Oregon Department of Transportation

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OREGON DEPARTMENT OF TRANSPORTATION

TRAFFIC SIGNAL MANAGEMENT PLAN

APRIL 2020

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1 EXECUTIVE SUMMARY

The purpose of this Traffic Signal Management Plan (TSMP) is to provide a framework for the management of the traffic signal system by the Oregon Department of Transportation (ODOT). A traffic signal system is defined as the hardware and software at an intersection that is used to operate a “local” traffic signal, the central traffic signal system that is used to monitor and manage (and sometimes control) the local traffic signals, and the communications infrastructure needed to connect the local and central components. Under a broad mission statement, the TSMP outlines agency objectives related to the design, operation and maintenance of traffic signals and the strategies to accomplish those objectives and achieve good basic service (GBS). Performance metrics are also established to ensure the objectives are being met.

A traffic signal system is defined as the hardware and software at an intersection that is used to operate a “local” traffic signal, the central traffic signal system that is used to monitor and manage the local traffic signals, and the communications infrastructure needed to connect the local and central components.

This plan is divided into several chapters that are organized around different elements of the traffic signal system, including Design, Operations, Maintenance, Management/Administration, and Interagency Coordination.

Achieving GBS requires implementation of strategies (design, operations, and maintenance) that work together to optimize the program, along with a clear understanding of the operational objectives. It is similar to a three-legged stool. If one area is weak, the stool will be unbalanced, meaning the two other legs must compensate to remain balanced. If detection is not maintained well, the signal will continue to operate, but the signal timings will need to be adjusted in order to efficiently serve the users. If the design increases the maintenance responsibilities (more detection or new communications medium) that improve operations, the agency must add maintenance resources or risk not seeing operational benefits.

This plan serves as the statewide guiding document for traffic signal system management activities that support the mission and goals of ODOT, while operating in a regional/local context. Local agencies may also use this TSMP as a guide for operating their signal systems.

2 INTRODUCTION AND BACKGROUND

PURPOSE OF THIS DOCUMENT

The traffic signal system is a dynamic infrastructure that is integral to meeting the travel needs of all users of the transportation network. To ensure the design, operations, and maintenance of the system reliably meets the needs of all users, ODOT must effectively plan and utilize its resources to meet this goal.

THE PURPOSE OF THIS DOCUMENT IS TO:

- Describe how the traffic signal system supports the transportation and mobility goals of ODOT and partner agencies
- Identify typical operational situations and objectives for varying context-based scenarios
- Provide a framework to sustain and advance the design, operation and maintenance of the traffic signal system
- Provide a basis for funding operations resources
- Provide a basis for succession planning

PREPARATION OF THIS DOCUMENT

The following reference documents were used in the preparation of this document.

- ODOT 2020 Traffic Signal Design Manual, January 2020
- ODOT Traffic Signal Policy and Guidelines, September 2017
- ODOT Operations Program Plan, August 14, 2018
- ODOT Strategic Business Plan, 2018-2022
- ODOT Transportation System Management & Operations (TSMO) Program Performance Management Plan, February 2017
- Oregon Transportation Plan, September 20, 2006
- Utah Department of Transportation Traffic Signal Management Plan, February 5, 2016
- National Cooperative Highway Research Program (NCHRP) Project 03-122: Performance-Based Management of Traffic Signals, Draft 2.0, January 2017

This document builds on the previous work done by:

FHWA WORKSHOP

FHWA conducted a workshop focused on Objectives and Performance Based Management of Traffic Signal Programs. The workshop was held on April 10 and 11, 2018 and included staff from ODOT and local agencies responsible for management of traffic signals. The goal of the workshop was to introduce the concepts of the TSMP and provide guidance on developing the document. FHWA facilitated a discussion on TSMP Goals, Objectives, Strategies and Tactics. The workshop also included a discussion on Operational Objectives based on context and linking performance measures to the objectives. Finally, FHWA conducted a high-level Capability Maturity Assessment to identify gaps and develop an action plan. Notes from the attendees were used to create the base for this document.

CAPABILITY MATURITY FRAMEWORK

ODOT conducted an informal Traffic Signal Systems Capability Maturity Self-Evaluation. The evaluation is intended to help agencies assess their current traffic management capabilities and develop an implementation plan for moving to a higher level of capability. This tool assesses traffic signal systems capability in six dimensions – Business Process, Systems and Technology, Culture, Organization and Workforce, Performance Measurement and Collaboration.

The aim of a traffic signal program is to achieve good basic service (GBS); defined as doing what's most important in the context of limited resources. GBS requires strategically aligning design, operations and maintenance strategies to ensure that the agency is able to effectively design, implement and operate the traffic signals it installs. Traffic signal management involves planning, design, integration, maintenance, and proactive operation of the traffic signal system in order to achieve policy-based objectives to improve the efficiency, safety and reliability of signalized intersections.

Capability for agencies are described in six dimensions as listed in the **Table 1** below.

TABLE 1: CAPABILITY MATURITY DIMENSIONS

BUSINESS PROCESS	SYSTEMS TECHNOLOGY	PERFORMANCE MEASUREMENT
• Formal Scoping • Planning • Programming • Budgeting	• Systems Engineering • Systems Architecture Standards • Interoperability	• Measures Definition • Data Acquisition • Data Utilization
CULTURE	**ORGANIZATION & WORKFORCE**	**COLLABORATION (RELATIONSHIPS WITH):**
• Technical Understanding • Leadership • Outreach • Program Legal Authority	• Programmatic Status • Organizational Structure • Staff Development • Recruitment • Retention	• Public Safety Agencies • Local Governments • Metropolitan Planning Organizations • Private Sector

Each dimension has four levels of capability as described below:

Level 1 (Ad-Hoc/High Risk) – Activities and relationships are largely ad-hoc, informal and champion-driven, substantially outside the mainstream of other DOT activities.

Level 2 (Established/Risk Acknowledgment) – Basic strategy application understood; key processes support requirements identified and key technology and core capacities under development but limited internal accountability and uneven alignment with external partners.

Level 3 (Measured/Managed Risk) – Standardized strategy applications implemented in priority contexts and managed for performance; technical and business processes developed, documented, and integrated into DOT; partnerships aligned.

Level 4 (Managed/Low Risk) – Full, sustainable core DOT program priority, established on the basis of continuous improvement with top level management status and formal partnerships.

The informal self-evaluation was conducted at the April 25, 2019 ODOT Signal Timers Meeting. The numerical results shown in Table 2. provide a snapshot self-evaluation and reflect the views of the staff that participated. For a more detailed evaluation, and to provide a baseline for tracking progress, ODOT should conduct another evaluation with increased participation. The "scores" reflect Level 1 - Level 4 as described above.

