CARSON AREA TRANSPORTATION SYSTEM MANAGEMENT PLAN

Final Report

August 2023

FINAL REPORT

FOR

CARSON AREA TRANSPORTATION SYSTEM MANAGEMENT PLAN

Prepared for:

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2023-08-23 CATSMP Report Final.docx

ACKNOWLEDGMENTS

The Technical Advisory Committee (TAC) members were instrumental in the development, review, and refinement of this study. Kimley-Horn and Associates, Inc. would like to express their appreciation to the TAC members and their supporting staff for their participation and contributions.

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EXECUTIVE SUMMARY

The Carson Area Metropolitan Planning Organization (CAMPO) is a federally recognized metropolitan planning organization (MPO) formed in February 2003. As an MPO, CAMPO is responsible for maintaining, planning, and operating a system of facilities, including roadways, traffic signals, crosswalks, and signage in the urbanized area of Carson City as well as surrounding rural areas, including northern Douglas County and western Lyon County. Carson City provides signal maintenance for the CAMPO region and beyond, including coordination with Storey County for two signalized intersections located along USA Parkway in the Tahoe-Reno Industrial Center.

Project Description

The Carson Area Transportation System Management Plan (CATSMP) was initiated as a planning effort for CAMPO to establish commonly held operations and management objectives and as an asset management plan to support improved transportation system performance for the CAMPO region. This plan reviews CAMPO's current transportation system and identifies its needs related to operations and management to inform future investments needed to provide a safe and reliable transportation system for the region. This plan includes stakeholder engagement, existing conditions with respect to physical and logistical elements, a needs assessment, life-cycle costing to inform recommended future system improvement strategies, and the development of data-driven performance measures and benchmarks.

Goals and Objectives

The goals and objectives for this study were developed to assist CAMPO in maintaining its transportation and signal systems. The goals are:

- Identify key components of the traffic signal system
- Identify life-cycle costs and replacement needs
- Identify and document any program deficiencies and understand needed enhancements
- Understand funding and staffing needs
- Identify performance measures and benchmarks utilizing readily-available data
- Utilize the results of the study to seek more funding/reimbursement through agreements with the Nevada Department of Transportation (NDOT) or other sources for maintenance activities

Project Recommendations

Project recommendations based on the feedback from the TAC, review of existing conditions, Self-Assessment Workshop, life-cycle costing, and performance measures and benchmarks are summarized below. CAMPO should work closely with NDOT to ensure applicable recommendations from this study are incorporated into the plan for the Northern Nevada Traffic Management Center (NNTMC) currently being developed by NDOT.

Physical and Logistical Elements

Recommendations regarding the review of physical and logistical elements include:

- ***Maintain an accurate and up-to-date inventory of assets for the physical elements collected as part of this plan*****.** Integration of transportation assets into Carson City's asset management strategy will help ensure program elements are maintained.
- ***Adopt formal Incident and Special Event Management Procedures.*** The Incident and Special Event Management Procedures should, at a minimum, identify the event originator, reviewing department, approver, implementation process, and timeline when the signals are to return to standard operations.
- ***Implement consistent language and terms among all signal systems covered under the existing agreements.*** It is recommended that all county and NDOT agreements be updated to have consistent agreement terms. The Douglas County agreement should be used as a starting point to update all county agreements, as this is the most recent agreement that was negotiated.
- ***Coordinate with District Attorney regarding interlocal agencies and Nevada Revised Statute 277A.*** CAMPO has recently experienced challenges with interlocal agencies and Nevada Revised Statute 277A, specifically with respect to NDOT purchasing signal equipment for Carson City to install in Lyon and Douglas Counties. CAMPO should work with their District Attorney to determine how to accomplish this efficiently.
- ***Provide instructions on how to read the signal timing plans*** **(located in Appendix E)** ***to consultants when signal timing requests are made*****.** Instructions explaining how to read CAMPO's signal timing plans should increase the consultants' understanding of the plans.

Self-Assessment Workshop

A Self-Assessment Workshop was conducted to promote a process-driven approach to improve transportation systems management and operations within the CAMPO region. The Self-Assessment Workshop focused on four key dimensions (evaluation elements) shown in **Figure E1**. Actions identified at the workshop were prioritized from short-term (1-2 years) to long-term (over 5 years). It is recommended that CAMPO use the short-term (1-2 year) Self-Assessment actions as a starting point for tracking progress to move the transportation system management activities on a path toward continual, improved outcomes. Implementation of actions are dependent on funding and staffing availability. Recommended short-term actions are summarized below.

- Document formal processes/procedures
- Identify opportunities for intentional communication among departments
- Establish and conduct reoccurring meetings for collaboration with partner agencies on a quarterly basis
- Establish reoccurring meetings with the region on a quarterly basis – consider different levels (e.g., traffic technician versus engineering level)
- Identify and actively pursue opportunities for external funding
- Agencies collaborate to update standards and requirements for consistency in technology
- Identify planning for known deficiencies

- Establish what data should be collected and identify where systems and technology can be leveraged to collect that data
- Leverage and begin to use existing performance software (Regional Integrated Transportation Information [RITIS])
- Share data for efficiency between agencies
- Complete analysis focused on individual data elements to track incremental improvements

Recommended mid-term (3-5 years) and long-term (over 5 years) actions from the Self-Assessment Workshop are summarized below.

Mid-Term Actions

- Acknowledge that regional planning should include traffic operations as a priority and identify investments to support that priority
- Establish more coordination and investment by NDOT
- Identify the disconnect in funding sources with what needs to be funded
- Hire additional staff (planning/engineering/program management) to plan and secure funding

Long-Term Actions

- Provide external resources to assist partnering agencies with design and operations (regionally available engineer to assist other counties)
- Centralize data analysis and reporting
- Communicate to all traffic signals
- Identify roles and responsibilities of the local agencies in providing traveler information that can support state distribution

Many of the mid- and long-term recommendations should be considered by NDOT in the development of the NNTMC.

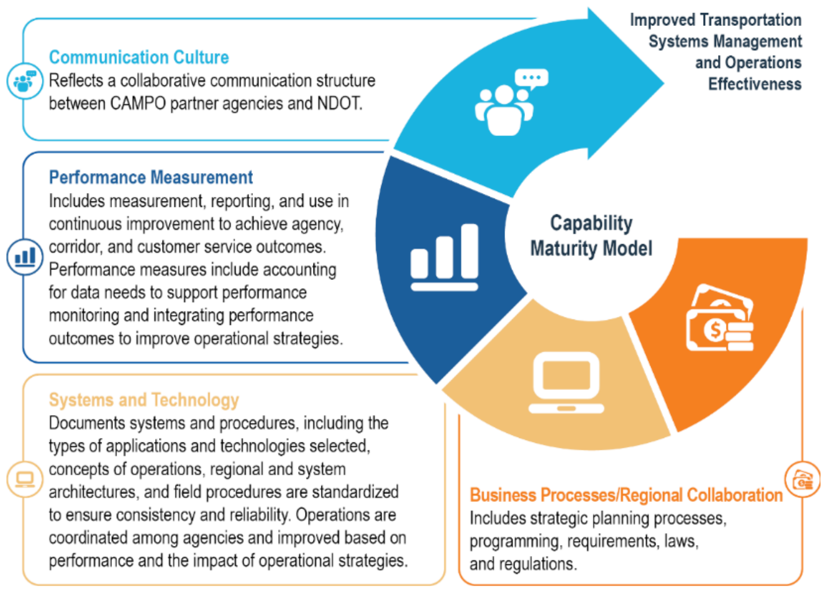

Figure E1– Four Key Dimensions for the Capacity Maturity Model (CMM)

Life-Cycle Costing

It is recommended that Carson City, NDOT, and partner agencies budget $8.2 million per year for the replacement of transportation equipment (traffic signal system and detection and other intelligent transportation systems [ITS] equipment) on a routine basis. This budget should be increased from year to year to account for inflation. It is also recommended that Carson City hire two additional maintenance staff to provide proactive maintenance of the signal system based on an evaluation of current operation and maintenance practices and considerations of Federal Highway Administration (FHWA) best practices. The two additional maintenance staff should spend 70% of their time on preventative maintenance, 25% of their time on response maintenance, and 5% of their time on signal timing design modifications. An additional position for a traffic systems engineer/signal operations engineer is also recommended to oversee the network's performance and optimization.

Performance Measures and Benchmarks for Tracking Traffic

It is recommended that bi-annual downloads and analyses of RITIS eXtreme Definition (XD) data be conducted as part of CAMPO's monitoring process. The downloads are estimated to take six to eight hours of effort each and would include regular checks of travel time and congestion trends along the corridors defined in this study. Additional external reporting maps and visualizations, such as those in PowerBI dashboards, could be applied once staff is familiar with the datasets.

Collaboration between a transportation planner/analyst responsible for the data monitoring and analysis and a transportation manager is also desirable with planned regular check-ins and strategy meetings. This will allow staff to coordinate on data findings, provide a quality control step for internal reporting, and provide a venue for review of long-term trends and policy interventions. These meetings and subsequent tasks for traffic engineer staff may require one to two hours per download, depending on the outcome of the performance reporting.

CAMPO should also consider implementing Automated Traffic Signal Performance Measures (ATSPM) or trajectory data to increase the granularity and diversity of the data available to assess signal operations. These approaches would allow CAMPO to collect information such as the percentage of vehicles arriving on a green light, split failures, and the prevalence of phase max-outs or gap-outs. Connected vehicle data can be used for studies now, but it is recommended that this be limited to periodic purchases of data for well-scoped studies rather than a subscription. It is recommended that CAMPO actively monitor the marketplace for connected vehicle data as it is emerging and still evolving.

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LIST OF ACRONYMS

AADT	Average Annual Daily Traffic
APS	Accessible Pedestrian Signal
ASWS	Advance Signal Warning System
ATMS	Active Traffic Management System
ATSPM	Automated Traffic Signal Performance Measures
CAMPO	Carson Area Metropolitan Planning Organization
CATSMP	Carson Area Transportation System Management Plan
CFR	Code of Federal Regulations
CMM	Capability Maturity Model
FAST	Freeway and Arterial System of Transportation
FHWA	Federal Highway Administration
GIS	Geographic Information System
ITS	Intelligent Transportation Systems
JAC	Jump Around Carson
Lidar	Light Detection and Ranging
MPO	Metropolitan Planning Organization
MSA	Metropolitan Statistical Area
NDOT	Nevada Department of Transportation
NNTMC	Northern Nevada Traffic Management Center
PTI	Planning Time Index
RITIS	Regional Integrated Transportation Information
TAC	Technical Advisory Committee
TRINA	Traffic Records Information Access
TTI	Travel Time Index
VMT	Vehicle Miles Traveled
VRM	Vehicle Revenue Mile
WisDOT	Wisconsin Department of Transportation
XD	eXtreme Definition

1. Introduction

The Carson Area Metropolitan Planning Organization (CAMPO) is a federally recognized metropolitan planning organization (MPO) formed in February 2003. As an MPO, CAMPO is responsible for maintaining, planning, and operating a system of facilities, including roadways, traffic signals, crosswalks, and signage in the urbanized area of Carson City as well as surrounding rural areas, including northern Douglas County and western Lyon County. The CAMPO boundary is shown in **Figure 1**. Carson City provides signal maintenance for the CAMPO region and beyond, including coordination with Storey County for two signalized intersections located along USA Parkway in the Tahoe-Reno Industrial Center.

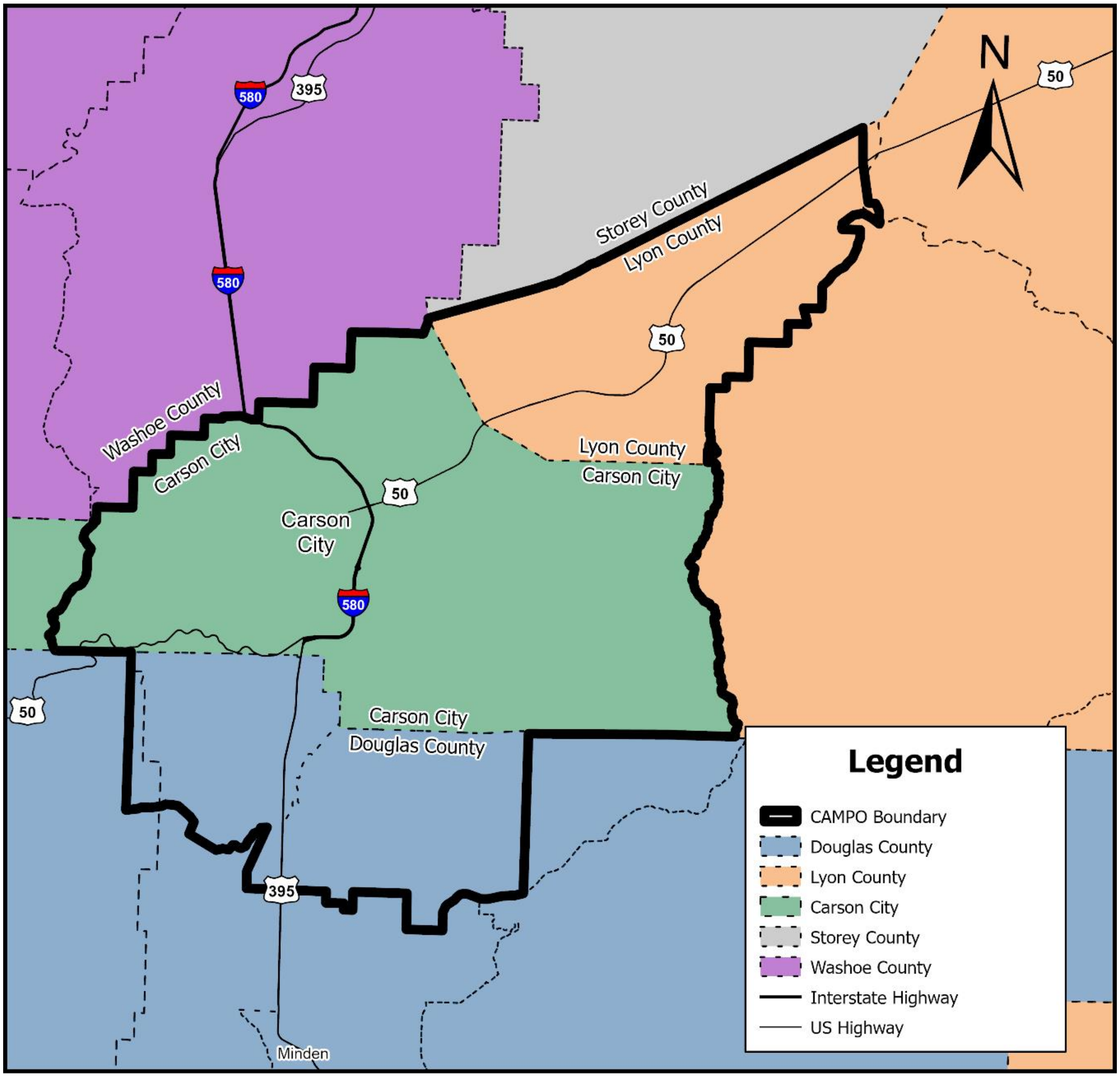

Figure 1 – CAMPO Boundary

1.1 Project Description

The Carson Area Transportation System Management Plan (CATSMP) was initiated as a planning effort for CAMPO to establish commonly held operations and management objectives and as an asset management plan to support improved transportation system performance for the CAMPO region and beyond. This plan reviews CAMPO's current transportation system and identifies needs related to operations and management to inform future investments required to provide a safe and reliable transportation system for the region. This plan includes stakeholder engagement, existing conditions with respect to physical and logistical (intangible) elements, a needs assessment, life-cycle costing to inform recommended future system improvement strategies, and the development of data-driven performance measures and benchmarks.

1.2 Goals and Objectives

The goals and objectives for this study were developed to assist CAMPO in maintaining its transportation and signal systems. The goals are:

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1.3 Report Organization

This document is organized into the following sections:

- **Section 1** summarizes the project background, goals, and objectives.
- **Section 2** provides an overview of the stakeholder engagement for the project.
- **Section 3** includes a summary of the existing conditions, including physical elements and logistical elements.
- **Section 4** describes the Self-Assessment Workshop methodology and outcomes.
- **Section 5** summarizes the life-cycle costing methodology and results.
- **Section 6** provides recommended performance measures and benchmarks for CAMPO based on a data-driven approach and review of national best practices.
- **Section 7** describes the recommendations resulting from the development of this study.
- **Appendices** include a summary of data collected, list of spare inventory parts, logistical elements, peer cities' survey details, Self-Assessment Workshop summary, life-cycle costing, and a summary of performance measures and benchmarks.

2. Stakeholder Engagement

Key stakeholders for the development of the CATSMP included:

- CAMPO
- Carson City Public Works
- Douglas County
- Lyon County
- NDOT
- Storey County

The Technical Advisory Committee (TAC) was comprised of representatives from each key stakeholder agency.

2.1 TAC Meetings

Several TAC meetings were held to gather input from the stakeholders and present progress throughout the course of the project. A summary of meeting topics from each TAC meeting is provided in **Table 1**.

Table 1 – TAC Meeting Topics

TAC Meeting	Meeting Topics
TAC Meeting #1, December 1, 2020	▪ Brief project history and task overview. ▪ Outline of data and data attributes to be collected manually or using Light Detection and Ranging (lidar). ▪ Outline of logistical elements to be collected. ▪ Summary of other objectives, discussion items, and next steps.
TAC Meeting #2, November 3, 2021	▪ Brief project update and task overview. ▪ Summary of the data collection processes. ▪ Summary of logistical elements. ▪ Introduction to the existing system condition assessment and needs assessment tasks.
TAC Meeting #3, February 8, 2022	▪ Brief project update and task overview focusing on the summary of elements collected and reviewed as part of the data collection process. ▪ Overview of the outcomes from the Needs Assessment (Self-Assessment Workshop) documenting short- to long-term priorities. ▪ Introduction to the life-cycle costing task including an overview of the elements to be reviewed. ▪ Open discussion on the benchmarks and performance measures in the original project scope and opportunity for input from the TAC on additional considerations.

Table 1 – TAC Meeting Topics (Continued)

TAC Meeting	Meeting Topics
TAC Meeting #4, October 10, 2022	▪ Discussion on the life-cycle costing including traffic signal system replacement cycle and operations and maintenance cost considerations. ▪ Summary of benchmark and performance measures in line with needs assessment results. ▪ Roadmap for future investment.
TAC Meeting #5, February 21, 2023	▪ Summary of performance measures and benchmark findings. ▪ Implementation recommendations.
TAC Meeting #6, June 6, 2023	▪ Updates on performance measures and benchmark findings: corridor refinement, side street delay, expansion of hotspot analysis, peak periods for each corridor, and free flow travel times. ▪ Signal retiming implementation.

In addition to the TAC meetings, a self-assessment workshop was conducted on November 16, 2021, to evaluate current levels of interagency collaboration, specifically assessing each agency's strengths and challenges. A summary of the Self-Assessment Workshop is provided in **Section 4**.

2.2 CAMPO Board Meetings

A presentation on the progress of the project was provided to the CAMPO Board during their March 9, 2022, Board Meeting. The board wanted to understand how this project relates to the 23 Code of Federal Regulations (CFR) Part 940 Intelligent Transportation System (ITS) Architecture and Standards. A discussion on how CAMPO meets these regulations is provided in **Section 3.2.8**.

The final report was approved by the CAMPO Board during the July 12, 2023 Board Meeting with the condition that comments received during the meeting would be addressed in the final version submitted in August 2023.

3. EXISTING CONDITIONS

This section summarizes details of the existing conditions analysis to review both physical and logistical (intangible) elements. Updates to CAMPO's traffic control system geodatabase schema were made before mobile lidar, field, and manual data collection occurred. Physical elements collected included traffic signals, signalized pedestrian crossings, flashing beacons (including school flashers and some advance signal warning beacons), and radar speed feedback signs. The logistical elements included a review of policies, agreements, and other planning documents received from CAMPO. Details on each element type reviewed are provided in the following sections.

3.1 Physical Elements

A review of the existing traffic control systems geodatabase was completed to establish new feature classifications, attributes, and relationships between different tables within the schema for the supports, signs, and signalized crosswalk layers. Information summarizing the schema for the data collection portion of the project is located in **Appendix A.**

Mobile lidar technology was used for the collection of supports, signs, and signalized crosswalks in alignment with the updated schema along the drive routes illustrated on the following page in **Figure 2**. The total number of physical elements collected as part of this project (as of 2021) included:

- 73 signalized intersections
- 22 signalized pedestrian crossings
- 21 flashing beacons
- 10 radar speed feedback signs
- 472 supports
- 1,172 signal related signs

Of the 1,172 signal related signs, 753 signs were evaluated for reflectivity levels. Only 105 of the 753 signs evaluated for reflectivity had a reflectivity score of "Pass Excellent". This project helps Carson City to understand where signal related signs are located. Carson City may want to explore a sign maintenance program in the future allowing them to track sign replacements.

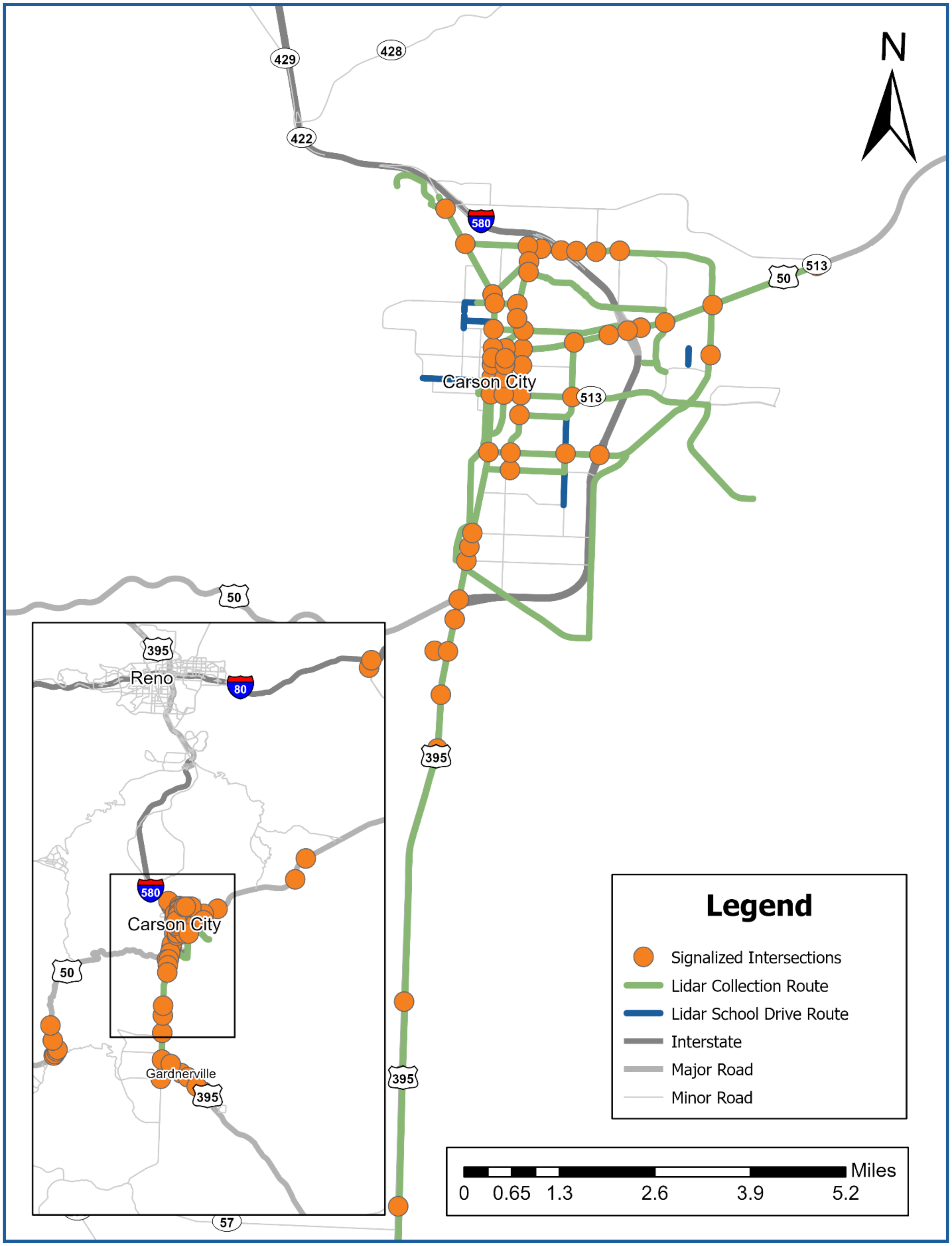
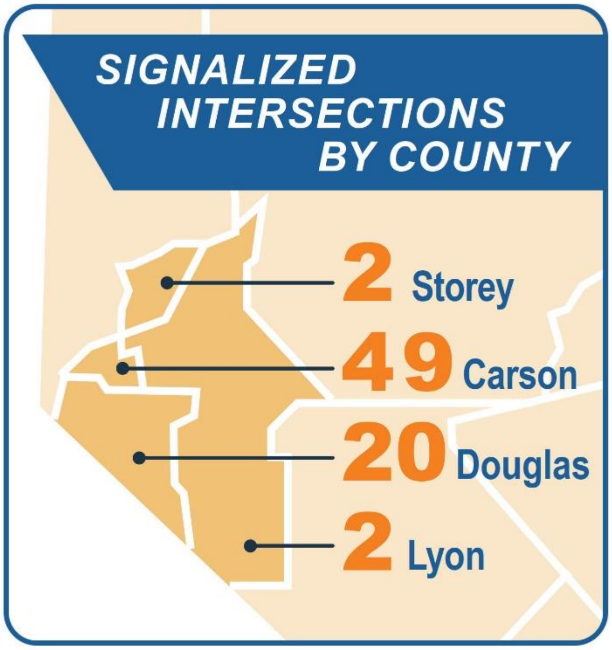


Figure 2 – Lidar Data Collection Drive Routes

Of the 73 signalized intersections maintained by Carson City, 57 are within the CAMPO boundary while 16 are outside of the boundary (14 signals in Douglas County including those in Lake Tahoe and two signals in Storey County). Overall, Carson City maintains 49 signals within Carson City, 20 in Douglas County, two in Lyon County, and two in Storey County. A detailed summary of the lidar elements collected is provided in **Appendix B**.



Additional manual field data collection was performed by Carson City staff using a mobile geospatial reference application. Items collected by Carson City included: mast arms, cabinets, pedestrian push buttons, and curb ramps.

3.1.1 Spares Inventory

An inventory of spare transportation infrastructure parts stored by Carson City Public Works was conducted. This inventory falls under two groups: a detailed list of ITS parts and another stockpile of signal poles. The ITS parts, which are stored indoors at the Carson City Public Works yard, are tracked in detail to include the item number, type, and class, along with the description, location, last known item price, the number of items stored, and estimated value for all items on hand. The signal poles are stored outdoors, and an infield review of the signal pole inventory was conducted on May 3, 2021, to collect the pole type and pole geometry. Documentation of the inventory is provided in **Appendix C**.

3.2 Logistical Elements

Available logistical elements, those elements defined as “intangible,” such as policies, agreements, and other planning documents received by CAMPO, were reviewed for incorporation into the CATSMP. The documents reviewed include the following:

- Incident and special event management procedures
- City policies and procedures
- Funding
- Staffing
- Safety
- Maintenance agreements with quad county agencies
- Process for storage of data in Advanced Traffic Management System (ATMS)

A summary of the collected logistical elements listed above is provided in the following sections. More detailed information is included in **Appendix D.**

3.2.1 Incident and Special Event Management

Carson City does not currently have an incident management signal timing modification plan. For special event management, the Carson City Sheriff's Office and Public Works Department meet ahead of the special event to identify intersections that should be used to move people in and out of the special event quickly. A list of impacted roads due to an event is coordinated and communicated to the Control Systems Operations Manager. The Control Systems Group then updates the signal timings at impacted intersections to prioritize the throughput of each intersection for the duration of the event.

3.2.2 Policies

Several Carson City policies were reviewed. These policies are summarized in **Appendix D** and include the following:

- Speed Limit Policy
- Resolution No. 2020-R-14 (Designation of school zones within portions of highways)
- Sign Installation
- Signal Timing – Yellow, All-Red, and Pedestrian Intervals
- Signal Timing – Signalized Crosswalk Warning Intervals
- Signal Timing Changes – NDOT Advanced Signal Warning System (ASWS)

3.2.3 Funding

The fiscal year budget for capital improvements and infrastructure capital covers roadway reconstruction pavement preservation projects. Carson City adopted a Carson City Pavement Management Plan in April 2018 which established five performance districts to prioritize roadway funding in an efficient and effective strategy. The funding for each performance district is primarily used for construction projects and is covered by both local and federal funds. On average, Carson City has $5 million available per year in local and federal funding for roadway capital improvements. Historical data since 2019 shows a 65% local and 35% federal fund distribution.

A traffic control system budget, which covers signal maintenance and operations, funded by the street maintenance fund, also exists. On average, Carson City receives approximately $500,000 per year for traffic control systems. Additionally, Carson City earns revenue as part of signal maintenance completed for Douglas, Lyon, and Storey Counties.

3.2.4 Agreements with Partnering Agencies

Carson City has signal maintenance agreements with Douglas, Lyon, and Storey Counties. These agreements define responsibilities for Carson City and the partnering agencies for the maintenance of signals within the CAMPO area. The Douglas County agreement is the most recent agreement Carson City has established with a partnering agency. Carson City also has intersection and other location specific agreements with NDOT; however a master agreement with NDOT is not in place. There are currently 38 agreements between Carson City and NDOT with some agreements older than 60 years. Upon review of the agreement list, it was noted that the NDOT thresholds and reimbursement terms vary among the 38 agreements. For example, Carson City funds cover all maintenance costs in some agreements, while NDOT funds the maintenance costs in others. Carson City and the other agencies within CAMPO also have right-of-way occupancy permits with NDOT to allow for the general maintenance of traffic signals.

3.2.5 Safety

CAMPO has adopted the state targets for safety performance measures to increase safety for the transportation system as follows:

- Number of fatalities (five-year rolling average)
- Rate of fatalities per 100 million Vehicle Miles Traveled (VMT)
- Number of serious injuries (five-year rolling average)
- Rate of serious injuries per 100 million VMT
- Number of non-motorized fatalities and non-motorized serious injuries (five-year rolling average)

CAMPO coordinates safety performance measures with NDOT and adopts these safety targets each year. As stated in the 2050 Regional Transportation Plan, CAMPO was able to meet four of the five targets when compared against the 2018 targets. It was noted that CAMPO experienced a 93% increase in the number of fatalities (five-year rolling average) from 2012 to 2018 even though a 33% reduction in the total number of serious injury crashes over the same period was observed. It was reported that the extension of I-580 may have been an influencing factor in the fluctuation of fatalities and serious injuries.

Safety performance targets for public transportation within the region, as outlined in the 2023 Public Transportation Agency Safety Plan, include:

- **Fatalities, and Fatalities per Vehicle Revenue Mile (VRM):** Total number of reportable fatalities and rate of fatalities per total VRM, by mode.
  - Jump Around Carson's (JAC's) performance target is zero fatalities.
- **Injuries, and Injuries per VRM:** Total number of reportable injuries and rate of injuries per total VRM, by mode.
  - JAC's performance target is zero injuries for the year, and 0.00002 injuries per VRM (1 injury per 50,000 VRM) for fixed route and 0.00001 injuries per VRM (1 injury per 100,000 VRM) for paratransit.
- **Safety Events, and Safety Events per VRM:** Total number of reportable events (Event, as defined in the 2021 National Transit Database Reduced Reporter Policy Manual) and rate of reportable events per total VRM, by mode.
  - JAC's performance target is two safety events in total for the year for fixed route and one safety event for paratransit for the year. The goals are 0.00001 safety events per VRM (1 safety event per 100,000 VRM) for fixed route and 0.00001 safety events per VRM (1 safety event per 100,000 VRM) for paratransit.
- **System Reliability:** Mean (or average) distance in miles between major mechanical failures, by mode.

3.2.6 Process for Storage of Data in ATMS

The signal timing data is stored in the ATMS system, and the Control Systems Operations Manager downloads signal timing data from the ATMS system when requests come in. However, some consultants find it hard to read the signal timing plans produced by the ATMS system. Instructions to read the signal timing plans were developed as part of this project and are included in **Appendix E**.

3.2.7 Existing Staffing

Information related to the organizational structure of Carson City Public Works, which manages CAMPO, as it relates to signal operations and management was conducted. The responsibilities of operating and maintaining the transportation system fall under two groups, Transportation and Control Systems, as illustrated in **Figure 3**.

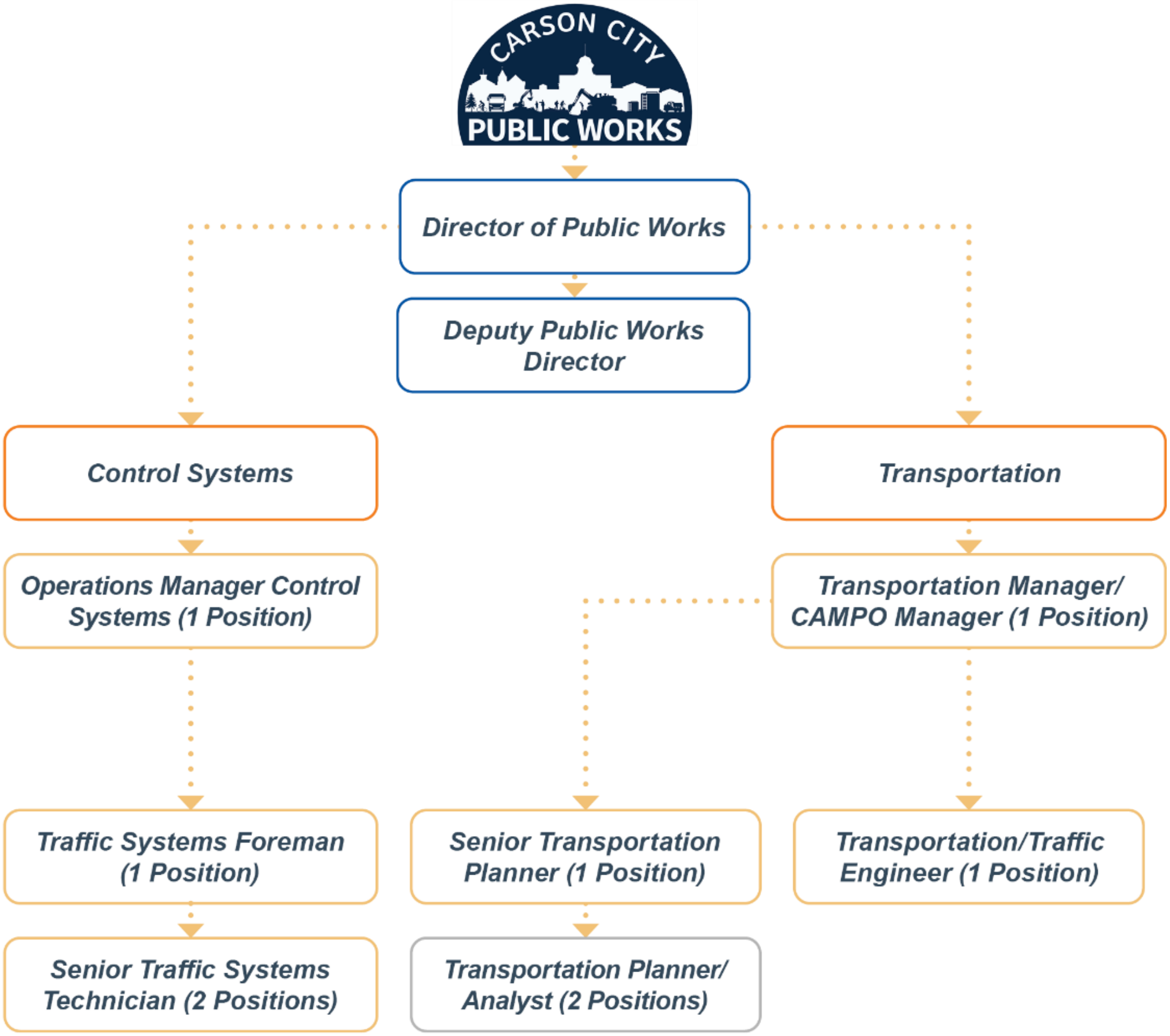


Figure 3 – Carson City Public Works Organization Chart

Details on the positions under these two groups are provided below:

- **Control Systems**
  - **Operations Manager Control Systems:** Under general direction, plans, assigns, supervises, reviews, and evaluates the work of the staff assigned to the operation and maintenance of the electrical, instrumentation, process control, data acquisition, and city-wide communication systems for public works operations.
  - **Traffic Systems Foreman:** Under general direction, plans, assigns and oversees the work of the Traffic Systems section while performing the same and/or more difficult duties as those being led; ensures completion of tasks in accordance with established policies and procedures; communicates policies, procedures, and job expectations; and provides training to staff.
  - **Senior Traffic Systems Technician:** Under general supervision, performs complex technician-level installation, repair, and preventive maintenance of electrical and electronic components of traffic systems equipment in a variety of City locations.
- **Transportation**
  - **Transportation Manager:** Under general direction, manages, coordinates, and directs all transportation and transit-related planning, review, and impacts for the City. Serves as the Manager of CAMPO.
  - **Senior Transportation Planner:** Under general supervision, provides advanced-level professional transportation planning support for City projects and programs; may lead the work of planning and technical support staff.
  - **Transportation Planner/Analyst:** Under general supervision, provides professional transportation planning support for City projects and programs.
  - **Transportation Traffic Engineer:** Under general supervision, performs engineering work related to the coordination and supervision of major and minor construction and renovation projects, assuring that plans, specifications, codes, time schedules, and budgets are adhered to; provides complex inspections of projects; confers with contractors and consultants on the development and completion of projects; plans and directs traffic engineering and transportation activities, including traffic impact studies, traffic signal timing, and various technical engineering studies.

Operations Managers and Traffic Systems Technicians are engaged in a multitude of tasks, including but not limited to the tasks on the next page (refer to **Appendix F** for further job descriptions).

- Managing task scheduling, performance evaluation, and accurate record keeping.
- Applying codes and regulations, safe work methods, and safety procedures.
- Designing and preparing sketches for traffic signal and related installation and maintenance jobs.
- Coordinating, performing, and overseeing maintenance operations, inspections, and repairs of all traffic signal systems within the CAMPO area.
- Reviewing plans, specifications, and estimate packages for traffic-related components.
- Contributing to efficiency and effectiveness of services by offering suggestions and directing or participating as an active member of the work team.

3.2.8 23 CFR Part 940

The 23 CFR Part 940 ITS Architecture and Standards Code of Federal Regulations requires that all regions implementing ITS projects have a regional ITS architecture and that all ITS projects conform to the National ITS Architecture and standards. Within Nevada, NDOT has developed three regional ITS architectures covering all jurisdictions within the state (Northwest Nevada, Southern Nevada, and Statewide which covers the remaining areas of the state). CAMPO is currently included in NDOT's 2019 Statewide Architecture and is one of the 25 stakeholders covering all areas outside the Reno/Sparks and Las Vegas urbanized areas. NDOT is updating their Statewide Architecture in 2023 and should consider the CATSMP during the update.

4. Self-Assessment Workshop

A Self-Assessment Workshop was conducted to collaboratively engage project stakeholders and promote a process-driven approach to improve transportation systems management and operations within the CAMPO region as it relates to the CATSMP. The Self-Assessment Workshop was based on a modified version of the Federal Highway Administration (FHWA) Capability Maturity Model (CMM) Framework for Transportation Systems Management and focused on four key dimensions (evaluation elements) identified in **Figure 4**. Organizational aspects of CAMPO with respect to the transportation system that are necessary for improving program efficiency and effectiveness, such as business processes/regional collaboration, systems and technology, performance measurements, and communication culture were explored and evaluated. The workshop supported self-evaluation and identification of critical priority "next steps to" placing activities on a path to improved outcomes on a continuing basis by identifying key dimensions for improving efficiency, recognizing manageable improvements, and prioritizing efficiency and effectiveness.

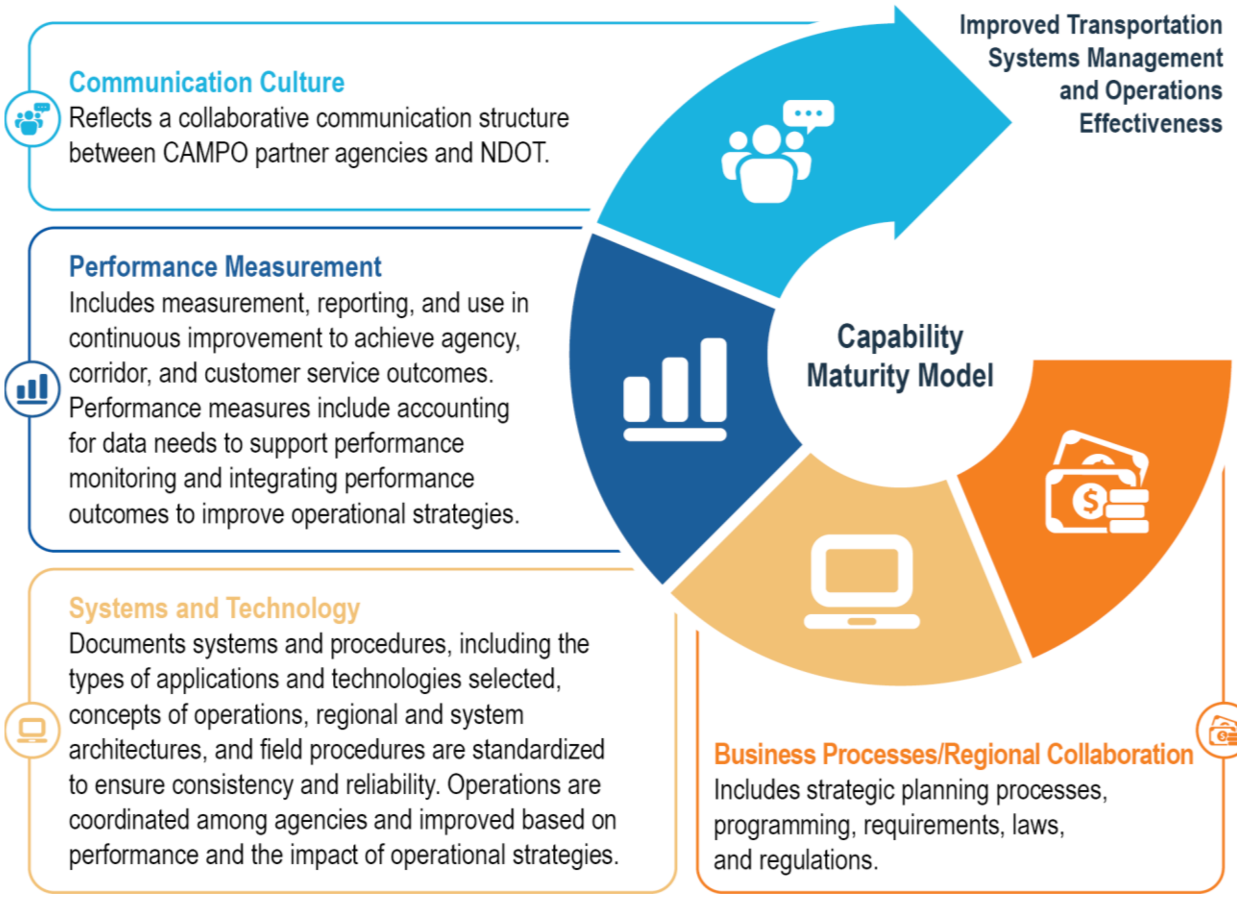


Figure 4 – Four Key Dimensions for the CMM

4.1 Self-Assessment Outputs

Attendees of the workshop were asked to cite strengths and challenges experienced by CAMPO and the partnering agencies for each of the key dimensions. The participants then identified actions for CAMPO to advance to the next level of implementation for each key dimension.

The actions from the workshop were then incorporated into an action checklist that places each action by associated dependencies to provide a framework CAMPO can work towards. Each action from the workshop was prioritized into the following timeframes:

- **Short-Term:** 1 to 2 Years
- **Mid-Term:** 3 to 5 Years
- **Long-Term:** Over 5 Years

A summary of the Self-Assessment Workshop actions, along with their priority, associated dimension and responsible agency, are summarized in **Table 2**. The outcomes from this workshop should be the basis for CAMPO to start tracking metrics to help them continuously improve on each dimension. These actions should be considered a living process that can be refined as metrics and outcomes become available. Further details on the workshop, including notes and final outcomes, are provided in **Appendix G**.

Table 2 – Self-Assessment Workshop Outputs

Priority	Dimension	Actions	Responsibility
Short-Term (1-2 Years)	**Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture**	Document formal processes/procedures	CAMPO
	Systems and Technology	Collaborate between agencies to update standards and requirements for consistency in technology	CAMPO and Partnering Agencies
	Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture	Identify opportunities for intentional communication among departments	CAMPO
		Establish and conduct reoccurring meetings for collaboration with partner agencies (quarterly)	CAMPO and Partnering Agencies (Storey, Lyon, Douglas County)
		Establish reoccurring meetings with the region (quarterly) – consider different levels (i.e., traffic technician versus engineering level)	CAMPO and Partnering Agencies (Regional Transportation Commission of Washoe County, Tahoe MPO, NDOT, etc.)
		Identify and actively pursue opportunities for external funding	CAMPO
	Systems and Technology	Identify planning for known deficiencies	CAMPO and Partnering Agencies
	Performance Measurement	Establish what data should be collected and identify where systems and technology can be leveraged to collect that data	CAMPO and Partnering Agencies
		Leverage and begin to use existing performance software (Regional Integrated Transportation Information System [RITIS]	CAMPO and Partnering Agencies
		Share data for efficiency between agencies	CAMPO and Partnering Agencies
		Complete analysis focused on individual data elements to track incremental improvements	CAMPO and Partnering Agencies
Mid-Term (3-5 Years)	**Systems and Technology**	Acknowledge that regional planning should include traffic operations as a priority and identify investments to support that priority	CAMPO
		Establish more coordination and investment by NDOT (assisting in establishing level of services and capabilities)	CAMPO
		Identify the disconnect in funding sources with what needs to be funded (NDOT Funding)	CAMPO, NDOT, and Partnering Agencies

Table 2 – Self-Assessment Workshop Outputs (Continued)

Priority	Dimension	Actions	Responsibility
Mid-Term (3-5 Years)	**Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture**	Hire additional staff (planning/engineering/program management) to plan and secure funding	CAMPO
Long-Term (Over 5 Years)	**Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture**	Provide external resources to assist partnering agencies with design and operations (regionally available engineer to assist other counties)	CAMPO
	Performance Measurement	Centralize data analysis and reporting	CAMPO
	Systems and Technology	Communicate to all traffic signals	CAMPO and Partnering Agencies
		Identify roles and responsibilities of the local agencies in providing traveler information that can support state distribution	CAMPO and Partnering Agencies

5. Life-Cycle Costing

Life-cycle costing is a methodology that provides an estimate of the total capital, operating, and maintenance cost of an asset over its operating life. The life-cycle costing analysis quantified the different traffic signal system equipment types, identified a life-cycle timeframe, and recommended a replacement cycle. The analysis was projected 30 years into the future, and many items used a uniform replacement schedule to normalize budgets from year to year to allow for better budget planning. Capital costs were obtained from a review of recent Northern Nevada construction bids.

The NDOT Life-Cycle Costing methodology was also reviewed and considered as part of the process, but it did not align with CAMPO because of differing asset types. For example, CAMPO's assets relate directly to signals whereas NDOT's devices are more freeway focused (such as ramp meters, dynamic message signs, and highway advisory radio).

5.1 Replacement Cycle

A summary of the replacement of transportation system elements for the life-cycle costing analysis is provided in **Table 3**. The life-cycle timeframe is based on best practices and information from contractors that maintain these types of equipment. It is recommended that the equipment listed in **Table 3** be quantified on an annual basis.

Table 3 – Replacement Cycle Summary

Equipment Type	Life-cycle Timeframe	# of Locations	Replacement Cycle Recommended
Traffic Signal Systems			
Cabinet and Service Pedestal	20 years	73	Replace four cabinets per year, allowing for even distribution over 20 years. If CAMPO is experiencing difficulties with older cabinets, replacement of cabinets can be accelerated over the next several years to bring cabinets to up to date and four cabinets per year thereafter.
Controller	10 years	73	All controllers are to be replaced in the same year starting in 2025.
Field Network Switches	7 years	73	Begin upgrading on a seven-year cycle. (Assumes one per signal)
Traffic Signal Replacement	50 years	73	Full traffic signal replacement or new signals. (Assumes 5 upgrades per year)
Traffic Signal Upgrades – Poles and Mast Arms	50 years	73	Upgrades to existing traffic signal poles. (Assumes five upgrades per year)

Table 3 – Replacement Cycle Summary (Continued)

Equipment Type	Life-cycle Timeframe	# of Locations	Replacement Cycle Recommended
Traffic Signal Systems			
Traffic Signal Upgrades - LEDs, push buttons, etc.	10 - 15 years	73	Upgrades to existing traffic signal LED, Accessible Pedestrian Signal (APS) push buttons, and signal heads. (Assumes five upgrades per year)
Wire Re-Cabling	20 years	73	Begin upgrading on a 20-year cycle. (Assumes even number per year)
Traffic Signal Vehicle Detection Systems			
Vehicle Detection (in-pavement, video, radar) (per intersection)	10 years	73	Begin upgrading on a 10-year cycle. (Assumes even number per year)
Emergency Vehicle Preemption	10 years	73	Begin upgrading on a 10-year cycle (Assumes all signals have emergency vehicle preemption)
CCTV Camera Systems			
Cameras	7 years	146	Begin upgrading on a 7-year cycle with two cameras per intersection for a total of 146 cameras. (Assumes even number per year)
ATMS Software			
Traffic Management Software	10 years	1	Upgrade system every 10 years in coordination with controller replacement. Start replacement in 2025. Includes yearly $25K license fee each year ($400K for the system plus $250K for yearly fees).
ITS Communications Systems			
Communications and Connectivity (cellular, wireless, or fiber optic)	10 years	73	Begin upgrading on a 10-year cycle. (Assumes even number per year)
TMC Equipment			
Employee Overhead Equipment	10 years	1	Obtain one new set of equipment per year.

Source: CC_Transportation_20211203 Geodatabase, Douglas Reoccurring Work Report, and Transportation Technician RW Export

5.1.1 Assessment of Existing Signalized Intersection Age

An assessment of the current state of signalized intersections was conducted based on available data, including signalized intersection construction date and design support model information collected by Carson City as part of this project. Assumptions made to estimate the age of each signalized intersection with the available data include:

- All signal supports of an intersection were reviewed and the oldest timeframe from the available design support information was used when the construction date listed was older than the support model information provided. For example, if an intersection had a construction year of 1963 but the field review indicated signal pole supports from 1980-1985, 1980-1992, and 1986-2016, the year 1980 was used.
- The construction date provided in the signalized intersection information provided by Carson City was used in instances where the construction date fell within the design support model years denoted for the supports.
- Locations with missing design support model details used the construction date provided.

Two priorities were identified to determine which signalized intersections are in the most need for upgrades, these priorities are:

- **High Priority (Table 4):** Signalized intersections older than 50 years, recommended to be upgraded in the near-term as funding becomes available.
- **Medium Priority (Table 5):** Signalized intersections 40 to 49 years old, recommended to be upgraded in the mid-term as funding becomes available.

Prioritization of intersections or features should consider a balance between corridors with higher volumes and areas where there is a need for upgrades based on the asset's condition. Coordination with signal maintenance staff is recommended to further refine the lists provided in **Table 4** and **Table 5** based on those locations/devices that have the greater need and greatest impact on the network. Based on the available construction date and design support model timeframes, a total of seven intersections were categorized as High Priority while 16 were categorized as Medium Priority. Five signalized intersection replacements are recommended per year within the life-cycle analysis. CAMPO may choose to accelerate the replacement schedule as funding becomes available.

Table 4 – High Priority Intersections (Older than 50 Years)

Asset ID	Intersection	Approximate Age (Years)*
ITS.C.1001	Carson Street and 5th Street	52
ITS.C.1012	Carson Street and Washington Street	50
ITS.C.1014	Carson Street and Winnie Lane	51
ITS.C.1039	Stewart Street and Musser Street	50
ITS.D.1002	Hwy 50 and Hard Rock Hotel	51
ITS.D.1004	Hwy 50 and Kingsbury Grade Road	52
ITS.D.1016	US 395 and Mica Drive	52

** Age estimated from the construction date and design support model information provided by Carson City staff.*

Table 5 – Medium Priority Intersections (40-49 Years Old)

Asset ID	Intersection	Approximate Age (Years)*
ITS.C.1008	Carson Street and Long Street	43
ITS.C.1010	Carson Street and Musser Street	43
ITS.C.1011	Carson Street and Robinson Street	43
ITS.C.1013	Carson Street and William Street	43
ITS.C.1023	Hwy 50 and Airport Road	49
ITS.C.1027	Roop Street and 5th Street	43
ITS.C.1038	Stewart Street and 5th Street	43
ITS.C.1040	Stewart Street and Robinson Street	46
ITS.C.1046	William Street and Roop Street	48
ITS.C.1047	William St and Saliman Road	43
ITS.D.1001	Hwy 50 and Elks Point Road	43
ITS.D.1003	Hwy 50 and Kahle Drive	43
ITS.D.1005	Hwy 50 and Lake Parkway	43
ITS.D.1006	Hwy 50 and Zephyr Cove Resort	43
ITS.D.1007	Hwy 88 and Mottsville Lane	43
ITS.D.1014	US 395 and Jacks Valley Road	43

** Age estimated from the construction date and design support model information provided by Carson City staff. .*

Carson City's current Capital Improvements budget is $500,000. Based on the life-cycle timeframe, amount of equipment, and replacement cycle recommendations, Carson City, NDOT, and partner agencies should budget $8.2 million per year for equipment replacement and should increase the amount from year to year due to inflation. Therefore, an additional $7.7 million per year is required to provide adequate replacement of equipment. A detailed summary of the life-cycle costing analysis is included in **Appendix H.**

5.2 Operations and Maintenance

A review of Carson City's existing work orders was conducted to determine the amount of time existing staff take to operate and maintain the transportation system. The analysis of historical work orders yielded an annual maintenance time of 1,906 hours, of which 1,151 hours were directly related to maintaining the traffic signals for the region. Research on the FHWA best practices regarding signal operations and maintenance recommends that a total of 60 hours per signal should be spent annually on maintenance, as indicated in the FHWA *Traffic Signal Operations and Maintenance Staffing Guidelines*. The FHWA guidelines recommend that the 60 hours be divided into three categories of maintenance: 70% for preventative maintenance (42 hours), 25% for responsive maintenance (15 hours), and 5% for signal timing design modifications (3 hours). Considerations for complex intersections would require additional person-hours for those signals. With 73 signals, this equates to a total of 4,380 hours that are required to maintain the signal system, meaning Carson City would need to provide an additional 3,229 hours of signal maintenance to meet best practices.

