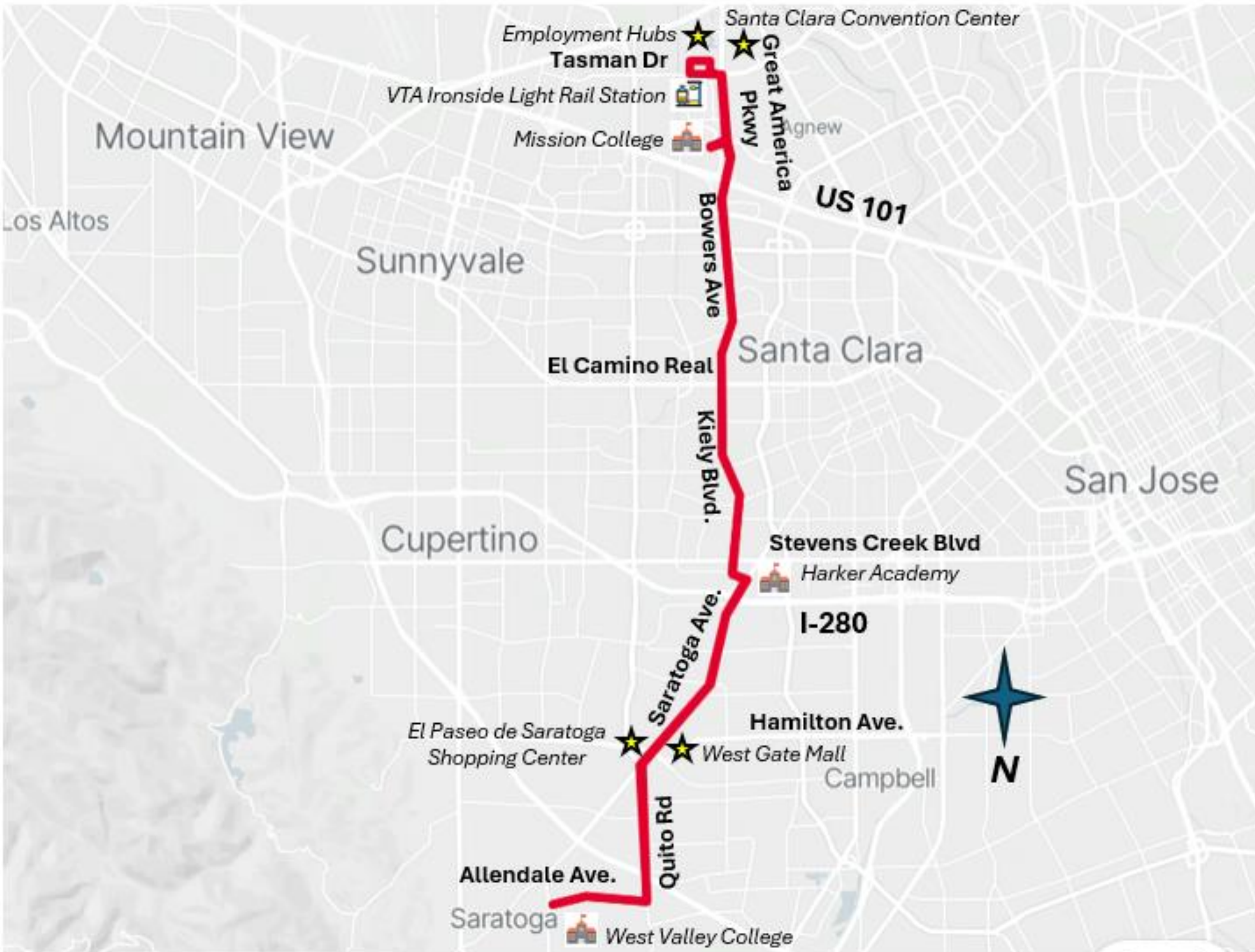
1.0 Introduction

Two local agencies in Santa Clara County, the City of San Jose and the City of Santa Clara, have taken the initiative to implement centralized transit signal priority (TSP) systems along Santa Clara Valley Transportation Authority's (VTA) Route 57. Ahead of the countywide deployment planned under the VTA's Transit Reliability Improvement and Performance System (TRIPS) project. Although TRIPS was in the development phase at the time of this proof-of-concept, specifically working on the System Engineering Management Plan (SEMP), the systems deployed by these two cities align with the TRIPS Concept of Operations (ConOPS). The TRIPS ConOPS outlines various TSP system architectures, including distributed and centralized approaches, each with its own technical and operational implications. These early deployments, made through separate procurements from two solution providers, present a valuable opportunity to evaluate system capabilities, identify operational strengths and weaknesses, and gather insights that will help inform the final design and implementation of the TRIPS project.

2.0 Route 57 Existing Conditions

To better understand the context and impact of the early TSP deployments, it is important to examine the characteristics of the corridor served by VTA's Route 57. Spanning multiple jurisdictions, Route 57 traverses both the City of Santa Clara, from Bunker Hill Lane and Great America Parkway to Kiely Boulevard and Stevens Creek Boulevard, and the City of San Jose, continuing westward to Quito Road and Westmont Avenue as shown in Figure 1.

Figure 1 – Route 57 Map with Points of Interest



Route 57 originates at the Ironsides Light Rail Station and travels west along Tasman Drive, a six-lane arterial. It loops through Patrick Henry Drive and Old Ironsides Drive before continuing west on Tasman and then turning south onto Great America Parkway, a major six-lane thoroughfare. As the route progresses, Great America Parkway transitions into Bowers Avenue and then Kiely Boulevard, both four-lane arterials that form a vital north-south spine through the City of Santa Clara. At Kiely Boulevard and Saratoga Avenue, the bus turns west, traveling along Saratoga Avenue—which starts with three lanes in each direction and narrows to two lanes beyond Payne Avenue—before continuing south on Quito Road, a two-lane roadway that leads to the West Valley College Transit Center. Route 57 operates on 15-minute headways throughout the day, supporting consistent service for a broad ridership base.

The corridor served by Route 57 is notable for its diversity of land uses and high-demand destinations, including:

- Educational institutions: Mission College, West Valley College, and Harker School.
- Employment hubs: Major employers such as GoDaddy, Silicon Valley Bank Financial Group, Coherent, Aisera, Abbott Diagnostics, and Applied Materials.
- Commercial centers: El Paseo de Saratoga and Westgate Mall.
- Regional attractions: Santa Clara Convention Center, which attracts more than 350,000 visitors annually.
- Recreational areas: Central Park in Santa Clara, a 52-acre city park.

Along the corridor, there are 42 signalized intersections under the control of five different agencies as shown in Table 1.

Table 1 – Number of Traffic Signals Per Agency on Route 57

Agencies	Number of Intersections
City of Santa Clara	23
City of San Jose	15
Santa Clara County	2
Caltrans	1
City of Saratoga	1
Total	**42**

To manage traffic volumes and improve transit performance along this heavily traveled corridor, both the City of San Jose and the City of Santa Clara have implemented centralized TSP systems tailored to their respective operations. While both agencies followed the centralized architecture outlined in the TRIPS Concept of Operations, they procured solutions from different vendors. San Jose selected LYT's cloud-based TSP platform, while Santa Clara deployed Kimley-Horn Associates' (KHA) Traction Priority system. Despite these differences, both systems utilize standardized communication protocols—specifically, the National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP) for signal interface and the Google Transit Feed Specification (GTFS) for accessing real-time vehicle location data from VTA buses.