TABLE 2: ODOT CAPABILITY MATURITY SELF-EVALUATION SCORES

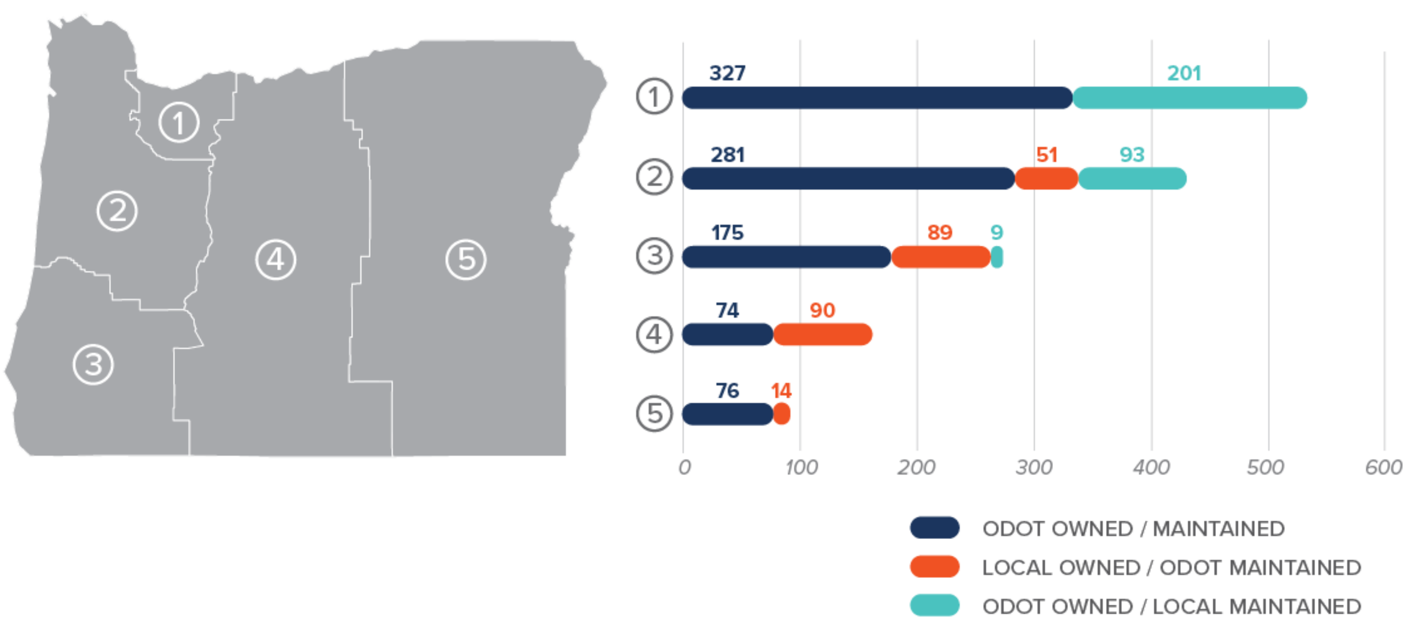
BUSINESS PROCESS	SYSTEMS TECHNOLOGY	PERFORMANCE MEASUREMENT
• Design: 2.1 • Operations: 1.9 • Maintenance: 1.5 • Management: 1.3	• System & Technology: 1.5 • Infrastructure: 1.6	• Performance Measurement: 1.5
CULTURE	**ORGANIZATION & WORKFORCE**	**COLLABORATION (RELATIONSHIPS WITH):**
• Culture: 1.5	• Organization and Staffing: 1.3 • Workforce: 1.8	• Collaboration: 1.2

STATE OF TRAFFIC SIGNALS IN OREGON

As of this writing, ODOT owns, operates, and/or maintains 1,480 traffic signals across the state. Most of these traffic signals are owned and maintained by ODOT. ODOT also maintains traffic signals that are owned by local agencies (cities and counties) and in some cases, local agencies maintain traffic signals that are owned by ODOT, through intergovernmental agreements (IGAs). The ownership/maintenance responsibilities include: 933 ODOT-owned/ODOT-maintained, 244 local-owned/ODOT-maintained, 303 ODOT-owned/local maintained. **Figure 1** summarizes the traffic signals owned and/or maintained by ODOT and local agencies per region. ODOT also manages and operates approximately 152 freeway ramp meters in the Portland and Eugene metropolitan areas and numerous actuated warning systems statewide (RRB, PHB, VAS, etc.).

This document does not discuss the operations or maintenance of the ramp meters or actuated warning systems (at this time). This document also does not discuss the traffic signals owned and maintained by local jurisdictions.

FIGURE 1: ODOT-RELATED TRAFFIC SIGNALS IN OREGON PER REGION



ODOT traffic signals operate using a variety of local controller types with specific firmware, including:

- Type 170 controllers operating Wapiti 4IKS software
- Type 2070 controllers operating NWS Voyage and SCATS adaptive software
- ATC controllers operating Intelight MaxTime software and Trafficware software

Local agency traffic signals operated/maintained by ODOT mostly use one of the controllers/software listed above. However, some local agencies use Type 170 and Type 2070 controllers operating McCain BiTran software. The Type 170 controllers and Type 2070 controllers operating NWS Voyage are considered legacy equipment and are no longer being installed. The new standard is the ATC controller for new installations and controller replacements.

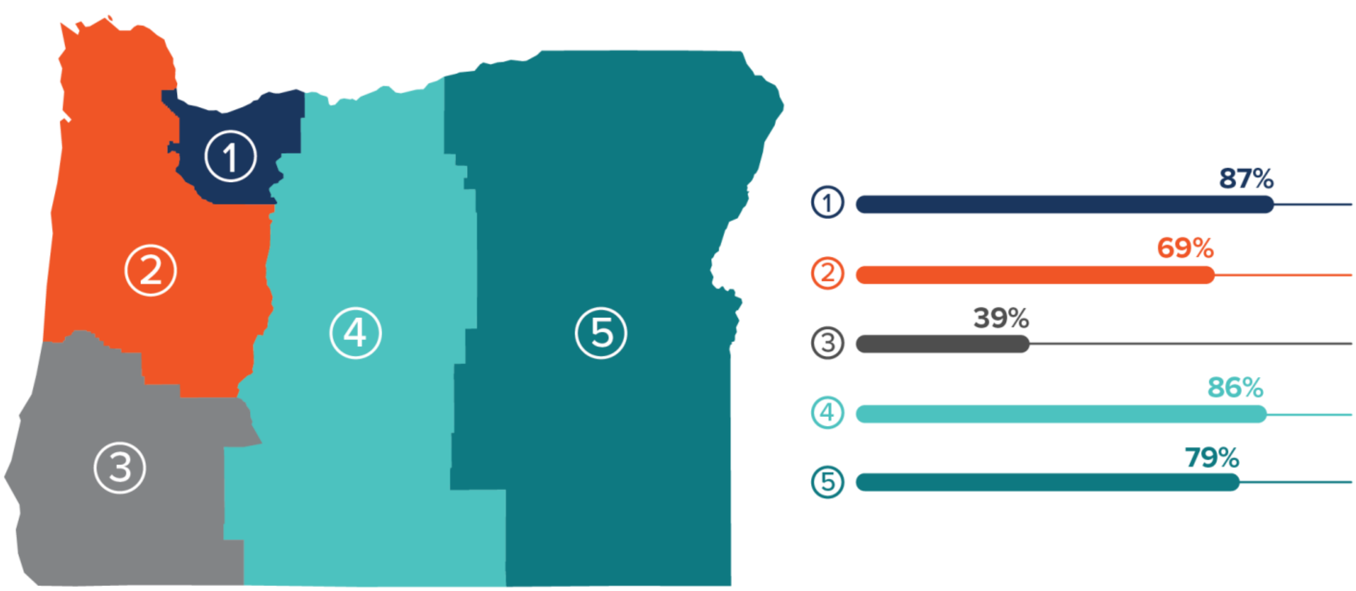
ODOT currently operates three central signal systems:

- TransCore TransSuite – connected to Type 170 and Type 2070 controllers
- SCATS adaptive – connected to Type 2070 controllers
- Intelight MaxView – connected to ATC controllers

TransSuite and SCATS are intended to be phased out in the early 2020s.ODOT can also access the Portland regional TransSuite central signal system which is connected to the majority of local agency-maintained traffic signals in Region 1.

ODOT currently has communications to approximately 780 traffic signals connected to one of the three central systems via a variety of medium; twisted pair copper, fiber optic, wireless, and cellular. Connection to the ODOT Computer Network is through standardized Ethernet switches and firewalls. **Figure 2** shows the percent of ODOT-maintained traffic signals that are connected to one of the three central signal systems by Region.