Until recently, Carson City's two technicians maintained all 73 traffic signals, which equates to 36.5 signals per technician. A third technician (traffic systems foreman) was recently hired in 2023, but this technician is only expected to be in the field 30% of the time to provide oversight on construction, maintenance, and repairs with the rest of their time spent in the office. The large number of signals being maintained by each technician does not allow for proactive maintenance resulting in technicians maintaining signals in a reactive manner when issues do arise. Understanding that signal technicians do not work in the field full time, FHWA recommends that a total of 1,627 annual work hours be dedicated per signal technician to address signal maintenance efforts. With this estimate, Carson City would need two additional signal technicians (one senior traffic systems technician and one traffic systems technician) dedicated to maintenance of the system to ensure they can cover the additional 3,229 hours of signal maintenance required to meet FHWA best practices. This will ensure proactive maintenance of the system is taking place. The cost to hire two additional maintenance staff would be approximately $250,000. An additional position for a traffic systems engineer/signal operations engineer, estimated to cost $158,000 per year, is also recommended to oversee the network's performance and optimization described in **Section 6** as well as leading the signal timing program for the region. A detailed summary of the life-cycle costing analysis is included in **Appendix H.**

A peer cities survey was also conducted to determine how existing staffing conditions in CAMPO/Carson City compare with other cities of similar size (peer cities). From the survey, it was noted that the number of traffic systems technicians range from one to four. While some peer cities appear to meet the FHWA best practice, others are experiencing similar conditions as CAMPO. For example, Sparks, Nevada, one of the peer cities, needs additional signal maintenance staff. Sparks has 110 signals that are maintained by two signal technicians, in other conversations with the City of Sparks it was determined that their technicians also maintain other non-signal related assets therefore they are also in need of additional staff to ensure their system is proactively maintained. Peer cities survey results are located in **Appendix I**.

6. PERFORMANCE MEASURES AND BENCHMARKS

As part of the CATSMP, CAMPO desires to track the performance of its transportation network to support proactive traffic operations, assist with project prioritization, and measure the effectiveness of the corridor and signal related projects. This section documents work completed in collaboration with CAMPO to:

- Recommend performance measures and benchmarks based on available data
- Produce an initial base-year report with available data
- Develop a plan for regular reporting
- Develop a roadmap for the expansion of performance reporting

The recommended performance measures are based on a review of current performance reporting in Nevada and the United States and on what data is available to CAMPO.

6.1 CAMPO Performance Monitoring Corridors

To establish which data CAMPO should collect to monitor the performance of the area's transportation system, the team worked with CAMPO staff to identify road segments for initial performance reporting. These segments, shown in **Figure 5** and **Table 6**, are the region's more heavily traveled signalized corridors and were identified for performance measure data collection to help make informed decisions on capital project prioritization and to track incremental operational improvements. The corridor-level performance data will assist in the development and execution of monitoring goals through:

- Conducting before and after studies along a specific corridor or sub-corridor to document changes to traffic conditions before and after project implementation
- Measuring long-term corridor trends over time to determine if improvements are needed
- Comparing similar corridors to determine why they perform differently

The corridors were separated into coordinated and uncoordinated corridors based on the signal timing groups currently in place. Signal coordination is the process of synchronizing the start of the "green light" along major corridors to allow vehicles to travel together through multiple signals with minimal or no stops. While these are analyzed similarly, keeping the signals in a coordinated group makes for a more meaningful assessment of the corridor's performance.

Signal coordination within corridors may change over time, and CAMPO staff should collaborate with partner agencies through regular meetings to ensure data is consistent. It is also recommended that CAMPO staff focus performance management reporting efforts on more heavily traveled corridors or corridors with a higher density of traffic signals.

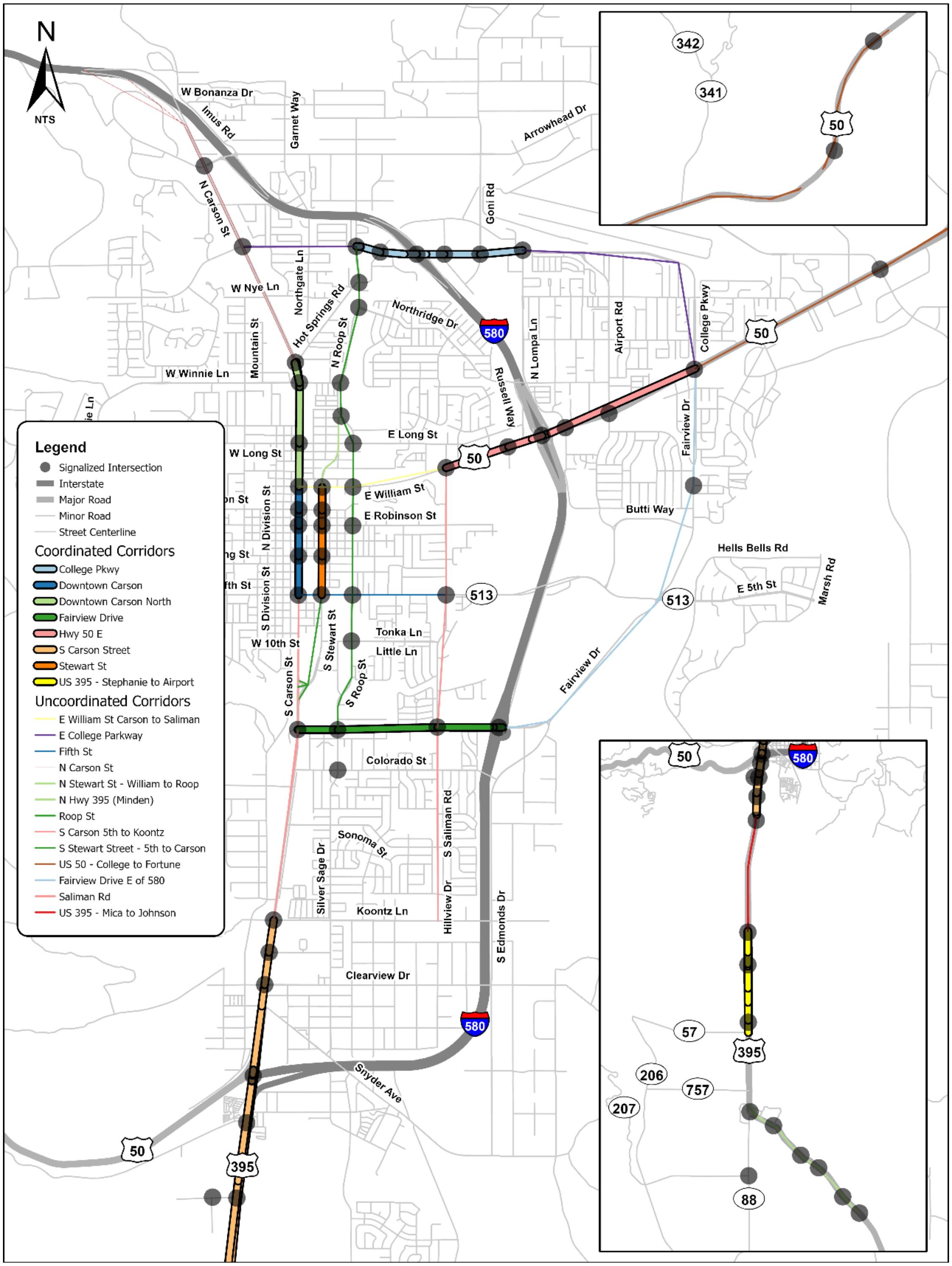


Figure 5 – CAMPO Performance Monitoring Corridors

Table 6 – Performance Monitoring Corridors

Corridor Name	Number of Signalized Intersections	Length (Miles)
College Pkwy* (North Roop Street to North Loompa Lane)	6	1.0
Downtown Carson* (William Street to 5th Street)	5	0.6
Downtown Carson North* (William Street to Hot Springs)	4	0.8
Fairview Drive* (Lincoln Highway to I-580)	4	1.2
Hwy 50 E* (Saliman Road to Fairview Drive)	6	1.6
S Carson Street* (Koontz Lane to Stephanie Way)	8	3.8
Stewart St* (East William Street to 5th Street)	5	0.6
US 395 - Stephanie to Airport*	3	6.3
E College Parkway (N Carson Street to Lincoln Highway)	4	2.2
US 50 (College Parkway to Fortune Drive)	4	6.3
E William Street (Carson Street to Saliman Road)	4	0.9
Fairview Drive E of 580	3	2.7
Fifth St (Carson Street to I-580)	4	0.9
N Carson St (Hot Springs to I-580)	3	4.2
N Hwy 395 (Minden)	6	7.9
N Stewart St (William Street to Roop Street)	2	0.5
Roop Steet (College Parkway to 5th Street)	11	2.9
S Carson (5th Street to Koontz Lane)	3	3.0
S Stewart Street (5th Street to Carson Street)	1	0.8
Saliman Rd (East William Street to Koontz Lane)	3	2.7
US 395 (Mica to Johnson)	2	6.2

Note: Signals located at corridor break points are counted in both corridors.
**Denotes coordinated groups*

6.2 Data Sources

Based on a review of readily available data to establish performance measures and benchmarks, the following datasets were identified as appropriate for CAMPO:

- **INRIX eXtreme Definition (XD) data:** CAMPO has free, unlimited access to INRIX XD data through NDOT's preexisting contract with the Regional Integrated Transportation Information System (RITIS), which acts as an interface and data store for INRIX. This data provides travel times.
- **Traffic Records Information Access (TRINA) data:** TRINA is NDOT's traffic volume database and is available for free.

Travel time data was weighted by traffic volumes within and across corridors to best capture system performance. **Figure 6** shows Average Annual Daily Traffic (AADT) by corridor for 2021. Details on how the data was accessed, updated, and analyzed are included in **Appendix J**.

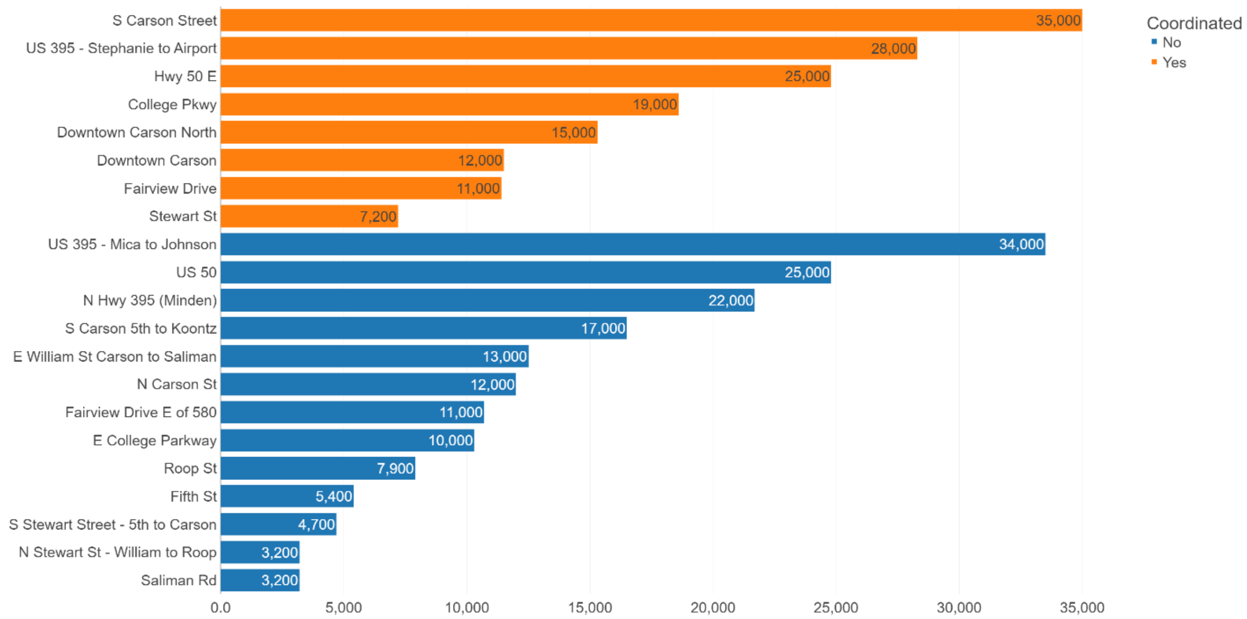


Figure 6 – CAMPO Corridor AADT from TRINA (2021)

6.3 Recommended Performance Measures

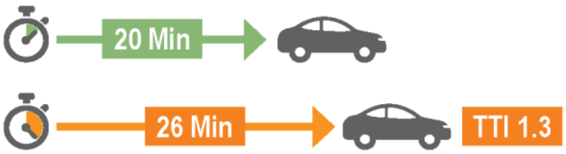
The Travel Time Index (TTI) and Planning Time Index (PTI) from INRIX data are recommended to track performance and prioritize future investments.

TRAVEL TIME INDEX (TTI)

Measures the unexpected delay or congestion experienced in a traffic versus a no-traffic situation. The TTI is the ratio of the travel time during the peak period to the time required to make the same trip at free-flow speeds.

SAMPLE SCENARIO

A **TTI** value of **1.3**, for example, indicates a **20-minute** free-flow trip requires **26 minutes**.



20 Minutes x 1.3 TTI = 26 Minutes

PLANNING TIME INDEX (PTI)

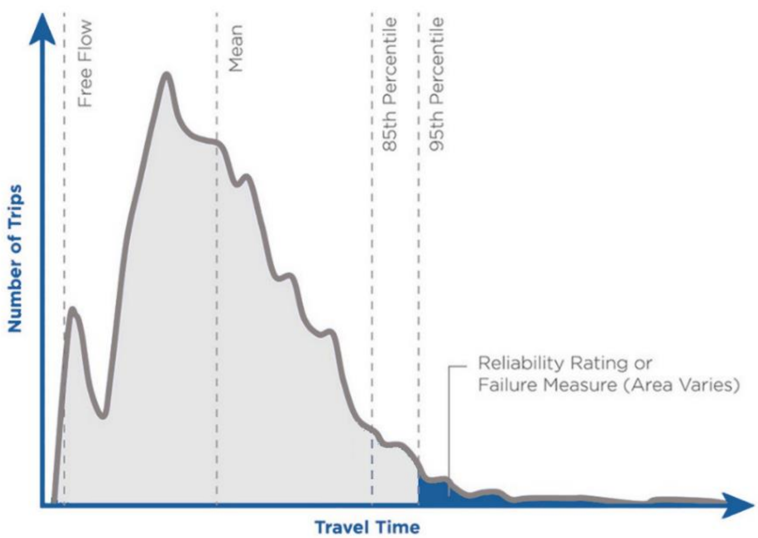
Measures the day-to-day variability of travel time experienced by drivers. It is calculated as the 95th percentile travel time compared to the free flow travel time. The 95th percentile is the 19th worst travel day in a month of 20 travel days.

SAMPLE SCENARIO

A **PTI** value of **2.0** suggests that travelers should budget **double** their free-flow travel time to reach their destination on time 95% of the time.

20 Minutes x 2.0 PTI = 40 Minutes

Figure 7 shows an example of which travel time records should be used for travel time reliability rating. Trips that fall within the 95th percentile of travel time are the typical samples used to accurately measure reliability. The data utilized for the analysis was limited to the 95th percentile or above.



Source: Incorporating Travel-Time Reliability into the Congestion Management Process, FHWA

Figure 7 – A Sample Travel-Time Distribution and Measures of Reliability

6.4 Peak Period Analysis

The TTI and PTI are most meaningful for the times of day with the most traffic. Since the travel patterns in the CAMPO region are such that different corridors experience peak hours at different times of the day, the average travel rate by time of day for each corridor was assessed to identify peaks in TTI and PTI, drawing upon feedback from CAMPO. In the two example corridors below, it can be seen that Downtown Carson peaks in the middle of the day (**Figure 8**) while Stewart Street has three different peaks during the day (**Figure 9**). A summary of the peak periods for the selected corridors is shown in **Table 7**.

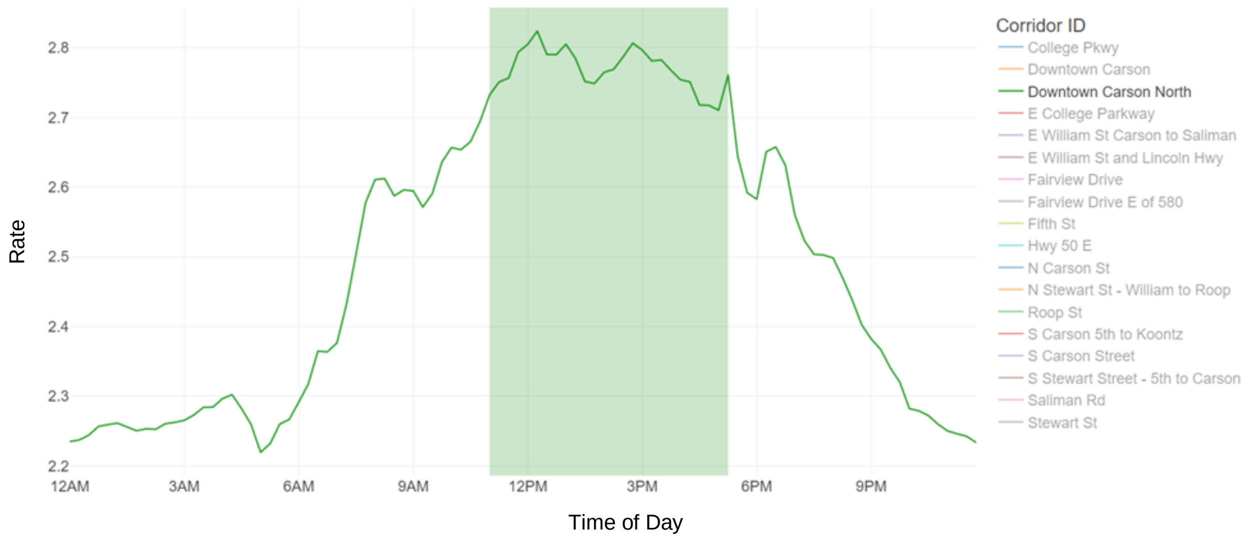


Figure 8 – Average Travel Rate by Time of Day – Downtown Carson North

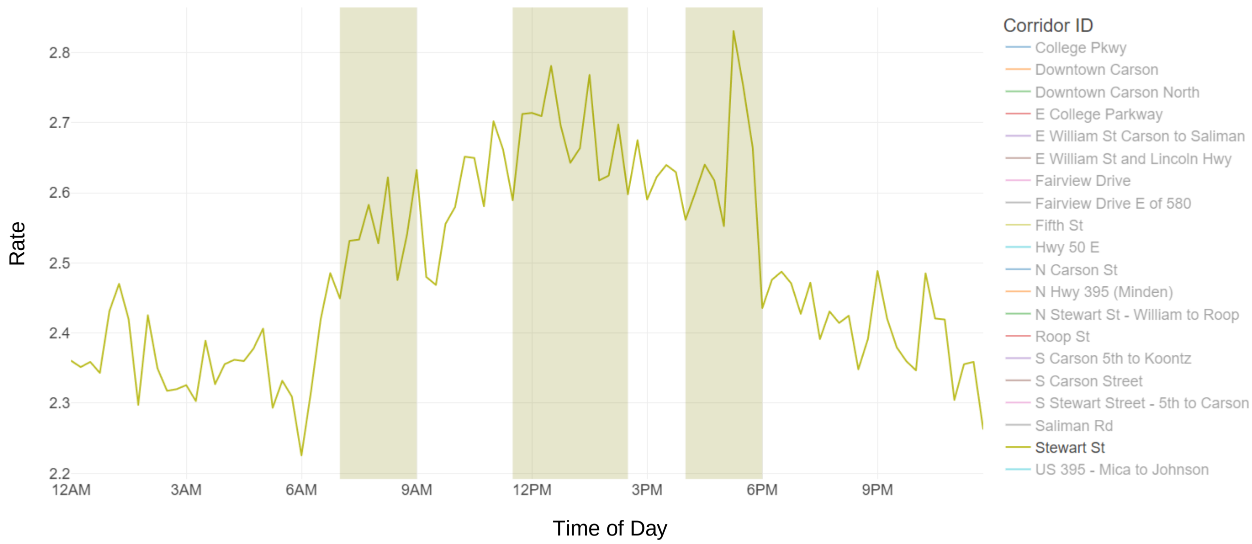


Figure 9 – Average Travel Rate by Time of Day – Stewart Street

Table 7 – Peak Periods by Corridor

Corridor Name	Peak 1 Start	Peak 1 End	Peak 2 Start	Peak 2 End	Peak 3 Start	Peak 3 End
College Pkwy	7:00 AM	9:00 AM	11:30 AM	2:30 PM	4:00 PM	6:00 PM
Downtown Carson	11:00 AM	3:00 PM	-	-	-	-
Downtown Carson North	11:00 AM	5:30 PM	-	-	-	-
Fairview Drive	7:00 AM	9:00 AM	1:00 PM	5:30 PM	-	-
Hwy 50 E	2:00 PM	6:00 PM	-	-	-	-
S Carson Street	12:00 PM	5:00 PM	-	-	-	-
Stewart St	7:00 AM	9:00 AM	11:30 AM	2:30 PM	4:00 PM	6:00 PM
US 395 - Stephanie to Airport	12:00 PM	5:00 PM	-	-	-	-
E College Parkway	7:00 AM	9:00 AM	1:00 PM	5:30 PM	-	-
US 50 (College to Fortune Drive)	2:00 PM	6:00 PM	-	-	-	-
E William St Carson to Saliman	2:00 PM	6:00 PM	-	-	-	-
Fairview Drive E of 580	7:00 AM	9:00 AM	1:00 PM	5:30 PM	-	-
Fifth St	7:00 AM	9:00 AM	1:00 PM	5:30 PM	-	-
N Carson St	11:00 AM	1:00 PM	3:00 PM	5:30 PM	-	-
N Hwy 395 (Minden)	12:00 PM	4:00 PM	-	-	-	-
N Stewart St - William to Roop	7:00 AM	9:00 AM	11:30 AM	2:30 PM	4:00 PM	6:00 PM
Roop St	7:00 AM	9:00 AM	3:00 PM	5:30 PM	-	-
S Carson 5th to Koontz	11:00 AM	3:00 PM	-	-	-	-
S Stewart Street - 5th to Carson	7:00 AM	9:00 AM	11:30 AM	2:30 PM	4:00 PM	6:00 PM
Saliman Rd	7:00 AM	9:00 AM	1:30 AM	4:00 AM	-	-
US 395 - Mica to Johnson	1:00 PM	5:00 PM	-	-	-	-

6.5 Calculation of Reference Speeds

The TTI and PTI metrics are based on the additional travel time over and beyond the free flow travel time. In its dataset, INRIX provides a reference speed for each segment, which is meant to capture free flow conditions. The TTI and PTI are highly sensitive to the selection of free flow speed, however, the review of reference speeds from INRIX revealed some room for improvement, especially for low-volume segments. INRIX provides an estimated speed for every segment and time period, but sometimes there is little or no real-time data to draw upon, depending on the density of INRIX's data sources. As a result, INRIX uses an algorithm to combine historical data, the speed limit, and any nearby real-time data to derive a travel time estimate, to which a confidence level is assigned.

Improper reference speeds can lead to outliers in the congestion data. As a result, new free flow speeds were calculated based on documented speed data. A sample of the INRIX reference speed for the low-volume segment on Dressler Lane near the California border along Highway 88 is shown in **Figure 10**. The top figure shows the average and reference speeds for one month. The vast majority of the time, actual speeds were much lower. Most of the periods where average speeds matched the reference speed are overnight or in the early morning. The bottom figure shows the same time period with the overnight periods omitted (9 PM to 6 AM) and periods where the INRIX confidence score was greater than 20 (out of a maximum of 30). Based on the remaining data, the actual speeds were lower and more representative of travel times on the corridor during the daytime. The free flow travel times shown in aqua were calculated as a rolling 80% percentile of the actual speeds.

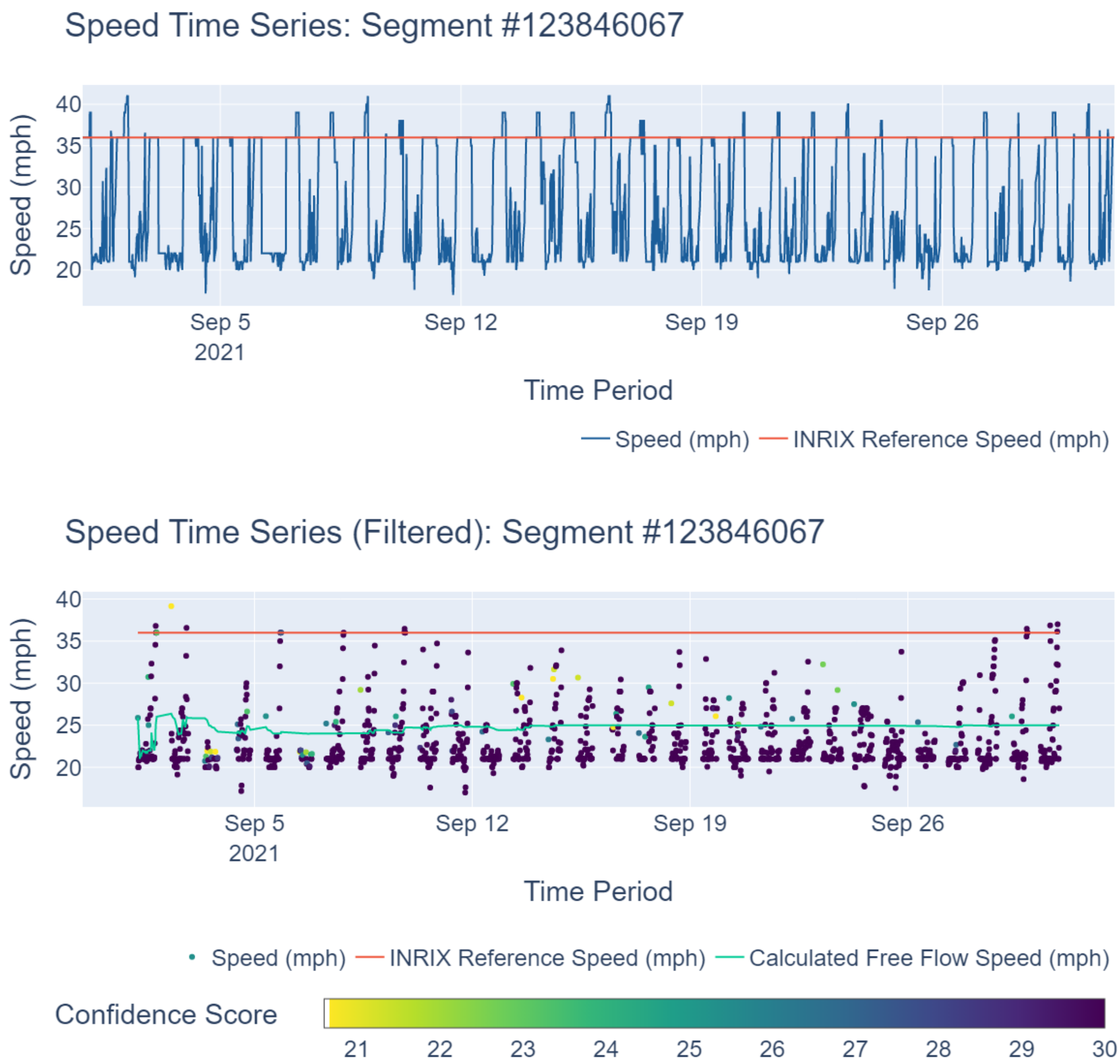


Figure 10 – INRIX Reference Speeds and Calculated Free Flow Speeds – Low Volume Segment

This is just one example, but it shows that for low volume roads, the INRIX reference speed can be too high, which overestimates congestion. There are other instances where the free flow speed was higher than the reference speed. A higher volume segment on US 50 East is shown in **Figure 11**. In this case, there was more data with high confidence scores, and the reference speed was much closer to the calculated free flow speed than in the previous example. However, the calculated free flow speed was higher than the reference speed, which resulted in slightly higher TTI values.

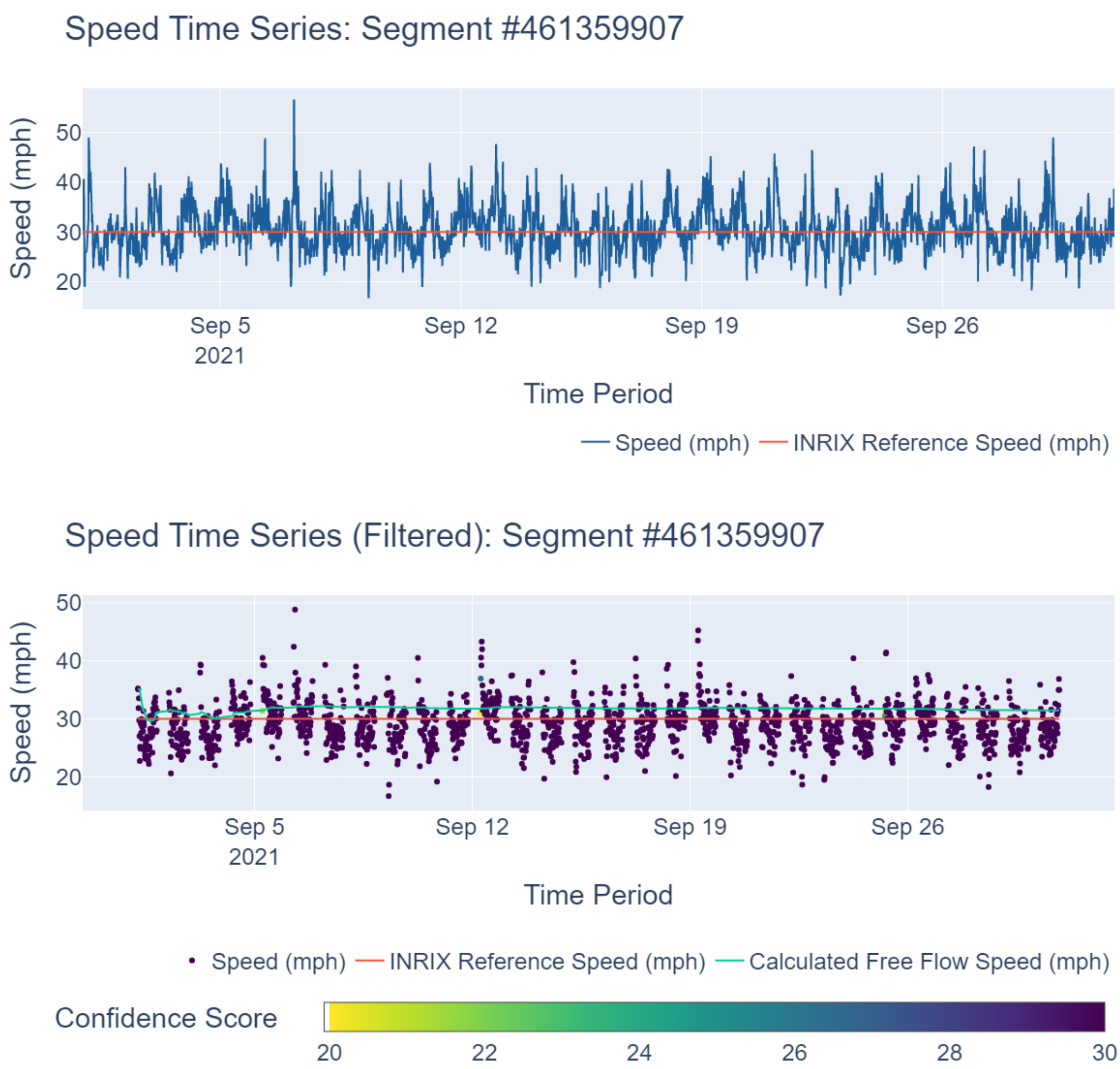


Figure 11 – INRIX Reference Speeds and Calculated Free Flow Speeds – High Volume Segment

6.6 Initial Base-Year Performance Report for CAMPO

6.6.1 Initial Performance Findings and Benchmarks

INRIX's XD segments, which range from one-tenth to one-mile in length, were combined to create the longer corridors listed in **Table 6**. Visualizing the performance of these shorter segments on a map can also be helpful, as they can show where bottlenecks or other congestion hot spots occur within the longer corridors. Corridor-level and segment-level performance are shown in the following two sections.

Corridor-Level Performance

A summary of the peak period TTI by corridor is shown in **Table 8**. TTI measures the unexpected delay or congestion experienced in traffic versus a no-traffic situation. The TTI is the ratio of the travel time during the peak period to the time required to make the same trip at free flow speeds. The average peak hour TTI for all the corridors analyzed was 1.15, and the range was from 1.05 to 1.31. Based on the annual peak period TTI, the four corridors with the highest TTI were:

- Fairview Drive East of 580
- Downtown Carson
- Highway 50 East
- College Parkway

Table 8 – Peak Period TTI by Corridor

Corridor Name	2021 AADT	Signals per Mile	2021 TTI	2022 TTI	Percent Change
Fairview Drive E of 580	10,700	1.1	1.45	1.31	-10.0%
Downtown Carson*	11,500	8.3	1.32	1.29	-2.1%
Hwy 50 E*	24,800	3.8	1.21	1.20	-1.1%
College Pkwy*	18,600	6.0	1.20	1.19	-0.9%
E William St Carson to Saliman	12,500	4.4	1.19	1.18	-0.6%
S Stewart Street - 5th to Carson	4,700	1.3	1.22	1.18	-3.0%
Downtown Carson North*	15,300	5.0	1.19	1.17	-1.3%
S Carson Street*	35,000	2.1	1.21	1.17	-3.2%
Stewart St*	7,200	8.3	1.15	1.16	0.3%
Saliman Rd	3,200	1.1	1.11	1.16	5.0%
Fifth St	5,400	4.4	1.15	1.14	-1.3%
Fairview Drive*	11,400	3.3	1.14	1.13	-1.0%
N Hwy 395 (Minden)	21,700	0.8	1.12	1.12	-0.7%
Roop St	7,900	3.8	1.13	1.12	-0.4%
S Carson 5th to Koontz	16,500	1.0	1.13	1.12	-0.9%
N Stewart St - William to Roop	3,200	4.0	1.13	1.11	-1.4%
N Carson St	12,000	0.7	1.12	1.10	-1.4%
US 395 - Stephanie to Airport*	28,300	0.5	1.08	1.09	0.8%
E College Parkway	10,300	1.8	1.08	1.07	-0.8%
US 395 - Mica to Johnson	33,500	0.3	1.06	1.06	0.4%
US 50	24,800	0.6	1.05	1.05	-0.3%
Total / Average			**1.16**	**1.15**	**-1.1%**

Note: Percent change is calculated based on non-rounded values for 2021 and 2022 TTI.
** - Denotes coordinated groups*

A summary of the peak period PTI by corridor is shown in **Table 9.** The PTI measures the day-to-day variability of travel time experienced by drivers. It is calculated as the 95th percentile travel time compared to the free flow travel time. The 95th percentile is the 19th worst travel day in a month of 20 travel days. A PTI over 1.0 indicates less predictable travel times from day to day. Unsurprisingly, the corridors with the most unpredictable travel are the same as those with the highest TTI.

Table 9 – Peak Period PTI by Corridor

Corridor Name	2021 AADT	Signals per Mile	2021 PTI	2022 PTI	Percent Change
Fairview Drive E of 580	10,700	1.1	1.74	1.63	-6.2%
Downtown Carson*	11,500	8.3	1.60	1.61	1.0%
Hwy 50 E*	24,800	3.8	1.46	1.48	1.1%
S Stewart Street - 5th to Carson	4,700	1.3	1.46	1.48	0.8%
College Pkwy*	18,600	6.0	1.44	1.47	1.8%
E William St Carson to Saliman	12,500	4.4	1.42	1.46	2.8%
Downtown Carson North*	15,300	5.0	1.41	1.45	2.4%
S Carson Street*	35,000	2.1	1.46	1.45	-0.6%
Saliman Rd	3,200	1.1	1.33	1.45	8.7%
Stewart St*	7,200	8.3	1.38	1.43	3.5%
Fairview Drive*	11,400	3.3	1.37	1.39	1.7%
Fifth St	5,400	4.4	1.37	1.39	1.5%
Roop St	7,900	3.8	1.35	1.38	2.3%
N Carson St	12,000	0.7	1.33	1.36	1.8%
N Hwy 395 (Minden)	21,700	0.8	1.34	1.37	1.9%
N Stewart St - William to Roop	3,200	4.0	1.35	1.37	1.2%
S Carson 5th to Koontz	16,500	1.0	1.35	1.37	1.3%
US 395 - Stephanie to Airport*	28,300	0.5	1.29	1.33	3.3%
E College Parkway	10,300	1.8	1.28	1.31	2.0%
US 395 - Mica to Johnson	33,500	0.3	1.27	1.31	3.1%
US 50	24,800	0.6	1.27	1.29	1.4%
Total / Average			**1.39**	**1.42**	**1.7%**

Note: Percent change is calculated based on non-rounded values for 2021 and 2022 PTI.
** - Denotes coordinated groups*

Segment-Level Performance

Beyond corridor-level analysis, drilling down into segment-level performance provides more specific detail on areas of congestion within corridors. This allows CAMPO to view more focused locations of poor performance within corridors, such as at freeway on-ramps, intersections, or along roads with many driveways and access points.

The average TTI by XD segment throughout the CAMPO study area from July 2020 to January 2023 is illustrated in **Figure 12**. Areas with the worst TTI are in the downtown area and on William Street. A separate analysis was done for PTI, and the results and conclusions are similar to TTI.

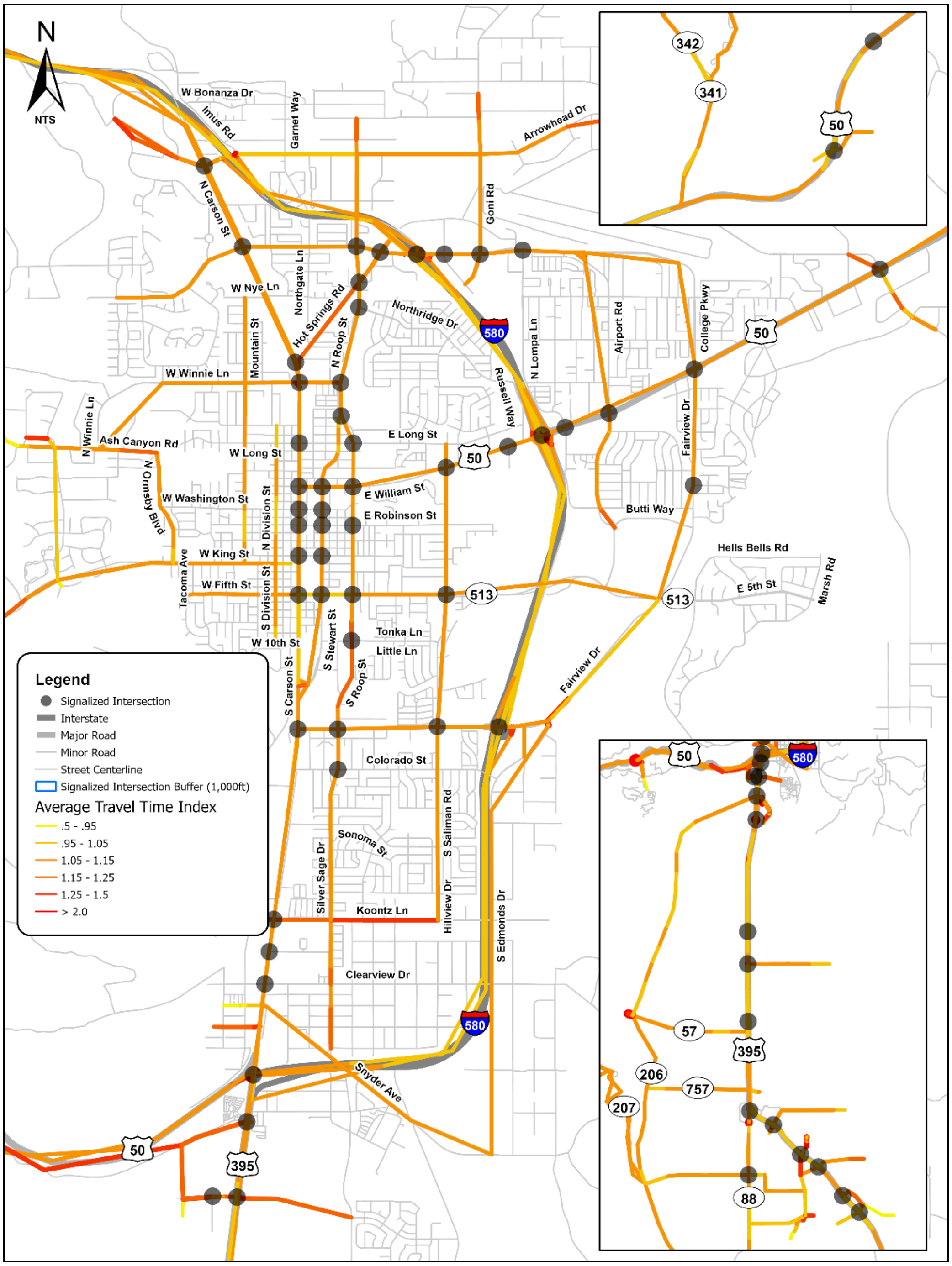


Figure 12 – XD Segment TTI

Discussion and Recommended Benchmarks

The base year performance, measured from July 2022 to January 2023, indicates that while congestion does not appear severe on major CAMPO corridors, specific areas and long-term trends should be monitored, especially after travel patterns stabilize post-pandemic. In 2022, the peak period TTI for all corridors was 1.15, and the peak period PTI for all corridors is 1.42, which indicates travel is "moderately unreliable." Travel in the winter months is also less reliable than the yearly average.

To establish performance benchmarks, it is helpful to baseline against other metropolitan areas across the United States. The FHWA has been reporting TTI for the largest Metropolitan Statistical Areas (MSAs) according to the United States Census since the 1980s. A summary of the TTI by population group for cities across the country is shown in **Figure 13**. With the exception of pandemic-affected travel in 2020, the average TTI across small population groups comparable in size to Carson City, was 1.14 over the most recent four-year period (2016-2019). These data are comparable to the 2021 and 2022 peak period TTI values for Carson City.

Table 1-70: Travel Time Index

Urban area	Population group	2016	2017	2018	2019	2020	Points change			
							Short-term		Long-term	
							Points	Rank[a]	Points	Rank[a]
Anchorage, AK	Small	(R) 1.19	(R) 1.19	1.19	1.18	1.07	-11	52	6	14
Beaumont, TX	Small	1.13	1.13	1.12	1.12	1.10	-3	3	7	10
Boise, ID	Small	1.16	1.16	1.16	1.18	1.05	-10	40	5	19
Boulder, CO	Small	1.21	1.21	1.22	1.22	1.08	-13	67	6	14
Brownsville, TX	Small	1.13	1.13	1.13	1.13	1.10	-3	3	9	5
Corpus Christi, TX	Small	1.13	1.13	1.13	1.13	1.11	-2	2	7	10
Eugene, OR	Small	1.17	1.17	1.16	1.15	1.07	-10	40	3	34
Greensboro, NC	Small	1.13	1.13	1.13	1.13	1.11	-1	1	9	5
Indio-Cathedral City-Palm Springs, CA	Small	1.10	1.10	1.10	1.10	1.05	-5	15	0	64
Jackson, MS	Small	1.13	1.13	1.13	1.13	1.07	-6	22	5	19
Lancaster-Palmdale, CA	Small	1.10	1.10	1.09	1.09	1.05	-5	15	0	64
Laredo, TX	Small	1.17	1.17	1.17	1.17	1.07	-10	40	5	19
Little Rock, AR	Small	1.13	1.13	1.13	1.14	1.10	-3	3	8	7
Madison, WI	Small	1.15	1.15	1.16	1.16	1.05	-10	40	-2	80
Oxnard-Ventura, CA	Small	1.16	1.16	1.16	1.16	1.05	-11	52	3	34
Pensacola, FL-AL	Small	1.17	1.17	1.16	1.16	1.07	-10	40	3	34
Poughkeepsie-Newburgh, NY	Small	1.11	1.11	1.10	1.10	1.07	-4	9	3	34
Salem, OR	Small	1.15	1.15	1.15	1.15	1.05	-10	40	2	45
Spokane, WA	Small	1.16	1.16	1.16	1.16	1.07	-9	39	-9	98
Stockton, CA	Small	1.15	1.15	1.16	1.17	1.10	-5	15	6	14
Winston-Salem, NC	Small	1.11	1.11	1.11	1.10	1.04	-7	27	1	56
494 Urban area average[b]	**494 Areas**	**1.23**	**1.23**	**1.23**	**1.23**	**1.09**	**-14**	**NA**	**-1**	**NA**
101 Urban area average[b]	**101 Areas**	**(R) 1.27**	**1.28**	**1.28**	**1.28**	**1.11**	**-16**	**NA**	**-1**	**NA**
Small area average[b]	**Small**	**1.14**	**1.14**	**1.14**	**1.14**	**1.07**	**-7**	**NA**	**3**	**NA**

Source: https://www.bts.gov/content/travel-time-index
Note: Small urban areas – less than 500,000 population.
NA = not applicable; R = revised.
a Rank is based on the calculated percent change with the highest number corresponding to a rank of 1.
b Averages weighted by Vehicle Miles Traveled.

Figure 13 – Travel Time Index for Select U.S. Cities by Size

As another point of reference, Wisconsin DOT (WisDOT) has established benchmarks for PTI. WisDOT tracks ten interstate corridors and 28 urban freeway and highway segments. The thresholds established by WisDOT are shown in **Figure 14.** Carson City travel is considered "moderately unreliable" over most corridors by these benchmarks.

Source: Benchmarking values obtained from WisDOT: https://wisconsindot.gov/Documents/projects/sfp/chap6.pdf

Figure 14 – PTI Benchmarking Values

In addition to comparisons with national averages, it is recommended that similar benchmarks to those used by WisDOT be established by comparing corridors in Carson City and evaluating corridor trends over time, considering contributing factors such as AADT and the density of traffic signals. The data is limited (it only goes back to June 2020) and, given the effects of the COVID-19 pandemic, is not sufficient to identify true year-over-year trends. Nonetheless, this will become more valuable once multiple post-pandemic years are available. It is possible, however, to compare across corridors. Similar corridors should have similar performance, all else being equal. Therefore, it can be informative for CAMPO to evaluate whether any corridors perform worse than their "peers" and, if so, investigate whether improvements can be made. For example, Fifth Street has worse performance than several other corridors, such as Stewart Street and Roop Street. Based on feedback from CAMPO, this is due to signal timing deliberately favoring the more heavily traveled north-south streets downtown compared to Fifth Street, which runs east-west. Such a case-by-case analysis would not be as feasible for a large metropolitan area with many corridors, but it is appropriate for a city like Carson City.

6.7 Plan for Regular Reporting

6.7.1 Internal Data Reporting Process

For CAMPO to develop a sustainable performance reporting workflow, it is recommended that staff regularly monitor and analyze the RITIS XD-derived performance data at the corridor and segment levels as sampled in the base year existing conditions. The general reporting process and responsibilities for the analysis of RITIS XD data include, but are not limited to, the following steps and technical requirements:

- Bi-annual download of RITIS XD data for CAMPO established corridors. (RITIS website, Excel)
- Raw XD travel time data management and running executable Python script (provided as part of this project) to calculate custom TTI and PTI and corridor/segment ranking metrics (Excel)
- Monitoring of travel time and congestion trends across time, including analysis of specific segment-level analysis to screen for degraded performance. (Excel, Geographic Information Systems [GIS])
- Operationalizing travel time and congestion performance findings into updating traffic signal systems and long-term capital planning. (Excel, GIS, CAMPO traffic systems)
- Creating reports for external stakeholders to visualize corridor performance. (Excel, GIS, Microsoft PowerBI)

A sample workflow is included in **Figure 15**, with additional details included in **Appendix J**.

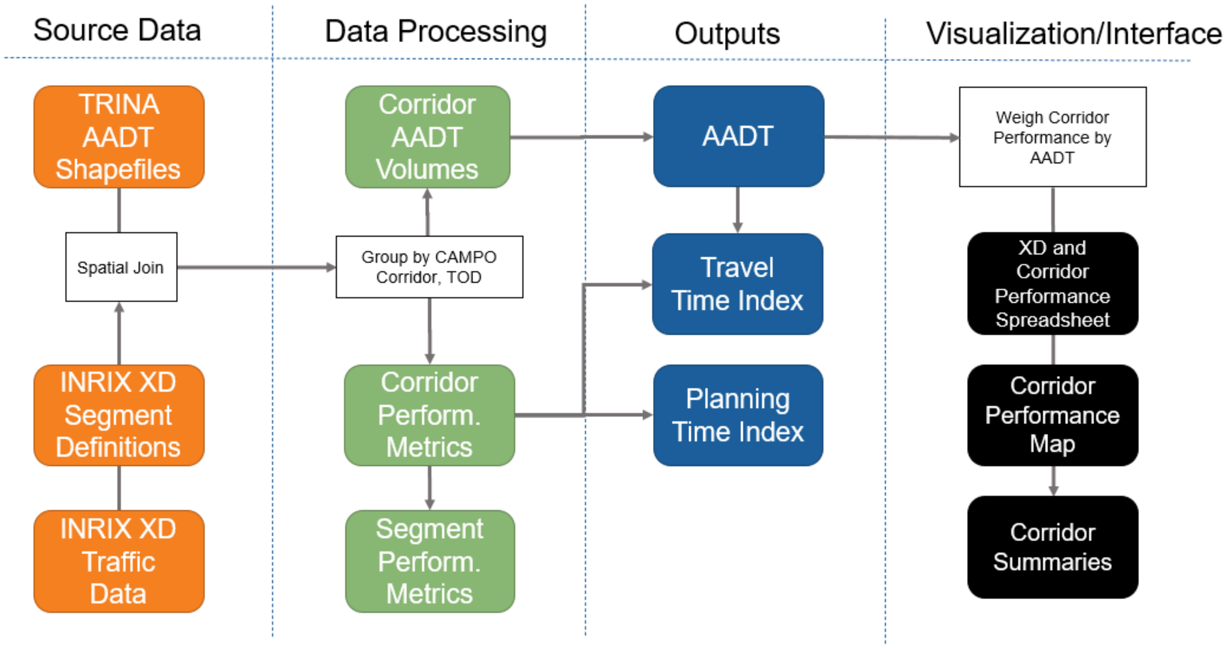


Figure 15 – Sample Workflow for Data Reporting Process

All tables and figures in this section pertaining to CAMPO were generated by the Python script developed as part of this project. The script aggregates the raw RITIS XD data so it can be analyzed in Excel while retaining route and segment data. With most of the data processing tasks automated, the primary outstanding task for CAMPO to conduct in a regular reporting regime is to contextualize and develop steps to convert the observations of travel time performance into traffic adjustments. For example, if CAMPO were to consistently monitor and address at least the bottom third worst-performing XD segments, this would develop a consistent workflow to improve performance over time. Over the longer term, CAMPO staff should identify capital needs where improvements cannot be made through operations improvements alone (i.e., additional technology or roadway capacity is required to ease demand on underperforming routes).

Staffing Needs and Level of Effort for Performance Reporting

Primary roles and responsibilities required for CAMPO staff include an initial effort spent on familiarization with the RITIS XD data and the data format. While the primary requirement is knowledge of the CAMPO route network, system responsibilities, and awareness of ongoing projects, some basic technical skills, such as experience in Excel and GIS, are desirable to extract the most value out of the RITIS XD data. Specific skills in Excel include merging datasets, lookups, pivot tables, and basic calculations, while GIS skills include mapping, visualization, symbology, and simple geoprocessing functions.