It's important to note intersections within the City of San José's jurisdiction are coordinated, whereas those within the City of Santa Clara are not. This coordination is essential for managing traffic flow, particularly along San José's corridors, which experience high traffic volumes.

Traffic conditions along Route 57 vary based on segment characteristics. Great America Parkway maintains a posted speed limit of 45 mph, which drops to 40 mph along Bowers Avenue and further to 35 mph as the corridor transitions into Kiely Boulevard. Saratoga Avenue increases again to 40 mph. While Great America Parkway, Bowers Avenue, and Kiely Boulevard generally experience smoother traffic flow, Saratoga Avenue is known for heavier congestion, particularly during peak travel times.

With an average weekday ridership of 1,786 and approximately 832 riders on weekends, Route 57 ranks as the 15th most utilized route within VTA's fixed-route transit system. The combination of high ridership, jurisdictional complexity, and diverse operating conditions makes Route 57 a valuable case study for evaluating the functionality, interoperability, and scalability of early TSP deployments as part of the broader TRIPS program.

3.0 Data Collection Methodology

To support a comprehensive evaluation of the centralized TSP systems deployed along Route 57, data were sourced from two distinct implementations, Santa Clara's Kimley-Horn Traction Priority system and San José's LYT cloud-based platform. Although the systems differ in architecture and vendor-specific features, both jurisdictions leverage a common data source: the traffic signal controller cabinets in conjunction with the CAD-AVL system on the vehicles. This shared foundation ensures consistency in the data used for performance analysis, despite operational and infrastructural differences.

To compare and assess the TSP impact, data was collected during two key periods: April 2024 (pre-implementation) and April 2025 (post-implementation). This one-year interval enables a clear before-and-after comparison, allowing for the assessment of system impacts on transit performance and traffic operations over time. It's important to note that all VTA bus and light rail services were suspended from March 10 to March 24, 2025, due to a strike organized by Amalgamated Transit Union (ATU) Local 265 and did not impact the data that was collected.

To capture the full scope of system effectiveness, the analysis incorporates multiple layers: an end-to-end evaluation of the entire Route 57 corridor (run time and dwell time), disaggregation by agency jurisdiction to reflect operational nuances, and segmentation by time-of-day, specifically AM peak, midday, PM peak, and evening period. This approach ensures a robust understanding of how each CTSP system performs under varying conditions and across different segments of the corridor.

4.0 Analysis

An evaluation of transit performance data from April 2024 and April 2025 reveals mixed outcomes in terms of run time and dwell time across the Route 57 corridor, offering insight into the early impacts of the TSP systems.

Northbound service experienced a slight increase in total run time, rising from 38.76 minutes in 2024 to 39.09 minutes in 2025. This change is primarily driven by an increase in dwell time, from 10.35 to 11.26 minutes, particularly within the San José and Santa Clara segments. While San José showed a modest improvement in run time (from 14.16 to 13.64 minutes), this gain was offset by a 0.48-minute increase in dwell time, suggesting that while TSP may be improving signal progression, boarding or operational delays may still affect overall performance.

Southbound service showed a more favorable trend. Although total run time increased slightly (from 34.35 to 34.98 minutes), this was partially offset by a reduction in dwell time, which dropped from 11.40 to 10.90 minutes. Notably, Santa Clara's southbound segment saw a 0.51-minute decrease in dwell time.

However, Santa Clara experienced the largest increase in run time in both directions, suggesting that localized congestion, suboptimal signal timing, or other operational constraints may be limiting the effectiveness of TSP in this segment. A possible contributing factor is the lack of signal coordination at intersections within Santa Clara, which can hinder smooth traffic progression and reduce the overall benefits of priority treatments.

Overall, the data suggest that while TSP is beginning to yield operational improvements particularly in reducing run times in San José and dwell times in Santa Clara, its effectiveness is uneven across the corridor. These findings highlight the need for targeted refinements, such as optimizing signal timing at key intersections and addressing boarding delays, to fully realize the potential of TSP in enhancing transit reliability and efficiency along Route 57. In addition, a single TSP provider might be able to improve operations along the entire route more evenly as opposed to multiple providers.

5.0 Lessons Learned

The Route 57 CTSP prototype has provided VTA with valuable insights into the conditions under which TSP delivers the greatest operational benefits. One of the key takeaways from this pilot is that TSP is significantly more effective in corridors where traffic signals are coordinated. In San José, where signal coordination is in place, the system demonstrated modest improvements in run time, suggesting that TSP can enhance transit flow when integrated with a synchronized signal network. In contrast, Santa Clara, where signals are not coordinated, saw increased run times despite TSP deployment, highlighting the limitations of implementing TSP in isolation. These findings underscore the importance of signal coordination as a foundational element for successful TSP performance. As a result, VTA is now better positioned to identify and prioritize future TSP deployments along corridors with existing signal coordination infrastructure, ensuring more consistent and impactful improvements in transit reliability and efficiency.

6.0 Conclusions

The performance analysis of Route 57 highlights several key findings such as operational benefits from TSP measures. While overall run times remained relatively stable, a slight increase in northbound travel time was primarily due to longer dwell times in the San Jose and Santa Clara segments. While the southbound service shows a decrease in dwell time. Segment-level analysis consistently identified Santa Clara as a source of delay in both directions, while timepoint data pointed to increasing dwell durations at major northbound stops, likely tied to boarding activity or operational constraints.

These findings support the conclusion that TSP implementation does yield measurable benefits, particularly in improving overall travel time. To build on this progress, targeted operational assessments should be conducted at high-delay locations to identify specific causes of increased dwell and run times. Based on these insights, further enhancements to TSP, such as refining detection zones and integrating adaptive signal logic, should be piloted. Continuous monitoring and data collection will be essential to evaluate the effectiveness of these improvements and guide broader, system-wide optimization of TSP strategies.