FIGURE 2: PERCENT OF ODOT SIGNALS CONNECTED TO CENTRAL SYSTEM PER REGION



ROLES AND RESPONSIBILITIES

Traffic control devices on any state facility are under the authority of the State Traffic-Roadway Engineer. Traffic signal operation and design standards as well as asset management originate from the ODOT Traffic-Roadway Section located at headquarters in Salem, while the day-to-day functions related to design, maintenance and operations occur at the Region level. Regions are also responsible for project delivery. The Traffic Systems Services Unit (TSSU) conducts traffic signal cabinet testing, annual traffic signal inspections, traffic signal turn-ons and maintenance. TSSU is also responsible for the installation and maintenance of Intelligent Transportation Systems (ITS) equipment across the state. Project development and delivery, inspection, and maintenance of the communications systems between the central signal system and the traffic signals is provided by the Systems Operations & ITS Section. Systems Operations & ITS also develop and maintain operations related software systems and server requirement associated with those systems. TSSU and Systems Operations & ITS are responsible for coordinating ODOT Network and firewall connection services.

ODOT provides testing services for the traffic signal controller and cabinets for ODOT and local agencies with traffic signals operated and maintained by ODOT through intergovernmental agreement (IGA).

The relationship/coordination between the Traffic Engineering, ITS Services, and Maintenance staff varies depending on the Region and what the specific task is. The assorted reporting/coordinating paths between the different levels and groups makes a formal organizational chart difficult to produce.

Table 3 shows the high-level responsibilities for design, operations and maintenance of the traffic signal system. Some tasks are the responsibility of headquarters (HQ), the Region, or Traffic Signal Services Unit (TSSU). ODOT receives outside support from local agencies, consultants and vendors for a variety of tasks.

TABLE 3: ROLES AND RESPONSIBILITIES

ROLE	DESIGN	SIGNAL OPERATIONS	SIGNAL MAINTENANCE	ASSET MANAGEMENT	BUDGETING
LEAD	Region	Region	Region	HQ	Region
SUPPORT	HQ	HQ	TSSU	TSSU	HQ/TSSU
EXTERNAL SUPPORT	Consultants	Vendor/ Consultants	Local Agencies	–	None

3 MISSION, GOALS, AND OBJECTIVES

This chapter summarizes ODOT's Mission Statement and Strategic Priorities based on the ODOT Strategic Business Plan[1]. It also lists the goals and objectives of the traffic signal program that support the mission statement and priorities and describes the context within which the TSMP exists.

ODOT MISSION STATEMENT

Oregon Department of Transportation provides a safe and reliable multimodal transportation system that connects people and helps Oregon's communities and economy thrive.

STRATEGIC PRIORITIES

- Unify and Align ODOT Operational Governance
- Build a Qualified and Diverse Workforce for Today and the Future
- Optimize and Modernize Technology and Data
- Strengthen Strategic Investment Decision Making

[1] Oregon Department of Transportation Strategic Business Plan 2018-2022

TRAFFIC SIGNAL MANAGEMENT PLAN GOALS AND OBJECTIVES

The TSMP goals, specific to this document, were developed at the **FHWA Workshop in April 2018** and are consistent with the goals and policies described in the 2018 ODOT Operations Program Plan. A Goal is a broad statement that describes the end state. It is the **what** ODOT is trying to achieve. An objective is more specific and measurable and is defined as what needs to be **done** in order to achieve the goal.

The table below lists the TSMP goals that were developed at the FHWA Workshop**,** as described in the previous chapter. Each goal has one or more objective associated with it. The objectives are classified as Design (D-x), Operations (O-x) and Maintenance (M-x).

GOAL 1 OPTIMIZE MOBILITY AND ACCESSIBILITY

Objective D-1: Provide facilities at traffic signals to efficiently accommodate all users (pedestrians, bicycles, vehicles, transit, rail, emergency and freight)

Objective D-2: Design traffic signals with appropriate infrastructure (controllers, detection, communication) to allow flexible operations

Objective O-1: Operate traffic signals to accommodate all users (pedestrians, bicycles, vehicles, transit, rail, emergency, and freight)

Objective O-2: Operate traffic signals based on context and operational objectives

Objective M-3: Reduce time to return intersection to operation after incident or fault

GOAL 2 MAXIMIZE OPERATIONAL EFFICIENCY

Objective D-2: Design traffic signals with appropriate infrastructure (controllers, detection, communication) to allow flexible operations.

Objective O-2: Operate traffic signals based on context and operational objectives

Objective O-3: Proactively monitor traffic signal (system) operations

Objective O-4: Coordinate with neighbor agencies to develop regional solutions

Objective M-1: Maintain traffic signal infrastructure to ensure it operates as designed

Objective M-3: Reduce time to return intersection to operation after incident or fault

GOAL 3 PROVIDE SAFE RIGHT-OF-WAY ASSIGNMENT FOR ALL MODES AT TRAFFIC SIGNALS

Objective D-3: Provide facilities at traffic signals with appropriate infrastructure (controllers, detection, communication) and signal phasing to safely accommodate all road users

Objective D-5: Design traffic signal upgrades based on ODOT safety evaluation procedures (i.e. annual SPIS site reviews)

Objective O-1: Operate traffic signals to accommodate all users (pedestrians, bicycles, vehicles, transit, rail, emergency, and freight)

Objective O-2: Operate traffic signals based on context and operational objectives

Objective O-3: Proactively monitor traffic signal (system) operations

Objective O-5: Update traffic signal operations based on ODOT safety evaluation procedures (i.e. annual SPIS site reviews)

Objective M-1: Maintain traffic signal infrastructure to ensure it operates as designed

Objective M-2: Undertake maintenance in a cost-effective manner

Objective M-3: Reduce time to return intersection to operation after incident or fault

GOAL 4 SUPPORT ECONOMIC VITALITY

Objective D-1: Design traffic signals to accommodate all users (pedestrians, bicycles, vehicles, transit, rail, emergency, and freight)

Objective D-2: Design traffic signals with appropriate infrastructure (controllers, detection, communication) to allow flexible operations

Objective O-1: Operate traffic signals to accommodate all users (pedestrians, bicycles, vehicles, transit, rail, emergency, and freight)

Objective O-4: Coordinate with neighbor agencies and private sector to develop regional solutions

Objective M-1: Maintain traffic signal infrastructure to ensure it operates as designed

Objective M-2: Undertake maintenance in a cost-effective manner

GOAL 5 PRESERVE TRAFFIC SIGNAL INFRASTRUCTURE

Objective D-4: Design traffic signals with reliable infrastructure and equipment

Objective D-6: Maintain uniformity of traffic signal infrastructure (avoid non-standard hardware/software/equipment to enable efficient operations and maintenance)

Objective M-1: Maintain traffic signal infrastructure to ensure it operates as designed

Objective O-3: Proactively monitor traffic signal (system) operations

Objective M-2: Undertake maintenance in a cost-effective manner

Objective M-3: Reduce time to return intersection to operation after incident or fault

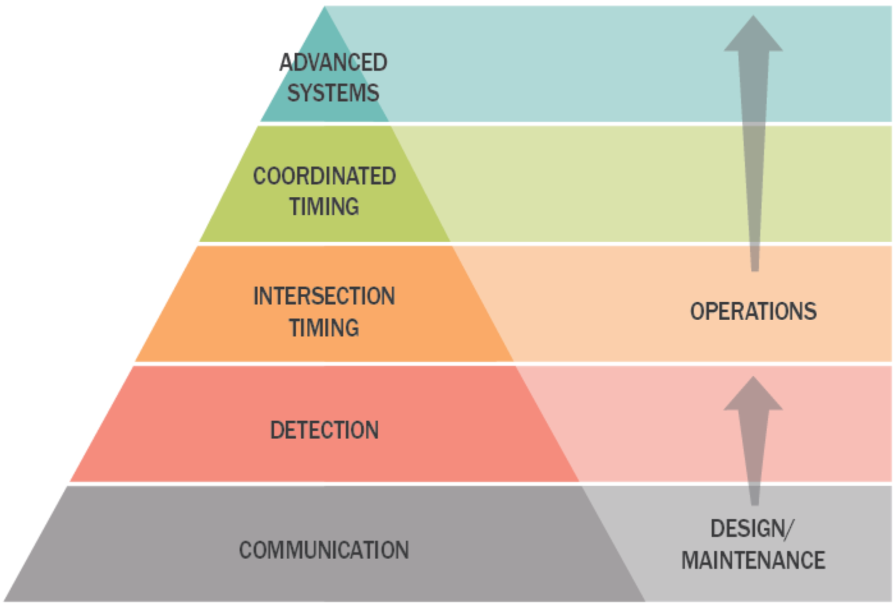
D = design objective, O = operational objective, M = maintenance objective

Achieving good basic service requires implementation of strategies (design, operations, and maintenance) that work together to optimize the program, along with a clear understanding of the operational objectives. It is similar to a three-legged stool. If one area is weak, the stool will be unbalanced, meaning the two other legs must compensate to remain balanced. If detection is not maintained well, the signal will continue to operate, but less efficiently as the signal timings are adjusted to serve anticipated rather than actual demand.

