



Puget Sound Regional Council

## Regional Concept of Transportation Operations: Best Practices

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## 1. INTRODUCTION

The Regional Traffic Operators Committee (RTOC) is a coalition of Central Puget Sound Region city, county and state agencies that was formed to provide regional traffic operations leadership, in response to a Federal Highways Administration (FHWA) study of our region. The RTOC is leading two projects to implement cross-jurisdictional signal coordination and other Intelligent Transportation Systems (ITS) improvements:

- **Regional ITS Implementation Plan (RITSIP):** The RITSIP has identified ITS improvements for 25 key multi-jurisdictional arterial corridors. These 25 corridors were collaboratively selected by the group based upon a number of criteria that assessed the regional significance of over 130 multi-jurisdictional arterials.
- **Regional Concept of Transportation Operations (RCTO):** The RCTO will identify the relationships, procedures, and resource arrangements needed to operate these corridors.

Different from a traditional ITS plan or Concept of Operations, an RCTO documents the identified strategies that a region will implement to accomplish certain objectives and performance measures for a given functional area (i.e., traveler information, incident management, etc). The RTOC has identified regional signal coordination as the functional area of focus.

The RCTO is a relatively new concept, initiated in the past few years as a result of efforts by the FHWA to highlight operations as a key factor of a regional transportation program. The San Francisco Bay Area and the Maricopa (AZ) Association of Governments were the first jurisdictions to develop RCTO frameworks, followed by “pilot” projects in Portland, OR; Detroit, MI; Pima County (Tucson) AZ; and Hampton Roads, VA. In comparison to another regional ITS planning effort, the Regional ITS Architecture, an RCTO is much less structured in that there are no Federal requirements for format or implementation. However, the RCTO can also be quite challenging to develop, as a high level of involvement and buy-off from many different agencies is required for success.

While there are only a handful of completed RCTOs nationwide, there are more examples of regions that have implemented some type of regional signal coordination. The purpose of this technical memorandum is to present some of the elements from these programs that might be most applicable to the Puget Sound Region, i.e., “Best Practices”.

## 2. BEST PRACTICES IN REGIONAL SIGNAL OPERATIONS

Taking a regional approach to signal timing helps to “smooth” the roadway network by coordinating signals across jurisdictional boundaries and providing a more seamless experience for the traveling public. While many regions have recognized the benefits of coordinated signal operations, one size does not fit all when it comes to defining a model for this type of program. However, three general strategies have commonly been used:

- **Time-Based Coordination:** Coordination between two traffic signal systems is achieved by using the same time source, and through the coordination of signal timing plans. For example, Snohomish County and WSDOT have coordinated their signal operations (i.e. common cycle lengths and offsets), but do not have access to each other’s traffic control computer systems. The challenge with this approach is that the

synchronization different system clocks. The agency's system clocks may be set by the IT department, and different "standard" clocks are used. Furthermore, traffic signal system vendors often use different terminology/approaches to establish coordination, making it challenging to compare offsets from different traffic signal systems.

An institutional challenge with this approach is keeping the lines of communication open between agencies so that any updates or changes to the timing plans are developed jointly, or at least communicated. Even small adjustments by one agency can greatly decrease the plan's effectiveness if the other agencies are not informed. When undertaken on a regional basis, timing plan development may be led by a central entity that develops all of the plans for the region's program. This is an approach taken in the Denver region. However the same issues can occur after the plans are turned over to the agencies.