Santa Clara Valley Transportation Authority

Appendix – Data

Route 57 Northbound

	Run Time								Dwell Time							
	AM Peak		Midday		PM Peak		PM Late		AM Peak		Midday		PM Peak		PM Late	
Intersection	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**
SARATOGA + QUITO	0.57	0.62	0.67	0.68	0.71	0.70	0.66	0.63	0.15	0.12	0.19	0.24	0.42	0.24	0.20	0.13
SARATOGA + CAMPBELL	1.04	0.99	1.34	1.29	1.53	1.52	1.35	1.10	0.52	0.61	0.57	0.80	0.95	0.79	0.60	0.67
SARATOGA + GRAVES	0.56	0.47	0.77	0.74	0.89	0.89	0.80	0.70	0.12	0.15	0.23	0.26	0.46	0.33	0.31	0.27
SARATOGA + LATIMER	0.58	0.63	0.59	0.62	0.62	0.64	0.62	0.62	0.11	0.10	0.12	0.20	0.24	0.12	0.13	0.08
SARATOGA + PAYNE	0.50	0.54	0.53	0.59	0.74	0.75	0.68	0.63	0.25	0.18	0.24	0.36	0.50	0.40	0.50	0.28
SARATOGA + MITZI	0.87	0.76	0.80	0.87	1.55	1.39	1.12	1.13	0.28	0.29	0.20	0.32	0.40	0.31	0.16	0.21
SARATOGA + WILLIAMS	1.03	1.15	1.13	1.26	1.20	1.51	1.01	1.12	0.43	0.55	0.51	0.78	0.61	0.48	0.59	0.40
SARATOGA + MANZANITA	0.33	0.36	0.32	0.36	0.35	0.37	0.32	0.37	0.17	0.27	0.17	0.28	0.32	0.25	0.16	0.26
SARATOGA + BLACKFORD	0.90	0.81	1.11	0.96	0.96	1.03	0.76	0.68	0.43	0.31	0.38	0.38	0.43	0.37	0.59	0.28
KIELY + SARATOGA	2.28	2.12	2.10	2.05	2.27	2.08	2.26	1.97	0.24	0.25	0.32	0.40	0.50	0.32	0.56	0.28
KIELY + STEVENS CREEK	1.46	1.30	1.67	1.40	1.74	1.51	1.47	1.26	0.79	1.38	0.71	1.33	1.05	1.07	0.59	0.85
Total	**10.11**	**9.74**	**11.03**	**10.82**	**12.57**	**12.38**	**11.06**	**10.21**	**3.49**	**4.22**	**3.64**	**5.36**	**5.89**	**4.68**	**4.38**	**3.70**

	AM Peak	Midday	PM Peak	PM Late	Total
Run Time Change:	-0.37	-0.21	-0.19	-0.85	-0.55
Dwell Time Change:	0.73	1.71	-1.21	-0.68	0.29
Timepoint Dwell Change:	0.80	1.12	-0.28	0.13	0.57

Route 57 Southbound

	Run Time								Dwell Time							
	AM Peak		Midday		PM Peak		PM Late		AM Peak		Midday		PM Peak		PM Late	
Intersection	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**	**2024**	**2025**
KIELY + STEVENS CREEK	1.41	1.22	1.37	1.28	1.56	1.40	1.18	1.06	1.03	1.26	0.79	1.07	1.10	1.00	0.75	0.76
SARATOGA + KIELY	1.27	1.36	1.36	1.30	1.51	1.55	1.17	1.07	0.41	0.48	0.36	0.50	0.50	0.38	0.27	0.27
SARATOGA + MOORPARK	1.60	1.43	1.50	1.52	1.96	1.75	1.48	1.39	0.31	0.31	0.35	0.39	0.56	0.46	0.22	0.23
SARATOGA + MANZANITA	0.59	0.62	0.66	0.70	0.65	0.62	0.61	0.62	0.14	0.20	0.13	0.26	0.55	0.30	0.14	0.18
SARATOGA + WILLIAMS	0.96	0.90	0.98	0.93	1.05	1.03	0.86	0.91	1.08	0.85	0.89	1.06	1.18	0.82	0.42	0.48
SARATOGA + VENICE	0.41	0.41	0.39	0.42	0.46	0.46	0.43	0.49	0.17	0.17	0.18	0.28	0.63	0.38	0.18	0.27
SARATOGA + PAYNE	0.79	0.75	0.71	0.78	1.04	1.01	0.86	0.75	0.22	0.29	0.30	0.38	0.43	0.44	0.22	0.22
SARATOGA + LATIMER	0.43	0.43	0.44	0.44	0.46	0.46	0.45	0.47	0.09	0.10	0.13	0.25	0.33	0.24	0.09	0.09
SARATOGA + ATHERTON	0.51	0.48	0.48	0.48	0.53	0.49	0.49	0.48	0.09	0.07	0.10	0.20	0.29	0.20	0.08	0.08
SARATOGA + GRAVES	0.43	0.46	0.55	0.62	0.57	0.60	0.58	0.54	0.19	0.17	0.31	0.43	0.44	0.22	0.31	0.17
SARATOGA + PROSPECT	0.32	0.32	0.32	0.32	0.35	0.32	0.31	0.29	1.11	1.05	1.22	1.47	1.12	1.12	0.57	0.81
QUITO + SARATOGA	2.26	2.16	2.08	1.99	2.64	2.55	2.18	1.82	0.11	0.09	0.16	0.18	0.31	0.12	0.15	0.11
Total	**8.72**	**8.39**	**8.77**	**8.78**	**10.14**	**9.69**	**8.41**	**8.07**	**4.85**	**4.96**	**4.76**	**6.30**	**7.12**	**5.56**	**3.24**	**3.55**

	AM Peak	Midday	PM Peak	PM Late	Total
Run Time Change:	-0.34	0.01	-0.45	-0.33	-0.32
Dwell Time Change:	0.10	1.54	-1.56	0.31	0.16
Timepoint Dwell Change:	-0.06	0.70	-0.46	0.32	0.18

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Appendix D – Public Engagement Report

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VTA Speed & Reliability Program: Transit Reliability and Improvement Performance System (TRIPS) Engagement Report

Valley Transportation Authority

VISIONARY NETWORK
Speed & Reliability

Table of Contents

Executive Summary

The VTA Speed & Reliability Program, part of the Visionary Network, aims to improve bus and light rail travel times and service reliability across Santa Clara County. Between November 2024 and January 2025, the outreach team engaged key community stakeholders. This multi-format outreach effort included focus groups, community event pop-up booths, and community-based partnerships that helped to gather input on improving speed and reliability to inform the TRIPS project and other transit improvement efforts.

The outreach team held events virtually and in person to accommodate a wide range of community needs and preferences, and to ensure representation from VTA riders in areas where in-person engagement was not planned. The team also convened a Community-Based Organization Working Group (CBOWG), which brought together representatives from community organizations across VTA's service area. These representatives met three times to offer their expertise and strengthen outreach planning. **Engagement concluded with over 1,200 community interactions across 36 outreach opportunities** providing valuable insights into service challenges and potential solutions.

Figure 1 Community member with VTA foldable bus at Morgan Hill Sidewalk Saturdays event on November 11, 2024.

Findings revealed strong public support for TSP but also highlighted concerns about where TSP would be implemented, particularly in East San José and South County.

Outreach Approach

The VTA Speed & Reliability outreach team (the outreach team) planned and executed community discussions focused on speed and reliability issues and concerns that could help inform decisions about

Transit Signal Priority (TSP) such as policy needs, business rule development, priorities among routes, and priorities for implementing TSP. This report notes and analyzes feedback.

To strengthen engagement, the team created the Community-Based Organization Working Group (CBOWG), which provided direct advice on reducing barriers to participation to ensure access for all. The CBOWG met three times for TRIPS. The outreach team also partnered with CBOWG members to host three focus groups tailored to the community.

Content Development

The outreach team developed a variety of printed and digital materials, including written and graphic content they designed to help community members clearly understand the goals for TSP and speeding up transit. The following is a partial list of materials the team produced:

- **Pop-up tabling boards:** Included basic information about the project, guiding questions, visual aids, and a Frequent Network map to orient participants around the various lines and services VTA operates.
- **Screen reader-friendly slide decks:** Developed to ensure all participants could fully participate in outreach discussions.
- **Comments/contact cards:** For interested community members keen to share their contact information with staff for future updates and discussions.
- **Flyers:** Handouts to share information about the project when outreach staff could not communicate directly with community members due to time constraints or other barriers.
- **Project website:** A microsite about the project with information including project goals, planning updates, and up-to-date information on upcoming in-person and virtual engagement.