If the design increases the maintenance responsibilities (more detection or new communications medium) that improve operations, the agency must add maintenance resources or risk not seeing operational benefits.

Efficient traffic signal operation depends on a number of factors that build upon each other. As you can see in **Figure 3**, **communications** and **detection** form the base of operations. Without reliable and adequate communications and detection, the signal cannot respond to variable traffic demand and the operator cannot easily observe and manage the operations. Once the signal has those in place, the local and/or coordinated **signal timings** can be optimized, based on the *operational objectives*. Additional efficiency may be gained with **advanced systems** only if the rest of the system has been optimized and all the existing tools used. You can see in the graphic how maintenance and operations staff must work together to make the system the best it can be.

FIGURE 3: TRAFFIC SIGNAL COMMUNICATIONS



Chapters 4 to 6 will discuss the objectives and strategies (and tactics) of the traffic signal design, operations, and maintenance programs, as well as the meaningful performance measurements that will link goals and strategies. The strategies are meant to focus on creating and managing a system that aligns with **Figure 3.**

Each objective is followed by a list of strategies (a strategy may apply to multiple objectives). The strategies listed here should be applied based on context. The specific tactics (activities undertaken to fulfill the strategy) are typically included in other documents and will be referenced where applicable. Action plans will be identified to address the gaps in achieving the desired objectives.

4 DESIGN STRATEGIES AND TACTICS

Chapter 4 includes the objectives and strategies (and tactics) related to traffic signal design and the meaningful performance metrics that will link goals and strategies. The Objectives are defined as what needs to be done in order to achieve the goals listed in Chapter 3. A Strategy is defined as the capability put in place to achieve an Objective, while a Tactic is the specific method to implement the strategy (action or activity). The strategies are meant to focus on creating and managing a system that aligns with Figure 3. Each objective is followed by a list of strategies (a strategy may apply to multiple objectives). The specific tactics (activities undertaken to fulfill the strategy) are typically included in other documents and will be referenced where applicable. Performance Metrics that can be used to track progress are listed at the end of the chapter along with Action Plans to address the gaps in achieving the desired objectives.

The MUTCD[1] and the ODOT Signal Design Manual[2] are be the primary sources for information related to traffic signal design.

[1] 2009 MUTCD with Revisions 1 and 2, May 2012

[2] 2020 Oregon Department of Transportation Traffic Signal Design Manual, January 2020

The following are ODOT's TSMP specific strategies related to the design objectives:

OBJECTIVE D-1

Provide facilities at traffic signals to efficiently accommodate all users (pedestrians, bicycles, vehicles, transit, rail, emergency, and freight)

- Design traffic signals only where warranted (per MUTCD and ODOT Traffic Manual) and determined to be appropriate.
- Design vehicle and bicycle detection that provides for actuated operations on all approaches at all signals and adheres to ODOT standard detection layout practices.
- Design pedestrian detection for all signalized pedestrian crossings at signalized intersections that adheres to ODOT standards.
- Upgrade intersection elements to current ADA standards per ODOT guidance* when significant modifications or construction work are undertaken in the vicinity of the intersection.
- Design detection for emergency vehicles.
- Design detection for transit vehicles where transit signal priority operation is proposed.
- Design detection for heavy vehicles where freight priority operation is proposed.
- Maintain a design review checklist to identify all elements that must be included in a design and the appropriate standard or specification.

**ODOT Highway Division Leadership Team Operational Notice (MG 144-03, October 18, 2016)*

OBJECTIVE D-2

Design traffic signals with appropriate infrastructure (controllers, detection, communications) to allow flexible operations

- Specify traffic signal controller that can collect and store high-resolution controller enumeration data.
- Design vehicle and bicycle detection that provides for actuated operations on all approaches at all signals and adheres to ODOT standardized detection layout practices.
- Design vehicle and bicycle detection that provides inputs for high-resolution performance metric reporting (per the Detector Layout section that follows).
- Design communication system that connects all traffic signals to central system to allow for system monitoring.
- Design communication system that allows for transfer of high-resolution data (from local to central/cloud).
- Design communication system that provides peer-to-peer operation between two or more controllers on a corridor.
- Design communication system to connect to partner agency intersections (based on IGA).

OBJECTIVE D-3

Design traffic signals with appropriate infrastructure (controllers, detection,communications) and signal phasing to safely accommodate all road users

- Specify traffic signal controller that can collect and store high-resolution controller enumeration data.
- Design vehicle and bicycle detection that provides for actuated operations on all approaches at all signals and adheres to ODOT standardized detection layout practices.
- Design vehicle and bicycle detection that provides inputs for high-resolution performance metric reporting (per the Detector Layout section below).
- Design communication system that connects all traffic signals to central system to allow for system monitoring.
- Design communication system that allows for transfer of high-resolution data (from local to central/cloud).
- Design communication system that provides peer-to-peer operation between two or more controllers on a corridor.
- Design traffic signal with appropriate left- and right- turn phasing in accordance with the ODOT Traffic Signal Policy and Guidelines.
- Design traffic signals to accommodate future growth (i.e. adding left turn phasing, widen for a turn lane).

OBJECTIVE D-4

Design traffic signals with appropriate infrastructure to provide safe and efficient operations

- Specify detection systems that have a proven record of high performance, reliability, ease of maintenance and have are readily available.
- Design detection system to automatically detect and report faults.
- Design signal system to minimize failure rates of equipment units.
- Design communications system to self-diagnose and report faults.
- Design communications system to minimize damage by others (location of equipment).
- Design communications to minimize risk of cyber security issues.
- Replace legacy traffic signal controllers, cabinets, and communications per deployment plan.
- Design signal system that is uniform to allow for ease of maintenance and troubleshooting.
- Design signal equipment to facilitate maintenance access to cabinet and other equipment.
- Design traffic signal cabinets that can only be accessed by authorized personnel.

OBJECTIVE D-5

Design traffic signal upgrades based on ODOT safety evaluation procedures (i.e. annual SPIS site reviews)

- Coordinate with Safety Investigations Group to review SPIS, ARTS and other safety data to identify design counter measures.

OBJECTIVE D-6

Maintain uniformity of traffic signal infrastructure (avoid non-standard hardware/ software/equipment to enable efficient operations and maintenance).

- Design and specify ODOT approved equipment for traffic signals and communications systems.
- Design signal system that is uniform to allow for ease of maintenance and troubleshooting.
- Get approval from Standards engineer for non-standard equipment.
- Review and approve equipment list (blue sheets and green sheets) every year.