- One Regional System:** While simple in concept, the implementation of a single regional centralized signal system has many implications. Under this concept, the participating agencies in the region agree to implement the same signal control system (same vendor and version). Operators can then have visibility into each others' systems, and may have shared control. This approach avoids the "one clock" synchronization and reference offset issues of time-based coordination, and can also support traffic responsive and traffic adaptive control. Additionally, the procurement of a regional system license can result in an overall cost savings over individual systems. The difficulty lies with the replacement of significant existing system investments, including both hardware and software upgrades as well as operator and technician training. The most significant cost is at the traffic signal controller level and possibility for the communications infrastructure. The Portland, OR area is moving towards this model with the implementation of the TransSuite system by ODOT, City of Portland and surrounding cities. Locally, this approach has been successfully implemented on a smaller scale by King County and partner cities for operation of the Trans-Valley corridor in south King County.
- Center to Center (C2C) Interoperability:** C2C requires an electronic interface built to exchange information between traffic signal systems that are provided by different vendors and otherwise incompatible. The benefit of C2C is that it allows each agency to focus on implementing their preferred system without tying the entire region to a single vendor. C2C requires the cooperation of all of the individual vendors for the development of the interface, and then the interface can require ongoing maintenance when systems are upgraded. The San Jose area has successfully implemented this approach.

## 2.1 Existing Programs

The Puget Sound region is not the first metropolitan area to tackle the challenge of regional signal coordination. Although no other region is an exact "match" for Puget Sound in terms of the issues, challenges and current conditions, these existing programs can offer proof of concept, lessons learned, and strategies for funding and building support from key decision makers.

The following programs were contacted for this memorandum:

- Denver Regional Council of Governments (DRCOG):** DRCOG began the Traffic Signal System Improvement Program (TSSIP) in 1989 with an energy grant that funded one traffic engineer to perform signal timing improvements. The program has since grown to a budget of \$1.5 - \$2 million per year that funds capital and timing

improvements. The program is administered by DRCOG staff with traffic engineering assistance provided by consultants. Funding is from CMAQ funds. The individual projects funded by the program are decided cooperatively by the participating agencies. The projects are undertaken on a corridor basis and primarily use time-of-day and some adaptive control (for single jurisdiction projects) timing. Projects are selected based upon criteria such as base functionality and reliability, improved communications, ADT of the roadway, and relationships to other roadways.

- **Monroe County, NY:** Monroe County operates a regional signal system that includes the City of Rochester and the unincorporated areas of the County. In addition, the county has an MOU with the State of New York, enabling the County to operate state-owned signals in the area. Monroe has been a leader in the use of SYNCHRO modeling and has all signals in the county in a single model. The Regional Transportation Operations Center operated by the County receives notifications from the 911 service and is able to quickly adjust signal timings to control traffic congestion in the case of accidents.
- **Pima Association of Governments, Pima County, AZ:** The City of Tucson operates a Regional Traffic Operations Center, which operates 400 signals within the city limits and is able to monitor 500-600 signals in the entire region for modeling and coordination purposes. The RTOC is also able to monitor a large network of cameras and sensors as well as various devices owned by the State of Arizona along its highway system. The City is the lead agency for signal coordination in the region and works with other agencies on an ad-hoc basis to develop signal timing plans.
- **Southeast Michigan Council of Governments (SEMCOG):** Southeast Michigan is in the beginning stages of implementing an RCTO for traffic signal coordination. Oakland County, part of the Detroit metro area, has led the region in signal timing coordination. Using MOUs with various cities in the county, Oakland County was able to meet its goal of retiming 1000 regional traffic signals in four years and is in the process of expanding its FAST-TRAC (Faster And Safer Travel Through Routing and Advanced Controls) variable signal control program based on the Sydney Coordinated Adaptive Traffic System (SCATS). Other regional activities include the use of a joint traffic signal timing database among multiple counties in the region. The State of Michigan and most of the local agencies use Eagle™ hardware and software products, which somewhat simplifies coordination efforts.