Simplicity

TSP and speeding up transit, in general, can be difficult concepts to understand. The outreach team developed all public-facing project materials to ensure they could be easily understood by community members. Project materials and facilitation avoided acronyms and technical jargon that could intimidate participants. During in-person events and focus groups, facilitators ensured that their facilitation was clear, simple, and concise.

Multi-Format Availability

The outreach team standardized all public-facing content, whether virtual or physical, to ensure that all community members received the same project information. Whether through a pop-up poster board, slide deck, or informational handout, staff ensured participants had a consistent experience, accommodating differences in technology access and skill levels among community members.

Time of Day

The outreach team scheduled activities on weekday evenings and weekend mornings to better engage working riders. Staff also hosted pop-ups at major transit hubs and destinations during both morning and evening peak commute hours and staffed community event tables at night markets, morning farmers markets, and all-day festivals to reach a broader range of riders.

Figure 2. Pop-Up at Sunnyvale Farmers Market on November 16, 2024.

Outreach Logistics

To optimize for a higher number of interactions with target audiences, the outreach team identified a diverse selection of relevant events and locations where community members already convened.

Areas with Key Routes

The outreach team prioritized outreach efforts in communities located along key bus routes. Following is a list of events illustrating how outreach was planned and carried out with location and routing in mind:

- Alviso Community Meeting – January 8, 2025, Virtual: *Focused on Routes 59 (connects to light rail), 66 (Frequent Network)*
- Gilroy Community Meeting – January 10, 2025, Gilroy: *Near Routes 68 (Frequent Network), 84 (local coverage)*
- Student Focus Group – January 13, 2025, Virtual (Countywide impact on college students): *Focused on Routes 22, 522 (Frequent Network), 68 (South County link)*
- East San José Focus Group – January 14, 2025, Virtual: *Focused on Routes 22, 522 (El Camino Real), 23, 25, 70, 71, 77 (Frequent Network)*
- Nueva Vida Focus Group– January 14, 2025, South County (Gilroy & Morgan Hill): *Near Routes 68 (Frequent Network), 84*

- Commuter Focus Group – January 15, 2025, Virtual (Countywide impact on daily transit users): *Near Routes 22, 522, 68 (Frequent Network)*
- VIVO Focus Group– January 15, 2025, Vietnamese American Cultural Center, San José: *Near Routes 25, 72, 73 (Frequent Network)*
- Berryessa Transit Center Outreach – January 19, 2025, San José: *Near Routes 61, 70 (Frequent Network), Berryessa BART connections*
- Palo Alto Transit Center Outreach – January 22, 2025, Palo Alto: *Near Routes 22, 522 (Frequent Network), Caltrain connections*
- SASCC Focus Group– January 22, 2025, Saratoga: *Near Routes 55, 59, 22 (Frequent Network)*
- Day Worker Center Community Presentation – January 27, 2025, Mountain View: *Near Routes 22, 522, 40 (Frequent Network)*
- Ortega Park Community Presentation – January 30, 2025, Sunnyvale: *Near Routes 53, 55, 523 (Frequent Network)*

Familiar Places

Outreach was carried out in familiar neighborhood spaces where people felt comfortable and at ease. Examples of such places included local libraries and community centers, CBO office spaces, neighborhood parks, educational institutions, churches, local transit centers. Following is a list of events carried out in familiar spaces to optimize community comfort and participation.

- Gilroy Community Meeting Presentation on January 10, 2025: Took place at a local library, ensuring an accessible, indoor environment in a well-known community hub that serves transit riders, families, and working residents.
- VIVO Focus Group on January 15, 2025: Was conducted at the Vietnamese American Cultural Center in San José.
- Berryessa Transit Center Pop-Up on January 19, 2025: Held at the connection point between the Berryessa BART station, a major transit hub, and the San José Flea Market. This allowed the outreach team to engage riders in a high-traffic location where outreach was immediately relevant to their daily transit use.
- Palo Alto Transit Center Pop-Up on January 22, 2025: Took place at a major hub, strategically selected to connect with riders transferring between VTA and Caltrain, ensuring outreach reached both local and regional commuters.
- Day Worker Center Community Presentation on January 27, 2025: Held at Day Worker Center office space, a trusted organization serving low-income and transit-dependent workers, ensuring familiarity and accessibility for participants.

- **Ortega Park Community Presentation on January 30, 2025**: Conducted at facilities within a popular neighborhood park.

Community Celebrations

The outreach team carried out targeted outreach at events a community celebrations in areas where speed and reliability outcomes would benefit the people at the gatherings. The outreach team attended the following events:

- **Downtown Gilroy Holiday Festival & Parade – December 7, 2024, Gilroy**: Reached local families and residents attending seasonal celebrations.
- **Winter Wonderland Downtown San José – December 8, 2024, Downtown San José**: Engaged transit riders during a major holiday-themed event in a high-traffic pedestrian area.
- **Fiesta Navideña – December 14, 2024, San José**: Reached local families and engaged residents in discussions about transit improvements.
- **Lunar New Year – January 25-26, 2025, San José**: Reached local families and engaged residents in discussions about transit improvements.

Figure 3. Pop-up booth located to the left of the stage at San José Lunar New Year event on December 25, 2024.

Virtual Outreach

The outreach team organized a series of targeted virtual focus groups to reach community members who could not attend in-person events. The outreach team offered virtual participation options to make it easier for those with limited time or transportation access to share their input. Using Zoom, participants interacted directly with each other and with outreach team facilitators through conversations and interactive activities.

Target Audiences

The outreach team designed outreach efforts to engage a broad cross-section of the County's population and VTA bus riders in various contexts. Prioritizing these audiences ensured those most impacted by transit speed and reliability challenges had the opportunity to share their experiences and contribute to the development of targeted improvements.

Figure 4. Pop-up at Fiesta Navideña on December 14, 2024.

Residents and Workers in Strategically Significant Areas (SSAs)

This target audience category includes workers and residents of Santa Clara County economic activity centers such as Downtown San José and Silicon Valley North spanning Sunnyvale through Palo Alto. The project prioritized engagement with workers in and around areas such as East Side San José and South Santa Clara County, because VTA ridership is high.

Setting up booths at several key transit centers allowed staff to connect with commuters traveling to and from Strategically Significant Areas (SSAs). These transit hubs are important to commuters due to their multimodal connections and proximity to economic and activity centers. Given this dynamic, staff engaged with riders at Diridon Station, Berryessa BART Station in San José, and the Palo Alto Transit Center in North Santa Clara County, where many commuters transfer between VTA buses, Caltrain trains, and SamTrans buses heading north.

Staff hosted a booth at a key stop next to San José City Hall, the busiest bus stop in VTA's entire network, to engage riders of varied backgrounds commuting from Downtown San José to points east and south at the end of their day.