DETECTOR LAYOUT

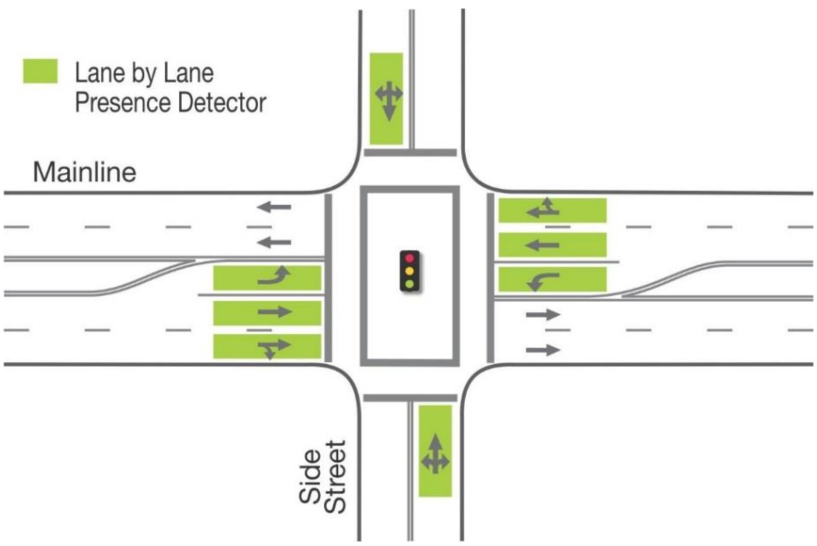
Automated Traffic Signal Performance Measures (ATSPMs) require specific detector layouts. The graphics below show the detector configurations required for different ATSPMs. The ATSPMs should support the operational objectives of the intersection/corridor. Even though the detection is not required to report Phase Termination or Split Monitor, presence detection provides information to the operator on the operational efficiency of the traffic signal. With ATCs and radar detection, ODOT is increasingly using SDLC connections for increased functionality. Contact Traffic-Roadway layout for most up to date SDLC layout standards.

STOP BAR PRESENCE DETECTION:

Phase Termination – graphical representation of why each phase terminated (Gap Out, Max Out, Force Off, Ped)

Split Monitor – report showing the duration of each phase per cycle and the reason for phase termination.

Split Failure – report showing when a phase "fails" (based on occupancy ratios)



Benefits:

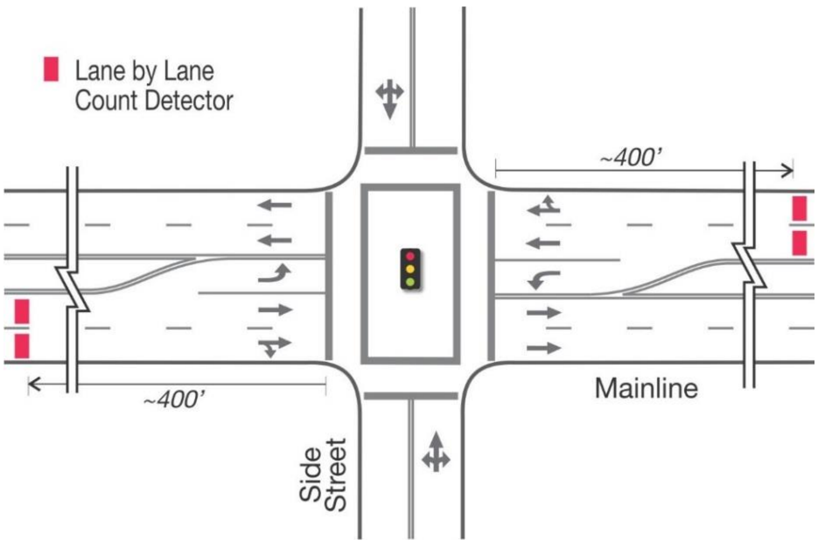
- Helps evaluate/optimize local operations
- Helps determine if Max/Split times set appropriately
- Helps identify potential detector failures

ADVANCE DETECTION (LANE BY LANE):

Approach Volume – graphic showing the traffic volume approaching the intersection

Approach Delay – calculates the time starting when the advance detector is actuated and ending when the phase turns green

Purdue Coordination Diagram – graphical representation of all phases (green, yellow, red) and vehicle detections each cycle (per phase), shows if vehicle is arriving when phase is green or red, calculates a percent arrival on green and platoon ratio



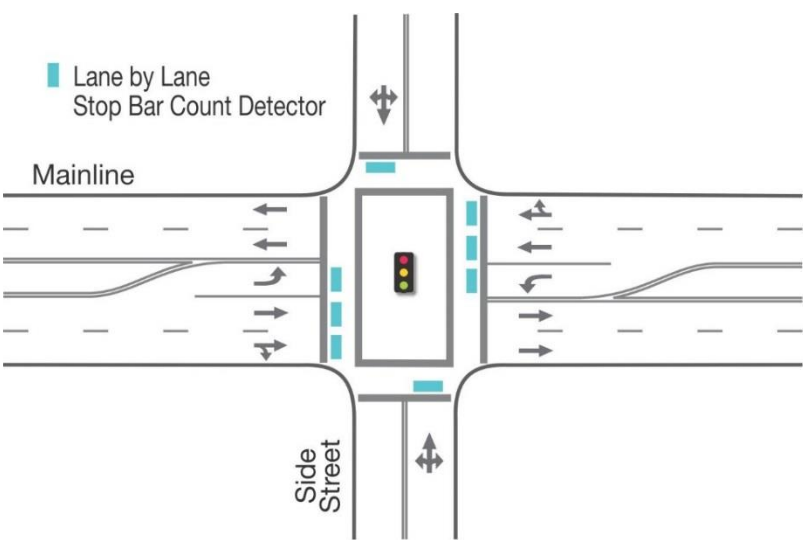
Benefits:

- Helps evaluate/optimize arterial operations
- Helps understand vehicle and platoon arrival patterns
- Helps during fine-tuning (short term) and tracking trends (long term)

STOP BAR COUNT DETECTION:

Turn movement counts – report showing the volumes associated with each phase.

Yellow and red actuations – graphic showing when vehicles enter the intersection (activate detector) when signal during the yellow or red interval.



Benefits:

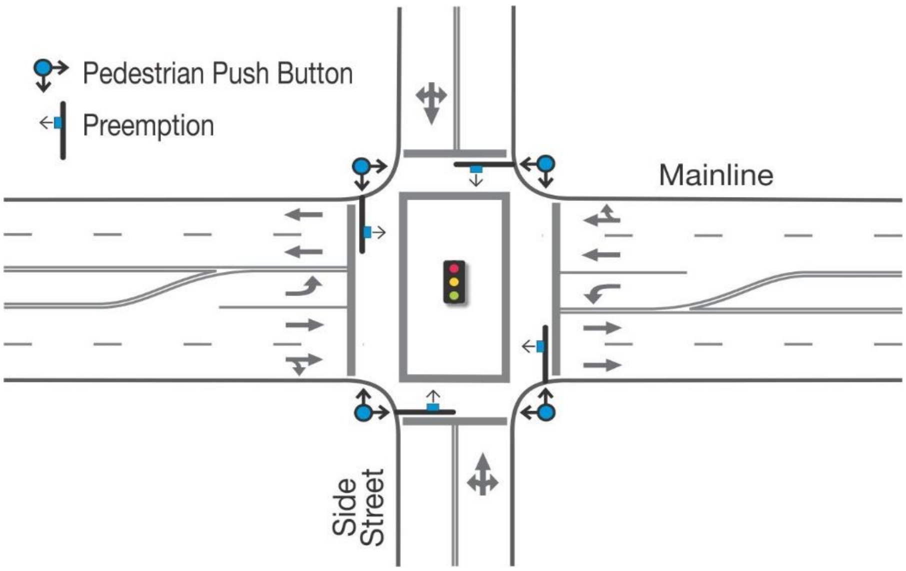
- Cost effective data collection
- Permanent and continuous collection can measure traffic variation
- Helps identify potential safety issues related to vehicles entering on yellow and red

OTHER DETECTION:

Pedestrian Actuation – number of pedestrian actuations. Included in phase termination chart.

Pedestrian Delay – duration of time a pedestrian waits for the walk signal after pushing the ped push button.

Emergency/Heavy Rail/Light Rail Preemption – graphic showing number and length of preemption requests.