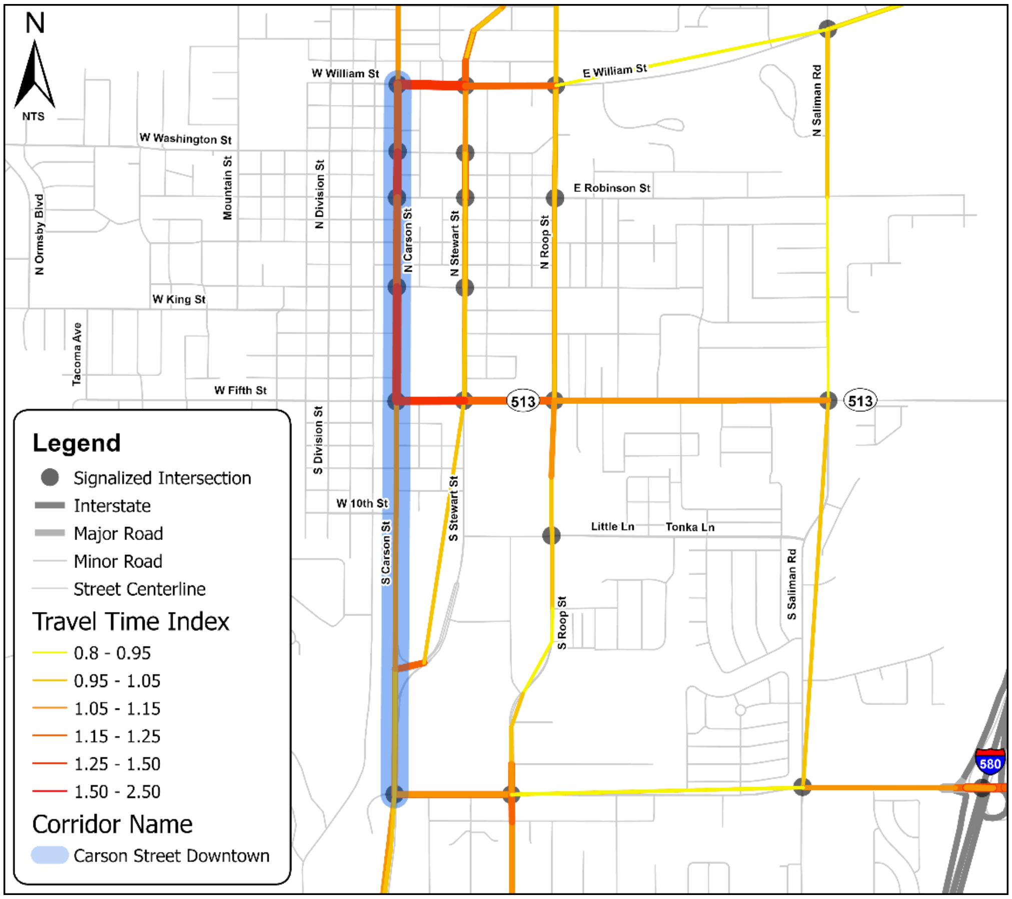
Depending on the desired frequency of reporting, the technical data can be processed by existing staff, such as a CAMPO transportation planner/analyst that has experience with data analysis and visualization. Bi-annual downloads and analysis of RITIS XD data are estimated to require six to eight hours of effort each and would include regular checks of travel time and congestion trends along the corridors defined in this study. With experience, this process could become more streamlined, and the level of effort could decrease. Additional external reporting maps and visualizations, such as those in PowerBI dashboards, could be applied once staff is familiar with the datasets.

Collaboration between a transportation planner/analyst responsible for the data monitoring and analysis and a transportation manager is also desirable with planned regular check-ins and strategy meetings. This will allow staff to coordinate on data findings, provide a quality control step for internal reporting, and provide a venue for review of long-term trends and policy interventions. Additionally, the transportation planner/analyst identifying travel or congestion performance data may not possess intimate details of traffic signal systems or best practices for traffic interventions in the CAMPO area of operations. As a result, a transportation manager may also need to review the data. These meetings and subsequent tasks for traffic engineer staff may require one to two hours per download, depending on the outcome of the bi-annual performance reporting. A description of the steps to download and process the data is included in **Appendix J**.

6.7.2 Prototype Base-Year Report

A prototype report with base year metrics for external reporting is included in **Figure 16.** The format of this prototype is intended to provide external stakeholders with a high-level overview of each CAMPO performance corridor, highlighting the most relevant metrics, figures, and contextual information in a sustainable and accessible format. The data from this prototype is directly associated with the dataset exports automatically calculated for all CAMPO corridors. These reports use only the performance data generated from the INRIX data and the calculations provided so they can be generated for all corridors.

CARSON STREET DOWNTOWN CORRIDOR PROFILE



DESCRIPTION

TRAVEL PERFORMANCE ON CARSON STREET DOWNTOWN CORRIDOR

The Carson Street Corridor Downtown Corridor extends from East William Street to Fairview Drive and is approximately 1.4 miles long. The corridor provides north-south access to downtown businesses including the Nevada State Legislature. There are 6 signalized intersections along the Carson Street Downtown Corridor.

PERFORMANCE

6 SIGNALIZED INTERSECTIONS

AVERAGE DAILY TRAFFIC (2021) = 12,200

2022 TTI = 1.13

TTI % CHANGE FROM 2021 = -1%

2022 PTI = 1.28

PTI % CHANGE FROM 2021 = -2%

WEEKDAY SPEEDS:

AM =17 MPH

PM = 15 MPH

Figure 16 – Prototype Corridor Performance Profile

6.8 Implementation Plan for Performance Reporting and Signal Retiming

Beyond the initial year performance report and metrics based on readily available data, another component of this project was to develop a roadmap for incorporating additional performance measures.

While travel time-based metrics based on INRIX data are an excellent starting point to assess transportation network performance, other metrics are also valuable, particularly for signal operations. For signalized arterials, capturing metrics such as the percentage of vehicles arriving on a green light, split failures, and the prevalence of phase max-outs or gap-outs is valuable. These metrics reveal aspects of signal operations that contribute to signal-based travel delays, which lead to increased corridor travel times. Tracking these signal related performance measures can help traffic engineers adjust timing plans to improve travel times and travel time reliability. In addition, accurate and reliable detection is needed to operate signals effectively and to capture many of these signal related performance measures. As a result, measuring the availability of detector data is valuable.

6.8.1 Automated Traffic Signal Performance Measures

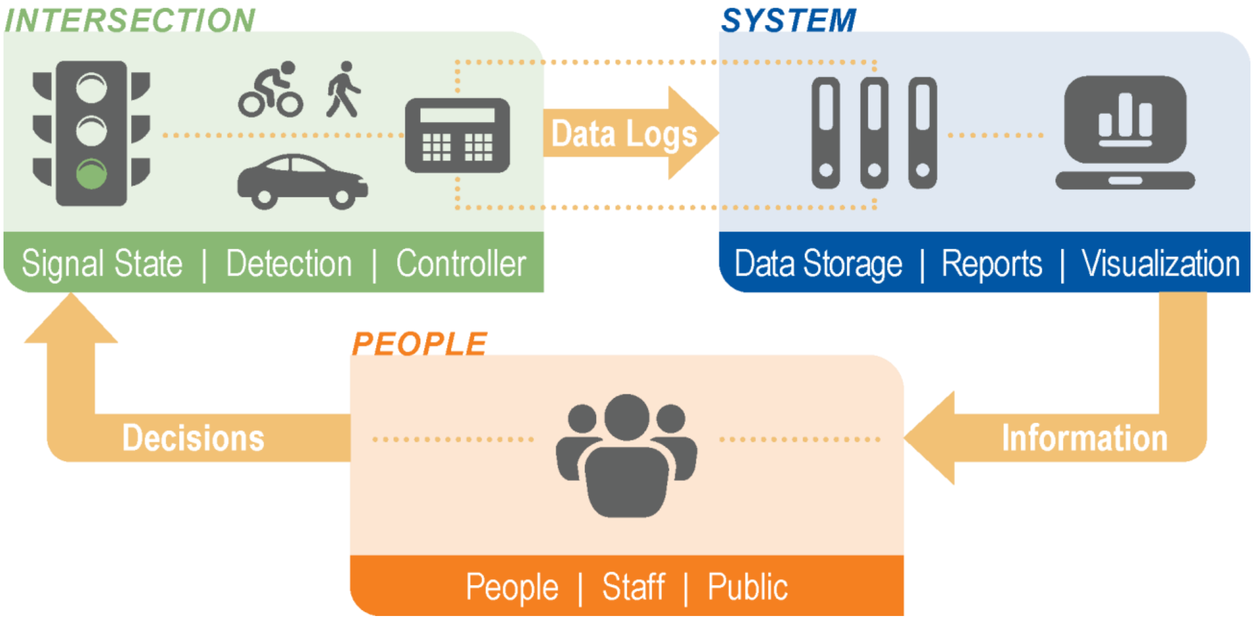
Automated Traffic Signal Performance Measures (ATSPM) have become an industry standard method for traffic signal performance reporting. ATSPMs are the product of industry collaboration between FHWA, state departments of transportation (DOTs), universities, and traffic signal vendors. At the present time, all modern signal controllers support ATSPMs, meaning they log a base set of signal related events with standard high-resolution (0.1-second resolution) event codes, which are common across controller platforms. The Utah DOT developed an open-source web application for agencies to adopt, which generates reports for various metrics that use these event codes. Metrics available in the open-source ATSPM application include percent arrivals on red (or green), phase termination, split failures, turning movement counts, and approach delay.

The Freeway and Arterial System of Transportation (FAST) in Southern Nevada, a division of the Regional Transportation Commission of Southern Nevada, is a pioneer agency that has implemented ATSPM at a selected group of intersections in the Las Vegas region. FAST uses the open-source ATSPM software developed by Utah DOT (refer to **Appendix K**).

It is not a big lift for a small or mid-sized agency to set up ATSPM, provided its traffic signals log the event codes and have reliable communications back to the application server. The following components are needed:

- Web/Application Server
- Database
- Utah DOT ATSPM Software installation and configuration
- Installation of data loader specific to the manufacturer(s) of traffic signals in the field

The ATSPM process, shown in **Figure 17,** transforms the high-resolution data logs from the signal controllers into visualizations that help inform staff to make decisions related to the traffic signal system.



Source: Modified from NCDOT Guide on ATSPM

Figure 17 – ATSPM System Components

The greatest effort is in the initial setup, which includes installing the software and configuring all intersections and detectors. While this can be time-consuming, it only needs to be completed once. After that, managing the servers and database are the primary ongoing administrative tasks.

The number and location of detectors at an intersection affect which ATSPMs can be calculated. For example, a split failure occurs when a phase cannot serve its entire demand in the green interval. ATSPM calculates split failures by measuring vehicle presence at the stop bar during the green interval and the first five seconds of red. If there is vehicle presence during both periods, it interprets that as a split failure for that phase and that cycle. Therefore, to calculate split failures for a phase, it needs stop bar detection for the lanes serving that phase. As another example, approach volume requires detection that can reliably measure vehicle counts, which could be advance detection or passage (just past the stop bar) detection. On the other hand, stop-bar presence detectors tend to undercount and do not make suitable volume detectors. They tend to be long (often as long as 40 feet) and therefore often fail to differentiate between vehicles. The detection requirements for different ATSPM metrics are summarized in **Table 10.**

Table 10 – Detection Requirements for ATSPMs

ATSPM	No Additional Detection	Advance	Stop Bar Presence	Stop Bar Count	Speed
Purdue Phase Termination	✓				
Split Monitor	✓				
Pedestrian Delay	✓				
Preemption Details	✓				
Purdue Coordination Diagram		✓			
Purdue Link Pivot		✓			
Turning Movement Counts				✓	
Purdue Split Failure			✓		
Approach Volume		✓			
Approach Delay		✓			
Arrivals on Red		✓			
Approach Speed					✓
Yellow and Red Actuations				✓	

Source: North Carolina Department of Transportation Guide On Automated Traffic Signal Performance Measures

While detectors are useful for signal operations performance measurement, their primary purpose is detecting vehicle presence for actuated signal control. Therefore, detector uptime is important for effective actuated signal operations and should be tracked as a maintenance-related performance measurement. Other maintenance-related performance metrics include communications uptime and the frequency with which the signal goes into flash mode. While staff time is required for the configuration and monitoring of the system, the ability to troubleshoot issues from the office can reduce the number of required troubleshooting trips to the field. Additionally, maintenance performance measures can be derived from ATMS reports.

6.8.2 Connected Vehicle Data

ATSPMs are a powerful tool for signal operations performance management. However, they are not without limitations. First and foremost is the reliance on adequate and reliable detector data. Traffic patterns at some signals do not warrant widespread detection, which limits the ability of ATSPMs to collect data for desirable metrics. Furthermore, they are not always reliable. Unreliable detectors can result in erratic performance data. In addition, they require configurations to be kept up to date. Changes in the field need to be reflected in the system configurations, or the data will not be accurate. This may include changing the location and type of detection or changes to phasing and lane layouts.

As vehicles become more connected, more data becomes available from vehicles, which can replace roadside detectors for some applications. Acquiring data from vehicles instead of detectors can reduce an agency's deployment and maintenance footprint. INRIX travel time data comes from connected vehicles, but more recently, trajectory data has become available as a product from other vendors. Trajectory data is a stream of points, with an identifier, latitude/longitude, and timestamp, which enables software to track the trajectory of individual vehicles. For traffic signal operations, trajectory data can capture individual vehicle delays, stops, etc., which can be used to derive ATSPM-type metrics without relying on detectors. This data represents a sample of the traffic stream, so it is not as complete as sensor data, but with sufficient market penetration, it can be representative of the traffic stream.

Trajectory data represent vehicle trips along urban arterials, portraying travel time, the number of stops, stop time, and stop location in detail. As a result, trajectory data can be used to evaluate the traffic signal control level of service at an intersection and the quality of signal coordination along an arterial.

Automated traffic signal performance measures based on vehicle trajectory data are developed through similar methodologies compared to traditional floating-car investigations. Nevertheless, as technologies advance, high-resolution trajectory data can be broadly obtained in an automated manner. Hence, trajectory based ATSPMs can be cost-effective for traffic signal performance evaluation and monitoring.

6.8.3 Traditional Traffic Counts and Signal Retiming

A third approach to ongoing performance monitoring and signal retiming relies on traditional methods. By revisiting signals in the network regularly, taking traffic counts, and retiming, Carson City can ensure timings do not stray too far from their optimal settings. This approach does not require additional infrastructure or software tools, nor does it require purchasing data. The new signal timings are comprehensive and address all phases and all times of the day. No specialized expertise is needed beyond what is available from any traffic engineering consultant. There are downsides to this approach, however. Timings are based on a few days of counts, which may not fully represent the traffic dynamics. Also, it does not take advantage of methods that can reveal opportunities for small changes (e.g., offset adjustment or split) that may impact operations.

6.8.4 Comparison of Approaches

The pros and cons of each approach are outlined in **Table 11**, displaying the estimated staff time required, and the estimated cost. There is no clear winner, and the preferred approach comes down to Carson City's comfort level with maintaining servers and database infrastructure and the prospects of the market for trajectory data. ATSPM requires continual investment in sustaining the system, but the other approaches can be implemented as projects as often as desired. Trajectory data can be purchased by subscription for a lower monthly cost, but it can also be purchased in limited amounts, such as a month, and used to analyze signal operations once per year or so.

Table 11 – Comparison of Performance Monitoring Approaches

	ATSPM	Trajectories	Traditional
Pros	▪ Detailed performance information ▪ Mature software ▪ Community support ▪ Many different metrics available ▪ Enables monitoring of detector health ▪ Enables tweaking to timing parameters without full retiming efforts.	▪ No additional infrastructure required ▪ Allows tracing of a vehicle through multiple signals ▪ Shows stops and slowdowns between signals	▪ No additional infrastructure required ▪ Comprehensive
Cons	▪ Ongoing configuration effort. Changes to field equipment require configuration updates. ▪ Requires additional detection for some metrics beyond what is used for operations ▪ A lot of data to manage and monitor	▪ Expensive for continuous data ▪ No mature software or analysis tools available—requires consultant or university support ▪ Emerging technology—marketplace is unstable	▪ Based upon turning movement counts at a snapshot in time ▪ Labor-intensive ▪ Expensive per signal—still need a way to prioritize which to retime each year
Staff Time	▪ Configuration, monitoring, interventions ▪ Approx 120 hrs/yr ▪ Approx 16 hrs/yr (implementation)	▪ Time to review analysis, interventions ▪ Approx 30 hrs/yr ▪ Approx 16 hrs/yr (implementation)	▪ Time to review analysis ▪ Approx 20 hrs/yr ▪ Approx 160 hrs/yr (implementation)
Costs	▪ $10k initial [1] ▪ $20k/yr (50 signals) [1] ▪ $40k/yr (analysis of areas to address) ▪ $16k/yr (retiming 2 signals/yr) [3] ▪ $8k/yr (staff time at $59/hr) ▪ $84k/yr (TOTAL ANNUAL)	▪ $10k/yr [2] ▪ $40k/yr (analysis of areas to address) ▪ $16k/yr (retiming 2 signals/yr) [3] ▪ $3k/yr (staff time at $59/hr) ▪ $69k/yr (TOTAL ANNUAL)	▪ $80k/yr (retiming 10 signals/yr) [3] ▪ $8k/yr (staff time at $38/hr) ▪ $88k/yr (TOTAL ANNUAL)

Note: 1 – Quote from Trafficware; 2 – Estimate from separate Wejo quote; and 3 – $8k/signal estimate from experience

6.8.5 Recommendations

As far as recommendations, none of these approaches are mutually exclusive. If Carson City can allocate the staff resources to set up and monitor ATSPM, setting it up and configuring a few key corridors could provide a good return on investment. By starting small, the agency can assess the value of the data to its operations and determine whether to invest in detection to derive additional performance measures. Many other agencies use this system, and an active community of users share experiences and ideas. The FHWA hosts a discussion forum that is an excellent resource to learn from other agencies' experiences.

With or without ATSPM, CAMPO can continue to work with university partners to apply trajectory data to assess signal timing operations. It is recommended that CAMPO procure connected vehicle data for a few critical timeframes (peak tourism seasons, during the Legislative Session, the start of the school year, etc.) and evaluate signal timing using trajectory data. For these periods, CAMPO could compare with ATSPM reports to better understand the strengths and weaknesses of each approach for its specific operations.

It is recommended that CAMPO keep abreast of the market for trajectory data from connected vehicles and performance software that makes use of this data for signal operations. Currently, few product offerings make it easy for agencies to ingest this data and report meaningful metrics. However, the industry is trending toward less infrastructure-dependent solutions. As a result, more cost-effective solutions should become available as the market grows and the costs for connected vehicle data decrease. That being said, as of this writing, the marketplace for this data is not well established, and start-up firms specializing in this area have not demonstrated a path toward profitability. Therefore, it is recommended that CAMPO be cautious about investing too much in a solution that relies on one particular provider.

Finally, none of the approaches limit CAMPO from periodic signal retiming. Congestion Mitigation and Air Quality funds are typically available for this, and while CAMPO does not qualify, there may be opportunities to partner with NDOT. While there are no generally agreed-upon rules for when retiming should take place, ATSPM and trajectory data allow for far greater insight into where timings are degrading or failing and where targeted improvements are most needed.

7. RECOMMENDATIONS

This section provides project recommendations that cover the findings from the review of physical elements, logistical elements, the Self-Assessment Workshop, life-cycle costing, and performance measures and benchmark tasks for this project. CAMPO should work closely with NDOT to ensure applicable recommendations from this study are incorporated into the plan for the Northern Nevada Traffic Management Center (NNTMC) currently being developed by NDOT.

7.1 Physical and Logistical Elements

Recommendations regarding the review of physical and logistical elements include:

- Maintain an accurate and up-to-date inventory of assets for the physical elements collected as part of this plan. Integration of transportation assets into Carson City's asset management strategy will help ensure program elements are maintained.
- Adopt formal Incident and Special Event Management Procedures. The Incident and Special Event Management Procedures should, at a minimum, identify the event originator, reviewing department, approver, implementation process, and timeline when the signals are to return to standard operations.
- Implement consistent language and terms among all signal systems covered under the existing agreements. It is recommended that all county and NDOT agreements be updated to have consistent agreement terms. The Douglas County agreement should be used as a starting point to update all county agreements, as this is the most recent agreement that was negotiated.
- Coordinate with District Attorney regarding interlocal agencies and Nevada Revised Statute 277A. CAMPO has recently experienced challenges with interlocal agencies and Nevada Revised Statute 277A, specifically with respect to NDOT purchasing signal equipment for Carson City to install in Lyon and Douglas Counties. CAMPO should work with their District Attorney to determine how to accomplish this efficiently.
- Provide instructions on how to read the signal timing plans (located in Appendix E) to consultants when signal timing requests are made. Instructions explaining how to read CAMPO's signal timing plans should increase the consultants' understanding of the plans.

7.2 Self-Assessment Workshop

It is recommended that CAMPO use the short-term (1-2 year) Self-Assessment actions as a starting point for tracking progress to move the transportation system management activities on a path toward continual, improved outcomes. Implementation of actions are dependent on funding and staffing availability. Recommended actions that can be started immediately are summarized below:

- Document formal processes/procedures
- Identify opportunities for intentional communication among departments
- Establish and conduct reoccurring meetings for collaboration with partner agencies on a quarterly basis
- Establish reoccurring meetings with the region on a quarterly basis – consider different levels (e.g., traffic technician versus engineering level)
- Identify and actively pursue opportunities for external funding

- Agencies collaborate to update standards and requirements for consistency in technology
- Identify planning for known deficiencies
- Establish what data should be collected and identify where systems and technology can be leveraged to collect that data
- Leverage and begin to use existing performance software (RITIS)
- Share data for efficiency between agencies
- Complete analysis focused on individual data elements to track incremental improvements

7.2.1 Mid-Term and Long-Term Actions

Recommended mid-term (3-5 years) and long-term (over 5 years) actions from the Self-Assessment Workshop are summarized below.

Mid-Term Actions

- Acknowledge that regional planning should include traffic operations as a priority and identify investments to support that priority
- Establish more coordination and investment by NDOT
- Identify the disconnect in funding sources with what needs to be funded
- Hire additional staff (planning/engineering/program management) to plan and secure funding

Long-Term Actions

- Provide external resources to assist partnering agencies with design and operations (regionally available engineer to assist other counties)
- Centralize data analysis and reporting
- Communicate to all traffic signals
- Identify roles and responsibilities of the local agencies in providing traveler information that can support state distribution

Many of the mid- and long-term recommendation should be considered by NDOT in the development of the NNTMC.

7.3 Life-Cycle Costing

Recommendations for the replacement of equipment on a routine basis were provided, and detailed replacement cycles by equipment type are summarized in **Section 5**. Based on the life-cycle timeframe, amount of equipment, and replacement cycle recommendations, Carson City, NDOT, and partner agencies should budget $8.2 million per year for equipment replacement and should increase the amount from year to year due to inflation. It is recommended that Carson City hire two additional maintenance staff (one senior traffic systems technician and one traffic systems technician) to provide proactive maintenance of the signal system based on an evaluation of current operation and maintenance practices and considerations on FHWA best practices. The two additional maintenance staff should spend 70% of their time on preventative maintenance, 25% of their time on response maintenance, and 5% of their time on signal timing design modifications. An additional position for a traffic systems engineer/signal operations engineer is also recommended to oversee the network's performance and optimization by applying the performance measure reporting techniques such as ATSPM and trajectory data and leading the signal timing program.

7.4 Performance Measures and Benchmarks for Tracking Traffic

It is recommended that bi-annual downloads and analyses of RITIS eXtreme Definition (XD) data be conducted as part of CAMPO's monitoring process. The downloads are estimated to take six to eight hours of effort each and would include regular checks of travel time and congestion trends along the corridors defined in this study. Additional external reporting maps and visualizations, such as those in PowerBI dashboards, could be applied once staff is familiar with the datasets.

Collaboration between a transportation planner/analyst responsible for the data monitoring and analysis and a transportation manager is also desirable with planned regular check-ins and strategy meetings. This will allow staff to coordinate on data findings, provide a quality control step for internal reporting, and provide a venue for review of long-term trends and policy interventions. These meetings and subsequent tasks for traffic engineer staff may require one to two hours per download, depending on the outcome of the performance reporting.

In addition to relying on INRIX data and creating quarterly performance reports, it is recommended that CAMPO consider implementing ATSPM or trajectory data to increase the granularity and diversity of the data available to assess signal operations. These approaches would allow CAMPO to collect information such as the percentage of vehicles arriving on a green light, split failures, and the prevalence of phase max-outs or gap-outs. Connected vehicle data can be used for studies now, but it is recommended that this be limited to period purchases of data for well-scoped studies rather than a subscription. It is recommended that CAMPO actively monitor the marketplace for connected vehicle data as it is emerging and still evolving.

APPENDIX A

TRANSPORTATION GEODATABASE SCHEMA

Supports - Feature Class

Field	DataType	Length	Alias	Description	Domain	DefaultValue	IsNullable	Precision	Scale
C_ID	String	20	eRPortal ID	C_ID			TRUE		
TAGID	String	20	Tag Number	TAGID			TRUE		
SUPTYPE	String	50	Support Type	SUPTYPE	SupportType		TRUE		
MASTARM	String	255	Mast Arm	MASTARM	SupportMastArmType		TRUE		
SUPPDESIGN	String	50	Design of support/model, etc.	SUPPDESIGN	SupportDesign		TRUE		
ATTSIGNS							TRUE		
HEAD	Integer	10	Number of Heads	HEAD			TRUE		
CAMERA	String	5	Camera Presence	CAMERA	YesNo		TRUE		
SUPPUSE	String	255	Support Use	SUPPUSE	SupportUseType		TRUE		
CONDITION	String	255	Condition	CONDITION	SupportCondition		TRUE		
GlobalID	GlobalID	38	GlobalID	GlobalID			FALSE		
PEDBUTTON	String	5	Pedestrian Crossing Buttons	Pedestrian Push Button	YesNo		TRUE		
INSTALLDATE	Date	8	Installation Date	INSTALLDATE		1899-12-30T00:00:00	TRUE		
SIGINT_C_ID	String	20	Signalized Intersection	Signalized Intersection			TRUE		
SIGCROSS_C_ID	String	20	Signalized Crossing	Signalized Crossing			TRUE		

Cameras – Table

Name	Cameras
AliasName	Cameras
HasAttachments	FALSE
Description	Cameras

Field	DataType	Length	AliasName	Description	Domain	DefaultValue	IsNullable	Precision	Scale
C_ID	String	20	eRPortal ID	C_ID			TRUE		
SUPPORT_C_ID	String	20	Supports ID	SUPPORT_C_ID			TRUE		
CAMERATYPE	String	50	Camera Type	CAMERATYPE	CameraType		TRUE		

PushButtons – Table

Name PushButtons
AliasName PushButtons
HasAttachments FALSE
Description PushButtons

Field	DataType	Length	AliasName	Description	Domain	DefaultValue	IsNullable	Precision	Scale
C_ID	String	20	eRPortal ID	C_ID			TRUE		
SUPPORT_C_ID	String	20	Supports ID	SUPPORT_C_ID			TRUE		
BUTTONTYPE	String	20			ButtonType				

Supports_Cameras_REL – RelationshipClass

Name Supports_Cameras_REL
Cardinality OneToMany
IsAttributed FALSE
IsComposite TRUE
ForwardPathLabel Cameras
BackwardPathLabel Supports
Description Supports_Cameras_REL

Origin Class Name	Origin Primary Key	Origin Foreign Key
Supports	C_ID	SUPPORTS_C_ID
Destination Class Name	**Destination Primary Key**	**Destination Foreign Key**
Cameras		

Supports_PushButtons_REL – RelationshipClass

Name	Supports_PushButtons_REL
Cardinality	OneToMany
IsAttributed	FALSE
IsComposite	TRUE
ForwardPathLabel	PushButtons
BackwardPathLabel	Supports
Description	Supports_PushButtons_REL

Origin Class Name	Origin Primary Key	Origin Foreign Key
Supports	C_ID	SUPPORTS_C_ID
Destination Class Name	**Destination Primary Key**	**Destination Foreign Key**
PushButtons		

SupportDesign - Domain

DomainName	SupportDesign
FieldType	String
Domain Type	CodedValue

The associated domains will be populated by CAMPO with known pole types with sufficient context to capture the era via specification (i.e., NDOT Type 35 R1998, where the R(YEAR) being the revision of the NDOT standard drawing.

Code	Name

SupportCondition - Domain

DomainName SupportCondition
FieldType String
Domain Type CodedValue

Code	Name
Good	Good
Fair	Fair
Poor	Poor
Critical	Critical

CameraType - Domain

DomainName CameraType
FieldType String
Domain Type CodedValue

Code	Name
Surveillance	Surveillance
Detection	Detection
Both	Both

ButtonType - Domain

DomainName	ButtonType
FieldType	String
Domain Type	CodedValue

Code	Name
Mechanical	Mechanical
Solid State	Solid State
Accessible	Accessible

Signs - Table

Field	DataType	Length	AliasName	Description	Domain	DefaultValue	IsNullable	Precision	Scale
C_ID	String	20	eRPortal ID	C_ID			TRUE		
ATTACHID							TRUE		
SIGNTYPE	String	50	Sign Type	SIGNTYPE	SignType		TRUE		
SIGNTEXT	String	100	Text	SIGNTEXT			TRUE		
FACING	String	30	Facing Direction	FACING	Direction		TRUE		
CONDITION	String	50	Condition	CONDITION	SignCondition		TRUE		
ILLUMINATED	String	5	Illuminated	ILLUMINATED	YesNo		TRUE		
SIGNREFLECT	String	50	Sign Retroreflectivity	SIGNREFLECT	SignReflect		TRUE		
MUTCD	String	130	Style	MUTCDSTYLE	SignCode		TRUE		

Supports_Signs_REL – RelationshipClass

Name	Supports_Signs_REL
Cardinality	OneToMany
IsAttributed	FALSE
IsComposite	TRUE
ForwardPathLabel	Signs
BackwardPathLabel	Supports
Description	Supports_Signs_REL

Origin Class Name	Origin Primary Key	Origin Foreign Key
Supports	C_ID	SUPPORTS_C_ID
Destination Class Name	**Destination Primary Key**	**Destination Foreign Key**
Signs		

SignCondition - Domain

DomainName SignCondition
FieldType String
Domain Type CodedValue

Code	Name
Good	Good
Fair	Fair
Poor	Poor
Critical	Critical

SignReflect - Domain

DomainName SignReflect
FieldType String
Domain Type CodedValue

Code	Name
Pass Excellent	Pass Excellent
Pass Mediocre	Pass Mediocre
Fail	Fail

Signalized Crosswalk - Feature Class

Field	DataType	Length	AliasName	Description	Domain	DefaultValue	IsNullable	Precision	Scale
Street	String	255	Street	Street			TRUE		
Notes	String	255	Notes	Notes			TRUE		
C_ID	String	20	Crosswalk Identifier	C_ID			TRUE		
Description	String	255	Description of signalized crosswalk type	Description			TRUE		
CROSSINGTYPE	String	50	Crossing Type	Crossing Type	CrossingType		TRUE		
LIGHTING	String	5	Crosswalk Lighting	Lighting at marked or better crosswalks	YesNo		TRUE		
CROSSMATTYPE	String	50	Crosswalk Material	Crosswalk Material	CrosswalkMaterial		TRUE		
POWER	String	50	Power	Power	Power		TRUE		

CrossingType - Domain

DomainName	CrossingType
FieldType	String
Domain Type	CodedValue

Code	Name
RRFB	RRFB
HAWK	HAWK
Beacon	Beacon
Embedded LED	Embedded LED

Power - Domain

DomainName	Power
FieldType	String
Domain Type	CodedValue

Code	Name
Solar	Solar
Utility	Utility

APPENDIX B

LIDAR DATA COLLECTION SUMMARY, TABLES, AND INVENTORY MAPS

Table 1 – Elements Collected/Reviewed with LiDAR

Elements	Actual Number Collected/Reviewed
Signalized Intersection	73
Signalized Pedestrian Crossings	22
Flashing Beacons*	21
Radar Speed Feedback Signs	10
Signal Related Supports (with attributes extracted from LiDAR data)	367
Supports (manually collected in the field)	105
Supports Reviewed (new supports and supports that were updated from dataset provided by Carson City)	653
Signs	1,172 (*Total of 8,385 signs*)

**Flashing beacons include school flashers and some advance signal warning beacons.*

Table 2 – Detailed Summary of Supports Collected/Reviewed

Support Type	Supports Added/Modified/Updated
Crosswalk Supports	92
Flashing Beacons	21
Radar Speed Feedback Sign Supports	10
Sign Supports	223
Signal Supports	367
Ped Signal Supports at Intersections	30
Streetlights/Utility	3
Update No: Location Issue	2
Update No: Not Found	10
Total	**758**

Table 3 – Traffic Signal Related Supports Camera Presence

Camera Present	Number
Yes	267
No	211
Total	**478**

Source: CC_Transportation_20211203 Geodatabase

Table 4 – Mast Arm Type

Mast Arm Type	Number
Single	313
Double	8
Total	**321**

Source: CC_Transportation_20211203 Geodatabase

Table 5 – Design Support/Model Type

Design Support/Model	Number
14 (1980-Current)	2
19 (1971-1979)	2
1A (1998-Current)	74
1A-Custom 15’	8
1B (1998-Current)	30
20 (1980-1992)	25
23 (1971-1979)	1
24 (1971-1979)	3
28 (1980-2016)	14
30 (1980-1985)	3
30 (1986-2016)	14
30 (2017-Current)	6
30A (1986-2016)	2
30A (2017-Current)	1
30B (2017-Current)	1
35 (1980-1985)	24
35 (1986-2016)	113
35 (2017-Current)	1
35A (1986-2016)	70
35A (2017-Current)	12
35B (2017-Current)	4
45 (1975-1992)	6
5 (1971-1979)	1
5A (1980-1992)	4
6 (1971-1979)	8
6A (1980-1992)	10
7 (1971-Current)	43
7 Safety (1971-Current)	200
Braced 3-Point Sign	2
Commercial	6
Decorative dual HPS 250W	8
DMS	1
High Mast	2
NVE Streetlight	3
Overhead Structural Frame	13

Source: CC_Transportation_20211203 Geodatabase

Table 5 – Design Support/Model Type (Continued)

Design Support/Model	Number
Ped Post	53
Post top	3
Round Sign Post	77
Safety Post 30' (2015-Current)	43
Sign Gantry	2
Sign Structure	2
Square Commercial	5
Sternberg Birmingham 30'	2
Telespar	209
Type 10 ?	1
Type 20 cropped custom banner pole	2
Wood Utility	8
Unknown	49
Total	**1,173**

Source: CC_Transportation_20211203 Geodatabase

Table 6 – Traffic Signals by County

County	Number of Signals
Carson County	49
Douglas County	20
Lyon County	2
Storey County	2
Total	**73**

Source: Geodatabase from January 19, 2022

Table 7 – Signal Head Summary

Signal Head Type	Number
Traffic Signal Head	1,177
Pedestrian Head	484
Total	**1,661**

Source: LiDAR Data Collection

Table 8 – Traffic Signal Cabinet Specifications

Cabinet Type	Number
NEMA 1	2
NEMA 3	41
NEMA 3R	44
NEMA TS1	66
NITS	8
Service Pedestal	65
Unknown	3
Total	**229**

Source: Geodatabase from January 19, 2022

Table 9 – Traffic Cabinet Types

Cabinet Type	Number
Ground Mount	145
Pole Mount	6
Wall Mount	77
Unknown	1
Total	**229**

Source: Geodatabase from January 19, 2022

Table 10 – Vehicle Detection System 1

Detection System Type	Number of Intersections
Iteris Next (Video)	1
Iteris Plus	4
Iteris Vantage Edge2 (Processor for Video)	56
Loops	6
Traficon VIP (Vehicle Presence Detection Board - Video)	5
Wavetronic Smart Presence (radar)	1
Total	**73**

Source: Signalized Intersection Cabinets and Detection Excel File from May 21, 2021

Table 11 – Vehicle Detection System 2

Detection System Type	Number of Intersections
Iteris Vantage Vector	1
Loops	6
N/A	64
Wavetronix Smart Advance	1
Wavetronix Smart Presence	1
Total	**73**

Source: Signalized Intersection Cabinets and Detection Excel File from May 21, 2021

Table 12 – Sign Reflectivity

Reflectivity	Number
Pass Excellent	105
Pass Mediocre	542
Fail	103
Fail – Obstructed	3
N/A (Illuminated Signs)	161
Unknown (Manually Collected in Field)*	258
Total	**1,172**

**Note: Only the signs collected by LiDAR had sign reflectivity recorded, the 258 signs collected manually did not have sign reflectivity measured as they were collected during daylight conditions.*

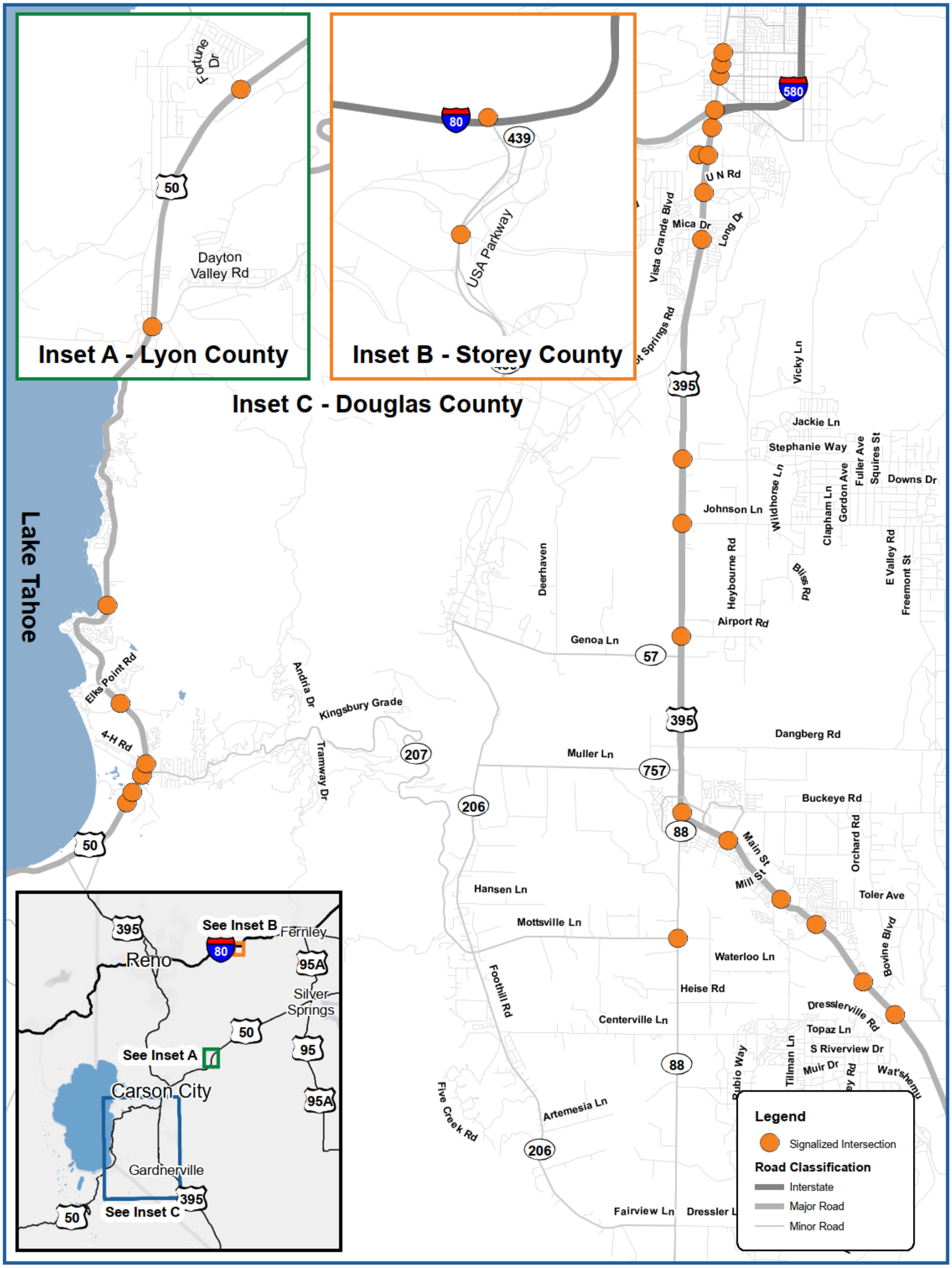


Figure 1 – Traffic Signal Locations in Rural Counties

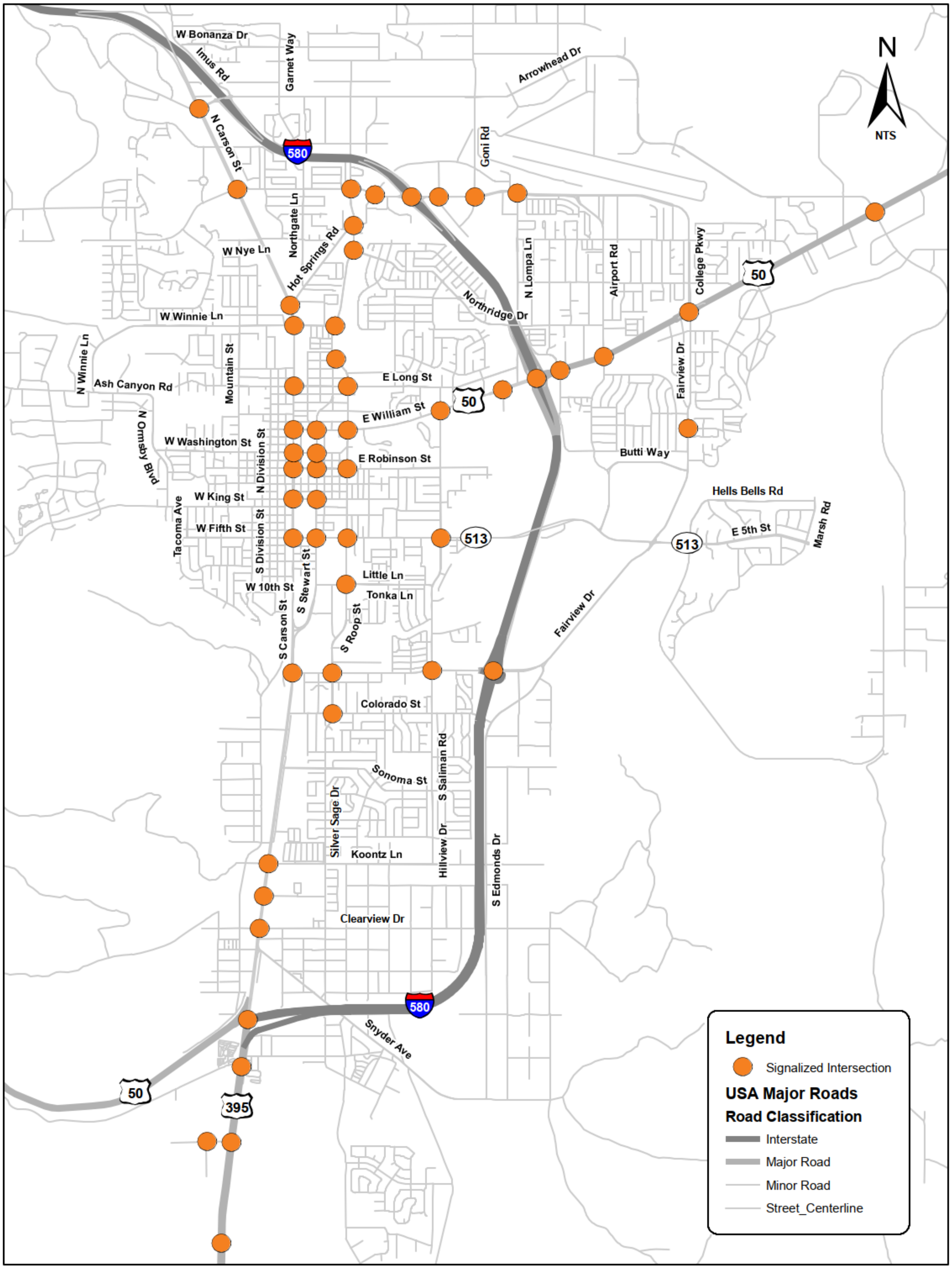


Figure 2 – Carson City Traffic Signal Locations

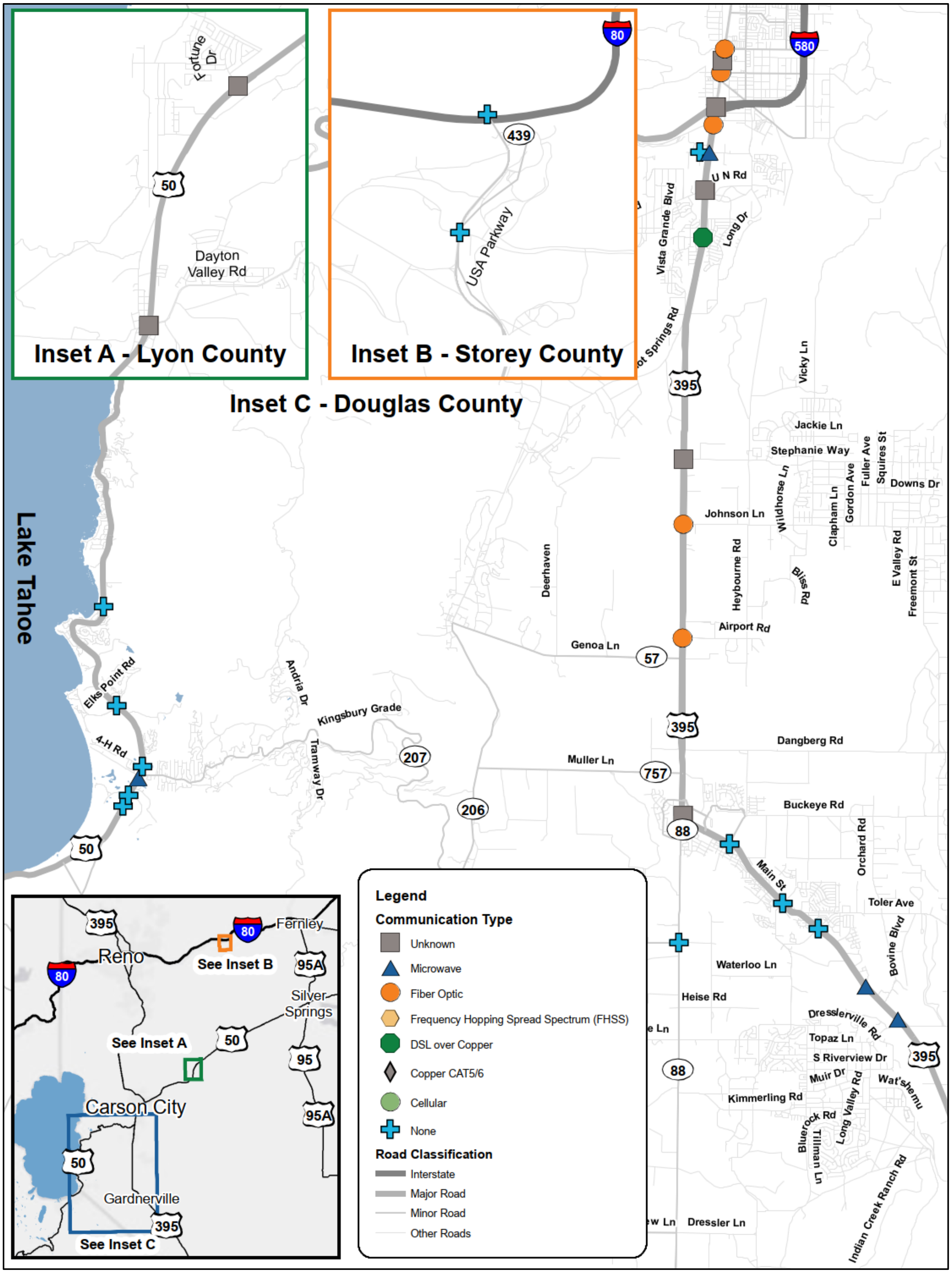


Figure 3 – Signal Communication Types in Rural Counties

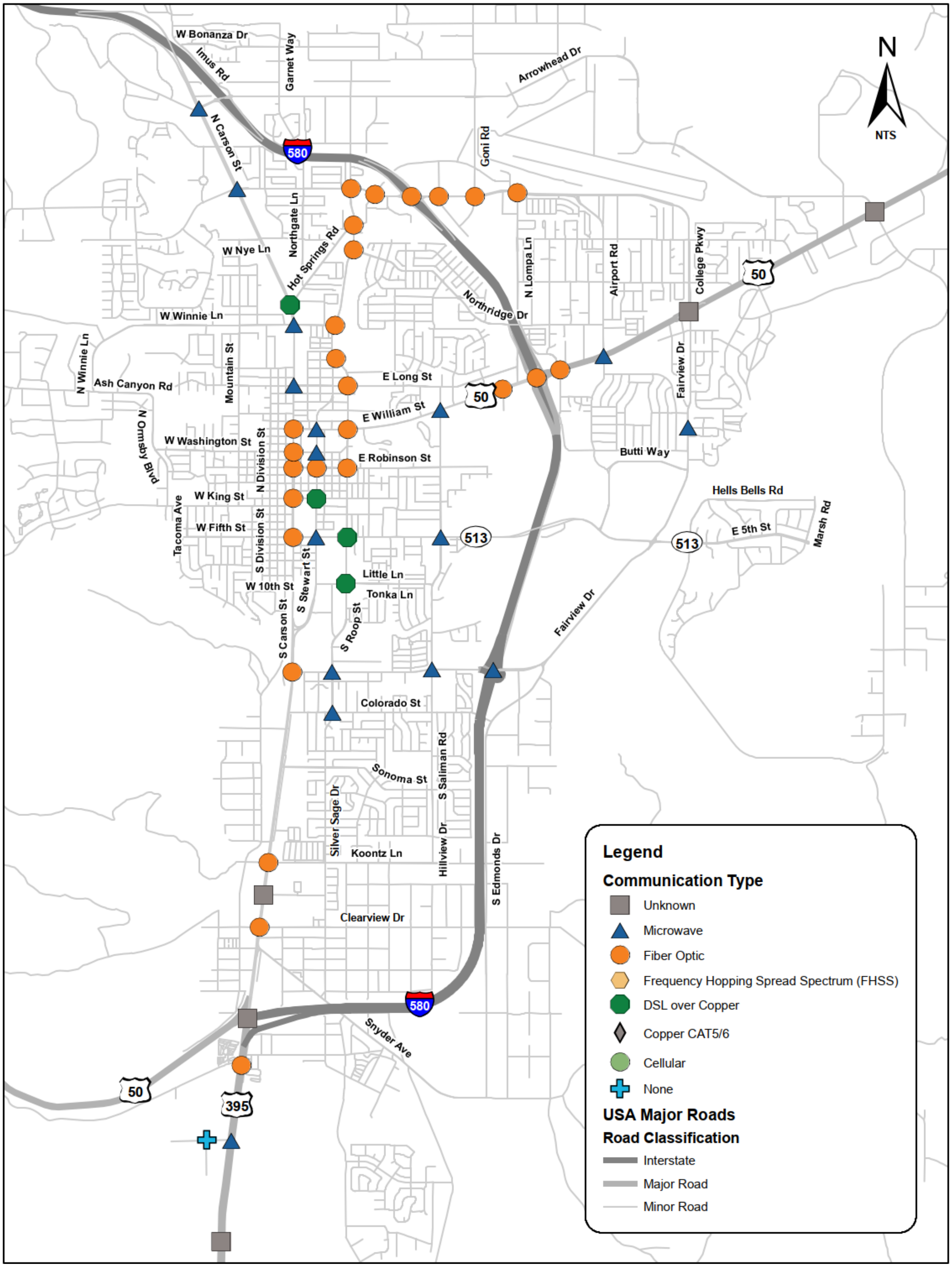
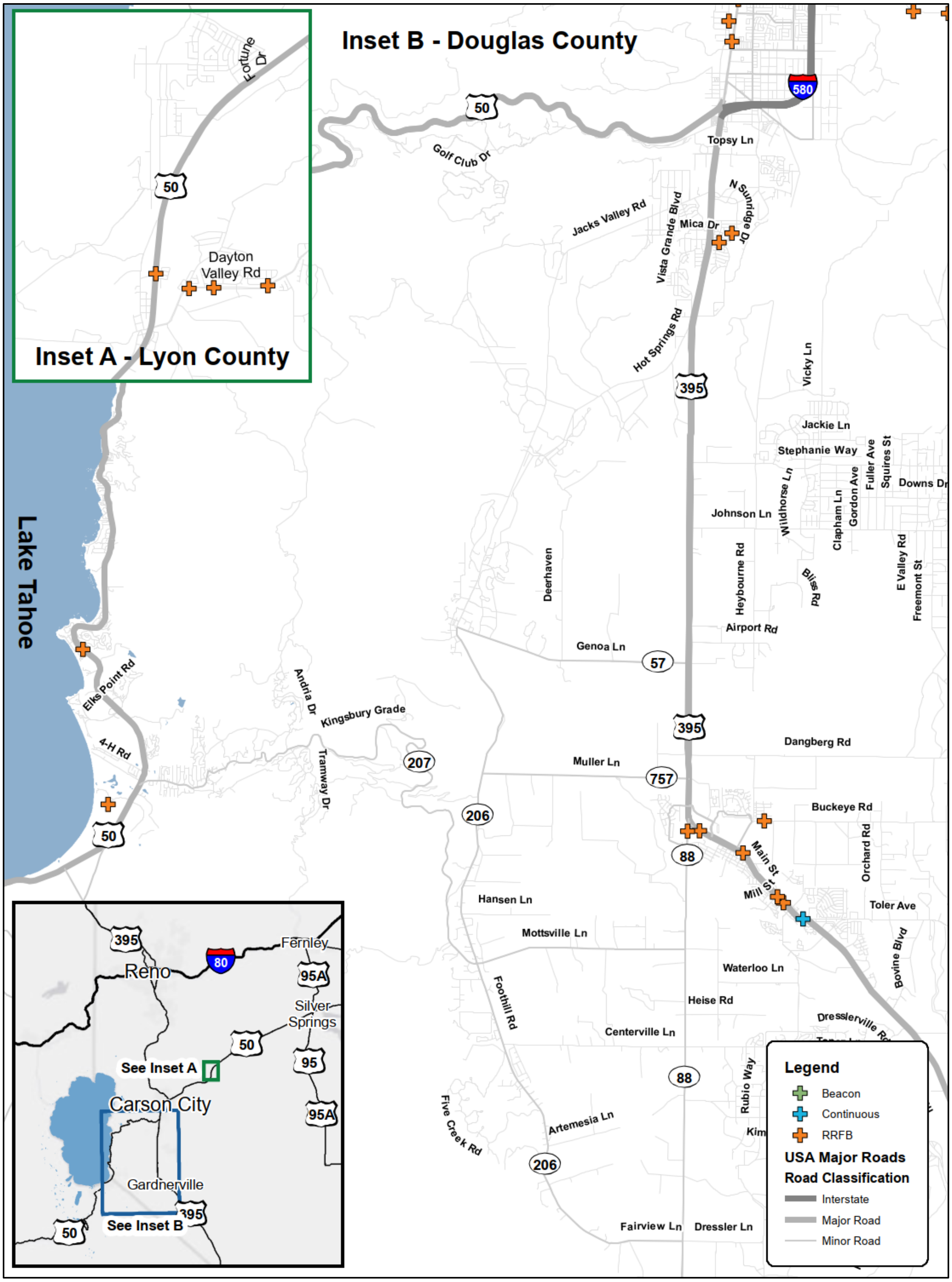


Figure 4 – Carson City Signal Communication Types



Note: No signalized crossings are maintained by CAMPO within Storey County.