High School and College Students

VTA recognizes the importance of transit for students, with one of the proposed service enhancements in the Visionary Transit Network being "Additional School Service Routes offering trips to/from schools, coordinated with morning and afternoon bell schedules." The outreach team prioritized students as a key target audience throughout outreach efforts, including through a student-centered focus group and an on-campus pop-up at De Anza College.

Outreach Performance

The team engaged over 1,000 unique community members through 36 outreach events to ensure that direct rider feedback informs transit improvements. The geographic distribution of responses aligns with areas with the most transit dependency:

- San José (including East San José): **52%**
- South County (Gilroy & Morgan Hill): **18%**
- Silicon Valley North (Sunnyvale, Cupertino & Palo Alto): **21%**
- Other locations: **9%**

Outreach Formats

The extensive, participatory, community outreach effort ensured that key stakeholders had the opportunity to provide input on their experiences with bus speed and reliability.

The **36 engagement events** included:

- **10 Focus Groups** These sessions offered in-depth discussions on improving transit speed and reliability with TSP, providing a space for structured, solution-focused dialogue. Focus groups provided more structured discussions, gathering detailed feedback from 75 participants
- **14 Pop-Up Events** held at high-traffic locations such as transit centers, farmers' markets, and community spaces to engage a broad range of riders, including regular transit users, first-time riders, and residents exploring alternative transit options. These events offered concise, overview-style engagement opportunities, allowing passersby to learn about speeding up transit, share quick feedback, and access materials. Pop-ups engaged the most participants, capturing quick feedback from **850+ transit riders** at high-traffic locations such as farmers' markets, transit hubs, and community centers.
- **7 Community Presentations** provided detailed briefings on transit speed and reliability, incorporating interactive elements like Q&A sessions and live polling to facilitate deeper

engagement with local organizations, advocacy groups, and city representatives. Community meeting presentations reached **315 participants** including residents, advocacy groups, and local stakeholders to discuss transit priorities in a more formal setting.

- **3 Working Group Meetings** convened trusted community organizations to shape outreach strategies.
- **2 "Ask VTA" Q&A Sessions** invited members of the public to ask questions on all aspects of TSP including planning, policy, and infrastructure directly to subject matter experts at VTA.

Map Survey

VTA collected feedback on a map-based survey advertised across social media channels. This survey solicited geographical specific data on intersections and routes affected by slow transit.

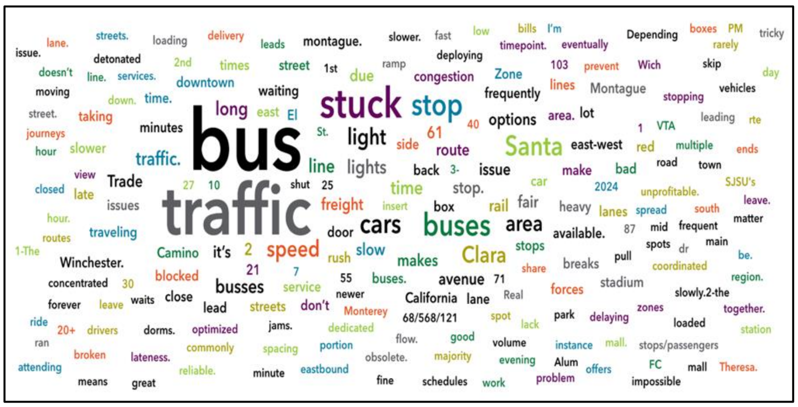

Figure 5. Word cloud of responses to the Map Survey question, "Please describe the speed issue you identified.

Summary of Outreach Activities (Page 1 of 2)

Event	Location	Event Type	Date
De Anza College	Cupertino	Pop-up	Thursday, 11/7/24
Morgan Hill Sidewalk Saturdays	Morgan Hill	Pop-up	Saturday, 11/9/24
San José City Hall	San José	Pop-up	Thursday, 11/14/24
Sunnyvale Farmers Market	Sunnyvale	Pop-up	Saturday, 11/16/24
La Placita Tropicana	San José	Pop-up	Friday, 12/6/24
Downtown Gilroy Holiday Festival	Gilroy	Pop-up	Saturday, 12/7/24
Winter Wonderland Night Market Gift Fair	San José	Pop-up	Sunday, 12/8/24
Mexican Heritage Holiday Event	San José	Pop-up	Saturday, 12/14/24
Diridon Station	San José	Pop-up	Thursday, 1/16/24
Berryessa BART Station (Flea Market)	San José	Pop-up	Sunday, 1/19/24
Palo Alto Transit Center	Palo Alto	Pop-up	Wednesday, 1/22/24
San José Lunar New Year	San José	Pop-up	Sat & Sun, 1/25-1/26/24
Sunnyvale Climate Change Summit	Sunnyvale	Pop-up	Saturday, 1/25/24

Vista Center for the Blind	Virtual	Focus Group	Monday, 12/9/24
Transit Advocates	Virtual	Focus Group	Monday, 12/16/24
Caregivers	Virtual	Focus Group	Monday, 1/13/25
Students	Virtual	Focus Group	Monday, 1/13/25
East Side San José Residents	Virtual	Focus Group	Tuesday, 1/14/25
Nueva Vida	Virtual	Focus Group	Tuesday, 1/14/25
Commuters	Virtual	Focus Group	Wednesday, 1/15/25
VIVO	San José	Focus Group	Wednesday, 1/15/25
SASCC	Virtual	Focus Group	Wednesday, 1/22/25
Resilience & Pre-disaster Mitigation	Virtual	Focus Group	Thursday, 1/30/25
South County Youth Task Force	Gilroy	Community Presentation	Tuesday, 11/19/24
Alviso Neighborhood Group	Virtual	Community Presentation	Wednesday, 1/8/25
Gilroy Friday Night Community Meeting	Gilroy	Community Presentation	Friday, 1/10/25
South County Youth Task Force	Gilroy	Community Presentation	Wednesday, 1/22/25
Day Worker's Center	Mountain View	Community Presentation	Monday, 1/27/25
Palo Alto Transportation & Planning Commission	Palo Alto	Community Presentation	Wednesday, 1/29/25
Ortega Park Neighborhood Association	Sunnyvale	Community Presentation	Thursday, 1/30/25
CBOWG Meeting #1	Virtual	CBOWG	Thursday, 11/14/24
CBOWG Meeting #2	Virtual	CBOWG	Tuesday, 12/10/24
CBOWG Meeting #3	Virtual	CBOWG	Tuesday, 1/28/25
Ask VTA #1	Virtual	Ask VTA	Thursday, 10/26/23
Ask VTA #2	Virtual	Ask VTA	Tuesday, 1/21/25

Summary of Findings

Community members voiced strong support for improving bus speed and reliability and identified TSP as a key strategy to reduce delays at intersections. Many described TSP as a necessary investment to make public transit more competitive with driving. Community members also urged VTA to ensure these improvements benefit as many routes as possible. In addition, community members emphasized TSP must be paired with more frequent service, better stop accessibility, and real-time communication tools to deliver meaningful improvements.

Many in the community emphasized the need for stronger public education, ways to stay informed about transit service changes, and frustration with unreliable service. They called on VTA to improve communication around delays, upgrade bus stop infrastructure, and implement stronger safety measures. Overall, community members urged VTA to invest in faster, more reliable, and more accessible transit, with a clear focus on benefiting the riders who depend on the system most.