<u>Benefits:</u>

- Monitors frequency of pedestrian actuations
- Calculate pedestrian delay
- Monitors frequency and duration of preemption

4.1 DESIGN METRICS

- Number of intersections with ATC controllers
- Number of intersections with appropriate detection for efficient operations
- Number of intersections with appropriate detection for ATSPM reporting
- Number of intersections connected to central signal system
- Number of intersections that are configured to report ATSPMs

4.2 DESIGN ACTION PLAN

- Develop deployment (prioritization) plan for ATC controllers
- Develop deployment (prioritization) plan for upgraded detection
- Develop deployment (prioritization) plan for upgraded communications
- Develop deployment (prioritization) plan for replacing traffic signal cabinets
- Develop deployment (prioritization) plan for replacing aging traffic signal hardware
- Enhance asset management evaluation ranking/scoring tool to incorporate infrastructure required to operate ATSPMs
- Finalize detection layout standards for ATSPM
- Develop funding strategy for controller and detection upgrades and other aging infrastructure

- Work with ITS Group to develop common understanding of design and maintenance of communications system
- Develop a strategy for incorporating/evaluating future technologies and triggers for when to potentially sunset old technologies. This assumes that traffic operations infrastructure including control has a life expectancy of five to 10 years and should be re-evaluated on that schedule
- Create SPIS/ARTS review group to coordinate efforts and identify countermeasure(s) based on safety assessment
- Include new design standards in existing TSSU training program for design and maintenance audiences (internal and external to ODOT)

5 OPERATIONS STRATEGIES AND TACTICS

Chapters 5 includes the objectives and strategies (and tactics) related to traffic signal operations and the meaningful performance metrics that will link goals and strategies. The Objectives are defined as what needs to be done in order to achieve the goals listed in Chapter 3. A Strategy is defined as the capability put in place to achieve an Objective, while a Tactic is the specific method to implement the strategy (action or activity). The strategies are meant to focus on creating and managing a system that aligns with Figure 3. Each objective is followed by a list of strategies (a strategy may apply to multiple objectives). The strategies listed here should be applied based on context. The specific tactics (activities undertaken to fulfill the strategy) are typically included in other documents and will be referenced where applicable. Performance Metrics that can be used to track progress are listed at the end of the chapter along with Action Plans to address the gaps in achieving the desired objectives.

The MUTCD[1] and the ODOT Signal Policy and Guidelines[2] are be the primary sources for information related to traffic signal operations.

[1] 2009 MUTCD with Revisions 1 and 2, May 2012

[2] Oregon Department of Transportation Traffic Signal Policy and Guidelines, September 2017

The following are ODOT's TSMP specific strategies related to the operations objectives:

OBJECTIVE O-1

Operate traffic signals to accommodate all users (pedestrians, bicycles, vehicles, transit, rail, emergency, and freight)

- Provide calculated/engineered clearance intervals for all modes on each traffic signal phase, using guidelines outlined in ODOT Traffic Signal Policy and Guidelines.
- Operate traffic signals using Operational Objectives scenarios as a guide (end of this chapter).
- Program phases and ring & barrier sequences that provide safe assignment of green time based on Signal Policy and Guidelines and engineering judgment.
- Program pedestrian phases based on context.
- Program bicycle phasing based on Signal Policy and Guidelines.
- Program transit signal priority timing based on Signal Policy and Guidelines.
- Program emergency vehicle and rail preemption to safely serve modes.
- Review and update signal timing parameters whenever a policy related to timing is modified.
- Maintain record of traffic signal timing parameter changes (who, when, why).

OBJECTIVE O-2

Operate traffic signals based on context and operational objectives (shown below)

- Operate traffic signals using Operational Objectives scenarios as a guide (end of this chapter).
- Operate traffic signals using the simplest timing method to achieve acceptable results.
- Use high resolution data performance metrics to review and monitor operations in real time.
- Operate signals in a mode most appropriate for current traffic conditions (e.g., use fully-actuated, coordinated, traffic responsive, or adaptive traffic system to suit current traffic conditions).
- Update traffic signal timing parameters due to construction (develop temporary timings).
- Maintain record of traffic signal timing parameter changes (who, when, why).

OBJECTIVE O-3

Proactively monitor traffic signal (system) operations

- Install ATC controller and configure high resolution data collection.
- Connect controller to central system.
- Program automated reports of intersection/corridor operations.
- Upload and review performance metrics based on Operational Objective.
- Update signal timing parameters based on Operational Objectives, if conditions justify.
- Modify signal timing parameters due to hardware malfunction (revise min/max green if detector fails).
- Maintain record of traffic signal timing parameter changes (who, when, why).

OBJECTIVE O-4

Coordinate with neighbor agencies and private sector to develop regional solutions

- Operate traffic signals using Operational Objectives scenarios as a guide (end of this chapter).
- Where appropriate and authorized, coordinate signals across jurisdictional boundaries by synchronizing clocks or interconnecting systems.
- Review/update intergovernmental agreements to allow for shared operations of signal system.
- Pursue regional and statewide cooperation in the sharing of infrastructure, tools, resources, and programs.
- Maintain record of traffic signal timing parameter changes (who, when, why).
- Configure traffic signal controllers and system to broadcast Signal Phase and Timing (SPaT) and MAP data.

OBJECTIVE O-5

Update traffic signal operations based on ODOT safety evaluation procedures (i.e. annual SPIS site reviews)

- Coordinate with Safety Investigations Group to review SPIS/ARTS and other safety data to identify operations counter measures.
- Upload and review performance metrics based on Operational Objective.

5.1 OPERATIONS METRICS

- ATSPM based on **Operational Objectives** (see specifics below)
  - Split Failure
  - Phase Termination
  - Split Time
  - Yellow/Red Actuations
  - Approach Delay
  - Queue Length
  - Percent Arrival on Green
- Number of citizen complaints
- Travel time along a corridor
- Travel time reliability along a corridor
- Number of traffic signals broadcasting SPaT and MAP data

5.2 OPERATIONS ACTION PLAN

- Develop Performance Measures Plan to determine what metrics to track for specified operational strategies (see operational strategies)
- Develop operations plan for ATSPM (what data to review, how to use data, how often to review, who is responsible)
- Develop plan for annual reporting of performance metrics to be included in statewide annual performance plan
- Determine funding strategy for operations resources
- Develop review cycle and process to track changes for signal timing updates
- Configure ATSPM system
- Develop "corridor atlas" with generic or specific performance measure plan
- Develop plan for cross jurisdictional coordination through IGAs
- Create SPIS/ARTS review group to coordinate efforts and identify countermeasure(s) based on safety assessment
- Create training plan (internal and external) on the use of ATSPM data in operations

OPERATIONAL OBJECTIVES

The following pages include a list of Scenarios commonly found on ODOT facilities along with the Operational Objective (what signal timing is programmed to do), the strategies/tactics to accomplish the objective and the performance metrics that can be used to measure/track performance, and the associated vehicle detection needed. Listed below are scenarios that provide the context of the operational issue followed by a detailed description of the scenario, objective, tactics and performance measures. The tactics listed in each scenario are examples and should be applied as deemed appropriate.

Scenario Context:

ISOLATED INTERSECTION	CORRIDOR / NETWORK	INTERCHANGE
• Congested • Uncongested	• Congested • Uncongested	• Isolated • Corridor

SPECIAL CONDITIONS		
• Event • Downtown grid	• Bicycles • Transit	• Freight • Inter-agency

ISOLATED INTERSECTION

CONGESTED

In this context, the intersection operates in isolation (all or part of day). It may operate isolated because:

1. It is not physically close to other traffic signals.
2. The natural cycle length is different than nearby signals.
3. There is a sudden traffic surge that overwhelms the coordinated cycle length (school dismissal).

OBJECTIVE: MAXIMIZE THROUGHPUT

STRATEGY:

Provide green phase times that maintain high degree of saturation without causing unacceptable congestion or delay on minor movements (move as many cars as possible through the intersection – on all approaches).