Figure 5 – Signalized Crosswalks in Rural Counties

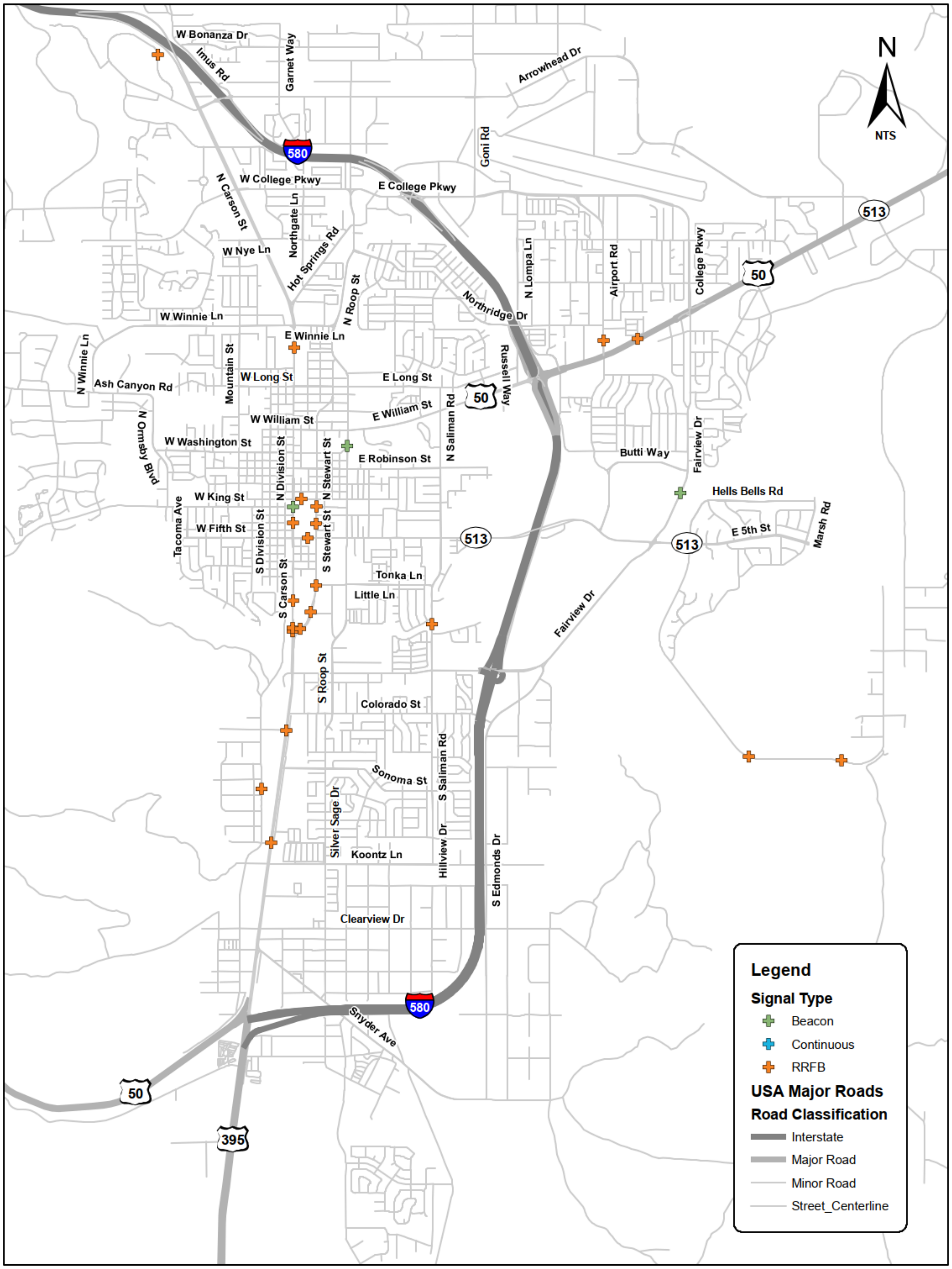


Figure 6 – Carson City Signalized Crosswalks

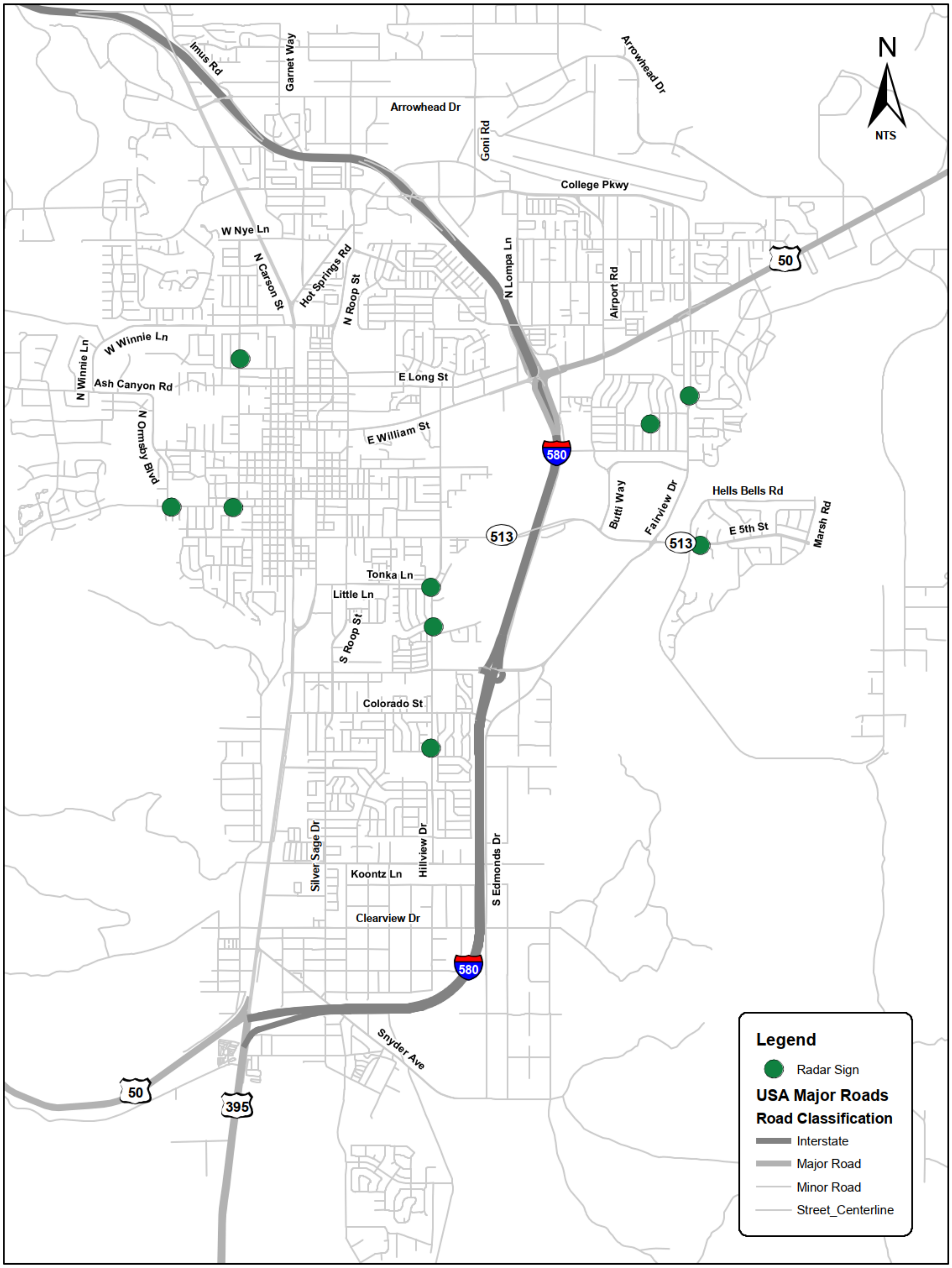


Figure 7 – Carson City Radar Sign Locations

APPENDIX C

SPARES INVENTORY DETAILS

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0010	Lamp - HPS - 250W	Transportation	Intelligent Transportation System	04	B_Storage: 5, VH6618: 6, VH6622: 2	$21.99	13	$285.87
TS0014	Cabinet Component - Detection Rack (Northwest Traffic)	Transportation	Intelligent Transportation System	04	B_Storage: 0	$499.00	0	$0.00
TS0015	Pedestrian Push Button - Polara BullDog	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 11, VH6622: 0	$75.25	11	$827.75
TS0018	Cabinet Component - Fan	Transportation	Intelligent Transportation System	04	B_Storage: 3, VH6618: 0, VH6622: 0	$0.00	3	$0.00
TS0027	Cabinet Component - Power Supply - Heavy Duty TS1 Rack - PS-175	Transportation	Intelligent Transportation System	04	B_Storage: 5, VH6618: 2, VH6622: 0	$213.00	7	$1,491.00
TS0034	Lamp - Fluorescent - 6'	Transportation	Intelligent Transportation System	04	B_Storage: 4	$13.99	4	$55.96
TS0035	Lamp - Fluorescent - 8'	Transportation	Intelligent Transportation System	04	B_Storage: 0	$9.50	0	$0.00
TS0036	Filter 12" X 16"	Transportation	Intelligent Transportation System	04	B_Storage: 7, VH6618: 6, VH6622: 0	$5.25	13	$68.25
TS0038	Cabinet Component - Flasher Module - Model 204	Transportation	Intelligent Transportation System	04	B_Storage: 20, VH6618: 6, VH6622: 4	$30.00	30	$900.00
TS0040	Indication - Green Arrow 12" LED	Transportation	Intelligent Transportation System	04	B_Storage: 33, VH6618: 1, VH6622: 0	$50.12	34	$1,704.08
TS0041	Indication - Green Ball 12" LED	Transportation	Intelligent Transportation System	04	B_Storage: 38, VH6618: 1, VH6622: 0	$44.24	38	$1,774.23

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0043	Ballast - T12 IISNS	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 2, VH6622: 0	$73.00	2	$146.00
TS0047	Cabinet Component - Load Switch - Model 200	Transportation	Intelligent Transportation System	04	B_Storage: 23, VH6618: 6, VH6622: 0	$31.00	29	$899.00
TS0048	Contactor - Street Lighting - for Service Pedestal	Transportation	Intelligent Transportation System	04	B_Storage: 5, VH6618: 0, VH6622: 0	$79.00	5	$395.00
TS0057	Material - Spray Paint - Black	Transportation	Intelligent Transportation System	04	B_Storage: 24, VH6618: 0, VH6622: 0	$3.98	24	$95.52
TS0060	Pedestrian Signal Housing - Framework Mount	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 0, VH6622: 0	$0.00	1	$0.00
TS0061	Indication - Pedestrian Countdown LED Module - 16" X 18"	Transportation	Intelligent Transportation System	04	B_Storage: 2, VH6618: 2, VH6622: 1	$156.00	5	$780.00
TS0065	Visor - PELCO Programmable Visibility	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 0, VH6622: 0	$0.00	0	$0.00
TS0066	Photocell - Standalone	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 1, VH6622: 0	$10.47	2	$20.94
TS0067	Photocell - Twist Lock	Transportation	Intelligent Transportation System	04	B_Storage: 3, VH6618: 3, VH6622: 0	$13.74	6	$82.44
TS0072	Indication - Red Arrow 12" LED	Transportation	Intelligent Transportation System	04	B_Storage: 27, VH6618: 1, VH6622: 0	$48.58	28	$1,360.24
TS0074	Indication - Red Ball 12" LED	Transportation	Intelligent Transportation System	04	B_Storage: 32, VH6618: 2, VH6622: 1	$42.92	35	$1,525.89

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0080	Signal Head - 3 Section with Plumbizer	Transportation	Intelligent Transportation System	04	B_Storage: 6	$605.00	6	$3,630.00
TS0087	Tomar - EVP Preempt Head	Transportation	Intelligent Transportation System	04	B_Storage: 19, VH6618: 6, VH6622: 0	$275.00	25	$6,875.00
TS0090	Tomar - EVP-CARD-Strobecom II 2080 optical signal processor w/ 4 sig. proc	Transportation	Intelligent Transportation System	04	B_Storage: 7, VH6618: 2, VH6622: 0	$0.00	9	$0.00
TS0092	Box - B1017 - H20	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0094	Box - Lid for B1017 - H20 - Bolt Down	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0096	Iteris - Single USB Dual Ch. Detector Processor	Transportation	Intelligent Transportation System	04	B_Storage: 6, VH6618: 1, VH6622: 0	$2,500.00	7	$17,500.00
TS0097	Iteris - RZ4 Advanced WDR Camera	Transportation	Intelligent Transportation System	04	B_Storage: 9, VH6618: 2, VH6622: 0	$750.00	11	$8,250.00
TS0098	Visor - 12" Tunnel	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 2, VH6622: 0	$18.00	2	$36.00
TS0106	Indication - Yellow Arrow 12" LED	Transportation	Intelligent Transportation System	04	B_Storage: 22, VH6618: 1, VH6622: 0	$52.43	23	$1,205.89
TS0113	Lamp - Metal Halide - 200W	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 0, VH6622: 0	$22.80	0	$0.00
TS0116	Battery - 12V 12AH - F2 Connection	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0117	Material - Security Bolt - Penta 3/8 x 16 x 1 Stainless Steel	Transportation	Intelligent Transportation System	04	B_Storage: 50, VH6618: 0, VH6622: 0	$3.06	50	$153.00
TS0118	Pedestrian Pushbutton Housing - Pushbutton Plate Only - McCain Style	Transportation	Intelligent Transportation System	04	B_Storage: 17, VH6618: 6, VH6622: 0	$15.00	23	$345.00
TS0119	Visor - 12" Ball Cap	Transportation	Intelligent Transportation System	04	B_Storage: 299, VH6618: 10, VH6622: 0	$10.00	309	$3,072.00
TS0120	Indication - Yellow Ball 12" LED	Transportation	Intelligent Transportation System	04	B_Storage: 30, VH6618: 1, VH6622: 0	$47.44	31	$1,492.30
TS0121	Pedestrian Pushbutton Housing - 9" X 12" Full Size McCain Style	Transportation	Intelligent Transportation System	04	B_Storage: 8, VH6618: 0, VH6622: 0	$97.00	8	$776.00
TS0124	Pole - NDOT Type 1A modified with special 15' Length	Transportation	Intelligent Transportation System	04	Yard: 0	$0.00	0	$0.00
TS0125	Pole - NDOT Type 1B - 8' Length	Transportation	Intelligent Transportation System	04	Yard: 0	$0.00	0	$0.00
TS0126	Cabinet - R-44 Type - TS1 Spec - without plug-ins	Transportation	Intelligent Transportation System	04	B_Storage: 0, Yard: 0	$11,989.00	0	$0.00
TS0127	Cabinet Component - Flash Transfer Relay - TS1	Transportation	Intelligent Transportation System	04	B_Storage: 14, VH6618: 29, VH6622: 0	$28.00	43	$1,221.00
TS0139	Signal Head - Solid Backplate 3 Section	Transportation	Intelligent Transportation System	04	B_Storage: 13	$0.00	13	$0.00
TS0141	Iteris - 2 ch. Edge 2 Video Processor card	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 0, VH6622: 0	$2,500.00	1	$2,500.00

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0144	Cabinet Component - Video Monitor - 9.7" LED CCTV Monitor - BNC input	Transportation	Intelligent Transportation System	04	B_Storage: 2, VH6618: 0, VH6622: 0	$235.00	2	$470.00
TS0145	Fixture - Cree LED Luminaire	Transportation	Intelligent Transportation System	04	B_Storage: 5	$500.00	5	$3,211.00
TS0304	Ballast - Metal Halide - V&T Bridge Lighting	Transportation	Intelligent Transportation System	04	B_Storage: 1	$104.12	1	$104.12
TS0307	LED Driver - ISNS	Transportation	Intelligent Transportation System	04	B_Storage: 20, VH6618: 0, VH6622: 0	$27.95	20	$559.00
TS0308	Photocell - Socket / Bracket	Transportation	Intelligent Transportation System	04	B_Storage: 8, VH6618: 0, VH6622: 0	$10.47	8	$83.76
TS0309	Battery - 12V 55AH AGM	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0312	Lamp - HPS 100W	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 0, VH6622: 0	$14.99	0	$0.00
TS0314	Photocell - Shorting Cap	Transportation	Intelligent Transportation System	04	B_Storage: 7, VH6618: 1, VH6622: 0	$5.00	8	$40.00
TS0315	Material - CadWeld Plus Metal Weld - light blue	Transportation	Intelligent Transportation System	04	B_Storage: 7, VH6618: 0, VH6622: 0	$3.92	7	$27.44
TS0317	Iteris - Vector video system-cam/radar detection	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0320	Cabinet Component - SDLC Cable 60"	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 6, VH6622: 0	$65.00	6	$390.00

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0321	Contactor - Solid State Relay - Normally Open - NEMA TS1	Transportation	Intelligent Transportation System	04	B_Storage: 2, VH6618: 0, VH6622: 0	$51.00	2	$102.00
TS0322	Contactor - Solid State Relay - NEMA TS2 Cabinet	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 0, VH6622: 0	$83.71	1	$83.71
TS0323	Battery - 12V 16AH used in Bus Shelter Lighting	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0324	Battery - 12v 40AH	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0325	LED Driver - Cree Luminaire	Transportation	Intelligent Transportation System	04	B_Storage: 2, VH6618: 6, VH6622: 3	$29.35	11	$322.85
TS0334	Pole - NDOT Type 1A - 10' Length	Transportation	Intelligent Transportation System	04	B_Storage: 0, Yard: 0	$0.00	0	$0.00
TS0335	Pedestrian Signal Housing - Clamshell - Left	Transportation	Intelligent Transportation System	04	B_Storage: 2, VH6618: 0, VH6622: 0	$170.00	2	$340.00
TS0336	Pedestrian Signal Housing - Clamshell - Right	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 0, VH6622: 0	$170.00	1	$170.00
TS0337	Tomar - Detector-2 channel (new ver) 4090	Transportation	Intelligent Transportation System	04	B_Storage: 4, VH6618: 0, VH6622: 0	$650.00	4	$2,600.00
TS0338	Battery - 12V 100AH	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0339	Mushroom Flasher - Dual Channel - 1.5" NPT	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 1, VH6622: 0	$127.00	2	$254.00

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0341	Padlock - Long Shank - Masterlock - keyed for Signal Maintenance	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 4, VH6622: 5	$9.23	9	$83.07
TS0342	Lamp - HPS 400W with mogul base	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 5, VH6622: 2	$16.95	7	$118.65
TS0344	Material - 96" X 19.75 Lexan (for Temple Edge-Lit ISNS)	Transportation	Intelligent Transportation System	04	B_Storage: 2	$137.26	2	$274.52
TS0345	Cabinet Component - Power Supply - TS2 Cabinet - EDI PS-200	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 0, VH6622: 0	$298.00	0	$0.00
TS0346	Cabinet Component - BIU Card - TS2	Transportation	Intelligent Transportation System	04	B_Storage: 5, VH6618: 0, VH6622: 0	$275.00	5	$1,285.00
TS0347	Material - Fluorescent Yellow Tape - 2" x 50' - Retro-Reflective Backplates	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 0, VH6622: 0	$1.17	0	$0.00
TS0348	Filter 14" X 20"	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 1, VH6622: 1	$5.47	2	$10.94
TS0350	Lamp - Metal Halide - T6 70W	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 0, VH6622: 0	$16.70	0	$0.00
TS0351	Pedestrian Pushbutton Housing - 5" x 7"	Transportation	Intelligent Transportation System	04	B_Storage: 6, VH6618: 0, VH6622: 0	$175.00	6	$1,050.00
TS0352	Pedestrian Placard - 5" X 7" - Bi-Directional	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 0, VH6622: 7	$20.00	7	$140.00
TS0355	LED Module - Light Bar - Cree	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 5, VH6622: 0	$67.00	5	$335.00

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0359	Cabinet Component - Detector System 4 ch. compact det. amplifier	Transportation	Intelligent Transportation System	04	B_Storage: 4, VH6618: 0, VH6622: 0	$375.00	4	$1,500.00
TS0362	Opticom - Detector, 2 ch/2 Dir.-722	Transportation	Intelligent Transportation System	04	B_Storage: 11, VH6618: 0, VH6622: 0	$741.00	11	$7,965.75
TS0363	Opticom - 764 Multimode Phase Selector	Transportation	Intelligent Transportation System	04	B_Storage: 13, VH6618: 0, VH6622: 0	$2,946.00	13	$38,298.00
TS0364	Cable - Belden 8281 Coaxial	Transportation	Intelligent Transportation System	04	B_Storage: 956	$1.57	956	$1,503.79
TS0365	Battery - 12V 22AH	Transportation	Intelligent Transportation System	04	B_Storage: 0	$54.50	0	$0.00
TS0366	Mounting Bracket - Astro Brac Sign	Transportation	Intelligent Transportation System	04	B_Storage: 6	$23.92	6	$143.52
TS0368	LED Driver - Temple Style IISNS - Eagle Station Type	Transportation	Intelligent Transportation System	04	B_Storage: 2, VH6618: 0, VH6622: 0	$29.12	2	$58.24
TS0369	Lamp - HPS - 150W	Transportation	Intelligent Transportation System	04	B_Storage: 0, VH6618: 2, VH6622: 0	$17.40	2	$34.80
TS0370	Lamp - ISNS T8 LED Bypass bulbs 43W	Transportation	Intelligent Transportation System	04	B_Storage: 9	$20.93	9	$188.37
TS0372	Opticom - Detector 1ch/2 dir.-721	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 0, VH6622: 0	$535.00	1	$535.00
TS0373	Pedestrian Placard - R10-3 - 9"X12" - Left-Retro-Reflective Graffiti Resist.	Transportation	Intelligent Transportation System	04	B_Storage: 49, VH6618: 0, VH6622: 0	$40.00	49	$1,960.00

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0374	Pedestrian Placard - R10-3 - 9"X12" - Right - Retro-Reflective Graffiti Resist.	Transportation	Intelligent Transportation System	04	B_Storage: 52, VH6618: 0, VH6622: 0	$40.00	52	$2,080.00
TS0375	Mounting Bracket - Street Name sign link EC65	Transportation	Intelligent Transportation System	04	B_Storage: 10, VH6618: 6, VH6622: 2	$35.00	18	$630.00
TS0376	Material - Extruded channel for street name signs 10 ' length	Transportation	Intelligent Transportation System	04	B_Storage: 10	$55.55	10	$555.50
TS0377	Pole - NDOT Type - Pedestrian Pushbutton	Transportation	Intelligent Transportation System	04	B_Storage: 2, Yard: 0	$500.00	2	$1,000.00
TS0379	Pedestrian Placard - 9" X 12" Bi-directional	Transportation	Intelligent Transportation System	04	B_Storage: 57, VH6618: 15, VH6622: 12	$17.75	84	$1,491.00
TS0380	Material - Spray Paint - Brown (Tahoe)	Transportation	Intelligent Transportation System	04	B_Storage: 1, VH6618: 9, VH6622: 2	$4.27	12	$51.24
TS0381	Battery - ES24-18 Tesco Controls Battery Backup	Transportation	Intelligent Transportation System	04	B_Storage: 0	$125.00	0	$0.00
TS0382	Cabinet Component - Fluorescent Cabinet Lamp	Transportation	Intelligent Transportation System	04	B_Storage: 4, VH6618: 0, VH6622: 0	$17.00	4	$68.00
TS0383	Snow Proof Shield 12" Black - Traffic Signal Indication Cover	Transportation	Intelligent Transportation System	04	B_Storage: 39	$244.40	39	$9,531.60
TS0384	Filter 12" x 24" NITS Cabinet	Transportation	Intelligent Transportation System	04	B_Storage: 15	$6.00	15	$90.00
TS0385	Trafficware 16-Position NITS Cabinet without Controller, MMU, or any plugins.	Transportation	Intelligent Transportation System	04	B_Storage: 2	$14,966.00	2	$29,932.00

Inventory Master List

Item #	Description	Item Type	Item Class	Stkrm	Location	Last Cost	On Hand Qty	On Hand Value
TS0386	Photo Cell- Stem mount	Transportation	Intelligent Transportation System	04	VH6622: 5	$16.30	5	$81.50
TS0387	Circuit Breaker - 15A QC Type 1P	Transportation	Intelligent Transportation System	04	VH6622: 1	$21.48	1	$21.48
TS0388	Circuit Breaker - 20A QC Type 1P	Transportation	Intelligent Transportation System	04	VH6622: 2	$21.48	2	$42.96
TS0389	Battery - 12V AGM 112AH - 240 minutes - 8.57 x 13.5 x 6.71 Alpha Battery Backup	Transportation	Intelligent Transportation System	04	B_Storage: 0	$280.00	0	$0.00
TS0390	Battery - 12V AGM 35AH Threaded Insert Generic 7.69 x 5.13 x 7.00	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0391	Battery - 7AH AGM - F2 Connections - NP7-12 - Carmanah RRFB Style	Transportation	Intelligent Transportation System	04	B_Storage: 0	$0.00	0	$0.00
TS0392	Opticom- Detector, 1 ch/ 1 dir 711	Transportation	Intelligent Transportation System	04	B_Storage: 30	$479.00	30	$14,370.00
						Grand Total:		**$183,656.17**

Carson City Public Works Yard Inventory

Luminaire Arm Attachment?	Mast Arm Attachment?	Wrap-Around Gusset at Mast Arm?	Safety Base	Height (Feet)	Base Plate Width Square	Base Plate Thickness	Bolt Size (inches)	Bolt Circle Diameter (inches)	Distance Between Two Bolts -Single Side (inches)	Pole Diameter at base (inches)	Mast Arm Bolt Pattern (inches)	Mast Arm Type	Notes	Pole type
N	N	N	N	10	9	0.5	0.75	8.5	6.0	5 ID	NA	NA	10' Tall	**1A (1998-Current)**
N	N	N	N	15	9	0.5	0.75	8.5	6.0	5	NA	NA	15' Tall	**1A-Custom 15'**
N	N	N	N	7	9	0.5	0.75	8.5	6.0	5 ID	NA	NA	7' Tall	**1B (1998-Current)**
N	N	N	N	4	5	0.375	0.625	4.5	3.2	3	NA	NA		**Ped Post**
N	N	N	N	5-12	NA	NA	NA	NA		NA	NA	NA		**Telespar**
N	N	N	N	5-10	NA	NA	NA	NA		NA	NA	NA		**Wood Post**
N	N	N	N	20-50	NA	NA	NA	NA		NA	NA	NA		**Wood Utility**
N	N	N	N	12	TBD	NA	TBD	TBD		TBD	NA	NA	Downtown black post	**Sternberg Richmond 12'**
N	N	N	Y	30	Triangle	0.625	0.625	7	4.9	3	NA	NA	Pole may be less than 30' tall	**Safety Post 30' (2015-Current)**
N	Y	N	N	20	18	1.75	2"	17.5	12.4	10.75-12.125	11 or 13 Dia Cir	Straight	Mast arm 40' or less	**10 (1980-1992)**
N	Y	N	N	17	16	1.25	1.75	14.5	10.3	10.75	11 Dia Circle	Curved	Mast arm attachment plate is angled up. Mast arm 25-30'	**18 (1971-1979)**
N	Y	N	N	20	11.5	1.25	1	9.5	6.7	6.625	Three Bolts	Curved with Tie Rod Support	Tie Rod supported mast arm	**2 (1971-1979)**
N	Y	N	N	16.17	16	1.75	1.75	16.5	11.7	12.125	11 Dia Circle	Curved	Mast arm attachment plate is angled up. Mast arm 35-40'	**23 (1971-1979)**
N	Y	N	N	20	17	2	1.75	16.5	11.7	Varies	15 Diameter Circle	Straight		**30 (1980-1985)**
N	Y	N	N	20	17	1.5	1.75	16.5	11.7	Varies	14x18	Straight		**30 (1986-2016)**
N	Y	N	N	20	19 - 19.5	1.75	2	19	13.4	Varies	14x18	Straight	50' Mast Long Arms	**30A (1986-2016)**
N	Y	N	N	18.5	18	2	2	17.5	12.4	12.125	13 Diameter Circle	Straight	Mast arm length 45'	**40 (1980-1992)**
N	Y	N	N	20	20	2.5	2	19	13.4	13.5	15 Diameter Circle	Straight	Mast Arm 50'	**49 (1980-1992)**
N	Y	N	N	18	11.5	1.5	1	11	7.8	7.75	Three Bolts	Curved	Mast arm attachment plate is plumb	**5 (1971-1979)**
N	Y	N	N	20	13.5	1.25	1.25	12.5	8.8	9.375	9 Diameter Circle	Straight	Mast Arm plate has 5 degree tilt	**5A (1980-1992)**
N	Y	Y	N	20	17	2	1.75	16.5	11.7	Varies	14x18?	Straight		**30 (2017-Current)**
N	Y	Y	N	20	19	2	2	19	13.4	Varies	14x18?	Straight		**30A (2017-Current)**
N	Y	Y	N	20	26	2.5	2.25	25	17.7	Varies	14x18?	Straight	65'-85' spans	**30B (2017-Current)**

Carson City Public Works Yard Inventory

Luminaire Arm Attachment?	Mast Arm Attachment?	Wrap-Around Gusset at Mast Arm?	Safety Base	Height (Feet)	Base Plate Width Square	Base Plate Thickness	Bolt Size (inches)	Bolt Circle Diameter (inches)	Distance Between Two Bolts -Single Side (inches)	Pole Diameter at base (inches)	Mast Arm Bolt Pattern (inches)	Mast Arm Type	Notes	Pole type
Y	N	N	N	30	11.5	1	1	11	7.8	7.75	NA	NA	Has two luminaire arms opposite each other	**14 (1980-Current)**
Y	N	N	N	28.5	11.5	1.375	1	11	7.8	8	NA	NA	Tie Rod supported luminaire arm	**4 (1971-1979)**
Y	N	N	N	30	11.5	1	1	11	7.8	7.75	NA	NA		**7 (1971-Current)**
Y	N	N	N	30	TBD	TBD	TBD	TBD		TBD	NA	NA	Fairview Dr. Green Decorative Tall	**Sternberg Birmingham 30'**
Y	N	N	N	20	TBD	TBD	TBD	TBD		TBD	NA	NA	Fairview Dr. Green Decorative Short	**Sternberg Birmingham 20'**
Y	N	N	Y	30	13.5	1	1	13	9.2	7.75	NA	NA	Has two luminaire arms opposite each other	**14 Safety (1980-Current)**
Y	N	N	Y	30	13.5	1	1	13	9.2	8	NA			**4 Safety (1971-1979)**
Y	N	N	Y	30	13.5	1	1	13	9.2	7.75	NA	NA		**7 Safety (1971-Current)**
Y	Y	N	N	28.5	16	1.25	1.75	14.5	10.3	10.75	11 Dia Circle	Curved	Mast arm attachment plate is angled up. Mast arm 25-30'	**19 (1971-1979)**
Y	Y	N	N	30	18	1.75	2"	17.5	12.4	10.75-12.125	11 or 13 Dia Cir	Straight	Mast arm 40' or less	**20 (1980-1992)**
Y	Y	N	N	28.5	16	1.75	1.75	16.5	11.7	12.125	11 Dia Circle	Curved	Mast arm attachment plate is angled up. Mast arm 35-40'	**24 (1971-1979)**
Y	Y	N	N	30	18	2	2	17.5	12.4	12.125	12 Dia Cir Typical	Two Arms-straight	Double Mast Arm (one at 20', one at 40')	**28 (1980-2016)**
Y	Y	N	N	30	11.5	1.375	1.25	11	7.8	8	Three Bolts	Curved with Tie Rod Support	Tie Rod supported mast arm and luminaire arm	**3 (1971-1979)**
Y	Y	N	N	30	17	2	1.75	16.5	11.7	Varies	15 Diameter Circle	Straight		**35 (1980-1985)**
Y	Y	N	N	30	17	1.5	1.75	16.5	11.7	Varies	14x18	Straight		**35 (1986-2016)**
Y	Y	N	N	30	19 - 19.5	1.75	2	19	13.4	N/A	14x18	Straight	50' Long Mast Arms	**35A (1986-2016)**
Y	Y	N	N	30	18	2	2	17.5	12.4	12.125	13 diameter Circle	Straight	Mast arm length 45'	**45 (1975-1992)**
Y	Y	N	N	30	20	2.5	2	19	13.4	13.5	15 Diameter Circle	Straight	Mast Arm 50'	**50 (1980-1992)**
Y	Y	N	N	18.5	11.5	1.5	1.25	11	7.8	7.75	Three Bolts	Curved	Mast arm attachment plate is plumb	**6 (1971-1979)**
Y	Y	N	N	28.5	13.5	1.25	1.25	12.5	8.8	9.375	9 Diameter Circle	Straight	Check dates, did it start in 1979???	**6A (1980-1992)**
Y	Y	Y	N	30	17	2	1.75	16.5	11.7	N/A	14x18?	Straight		**35 (2017-Current)**
Y	Y	Y	N	30	19	2	2	19	13.4	N/A	14x18?	Straight		**35A (2017-Current)**
Y	Y	Y	N	30	26	2.5	2.25	25	17.7	N/A	14x18?	Straight		**35B (2017-Current)**

APPENDIX D

LOGISTICAL ELEMENTS SUMMARY

LOGISTICAL ELEMENTS SUMMARY

Available logistical elements, those elements defined as “intangible,” such as policies, agreements, and other planning documents received from the Carson Area Metropolitan Planning Organization (CAMPO) were reviewed for incorporation into the Carson Area Transportation System Management Plan (CATSMP). The documents reviewed include the following:

- Incident and special event management procedures
- City policies and procedures
- Funding
- Staffing
- Safety
- Spares Inventory
- Maintenance agreements with quad county agencies
- Process for storage of data in Advanced Traffic Management System (ATMS)

A summary of the collected logistical elements listed above is provided in the following sections.

1 Incident and Special Event Management Procedures

Carson City does not currently have an incident management signal timing modification plan. For special event management, the Carson City Sheriff’s Office and Public Works Department meet ahead of the special event to identify intersections that should be used to move people in and out of the special event quickly. A list of impacted roads due to an event is coordinated and communicated to the Control Systems Operations Manager. The Control Systems Group then updates the signal timings at impacted intersections to prioritize the throughput of each intersection for the duration of the event.

2 Policies

Several Carson City policies were reviewed. These policies include the following and are summarized in the subsections that follow:

- Speed Limit Policy
- Resolution No. 2020-R-14 (Designation of school zones within portions of highways)
- CCPW Sign Installation
- Signal Timing – Yellow, All-Red, and Pedestrian Intervals
- Signal Timing – Signalized Crosswalk Warning Intervals
- Signal Timing Changes – Nevada Department of Transportation (NDOT) Advance Signal Warning System (ASWS)

A copy of the above referenced policies is available upon request.

2.1 Speed Limit Policy

The CCPW Speed Limit Policy and Procedure became effective on April 28, 2020 and was updated on June 23, 2020. The policy was established to set forth the guidelines in use by CCPW for establishing and reviewing speed limits on new and existing roadways within Carson City. Using a uniform procedure allows for consistent and safe speed limits within Carson City.

2.2 Resolution for School Zones within Portions of Highway

A resolution was established in June 2020 and updated in June 2021, to designate highways or portions of highways as school zones for ten (10) schools within Carson City. Designated school zones provide safety for children in and around schools as they help to moderate traffic speeds which can reduce injury severity. School zones include physical elements maintained by Carson City including school flashers and Rectangular Rapid Flashing Beacons (RRFBs).

2.3 CCPW Sign Installation

CCPW's Sign Installation policy defines the procedure for tracking the installation of new signs as well as existing signs in need of modification, repair, or replacement.

2.4 CCPW Signal Timing – Yellow, All-Red, and Pedestrian Intervals

The CCPW's Signal Timing Yellow, All-Red, and Pedestrian Intervals policy documents standards, methods, and calculations adopted for use in determination of the yellow, all red, and pedestrian signal timing intervals for application at signalized intersections. The policy is not applicable to RRFB crosswalk beacons or pedestrian hybrid (HAWK) beacons.

2.5 CCPW Signal Timing – Signalized Crosswalk Warning Intervals

The CCPW Signal Timing Policy for Signalized Crosswalk Warning Intervals documents the adopted standards, methods, and calculations for use in the determination of the duration of the operation of RRFBs, or warning beacons when installed at an actuated signalized crosswalk. This policy is not applicable to signalized intersections or HAWK crossings.

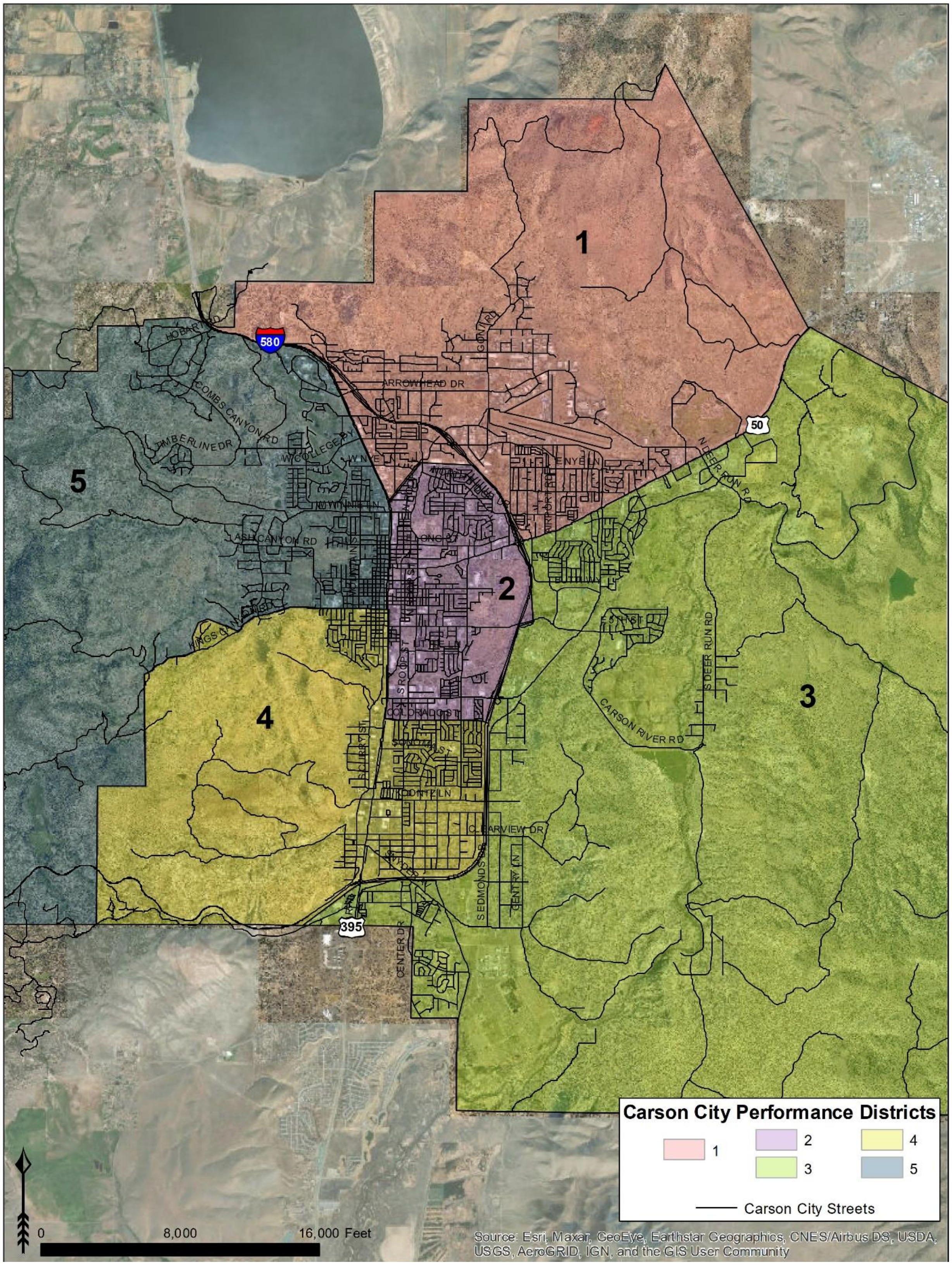
2.6 Signal Timing Changes – NDOT ASWS

NDOT developed a unified statewide approach that promotes uniformity and consistency in the treatment of ASWSs. The changes enhance the safety of the traveling public and promote better driver behaviors. Other states have shown a reduction in crashes (severe crashes and red-light running crashes) when implementing similar modifications. The improvements recommended for the CAMPO area as part of the ASWS project have been completed.

3 Funding

Funding documents provided by Carson City were reviewed. The fiscal year budget for capital improvements and infrastructure capital covers roadway reconstruction pavement preservation projects. Carson City adopted a Carson City Pavement Management Plan in April 2018 to formalize and establish an efficient and effective strategy for preserving and maintaining Carson City's roadways. The current Pavement Management Plan covers fiscal year 2024-2028 and established five performance districts functioning on a five-year rotating schedule and budget. The funding for each performance district is primarily used for construction projects and is covered by both local and federal funds, historical data since 2019 shows a 65% local and 35% federal fund distribution. A map of the five performance districts established is shown in **Figure 1**.

A traffic control systems budget, which covers signal maintenance and operations, is funded by the street maintenance fund through the sales tax fund. Carson City earns revenue as part of the signal maintenance completed for Douglas County, Lyon County, and Storey County.



Source: Carson City Pavement Management Plan, April 11, 2018

Figure 1 – Five Performance Districts

4 Agreements with Partnering Agencies

Carson City has signal maintenance agreements with Douglas, Lyon, and Storey Counties. These agreements define responsibilities for Carson City and the partnering agencies for the maintenance of signals within the CAMPO area. The Douglas County agreement is the most recent agreement Carson City has established with a partnering agency. Carson City also has intersection and other location-specific agreements with NDOT; however, a master agreement with NDOT is not in place. There are currently 38 agreements between Carson City and NDOT with some agreements older than 60 years. Upon review of the agreement list, it was noted that the NDOT thresholds and reimbursement terms vary among the 38 agreements. For example, Carson City funds cover all maintenance costs in some agreements, while NDOT funds the maintenance costs in others. Carson City and the other agencies within CAMPO also have right-of-way occupancy permits with NDOT to allow for the general maintenance of traffic signals.

5 Functional Organizational Chart

Figure 2 shows the CCPW organizational chart as it relates to the Control Systems and Transportation Divisions.

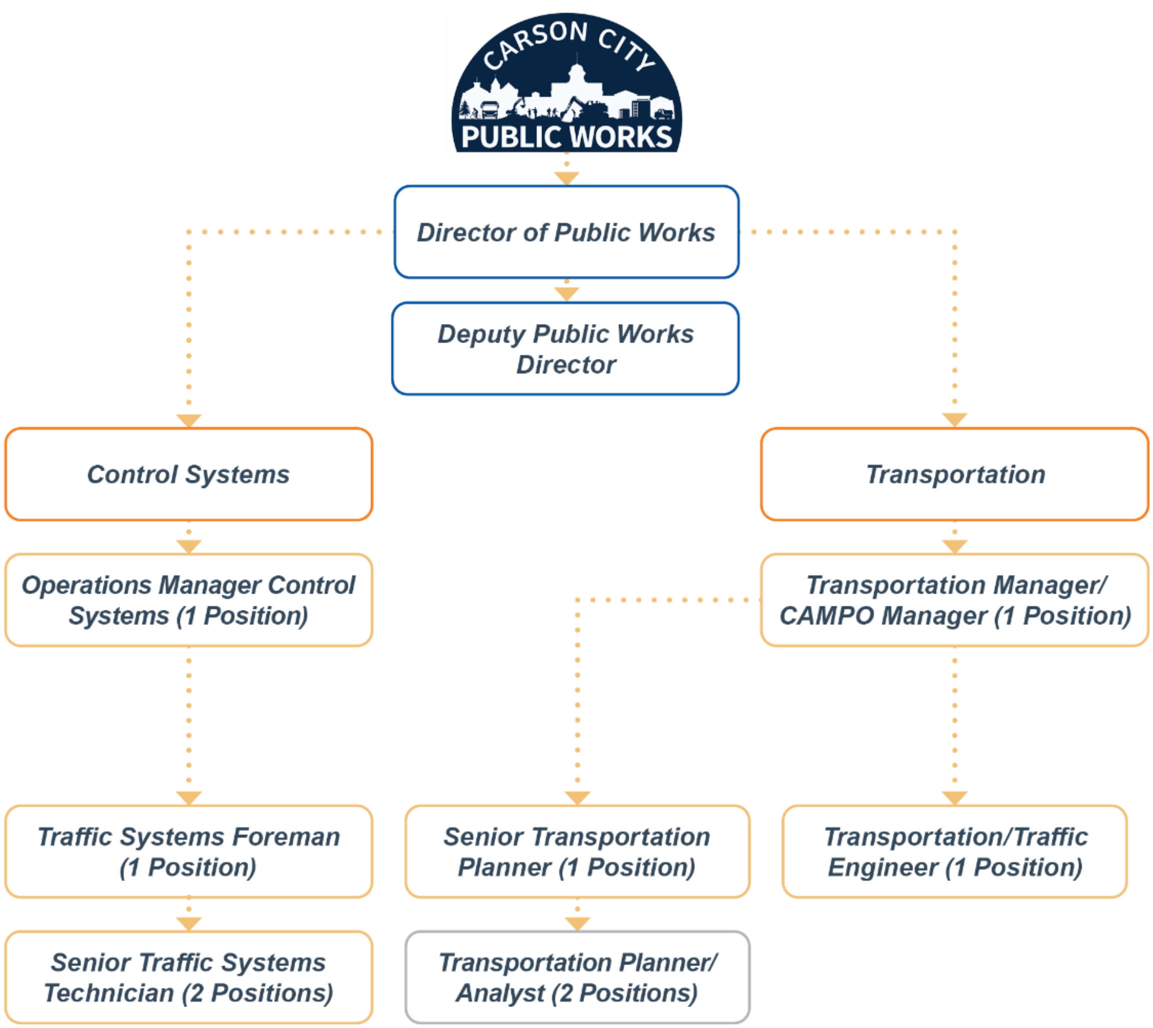


Figure 2 – CCPW Organizational Chart

The following positions within the Carson City organizational chart are relevant to the operations of the City's traffic signal system.

- **Control Systems**
  - **Operations Manager Control Systems:** Under general direction, plans, assigns, supervises, reviews, and evaluates the work of the staff assigned to the operation and maintenance of the electrical, instrumentation, process control, data acquisition, and city-wide communication systems for public works operations.
  - **Traffic Systems Foreman:** Under general direction, plans, assigns and oversees the work of the Traffic Systems section while performing the same and/or more difficult duties as those being led; ensures completion of tasks in accordance with established policies and procedures; communicates policies, procedures, and job expectations; and provides training to staff.
  - **Senior Traffic Systems Technician:** Under general supervision, performs complex technician-level installation, repair, and preventive maintenance of electrical and electronic components of traffic systems equipment in a variety of City locations.
- **Transportation**
  - **Transportation Manager:** Under general direction, manages, coordinates, and directs all transportation and transit-related planning, review, and impacts for the City. Serves as the Manager of CAMPO.
  - **Senior Transportation Planner:** Under general supervision, provides advanced-level professional transportation planning support for City projects and programs; may lead the work of planning and technical support staff.
  - **Transportation Planner/Analyst:** Under general supervision, provides professional transportation planning support for City projects and programs.
  - **Transportation Traffic Engineer:** Under general supervision, performs engineering work related to the coordination and supervision of major and minor construction and renovation projects, assuring that plans, specifications, codes, time schedules, and budgets are adhered to; provides complex inspections of projects; confers with contractors and consultants on the development and completion of projects; plans and directs traffic engineering and transportation activities, including traffic impact studies, traffic signal timing, and various technical engineering studies.

6 Safety

The safety performance measures adopted by CAMPO in order to increase safety for the transportation system will follow the state targets. The targets identified must be data-driven, realistic, and attainable by CAMPO. A total of five safety performance targets are identified, these include:

- Number of fatalities (five-year rolling average)
- Rate of fatalities per 100 million Vehicle Miles Traveled (VMT)
- Number of serious injuries (five-year rolling average)
- Rate of Serious Injuries per 100 million VMT
- Number of non-motorized fatalities and non-motorized serious injuries (five-year rolling average)

CAMPO coordinates safety performance measures with NDOT and adopts these safety targets each year. As stated in the 2050 Regional Transportation Plan, CAMPO was able to meet four of the five targets when compared against the 2018 targets. It was noted that CAMPO experienced a 93% increase in the number of fatalities (five-year rolling average) from 2012 to 2018 even though a 33% reduction in the total number of serious injury crashes over the same period was observed. It was reported that the extension of I-580 may have been an influencing factor in the fluctuation of fatalities and serious injuries.

Safety performance targets for public transportation within the region, as outlined in the 2023 Public Transportation Agency Safety Plan, include:

- **Fatalities, and Fatalities per Vehicle Revenue Mile (VRM):** Total number of reportable fatalities and rate of fatalities per total VRM, by mode.
  - Jump Around Carson's (JAC's) performance target is zero fatalities.
- **Injuries, and Injuries per VRM:** Total number of reportable injuries and rate of injuries per total VRM, by mode.
  - JAC's performance target is zero injuries for the year, and 0.00002 injuries per VRM (1 injury per 50,000 VRM) for fixed route and 0.00001 injuries per VRM (1 injury per 100,000 VRM) for paratransit.
- **Safety Events, and Safety Events per VRM:** Total number of reportable events (Event, as defined in the 2021 National Transit Database Reduced Reporter Policy Manual) and rate of reportable events per total VRM, by mode.
  - JAC's performance target is two safety events in total for the year for fixed route and one safety event for paratransit for the year. The goals are 0.00001 safety events per VRM (1 safety event per 100,000 VRM) for fixed route and 0.00001 safety events per VRM (1 safety event per 100,000 VRM) for paratransit.
- **System Reliability:** Mean (or average) distance in miles between major mechanical failures, by mode.

7 Spares Inventory

An inventory of spare items stored by the City was conducted on Tuesday, May 11, 2021. The inventory of spare items consisted of signal poles, mast arms, and luminaire arms. A summary of the items identified during the inventory site visit are provided in **Appendix C** of the final report. An inventory list of other items including cabinet components, pedestrian push buttons, lamps, and signal heads was also provided.

8 Process for Storage of Data in ATMS

The signal timing data is stored in the ATMS system, the Control Systems Operations Manager downloads signal timing data from the ATMS system when requests come in. Some consultants find it hard to read the signal timing plans produced by the ATMS system. It is recommended that instructions of how to read the signal timing plans be implemented. Sample instructions on how to read the signal timing plans are located in **Appendix E** of the final report.

APPENDIX E

EXAMPLE INSTRUCTIONS FOR SIGNAL TIMING

Note: Detailed signal timing report reference material is provided on page E28 of this appendix.

Controller Database Timing Sheet

Station: 1004 - Hwy 50 & Fairview (Standard File)

Type: NTCIP 76.x 2070 Ethernet

Firmware: 76.15t

Created By: dfong

Modified By:

Reviewed By:

Step 1: Determine Phase Timing Options
Use the highlighted phase timing values for each phase.