Community Reactions to TSP

During outreach, community members shared a wide range of reactions to Transit Signal Priority (TSP). Many voiced strong support for the TRIPS project, citing its potential to improve bus speed and reliability. Others raised concerns about how VTA would implement TSP and whether it might negatively affect personal vehicle traffic.

General Support for TSP

Community members who spoke with VTA staff widely supported TSP as a practical solution to reduce delays and keep buses running on schedule. Many expressed excitement when they learned how TSP prioritizes buses at intersections, noting that they hadn't realized transit could benefit from this kind of technology. Once they understood how TSP works, they voiced optimism about its potential to make transit more competitive with driving by helping buses move more efficiently through congested corridors.

Riders consistently described how signal delays and traffic congestion prevent them from arriving on time at work, school, or appointments. They emphasized that reliable, on-time service would not only improve their daily experience but could also attract more people to public transit and reduce car use. As one rider said, "If the buses are running on time and getting through lights quicker, I'd actually consider leaving my car at home."

Overall, this feedback showed strong enthusiasm for TSP's potential to improve reliability, especially in high-traffic corridors where delays are common. At the same time, community members urged VTA to apply TSP strategically in areas with the most congestion to ensure it has the greatest possible impact.

Concerns About TSP Implementation

While many riders supported TSP to improve transit speed and reliability, they also raised thoughtful concerns about its limitations and potential unintended consequences. These concerns focused on whether TSP could meaningfully reduce transit delays, how it might affect other road users, and whether VTA would implement fairly across the region.

One of the most common concerns centered on TSP's effectiveness in heavily congested areas, especially during peak traffic hours. Participants pointed to backed-up corridors like Capitol Avenue near Capitol Expressway and questioned whether giving buses signal priority would make a difference when traffic is already at a standstill.

Riders also voiced concern about TSP's potential impact on drivers, pedestrians, and cyclists. Some worried that prioritizing buses at signals could increase wait times for cars, particularly on cross streets without TSP, and cause driver frustration. Others flagged safety risks for pedestrians and cyclists at busy intersections. One rider stressed the need to balance TSP's benefits with the safety of all road users, saying, "I worry about pedestrians not having enough time to cross if the buses are getting priority."

Figure 6. Pop-up at San José City Hall on November 14, 2024.

Several community members questioned whether VTA would concentrate improvements in high-profile areas like Downtown San José while neglecting smaller or underserved neighborhoods. South County residents in particular expressed frustration that their communities often receive fewer transit investments. Their feedback underscored the need to distribute TSP upgrades fairly across the county to close service gaps.

Key Corridors/Areas and Intersections Noted for TSP Need

Community members provided detailed feedback on where they feel TSP should be implemented to deliver the greatest impact, emphasizing specific corridors, intersections, and routes that experience delays and reliability challenges. These corridors are listed below in order of priority, based on the level of need expressed by community members and the frequency with which each corridor was mentioned during outreach efforts, as perceived by staff.

- El Camino Real (Routes 22 and 522) was repeatedly highlighted as a critical candidate for TSP implementation. Riders noted that buses on Routes 22 and 522 often experience significant delays at several major intersections along the corridor, particularly during peak hours.
    - Intersections with San Tomas Expressway in Santa Clara and Wolfe Road in Sunnyvale were noted as particularly slow intersections along Routes 22 and 522.

- East Side San José was most often highlighted as having very slow-moving routes often stuck at congested intersections for long periods of time with a community member noting they would be able to bike between stops faster than the bus could make it.
    - East Side San José intersections often cited for their congestion include Story Road and King Road, Alum Rock and Capitol Avenue, Capitol Avenue leading to Capitol Expressway, and other intersections along key corridors like White and Tully Roads.

- Stevens Creek Boulevard (Routes 23 and 523) was frequently identified as a key corridor for TSP for its connection to key economic centers like Santana Row and Westfield Valley Fair, De Anza College, and its consistent traffic congestion leading to very slow bus speeds.
    - Intersections with Winchester Boulevard, and San Tomas/Lawrence Expressways were often suggested as candidates for TSP implementation.

- Monterey Road (Routes 68 and 568) emerged as a priority corridor at all community conversations in South Santa Clara County. Community members mentioned rush hour delays at intersections in South San José, downtown Morgan Hill and downtown Gilroy.
    - Route 68 was often brought up as being slow on Santa Teresa Boulevard.

Riders frequently highlighted the difficulty of making connections between VTA buses, light rail, and regional transit systems like Caltrain, BART, and SamTrans.

- Missed connections were a common frustration, with participants citing poor schedule alignment between buses and trains as a reason they avoid public transit.
- Sunnyvale and Palo Alto Transit Centers were frequently mentioned as transfer points where riders struggle to connect between systems. Riders transferring between Route 523 and Caltrain at Sunnyvale or Routes 22/522 and Caltrain at Palo Alto often miss trains due to bus delays or inconsistent schedules.
- Commuters requested better real-time coordination between VTA and other agencies, suggesting improved trip planning apps, real-time updates at transit centers, and clearer signage for transfers.

Frustrations with Reliability and Real-Time Information

Many riders expressed frustration with inconsistent bus arrival times and unreliable real-time tracking.

- Community members frequently reported buses arriving early, late, or being canceled without warning, making trip planning difficult.

- Riders cited issues with transit apps like Google Maps and VTA's own real-time tracking, stating that arrival times often do not match reality.
- Several participants suggested improving communication during service disruptions, such as text alerts or digital signs at bus stops that display accurate arrival times

Community Outreach Considerations

Focus Group and Community Presentation Feedback

Eighty percent of focus group participants who completed the post-session evaluation survey reported to be "very satisfied" with the quality of the discussion. Some participants suggested improvements in organization and logistics. Specifically, a few wanted to receive the Zoom link earlier, while others recommended adding a Q&A section to make the experience more interactive. One participant proposed setting up a Slack or Discord chat to enhance engagement beyond the limited Zoom chat.

CBOWG Feedback

Many of the participants of the CBOWG remarked that the focus group meetings were very well organized, provided clear information and allowed room for good discussion. Members appreciated being compensated for their time and knowledge.

Digital Tools

The outreach team used a variety of Artificial Intelligence (AI) and software tools to analyze and synthesize the large volume of comments collected during community engagement activities. These tools included, but were not limited to:

- PLAUD: The outreach team used this device and AI tool to capture conversations during pop-up tabling events, especially during busy moments when manual notetaking was difficult. After each event, the project team used the AI software integrated with Plaud to generate concise conversation highlights and takeaways. Project staff who attended the events verified these summaries before incorporating them into the overall findings. For all focus groups and CBOWG meetings, the team requested participant consent prior to recording. At pop-ups, the team posted clear signage notifying participants that conversations were being recorded for project purposes.
- ChatGPT: The outreach team created an After Activity Report after each engagement event to summarize key highlights and themes from community input. They used ChatGPT to aggregate and synthesize these highlights across all reports, identifying overarching themes from the full

range of engagement activities. The team then reviewed and verified the summarized themes to ensure they accurately reflected community concerns and support for the project.