TACTICS:

- Program Max green times and detector settings based on traffic conditions to optimize use of green time (may be different max time and/or passage time at different times of day).
- Program Dynamic Maximum green times to allow timings to adjust to conditions.
- Program Phase Sequence to optimize use of green time.
- Operate left turn phase type to provide safe assignment of right of way.
- Consider time-of-day (TOD) restrictions on flashing yellow left-turn arrow (FYLTA) during peak periods.
- If in rural location, review phase times and detector settings to match expected vehicle type.

PERFORMANCE MEASURES:

- Split failure (ROR/GOR)*
- Phase termination
- Split time
- Yellow/red actuations
- Approach delay time

REQUIRED DETECTION:

- Stop bar presence
- Stop bar presence
- Stop bar presence
- Stop bar count
- Advance

*Red Occupancy Ratio/Green Occupancy Ratio

ISOLATED INTERSECTION

CONGESTED OR UN-CONGESTED

In this context, the intersection operates in isolation (all or part of day). There may be one or more phases/approaches that are prone to queuing, which may or may not impact nearby intersections. It may operate isolated because:

1. It is not physically close to other traffic signals.
2. The natural cycle length is different than nearby signals.
3. There is a sudden traffic surge that overwhelms the coordinated cycle length (school dismissal).

OBJECTIVE: MINIMIZING QUEUING

STRATEGY:

Provide green phase times to prevent or minimize phase failures/queuing. Too short may strand vehicles, too long may increase queues on other movements.

TACTICS:

- Program Max green times and detector settings based on traffic conditions to optimize use of green time (limit green times to prevent queueing).
- Program Dynamic Maximum green time for phases prone to queueing to allow timings to adjust to conditions.
- Program Phase Sequence to optimize use of green time.
- Operate left turn phase type to provide safe assignment of right of way.
- Consider time-of-day (TOD) restrictions on flashing yellow left-turn arrow (FYLTA) during peak periods.
- Program left turn phase(s) to operate more than once per cycle.
- If in rural location, review phase times and detector settings to match expected vehicle type.

PERFORMANCE MEASURES:

- Split failure (ROR/GOR)
- Phase termination
- Split time
- Yellow/red actuations
- Queue length

REQUIRED DETECTION:

- Stop bar presence
- Stop bar presence
- Stop bar presence
- Stop bar count
- Queue detector

ISOLATED INTERSECTION

UN-CONGESTED

In this context, the intersection operates in isolation (all or part of day). The volumes are light to moderate with the higher volume of vehicles on the mainline. This may be a signal near a shopping center. It may operate isolated because:

1. It is not physically close to other traffic signals.
2. The natural cycle length is different than nearby signals.
3. There is a sudden traffic surge that overwhelms the coordinated cycle length (school dismissal).

OBJECTIVE: EQUITABLY DISTRIBUTE GREEN TIME

STRATEGY:

Provide green phase times that serve all movements in an equitable manner and minimize delay.

TACTICS:

- Program Max green times and detector settings based on traffic conditions to optimize use of green time and minimize delay for minor movements.
- Program Phase Sequence to optimize use of green time.
- Operate left turn phase type to provide safe assignment of right of way and minimize delay for left turning vehicles.
- Program left turn phase(s) to operate more than once per cycle.
- If in rural location, review phase times and detector settings to match expected vehicle type.

PERFORMANCE MEASURES:

- Split failure (ROR/GOR)
- Phase termination
- Split time
- Yellow/red actuations

REQUIRED DETECTION:

- Stop bar presence
- Stop bar presence
- Stop bar presence
- Stop bar count

CORRIDOR/NETWORK INTERSECTION

CONGESTED

In this context, the intersections operate in a group so as to progress traffic between them. The mainline volumes are high and may be directional at certain times of day and balanced at others.

OBJECTIVE: MAXIMIZE THROUGHPUT

STRATEGY:

Design coordinated timings that maintain high degree of saturation without causing unacceptable congestion or delay on minor movements and provide progression along a corridor.

TACTICS:

- Develop coordinated cycle length and splits to optimize operations at critical intersection(s).
- Program intersection splits to adequately serve minor movements.
- Program offsets to progress heaviest traffic flow.
- Progress heavy left turn movement from one intersection through downstream signals.
- Program phase sequence to maximize mainline green band.
- Operate left turn phase type to provide safe assignment of right of way.
- Consider time-of-day (TOD) restrictions on flashing yellow left-turn arrow (FYLTA) during peak periods.
- Split into smaller groups and operate different cycle lengths (meter traffic into/out of systems).
- If in rural location, review phase times and detector settings to match expected vehicle type.

PERFORMANCE MEASURES:

- Split failure (ROR/GOR)
- Phase termination
- Split time
- Percent arrival on green (Purdue coordination diagram)
- Yellow/red actuations

REQUIRED DETECTION:

- Stop bar presence
- Stop bar presence
- Stop bar presence
- Advance
- Stop bar count

CORRIDOR/NETWORK INTERSECTION

CONGESTED

In this context, the intersections operate in a group so as to progress traffic between them. The volumes on one or more approaches are high, which may cause queuing or gridlock at times.

OBJECTIVE: MANAGE QUEUES

STRATEGY:

Design coordinated timings that prevent or minimize phase failures and provide progression along a corridor. Choose cycle length that balances the need to serve vehicles and minimizes queues.

TACTICS:

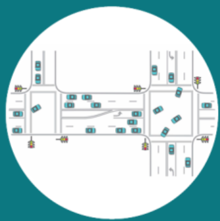
- Program split times and detector settings based on traffic conditions to optimize use of green time (shorter cycle length to prevent queueing).
- Program Dynamic Maximum for phases prone to queueing to allow timings to adjust to conditions.
- Program offsets to progress heaviest traffic flow.
- Program offsets to control where vehicles are stored and not blocking intersections.
- Program offsets to prevent turn lane spillover.
- Program offsets with negative or simultaneous offset to clear out queue.
- Program phase sequence to minimize queuing (lag heavy side street left turn where it can use unused green time from opposing through phase).
- Operate critical intersections in Free mode to deal with short spikes in traffic.
- Progress heavy left turn movement from one intersection through downstream signals.
- Operate minor intersections at half cycle (or asymmetrical cycle length).
- Operate left turn phase type to provide safe assignment of right of way.
- Consider time-of-day (TOD) restrictions on flashing yellow left-turn arrow (FYLTA) during peak periods.
- Break corridor into smaller groups with different cycle lengths (meter traffic into/out of systems).
- If in rural location, review phase times and detector settings to match expected vehicle type.
- Allow coordinated phases to gap out at end of split.

PERFORMANCE MEASURES:

- Split failure (ROR/GOR)
- Phase termination
- Split time
- Queue length
- Yellow/red actuations

REQUIRED DETECTION:

- Stop bar presence
- Stop bar presence
- Stop bar presence
- Queue detector
- Stop bar count



CORRIDOR/NETWORK INTERSECTION

UN-CONGESTED

In this context, the intersections operate in a group so as to progress traffic between them. The mainline volumes are moderate and higher than the side street volumes. The volumes may be directional at certain times of day and balanced at others.

OBJECTIVE: SMOOTH FLOW

STRATEGY:

Design coordinated timings that provide green band along corridor in one or both directions to minimize stops for platoon.

TACTICS:

- Develop coordinated cycle length and splits to optimize operations at critical intersection(s).
- Program intersection splits to adequately serve minor movements.
- Program offsets to progress traffic in one or both directions – depending on volume.
- Program phase sequence to maximize mainline green band.
- Operate left turn phase type to provide safe assignment of right of way.
- Program phase reservice where necessary.
- Operate low volume intersections at half-cycle.
- Allow coordinated phases to gap out at end of split.