Phase Times and Options(1.1.1/1.1.2)

	1	2	3	4	5	6	7	8								
TABLE - 1																
Min Green	5	5	5	10	5	5	5	10	0	0	0	0	0	0	0	0
Gap Ext	1.8	1.8	1.5	2.5	1.5	1.8	1.8	2.5	0	0	0	0	0	0	0	0
Max1	33	40	25	60	23	30	20	50	0	0	0	0	0	0	0	0
Max2	33	40	25	60	23	30	20	50	0	0	0	0	0	0	0	0
Yellow Clr	3.2	4	3.9	4.8	3.3	4.1	3.9	4.8	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red Clr	2.9	1.2	4.8	1	2.4	1.2	4.4	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Walk	0	9	0	14	0	9	0	10	0	0	0	0	0	0	0	0
Ped Clearance	0	21	0	17	0	25	0	19	0	0	0	0	0	0	0	0
Red Revert	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Added Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Max Initial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Time Before Reduce	10	20	20	25	10	15	15	25	0	0	0	0	0	0	0	0
Cars Before Reduce	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Time To Reduce	5	5	5	10	5	5	5	10	0	0	0	0	0	0	0	0
Reduce By	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Min Gap	1.5	1.4	1.5	1.3	1.5	1.5	1.5	1.3	0	0	0	0	0	0	0	0
Dynamic Max Limit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dynamic Max Step	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Startup	RED	RED	RED	GREEN	RED	RED	RED	GREEN	RED	RED	RED	RED	RED	RED	RED	RED
Enable	X	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.
Auto Flash Entry	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.
Auto Flash Exit	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.
Non-Actuated 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Non-Actuated 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lock Calls	.	.	.	.	.	.	.	.	X	X	X	X	X	X	X	X

Phase Times and Options(1.1.1/1.1.2)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Min Recall	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Max Recall	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ped Recall	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Soft Recall	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.
Dual Entry	.	X	.	X	.	X	.	X	.	.	.	.	.	.	.	.
Sim Gap Enable	.	.	.	.	.	.	.	.	X	X	X	X	X	X	X	X
Guarantd Passage	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Added Init Calc	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ring	1	1	1	1	2	2	2	2	0	0	0	0	0	0	0	0
Concur 1	5	5	7	7	1	1	3	3	0	0	0	0	0	0	0	0
Concur 2	6	6	8	8	2	2	4	4	0	0	0	0	0	0	0	0
Concur 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concur 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concur 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concur 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concur 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concur 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Step 6: Determine Recall Mode
If the signal is coordinated use the values in Section 2.1.1 of the relevant split table. The values listed in 1.1.1/1.1.2 can be used when the signal is running freely.

Phase Times+ and Options+(1.1.3)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 1																
Reservice	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ped Clr Thru Yellow	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Skip Red-NoCall	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Red Rest On Gap	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Conflicting P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green Ped Delay Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Omit Yel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ped Out	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Start Yel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inhibit P1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Inhibit P16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Call Phs1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Call Phs2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Call Phs3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Call Phs4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redirect P Calls From 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redirect P Calls To 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Phase Times+ and Options+(1.1.3)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Redirect P Calls From 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redirect P Calls To 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redirect P Calls From 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redirect P Calls To 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redirect P Calls From 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redirect P Calls To 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Phase Times Alt(1.1.6.1)								
	1	2	3	4	5	6	7	8
TABLE - 1								
Walk	0	0	0	0	0	0	0	0
Ped Clear	0	0	0	0	0	0	0	0
Min Green	0	0	0	0	0	0	0	0
Gap Ext	0	0	0	0	0	0	0	0
Max 1	0	0	0	0	0	0	0	0
Max 2	0	0	0	0	0	0	0	0
Yellow Clr	0	0	0	0	0	0	0	0
Red Clr	0	0	0	0	0	0	0	0
Assign Ph	0	0	0	0	0	0	0	0
TABLE - 2								
Walk	0	0	0	0	0	0	0	0
Ped Clear	0	0	0	0	0	0	0	0
Min Green	0	0	0	0	0	0	0	0
Gap Ext	0	0	0	0	0	0	0	0
Max 1	0	0	0	0	0	0	0	0
Max 2	0	0	0	0	0	0	0	0
Yellow Clr	0	0	0	0	0	0	0	0
Red Clr	0	0	0	0	0	0	0	0
Assign Ph	0	0	0	0	0	0	0	0
TABLE - 3								
Walk	0	0	0	0	0	0	0	0
Ped Clear	0	0	0	0	0	0	0	0
Min Green	0	0	0	0	0	0	0	0
Gap Ext	0	0	0	0	0	0	0	0
Max 1	0	0	0	0	0	0	0	0
Max 2	0	0	0	0	0	0	0	0
Yellow Clr	0	0	0	0	0	0	0	0

Phase Times Alt(1.1.6.1)

	1	2	3	4	5	6	7	8
Red Clr	0	0	0	0	0	0	0	0
Assign Ph	0	0	0	0	0	0	0	0

Phase Options Alt(1.1.6.2)

	1	2	3	4	5	6	7	8
TABLE - 1								
Non Act1	.	.	.	.	.	.	.	.
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0
TABLE - 2								
Non Act1	.	.	.	.	.	.	.	.
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0
TABLE - 3								
Non Act1	.	.	.	.	.	.	.	.

Phase Options Alt(1.1.6.2)								
	1	2	3	4	5	6	7	8
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0
TABLE - 4								
Non Act1	.	.	.	.	.	.	.	.
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0
TABLE - 5								
Non Act1	.	.	.	.	.	.	.	.
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.

Phase Options Alt(1.1.6.2)								
	1	2	3	4	5	6	7	8
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0
TABLE - 6								
Non Act1	.	.	.	.	.	.	.	.
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0
TABLE - 7								
Non Act1	.	.	.	.	.	.	.	.
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X

Phase Options Alt(1.1.6.2)

	1	2	3	4	5	6	7	8
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0
TABLE - 8								
Non Act1	.	.	.	.	.	.	.	.
Lock Calls	X	X	X	X	X	X	X	X
Soft Recall	.	.	.	.	.	.	.	.
Dual Entry	.	.	.	.	.	.	.	.
Sim Gap Enable	X	X	X	X	X	X	X	X
Guar Passage	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.
Cond Service	.	.	.	.	.	.	.	.
Reservice	.	.	.	.	.	.	.	.
Red Rest	.	.	.	.	.	.	.	.
Max 2	.	.	.	.	.	.	.	.
Max Inhibit	.	.	.	.	.	.	.	.
Ped Delay	.	.	.	.	.	.	.	.
Conf Phs1	0	0	0	0	0	0	0	0
Conf Phs2	0	0	0	0	0	0	0	0
Assign Phase	0	0	0	0	0	0	0	0

Phase Times+(1.1.7)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 1																
Walk2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bike Clear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green Flash	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Safe Clear Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Safe Clear No Flash	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Adv Warning(1.1.9)

	Value
TABLE - 1	
Aux Out 1 P	0
Aux Out 1 Time	0
Aux Out 2 P	0
Aux Out 2 Time	0

Unit Parms(1.2.1)

	Value
TABLE - 1	
StartUp Flash	0
Auto Ped Clear	.
Red Revert	4
Local Flash Start	.
Allow < 3 sec Yel	.
Allow Skip Yel	.
MCE Timeout	0
Enable Run	X
Start Red Time	6
Phase Mode	USER
Startup Calls	.
Diamond Mode	4PH
Stop Time Over Preempt	.
Free Ring Sequence	1
Clearance Decide	.
Min Ped Clear Time	.
RingAlgo	0

Ring Sequences(1.2.4)

	1	2	3	4
TABLE - 1				
Ring P1	1	5	0	0
Ring P2	2	6	0	0
Ring P3	3	7	0	0
Ring P4	4	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0

Ring Sequences(1.2.4)				
	1	2	3	4
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 2				
Ring P1	2	6	0	0
Ring P2	1	5	0	0
Ring P3	4	7	0	0
Ring P4	3	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 3				
Ring P1	2	6	0	0
Ring P2	1	5	0	0
Ring P3	3	8	0	0
Ring P4	4	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 4				
Ring P1	2	6	0	0
Ring P2	1	5	0	0
Ring P3	3	8	0	0
Ring P4	4	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 5				
Ring P1	1	6	0	0
Ring P2	2	5	0	0
Ring P3	4	7	0	0
Ring P4	3	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0

Ring Sequences(1.2.4)				
	1	2	3	4
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 6				
Ring P1	1	5	0	0
Ring P2	2	6	0	0
Ring P3	4	7	0	0
Ring P4	3	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 7				
Ring P1	2	5	0	0
Ring P2	1	6	0	0
Ring P3	3	8	0	0
Ring P4	4	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 8				
Ring P1	2	6	0	0
Ring P2	1	5	0	0
Ring P3	3	8	0	0
Ring P4	4	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 9				
Ring P1	1	5	0	0
Ring P2	2	6	0	0
Ring P3	4	7	0	0
Ring P4	3	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0

Ring Sequences(1.2.4)				
	1	2	3	4
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 10				
Ring P1	1	6	0	0
Ring P2	2	5	0	0
Ring P3	4	7	0	0
Ring P4	3	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 11				
Ring P1	2	5	0	0
Ring P2	1	6	0	0
Ring P3	4	7	0	0
Ring P4	3	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 12				
Ring P1	2	6	0	0
Ring P2	1	5	0	0
Ring P3	4	7	0	0
Ring P4	3	8	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 13				
Ring P1	1	5	0	0
Ring P2	2	6	0	0
Ring P3	4	8	0	0
Ring P4	3	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0

Ring Sequences(1.2.4)				
	1	2	3	4
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 14				
Ring P1	1	6	0	0
Ring P2	2	5	0	0
Ring P3	4	8	0	0
Ring P4	3	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 15				
Ring P1	2	5	0	0
Ring P2	1	6	0	0
Ring P3	4	8	0	0
Ring P4	3	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0
TABLE - 16				
Ring P1	2	6	0	0
Ring P2	1	5	0	0
Ring P3	4	8	0	0
Ring P4	3	7	0	0
Ring P5	0	0	0	0
Ring P6	0	0	0	0
Ring P7	0	0	0	0
Ring P8	0	0	0	0

Ring Input Map(1.2.5)				
	1	2	3	4
TABLE - 1				
Input Map	1	2	1	2

Overlap Plus Parms(1.5.1)	
	Value

Overlap Plus Parms(1.5.1)	
	Value
TABLE - 1	
Extra Included Phases	.

Overlap Programming(1.5.2.X.1)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 1																
Included P1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Included P2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Included P3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Included P4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Included P5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Included P6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Included P7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Included P8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modify P8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Type	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
Green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Overlap+(1.5.2.X.2)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 1																
Conflict P1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict P2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict P3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict P4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict P5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict P6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Overlap+(1.5.2.X.2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Conflict P7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict P8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict O8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conflict Ped 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Coordination Parms Plus(2.1)

	Value
TABLE - 1	
Leave Walk Before	TIMED
Leave Walk After	TIMED
Walk Recycle	NO_RECYCLE
Stop In Walk	X
External	.
Auto Err Reset	X
Latch Sec Foff	.
Easy Float	.
NTCIP Yield	0
NTCIP Yield Sign	+
Closed Loop	.
Free OnSeq Chang	X
No Added Init	.
Ped Call Inh	.
Ext Pattern	.

Step 5: Determine Cycle Length, Offset, and Splits
Determine appropriate cycle length, offset, and split based on the Pattern identified in **Step 4**.
Note: *A cycle length of zero indicates free operations. Splits should be identified using* ***Section 2.7.X.1*** *and the sequence identified using* ***Section 1.2.4.***

Coordination Parms Plus(2.1)

	Value
Dyn Shortway	.
Plan A	0
Plan B	0
Plan C	0
Plan D	0

Patterns(2.4)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
TABLE - 1																								
Cycle Time	115	115	115	115	115	0	115	115	115	130	115	0	0	0	130	0	0	0	0	0	0	0	0	0
Offset Time	0	0	7	84	12	0	66	66	26	6	13	0	0	0	0	0	0	0	0	0	0	0	0	0
Split Number	1	1	2	3	2	0	7	8	9	10	11	0	0	0	15	0	0	0	0	0	0	0	0	0
Seq Number	3	3	3	2	2	1	4	4	5	6	6	1	1	1	2	1	1	1	1	1	1	1	1	1

	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
TABLE - 1																								
Cycle Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Offset Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Split Number	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Seq Number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Splits Expanded(2.7.X.1)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 1																
Time	17	37	30	31	25	29	20	41	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TABLE - 2																
Time	21	37	24	33	23	35	18	39	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TABLE - 3																
Time	21	37	24	33	23	35	18	39	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TABLE - 4																
Time	23	37	27	43	25	35	21	49	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 5																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Splits Expanded(2.7.X.1)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 6																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 7																
Time	18	37	29	31	18	37	20	40	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TABLE - 8																
Time	18	37	29	31	18	37	20	40	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TABLE - 9																
Time	21	37	24	33	23	35	18	39	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TABLE - 10																
Time	27	27	24	48	21	37	18	54	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 11																
Time	18	37	18	42	18	37	16	44	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TABLE - 12																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 13																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 14																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 15																

Splits Expanded(2.7.X.1)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Time	21	37	24	48	23	35	18	54	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 16																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 17																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 18																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TABLE - 19																
Time	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Coord Phase	.	.	.	.	.	.	.	.	.							
TABLE - 20																
Time	0	0	0	0	0	0	0	0	0							
Mode	NON	NON	NON	NON	NON	NON	NON	NON	NON							
Coord Phase	.	.	.	.	.	.	.	.	.							

Step 2: Determine Appropriate Table for use in Section 4.4
Identify applicable Table for use in **Section 4.4** by using the day of week being analyzed.

For example, analyzing weekdays (Monday-Friday) indicates that Table 1 in Section 4.4 should be used.

Adv Schedule(4.3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Plan
TABLE - 1																																																			
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X	X	X	X	X	.	1
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.	.	.	.	.	X	2
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Adv Schedule(4.3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Plan
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Adv Schedule(4.3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Plan
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Adv Schedule(4.3)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Plan
77	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
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Day Plan(4.4)

	1	2	3	4	5	6	7	8								
TABLE - 1																
Hour	6	8	9	15	15	18	0	0								
Minute	25	0	0	0	45	30	0	0	0	0	0	0	0	0	0	0
Action	1	2	3	4	6	6	6	0	0	0	0	0	0	0	0	0
TABLE - 2																
Hour	11	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	4	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0

Step 3: Determine Time of Day Plan
Using the Table number identified in **Step 2**, determine the action plan that corresponds with the peak period of the intersection by using the Tables in **Section 4.4**.

*For example, **Step 2** indicates that Table 1 in **Section 4.4** should be used.*

Day Plan(4.4)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 3																
Hour	6	8	11	15	18	0	0	0	0	0	0	0	0	0	0	0
Minute	25	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0
Action	7	8	9	10	6	6	0	0	0	0	0	0	0	0	0	0
TABLE - 4																
Hour	11	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	11	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
TABLE - 5																
Hour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TABLE - 6																
Hour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Day Plan Link(4.4_)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TABLE - 1																
Link	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Step 4: Identify Pattern Based on Actions from Section 4.4
Using the applicable Action from **Step 3**, identify the applicable Pattern using **Section 4.5** and proceed to **Section 2.4**.

Actions(4.5)

	Pattern	Aux 1	Aux 2	Aux 3	Pre1	Pre2	Special 1	Special 2	Special 3	Special 4	Special 5	Special 6	Special 7	Special 8
TABLE - 1														
1	1	.	.	.	0	0	.	.	.	.	.	.	.	.
2	2	.	.	.	0	0	.	.	.	.	.	.	.	.
3	3	.	.	.	0	0	.	.	.	.	.	.	.	.
4	4	.	.	.	0	0	.	.	.	.	.	.	.	.
5	5	.	.	.	0	0	.	.	.	.	.	.	.	.
6	6	.	.	.	0	0	.	.	.	.	.	.	.	.
7	7	.	.	.	0	0	.	.	.	.	.	.	.	.
8	8	.	.	.	0	0	.	.	.	.	.	.	.	.
9	9	.	.	.	0	0	.	.	.	.	.	.	.	.
10	10	.	.	.	0	0	.	.	.	.	.	.	.	.
11	11	.	.	.	0	0	.	.	.	.	.	.	.	.
12	0	.	.	.	0	0	.	.	.	.	.	.	.	.

Actions(4.5)														
	Pattern	Aux 1	Aux 2	Aux 3	Pre1	Pre2	Special 1	Special 2	Special 3	Special 4	Special 5	Special 6	Special 7	Special 8
13	0	.	.	.	0	0	.	.	.	.	.	.	.	.
14	0	.	.	.	0	0	.	.	.	.	.	.	.	.
15	15	.	.	.	0	0	.	.	.	.	.	.	.	.
16	0	.	.	.	0	0	.	.	.	.	.	.	.	.
17	0	.	.	.	0	0	.	.	.	.	.	.	.	.
18	0	.	.	.	0	0	.	.	.	.	.	.	.	.
19	0	.	.	.	0	0	.	.	.	.	.	.	.	.
20	0	.	.	.	0	0	.	.	.	.	.	.	.	.
21	0	.	.	.	0	0	.	.	.	.	.	.	.	.
22	0	.	.	.	0	0	.	.	.	.	.	.	.	.
23	0	.	.	.	0	0	.	.	.	.	.	.	.	.
24	0	.	.	.	0	0	.	.	.	.	.	.	.	.
25	0	.	.	.	0	0	.	.	.	.	.	.	.	.
26	0	.	.	.	0	0	.	.	.	.	.	.	.	.
27	0	.	.	.	0	0	.	.	.	.	.	.	.	.
28	0	.	.	.	0	0	.	.	.	.	.	.	.	.
29	0	.	.	.	0	0	.	.	.	.	.	.	.	.
30	0	.	.	.	0	0	.	.	.	.	.	.	.	.
31	0	.	.	.	0	0	.	.	.	.	.	.	.	.
32	0	.	.	.	0	0	.	.	.	.	.	.	.	.
33	0	.	.	.	0	0	.	.	.	.	.	.	.	.
34	0	.	.	.	0	0	.	.	.	.	.	.	.	.
35	0	.	.	.	0	0	.	.	.	.	.	.	.	.
36	0	.	.	.	0	0	.	.	.	.	.	.	.	.
37	0	.	.	.	0	0	.	.	.	.	.	.	.	.
38	0	.	.	.	0	0	.	.	.	.	.	.	.	.
39	0	.	.	.	0	0	.	.	.	.	.	.	.	.
40	0	.	.	.	0	0	.	.	.	.	.	.	.	.
41	0	.	.	.	0	0	.	.	.	.	.	.	.	.
42	0	.	.	.	0	0	.	.	.	.	.	.	.	.
43	0	.	.	.	0	0	.	.	.	.	.	.	.	.
44	0	.	.	.	0	0	.	.	.	.	.	.	.	.
45	0	.	.	.	0	0	.	.	.	.	.	.	.	.
46	0	.	.	.	0	0	.	.	.	.	.	.	.	.
47	0	.	.	.	0	0	.	.	.	.	.	.	.	.

Actions(4.5)														
	Pattern	Aux 1	Aux 2	Aux 3	Pre1	Pre2	Special 1	Special 2	Special 3	Special 4	Special 5	Special 6	Special 7	Special 8
48	0	.	.	.	0	0	.	.	.	.	.	.	.	.
49	0	.	.	.	0	0	.	.	.	.	.	.	.	.
50	0	.	.	.	0	0	.	.	.	.	.	.	.	.
51	0	.	.	.	0	0	.	.	.	.	.	.	.	.
52	0	.	.	.	0	0	.	.	.	.	.	.	.	.
53	0	.	.	.	0	0	.	.	.	.	.	.	.	.
54	0	.	.	.	0	0	.	.	.	.	.	.	.	.
55	0	.	.	.	0	0	.	.	.	.	.	.	.	.
56	0	.	.	.	0	0	.	.	.	.	.	.	.	.
57	0	.	.	.	0	0	.	.	.	.	.	.	.	.
58	0	.	.	.	0	0	.	.	.	.	.	.	.	.
59	0	.	.	.	0	0	.	.	.	.	.	.	.	.
60	0	.	.	.	0	0	.	.	.	.	.	.	.	.
61	0	.	.	.	0	0	.	.	.	.	.	.	.	.
62	0	.	.	.	0	0	.	.	.	.	.	.	.	.
63	0	.	.	.	0	0	.	.	.	.	.	.	.	.
64	0	.	.	.	0	0	.	.	.	.	.	.	.	.
65	0	.	.	.	0	0	.	.	.	.	.	.	.	.
66	0	.	.	.	0	0	.	.	.	.	.	.	.	.
67	0	.	.	.	0	0	.	.	.	.	.	.	.	.
68	0	.	.	.	0	0	.	.	.	.	.	.	.	.
69	0	.	.	.	0	0	.	.	.	.	.	.	.	.
70	0	.	.	.	0	0	.	.	.	.	.	.	.	.
71	0	.	.	.	0	0	.	.	.	.	.	.	.	.
72	0	.	.	.	0	0	.	.	.	.	.	.	.	.
73	0	.	.	.	0	0	.	.	.	.	.	.	.	.
74	0	.	.	.	0	0	.	.	.	.	.	.	.	.
75	0	.	.	.	0	0	.	.	.	.	.	.	.	.
76	0	.	.	.	0	0	.	.	.	.	.	.	.	.
77	0	.	.	.	0	0	.	.	.	.	.	.	.	.
78	0	.	.	.	0	0	.	.	.	.	.	.	.	.
79	0	.	.	.	0	0	.	.	.	.	.	.	.	.
80	0	.	.	.	0	0	.	.	.	.	.	.	.	.
81	0	.	.	.	0	0	.	.	.	.	.	.	.	.
82	0	.	.	.	0	0	.	.	.	.	.	.	.	.

Actions(4.5)

	Pattern	Aux 1	Aux 2	Aux 3	Pre1	Pre2	Special 1	Special 2	Special 3	Special 4	Special 5	Special 6	Special 7	Special 8
83	0	.	.	.	0	0	.	.	.	.	.	.	.	.
84	0	.	.	.	0	0	.	.	.	.	.	.	.	.
85	0	.	.	.	0	0	.	.	.	.	.	.	.	.
86	0	.	.	.	0	0	.	.	.	.	.	.	.	.
87	0	.	.	.	0	0	.	.	.	.	.	.	.	.
88	0	.	.	.	0	0	.	.	.	.	.	.	.	.
89	0	.	.	.	0	0	.	.	.	.	.	.	.	.
90	0	.	.	.	0	0	.	.	.	.	.	.	.	.
91	0	.	.	.	0	0	.	.	.	.	.	.	.	.
92	0	.	.	.	0	0	.	.	.	.	.	.	.	.
93	0	.	.	.	0	0	.	.	.	.	.	.	.	.
94	0	.	.	.	0	0	.	.	.	.	.	.	.	.
95	0	.	.	.	0	0	.	.	.	.	.	.	.	.
96	0	.	.	.	0	0	.	.	.	.	.	.	.	.
97	0	.	.	.	0	0	.	.	.	.	.	.	.	.
98	0	.	.	.	0	0	.	.	.	.	.	.	.	.
99	0	.	.	.	0	0	.	.	.	.	.	.	.	.
100	0	.	.	.	0	0	.	.	.	.	.	.	.	.

TOD Parameters(4.6)

	Value
TABLE - 1	
Time Base Sync Reference	0
Daylight Savings	ENABLE
GMT Offset Sign	+
GMT Offset Time	0
DST Spring Month	0
DST Spring Week	1
DST Fall Month	0
DST Fall Week	1

Signal Timing Report Reference

Caution: Traffic signal controllers are designed to support a wide variety of Intelligent Transportation Systems(ITS) applications. There are many configuration parameters and variables which are not referenced in this guide which could directly affect the operation of the traffic signal. If the person performing analysis of this data does not understand and consider these possible conditions when analyzing the information, they may end up with bad data or error in interpretation. There is no substitute for a qualified and experienced engineer equipped with the applicable signal controller manual. This reference guide is intended to assist the person performing analysis with basic instructions for deriving common parameters used to analyze typical signalized intersections. The person performing analysis should rule out any advanced or complex configuration at the specific location before concluding analysis.

Note: References created to controller Type Scout Ethernet v85.4

List of Parameters included in this reference guide:

Parameter	Description	Section	Page
Mode of Operation	Actuated uncoordinated (Free) or Actuated coordinated (Coordinated)	1-4	2-5
Cycle Length	Aka Dial. During coordination the cycle length is fixed. In free operation it is not applicable.	4	4
Offset	Offset in seconds, applicable only to coordinated operation.	4	4
Split Times	Phase split in seconds. Only applicable to coordinated operation.	4,6	4,7
Split Modes	Split mode determines whether the split time is fixed or variable. Only applicable to coordinated operation.	6	4,7-8
Offset Reference	Synchronizes the offset to either the beginning or end of the coordinated phase green.	5	6
Coordinated Phase	Offset reference phase. Only applicable to coordinated operation.	6	7,8
Sequence	Aka Ring Sequence. The order or sequence that splits or phases are served in both free or coordinated operation. Defines lead or lag configuration and more.	4,7	5,9
Concurrent Phases	Defines which phases or splits are permitted to be active together. Lack of concurrence is the same as a defined conflict. They are the same thing from two different perspectives.	8	10-11
Overlaps	Overlaps are used to implement certain modes of operation or configurations such as flashing yellow arrow, advanced signal warning systems, etc.	9-10	12-18
Min Green Time	Minimum amount of time a green indication may be displayed when served.	11	19-20
Max Green Time	Maximum amount of time a green indication may be displayed in free operation.	11	19-20
Yellow Clearance	Fixed interval consistent across all modes of operation.	11	19-20
All-Red Time	Fixed interval consistent across all modes of operation.	11	19-20
Walk Time	Minimum amount of time a walk indication may be displayed when served.	11	19-20
Flashing Don't Walk Time	Fixed interval consistent across all modes of operation.	11	19-20
Minimum Split	SUM of Min Green+Yellow+All-Red if the split is served during coordinated operation and not configured for any recall mode of operation. The same value is applicable to free operation if served.	NA	NA

Time of Day Schedule

Signalized intersections are typically configured to operate differently during different time periods. It is critical that you review the time-of-day schedule to determine which parameters are active during the period you are seeking information for. This must be done to determine the intersection **Mode of Operation** applicable for the period of interest.

1. Review "Adv Schedule (4.3)" to determine the applicable "Day Plan".

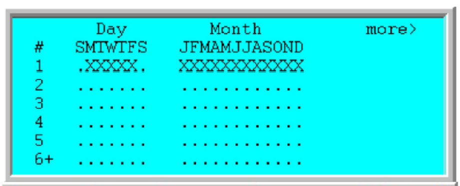
   In the example below the following is shown:
   Mon-Fri = Day Plan 1
   Sat-Sun = Day Plan 2

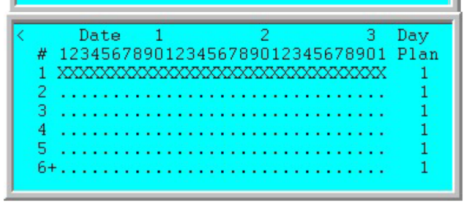
Adv Schedule(4.3)

	Table-	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		.	X	X	X	X	X	.	X	X	X	X	X	X	X	X	X	X	X	X
2		X	.	.	.	.	.	X	X	X	X	X	X	X	X	X	X	X	X	X
3		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Plan
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	2
3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1

7.3 Advanced Schedule (MM->4->3)





The NTCIP based *Advanced Schedule* is an annual calendar for the current year used to select the *Day Plan* for the current day. Each entry of the scheduler specifies a day-of-week, month, day-of-month, and the *Day Plan* assigned to the entry. Each entry identifies the day or range of days during which the *Day Plan* is in effect.

It is possible for two or more schedule entries to specify the same day of the year. In this situation, the scheduler will always select the most specific entry. An entry is defined as more specific if the range of days defined by that entry is narrower in scope than another entry. For example, the user may assign *Day Plan* 1 for the entire month of March in one entry and *Day Plan* 2 for March 7 in a separate entry. This would appear to be a duplicate entry because two different day plans are programmed for March 7. However, in this situation, the *Advanced Schedule* would select *Day Plan* 2, because it more specific to the current day. The priority order of day plan selection is based upon month, day-of-week, then day of month. If no *Day Plan* is assigned to the current date (based on the time base of the unit), the controller will run free in *Pattern # 0.*

The user may select multiple entries for *Day*, *Month*, and *Date*. For example, selecting all fields under *Day* implies that this entry applies to every day of the week. If a *Day* field is not selected, then the schedule is not considered valid for that particular day. Therefore, when entering a schedule event for a specific date, such as March 7, it is good practice to make that event applicable to every day of the week. This will prevent the user from having to change the day-of-week for the entry when the calendar year changes.

Day

The *Day* parameter defines the day-of-week or multiple days for the entry.

Month

The *Month* parameter defines the month or range of months for the entry based on *Begin Month–End Month*.

Date

The *Date* parameter indicates which days of the month that the entry will be allowed. More than one day of month may be selected.

Day Plan

The *Day Plan* number selects the Day Plan (1-64) placed in effect when the scheduled entry becomes active.

2. Review “Day Plan (4.4)” to determine the applicable “Action”.

   In the example below, review the Table that matches the “Day Plan” determined in step 1.
   Day Plan 1 = Table – 1
   Day Plan 2 = Table – 2
   Within the applicable table, there are times listed with actions. The time is the start time for the associated action.
   In the example below the following is shown:
   When Day Plan 1 is active (Mon-Fri as determined in step 1)
   06:15 activate Action 15
   09:00 activate Action 16
   16:00 activate Action 17
   20:00 activate Action 6
   00:00 activate Action 6

Day Plan(4.4)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Table - 1																								
Hour	6	9	16	17	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	15	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	15	16	17	16	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Table - 2																								
Hour	8	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	18	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Table - 1																								
Hour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Table - 2																								
Hour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minute	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7.5 Day Plan Table (MM->4->4)

The *Scheduler* reads the active *Day Plan* for the current date once per minute to update the current *Action*. The *Action* drives the active *Pattern* and controls the state of the special function outputs from the *Action Table*.

Time

The *Time* parameter in 24-hour military format (HH:MM) defines the time-of-day that the associated *Action* will become active. All four numeric digits must be entered, including any leading zeroes.

Action

The *Action* parameter (1-100) is associated with the *Action* in the *Action Table*. **NTCIP defines Action 0 as the “do-nothing” action.** Therefore, do not be misled into thinking that Action 0 places the intersection into “free” operation. It is good practice to assign an event and *Action* at 00:00 for every *Day Plan* called by the *Advanced Schedule*. This ensures that even if the controller date is changed and a new *Day Plan* is referenced that at least the first *Action* at specified for 00:00 will be selected.

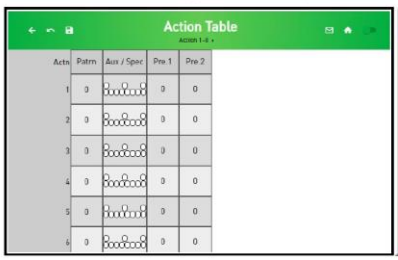
Link

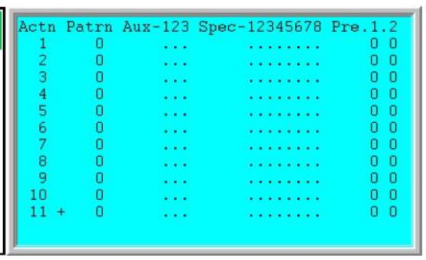
The Link parameter joins (or links) two or more *Day Plans* to increase the number event entries from 16 to 32. The link parameter contains the *Day Plan* number the *Day Plan* is linked to. Multiple *Day Plans* may link to the same *Day Plan* by specifying the same *Link* entry in each plan; however, linking more than two *Day Plans* in a chain is not supported.

3. Review “Actions (4.5)” to determine “Pattern” and associated “Outputs” (uncommon).
   In the example below the following is shown:
   Action 15 = Pattern 15
   Action 16 = Pattern 16
   Action 17 = Pattern 17
   Action 6 = Pattern 6
   No aux outputs, special function outputs or preempt outputs are indicated.
   Note: Pattern 254 always indicates Free/Fully actuated operation. Pattern 255 always indicates Flash operation, Pattern 0 is always ignored. All other patterns may be Free or Coordinated depending upon configuration.

Actions(4.5)																									
	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
Table - 1																									
Pattern	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
Aux 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aux 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aux 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Special 8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pre1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7.6 Action Table (MM->4->5)





[V85.2] The number of Actions have been increased from 100 to 255.

The *Action* selected by the current *Day Plan* controls the state of *Auxiliary* and *Special Function* hardware outputs. In addition, the source of the source of preempt 1 and 2 may be selected by the current *Action* table. The time-of-day *Scheduler* allows the Day Plan to call different *Actions* to turn outputs ON and OFF and share the same pattern between actions. This scheme minimizes the number of patterns required to cycle outputs ON and OFF.

Pattern

The *Pattern* parameter (1-253) defines the *TBC Pattern* selected by the current *Action*. A value of zero or 254 will cause the controller to run free. It is very easy to confuse Action 0 and Pattern 0. Just remember that a zero Action is no action and Pattern 0 may not always runs free. However, keep in mind that to ensure free operation in an NTCIP controller, one should program Pattern 254 instead of Pattern 0. A pattern value of 255 will run Automatic (time of day) Flash.

Aux Outputs

The *Auxiliary* settings define the state of each auxiliary output when the associated action is active. These outputs are activated by *Day Plan Actions* or are manually controlled from the central system. The 2070 and older TS2 controllers provide 3 *Aux* outputs and newer TS2 and some ATC controllers provide 8 *Aux* outputs per action.

Special Function Outputs

The *Special-Function* settings defines the state of each special function output when the associated action is active. These outputs are activated by *Day Plan Actions* or manually controlled from the central system. The 2070 and older TS2 controllers provide 8 *Special Function* outputs and newer TS2 and some ATC controllers provide 24 *Special Function* outputs per action.

Preempt Outputs

This setting allows the source of the inputs for preempt 1 and 2 to be remapped by time of day through the *Action Table*. The source for Pre.1 may be set to a value of “3” or “4”and Pre.2 may be set to a value of “5” or “6”. Programming zero (“0”) calls for the default input for each preempt. For example, setting Pre.1 to “3” would source the preempt 3 input when the time of day action is active instead of the preempt 1 input.

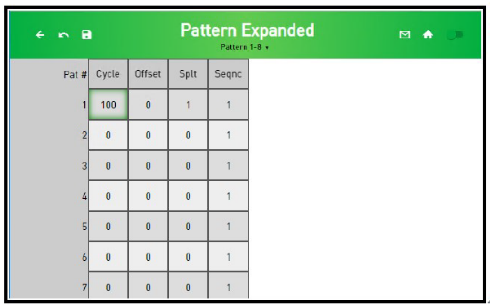
4. Review “Patterns (2.4)” to determine **Cycle Length**, **Offset**, Split, **Sequence**, and **Mode of Operation**.
   In the example below the following is shown:
   Pattern 15 = Cycle 160 seconds, Offset 133 seconds, Split 15, Sequence 15, mode Coordinated
   Pattern 16 = Cycle 160 seconds, Offset 9 seconds, Split 16, Sequence 15, mode Coordinated
   Pattern 17 = Cycle 160 seconds, Offset 13 seconds, Split 17, Sequence 15, mode Coordinated
   Pattern 6 = Cycle 0 seconds, Offset 0 seconds, Split 0, Sequence 1, mode Free (cycle time of zero implies Free)

Patterns(2.4)

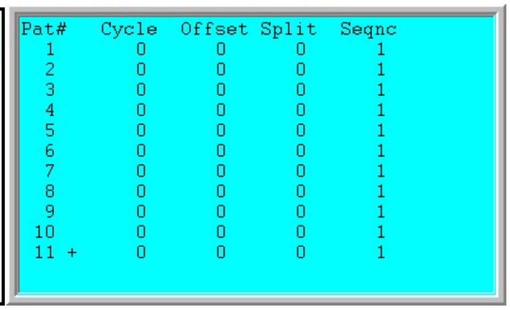
Table - 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Cycle	0	0	0	0	0	0	0	0	0	0	0	0	0	160	160	160	180	160	0	0	0	0	0	0
Offset	0	0	0	0	0	0	0	0	0	0	0	0	0	96	133	9	13	9	0	0	0	0	0	0
Split	0	0	0	0	0	0	0	0	0	0	0	0	0	14	15	16	17	18	0	0	0	0	0	0
seqnc	1	1	1	1	1	1	1	1	1	1	1	1	1	15	15	15	15	15	1	1	1	1	1	8

Table - 1	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Cycle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Offset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Split	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
seqnc	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

6.3 Pattern Table (MM->2->4)


Pattern Expanded
Pattern 1-8

Pat #	Cycle	Offset	Split	Seqnc
1	100	0	1	1
2	0	0	0	1
3	0	0	0	1
4	0	0	0	1
5	0	0	0	1
6	0	0	0	1
7	0	0	0	1



Pat#	Cycle	Offset	Split	Seqnc
1	0	0	0	1
2	0	0	0	1
3	0	0	0	1
4	0	0	0	1
5	0	0	0	1
6	0	0	0	1
7	0	0	0	1
8	0	0	0	1
9	0	0	0	1
10	0	0	0	1
11 +	0	0	0	1

Coordinated *Patterns* are defined by a *Cycle* length (normally 1-255 sec.). *Free patterns* are specified in the *Pattern Table* with a zero second Cycle length. The 253 patterns in the *Pattern Table* along with Pattern# 254 (free) and Pattern# 255 (flash) provide a total of 255 patterns. Only one pattern may be active at a time.

Cycle Time (Cycle)

Cycle Time specifies the cycle length and ranges from 0-255 seconds if *Expanded Splits* is OFF, or 0-999 if *Expanded Splits* is ON. Cycle Time is typically set to the sum of the split times in each ring during coordination. However, a *Cycle Time* of 0” implies a *free pattern*. Many features available to patterns under coordination are also available to a *free pattern* programmed with a zero second cycle length. This allows different *free patterns* to be called by time-of-day or through the system that vary the operation of the controller during free operation. Note in Version 65.x, if Expanded Splits is set to “ON cycle lengths can vary from 1-999 seconds.

Offset Time (Offset)

Offset Time defines the length of time that the local counter (Loc) lags behind the system time base (TBC). Offset ranges from 0-255 seconds if *Expanded Splits* is OFF, or 0-999 if *Expanded Splits* is ON. Each controller in a coordinated system references the system time base to midnight to synchronize the offset time for each active pattern in the system. The system maintains coordination as long as each controller in the system maintains the same midnight time reference. Note: if the offset value is greater than or equal to the cycle time, then the controller is forced into free mode by the coordination diagnostic.

Split Number (Split)

Split Number is used to reference one of the 253 *Split Tables* associated with the pattern. The *Split Tables* are interpreted differently based on the force-off method. Most of these modes require split times for each phase programmed through the Split Table. However, some of the OTHER force-off methods require the setting the force-off and yield points for each phase. This chapter on Basic Coordination discusses the FIXED and FLOAT force-off methods that simplify coordination under NTCIP coordination. The OTHER methods of coordination are discussed in Chapter 13 under Advanced Coordination.

Sequence Number (Seqnc)

The *Sequence Number* selects one of the 16 phase sequences to use with the pattern. Each phase sequence provides eight (8) entries per ring for each of the 8 rings. Phase sequences are fully discussed in chapter 4 of this manual. A sequence number of 0 in the database defaults to sequence number 1. Only entries between 1 and 16 are valid if entered through the keyboard.

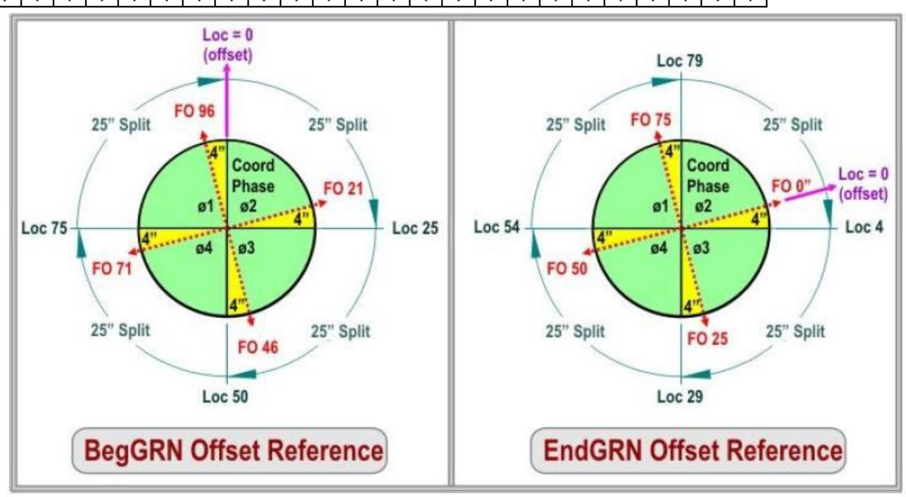
5. Review “Pattern Tran/CoorPhs(2.5/2.6) to determine **Offset Reference**.
In the example below Offset Reference is BEGGRN

Pattern Tran/CoorPhs(2.5/2.6)	1	2	3	4	5	6	13	14	15	16	17	18	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Table - 1																																	
Sht	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lng	24	24	24	0	0	0	0	0	0	0	0	0	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
Dwl	0	0	0	30	30	0	30	30	30	30	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ely Yld	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Off Ref	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN	BE GG RN
Ret Hld	.	.	.	.	.	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Flt	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MinV	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MinP	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Percentage	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MI	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sh Way 24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Offset Reference

The *Offset Reference* synchronizes the offset to either the beginning of the coord phase (BegGRN) or the end of the coord phase green (EndGRN). The 100” cycle example to the right shows how force-off points change when the *Offset Reference* is changed.

You must ensure the *Offset Reference* agrees with the offset reference in the computer model used to develop the pattern. For BegGRN corresponds with the Synchro “TS2 1st Green” offset method. EndGrn corresponds with “Begin Yellow” in Synchro.



6. Review “Splits Expanded(2.7.X.1)” to determine the **Split Times**, **Coordinated Phase**, and **Split Modes**. Review the Table number matching the Split number found in step 4 for the applicable pattern.
   In the example below the following is shown:
   Split 15=Table 15.
   - Phase 1=20 seconds, is not the coordinated phase, and is mode NON.
   - Phase 2=72 seconds, is not the coordinated phase, and is mode MAX.
   - Phase 6=65 seconds, is the coordinated phase, and is mode MAX.

Splits Expanded(2.7.X.1)

	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	26	27	28	29	30	31	32
Table - 15																																
Time	20	72	22	45	27	65	22	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coord Phase	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mode	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Table - 16																																
Time	20	72	22	46	27	65	22	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coord Phase	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mode	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON
Table - 17																																
Time	28	85	24	43	31	81	24	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coord Phase	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mode	NON	MAX	NON	NON	NON	MAX	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON	NON

Note: See manual on next page for detailed explanation of Split Table Mode Settings.

Coordinated Phase

The *Coordinated Phase* designates one phase in the split table as the offset reference. The offset may be referenced to the beginning or the end of the *Coordinated Phase* using the programming features from **MM->2->5** (right menu).

Only one phase should be designated as the *Coordinated Phase*. If multiple coord phases are specified in different rings, the coordinator will not be able to reference the offset if the phases do not begin (or end) at the same point in the cycle. Therefore, specify one *Coordinated Phase* for the offset reference and apply a MAX mode setting (discussed in the next section) if you want to guarantee split time allocated to the coordinated movements. Consider, for example, when a lead left-turn sequence is used, and there is only one designated lead left (Phase 1) as pictured. In this case the *Coordinated Phase* should be the first "standalone" through phase (Phase 2) in the sequence after crossing the barrier. The same will apply to lag left turn sequences.

Setting *Return Hold* (**MM->2->5**) ensures that the controller holds in the coordinated phase once it returns to the phase. Applying a MAX *Mode* setting to the coord phase in the *Split Table* also "holds" the coord phase with a max call. It is recommended that you set *Return Hold* for all lead/lag left-turn sequences, because this guarantees that the *Coordinated Phase* is held to its force-off even if the max timer expires.

It is possible to gap out of the *Coordinated Phase* if *Return Hold* and the MAX *Mode* parameters are not set. This allows the controller to leave the *Coordinated Phase* and re-service a preceding left turn phase if there is enough time in the cycle to service the phase before forcing off the coord phase and crossing the barrier. The *Early Yield* adjustment may also be used to yield to the cross street phases before the barrier to service the cross street early.

Split Table Mode Setting

The *Mode* settings **override** recalls programmed in *Phase Options* (**MM->1->1->2**) whenever the split table is active.

NON The *None* setting applies the base recall settings programmed under **MM->1->1->2**

MIN The *Min* setting applies a minimum recall to the phase when the split table is active

MAX The *Max* setting applies a maximum recall to the phase when the split table is active. Note that when the Force-off mode is set to **Float** mode, a *Max* setting on any non-coordinated phase will utilize the calculated Max Float time and have an opportunity to leave that phase depending on phase rotation and the calculated apply points.

PED The *Ped* setting applies a pedestrian recall to the phase when the split table is active

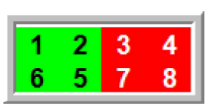
MxP The *Max + Ped* setting applies maximum and pedestrian recalls to the phase when the split is active

OMT The *Omit* setting omits the phase when the split table is active

Enb The *Enable* setting enables a phase that is not enabled in the phase options (**MM->1->1->2**) with ***NON*** selected.

NOTE: If a phase is disabled and the user programs a split time and a recall time other than NON, the phase is enabled.

Lead/Lag Considerations with the Coordinated Phase- First coordinated Phase



Many agencies switch lead lefts to lag lefts (and vice-versa) throughout the day to meet their traffic needs by calling different Phase Sequence tables by pattern. Choosing the coordinated phase may vary based on switching the phase sequence or the offset reference point. In the example to the left Phase 1 is a lead left, phase 2 and 6 are the straight through movements and phase 5 is a lag left. NTCIP specifies that the user must choose the first through phase as the coordinated phase for ***BegGrn*** offsets. The coordinated phase which occurs first within the concurrent group of phases containing the coordinated phase(s), when there are constant calls on all phases, is known as the **First Coordinated Phase**, in this case phase 6. In this case the user should choose Phase 6 as the Coord phase in the split table because it is the first through. If a lead/lag left-turn sequence is used and ***BegGrn*** offset reference point is used, the Coordinated Phase should be the first through phase in the sequence after crossing the barrier.

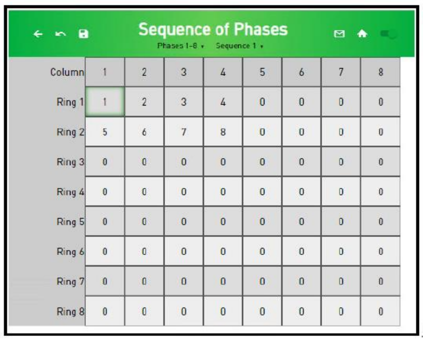
Using the ***EndGrn*** offset reference point, the user should choose Phase 2 as the Coordinated phase in the split table because it is the last through before crossing the barrier at the "0" point in the cycle.

7. Review “Ring Sequences(1.2.4)” to determine the phase **Sequence** as indicated in step 4 for Patterns 1-253. Note: The sequence for pattern 254 Free is specified in “Unit Parms(1.2.1)”

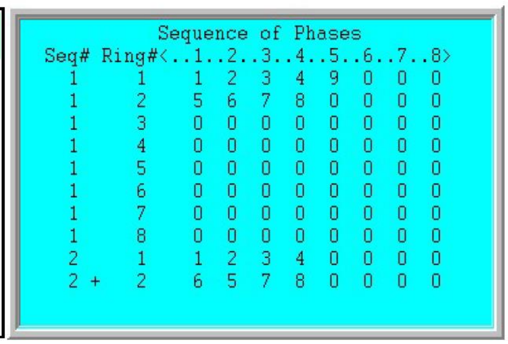
Note that the columns represent rings and the rows represent the sequence of phases.
For sequence 1 as reflected in step 4 you will look at table 1.
In the example below the following is shown:
Ring 1 phase sequence is 2,1,3,4
Ring 2 phase sequence is 6,5,7,8

Ring Sequences(1.2.4)				
	1	2	3	4
Table - 1				
1	2	6	0	0
2	1	5	0	0
3	3	7	0	0
4	4	8	0	0
5	0	0	0	0
6	0	0	0	0

4.2.1 Ring Sequence (MM->1->2->4, MM->1->2->4->1, MM->1->2->4->2)


Sequence of Phases
Phases 1-8 ▾ Sequence 1 ▾

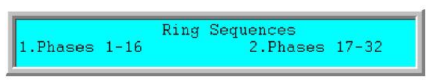
Column	1	2	3	4	5	6	7	8
Ring 1	1	2	3	4	0	0	0	0
Ring 2	5	6	7	8	0	0	0	0
Ring 3	0	0	0	0	0	0	0	0
Ring 4	0	0	0	0	0	0	0	0
Ring 5	0	0	0	0	0	0	0	0
Ring 6	0	0	0	0	0	0	0	0
Ring 7	0	0	0	0	0	0	0	0
Ring 8	0	0	0	0	0	0	0	0


```
           Sequence of Phases
Seq# Ring#<..1..2..3..4..5..6..7..8>
 1     1     1  2  3  4  9  0  0  0
 1     2     5  6  7  8  0  0  0  0
 1     3     0  0  0  0  0  0  0  0
 1     4     0  0  0  0  0  0  0  0
 1     5     0  0  0  0  0  0  0  0
 1     6     0  0  0  0  0  0  0  0
 1     7     0  0  0  0  0  0  0  0
 1     8     0  0  0  0  0  0  0  0
 2     1     1  2  3  4  0  0  0  0
 2 +   2     6  5  7  8  0  0  0  0
```

NOTE: There is no submenu selection for this data when using the Graphical User Interface. Access to this data is done directly via **MM->1->2->4**.

Sequence Number (Seq#)

Sixteen sequence number combinations are provided in the sequence table

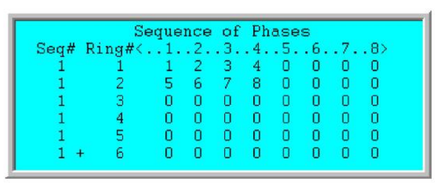

```
              Ring Sequences
1.Phases 1-16             2.Phases 17-32
```

Ring Number (Ring #)

Eight rings are provided for each of the sixteen sequences.

Sequence Data

A maximum of thirty-two consecutive phases may be programmed for each ring. STD-8ø initializes the controller with 16 default sequences that providing every lead/lag combination possible for eight-phase operation, dual ring operation.


```
           Sequence of Phases
Seq# Ring#<..1..2..3..4..5..6..7..8>
 1     1     1  2  3  4  0  0  0  0
 1     2     5  6  7  8  0  0  0  0
 1     3     0  0  0  0  0  0  0  0
 1     4     0  0  0  0  0  0  0  0
 1     5     0  0  0  0  0  0  0  0
 1 +   6     0  0  0  0  0  0  0  0
```

Each sequence must contain the same phases assigned to the same ring. Do not assign a phase to different rings in different sequences or you will generate a SEQ TRANS fault under **MM->7->9->5**) and send the controller to flash.

In addition, a phase must be provided in the coordinated ring for each concurrency (or barrier) group. For example, consider the USER sequence below in coordination with ø 6 selected as the coordinated phase. A “dummy phase” must be included in ring 2 because a phase must be assigned to each side of the barrier in the coordinated ring.

Wrong! No phase provided in coord ring right of barrier

Correct! Dummy Phase 8 provided in coord ring on the right of barrier

8. Review "Phase Times and Options(1.1.1/1.1.2/1.1.4)" to determine **Concurrent Phases**. Columns indicate the phases. C1 = Concurrent phase 1, C2=Concurrent phase 2, etc.

   In the example below the following is shown:
   Phase 1 is concurrent with phase 5 and 6.
   Phase 2 is concurrent with phase 5 and 6.
   Phase 3 is concurrent with phase 7 and 8.
   Phase 4 is concurrent with phase 7 and 8.
   Phase 5 is concurrent with phase 1 and 2.
   Phase 6 is concurrent with phase 1 and 2.
   Phase 7 is concurrent with phase 3 and 4.
   Phase 8 is concurrent with phase 3 and 4.

Phase Times and Options(1.1.1/1.1.2/1.1.4)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Auto Flash Entry	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
Auto Flash Exit	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.
Dual Entry	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.
Enable Simul Gap	.	X	.	.	.	X	.	.	.	.	X	X	X	X	X
Guarantd Passage	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rest In Walk	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Condit'l Service	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Non-Actuated 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Non-Actuated 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Added Init Calc	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Hold to Max	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ring	1	1	1	1	2	2	2	2	0	0	0	0	0	0	0
Startup	RED	GREEN	RED	RED	RED	GREEN	RED	RED	RED	RED	RED	RED	RED	RED	RED
C 1	5	5	7	7	1	1	3	3	0	0	0	0	0	0	0
C 2	6	6	8	8	2	2	4	4	0	0	0	0	0	0	0
C 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note see manual on next page for detail.

4.2.2 Ring, Concurrency, Startup (MM->1->1->4->1, MM->1->1->4->2)

Concur, Start, Inhibit, Misc

Phases 1-8

Phases	1	2	3	4	5	6	7	8
Ring	1	1	1	1	2	2	2	2
Start	Red	Red	Red	Red	Red	Red	Red	Red
Concurrent Φ	[5,6,0,0,...]	[5,6,0,0,...]	[7,8,0,0,...]	[7,8,0,0,...]	[1,2,0,0,...]	[1,2,0,0,...]	[3,4,0,0,...]	[3,4,0,0,...]
Call Φ	[0,0,0,0]	[0,0,0,0]	[0,0,0,0]	[0,0,0,0]	[0,0,0,0]	[0,0,0,0]	[0,0,0,0]	[0,0,0,0]
Inhibit Φ								
Redirect Φ Calls	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]

```
<         Concurrent Phases          >
 P Ring StartUp ..1..2..3..4..5..6..7..8
 1    1  RED       5  6  0  0  0  0  0  0
 2    1  RED       5  6  0  0  0  0  0  0
 3    1  RED       7  8  0  0  0  0  0  0
 4    1  RED       7  8  0  0  0  0  0  0
 5    2  RED       1  2  0  0  0  0  0  0
 6    2  RED       1  2  0  0  0  0  0  0
 7    2  RED       3  4  0  0  0  0  0  0
 8    2  RED       3  4  0  0  0  0  0  0
 9    1  GREEN     0  0  0  0  0  0  0  0
10 +  0  RED       0  0  0  0  0  0  0  0
```

NOTE: There is no submenu selection for this data when using the Graphical user interface. Access to this data is done directly via **MM->1->1->4**.