- **Respondent:** An online platform used to recruit participants within specific geographic areas for research. The outreach team used Respondent to identify riders with different purposes. However, the platform yielded limited success—many who signed up did not attend, ultimately reducing the effectiveness of this approach in reaching target audiences.
- **Zoom:** The outreach team used Zoom for all virtual focus group meetings, providing an accessible platform for participants who couldn't attend in person. By using Zoom, the team enabled participants to join from areas that would have otherwise been difficult to reach due to the geographic span of VTA's service area.

Appendix E – Centralized Transit Signal Priority Technical Deployment Evaluation

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VTA's TRIPS: Centralized Transit Signal Priority Technical Deployment Evaluation

Introduction

The evaluation of the proposed centralized TSP system deployment utilized a databased maintained by VTA for its planning and programming purposes called the Intelligent Transportation Systems (ITS) database. This ITS database contains information on the traffic signal controller type, traffic signal controller cabinet type, TSP functionality, and others. This first phase of the TRIPS project to develop a SEMP for the proposed countywide CTSP system updated the ITS database for its development of this plan and aide VTA to determine a potential deployment pathway for the countywide CTSP system.

Details of this database are not included in this implementation plan or its supporting documents as such as SEMP due to privacy and security concerns by the local agencies who maintain and operate these traffic signals on VTA's route. Table 1 is an overview summary inventory of the traffic signals on VTA's frequent and rapid transit routes without revealing specific information such as the traffic signal manufacturer and other details but focuses on the ability to provide TSP functionality and to utilize standardized communications protocols as shown in columns 9 through 17. The other column numbers in this table will be further expanded upon in the following sections.

General Transit Route Information

Table 1 in columns one through six are general information such as route number, a brief description of the route, vehicle type on route, if skip stop is utilized, and length of route.

Average Speed

Table 1 in columns seven through nine are average speeds for transit vehicle and regular vehicular traffic on public roadways and does not include roadways within transit centers. The reason for not including transit center roadway stems from the fact that regular vehicular traffic does not travel on these roadways. The source of the average speeds are as follows:

- VTA's Clever Computer Aided Dispatch/Automatic Vehicle Location System tracking VTA's transit vehicles in real-time. The reported travel times have dwell times at transit stops removed due to regular vehicular traffic do not have regular stop points like a transit vehicle.
- INRIX for the regular vehicular traffic speeds. INRIX is a "Big Data" source that leverages GPS probe data from mobile devices and other sources.

Both data sets were collected on October of 2024 during PM peak period (2:30 – 6:30 PM).

Current State of Traffic Signals

Table 1 in columns 10 through 15 provides information of the current state of the traffic signals on VTA's rapid and frequent routes. Information on the coverage mileage of TSP characteristics and others were determined utilizing Geographic Information System (GIS) tool such as ArcGIS. The TSP readiness determination is a combination of both the traffic signal to provide TSP service functionality (e.g. traffic signal timing treatments such as early green, green extension, etc.), and the ability to support communicating through standardized communication protocols. Those specific required standardized communications protocols for a CTSP system as described in the SEMP documentation are National Transportation Communication for Intelligent Transportation System Protocols (NTCIP) 1202 – Actuated Signal Control (ASC) and NTCIP 1211 – Objects Definition for Signal Control and Prioritization. Further details on the requirements for the CTSP system for the TRIPS effort are included in the SEMP.

Information about direct dedicated communications to the traffic signals on these routes is not included in this table, and it is not a unique distinguishing characteristic for each of VTA's transit routes. Most of Santa Clara County local agencies have made an investment to provide dedicated communication such as fiber optic cabling, ethernet over copper cabling, and radio to the traffic signals on these routes, excluding Cities of Morgan Hill and Gilroy in the southern part of the county.

Ranking of Transit Route and Traffic Signal Characteristics

Table 1 in columns 16 through 19 presents the ranking of the unique traffic signal and transit route characteristic that includes signal per mile, change in average transit speed compared to average vehicular speed, number of TSP ready traffic signals, and coverage corridor without TSP operations mileage. The specific ranking criteria for each are as follows:

- Traffic signal per miles was ranked based on the criterion with the highest number of signals per mile ranked highest as first and the lowest receiving the lowest (19th place). This corridor characteristic was included in the evaluation based on VTA's experience on previous deployment of TSP with TSP deployment working optimally with traffic signal coordination being in place. Specifically, to this ranking characteristic, corridors with higher density of traffic signals are more likely to have a need for traffic signal coordination to manage queues and delays. Corridors with a lesser density of traffic signals per mile are likely to have traffic signals spaced further apart being over a mile and are more likely to face challenges keeping cohesive platoons of traffic. Hence, the issue of not having cohesive platoons may not warrant implementing coordination and these corridors were rank lowest ranking.
- The change in average transit speed compared to average vehicular speed was included as route characteristic as a de-facto means to determine overall corridor delay to the transit mode by comparing it to the competing mode of travel (a regular vehicle). The highest

ranking was provided to the route with the highest differential and lowest ranking with lowest differential (19th place).

- The number of TSP ready traffic signal was ranked based on the criterion with the highest number of traffic signals receiving first and the lowest number of traffic signal receiving lowest (19th rank). This characteristic was included to evaluate which corridors has the highest readiness for a deployment of CTSP.
- The coverage corridor without TSP operations mileage was ranked based on the criterion with highest mileage ranked first and the lowest ranked the lowest (19th rank). This characteristic was included to determine where the greatest need for traffic signal equipment upgrades is needed to support CTSP on the corridor.

All 19 of VTA's frequent and rapid transit routes were included in the Table 1 for these rankings, and ten routes are included for informational purposes only. Those ten routes shaded grayed out in Table 1 have a CTSP system already deployed mainly by the City of San Jose. Although the City of San Jose elected to move forward ahead of the VTA's TRIP effort to deploy a countywide CTSP system, the procured solution from LYT complies with the requirements in TRIPS's SEMP documentation.

Composite Scoring of Transit and Traffic Signal Characteristics

Table 1 in columns 20 through 25 presents the scoring of each transit and traffic signal characteristic with a total combined scoring plus ranking. *The presented rankings are only informational and meant to provide guidance from a technical point of view on possible deployment paths. Other factors such as community support, political support, and availability of funding will need to be taken into consideration for final determination of the implementation of the countywide CTSP system.*

The scoring of ranked characteristics aims to target routes with the greatest readiness, routes with greatest potential to have traffic signal coordination (a key factor to support TSP operations), routes with greatest speed differential with the competing mode of travel (regular vehicles), and balancing it with corridors with greatest needs (not fully supporting TSP and needing upgrades). The scoring of each are as follows:

- **Traffic Signal Per Miles Scoring:** The maximum score of 30 is awarded to routes with greatest density and lower scores are awarded to routes with lesser densities. The scores are proportionally distributed by ranking. This assignment of scoring was allocated to target corridors with highest density of traffic signals, which are more likely corridors to have traffic signal coordination (an essential to successful TSP operations).
- **Change in Average Transit Speed in Comparison Vehicular Speed:** The maximum score of 40 is awarded to routes with greatest differential in speed and lower scores are awarded to routes with lower speed differentials. The scores are proportionally distributed by ranking. As previously described, this characteristic was included as a de-

facto means to determine overall corridor delay to the transit mode by comparing it to the competing mode of travel (a regular vehicle). Hence, the assignment of scoring was allocated to target routes with a high potential for delay.