PERFORMANCE MEASURES:

- Split failure (ROR/GOR)
- Phase termination
- Split time
- Delay (multimodal)
- Percent arrival on green (Purdue coordination diagram)
- Yellow/red actuations

REQUIRED DETECTION:

- Stop bar presence
- Stop bar presence
- Stop bar presence
- Advance/push button
- Advance
- Stop bar count

INTERCHANGE RAMPS

ISOLATED

In this context, two closely spaced intersections control the entrance and exit ramps to a freeway. The signals are typically not part of a larger corridor grouping.

OBJECTIVE: SMOOTH FLOW/MINIMIZE QUEUES/MINIMIZE STOPS

STRATEGY:

Progress traffic between the ramp signals in a way to avoid queuing onto the freeflow roadway and minimize the stops of vehicles traveling on, off and through the ramps - also known as “diamond timing.”

TACTICS:

- Develop cycle length, splits, and phase sequence to progress the traffic through on the mainline and also to progress traffic off ramp and through the downstream signal.
- Use cycle length that minimizes queuing.
- Use phase recall mode to control where vehicles are stored and how they progress through system.
- Configure “dump detection” to trigger special plan to flush queues that extend into freeflow facility.
- Use tactics from other scenarios as appropriate.

PERFORMANCE MEASURES:	REQUIRED DETECTION:
• Split failure (ROR/GOR)	• Stop bar presence
• Phase termination	• Stop bar presence
• Split time	• Advance
• Percent arrival on green (Purdue coordination diagram)	• Advance
• Yellow/red actuations	• Stop bar count

INTERCHANGE RAMPS

WITHIN NETWORK

In this context, two closely spaced intersections control the entrance and exit ramps to a freeway. The signals are typically part of a larger corridor group on one or both sides of the interchange.

OBJECTIVE: SMOOTH FLOW/MINIMIZE QUEUES/MINIMIZE STOPS

STRATEGY:

Progress traffic along the corridor in a way to maximize the green band on the mainline and minimize the queuing on the ramps.

TACTICS:

- Use tactics from other scenarios as appropriate (develop timings based on the corridor objective)

PERFORMANCE MEASURES:

- Depends on objective

EVENT TRAFFIC

NETWORK OR ISOLATED

In this context, the traffic signal(s) are located near a land use that generates event-type traffic. This could be concert venue, fairgrounds, school, etc. where a sudden surge of traffic occurs before and/or after an event. This could also include an incident causing traffic, such as a detour route.

OBJECTIVE: MOVE TRAFFIC TO OR FROM FACILITY (OBJECTIVE MAY BE TO MAXIMIZE THROUGHPUT, MINIMIZE QUEUES, SMOOTH FLOW, ETC.)

STRATEGY:

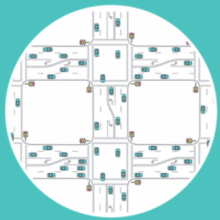
- Progress traffic to event area (typically spread out over an hour period).
- Progress traffic away from event area (typically occurs immediately after event).

TACTICS:

- For Planned events, develop Special Event timing plans and program them in the Time of Day scheduler. Review operations after events and make adjustments as needed.
- For Unplanned events, where special event traffic volumes occur routinely, manually enable/disable Special Event timing plans.
- Program a volume/occupancy trigger for one of the detectors and call in the Special Event timing plan when the thresholds are met. This could be programmed as Traffic Responsive.

PERFORMANCE MEASURES:

- Dependent on the operational objective
- Length of time that phase failures occur on a particular approach



DOWNTOWN GRID

CONGESTED OR UN-CONGESTED

In this context, the traffic signals are located in a downtown grid. Typically, the signals have one block spacing in one or more directions. The travel flow may be one-way or two-way or a combination and speeds are typically lower.

OBJECTIVE: MINIMIZE DELAY (FOR ALL MODES)

STRATEGY:

The goal is to provide access to the businesses within the downtown. There may be one or more major arterials as part of the network that provide access to and from (or through) the downtown.

TACTICS:

- Program cycle length that minimizes the delay yet provides progression between intersections.
- Use low progression speed.
- Program pre-timed mode to control platoon.
- Program actuated mode at locations where left turns or side street times should be minimized.
- Consider offsets based bicycle or walking speeds

PERFORMANCE MEASURES:

- If pre-timed mode, may need to use different metric.
- If actuated mode, metric should match objective

6 MAINTENANCE STRATEGIES AND TACTICS

Chapters 6 includes the objectives and strategies (and tactics) related to traffic signal maintenance and the meaningful performance metrics that will link goals and strategies. The Objectives are defined as what needs to be done in order to achieve the goals listed in Chapter 3. A Strategy is defined as the capability put in place to achieve an Objective, while a Tactic is the specific method to implement the strategy (action or activity). The strategies are meant to focus on creating and managing a system that aligns with Figure 3. Each objective is followed by a list of strategies (a strategy may apply to multiple objectives). The specific tactics (activities undertaken to fulfill the strategy) are typically included in other documents and will be referenced where applicable. Performance Metrics that can be used to track progress are listed at the end of the chapter along with Action Plans to address the gaps in achieving the desired objectives. The following are ODOT's TSMP specific strategies related to the maintenance objectives:

OBJECTIVE M-1

Maintain traffic signal infrastructure to ensure it operates as designed

- Perform annual preventative maintenance inspections of traffic signal equipment based on the Oregon State Highway Division, Traffic Signal Service Unit, Traffic Signal Inspection Procedural Guide, May 26, 2016.
- Respond to traffic signal maintenance requests based on the guidelines documented in MG-144-02 (Traffic Signal Maintenance Priority memo), effective date 4/14/14.
- Use high resolution data to identify issues remotely rather than in field.
- Use Micromain to log and track maintenance tickets and resolutions.
- Replace traffic signal components based on conditions at inspections and documented in asset management system.

OBJECTIVE M-2

Undertake maintenance in a cost-effective manner

- Use Micromain to log and track maintenance tickets and resolutions.
- Use high resolution data to identify issues remotely rather than in field.
- Use high resolution data to conduct initial assessment of maintenance resources needed to address problem in field.
- Maintain an up-to-date and available asset management database to track equipment failures.
- Maintain an accurate inventory of all pertinent traffic signal equipment, including the detection and timing configuration at each signal (may involve staff from other groups).
- Replace traffic signal components based on conditions at inspection and documented in asset management system.

OBJECTIVE M-3

Reduce time to return intersection after incident or fault

- Use Micromain to log and track maintenance tickets and resolutions.
- Use high resolution data to conduct initial assessment of maintenance resources needed to address problem in field.
- Use high resolution data to identify issues remotely rather than in field.
- Maintain an up-to-date and available asset management database to track equipment failures.
- Maintain an accurate inventory of all pertinent traffic signal equipment, including the detection and timing configuration at each signal (may involve staff from other groups).

6.1 MAINTENANCE METRICS

- Percent of functional detectors
- Number of hours of overtime due to emergency (reactive) maintenance
- Number of hours of preventative maintenance
- Number of signals visited for preventative maintenance
- Ratio of preventative/reactive maintenance
- Response time for emergency maintenance (per priority level)
- Number and type of equipment failures

6.2 MAINTENANCE ACTION PLAN

- Develop Preventive and Emergency Maintenance Plan (traffic signal equipment and communications system) to document procedures and best practices for maintenance of the traffic signal system. Include how to use high-resolution data for maintenance tasks, coordination with operations and ITS staff and response time expectations. Some procedures may vary depending on the region.
- Develop policy for down time of detection and communications during construction (i.e. how long a contractor has to fix/replace damaged detector)
- Develop an evaluation tool to calculate staff (signal timers, electricians, ITS technicians, designers, network technicians, etc.) hours required to operate and maintain each individual signal
- Review Inter-Governmental Agreements related to maintenance of ODOT traffic signals to ensure consistency
- Work with ITS Group to develop common understanding of design and maintenance of communications system
- Develop asset management plan for all pertinent traffic signal equipment, including the detection and timing configuration at each signal
- Develop additional chapters in the ODOT Traffic Signal Management Plan to report out on Management and Administration requirements and Interagency Communication and Collaboration requirements