Phase ø (P)

Phase ø identifies the phase of the entries in the row.

```
        Ring, Start, Concurence
1.Phases 1-16            2.Phases 17-32
```

Ring (Rg)

The Ring value assigns each phase to a ring.

```
<          Concurrent Phases           >
 P  Ring StartUp  ..1..2..3..4..5..6..7..8
 1    1   RED         5  6  0  0  0  0  0  0
 2    1   RED         5  6  0  0  0  0  0  0
 3    1   RED         7  8  0  0  0  0  0  0
 4    1   RED         7  8  0  0  0  0  0  0
 5    2   RED         1  2  0  0  0  0  0  0
 6    2   RED         1  2  0  0  0  0  0  0
 7    2   RED         3  4  0  0  0  0  0  0
 8    2   RED         3  4  0  0  0  0  0  0
 9    0   RED         0  0  0  0  0  0  0  0
10    0   RED         0  0  0  0  0  0  0  0
11    0   RED         0  0  0  0  0  0  0  0
```

Start Up Phases (StartUp)

- **RED** – phase startup in the red interval
- **WALK** - startup in the green and walk interval
- **GREEN** - startup in the green interval (pedestrian calls are removed for the startup phase)
- **YELLOW** - startup in the yellow interval
- **RedCl** - startup in the red interval (applies the *Start Red Time* defined under *Unit Parameters*)
- **OTHER**- reserved NTCIP value
  Note: You can also control which phases are serviced next using the *StartYel, Next Ø* option under **MM->1->1->3**.

Concurrent Phases

Concurrent Phases define which phases may time together in each ring. The *Phase ø* itself does not need to be included in the concurrency group. However, any phase that is allowed to time with the *Phase ø* in another ring must be listed as a concurrent phase. Phases that are assigned to a sequence and do not belong to a concurrency group time sequentially while are other phases in the sequence are resting in red.

9. Review "Overlap Programming(1.5.2.X.1) to determine **Overlap** utilization.
   In the example below there are three overlaps programmed.
   Overlap 2,6,10. They are each Type FYA-4

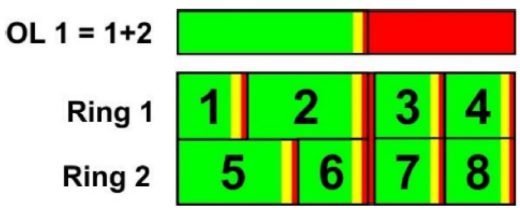
Overlap Programming(1.5.2.X.1)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Inc 1	0	1	0	0	0	5	0	0	0	3	0	0	0	0	0
Inc 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inc 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inc 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mod 1	0	2	0	0	0	6	0	0	0	2	0	0	0	0	0
Mod 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mod 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mod 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Type	NORMAL	FYA-4	NORMAL	NORMAL	NORMAL	FYA-4	NORMAL	NORMAL	NORMAL	FYA-4	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
Green	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

4.3 Overlaps (MM->1->5)

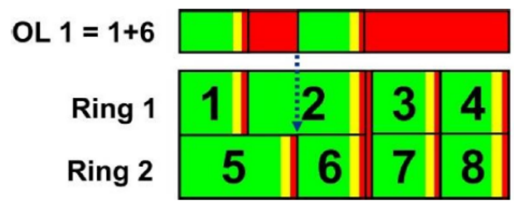
Thirty-two fully programmable overlaps may be assigned to any load switch channel in the terminal facility (cabinet) on Linux platforms.

Overlaps are customized channel outputs driven by one or more *included phases* that are typically consecutive phases in the ring sequence.

In the illustration to the right, OL1 is defined as an overlap of two included phases (Ø 1+ Ø 2). OL1 turns green when the first included phase turns green and clears with the last *included phase* in the sequence. Because Ø 1 and Ø 5 time together in this example, it does not matter if the *included phases* are defined as 1+2 or 1+6. The overlap extends from the beginning of Ø1 until the end of Ø2 or Ø6 green in either case. However, if Ø 5 extends past the end of Ø 1, the overlap operation varies significantly depending on whether the included phases are 1+2 or 1+6 as shown below.

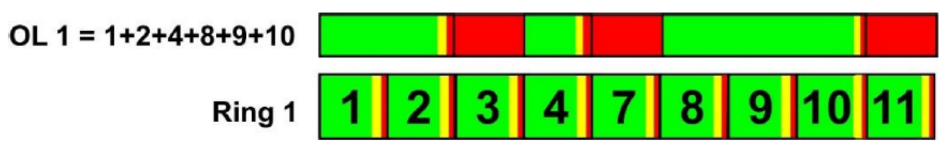


Consecutive Included Ø 1+ Ø 2 in the Same Ring



Non-consecutive Included Ø 1+6 in Separate Rings

Overlaps may be defined with any number of phases in the same ring as shown below. This feature is useful in sequential phase operation (8SEQ or USER phase mode) to create signal displays that overlap any number of phases in the sequence.



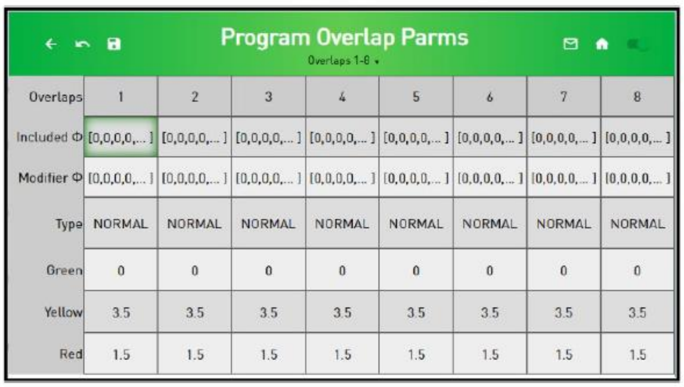
When Included Phases Are Not Consecutive, the Overlap Will Time Multiple Clearances during the Sequence

Note: Although Overlaps use phasing to control their outputs, they preform independently. Therefore if your agency uses specific features which may have an effect on included phases, modifier phases or various overlap types, you should thoroughly bench test the overlap to ensure proper operation. For example, a feature such as the unit parameter Clearance Decide, affects phase next decision making which will have ramifications on overlap behavior.

4.3.2 Overlap Program Selection and Configuration (MM->1->5->2)

Each overlap is selected separately from **MM->1->5->2**.

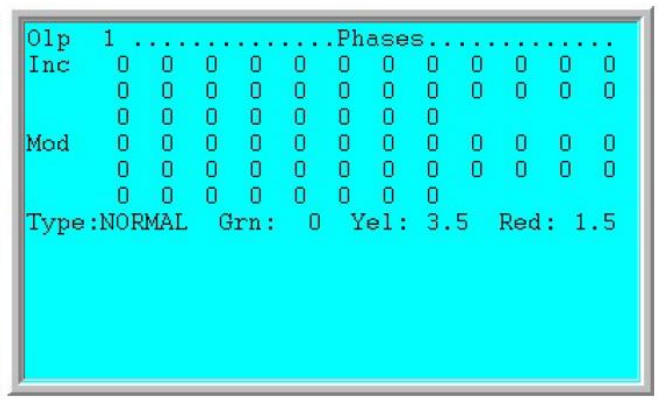
To program each overlap use the Program Params selection at **MM->1->5->2->1.**



Program Overlap Parms

Overlaps 1-8

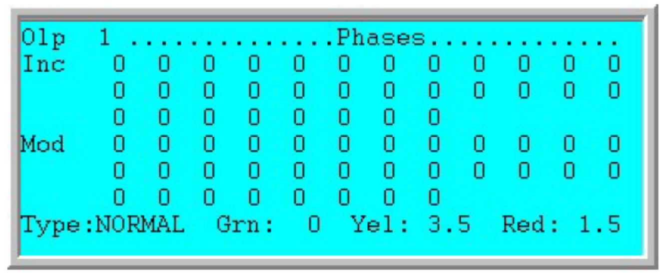
Overlaps	1	2	3	4	5	6	7	8
Included Φ	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]
Modifier Φ	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]	[0,0,0,0,...]
Type	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
Green	0	0	0	0	0	0	0	0
Yellow	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5



Included Phases

A maximum of 32 *Included Phases* (or parent phases) may be assigned to each overlap. The user should enter (program) the phases in order from the leftmost position to rightmost position.

Modifier Phases



A maximum of 32 *Modifier Phases* may be assigned to the overlap to alter the operation based on the *Overlap Type*. The user should enter (program) the phases in order from the leftmost position to rightmost position.

Overlap Type

The *Overlap Type* parameter (NORMAL, -Grn/Yel or other sets the overlap operation as described in the next section

Overlap "Trailing" Green Extension

The overlap Green parameter extends the overlap green for 0-255 sec after an included phase terminates and the controller moves to the non-included phases. This overlap parameter is called "trailing green" in some controllers.

When running a Green Extension during an Overlap, the controller overlap software has a special case added to its termination logic as shown below. If the overlap is terminating:

AND NO green extension is programmed

AND there is a preempt in the begin phase

AND the preempt is NOT configured for All Red Before Preempt (**PreRedClr**)

then the software will provide a "dummy" 1 second green extension time.

The intention of this code is to ensure that an overlap that is currently green does not go green->red->green as it terminates the overlap to enter the preempt, but then re-enables the overlap because one of the included phases of the overlap are used by the preempt.

This code provides an extension to **ANY** overlap being terminated by a preemption that does not have a green extension configured regardless of whether or not this overlap has an included phase that is going to be serviced "next" by the preempt. This can lead to a situation where the current overlap is extending and can be in conflict with the phases becoming active as part of the preemption. To mitigate this issue, program the parameter **PreRedClr to ON** under **MM->3->1->8**. In addition, the user can consider programming the green extend inhibit parameter (**ExtInh**) under **MM->1->5->2->3** to not allow certain phases to extend.

Overlap "Trailing" Yellow and Red Clearance

Parent Phase Clearance determines whether the overlap times yellow and all-red clearance with the included phases or uses the separate yellow and all-red clearances programmed in the menu above. If *Parent Ø Clearances* is OFF, the yellow and all-red clearances as programmed in each overlap are used.

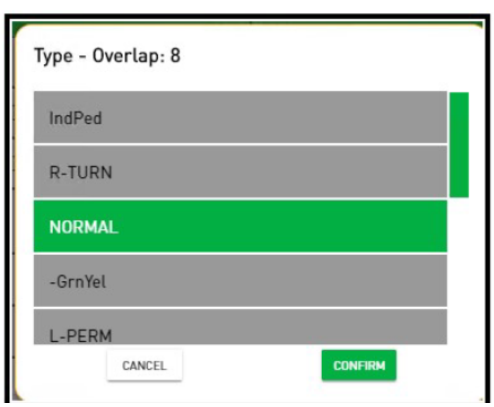
Please note that these timers are always used when exiting overlaps when a pre-emption is called.

4.4 Overlap Types

The operation of each of the 32 overlaps is governed by the *Overlap Type* and the *ModifierPhase(s)*. Examples are presented below to illustrate the operation available with each overlap type. We provide overlap features based on customer requirements and does not endorse any particular mode of operation provided in these examples. The user should develop applications from these features that comply with local policies and with the Manual of Traffic Control Devices.

- **Normal** (NTCIP) – modifier phase causes the overlap to go dark
- **–GrnYel** (NTCIP) – modifier phase used to suppress the overlap green
- **OTHER** (Proprietary MIB) – selects one of the following Types+ under overlap *Program Parms+:*
  - **L-Perm** – suppresses the steady green in a protected/permissive left-turn while the opposing left-turn (modifier phase) is green (this left-turn display is used by some agencies to resolve the "yellow-trap).
  - **Fl Red** – Flashing red arrow used by some agencies for the permissive left-turn indication (another left-turn display designed to address the "yellow trap" safety issue.
  - **FAST-FL** - Fast FL is used in Canada. It flashes the GREEN signal at the rate specified in the Fast-Fl Rate parameter (see **MM→1→5→1**). It is used for protected-permissive left turns. An overlap set to this type will flash green when the user programs both the included phase and modifier phase and that phase is active
  - **R-Turn** – used to drive a right-turn green arrow when a non-conflicting left-turn is being serviced and move immediately to a steady green indication of the through movement associated with the right turn
  - **Ped_1** – used to drive a walk indication timed with the first included phase and pedestrian clearance which overlaps the following included phases defined for the overlap
  - **MinGrn** – identical to the NORMAL overlap type, except that the overlap green extension is timed as a min green period when the overlap green period begins
  - **FlYel-4** – this is used to Flash a yellow arrow during permissive left turns.
  - **GoBAR** – This overlap was developed to meet specific requirements for the City of Houston light rail system. The go indication (vertical bar) is output to the overlap green and the stop indication (horizontal bar) is output to the overlap red. The overlap displays a flashing prepare-top-stop and prepare-to-go based on requirements for the City of Houston.
  - **IndPed** – The IndPed overlap is intended for applications that bridge pedestrian clearance over two or more sequential included phases assigned to the overlap. The pedestrian clearance time is programmed using the parameter called **PedClrTime** under the overlap parameter+ screen.

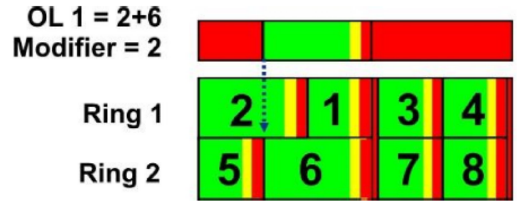
    Note: The **Ped_1** overlap is intended for applications that time phase walk and pedestrian clearance for included phases that do not follow each other in the sequence. The **Ped_1** overlap may also bridge the walk indication time over one or more included phases. If the application requires bridging pedestrian clearance, then use the **IndPed** overlap.



4.4.3 Overlap Type: Left Turn Permissive (L-PERM)

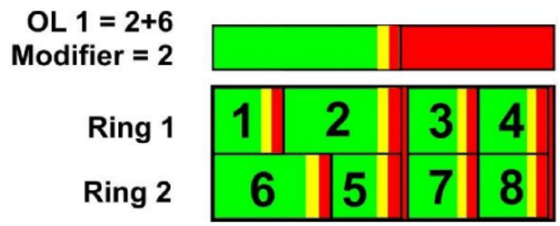
Both the Included Phases and the Modifier Phases control this overlap type as follows:

- The overlap turns green when an included phase, that is not a modifier phase, turns green (this is true even if a modifier phase is already displaying a green indication)
- The overlap remains green as long as one of the included phases remain green
- The overlap is yellow when an included phase is yellow and an included phase is not on or next
- The overlap is red when it is not green or yellow



These overlap outputs can provide the permissive green, yellow, and red indications for a 5-section left-turn display. The protected left-turn phase provides the green and yellow arrow indications. The *modifier phase* is used with the L-PERM type to suppress the overlap display when the protected movement is lagging but not leading. The *included phases* are entered as the two through movements for the barrier, and the modifier phase is entered as the conflicting through movement for the left turn. The example to the right defines an overlap used to drive the permissive indications in a left-turn display where Ø1 is the protected left-turn movement. This overlap is defined with Ø2 & Ø6 as the included phases, and Ø2 as the modifier phase.

The L-PERM overlap type suppresses the overlap green indication until the adjacent through phase turns green in the lagging left-turn display. This prevents the driver in the through direction (Ø6 in this case) from seeing a green indication in the left-turn display while the through indications are steady red. Once the adjacent through phase (in this case Ø6) turns green, the overlap remains green until the barrier is reached.



If the phase sequence is reversed (Ø1 leading instead of lagging), the overlap does not need to be suppressed, so the L-PERM overlap displays a steady green indication as shown to the right. During a dual-lead sequence (Ø1 and Ø5 leading), the overlap is suppressed with a steady red indication until the end of Ø1.

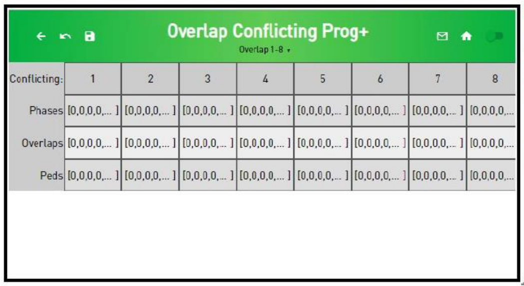
10. Review “Overlap Confl Prog+ (1.5.2.X.2)” to understand the behavior of the **Overlaps** identified in item 9.
    In the example below the following is shown:
    Overlap 2 conflicts with Ped phase 2
    Overlap 6 conflicts with Ped phase 6
    Overlap 10 conflicts with Ped phase 2

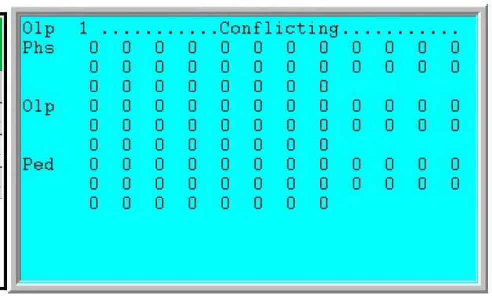
Overlap Confl Prog+(1.5.2.X.2)			
	2	6	10
Table - 1			
Phs 01	0	0	0
Phs 02	0	0	0
Phs 03	0	0	0
Phs 04	0	0	0

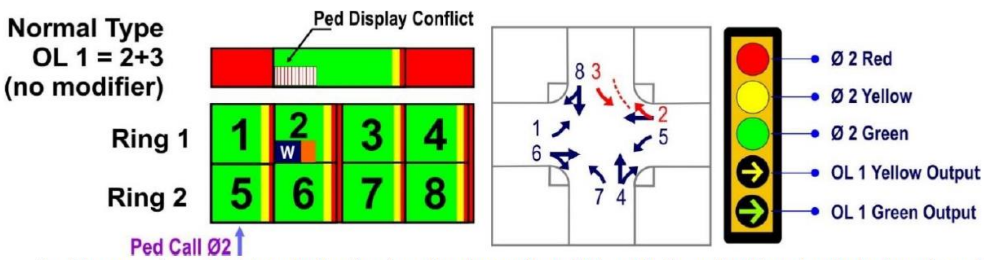
Ped 1	2	6	2
Ped 2	0	0	0
Ped 3	0	0	0
Ped 4	0	0	0
Ped 5	0	0	0

4.6 Overlap Conflict Program+ Menu (MM->1->5->2->2)

Up to 32 conflicting phases, pedestrian and overlaps terminate an overlap when the conflicting phase, pedestrian movement or overlap is next and continue to suppress the overlap while the conflicting phase, pedestrian movement or conflicting overlap is timing green and yellow clearance. *Conflicting Peds* may be used to omit a right-turn indication when a pedestrian movement is serviced. The example below shows the right-turn arrow (overlap 1) conflicting with the ped signals during phase 2.

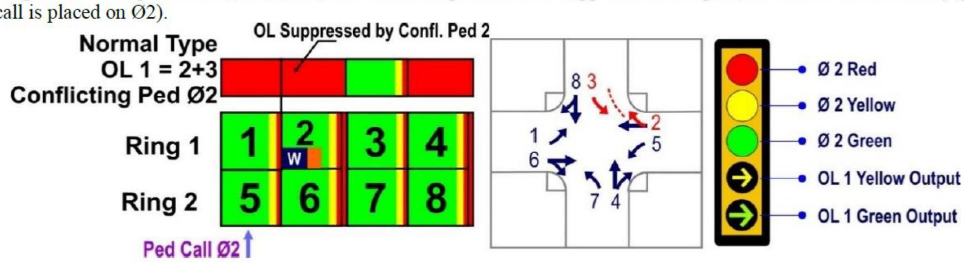






In this example, a right-turn indication (overlap 1 green) conflicts with the pedestrian signals during phase 2

The conflict between the right arrow and the walk indication may be avoided by programming the pedestrian phase as a *Conflicting Ped* to suppress the overlap whenever a ped call is placed on Ø2. The overlap will continue to be suppressed during Ø2 until the pedestrian call is serviced. The overlap will also be suppressed if the ped call is issued continuously (ped recall is placed on Ø2).



Here, a Conflicting Ped parameter is used to prevent the right-turn arrow conflict with the pedestrian signals

Note: the user should program **Conflict Lock Enable** to **ON** when programming conflicting phases(s) when using a FYA overlap.

11. Review "Phase Times and Options(1.1.1/1.1.2/1.1.4) for **Min Green Time**, **Max Green Time**, **Yellow Clearance**, **All-Red Time**, **Walk Time**, and **Flashing Don't Walk Time**.

In the example below the following is shown:
Phase 2

Min Green = 10 seconds
Max(1) Green = 40 seconds
Yellow Clearance = 4.4 seconds
All-Red = 2.3 seconds
Walk = 12
Flashing Don't Walk = 15

Phase Times and Options(1.1.1/1.1.2/1.1.4)								
	1	2	3	4	5	6	7	8
Table - 1								
MIN GRN	5	10	5	5	5	20	5	5
Gap Ext	2	3	2	2	2	3	2	2
MAX 1	30	40	25	20	30	40	25	20
Max 2	30	40	25	20	30	40	25	20
Yel Clr	3.1	4.4	3	3.4	3.3	4.3	3	3.3
Red Clr	2.3	2.3	2.4	1.2	2	2.3	2.5	1.4
Walk	0	12	0	13	0	8	0	9
Ped Clr	0	15	0	22	0	7	0	21
Red Revt	0	0	0	0	0	0	0	0
Add Init	0	2.5	0	0	0	2.5	0	0
Max Init	0	35	0	0	0	35	0	0
Gap Reduce Time B4	0	0	10	10	0	0	10	10
Gap Reduce Cars B4 Reduce	0	0	0	0	0	0	0	0
Gap Reduce Time To	0	0	5	5	0	0	5	5
Gap Reduce ReduceBy	0	0	0	0	0	0	0	0
Gap Reduce Min Gap	0	0	0.5	0.5	0	0	0.5	0.5
DyMaxLim	0	0	0	0	0	0	0	0
Max Step	0	0	0	0	0	0	0	0
Enable P	X	X	X	X	X	X	X	X
Min Recall	.	.	.	.	.	.	.	.
Max Recall	.	.	.	.	.	.	.	.
Ped Recall	.	.	.	.	.	.	.	.
Soft Recall	.	X	.	.	.	X	.	.
Lock Calls	.	.	.	.	.	.	.	.

4.1.5 Phase Times (MM->1->1->1)

Times
Phase 1-8

Phases	1	2	3	4	5	6	7	8
Min Grn	5	5	5	5	5	5	5	5
Gap,Ext	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max 1	25	25	25	25	25	25	25	25
Max 2	50	50	50	50	50	50	50	50
Yel Clr	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red Clr	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Times < >..	1...	2...	3...	4...	5...	6...	7...	8
Min Grn	5	5	5	5	5	5	5	5
Gap,Ext	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max 1	25	25	25	25	25	25	25	25
Max 2	50	50	50	50	50	50	50	50
Yel Clr	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red Clr	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Walk	0	5	0	5	0	5	0	5
Ped Clr	0	10	0	10	0	10	0	10
Red Revt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Add Init	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max Init+	0	0	0	0	0	0	0	0

Minimum Green (Min Grn)

The *Minimum Green* parameter (0-255 sec) determines the minimum duration of the green interval for each phase. When setting this time, consider the storage of vehicles between the detector and the stop-bar for the associated approach.

Gap, Extension (Gap, Ext)

Gap,extension (also known as *Passage* time) determines the extensible portion of the green interval (0-25.5 sec). The phase remains in the extensible portion as long as an actuation is present and the passage timer has not expired. The timer is reset with each subsequent actuation and does not start timing again until the actuation is removed.

Max-1 Green (Max 1)

Max-1 (0-999 sec) limits the maximum time of the green interval after a serviceable conflicting call is received. The maximum green timer does not begin timing until a serviceable conflicting call is received. *Max-1* is set as the default max setting but may be overridden *Max-2*.

Max-2 Green (Max 2)

Max-2 (0-999 sec) also limits the maximum time of the green interval after receiving a serviceable conflicting call. *Max-2* may be selected by ring from an external controller input or as a pattern option. *Max-2* may also be selected by-phase under *Phase Options+* (next section). This last method allows *Max-1* to be enabled for some phases and *Max-2* for others.

Yellow Clearance (Yel Clr)

The *Yellow Clearance* parameter (0-25.5 sec) determines the yellow clearance interval of the associated phase.

Red Clearance (Red Clr)

The *Red Clearance* parameter (0-25.5 sec) determines the all-red clearance interval of the associated phase.

Walk (Walk)

The Walk time parameter provides the length of the walk indication (0-255 sec).

Times < >..	1...	2...	3...	4...	5...	6...	7...	8
Ped Clr -	0	10	0	10	0	10	0	10
Red Revt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Add Init	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max Init	0	0	0	0	0	0	0	0
Gap Reduce								
Time B4	0	0	0	0	0	0	0	0
Cars B4+	0	0	0	0	0	0	0	0

Pedestrian Clearance (Ped Clr)

Pedestrian Clearance (0-255 sec) is the duration of the flashing pedestrian clearance ("Don't Walk") output.

Red Revert Time (Red Revt)

The *Red-Revert* Time parameter determines the minimum time (0-25.5 sec) that the phase must remain in red rest before it is recycled to green. The controller uses the greater of the phase *Red-Revert Time* or the *Unit Parameter, Red-Revert*, to limit how quickly each phase green is recycled.

Added Initial (Add Init)

Added-Initial (0-25.5 sec) is an optional volume-density feature that extends after the *Minimum Green* timer expires. *The T/Ac* (time per actuation) timer is set initially to *Min Green*. Each detector actuation during the yellow and red interval extends the *T/Ac* timer by the *Added Initial* value if the detector option *Added-Initial* is enabled. Detector actuations received during the red interval continue to extend *T/Ac* by the *Added Initial* value until the *Max Initial* limit is reached. In this way, the *T/Ac* timer behaves as a parallel timer with *Min-Green*. The greater of *Min-Green* or *T/Ac* defines the minimum green time period.

APPENDIX F

CARSON CITY JOB POSTINGS

Operations Manager-Control Systems

Class Code: 00807

Bargaining Unit: UNCLASSIFIED EMPLOYEES

CONSOLIDATED MUNICIPALITY OF CARSON CITY
Established Date: Jul 1, 2013
Revision Date: Mar 5, 2018

SALARY RANGE

$42.09 - $63.13 Hourly
$7,295.22 - $10,942.86 Monthly
$87,542.62 - $131,314.35 Annually

DESCRIPTION:

Under general direction, plans, assigns, supervises, reviews and evaluates the work of the staff assigned to the operation and maintenance of the electrical, instrumentation, process control, data acquisition and city-wide communication systems for public works operations.

EXAMPLE OF DUTIES:

This class specification lists the major duties and requirements of the job and is not all-inclusive. Incumbent(s) may be expected to perform job-related duties other than those contained in this document and may be required to have specific job-related knowledge and skills.

- Plans, organizes, assigns, supervises, reviews and evaluates the work of assigned staff.
- Recommends selection of staff; trains staff and provides for their professional development; administers discipline as required.
- Develops, implements and manages real-time computer process control systems and related utility programs; manages the modification, testing and implementation of systems to improve efficiency/effectiveness of performance.
- Manages technical tasks related to assigned operations such as intelligent transportation, utility automation, and public safety communications.
- Manages asset management, security access control, and video surveillance systems.
- Participates in the design, layout, modification, and installation of systems; prepares working drawings and sketches; assists in preparing project specifications.
- Estimates materials, parts, tools and equipment needed for work assignments; orders and picks up materials and supplies from outside vendors as appropriate; prepares cost estimates for job.
- Assists in development and maintenance of budget for assigned unit operations.
- Serves as liaison between City IS Department and Public Works to ensure compliance and compatibility with established standards.

- Reads diagrams, blueprints, specifications and manuals for installation/repair projects.
- Contributes to the efficiency and effectiveness of the unit's service to its customers by offering suggestions and directing or participating as an active member of a team.
- Drives City vehicles to work sites.
- Demonstrates courteous and cooperative behavior when interacting with public and staff; acts in a manner that promotes a harmonious and effective workplace environment.
- Directs the maintenance of records, including maintenance/repair records.
- Assists in development and management of unit budget.

QUALIFICATIONS:

To perform this job successfully, an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge, skill, and/or ability required.

Education and Experience:
Equivalent to High School diploma or GED; AND five (5) years of skilled experience in the operation and maintenance of electronic and electrical equipment; OR an equivalent combination of education, training and experience as determined by Human Resources.

REQUIRED CERTIFICATES, LICENSES, AND REGISTRATIONS:

- Valid Driver's License.

Required Knowledge and Skills
Knowledge of:

- Principles and practices of employee supervision, including selection, work planning, organization, performance review and evaluation, and employee training and discipline.
- Principles and practices of budget development and management.
- Principles, methods and materials used in a real-time process control environment.
- Methods and materials used in electronic information and control system installation, maintenance and repair, including digital solid state computers.
- Systems analysis and design procedures and techniques for real-time applications.
- Applicable codes and regulations related to the work.
- Safe work methods and safety procedures pertaining to the work.
- Computer programming as applied to controllers and electronic test equipment.
- Intelligent transportation systems and computer software and hardware related to transportation and communication systems.

Skill in:

- Planning, organizing, supervising, reviewing and evaluating the work of others.
- Training others in policies and procedures related to the work.
- Reviewing plans and inspecting contractor work for compliance with codes and City specifications.
- Designing, laying out and preparing sketches for systems installation, modification, and maintenance jobs.
- Estimating necessary materials, parts and equipment to complete assignments.
- Ensuring compliance with established safety practices and procedures related to operations assigned.
- Project planning, coordination and scheduling.
- Performing systems analysis, design and installation.
- Maintaining accurate records of work performed.
- Reading and interpreting manuals, specifications, drawings and blueprints.
- Using initiative and independent judgment within established procedural guidelines.

- Contributing effectively to the accomplishment of team or work unit goals, objectives and activities.
- Establishing and maintaining effective working relationships with those encountered in the course of the work.

SUPERVISION RECEIVED AND EXERCISED:
Under General Direction - Incumbents at this level have considerable latitude in the application of departmental policy, and they follow general guidelines or professional and administrative standards in accomplishing assignments. They are responsible for planning and organizing their own workload, but ordinarily cannot change methods of their assigned work unit, established operations, or departmental policy without supervisor approval. Supervision is minimal, indirect, and usually limited to technical oversight.

PHYSICAL DEMANDS & WORKING ENVIRONMENT:
The physical demands described herein are representative of those that must be met by an employee to successfully perform the essential functions of the job. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

Mobility to work in a field setting, use standard office equipment and stamina to sit and walk for extended periods of time; agility to navigate uneven terrain; strength to lift and carry up to 50 pounds; vision to read printed materials; and hearing and speech to communicate in person or over the telephone; work is subject to exposure to weather conditions, fumes, dust and hazardous chemicals.

SUPPLEMENTAL INFORMATION:

CONDITIONS OF EMPLOYMENT:

1. *Unclassified employees are "At Will" and as such, may be terminated at any time for any reason, or no reason.*
2. *Continued employment is contingent upon all required licenses and certificates being maintained in active status without suspension or revocation.*
3. *Any City employee may be required to stay at or return to work during emergencies to perform duties specific to this classification or to perform other duties as requested in an assigned response position. This may require working a non-traditional work schedule or working outside normal assigned duties during the incident and/or emergency.*
4. *Employees may be required to complete Incident Command System training as a condition of continuing employment.*
5. *New employees are required to submit to a fingerprint based background investigation which cost the new employee $56.25 and a drug screen which costs $36.50. Employment is contingent upon passing the background and the drug screen.*
6. *Carson City participates in E-Verify and will provide the Social Security Administration (SSA) and, if necessary, the Department of Homeland Security (DHS), with information from each applicant's Form I-9 to confirm work authorization. All candidates who are offered employment with Carson City must complete Section 1 of the Form I-9 along with the required proof of their right to work in the United States and proof of their identity prior to starting employment. Please be prepared to provide required documentation as soon as possible after the job offer is made. For additional information regarding acceptable documents for this purpose, please contact Human Resources at 775.887.2103 or go to the U.S. Citizenship and Immigration Services web page at www.ucis.gov .*
7. *Carson City is an Equal Opportunity Employer.*

Senior Transportation Planner

Class Code: 00719

Bargaining Unit: UNCLASSIFIED EMPLOYEES

CONSOLIDATED MUNICIPALITY OF CARSON CITY
Established Date: Mar 1, 2010
Revision Date: Mar 12, 2018

SALARY RANGE

$31.42 - $47.13 Hourly
$65,356.72 - $98,036.22 Annually

DESCRIPTION:

Under general supervision, provides advanced level professional transportation planning support for City projects and programs; may lead the work of planning and technical support staff.

EXAMPLE OF DUTIES:

This class specification lists the major duties and requirements of the job and is not all-inclusive. Incumbent(s) may be expected to perform job-related duties other than those contained in this document and may be required to have specific job-related knowledge and skills.

- Provides guidance, training and work review to professional and/or technical staff on a project or day-to-day basis; organizes and assigns work, sets priorities, and follows-up to ensure coordination and completion of assigned work.
- Coordinates and performs research, administrative and technical activities necessary to achieve planning project or program objectives; has responsibility for one or more specific programmatic areas.
- Creates long-range Regional Transportation Plan updates; coordinates with other jurisdictions, agencies, special interest groups, State and federal government.
- Develops Unified Planning Work Program for the MPO planning process.
- Interprets codes, regulations and policies related to current, long-term, transportation and other specialized planning; assists contractors, developers and others in the interpretation of codes.
- Provides direction to contracted consultants in regard to maintenance of travel demand model, analysis for specific studies and data provisions.
- Updates and maintains Transportation Improvement Plan to comply with federal requirements and maintain funding/eligibility for programmed projects.
- Prepares agendas, presents information, and seeks input from CAMPO Board, RTC and other associated Boards and Commissions.
- Submits applications for grant opportunities related to funding of transportation improvement projects.
- Represents the City and/or the MPO on working groups, committees and task forces.

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- Directs the preparation of and personally prepares maps, charts, models, sketches and other graphic presentations; prepares reports, presentations, correspondence and other written materials.
- Organizes own work, sets priorities and meets critical deadlines.
- Contributes to the efficiency and effectiveness of the unit's service to its customers by offering suggestions and directing or participating as an active member of a team.
- Demonstrates courteous and cooperative behavior when interacting with elected officials, public and City staff; acts in a manner that promotes a harmonious and effective workplace environment.

QUALIFICATIONS:

To perform this job successfully, an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge, skill, and/or ability required.

Education and Experience:
Bachelor's Degree with major course work in city, regional, environmental, transportation or urban planning, public or business administration, or related field; AND four (4) years of professional transportation planning experience; OR an equivalent combination of education, training and experience as determined by Human Resources.

REQUIRED CERTIFICATES, LICENSES, AND REGISTRATIONS:

- Valid Driver's License

Required Knowledge and Skills
Knowledge of:

- Objectives, principles, procedures, standards, practices, information services and trends in the field of professional planning.
- Land use, physical design, demographic, environmental and social/economic concepts as applied to the transportation planning process.
- Statistical analysis techniques and mathematical concepts.
- Application, modification, and interrelationships between ordinances, policies, standards, procedure and practices associated with the planning function.
- Applicable federal, state and local laws and regulations.
- Terminology, symbols, methods and techniques used in planning and map drafting.
- Local government organization and the functions and practices of transportation planning.
- Travel demand modeling concepts.
- Computer applications related to the work.
- Geographic Information Systems (GIS).
- Principles and practices of grant application and management.
- Principles and practices of project management.
- Business letter writing and the standard format for typed materials.
- Record keeping principles and practices.
- Correct business English, including spelling, grammar and punctuation.

Skill in:

- Planning, organizing, directing, reviewing and evaluating the work of others, including contract staff.
- Travel demand modeling.
- Training others in policies and procedures related to the work.
- Conducting complex planning studies and activities.

- Performing and coordinating activities, such as the collection and analysis of data and the preparation of reports and recommendations.
- Exercising sound independent judgment within established procedural guidelines.
- Contributing effectively to the accomplishment of team or work unit goals, objectives and activities.
- Contract management.
- Dealing successfully with advisory boards, agencies, elected officials, city staff at various levels, the public, in person and over the telephone.

SUPERVISION RECEIVED AND EXERCISED:
Under General Supervision - Incumbents at this level are given assignments and objectives that are governed by specifically outlined work methods and a sequence of steps, which are explained in general terms. The responsibility for achieving the work objectives, however, rests with a superior. Immediate supervision is not consistent, but checks are integrated into work processes and/or reviews are frequent enough to ensure compliance with instructions.

PHYSICAL DEMANDS & WORKING ENVIRONMENT:
The physical demands described herein are representative of those that must be met by an employee to successfully perform the essential functions of the job. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

Mobility to work in a typical office setting, use standard office equipment and stamina to sit for extended periods of time; agility to traverse rough terrain; strength to lift and carry up to 20 pounds; vision to read printed materials; and hearing and speech to communicate in person or over the telephone; exposure to traffic conditions and weather conditions in execution of field duties.

SUPPLEMENTAL INFORMATION:

CONDITIONS OF EMPLOYMENT:

1. Unclassified employees are "At Will" and as such, may be terminated at any time for any reason, or no reason.

2. Continued employment is contingent upon all required licenses and certificates being maintained in active status without suspension or revocation.

3. Any City employee may be required to stay at or return to work during emergencies to perform duties specific to this classification or to perform other duties as requested in an assigned response position. This may require working a non-traditional work schedule or working outside normal assigned duties during the incident and/or emergency.

4. Employees may be required to complete Incident Command System training as a condition of continuing employment.

5. New employees are required to submit to a fingerprint based background investigation which cost the new employee $56.25 and a drug screen which costs $36.50. Employment is contingent upon passing the background and the drug screen.

6. Carson City participates in E-Verify and will provide the Social Security Administration (SSA) and, if necessary, the Department of Homeland Security (DHS), with information from each applicant's Form I-9 to confirm work authorization. All candidates who are offered employment with Carson City must complete Section 1 of the Form I-9 along with the required proof of their right to work in the United States and proof of their identity prior to starting employment. Please be prepared to provide required documentation as soon as possible *after the job offer is made. For additional information regarding acceptable documents for this purpose, please contact Human Resources at 775.887.2103 or go to the U.S. Citizenship and Immigration Services web page at www.ucis.gov*

7. Carson City is an Equal Opportunity Employer.

Senior Traffic Systems Technician

Class Code: 00873

Bargaining Unit: CARSON CITY EMPLOYEES ASSOCIATION

CONSOLIDATED MUNICIPALITY OF CARSON CITY
Established Date: Jul 1, 2015
Revision Date: Mar 12, 2018

SALARY RANGE

$22.92 - $34.38 Hourly
$47,679.84 - $71,519.34 Annually

DESCRIPTION:

Under general supervision, performs complex technician level installation, repair and preventive maintenance of electrical and electronic components of traffic systems equipment in a variety of City locations.

EXAMPLE OF DUTIES:

This class specification lists the major duties and requirements of the job and is not all-inclusive. Incumbent(s) may be expected to perform job-related duties other than those contained in this document and may be required to have specific job-related knowledge and skills.

- Participates in the design, layout, modification, and installation of traffic control systems, controllers and related system elements; prepares working drawings and sketches; assists in preparing project specifications.
- Prioritize tasks, projects and repair orders; react to emergency repairs as required.
- Estimates materials, parts, tools and equipment needed for work assignments; orders and picks up materials and supplies from outside vendors as appropriate; prepares cost estimates for job.
- Performs skilled traffic signal work such as the installation, maintenance and repair of traffic signals, network communications, signal cables, relays, switches, boxes, controllers and other related equipment.
- Performs field and bench tests on electrical and electronic circuitry and various components, including solid state digital micro-processing systems; determines source of malfunctions and makes repairs as required.
- Inspects and performs preventive maintenance on systems and equipment; tests electronic and electrical elements to ensure ongoing usage.
- Maintains and repairs digital solid state traffic controllers, conflict monitors, video detection and incident detection systems, microwave detection systems, local communication interface units, load switches, pre-emption systems and vehicle induction loops.

- Troubleshoot and repairs knockdowns or damaged systems or components on an emergency basis.
- Reads diagrams, blueprints, specifications and manuals for installation and repair projects.
- Maintains and services electrical test and repair equipment and hand and power tools; keeps small inventory of frequently used supplies and parts.
- Contributes to the efficiency and effectiveness of the unit's service to its customers by offering suggestions and directing or participating as an active member of a work team.
- Maintains records of work performed and materials used.
- Ensures that proper safety precautions are followed, particularly around energized circuits.
- Drives City vehicles to work sites and transports materials; may work from lift trucks, ladders and other elevating devices.
- Demonstrates courteous and cooperative behavior when interacting with the public and City staff; acts in a manner that promotes a harmonious and effective workplace environment.

QUALIFICATIONS:

To perform this job successfully, an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge, skill, and/or ability required.

Education and Experience:
Equivalent to a High School education or GED; AND three (3) years of journey-level experience in the maintenance and repair of traffic control systems and equipment; OR an equivalent combination of education, training and experience as determined by Human Resources.

REQUIRED CERTIFICATES, LICENSES, AND REGISTRATIONS:

- A valid Class A Driver's License.
- Must possess valid International Municipal Signal Association (IMSA) Level III certification.
- Must take pre-employment physical examination and Respiratory Fit test.

Required Knowledge and Skills
Knowledge of:

- Principles, methods and materials used in the installation, repair, modification, and maintenance of a traffic signal systems and equipment, including microprocessor, digital, analog, and solid state systems.
- Methods and materials used electronic information and control system installation, maintenance and repair.
- Operation and maintenance of a variety of hand, power and shop tools and test equipment used in the trade.
- Applicable codes and regulations; safe work methods and safety procedures pertaining to the work.
- Shop mathematics; record keeping practices.
- Basic job estimation.
- Intelligent transportation systems and computer software and hardware related to transportation and communication systems.
- City geography.

Skill in:

- Operating and maintaining specialized equipment required for traffic signal installation, modification, maintenance and repair.
- Designing, laying out and preparing sketches for traffic signal and related installation and maintenance jobs.
- Estimating necessary materials, parts and equipment to complete assignments.
- Safely using and maintaining hand and power tools and test equipment related to the work.
- Directing and instructing others on a project basis.
- Maintaining accurate records of work performed.
- Reading and interpreting manuals, specifications, drawings and blueprints.
- Using initiative and independent judgment within established procedural guidelines.
- Contributing effectively to the accomplishment of team or work unit goals, objectives and activities.
- Establishing and maintaining effective working relationships with those encountered in the course of the work.

SUPERVISION RECEIVED AND EXERCISED:
Under General Supervision - Incumbents at this level are given assignments and objectives that are governed by specifically outlined work methods and a sequence of steps, which are explained in general terms. The responsibility for achieving the work objectives, however, rests with a superior. Immediate supervision is not consistent, but checks are integrated into work processes and/or reviews are frequent enough to ensure compliance with instructions.

PHYSICAL DEMANDS & WORKING ENVIRONMENT:
The physical demands described herein are representative of those that must be met by an employee to successfully perform the essential functions of the job. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

Strength and mobility to work in a typical field setting, including operating hand and power tools; stamina to perform sustained physical labor, including standing, walking, climbing and working in confined or awkward spaces; strength to lift and maneuver materials and equipment weighing up to 80 pounds with proper equipment; work at height of up to seventy-five (75) feet; vision to read printed materials; and hearing and speech to communicate in person or over a radio or telephone. Work outdoors, sometimes in adverse weather conditions and extreme temperatures. Work involves exposure to potentially hazardous electrical current and possibility of injury.

Employees must maintain an active telephone. Employees must reside within 30 minutes of Carson City. Employees must be willing to work overtime, shifts, weekends and holidays. Required to be on-call.

SUPPLEMENTAL INFORMATION:

CONDITIONS OF EMPLOYMENT:

1. All new employees will serve a probationary period of twelve (12) months. Such employees are not subject to the collective bargaining agreement and may be laid off or discharged during this period for any reason.

2. Continued employment is contingent upon all required licenses and certificates being maintained in active status without suspension or revocation.

3. Any City employee may be required to stay at or return to work during emergencies to perform duties specific to this classification or to perform other duties as requested in an *assigned response position. This may require working a non-traditional work schedule or working outside normal assigned duties during the incident and/or emergency.*

4. Employees shall be required to complete Incident Command System training as a condition of continuing employment.

5. New employees are required to submit to a fingerprint based background investigation which cost the new employee $56.25 and a drug screen which costs $84.00. Employment is contingent upon passing the background and the drug screen.

6. Carson City participates in E-Verify and will provide the Social Security Administration (SSA) and, if necessary, the Department of Homeland Security (DHS), with information from each applicant's Form I-9 to confirm work authorization. All candidates who are offered employment with Carson City must complete Section 1 of the Form I-9 along with the required proof of their right to work in the United States and proof of their identity prior to starting employment. Please be prepared to provide required documentation as soon as possible after the job offer is made. For additional information regarding acceptable documents for this purpose, please contact Human Resources at 775.887.2103 or go to the U.S. Citizenship and Immigration Services web page at www.ucis.gov

7. This position is covered under the authority of the Federal Motor Carrier Safety Administration (FMCSA) and/or the Federal Transit Administration (FTA).

All employees covered by this job description are subject to drug and alcohol testing in accordance with the requirements of the FMCSA, as set forth in 49 CFR part 382 as amended; or the FTA, as set forth in 49 CFR part 655 as amended; and the Carson City Anti-Alcohol Misuse Prevention Program; which are hereby referenced and made part of this job description, that mandate urine testing and breath alcohol testing for safety-sensitive positions, as well as those positions that require a commercial driver's license (CDL); requires termination of employment when there is a positive test result.

The US Department of Transportation (DOT) also imposes 49 CFR part 40 as amended, which is hereby referenced and made part of this job description, that establishes standards for collection and testing of urine and breath specimens.

Copies of parts 382, 655 and 40 are available in the Alcohol Program Manager's office and on the internet at the Office of Drug and Alcohol Policy an Compliance website www.dot.gov/ot/dapc/index.html .

8. Carson City is an Equal Opportunity Employer.

Transportation Manager

Class Code: 00581

Bargaining Unit: UNCLASSIFIED EMPLOYEES

CONSOLIDATED MUNICIPALITY OF CARSON CITY
Established Date: Jul 1, 2013
Revision Date: Mar 12, 2018

SALARY RANGE

$42.09 - $63.13 Hourly
$87,542.62 - $131,314.35 Annually

DESCRIPTION:

Under general direction, manages, coordinates and directs the all transportation and transit related planning, review and impacts for the City.

EXAMPLE OF DUTIES:

This class specification lists the major duties and requirements of the job and is not all-inclusive. Incumbent(s) may be expected to perform job-related duties other than those contained in this document and may be required to have specific job-related knowledge and skills.

- Plans, organizes, assigns, supervises, reviews and evaluates the work of professional and technical support staff.
- Recommends selection of staff; trains staff and provides for their professional development; administers discipline as required.
- Develops and implements goals, objectives, policies, procedures and work standards for the division; prepares and administers the division's budget.
- Prepares or directs the preparation of requirements for proposal, evaluates consultant qualifications and negotiates and administers contracts.
- Participates in long- and short-term departmental planning and policy formation.
- Contributes to the overall quality of the department's service provision by developing and coordinating work teams and by reviewing, recommending and implementing improved policies and procedures.
- Manages all aspects of the City's transit system including operations, system planning, capital acquisition, grant administration, and regulatory compliance.
- Direct and manage the planning, programming, and coordination activities required by the Carson Area Metropolitan Planning Organization's designation.
- Directs and coordinates strategic approach to the development of long-range goals and objectives to maximize and improve performance and accountability of key initiatives.
- Represents the City on task forces, committees and in meeting with other agencies.

- Leads efforts to locate, secure and utilize external funding sources to support transportation programs.
- Directs the maintenance of accurate records and files and prepares a variety of periodic and special reports and correspondence.
- Monitors developments in equipment, materials and techniques in the engineering design and construction field; gathers information, develops alternatives and makes recommendations.
- Demonstrates courteous and cooperative behavior when interacting with elected officials, public, contractors, and staff; acts in a manner that promotes a harmonious and effective workplace environment

QUALIFICATIONS:

To perform this job successfully, an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge, skill, and/or ability required.

Education and Experience:
Bachelor's Degree in engineering, planning, or a closely related field; AND five (5) years of supervisory level experience in transportation management; OR an equivalent combination of education, training and experience as determined by Human Resources.

REQUIRED CERTIFICATES, LICENSES, AND REGISTRATIONS:

- Valid Driver's license.
- Nevada Registration as a Professional Engineer (PE); OR,
- American Institute of Certified planners certification (AICP): OR,
- Professional Transportation Planner (PTP) certification.

Required Knowledge and Skills
Knowledge of:

- Administrative principles and practices, including goal setting, program development, implementation and evaluation, and the supervision of employees.
- Principles and practices of Metropolitan Planning Organization (MPO) operations.
- Principles and practices of fixed-route and demand-response transit systems planning and operations.
- Principles and practices of employee supervision, including selection, work planning, organization, performance review and evaluation, and employee training and discipline.
- Principles and practices of developing teams, motivating employees and managing in a team environment.
- Principles, practices and techniques of travel demand modeling processes.
- Principles and practices of contract management.
- Principles and practices of grant management.
- Budget development and administration.
- Applicable laws, codes and regulations; computer applications related to the work.
- Techniques for dealing with a variety of individuals, at all levels of responsibility, in person and over the telephone, where relations may be confrontational or strained.

Skill in:

- Developing effective work teams and motivating individuals to meet goals and objectives and provide customer services in the most cost effective and efficient manner.
- Travel demand modeling.
- Performing and overseeing contractors, including the negotiation and administration of contracts.

- Managing budgets.
- Preparing and interpreting a variety of documents, including contract specifications, sketches, diagrams and written reports and correspondence.
- Using initiative and independent judgment within general policy guidelines.
- Establishing and maintaining effective working relationships with those contacted in the course of the work.
- Interpreting, applying and explaining complex policies, codes and regulations.
- Setting priorities, coordinating multiple activities and meeting critical deadlines.
- Reading and interpreting plans, specifications and contracts.

SUPERVISION RECEIVED AND EXERCISED:
Under General Direction - Incumbents at this level have considerable latitude in the application of departmental policy, and they follow general guidelines or professional and administrative standards in accomplishing assignments. They are responsible for planning and organizing their own workload, but ordinarily cannot change methods of their assigned work unit, established operations, or departmental policy without supervisor approval. Supervision is minimal, indirect, and usually limited to technical oversight.

PHYSICAL DEMANDS & WORKING ENVIRONMENT:
The physical demands described herein are representative of those that must be met by an employee to successfully perform the essential functions of the job. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

Mobility to work in a typical office setting, use standard office equipment and stamina to sit for extended periods of time and/or negotiate construction sites and rough terrain; strength to lift and carry up to 50 pounds; vision to read printed materials; and hearing and speech to communicate in person or over the telephone; exposure to traffic conditions and external environment when traveling from one office to another.

SUPPLEMENTAL INFORMATION:

CONDITIONS OF EMPLOYMENT:

1. Unclassified employees are "At Will" and as such, may be terminated at any time for any reason, or no reason.

2. Continued employment is contingent upon all required licenses and certificates being maintained in active status without suspension or revocation.

3. Any City employee may be required to stay at or return to work during emergencies to perform duties specific to this classification or to perform other duties as requested in an assigned response position. This may require working a non-traditional work schedule or working outside normal assigned duties during the incident and/or emergency.

4. Employees may be required to complete Incident Command System training as a condition of continuing employment.

5. New employees are required to submit to a fingerprint based background investigation which cost the new employee $56.25 and a drug screen which costs $36.50. Employment is contingent upon passing the background and the drug screen.

6. Carson City participates in E-Verify and will provide the Social Security Administration (SSA) and, if necessary, the Department of Homeland Security (DHS), with information from each applicant's Form I-9 to confirm work authorization. All candidates who are offered *employment with Carson City must complete Section 1 of the Form I-9 along with the required proof of their right to work in the United States and proof of their identity prior to starting employment. Please be prepared to provide required documentation as soon as possible after the job offer is made. For additional information regarding acceptable documents for this purpose, please contact Human Resources at 775.887.2103 or go to the U.S. Citizenship and Immigration Services web page at www.ucis.gov .*

7. Carson City is an Equal Opportunity Employer.

Transportation Planner/Analyst

Class Code: 00580

Bargaining Unit: CARSON CITY EMPLOYEES ASSOCIATION

CONSOLIDATED MUNICIPALITY OF CARSON CITY
Established Date: Jul 1, 2015
Revision Date: Mar 12, 2018

SALARY RANGE

$28.57 - $42.85 Hourly
$59,416.66 - $89,124.46 Annually

DESCRIPTION:

Under general supervision, provides professional transportation planning support for City projects and programs.

EXAMPLE OF DUTIES:

This class specification lists the major duties and requirements of the job and is not all-inclusive. Incumbent(s) may be expected to perform job-related duties other than those contained in this document and may be required to have specific job-related knowledge and skills.