- **Number of TSP Ready Signals:** The maximum score of 20 is awarded to routes with highest number of traffic signals. The scores are proportionally distributed by ranking. The assignment of scoring was allocated to target routes with greatest opportunity to rapidly deploy a CTSP system with highest number of TSP ready traffic signals.
- **Coverage Corridor without TSP Operations:** The maximum score of 10 is awarded to routes with highest mileage of corridor without traffic signal controllers capable of supporting CTSP systems. The scores are proportionally distributed by ranking. The assignment of scoring was allocated to target routes with greatest need for traffic signal upgrades to support CTSP systems.

The maximum total score for any route being evaluate is 100 points, and total score of each route is summarized in column 24 in Table 1. The final column (25) in Table 1 is the ranking by score for each route with highest total score receiving first ranking and lowest total score receiving the lowest rank at 19th ranking.

The composite ranking shown in Table 1 in column 25 is only informational and not intended to provide direction on the final deployment and other factors will need to be taken in consideration as previously. This list of routes shown in Table 1 in un-highlighted sections aligns with the input received from community input.

Although the routes are similar, the preferred priority of the routes are different, including the inclusion of some pockets of County of Santa Clara intersections. The preferred priority is listed below with the highest on top and lowest at the bottom:

1. Route 22
2. Rapid 522
3. Route 66
4. Route 25
5. Route 68
6. Rapid 568
7. Rapid 523
8. Route 23
9. Santa Clara County intersections on Routes 70, 71, Rapid 522, and others

Table 1 - VTA Frequent and Rapid Routes Centralized Transit Signal Priority (TSP) Technicial Evaluation

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Route No.	Brief Description	Type of Transit Vehicle	Type of Service	Skip Stop	Length of Route (miles)	Transit Average Speed (mph)	Vehicular Average Speed (mph)	Change in Average Transit Speed Compared to Average Vehicular Speed (mph)	Number of TSP Ready Traffic Signals	Number of Not TSP Ready Signals	Total Number of Traffic Signals	Coverage of Corridor with TSP Operations (miles)	Coverage of Corridor without TSP Operations (miles)	Signal per miles	Traffic Signal Per Miles Ranking	Change in Average Transit Speed Compared to Average Vehicular Speed Ranking	Number of TSP Ready Signals Ranking	Coverage of Corridor without TSP Operations Mileage Ranking	Traffic Signal Per Miles Scoring (Max Score 30)	Change in Average Transit Speed Compared to Average Vehicular Speed Scoring (Max Score 40)	Number of TSP Ready Signals Scoring (Max Score 20)	Coverage Corridor without TSP Operations Scoring (Max Score 10)	Total Composite Score (Total 100)	Total Composite Score Ranking Highest score first and lowest score ranks last
22	Palo Alto Transit Center-Eastridge Transit Center	Bus	Frequent	N	45.9	14.9	20.6	-5.7	119	11	130	14.0	31.9	2.83	7	5	1	2	21	32	20	9.4	81	1
23	De Anza College-Alum Rock via De Anza	Bus	Frequent	N	22.8	13.8	18.8	-5.1	68	21	89	12.9	9.9	3.91	3	10	7	6	27	21	14	6.9	68	2
25	De Anza College-Alum Rock via Valley Med	Bus	Frequent	N	26.7	14.1	20.1	-6.1	57	16	73	20.8	5.9	2.74	11	3	10	10	14	36	11	4.4	65	4
523	San Jose State-Lockheed Martin via De Anza	Bus	Rapid	Y	30.1	14.9	19.9	-5.0	72	22	94	8.2	21.9	3.12	5	11	6	5	24	19	15	7.5	65	5
522	Palo Alto Transit Center-Eastridge Transit Center	Bus	Rapid	Y	48.0	15.5	20.7	-5.2	114	16	130	16.1	31.9	2.71	12	9	2	1	13	23	19	10.0	65	6
66	North Milpitas - Santa Teresa Station	Bus	Frequent	N	36.7	17.5	22.2	-4.7	87	18	105	27.1	9.6	2.86	6	14	4	7	22	13	17	6.3	58	9
60	Milpitas BART-Winchester Station via SJC Airport	Bus	Frequent	N	28.7	17.2	22.0	-4.8	43	23	66	19.3	9.3	2.30	13	12	15	8	11	17	5	5.6	39	15
68	San Jose Diridon-Gilroy Transit Center	Bus	Frequent	N	50.5	25.5	26.8	-1.2	77	24	101	27.7	22.8	2.00	18	18	5	4	3	4	16	8.1	31	16
568	Gilroy Transit Center-San Jose Diridon	Bus	Rapid	Y	55.9	28.7	29.5	-0.9	67	30	97	31.4	24.5	1.73	19	19	8	3	2	2	13	8.8	25	19
64A & 64B	Ohlone-Chynoweth Station-McKee & White Almaden& Camden-McKee & White	Bus	Frequent	N	46.4	15.1	21.4	-6.4	93	11	104	46.4	-	2.24	14	2	3	16	9	38	18	0.6	66	3
500	San Jose Diridon-Berryessa BART	Bus	Rapid	Y	6.6	12.4	17.8	-5.5	42	-	42	6.6	-	6.41	1	6	16	16	30	29	4	0.6	64	7
61	Sierra & Piedmont- Good Samaritan Hospital	Bus	Frequent	N	26.9	17.4	22.9	-5.5	66	10	76	22.9	4.0	2.83	8	7	9	11	19	27	12	3.8	62	8
70	Milpitas BART-Capitol Station via Jackson	Bus	Frequent	N	31.6	16.6	24.9	-8.2	48	21	69	29.4	2.2	2.18	17	1	13	14	5	40	7	1.9	54	10
26	West Valley College-Eastridge	Bus	Frequent	N	25.7	16.5	21.9	-5.4	44	28	72	16.4	9.3	2.80	9	8	14	9	17	25	6	5.0	54	11
71	Milpitas BART-Eastridge via White	Bus	Frequent	N	16.1	19.2	25.2	-6.1	24	12	36	12.8	3.4	2.23	15	4	18	12	8	34	2	3.1	47	13
73	Downtown San Jose-Senter & Monterey via Senter	Bus	Frequent	N	13.8	16.2	18.6	-2.4	57	1	58	13.8	-	4.19	2	16	10	16	28	8	11	0.6	48	12
72	Downtown San Jose-Senter & Monterey via McLaughlin	Bus	Frequent	N	14.5	17.9	19.6	-1.8	50	1	51	14.5	-	3.52	4	17	12	16	25	6	8	0.6	41	14
77	Milpitas BART - Eastridge via King	Bus	Frequent	N	16.0	17.3	21.9	-4.6	39	5	44	14.2	1.8	2.75	10	15	17	15	16	11	3	1.3	31	17
57	Old Ironside-West Valley College	Bus	Frequent	N	18.9	17.2	22.0	-4.8	16	26	42	16.0	2.9	2.22	16	12	19	13	6	17	1	2.5	27	18