- Contributes to multi-modal (bicycle, pedestrian, transit, roadway) transportation systems planning, including data collection, analysis, and technical reporting.
- Contributes to successful implementation of the MPO's performance-based planning activities, including monitoring and evaluating performance measures, and establishing performance targets to meet federal and State requirements.
- Performs research, studies, administrative and technical activities necessary to achieve planning project or program objectives.
- Contributes to development of long-range Regional Transportation plan updates; coordinates with other jurisdictions, agencies, special interest groups, State and federal government as required.
- Cooperates and coordinates efforts with planning departments, transit agencies, special interest groups, State and federal agencies.
- Updates and maintains the Transportation Improvement Program (TIP) to comply with federal requirements and maintain funding/eligibility for programmed projects.
- Conducts transportation system analysis using mapping, travel demand modeling, database, statistical, or other related software(s).
- Prepares agendas, presents information, and seeks input from CAMPO Board, RTC and other associated Boards and Commissions.
- Contributes to the development and implementation of the Unified Planning Work Program for the MPO.

- Represents the City and/or the MPO on working groups, committees and task forces.
- Prepares maps, charts, models, sketches and other graphic presentations; prepares reports, presentations, correspondence and other written materials that contribute to the strategic advancement of department objectives.
- Promote multi-modal (bicycle, pedestrian, transit , roadway) mobility and safety.
- Organizes own work, sets priorities and meets critical deadlines.
- Contributes to the efficiency and effectiveness of the unit's service to its customers by offering suggestions and directing or participating as an active member of a team.
- Demonstrates courteous and cooperative behavior when interacting with elected officials, public and City staff; acts in a manner that promotes a harmonious and effective workplace environment.

QUALIFICATIONS:

To perform this job successfully, an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge, skill, and/or ability required.

Education and Experience:
Bachelor's Degree with major course work in city, regional, environmental, transportation or urban planning, public or business administration, or related field; AND two (2) years of professional transportation planning experience; OR an equivalent combination of education, training and experience as determined by Human Resources.

REQUIRED CERTIFICATES, LICENSES, AND REGISTRATIONS:

- Valid driver's license.

Required Knowledge and Skills
Knowledge of:

- Geographic Information Systems (GIS).
- Current active transportation issues, including best practices
- Objectives, principles, procedures, standards, practices, information services and trends in the field of professional planning.
- Land use, physical design, demographic, environmental and social/economic concepts as applied to the transportation planning process.
- Statistical analysis techniques and mathematical concepts.
- Application, modification, and interrelationships between ordinances, policies, standards, procedure and practices associated with the planning function.
- Applicable federal, state and local laws and regulations.
- Terminology, symbols, methods and techniques used in planning and map drafting.
- Local government organization and the functions and practices of transportation planning.
- Computer applications related to the work.
- Principles and practices of grant application and management.
- Principles and practices of project management and/or contract procurement.
- Business letter writing and the standard format for typed materials.
- Record keeping principles and practices.
- Correct business English, including spelling, grammar and punctuation.

Skill in:

- Performing basic Travel demand modeling.

- Communicating complete streets and active transportation concepts, both orally and in writing.
- Conducting complex planning studies and activities.
- Performing and coordinating activities, such as the collection and analysis of data and the preparation of technical reports and recommendations.
- Exercising sound independent judgment within established procedural guidelines.
- Contributing effectively to the accomplishment of team or work unit goals, objectives and activities.
- Using tact, discretion and prudence in dealing with those contacted in the course of the work.
- Project management.
- Dealing successfully with advisory boards, agencies, elected officials, city staff at various levels, the public, in person and over the telephone.

SUPERVISION RECEIVED AND EXERCISED:
Under General Supervision - Incumbents at this level are given assignments and objectives that are governed by specifically outlined work methods and a sequence of steps, which are explained in general terms. The responsibility for achieving the work objectives, however, rests with a superior. Immediate supervision is not consistent, but checks are integrated into work processes and/or reviews are frequent enough to ensure compliance with instructions.

PHYSICAL DEMANDS & WORKING ENVIRONMENT:
The physical demands described herein are representative of those that must be met by an employee to successfully perform the essential functions of the job. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

Mobility to work in a typical office setting, use standard office equipment and stamina to sit for extended periods of time; agility to traverse rough terrain; strength to lift and carry up to 20 pounds; vision to read printed materials; and hearing and speech to communicate in person or over the telephone; exposure to traffic conditions and weather conditions in execution of field duties.

SUPPLEMENTAL INFORMATION:

CONDITIONS OF EMPLOYMENT:

1. *All new employees will serve a probationary period of twelve (12) months. Such employees are not subject to the collective bargaining agreement and may be laid off or discharged during this period for any reason, or no reason.*
2. *Continued employment is contingent upon all required licenses and certificates being maintained in active status without suspension or revocation.*
3. *Any City employee may be required to stay at or return to work during emergencies to perform duties specific to this classification or to perform other duties as requested in an assigned response position. This may require working a non-traditional work schedule or working outside normal assigned duties during the incident and/or emergency.*
4. *Employees may be required to complete Incident Command System training as a condition of continuing employment.*
5. *New employees are required to submit to a fingerprint based background investigation which cost the new employee $56.25 and a drug screen which costs $36.50. Employment is contingent upon passing the background and the drug screen.*
6. *Carson City participates in E-Verify and will provide the Social Security Administration (SSA) and, if necessary, the Department of Homeland Security (DHS), with information from each applicant's Form I-9 to confirm work authorization. All candidates who are offered employment with Carson City must complete Section 1 of the Form I-9 along*

with the required proof of their right to work in the United States and proof of their identity prior to starting employment. Please be prepared to provide required documentation as soon as possible after the job offer is made. For additional information regarding acceptable documents for this purpose, please contact Human Resources at 775.887.2103 or go to the U.S. Citizenship and Immigration Services web page at www.ucis.gov

7. *Carson City is an Equal Opportunity Employer.*

Transportation/Traffic Engineer

Class Code: 00934

Bargaining Unit: UNCLASSIFIED EMPLOYEES

CONSOLIDATED MUNICIPALITY OF CARSON CITY
Established Date: May 28, 2019
Revision Date: May 28, 2019

SALARY RANGE

$34.56 - $51.85 Hourly
$71,893.33 - $107,838.85 Annually

DESCRIPTION:

Under general supervision, performs engineering work related to the coordination and supervision of major and minor construction and renovation projects, assuring that plans, specifications, codes, time schedules, and budgets are adhered to; provides complex inspections of projects, confers with contractors and consultants on the development and completion of projects; plans and directs traffic engineering and transportation activities, including traffic impact studies, traffic signal timing and various technical engineering studies.

EXAMPLE OF DUTIES:

This class specification lists the major duties and requirements of the job and is not all-inclusive. Incumbent(s) may be expected to perform job-related duties other than those contained in this document and may be required to have specific job-related knowledge and skills.

- Participates in planning and directing traffic engineering and transportation activities; conducts a variety of technical engineering studies; reviews transportation planning studies; analyzes and prepares traffic impact studies.
- Interacts with the general public and other organizations to investigate and resolve various traffic issues; responds to citizen requests and complaints; prepares, reviews, and makes recommendations on various traffic issues taken to the Transportation Manager.
- Prepares and reviews plans, specifications and estimates for traffic engineering contracts; reviews subdivision and development plans; prepares, develops, and maintains traffic signal timing and system coordination plans.
- Performs a variety of traffic engineering studies involving the use of computer programs and models; assists in the solution of difficult problems; participates in the selection of outside consulting firms; coordinates and directs the work of outside professional engineering consultants on City projects; prepares Requests for Proposals for various traffic engineering tasks.
- Provides construction project coordination and management of construction/ development and renovation projects of varying degrees of complexity.

- Performs designs based on goals, objectives and specifications of projects.
- Visits construction/renovation sites as required; conducts site inspections.
- Confers with developers, engineers, architects, contractors, property owners and others to explain codes, regulations and procedures.
- Coordinates all utility installations with contractors, architects, engineers, and utility companies.
- Coordinates inspections as required of all aspects of the construction process; interpreting, explaining and enforcing regulations, ordinances, and policies to contractors' construction superintendent; approving minor change orders and discussing major change orders with the City Engineer.
- Provides cost estimates and bids; bids out the job; selects, negotiates contracts and works with the design consultants and contractors; serves as the primary contact with the Contractor.
- Reviews plans, maps, job specifications, material testing lab reports, contracts, and other documents to ensure conformance with federal, State, City and industry codes and regulations.
- Interprets, explains and enforces regulations, ordinances and policies to developers, contractors, representatives of other agencies and the public; confers with engineers and building inspection staff regarding possible changes to plans and problem resolution.
- Traffic modeling and capacity analysis using HCS and/or Synchro software.
- Assist with roadway, crosswalks, and bicycle facility design and the preparation of Intersection Design Studies.
- Conduct traffic control warrant analyses.
- Prepares daily progress notes on each project. Identifies needed changes to construction plans and details; evaluates alternatives and makes effective recommendations.
- Reviews proposals for changes to contracts; negotiates rates with contractor for changes; recommends acceptance/rejection based on value negotiation.
- Drives a motor vehicle to attend meetings and visit various work sites.
- Demonstrates courteous and cooperative behavior when interacting with elected officials, public, contractors, and staff; acts in a manner that promotes a harmonious and effective workplace environment.

QUALIFICATIONS:

To perform this job successfully, an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge, skill, and/or ability required.

Education and Experience:
Bachelor's degree in Civil or Transportation Engineering or closely related field; AND four (4) years of civil, traffic, or transportation engineering experience; AND registration as a Nevada Professional Engineer or the ability to obtain licensure within six (6) months from date of appointment; OR an equivalent combination of education, training and experience as determined by Human Resources.

REQUIRED CERTIFICATES, LICENSES, AND REGISTRATIONS:

- Valid driver's license
- Current Nevada Professional Engineer licensure, or ability to obtain within six months from date of appointment.

Required Knowledge and Skills
Knowledge of:

- Engineering objectives, principles, procedures, standards, and practices.
- Statistical analysis and mathematical concepts related to the traffic/transportation engineering process.
- Terminology, symbols, methods, techniques and instruments used in engineering graphics and drafting.
- Theory, principles, and practices of civil and traffic engineering and design.
- Familiarity with MUTCD, HCM, AASHTO, ITE guidelines, and ADA Accessibility.
- Principles and practices of materials and soils analysis and grading. Computer applications related to the work.
- Engineering mathematics.
- Business letter writing and the standard format for typed materials.
- Record keeping principles and practices.
- Safety principles and practices related to the work.
- Correct business English, including spelling, grammar and punctuation.
- Applicable laws, codes and regulations.
- Project design and management principles and techniques.
- Techniques for dealing with a variety of individuals, at all levels of responsibility, in person or over the telephone, where relations may be confrontational or strained.

Skills in:

- Researching, analyzing, and summarizing engineering data both manually and with computer applications.
- Interpreting maps, plans and specifications, graphs and statistical data.
- Making complex engineering calculations quickly and accurately.
- Preparing clear, concise and complete technical documents, reports, correspondence and other written materials.
- Exercising sound independent judgment within established procedural guidelines.
- Establishing and maintaining effective working relationships with those contacted in the course of the work.
- Understanding and applying federal, state and local laws, regulations, policies, procedures and standards pertaining to engineering and construction.
- Representing the City effectively in meetings with developers, contractors, representatives of business, community and professional groups and the public.

SUPERVISION RECEIVED AND EXERCISED:
Under General Supervision - Incumbents at this level are given assignments and objectives that are governed by specifically outlined work methods and a sequence of steps, which are explained in general terms. The responsibility for achieving the work objectives, however, rests with a superior. Immediate supervision is not consistent, but checks are integrated into work processes and/or reviews are frequent enough to ensure compliance with instructions.

PHYSICAL DEMANDS & WORKING ENVIRONMENT:
The physical demands described herein are representative of those that must be met by an employee to successfully perform the essential functions of the job. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

Mobility to work in a typical office setting, use standard office equipment and stamina to sit for extended periods of time and/or negotiate construction sites and rough terrain; strength to lift and carry up to 50 pounds; vision to read printed materials; and hearing and speech to communicate in person or over the telephone; exposure to traffic conditions and external environment when traveling from one office to another.

SUPPLEMENTAL INFORMATION:

CONDITIONS OF EMPLOYMENT:

1. *Unclassified employees are "At Will" and as such, may be terminated at any time for any reason, or no reason.*
2. *Continued employment is contingent upon all required licenses and certificates being maintained in active status without suspension or revocation.*
3. *Any City employee may be required to stay at or return to work during emergencies to perform duties specific to this classification or to perform other duties as requested in an assigned response position. This may require working a non-traditional work schedule or working outside normal assigned duties during the incident and/or emergency.*
4. *Employees may be required to complete Incident Command System training as a condition of continuing employment.*
5. *New employees are required to submit to a fingerprint based background investigation which cost the new employee $56.25 and a drug screen which costs $36.50. Employment is contingent upon passing the background and the drug screen.*
6. *Carson City participates in E-Verify and will provide the Social Security Administration (SSA) and, if necessary, the Department of Homeland Security (DHS), with information from each applicant's Form I-9 to confirm work authorization. All candidates who are offered employment with Carson City must complete Section 1 of the Form I-9 along with the required proof of their right to work in the United States and proof of their identity prior to starting employment. Please be prepared to provide required documentation as soon as possible after the job offer is made. For additional information regarding acceptable documents for this purpose, please contact Human Resources at 775.887.2103 or go to the U.S. Citizenship and Immigration Services web page at www.ucis.gov*
7. Carson City is an Equal Opportunity Employer.

APPENDIX G

SELF-ASSESSMENT WORKSHOP RESULTS

Self-Assessment Workshop Outputs

Priority	Dimension			
	Business Processes (Planning and Programming)/Regional Collaboration	Systems and Technology	Performance Measurement	Communication Culture
1 (Short-Term)	▪ Identify opportunities for external funding are identified and actively pursued ▪ Establish and conduct reoccurring meetings for collaboration with agencies (twice per year) ▪ Document formal processes/procedures ▪ Document formal standard operations procedures (communication flow chart for use during emergencies and special events)	▪ Identify planning for known deficiencies ▪ Agencies collaborate to update standards and requirements for consistency in technology	▪ Share data for efficiency between agencies ▪ Establish what data should be collected and identify where systems and technology can be leveraged to collect that data ▪ Complete analysis focused on individual data elements to track incremental improvements ▪ Leverage and begin to use existing performance software (Regional Integrated Transportation Information System [RITIS])	▪ Establish reoccurring meetings with the region – consider different levels (i.e. traffic technician versus engineering level) ▪ Identify opportunities for intentional communication among departments and agencies
2 (Mid-Term)	▪ Hire additional staff (planning/engineering/program management) to plan and secure funding	▪ Acknowledge that regional planning should include traffic operations as a priority and identify investments to support that priority ▪ Identify how funding can go to rural counties when there are limited resources ▪ Establish more coordination and investment by NDOT (assisting in establishing level of services and capabilities) ▪ Identify the disconnect in funding sources with what needs to be funded (NDOT Funding)	▪ Centralize data collection through CAMPO – identify essential data to report and document ▪ Create consistency in process, storage, and data types for data collection among partnering agencies ▪ Identify opportunities for sharing software among the partnering agencies	None
3 (Long Term)	▪ Provide external resources to assist partnering agencies with design and operations (regionally available engineer to assist other counties)	▪ Communicate to all traffic signals ▪ Identify roles and responsibilities of the local agencies in providing traveler information that can support state distribution	▪ Centralize data analysis and reporting	None

SELF-ASSESSMENT WORKSHOP ACTION CHECKLIST

Priority	Domain	Actions	Responsibility
Short-Term (1-2 Years)	**Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture**	**Document formal processes/procedures** *Step 1: Identify areas requiring formal processes and procedures within CAMPO* *Step 2: Coordinate with partnering agencies to gather each agencies formal processes and procedures* *Step 3: Review all current processes and procedures and develop a draft for entire CAMPO region including communication flow chart for use during emergencies and special events* *Step 4: Gain consensus among partnering agencies on processes and procedures to formalize*	CAMPO
	Systems and Technology	**Agencies collaborate to update standards and requirements for consistency in technology** *Step 1: Establish committee to gather and review existing standards and requirements from all partnering agencies* *Step 2: Develop uniform standards and requirements for CAMPO* *Step 3: Gain consensus on uniform standards and requirements for use by all CAMPO partnering agencies*	CAMPO and Partnering Agencies
		Identify opportunities for intentional communication among departments *Step 1: Create a directory with contact information for all CAMPO departments* *Step 2: Establish and conduct reoccurring meetings for collaboration within CAMPO* *Step 3: Establish reoccurring meetings – consider different levels (i.e., traffic technician versus engineering level)*	CAMPO
	Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture	***Establish and conduct reoccurring meetings for collaboration with partner agencies (quarterly)*** *Step 1: Create a directory with contact information for all partnering agencies* *Step 2: Schedule reoccurring meeting* *Step 3: Develop standing agenda, with topics to include update from each jurisdiction, funding opportunities and performance metrics.* *Step 4: Track actions from each meeting*	CAMPO and Partnering Agencies (Storey, Lyon, Douglas County)
	Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture	***Establish reoccurring meetings with the region (quarterly) – consider different levels (i.e., traffic technician versus engineering level)*** *Step 1: Create a directory with contact information for all partnering agencies* *Step 2: Schedule reoccurring meeting* *Step 3: Develop standing agenda, with topics to include update from each jurisdiction, funding opportunities and performance metrics* *Step 4: Track actions from each meeting*	CAMPO and Partnering Agencies (Washoe RTC, Tahoe MPO, NDOT, etc.)
		Identify and actively pursue opportunities for external funding *Step 1: Acknowledge the importance of hiring one person at CAMPO to research funding and be a resource for partnering agencies to pursue external funding (Step 2 and 3 are likely more mid-term)* *Step 2: Present external funding opportunities during reoccurring meetings with the region* *Step 3: Assign a champion from each partnering agency to coordinate with CAMPO Funding Specialist to track and secure funding opportunities*	CAMPO
	Systems and Technology	**Identify planning for known deficiencies** *Step 1: Facilitate a meeting with partnering agencies to identify deficiencies among each agency and CAMPO* *Step 2: Develop and track action strategies to address identified deficiencies*	CAMPO and Partnering Agencies
	Performance Measurement	**Establish what data should be collected and identify where systems and technology can be leveraged to collect that data** *Step 1: Determine and create a list of performance measures required for each CAMPO partnering agency* *Step 2: Review identified performance measures against existing performance software (Regional Integrated Transportation Information System [RITIS]) and identify additional systems and technology to collect all required performance measures* *Step 3: Discuss systems and technology capabilities in collecting performance measures during the reoccurring meetings with the region*	CAMPO and Partnering Agencies
		Leverage and begin to use existing performance software (Regional Integrated Transportation Information System [RITIS]) *Step 1: Ensure all partnering agencies have access to existing software*	CAMPO and Partnering Agencies

Priority	Domain	Actions	Responsibility
Short-Term (1-2 Years)	**Performance Measurement**	***Share data for efficiency between agencies*** *Step 1: Gain consensus among partnering agencies and establish data sharing processes and procedures* *Step 2: Share data following established processes and procedures*	CAMPO and Partnering Agencies
		Complete analysis focused on individual data elements to track incremental improvements *Step 1: Gain consensus among partnering agencies and establish data analysis processes and procedures* *Step 2: Analyze data per established data analysis processes and procedures* *Step 3: Report data analysis results*	CAMPO and Partnering Agencies
Mid-Term (3-5 Years)	**Systems and Technology**	**Acknowledge that regional planning should include traffic operations as a priority and identify investments to support that priority** *Step 1: Utilize results from discussions in quarterly meetings to identify and prioritize next steps*	CAMPO
		Establish more coordination and investment by NDOT (assisting in establishing level of services and capabilities) *Step 1: Initiate coordination with NDOT to discuss NDOT's involvement in assisting with the establishment of level of service and capabilities*	CAMPO
		Identify the disconnect in funding sources with what needs to be funded (NDOT Funding) *Step 1: Gather input from CAMPO partnering agencies on funding limitations* *Step 2: CAMPO to schedule meeting with NDOT to discuss identified funding limitations* *Step 3: CAMPO and NDOT to establish actionable plan to mitigate funding limitations allowing partnering agencies opportunities for funding*	CAMPO, NDOT, and Partnering Agencies
	Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture	**Hire additional staff (planning/engineering/program management) to plan and secure funding** *Step 1: Identify Job Descriptions* *Step 2: Contact HR to post position* *Step 3: Conduct Interviews* *Step 4: Identify Start Date*	CAMPO
Long-Term (Over 5 Years)	**Business Processes (Planning and Programming)/Regional Collaboration and Communication Culture**	**Provide external resources to assist partnering agencies with design and operations (regionally available engineer to assist other counties)** *Dependent on mid-term action to "Hire additional staff (planning/engineering/program management) to plan and secure funding"*	CAMPO
	Performance Measurement	**Centralize data analysis and reporting** *Dependent on short-term action to "Share data for efficiency between agencies"*	CAMPO
	Systems and Technology	**Communicate to all traffic signals** *Step 1: Secure funding for all partnering agencies to allow communications to all traffic signals* *Step 2: Advertise project to design infrastructure to allow for communications to all CAMPO traffic signals* *Step 3: Advertise bid package for the construction of communications infrastructure to all CAMPO traffic signals*	CAMPO and Partnering Agencies
		Identify roles and responsibilities of the local agencies in providing traveler information that can support state distribution *Step 1: CAMPO to facilitate meeting with all partnering agencies to discuss roles, responsibilities, and actions in providing traveler information for state distribution* *Step 2: Establish a reoccurring meeting with key staff to ensure all roles, responsibilities, and identified actions are be conducted*	CAMPO and Partnering Agencies

APPENDIX H

LIFE-CYCLE COSTING SUMMARY

Carson Area Transportation System Management Plan (CATSMP)

Overall Summary

Traffic Signal Related Elements Highlighted in Blue

Description	Cost
Year 1 Replacement Cycle Cost (2023)	$ 8,211,675
FY 2022 Capital Improvements	$ 500,000
Difference in Actual Budget Versus Year 1 Replacement Cycle	$ (7,711,675)
Existing Annual O&M Cost	$ 113,434
Other O&M Costs	$ 44,915
Existing Traffic Signal Annual O&M Cost	$ 68,519
FHWA Recommended Annual O&M Cost	$ 260,741
Difference in Actual Versus Recommended Maintenance at Signals	$ (192,222)
Recommended Annual O&M Cost (2 Technicians)	$ 250,000
Recommended Traffic Systems Engineer/Signal Operations Engineer	$ 158,080
Current FY 2022 Capital Improvement Budget and Existing O&M Costs	$ 613,434
Estimated Annual Budget (O&M and Replacement Cost)	$ 8,619,755
Difference between Actual and Recommended	$ (8,006,321)

Description	Cost
Year 1 Recommended Replacement Cycle Cost (2023)	$ 8,211,675
FY 2022 Capital Improvements	$ 500,000
Difference in Actual Budget Versus Year 1 Replacement Cycle	$ (7,711,675)
FHWA Recommended Annual O&M Cost	$ 260,741
Existing Annual O &M Cost	$ 113,434
Difference in Existing O&M Cost and Recommended	$ (147,307)
Recommended Annual Budget (O&M and Replacement Cost)	$ 8,472,416
Difference between Actual and Recommended	$ (7,858,982)
Difference between Actual and Recommended (assuming 2 Technicians for a total of $155,000)	$ (7,817,416)

Carson Area Transportation System Management Plan (CATSMP)

Replacement Cycle Summary
Only Five Years Shown for Illustrative Purposes

Inflation 5.00% (average inflation from 2002 to 2022)

Equipment Type	Lifecycle Timeframe	# of Locations/Elements	Replacement Cycle Recommended	Yearly Replacement Cycle (identified by 20XX year)																													
				23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Traffic Signal Systems																																	
Cabinet and Service Pedestal	20 years	73	If CAMPO replaced cabinets on an evenly distributed cabinets per year, it would be approximately 4 cabinets per year. However, if the cabinets are assumed to be installed at the time that correlates to the dates on the *Signalized Intersections Install Data* spreadsheet there are 48 signalized intersections that are older than 20 years old. If CAMPO is experiencing difficulties with older cabinets, replacement of cabinets can be accelerated over the next several years to bring cabinets to up to date and 4 cabinets per year thereafter. If CAMPO has additional information on cabinets, we can take this into account.	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Controller	10 years	73	All controllers are to be replaced in the same year starting in 2025.			73										73										73							
Field Network Switches	7 years	73	Begin upgrading on a 7 year cycle. (Assumes one per signal)	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Traffic Signal Replacement	50 years	73	Full traffic signal replacement or new signals. (Assumes 5 upgrades per year)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Traffic Signal Upgrades - Poles and Mast Arms	50 years	73	Upgrades to existing traffic signal poles and mast arms (Assumes 5 upgrades per year)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Traffic Signal Upgrades - LEDs, push buttons. Etc.	10 - 15 years	73	Upgrades to existing traffic signal LED, APS push buttons, and signal heads (Assumes 5 upgrades per year)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Wire Re-Cabling	20 years	73	Begin upgrading on a 10 year cycle (Assumes even number per year)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Subtotal																																	
Traffic Signal Vehicle Detection Systems																																	
Vehicle Detection (in-pavement, video, radar) (per intersection)	10 years	73	Begin upgrading on a 10 year cycle (Assumes even number per year)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Emergency Vehicle Preemption (per intersection)	10 years	73	Begin upgrading on a 10 year cycle (Assumes all signals have emergency vehicle preemption)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Subtotal																																	
CCTV Camera Systems																																	
Cameras	7 years	146	Begin upgrading on a 7 year cycle with two cameras per intersection for a total of 146 cameras. (Assumes even number per year)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Traffic Management Software																																	
Traffic Management Software	10 years	1	Upgrade system every 10 years in coordination with controller replacement. Start replacement in 2025. Includes yearly $25K license fee each year ($400K for the system plus $250K for yearly fees).			1										1										1							
ITS Communications Systems																																	
Communications and Connectivity (cellular, wireless, or fiber optic)	10 years	73	Begin upgrading on a 10 year cycle (Assumed $2K per intersection)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
TMC Equipment																																	
Employee Overhead Equipment	10 years	1	Assume 1 new set of overhead equipment per year	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Average Replacement Cost Per Year (2022-2052)			$ 18,255,346																														

Equipment Type	Typical Capital Cost (2022 Dollars)	Yearly Replacement Capital Costs (based on cycle outlined to left)				
		23	24	25	26	27
Cabinet and Service Pedestal	$ 50,000	$ 210,000	$ 220,500	$ 231,525	$ 243,101	$ 255,256
Controller	$ 7,000	$ -	$ -	$ 591,546	$ -	$ -
Field Network Switches	$ 7,000	$ 80,850	$ 84,893	$ 89,137	$ 93,594	$ 98,274
Traffic Signal Replacement	$ 800,000	$ 4,200,000	$ 4,410,000	$ 4,630,500	$ 4,862,025	$ 5,105,126
Traffic Signal Upgrades - Poles and Mast Arms	$ 500,000	$ 2,625,000	$ 2,756,250	$ 2,894,063	$ 3,038,766	$ 3,190,704
Traffic Signal Upgrades - LEDs, push buttons. Etc.	$ 25,000	$ 131,250	$ 137,813	$ 144,703	$ 151,938	$ 159,535
Wire Re-Cabling	$ 70,000	$ 294,000	$ 308,700	$ 324,135	$ 340,342	$ 357,359
	Subtotal	$ 7,541,100	$ 7,918,155	$ 8,905,609	$ 8,729,766	$ 9,166,254
Vehicle Detection (in-pavement, video, radar) (per intersection)	$ 50,000	$ 420,000	$ 441,000	$ 463,050	$ 486,203	$ 510,513
Emergency Vehicle Preemption (per intersection)	$ 10,000	$ 84,000	$ 88,200	$ 92,610	$ 97,241	$ 102,103
	Subtotal	$ 504,000	$ 529,200	$ 555,660	$ 583,443	$ 612,615
CCTV Camera Systems						
Cameras	$ 5,500	$ 121,275	$ 127,339	$ 133,706	$ 140,391	$ 147,411
Traffic Management Software	$ 600,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000
ITS Communications Systems						
Communications and Connectivity (cellular, wireless, or fiber optic)	$ 2,000	$ 16,800	$ 17,640	$ 18,522	$ 19,448	$ 20,421
TMC Equipment						
Employee Overhead Equipment	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500	$ 3,500
	Subtotal	$ 166,575	$ 173,479	$ 180,728	$ 188,339	$ 196,331
	Total	$ 8,211,675	$ 8,620,834	$ 9,641,997	$ 9,501,548	$ 9,975,200

Estimated Signalized Intersection Age

Asset ID	Description	Signal Construction Date	Supports (Used Most Conservative Estimate)	Estimated Upgraded	Estimated Years Since Install	CAMPO Notes	Assumptions
ITS.C.1001	Signalized Intersection - Carson St and 5th St	4/8/1963	5 (1971-1979)	1971	52		
ITS.C.1002	Signalized Intersection - Carson St and Clearview Dr	10/1/1990	35 (1980-1985)	1990	33		Used construction date of 1990
ITS.C.1003	Signalized Intersection - Carson St and College Pkwy	10/1/1992	35A (1986-2016)	1992	31		Used construction date of 1992
ITS.C.1004	Signalized Intersection - Carson St and Eagle Station Ln	6/29/2010	35A (1986-2016)	2010	13	Based on Google Earth	Used construction date of 2010
ITS.C.1005	Signalized Intersection - Carson St and Fairview Dr	3/1/1977	35 (1986-2016)	1986	37		
ITS.C.1006	Signalized Intersection - Carson St and Hot Springs Rd	1/1/1986	20 (1980-1992)	1986	37		Used construction date of 1986
ITS.C.1007	Signalized Intersection - Carson St and Koontz Ln	1/1/1986	20 (1980-1992)	1986	37	Based on satellite imagery	Used construction date of 1986
ITS.C.1008	Signalized Intersection - Carson St and Long St	2/7/1966	6A (1980-1992)	1980	43	Supports range from 1980-1992	
ITS.C.1009	Signalized Intersection - Carson St and Medical Pkwy/Arrowhead Dr	7/1/2007	35A (1986-2016)	2007	16	All supports labeled "ped post"	Used construction date of 2007
ITS.C.1010	Signalized Intersection - Carson St and Musser St	2/18/1957	28 (1980-2016)	1980	43		
ITS.C.1011	Signalized Intersection - Carson St and Robinson St	2/18/1957	28 (1980-2016)	1980	43		
ITS.C.1012	Signalized Intersection - Carson St and Washington St	9/28/1973	19 (1971-1979)	1973	50		Used construction date of 1973
ITS.C.1013	Signalized Intersection - Carson St and William St	3/27/1960	28 (1980-2016)	1980	43		
ITS.C.1014	Signalized Intersection - Carson St and Winnie Ln	10/1/1972	23 (1971-1979)	1972	51		Used construction date of 1972
ITS.C.1015	Signalized Intersection - College Pkwy and Goni Rd	8/1/1998	35A (1986-2016)	1998	25		Used construction date of 1998
ITS.C.1016	Signalized Intersection - College Pkwy and I580 SPUI	10/1/2006	1A (1998-Current)	2006	17	Likely installed post-1998. No satellite imagery in this part of Douglas	Used construction date of 2006
ITS.C.1017	Signalized Intersection - College Pkwy and Lompa Ln	1/1/2005	28 (1980-2016)	2005	18		Used construction date of 2005
ITS.C.1018	Signalized Intersection - College Pkwy and Research Way	10/1/2017	35A (1986-2016)	1986	37	Supports range from 1986-2016 and 1975-1992	Used 1986 since field review shows the support is from 1986-2016, before the construction date shown.
ITS.C.1019	Signalized Intersection - College Pkwy and Retail Dr	9/6/2005	35 (1986-2016)	2005	18	Supports range from 1980-1985	Used construction date of 2005

Estimated Signalized Intersection Age

Asset ID	Description	Signal Construction Date	Supports (Used Most Conservative Estimate)	Estimated Upgraded	Estimated Years Since Install	CAMPO Notes	Assumptions
ITS.C.1020	Signalized Intersection - College Pkwy and Roop St	8/1/1998	35 (1986-2016)	1998	25		Used construction date of 1998
ITS.C.1021	Signalized Intersection - Fairview Dr and I580 Interchange	1/1/2015	35 (1980-1985)	2015	8		Used construction date of 2015
ITS.C.1022	Signalized Intersection - Fairview Dr and Pheasant Dr	8/8/1996	7 (1971-Current)	1996	27		Used construction date of 1996
ITS.C.1023	Signalized Intersection - Hwy 50 and Airport Rd	12/17/1974	24 (1971-1979)	1974	49		Used construction date of 1974
ITS.C.1024	Signalized Intersection - Hwy 50 and Deer Run Rd/Arrowhead Dr	7/10/1995		1995	28		Used construction date of 1995
ITS.C.1025	Signalized Intersection - Hwy 50 and Fairview Dr	1/1/1994	35A (1986-2016)	1994	29		Used construction date of 1994
ITS.C.1026	Signalized Intersection - Hwy 50 and Lompa Ln	1/1/2005	35A (1986-2016)	2005	18	Supports range from 1980-1985	Used construction date of 2005
ITS.C.1027	Signalized Intersection - Roop St and 5th St	8/15/1979	6A (1980-1992)	1980	43	Based on satellite imagery	
ITS.C.1028	Signalized Intersection - Roop St and Colorado St	1/1/1986	6A (1980-1992)	1986	37		Used construction date of 1986
ITS.C.1029	Signalized Intersection - Roop St and Fairview Dr	1/1/1986	20 (1980-1992)	1986	37		Used construction date of 1986
ITS.C.1030	Signalized Intersection - Roop St and Hot Springs Rd	9/6/2005	35A (1986-2016)	2005	18	Likely installed post-1998. No satellite imagery in this part of Douglas	Used construction date of 2005
ITS.C.1031	Signalized Intersection - Roop St and Little Ln	6/1/2000	28 (1980-2016)	2000	23		Used construction date of 2000
ITS.C.1032	Signalized Intersection - Roop St and Long St	1/1/2010	35 (1986-2016)	2010	13		Used construction date of 2010
ITS.C.1033	Signalized Intersection - Roop St and Northridge Dr	3/1/2007	35 (1986-2016)	2007	16	Based on satellite imagery	Used construction date of 2007
ITS.C.1034	Signalized Intersection - Roop St and Robinson St	1/1/1990	20 (1980-1992)	1990	33		Used construction date of 1990
ITS.C.1035	Signalized Intersection - Roop St and Winnie Ln	8/1/2006	23 (1971-1979)	2006	17	Supports range from 1980-1985	Used construction date of 2006
ITS.C.1036	Signalized Intersection - Saliman Rd and 5th St	7/7/1995	30 (1980-1985)	1995	28		Used construction date of 1995
ITS.C.1037	Signalized Intersection - Saliman Rd and Fairview Dr	7/7/1995	30 (1980-1985)	1995	28		Used construction date of 1995
ITS.C.1038	Signalized Intersection - Stewart St and 5th St	10/6/1965	20 (1980-1992)	1980	43		

Estimated Signalized Intersection Age

Asset ID	Description	Signal Construction Date	Supports (Used Most Conservative Estimate)	Estimated Upgraded	Estimated Years Since Install	CAMPO Notes	Assumptions
ITS.C.1039	Signalized Intersection - Stewart St and Musser St	4/17/1973	6 (1971-1979)	1973	50		Used construction date of 1973
ITS.C.1040	Signalized Intersection - Stewart St and Robinson St	10/1/1977	6 (1971-1979)	1977	46		Used construction date of 1977
ITS.C.1041	Signalized Intersection - Stewart St and Roop St	1/1/2010	7 Safety (1971-Current)	2010	13	Supports range from 1980-1992	Used construction date of 2010
ITS.C.1042	Signalized Intersection - Stewart St and Washington St	1/1/1986	20 (1980-1992)	1986	37	Supports range from 1980-1992	Used construction date of 1986
ITS.C.1043	Signalized Intersection - US395 and Clear Creek Ave	1/1/2000	N/A	2000	23	Supports range from 1980-1992	Estimated construction date in 2000
ITS.C.1044	ignalized Intersection - US395 and I580/Hwy 50 W (Spooner Junction	3/1/2017	N/A	2017	6	pre 1994	Used estimated construction date of 2017
ITS.C.1045	Signalized Intersection - William St and Gold Dust Way	6/1/2004	35 (1986-2016)	2004	19		Used construction date of 2004
ITS.C.1046	Signalized Intersection - William St and Roop St	9/28/1973	45 (1975-1992)	1975	48		
ITS.C.1047	Signalized Intersection - William St and Saliman Rd	10/1/1977	20 (1980-1992)	1980	43		
ITS.C.1048	Signalized Intersection - William St and Stewart St	2/16/1971	35 (1986-2016)	1986	37	Supports range from 1980-1992	
ITS.C.1049	Signalized Intersection - William St/Hwy 50 E and I580 SPUI	5/24/2006	N/A	2006	17	Per support data listed in Portal	Used estimated construction date of 2006
ITS.D.1001	Signalized Intersection - Hwy 50 and Elks Point Rd	1/1/1980	35 (1980-1985)	1980	43		
ITS.D.1002	Signalized Intersection - Hwy 50 and Hard Rock Hotel	1/1/1972	7 (1971-Current)	1972	51		Used construction date of 1972
ITS.D.1003	Signalized Intersection - Hwy 50 and Kahle Dr	1/1/1980	45 (1975-1992)	1980	43		Used construction date of 1980
ITS.D.1004	Signalized Intersection - Hwy 50 and Kingsbury Grade Rd		7 Safety (1971-Current)	1971	52		No construction date provided, so earliest support date used
ITS.D.1005	Signalized Intersection - Hwy 50 and Lake Pkwy	1/1/1980	35 (1980-1985)	1980	43		
ITS.D.1006	Signalized Intersection - Hwy 50 and Zephyr Cove Resort	1/1/1980	N/A	1980	43		
ITS.D.1007	Signalized Intersection - Hwy 88 and Mottsville Ln		28 (1980-2016)	1980	43		No construction date provided, so earliest support date used
ITS.D.1008	Signalized Intersection - Topsy Ln and Walmart	1/1/2003	35A (1986-2016)	2003	20		Used construction date of 2003

Estimated Signalized Intersection Age

Asset ID	Description	Signal Construction Date	Supports (Used Most Conservative Estimate)	Estimated Upgraded	Estimated Years Since Install	CAMPO Notes	Assumptions
ITS.D.1009	Signalized Intersection - US 395 and 6th St / Buckeye Rd	N/A	N/A	2000	23	Early 2000s; pre-2009 per Google Street View; check support types in collector	Used 2000 based on note provided by CAMPO
ITS.D.1010	Signalized Intersection - US 395 and Airport Rd	2/1/2018	7 Safety (1971-Current)	2018	5		Used construction date of 2018
ITS.D.1011	Signalized Intersection - US 395 and Gilman Ave	1/1/1986	20 (1980-1992)	1986	37	Supports range from 1980-1992	Used construction date of 1986
ITS.D.1012	Signalized Intersection - US 395 and Grant Ave	1/1/2014	35 (1986-2016)	2014	9	Supports range from 1986-2016; were present in 1998	Used construction date of 2014
ITS.D.1013	Signalized Intersection - US 395 and Hwy 88	1/1/1992	35 (1986-2016)	1992	31		Used construction date of 1992
ITS.D.1014	Signalized Intersection - US 395 and Jacks Valley Rd	1/1/1980	45 (1975-1992)	1980	43		Used construction date of 1980
ITS.D.1015	Signalized Intersection - US 395 and Johnson Ln	1/1/2003	7 Safety (1971-Current)	2003	20		Used construction date of 2003
ITS.D.1016	Signalized Intersection - US 395 and Mica Dr		7 Safety (1971-Current)	1971	52		No construction date provided, so earliest support date used
ITS.D.1017	Signalized Intersection - US 395 and Muller Pkwy / Riverview Dr	1/1/1986	45 (1975-1992)	1986	37		Used construction date of 1986
ITS.D.1018	Signalized Intersection - US 395 and Stephanie Way	1/1/2003	7 Safety (1971-Current)	2003	20		Used construction date of 2003
ITS.D.1019	Signalized Intersection - US 395 and Topsy Ln	1/1/2005	35A (1986-2016)	2005	18	Per support data listed in Portal	Used construction date of 2005
ITS.D.1020	Signalized Intersection - US 395 and Waterloo Ln	1/1/1985	35 (1980-1985)	1985	38		Used construction date of 1985
ITS.L.1001	Signalized Intersection - Hwy 50 and Dayton Valley Rd/Main St	1/1/2000	1A (1998-Current)	2000	23	Based on satellite imagery	Used construction date of 2000
ITS.L.1002	Signalized Intersection - Hwy 50 and Fortune Dr	8/27/2015	35A (1986-2016)	2015	8		Used construction date of 2015
ITS.S.1001	Signalized Intersection - USA Parkway and Electric Avenue	5/1/2018	1A (1998-Current)	2018	5	Supports labeled 2017-present, but Street View would suggest otherwise	Used construction date of 2017
ITS.S.1002	Signalized Intersection - I580 and USA Parkway	6/14/2019	N/A	2019	4	Some supports range from 1980-1985, others from 1998-present	Used estimated construction date of 2019

APPENDIX I

PEER CITIES SURVEY RESULTS

Peer City Traffic Engineering Staff Comparison

	FHWA *		Carson City, NV	Sparks, NV	Casa Grande, AZ	Council Bluffs, IA	Dubuque, IA
Population (2019 Census)	N/A	N/A	54,773	100,589	55,653	62,355	58,196
Number of Traffic Signals	1-50	51-100	73	110	36	100	105
Service Area (Sq Miles)	N/A	N/A	3,000+	10,000+	10,650	20,000	580
Do you have a City Traffic Engineer?	N/A	N/A	Yes	Yes	Yes	Yes	Yes
Do you have an Assistant City Traffic Engineer?	N/A	N/A	No	No	No	No	Yes
Number of Traffic Signal Analyst/Technicians	1-2	2-4	1	2	0	2	1
Number of Traffic Signal Maintenance Technicians	N/A	N/A	2	2	2	4	2
Number of other staff Associated with Operations of the Transportation Network	N/A	N/A	0	4	0	2	0

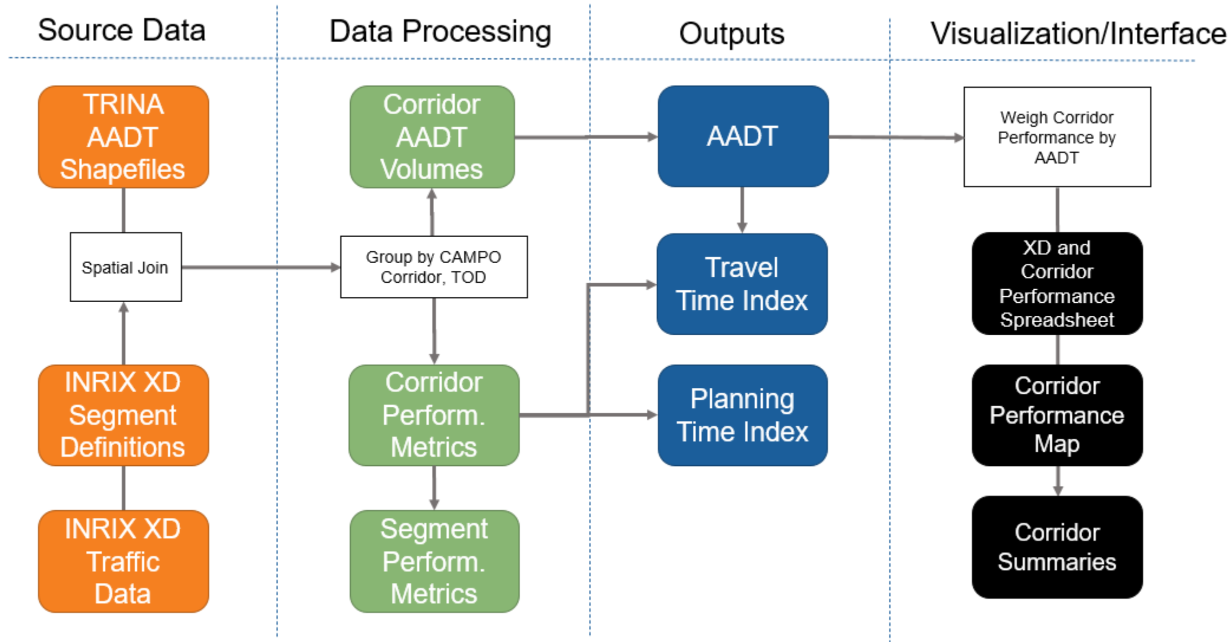
** Source: FHWA State of the Practice Traffic Signal Timing Manual – Chapter 8*

APPENDIX J

RITIS DATA DOWNLOAD GUIDE

RITIS DATA DOWNLOAD GUIDE

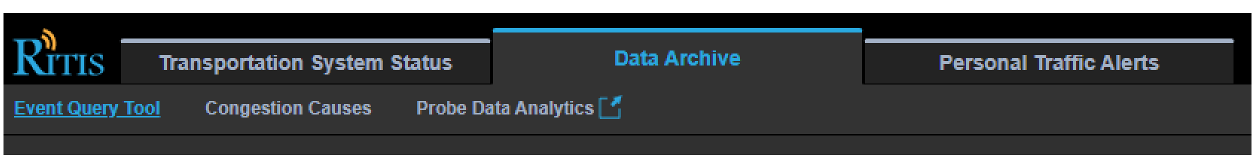
This guide provides step-by-step instructions on how to update the CATSMP Performance Report with new data. It describes how to download and process data from the Regional Integrated Transportation Information System (RITIS) website. This instruction set is broken down into four elements corresponding to the different steps of data processing below:

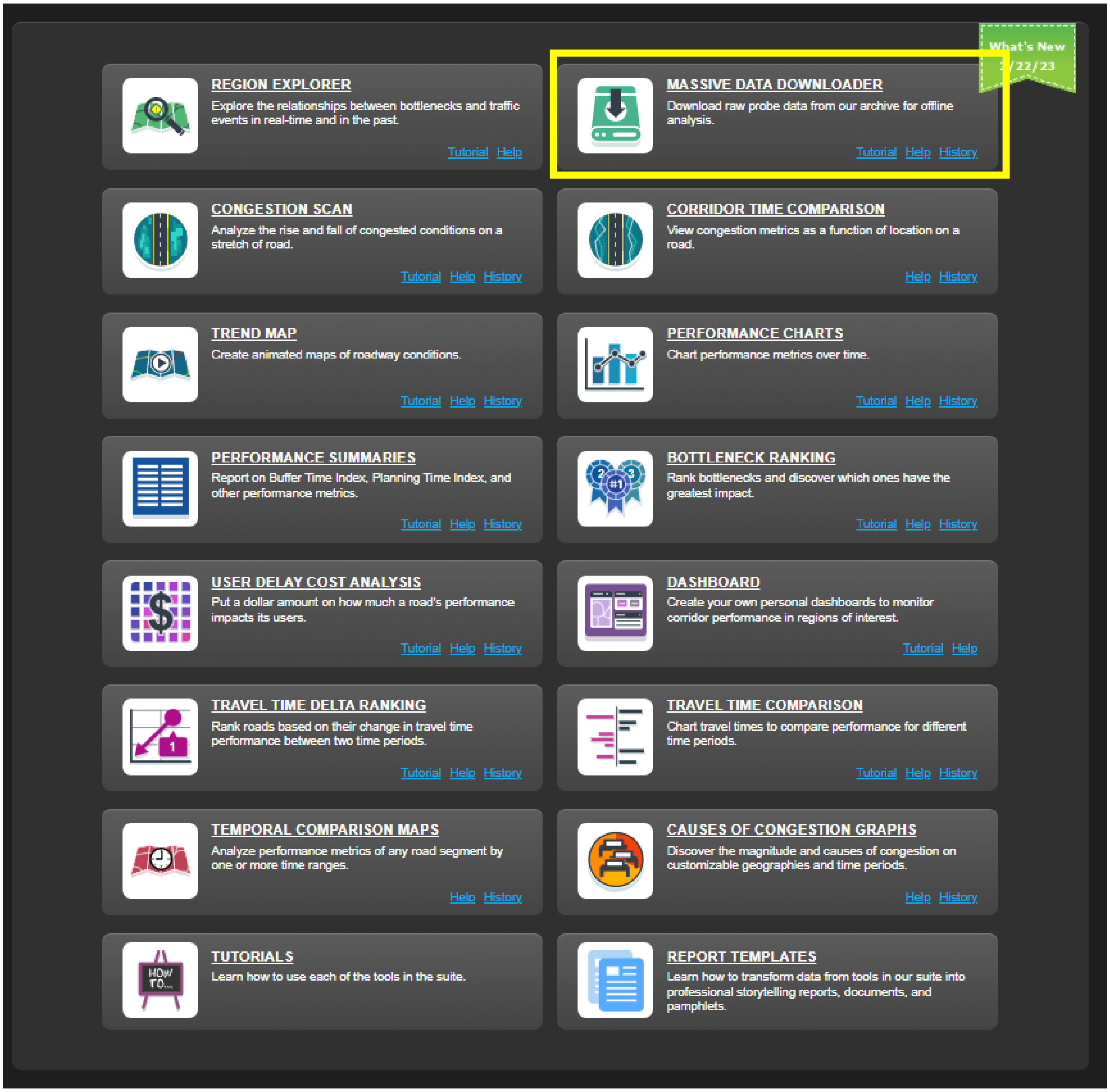


1 Downloading Source Data

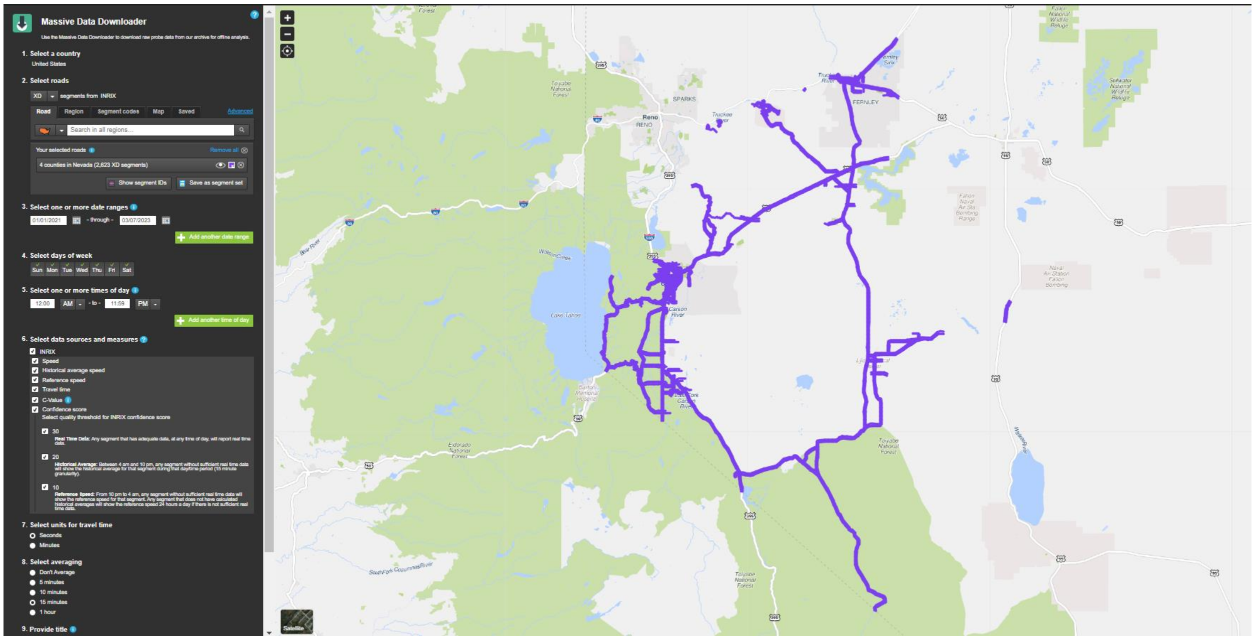
The RITIS login page is www.ritis.org and requires an email and password. Requests to access RITIS can be made by contacting NDOT.

Once logged in, the user is brought to the ritis.org/traffic home page, which displays various sources for traffic incidents, maps, radio, and real-time camera feeds. To access trend and historical data from RITIS, navigate to the “Data Archive” tab at the top of the page, then subtab “Probe Data Analytics.” This will direct you to the Probe Data Analytics Suite. https://pda.ritis.org/suite/



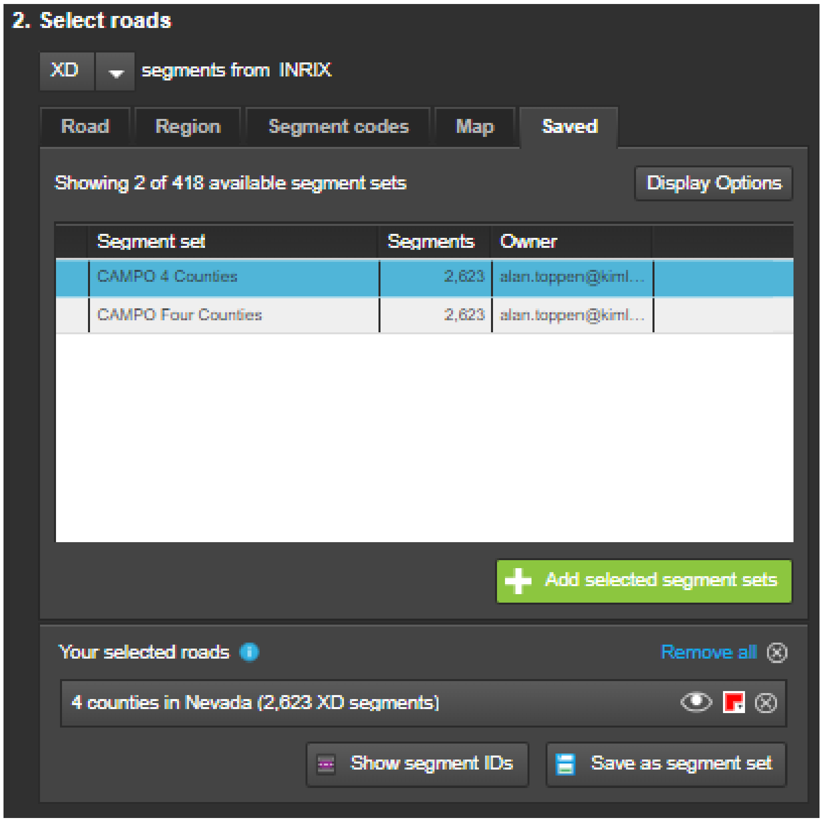


To download the raw INRIX XD (eXtreme Definition) data for offline analysis, navigate to the "Massive Data Downloader" tab (highlighted in the screenshot above). The Massive Data Downloader allows a user to define specific parameters for data download through a series of steps located on the left-hand side panel. As the user specifies parameters such as geographic extent or specific road segments, the map panel updates to reflect the selected areas. This is helpful to verify the correct areas are downloaded.



The following steps provide background for each step and the specific parameter inputs needed to download data for CAMPO analysis.

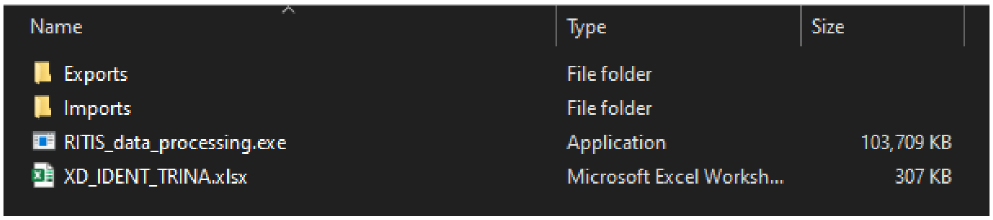
1. The first option is “Select Country.” This defaults to the United States.
2. The second option is “Select Roads.” This allows the user to define road segments for download.
    a. Switch the segment type from TMC to XD. XD segments are the only travel information available for all four counties in the CAMPO region.
    b. For the CAMPO analysis, use the “Region” tab to select all the XD segments within the four counties in the CAMPO area of operations. Under the “Regions” dropdown menu, select the state of “Nevada” and the counties of “Carson City (City),” “Douglas,” “Lyon,” and “Storey.”
    c. Click the “Add Region” button to add the selected XD segments to the download. There should be 2,623 XD segments.
    d. Select “Save as segment set” and give it a unique name such as “CAMPO 4 counties,” and check the box allowing other users in the agency to use the segment set. This option allows any user within your organization to load the predefined set of segments from the “Saved” tab. Once these segments are saved as presets, they can be used in other Probe Data Analytic suite tools.
    e. Verify that your segment set is saved by comparing it to the “Select roads” window in the reference image below.



3. Select a date range for the download using the calendar dropdowns. XD data is available from May 2020 to the present day. Choose the date range for new data only to add to previously downloaded data.
4. Select all days of the week.
5. Select all times of the day.
6. Select data sources and measures. Include all INRIX measures: Speed, Historical Average Speed, Referenced speed and Travel Time. The C-Value and Confidence Score indicate the extent to which the data represent directly measured speeds versus speeds inferred from historical data. Checks all thresholds as XD confidence scores as the CAMPO area rarely falls below 25, representing a good quality of samples.
7. Select units for travel time in seconds.
8. Choose a data aggregation level of 15 minutes.
9. Provide a unique title for the data download. Including a download date in the title helps with version tracking.
10. Large file exports can take hours to complete. Select to have an email sent to your account when the download is ready. Or check “My History” in the upper right section of the page to view the status of the download. When ready, a download link is provided to start the download in the form of a compressed ZIP file. Click on “Submit” to initiate the download.

2 RITIS Data Processing

This section provides an overview of processing the RAW XD data required for CAMPO corridor performance analysis. Much of the data processing is completely automated and only requires the user to provide the input of the RITIS download accomplished in the previous step.



The RITIS Data Processing folder structure was designed to assist the user in processing the raw data download from RITIS:

- **XD_IDENT_TRINA.xlsx** is a spreadsheet that contains the lookup of unique XD segments in the CAMPO area to its assigned Corridor ID and TRINA AADT data station. It also contains attributes of each XD segment, such as start and end points, length, road name association and location. This file only needs to be changed when the corridor definitions or AADTs change.
- **RITIS_data_processing.exe** is the script that automatically processes the XD data.
- The **Imports** folder is where the user unzips the RITIS data.
- The **Exports** folder is where all exports from the script are written.

The steps for RITIS data processing are:

1. Unzip RITIS download files into the “Imports” folder.
2. Run the “RITIS_data_processing.exe” script.
3. Verify results written to the “Exports” folder.

3 RITIS Data Outputs

This section describes the data processing script output and how it is used. The script writes output to folders in the “Exports” folder: “Corridor” and “XD analysis.”

- Corridor-Level analysis aggregates travel time metrics such as Travel Time Index (TTI), Planning-Time Index (PTI), and Annual Average Daily Traffic (AADT) into the CAMPO-defined corridors. All tables in this folder will be at the Corridor Level. These metrics can be used to communicate traffic trends along major roads with defined starting and ending points.
- XD-Level analysis reports travel time metrics for the XD segments. These are smaller segments and are useful for hotspot and bottleneck analyses.

Within each Corridor or XD folder are three.csv files exported from the script.

- **Corridor/XD_TTI_PTI.csv** summarizes travel time performance measures by month and week. The table includes columns for Corridor Name, AADT for the corridor, Month, Week, Average Travel Time, Average Speed, TTI and PTI for that specific time period as well as ranking for each travel time measure relative to other periods.
- **Corridor/XD_TTI_PTI_avg.csv** contains the same performance measures as the Corridor/XD_TTI_PTI.csv table but averaged across all time periods. For example, if data were to be downloaded from a period from 1/1/2021 to 3/1/2023, this table would display the average for CAMPO corridor and XD segments.
- **Corridor/XD Daily_Travel_Time_Metrics.csv** contains average travel times, average speeds, and average TTI for weekdays across the downloaded time period. This may be used to discern time of day trends, such as peaking behavior and speed changes across multiple days.

4 RITIS Data Analysis and Visualization

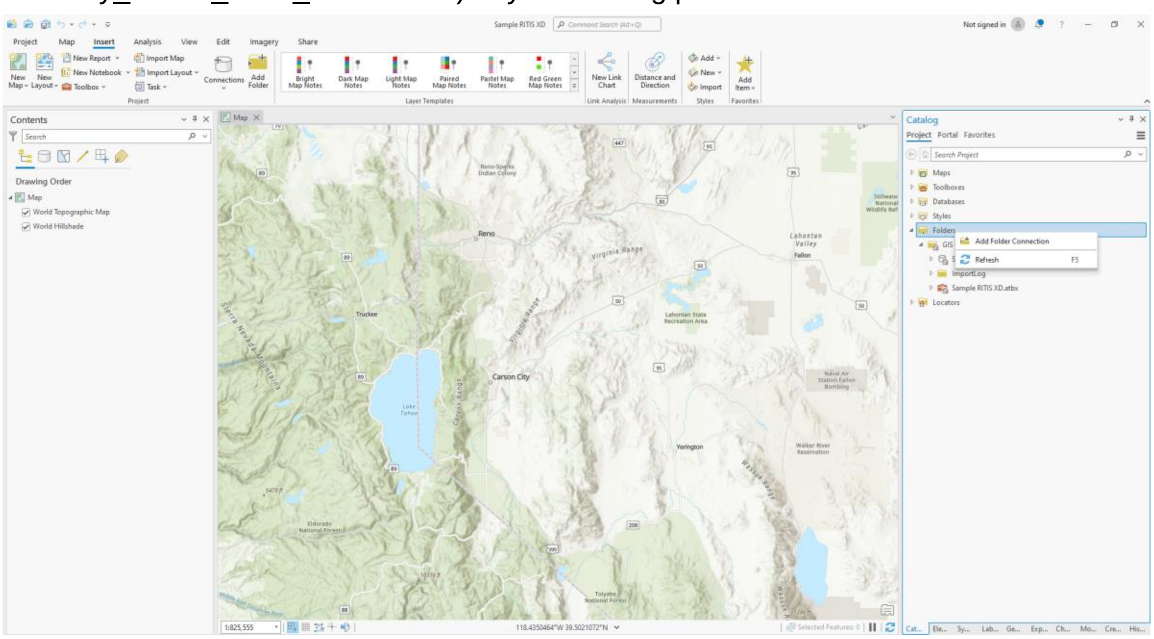
This section describes tools and processes for visualizing the RITIS data exports into detailed analyses suitable for corridor-level and segment-level reporting.

4.1 GIS Mapping and Before and After Spatial Analysis

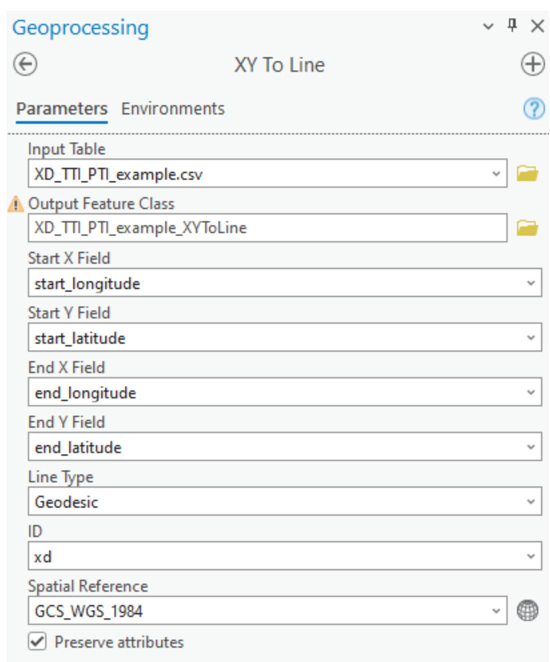
ArcGIS may be used to spatially plot data directly from the Corridor and XD-level data exports using the start and end points. The **XY to Line tool** available in all ESRI desktop GIS products under geoprocessing tools can take the start and end latitude and longitude of XD and Corridor-level data exports and display them as feature classes.

The steps to visualize the TTI and PTI by XD segment in ArcGIS are as follows:

1. Open ArcMap or ArcPro and create a new map project (or folder containing an .mxd for ArcMap) in your desired directory.
2. Add the folder containing the RITIS data exports (Corridor/XD_TTI_PTI.csv, Corridor/XD Daily_Travel_Time_Metrics.csv) to your catalog pane.

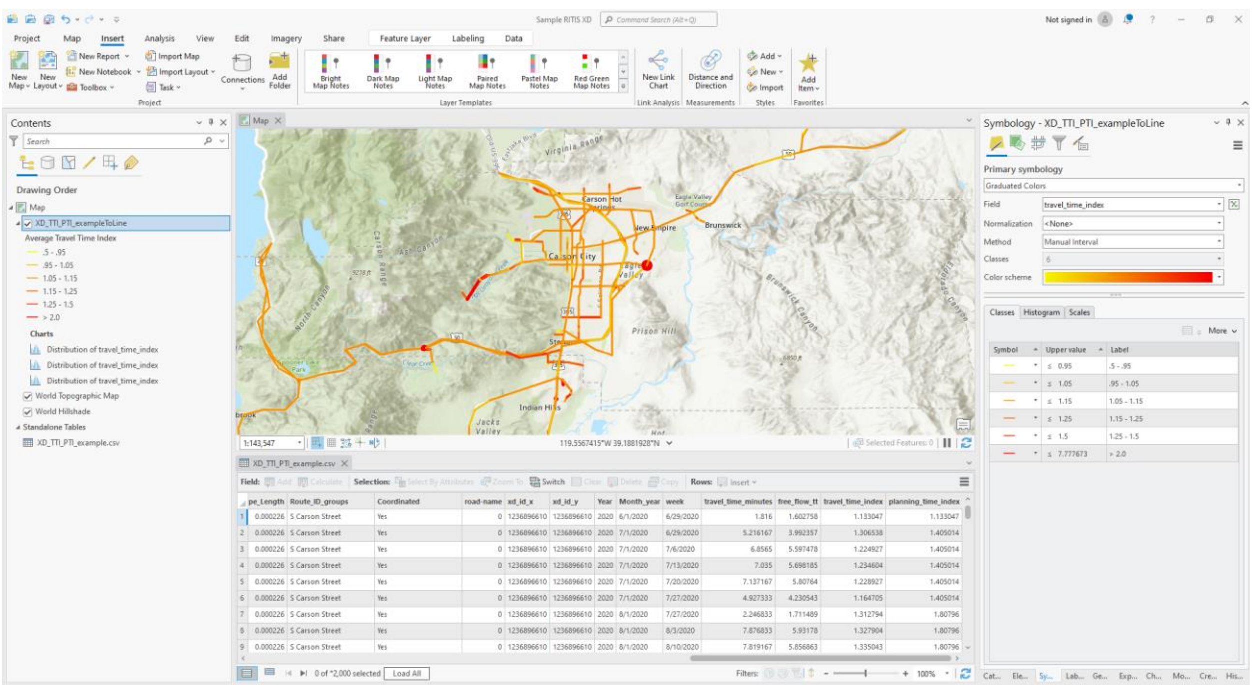


3. Add the data desired to be visualized to the contents pane by clicking and dragging. For this example, XD_TTI_PTI.csv is used. The data should appear on under the "Standalone Tables" section. Right-click the table and select "Open" or "Open Attribute Table" to inspect the table fields.
4. Open the geoprocessing pane in ArcPro or the Toolbox in ArcMap. Search for the tool 'XY to Line' under 'Data Management Tools' and open the tool. Select the input table as the XD_TTI_PTI.csv from the exports folder.
    - In the 'Output Feature Class' name and select the desired location of the shapefile that will contain the geometry.
    - The 'Start X' and 'Start Y' Field should be selected as the 'start_longitude' and 'start_latitude' while the 'End X' and 'End Y' field should be selected as 'end_longitude' and 'end_latitutde'.
    - Line Type should be selected as Geodesic as this provides the most accurate distance calculation
    - ID should be set to the 'xd' field. This provides the ability to sort on the 'xd' segment identification.
    - Spatial reference should default to 'GCS_WGS_1984'.
    - Preserve attributes box must be checked. This ensures that the fields like 'travel_time_index' and 'planning_time_index' are kept in the new shapefile.
    - After the parameters are checked, select 'Run.' The process should take a few minutes and should show status 'XY To Line completed' in green when finished. Verify that the new shapefile appears on the map contents pane.



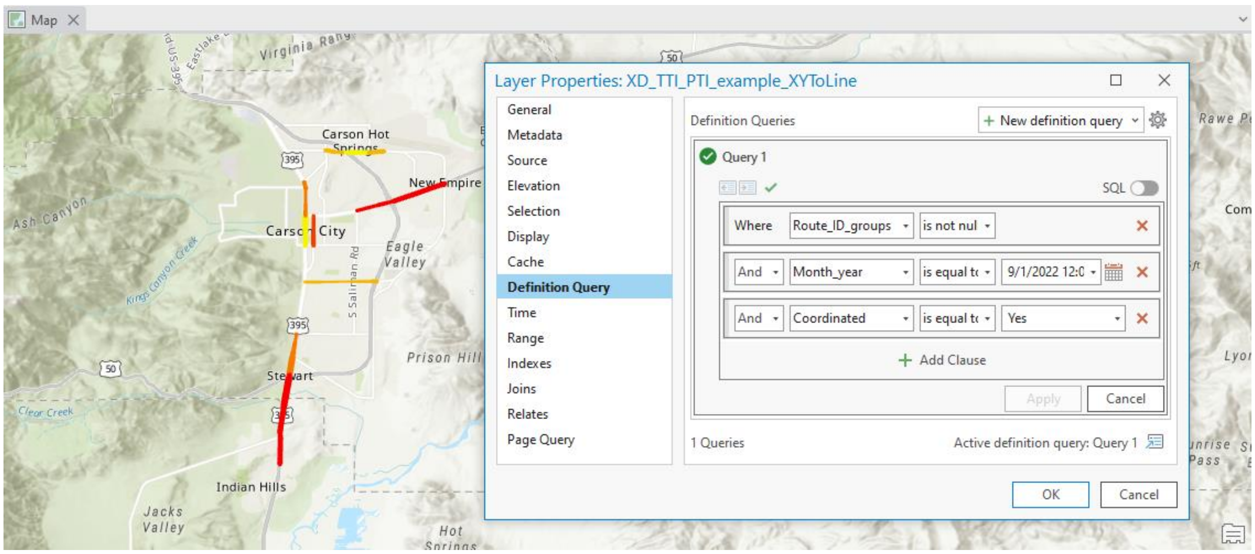
5. The data fields such as 'travel_time_minutes', 'free_flow_tt', 'travel_time_index', 'planning_time_index' can be visualized by their performance by right-clicking the new XD to line layer in the contents page and selecting 'Symbology'.
    - Under the 'Primary Symbology' dropdown, selected 'Graduated Colors'

- Under ‘Field’ select desired field from ‘travel_time_index’ or ‘planning_time_index’.
- Under ‘Method’ select the desired method in which the color symbology classes are deliniated. ‘Natural Breaks (Jenks)’ is the default, however ‘equal interval’ and ‘Manual Interval’ may also be used depending on the distribution of the values. If performing a ‘Manual Interval’ classification, select the ‘Histogram’ to determine the appropriate range of the data and logical breaks. See example of Manual Interval below.
- ‘Classes’ parameters are only applicable if selecting a method that is not ‘Manual Interval’. Adjusting the number of classes allows for more granular differences between the ranges of TTIs and PTIs.
- ‘Color scheme’ can be set as contiuous or diverging. Continuous is default the default but diverging can be used if setting the symobology for values that fall above a certain fixed measure, such as the median or benchmark TTI of 1.0.

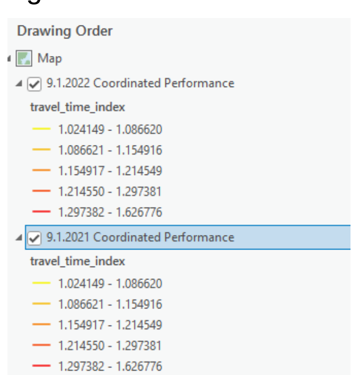


6. Before and after analysis as well as focused segment and corridor analysis can achieved through the use of the Definition Query tool on symbolized XD_TTI_PTI_XYToLine. This method allows users to query the specific fields that are in embedded in the attribute table include the Weeky, Month, Year that the metrics were taken from as well as Road Name, County, and specific CAMPO defined corridor. Users may also filter on the TTI and PTI measures themselves, showing only roadways with TTIs above or below certain benchmarks for example.
    - To open the Definition Query Tool, right-click the XD_TTI_PTI_XYToLine layer and select ‘Properties’. Under the properties side panel, navigate to ‘Definition Query’

- Select ‘New definition query’. Use the dropdown menu to first select the field to filter on. The second statement, the condition, defines the method of how to filter such as ‘is equal to’, ‘is not equal to’ and ‘is not null (blank)’. The third parameter under the query selects what value to filter on, and a dropdown menu is populated for all available values in an attribute field. More information on definition queries is available here: https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/definition-query.htm
- Adding additional clauses allows the users to become more specific in the data they are filtering.The example below shows a definition query that filters for only XD segments where the Route_ID_groups are defined, and specific to the month of September, 2022 through Month_year, and are definited as ‘Coordinated’.



- Definition queries may be saved and loaded locally to enable the user to create multiple views of the same dataset.
- The user may also export the dataset with a definition query applied by time of year, specific corridor or other filter to another shapefile/feature class to compare those filtered to conditions to other datasets with different time attributes.
- For example below, exporting two datasets filtered for different ‘Month_year’ or ‘week’ fields from the original XD_TTI_PTI_XYToLine layer measuring performance for the same month for multiple years (ex. September 2022 versus September 2021) would allow direct comparison between traffic performance conditions year over year. This may also be performed in consecutive months surround a major change such as signal timings or road closures to assess whether there was any significant effect before and after an event.



4.2 RITIS Spreadsheet Data Analysis and Figure Making

The use of tabular spreadsheet tools like excel and PowerBI destop allows users to directly manipulate the raw exports for the RITIS processing script into visuals that may be used in reporting and before and after analysis. The general steps for RITIS data analysis are as follows:

APPENDIX K

PERFORMANCE METRICS LITERATURE REVIEW

CARSON AREA TRANSPORTATION SYSTEM MANAGEMENT PLAN

Draft Performance Measure Review

DRAFT PERFORMANCE MEASURE REVIEW

FOR

CARSON AREA TRANSPORTATION SYSEM MANAGEMENT PLAN

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1. PERFORMANCE MEASURES AND BENCHMARKS

Traffic signals are a critical component of transportation systems, ensuring safe and efficient traffic operations at intersections and along arterials. As a major responsibility of a transportation agency, maintaining traffic signal devices in a good operational state and updating traffic signal timing can be a challenge without reliable performance measures for traffic signal systems. Emerging data sources (e.g., high-resolution vehicle trajectories and controller event-based) make it possible to automatically collect and generate comprehensive traffic signal performance measures, allowing for active and data-driven traffic signal system management decisions. A detailed review of the state of practice, both nationwide and within the state of Nevada, was conducted to provide the Carson Area Metropolitan Planning Organization (CAMPO) with a roadmap to facilitate future decisions on investing in a practical and cost-effective performance measurement system. Recommendations were made based on the review and evidence of successful performance measurement applications.

1.1 Review of Traffic Signal Performance Measures

Traditional performance measurement approaches for traffic signals are mainly based on manual methods, which can be time-consuming and resource intensive. Practitioners spend a considerable amount of time and effort verifying whether signal timing plans are running correctly and whether anticipated performance outcomes have been reached. Although agencies, such as Carson City Public Works, can use central traffic signal management software to perform in-house monitoring of timing plan operations and traffic signal device status, extensive floating-car investigations still need to be manually conducted to collect information on travel time, number of stops, etc., to evaluate the effectiveness of signal timing coordination.

Due to limited resources and staffing, applying signal performance measurement methods through traditional approaches is challenging, especially for small transportation agencies like CAMPO. The *2020 Traffic Signal Benchmarking and State of the Practice Report* [1] documents that smaller organizations (with fewer than 150 signals and five staff) underperform as their traffic signal performance measurements are largely functioning on an ad-hoc basis. Traffic signal timing development, implementation, and maintenance for timing and equipment can fall into a reactive and arbitrary procedure as it is difficult to make judgments and take timely actions when service requests are received.

Controller event or trajectory data-based automated signal performance measures are a cost-effective means of achieving active and data-driven decision making in traffic signal system management. In recent years, as promoted through the FHWA Arterial Management Program and the Every Day Count 4 Technology initiative, an increasing number of transportation agencies, including the Utah Department of Transportation (UDOT) and the Regional Transportation Commission of Southern Nevada Freeway & Arterial System of Transportation (RTCSN FAST), are implementing automated signal performance measures.

The remainder of this review focuses on two types of Automated Traffic Signal Performance Measures (ATSPMs): controller event-based and trajectory-based measurements.

1.1.1 Automated Signal Performance Measures Based on Controller Event Data

Controller event-based ATSPMs consist of a high-resolution controller event-based data logging capability added to existing traffic signal infrastructure and data analysis techniques. According to the NCHRP Report 954 [2], such controller event-based ATSPMs can lead to continuous performance monitoring for communication, detection, intersection/uncoordinated timing, and advanced systems and applications. **Table 1** shows detailed information on several major controller event-based ATSPMs. Some of them may be obtained from central systems such as ATMS.now, the most common way agencies access these metrics is through an ATSPM system such as the open-source ATSPM system developed and maintained by Utah DOT.

Table 1 – Major Performance Measures Based on Controller Event-Based Data

Performance Measures	Description	Implementation Requirements
Estimated Vehicle Volume and Delay	Volume and delay are estimated based on the number of arrivals and arrival times detected by roadway sensors. The estimates can be less accurate when congestion happens (i.e., queues exceed the range of sensors so late arrivals are missing from the estimation.)	High-resolution data-enabled controllers and advance detectors are required. Lane-by-lane detector schemes are preferred.
Split Failure	A split failure can be detected as a result of green and red occupancy ratios (i.e., detection occupancy ratios during the green time and the first 5 seconds of red time). When both ratios exceed 80%, an estimate of split failure is justified.	High-resolution data-enabled controllers and stop-bar presence detectors are required. Lane-by-lane detector schemes are preferred.
Red-light Running Occurrence	Red-light-running occurrences are captured through detector actuations that happen after the onset of red.	High-resolution data-enabled controllers and stop-bar presence detectors are required. Lane-by-lane detector schemes are preferred.
Purdue Coordination Diagram (PCD)	The diagram indicates percent arrivals on green and platoon ratio and shows individual vehicle arrival times relative to green intervals.	High-resolution data-enabled controllers and stop-bar presence detectors are required. Lane-by-lane detector schemes are preferred.
Estimated Pedestrian Volume and Delay	Pedestrian arrival times are estimated based on pedestrian pushbutton actuations. Pedestrian volume and delay can be underestimated or overestimated as pedestrians may not push the button or push the button multiple times.	High-resolution data-enabled controllers are required; actuated pedestrian signals are required (i.e., pedestrian pushbuttons should be installed).

Currently, there are a variety of applications for controller-data-based ATSPMs that public agencies and private firms have developed. The FHWA's application is an open-source web-based software [3]. The FHWA estimates that more than 300 downloads of the open-source software for ATSPMs have occurred from the FHWA Open-Source Application Development Portal, and more than 20 transportation agencies at both state and local levels are currently involved in implementing the software. Based on surveys of six agencies, including UDOT, Georgia DOT, and Maricopa County DOT in Arizona, an evaluation study indicates the benefit-cost ratios of implementing ATSPMs can range from 2:1 to 13.5:1 [4].

It should be noted that controller-data-based ATSPMs include several measures that are already embedded in central traffic signal management software, which have been implemented by transportation agencies (e.g., Carson City Public Works is using ATMS.now software that is developed by Cubic Trafficware), while this kind of capability may not be fully leveraged in practice. Performance measures, such as communication status, detection system status, phase operations timeline, and pedestrian call history are saved as reports in the software. Practitioners may need to manually access the reports and conduct further analyses. Current ATSPM applications can be beneficial by providing automated visualization and data analytics.

1.1.2 Automated Signal Performance Measures Based on Vehicle Trajectory Data

Vehicle trajectories, which are comprised of movement waypoints, can now be broadly obtained through vehicle telematics, onboard GPS units, and smartphone applications. Trajectory data with a high resolution of vehicle location information of less than 3 seconds per point can represent vehicle trips along urban arterials, portraying travel time, the number of stops, stop time, and stop location in detail. For transportation agencies, such trajectory data can be collected by conducting floating car runs or procured from third-party data companies. As a result, trajectory data can be used to evaluate traffic signal control level of service at an intersection and the quality of signal coordination along an arterial.

Automated traffic signal performance measures based on vehicle trajectory data are developed through similar methodologies compared to traditional floating-car investigations; nevertheless, as technologies advance, high-resolution trajectory data can be broadly obtained in an automated manner. Hence, trajectory-based ATSPMs can be a cost-effective approach to traffic signal performance evaluation and monitoring as it would not require any infrastructure upgrade for performance measurement purposes. Although trajectory data are of a low sample size in some cases, performance measurements for traffic signal control can be based on stacked data over days and even months (for the same time-of-day period). Hence, trajectory-based ATSPMs can provide reliable and informative results.

Table 2 presents several performance measures based on trajectory data.

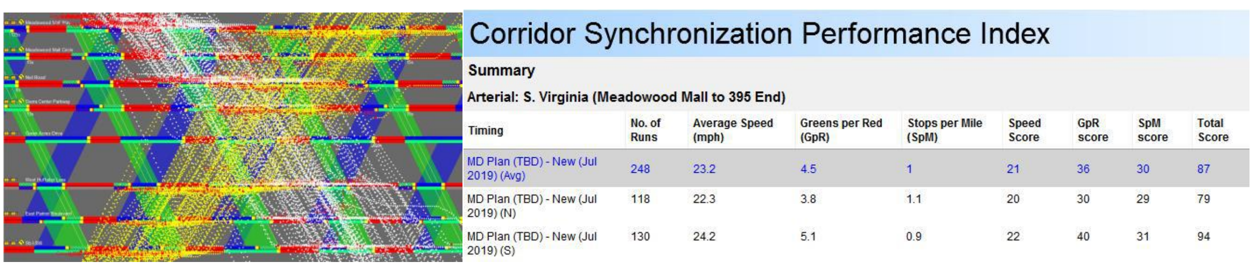
Table 2– Major Performance Measures Based on Trajectory Data

Performance Measures	Description	Implementation Requirements
Average Travel Speed	Trajectories can reflect travel speeds within arterial segments and therefore indicate arterial operational efficiency as compared to the posted speed limit.	An adequate sample size of trajectories is needed for accurate measures.
Number of Stops and Stop Times at Intersections	Based on cumulated trajectory points of stopped speed (e.g., speed is less than 5 mph for three consecutive seconds) at intersections, the number of stops and individual stop times can be gauged for a vehicle progressing along an arterial.	Trajectory data should be of high resolution (i.e., the interval between two consecutive trajectory points should be less than 3 seconds to ensure vehicle stops can be indicated.)

Table 2 – Major Performance Measures Based on Trajectory Data (Continued)

Performance Measures	Description	Implementation Requirements
Split Failures	Split failure can be detected when several trajectories show more than two stops at one intersection within a certain period.	High-resolution trajectory data are required; and an adequate number of trajectories are required to avoid random disturbances caused by traffic incidents.
Side-street Delay and Queue Length	Using trajectories that are from side streets turning onto an arterial, side-street delay and queue length can be estimated to show the effect of signal coordination on side-street traffic	High-resolution trajectory data are required; and an adequate number of trajectories are required.
Quality of Signal Timing Index	By integrating a group of performance measures, a quality of signal timing index can be developed to comprehensively indicate the quality of signal timing, which would potentially show needs for signal retiming and facility maintenance.	Besides data collection, a methodology should be developed to support reliable evaluation for signal timing with practically guiding significance.

A few public agencies have implemented trajectory-based ATSPMs. The Orange County Transportation Authority (OCTA) in California has developed a quality of signal timing index using trajectory data [5], and in 2020, the OCTA started to utilize automated trajectory data collection to produce performance measures in signal timing projects. As for software tools, there are only few packages that are capable of processing high-resolution trajectory data and producing trajectory-based ATSPMs. TranSync is employed by Caltrans, the Arizona Department of Transportation (ADOT), and the Regional Transportation Commission of Washoe County (RTC Washoe) in Nevada, to conduct trajectory-based traffic signal performance measurements. **Figure 1** shows high-resolution trajectories plotted on a time-space diagram and a performance report generated by TranSync.



(a) (b)

Figure 1– (a): High-resolution Trajectories on Time-space Diagram in TranSync; (b): Performance Report Generated by TranSync

1.1.3 Comparison Between Controller Event-Based Data and Trajectory-Based ATSPMs

Compared to traditional traffic signal performance measures, both controller event-based and trajectory-based ATSPMs can significantly influence the management of traffic signal operations and maintenance in support of an agency's safety, livability, and mobility goals. The two types of ATSPMs can have different strengths and limitations, particularly with respect to budgetary and staffing requirements. **Table 3** presents a comprehensive comparison between controller event-based data and trajectory-based ATSPMs.

Table 3 – Comparison between Controller Event and Trajectory-based ATSPMs

	Controller-data-based ATSPMs	Trajectory-based ATSPMs
Performance Measure Scope	1. Controller event -based ATSPMs include performance measures for communication, detection, individual intersections, etc. 2. Controller-data-based ATSPMs are for intersection movements, which can only indicate link-based progression performance. 3. Performance measures are produced based on detection actuations. Vehicle classification information cannot be obtained. 4. Controller-data-based ATSPM allows for continuous performance reporting	1. Trajectory-based ATSPMs focus on signal coordination. Other performance measures can be obtained through central traffic signal management software. 2. Trajectory-based ATSPMs can represent vehicle trips on various routes along an arterial, which reflect route-based progression performance. 3. Performance measures are produced based on vehicle trajectories. Vehicle classification such as trucks, transit buses, electric cars can be identified. Pedestrian information cannot be obtained. 4. Performance reporting is based on the frequency of data acquisition.
Required Budgetary Investments	1. The implementation can require a considerable amount of funding because equipment including controllers, cabinets, and detectors may need to be updated. Software costs vary with different choices of products. 2. Operational costs are minimal because data are collected at no additional costs. 3. Maintenance costs apply as infrastructure ages.	1. The implementation does not require additional investments except for the expense of software tools. 2. Operational costs are the primary expense depending on data acquisition. Trajectory data can be automatically procured from third-party traffic data companies at a cost. Such data procurements need to be conducted on a regular basis. 3. Maintenance costs are minimal.
Performance Measure Scope	1. Controller-data-based ATSPMs include performance measures for communication, detection, individual intersections, etc. 2. Controller-data-based ATSPMs are for intersection movements, which can only indicate link-based progression performance. 3. Performance measures are produced based on detection actuations. Vehicle classification information cannot be obtained. 4. Controller-data-based ATSPM allows for continuous performance reporting.	1. Trajectory-based ATSPMs focus on signal coordination. Other performance measures can be obtained through central traffic signal management software. 2. Trajectory-based ATSPMs can represent vehicle trips on various routes along an arterial, which reflect route-based progression performance. 3. Performance measures are produced based on vehicle trajectories. Vehicle classification such as trucks, transit buses, and electric cars can be identified. Pedestrian information cannot be obtained. 4. Performance reporting is based on the frequency of data acquisition.

Table 3 – Comparison between Controller Event and Trajectory-based ATSPMs (continued)

	Controller-data-based ATSPMs	Trajectory-based ATSPMs
Required Budgetary Investments	1. The implementation can require a considerable amount of funding because equipment including controllers, cabinets, and detectors may need to be updated. Software costs vary with different choices of products. 2. Operational costs are minimal because data are collected at no additional costs. 3. Maintenance costs apply as infrastructure ages.	1. The implementation does not require additional investments except for the expense of software tools. 2. Operational costs are the primary expense depending on data acquisition. Trajectory data can be automatically procured from third-party traffic data companies at a cost. Such data procurements need to be conducted on a regular basis. 3. Maintenance costs are minimal.
Required Staff Expertise and Time	1. Experienced IT staff will be needed to implement and maintain the software and website. 2. ATSPMs can help practitioners identify problematic signal operations, though practitioners need to use engineering judgement to determine timing changes in a systematic view, e.g., offset and phase sequence changes.	1. Traffic engineering practitioners can easily use the software tool. 2. Overlaying trajectory data and time-space diagrams can illustrate what cause vehicle stops and what timing adjustments can avoid such stops, which would save significant time in signal timing development
Public Involvement and Influence	1. Performance measures are automatically published on a website. 2. The public without traffic engineering knowledge may not be able to understand the performance measures	1. Trajectory data can be obtained through crowdsourced programs. For example, RTCSN FAST includes trajectories provided by Boys & Girls Club as a data source in performance measurements 2. Trajectories, along with videos, can provide an intuitive demonstration to the public regarding what is being accomplished with public funds on the transportation system.

A fundamental difference between controller event-based and trajectory-based ATSPMs is in signal coordination performance measurements. Controller-based data ATSPM software can generate the percent of arrivals on green and platoon ratios for individual movements at intersections. However, signal coordination involves a set of movements in two directions and at a group of intersections, and any signal timing changes can result in a systematic influence on multiple movements. In this case, signal retiming design needs to be based on an integrated measure that represents the overall operational performance for the signals in coordination, but how to use controller-based data ATSPMs to derive the integrated measure is still a question to be answered. Therefore, although ATSPMs provide very detailed information that identifies problematic traffic signal operations, it is difficult to leverage the information to develop signal retiming solutions. Unlike controller event-based data ATSPMs, once unsatisfactory arterial progression is identified, trajectory data can be plotted on a time-space diagram for practitioners to view the influence of offset and phase sequence changes on arterial progression. Thus, new signal timing plans can be easily generated to improve operations.

1.2 State-of-the-Practice in Nevada

1.2.1 FAST of RTCSN

FAST, a division of the RTCSN, is a pioneer agency that has implemented ATSPM at select intersections in the Las Vegas region. Currently, FAST has both controller-based and trajectory-based ATSPMs. **Figure 2** shows a screenshot of FAST's Signal Performance Metrics website. This website was developed using the FHWA's open-source software.

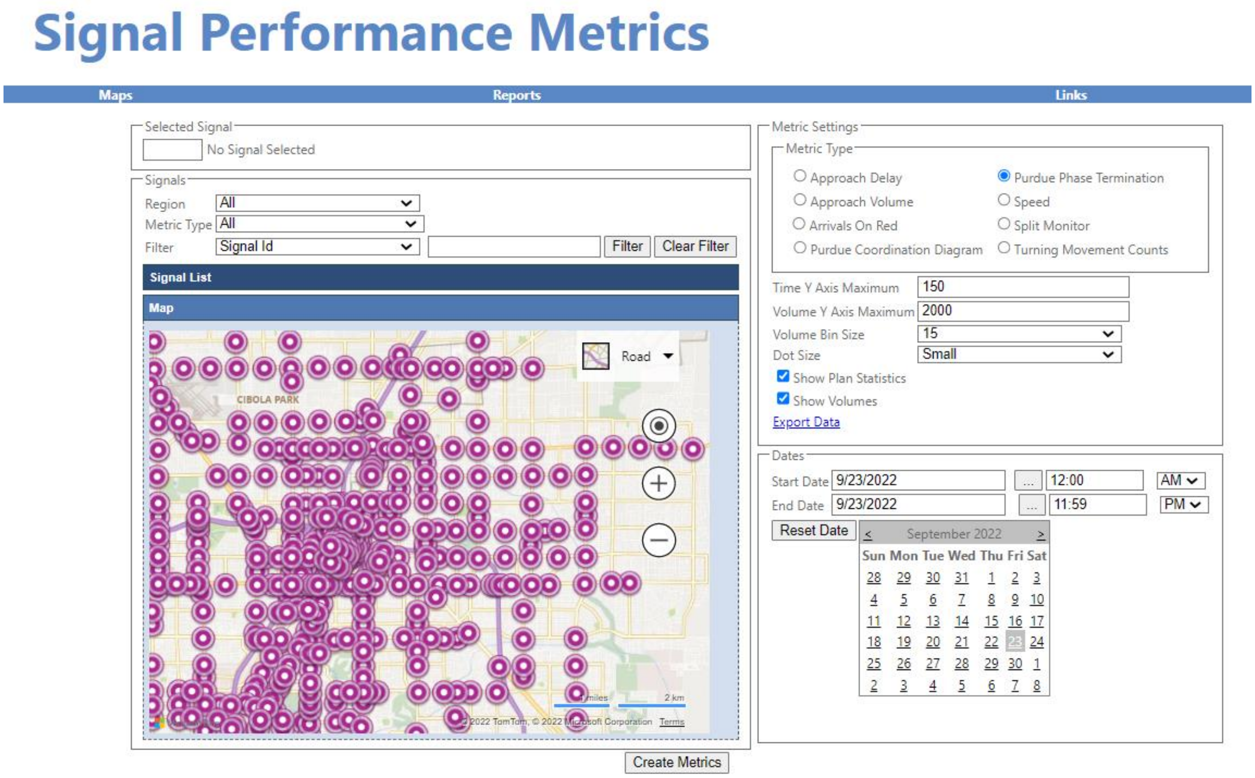


Figure 2– RTCSN FAST's Signal Performance Metrics

Through this website, controller-based data ATSPMs can be generated and plotted into charts. Due to the limitations of old controllers and the lack of advanced detection, a few performance measures, including the Purdue Coordination Diagram, are only available for a small group of intersections. Since the initial stage of implementation, the data generated by the system has not been routinely used due to the limitations discussed above. Staff at FAST who actively manage the signal systems see difficulties in leveraging ATSPM results in timing and coordination development because of the abovementioned reasons. Even though ATSPM can report performance at each intersection approach, practitioners need to use engineering judgment to determine timing changes in a systematic view. This seems to be a common phenomenon for many other agencies across the nation. Even with states like Utah and Georgia that represent advanced users of ATSPM, the state of practice is still limited to only compare measures like percent arrival on green link by link without a systematic performance measure for assessing an entire arterial.

FAST is also leveraging trajectory data to report travel times and stops along arterials. The trajectory data sources data from an agency's vehicles which are equipped with GPS units, from paratransit vehicles, and from trajectories generated using a mobile phone application named "Enlighten"[1]. **Figure 3** presents the webpage to view trajectory data and trajectory-based performance measures.

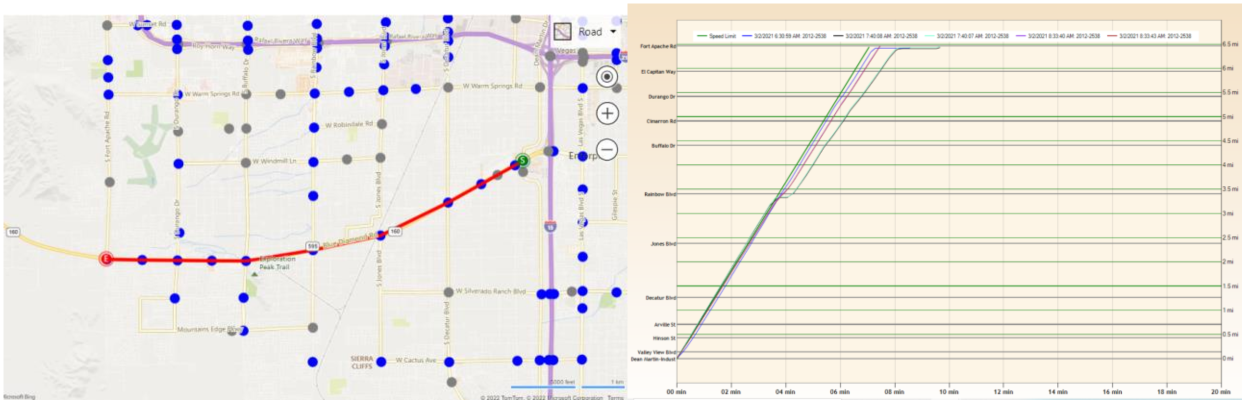


Figure 3– Performance Measures Based on Trajectory Data

In addition, FAST has developed a tool to recognize and visualize detection issues using extracted information on detection status and signal phase operations. **Figure 4** shows the webpage of the detection issues map and data sheet.

Signal ID	Primary Street	Secondary Street	Count	Rate	Today
2011	Boulder Hwy	Desert Inn Rd-Lamb Blvd	30	96.8%	0
2013	Boulder Hwy	Nellis Blvd	30	96.8%	0
2019	Las Vegas Blvd	Craig Rd	30	96.8%	0
2024	Eastern Ave	Windmill Ln	30	96.8%	0
2027	Nellis Blvd	Bonanza Rd	30	96.8%	0
2030	Pecos Rd	Patrick Ln	30	96.8%	0
2035	Jones Blvd	Harmon Ave	30	96.8%	0
2036	Durango Dr	South CC215 WB Ramp	30	96.8%	0
2042	Twain Ave	Wynn Rd	30	96.8%	0
2045	Jones Blvd	South CC 215 WB Ramp	30	96.8%	0

Showing 1 to 10 of 694 entries

Figure 4– Detector Issues Map and Data Sheet

1.2.2 RTC Washoe

RTC Washoe is the primary agency funding regional signal retiming projects in Reno and Sparks. TranSync is the primary software tool for signal timing development and performance evaluation. A region-wide TranSync network has been developed for the Reno-Sparks region, as shown in **Figure 4.** The entire network consists of numerous user-definable sub-systems with the signal coordination timing plans in a single file, making timing visualization, quality evaluation, and new timing development easier.

[1] Enlighten is no longer in operation.

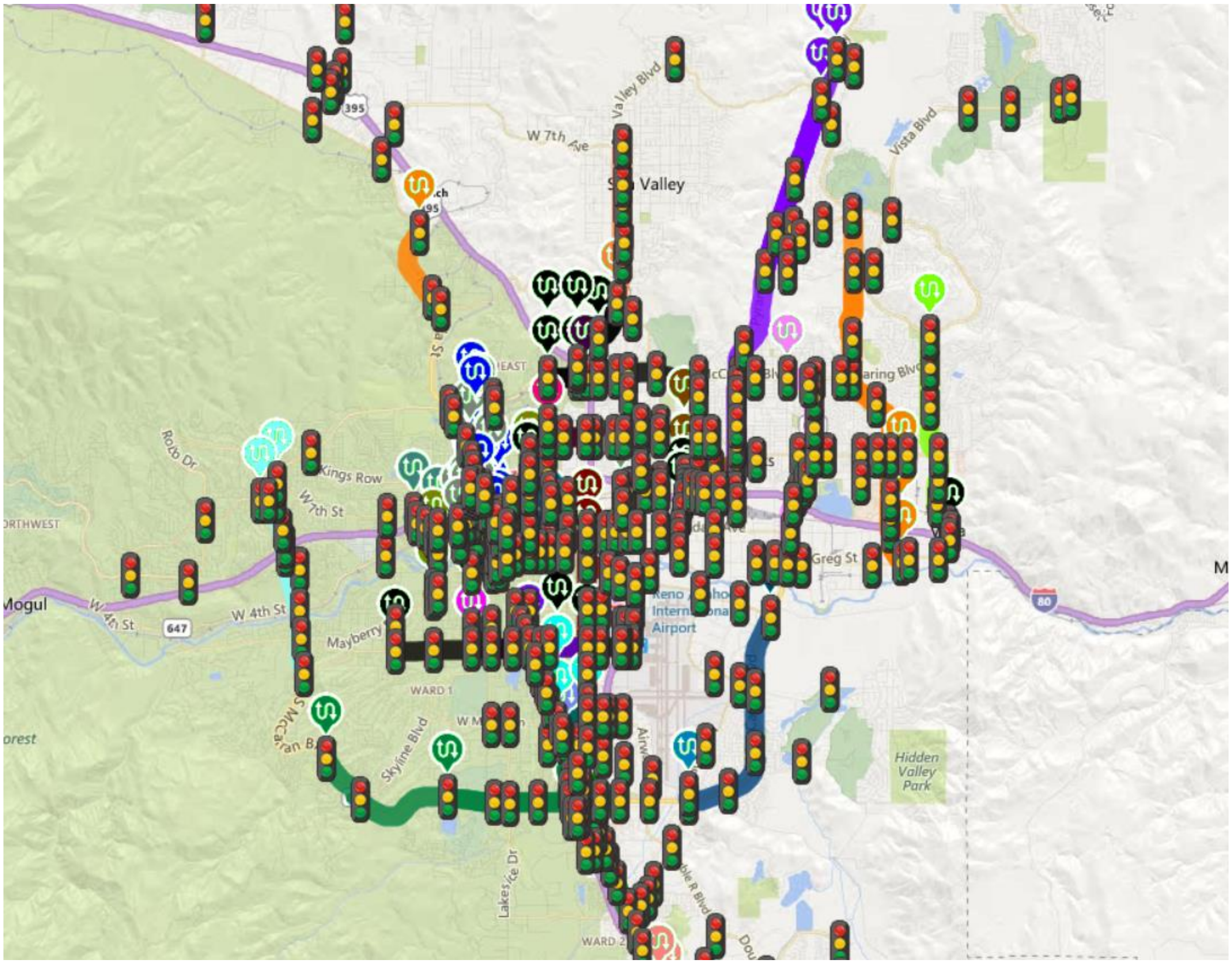
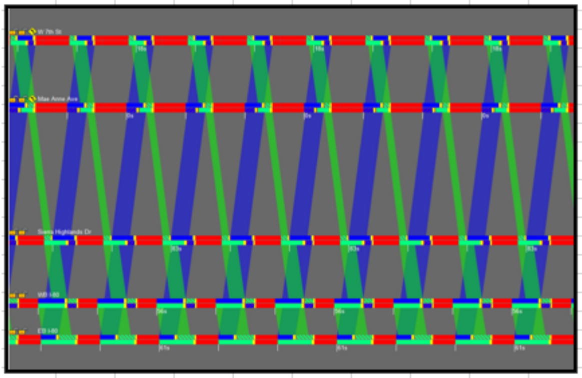


Figure 5 – TranSync Traffic Signal Model for Reno-Sparks Region

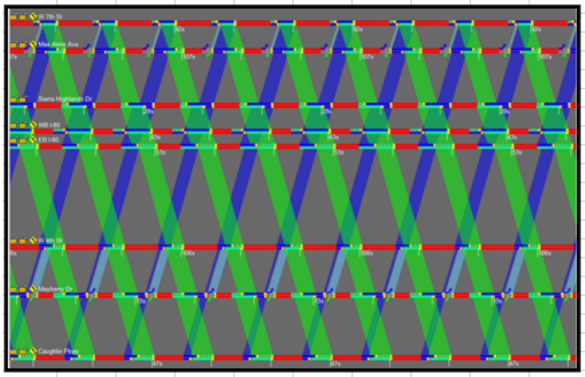
In the Signal Timing Project Phase 5 (2017-2019), floating car runs were conducted to collect trajectory data, and the collected data were imported into TranSync. Traffic signal performance measurements were conducted as before-and-after studies, an example of which is shown in **Figure 5**.

RTC Washoe is exploring third-party trajectory data sources for the evaluation and monitoring of signal performance. A study conducted by UNR [6] shows that this automated approach can lead to a significantly increased trajectory sample size and considerable reductions in data collection effort compared to the manual methods.

Time Space Diagram (Old)



Time Space Diagram (New)



Re-Timing Results

		Old	New	
	Number of Runs (SB):	9	10	
	Number of Runs (NB):	8	9	DIFFERENCE
SB	AGE TRAVEL TIME (sec):	271.3	227.9	-43.4
	AVERAGE SPEED (mph):	37.1	40.4	3.2
	AVERAGE NO. STOPS:	1.3	0.2	-1.1
NB	AGE TRAVEL TIME (sec):	241	225.1	-16
	AVERAGE SPEED (mph):	40.4	40.8	0
	AVERAGE NO. STOPS:	0.6	0.3	-0.2

Exsisting Travel Run Data

	Run #	Time @ Trip End	Avg. Speed	No. Stops	TT (min)	TT (sec)	Total TT (sec)
SB (7th – EB I-80)	1	7:16am	35	0	1	35	95
	2	7:38am	28.3	1	2	1	121
	3	7:40am	28	1	1	58	118
	4	7:45am	28.6	1	1	56	116
	5	7:56am	29.2	1	1	55	115
	6	8:03am	42	0	1	21	81
	7	8:09am	37.5	0	1	28	88
	8	8:11am	34.8	0	1	34	94
	9	8:25am	42.5	0	1	19	79
		Average =	33.9	0.5			101.5
NB (7th – EB I-80)	1	7:33am	42.1	0	1	18	78
	2	7:37am	42.6	0	1	20	80
	3	7:42am	41.6	0	1	19	79
	4	7:53am	44.2	0	1	17	77
	5	8:00am	30.5	1	1	48	108
	6	8:01am	43.5	0	1	17	77
	7	8:08am	29.7	0	1	52	112
	8	8:24am	44.9	0	1	15	75
		Average =	39.9	0.1			85.8
SB (4th – Plumb)	1	7:20am	20.7	2	2	23	143
	2	7:26am	27.3	0	1	42	102
	3	7:43am	23.1	1	2	13	133
	4	7:50am	20.5	1	2	25	145
	5	8:13am	23.3	1	2	6	126
	6	8:14am	26.5	1	1	57	117
		Average =	28.3	0.8			115.8

Figure 6– Traffic Signal Performance Measures Sheet

1.3 Roadmap to Traffic Signal Performance Measures for CAMPO

Based on the existing literature and state-of-the-practice review, the following recommendations can lead to a successful roadmap for CAMPO.

1.3.1 Near-Term Recommendations

- ATSPMs can be a valuable part of the CAMPO's transportation system management to facilitate traffic signal timing development and maintenance through better-informed, data-driven decisions.
- Considering the costs and difficulties of implementation, trajectory-based ATSPMs are recommended rather than controller-based data ATSPMs.
- The major challenge to implementing trajectory-based ATSPMs is data acquisition. Automated trajectory data sources are emerging and require further investigation and evaluation. In the near term, CAMPO can consider using relatively mature applications, such as Traction^{TM}, a corridor analysis tool developed by Kimley-Horn, to obtain travel time measures, and use TranSync to conduct trajectory data collection and produce trajectory-based performance measures.
- The capabilities of existing central traffic signal management software need to be fully explored and utilized. The data available from existing systems in Carson City include histories of detector status (calls on and off), signal phase status (times of green, yellow, red, whether it is max-out or gap-out), and times of ped pushbutton activations.

1.3.2 Long-Term Recommendations

- Trajectory data can be automatically acquired and processed for the entire CAMPO region. There are already established companies that supply high-resolution trajectory data. Software tools can be developed to assist data processing, and such automated trajectory data can be produced reliably for traffic signal performance measures to achieve CAMPO's performance management goals.
- Controller-data-based ATSPMs may be implemented at some critical intersections to achieve continuous performance monitoring and reporting.

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[5] NDOT-607-17-803: Developing a Quality of Signal Timing Performance Measure Methodology for Arterial Operations. Accessible via https://www.dot.nv.gov/home/showpublisheddocument/19217/637527816359770000

[6] Feasibility of Traffic Signal Performance Measurement Based on Wejo Vehicle Trajectory Data. Research report for the topic 3. Regional Transportation Commission of Washoe County. 2022. Available upon request.