Other organizations researched included:

- **Metro Washington Council of Governments:** In 2002, a group of agencies in the metropolitan Washington, DC region signed an agreement to improve air quality. Each transportation agency uses monies from its own budget for funding traffic signal timing efforts, including coordination with neighboring jurisdictions throughout the region. As there are no physical connections between the various traffic signal systems in the Washington region, synchronization across jurisdictional boundaries is provided by using the same cycle length and appropriate offsets in each jurisdiction, with the reference points of their cycle lengths based on a common time-of-day reference.<sup>1</sup>
- **Maryland Metropolitan Areas:** A Traffic Signal Subcommittee has been established to provide a forum for the region's traffic signal engineers, managers, and field staff to discuss issues of common concern; and Identify and undertake projects that improve

<sup>1</sup> *Case Studies of Regional Traffic Signal Timing Programs*; U.S. Department of Transportation Federal Highway Administration Office of Transportation Management; 2004

the operation and coordination of the region's traffic signals. In addition, the committee has worked for the last two years to put together a Traffic Signal Forum on important issues related to traffic signalization and management. The committee consists of traffic signal engineers/managers from the five jurisdictions (Anne Arundel, Baltimore, Carroll, Harford, and Howard Counties and the Cities of Baltimore and Annapolis); and the State Highway Administration and Federal Highway Administration.

- **Orange County Transportation Authority (OCTA), California:** The OCTA has led a program since the early 1990's that works with Caltrans and local cities to develop traffic signal coordination programs, including a master plan for countywide synchronization. The program leaves it up to partnering agencies to develop signal timing plans for peak periods. OCTA administers funding for select corridors based on criteria related to cost and expected benefits.
- **Silicon Valley Smart Corridor Project:** The Silicon Valley Smart Corridor Project Committee is a public sector consortium including the California Department of Transportation, Santa Clara County, and Cities of Campbell, Los Gatos, Milpitas, Santa Clara and San Jose. Smart Corridors is a multi-jurisdictional information and traffic signal control systems integration project. The Silicon Valley Smart Corridor system architecture is based on a non-proprietary, open, peer to peer concept which allows the following basic capabilities:
  - Existing traffic signal control systems, freeway traffic management systems and advance travel information systems to communication between each other in a unified manner;
  - Common graphical user interface that provides information and control functions of many legacy traffic control systems;
  - Flexible, expandable design allowed deployment with minimum changes/modifications to existing signal control systems.
- **San Bernardino Valley Regional Governments (SANBAG), California:** In September 1999, the SANBAG Board of Directors authorized the development of a strategic plan for interconnecting and coordinating traffic signals in the San Bernardino valley area across jurisdictional boundaries. Long term, the study recommends establishing Traffic Monitoring Centers with Caltrans and the California Highway Patrol to operate and monitor the system throughout the valley. The study objectives included preparing an inventory of existing signals, identifying potential corridors for signal synchronization, evaluating alternative interconnect and signal systems, and recommending an improvement program to coordinate traffic signals on a regional basis. To evaluate and prioritize the most effective system, 14 weighted factors were applied to 75 major streets to identify the highest priority corridors. Of the more than 1,200 existing and proposed near-term signals in the valley, nearly 1,000 were recommended for coordination; approximately 800 of these are on the Congestion Management Program (CMP) network of major streets.

A strategic plan was developed to synchronize these significant arterials. The cost of implementing this system is approximately \$15 million. This cost includes the necessary communication links, computer hardware and software, and development of coordinated signal timing plans.

## 2.2 Best Practices for Multi-Jurisdictional Corridor Operations

“Operations” can have a range of meanings. The FHWA recently asked for a 25 word definition of operations and received several dozen different answers from workshop attendees and experts in the field. When multiple agencies are involved, there are nuances of operations beyond one agency fully designing, timing, implementing and adjusting signals. One agency may have primary operational responsibility, but others may provide data entry or timing plan support, or perform maintenance. For example, the City of Edmonds signals on SR 99 are centrally controlled and operated by the City of Lynnwood, but Edmonds has contributed funds to develop signal timing. Eventually Edmonds may assist with developing the timing plans and could access the central system to change plans when needed.

Key issues to be resolved for multi-jurisdictional corridor operations on a day-to-day basis include:

- Defining the roles and responsibilities of participating agencies
- Establishing a plan for developing, implementing and maintaining signal plans
- Identifying a technical strategy for implementing cross-jurisdictional coordination
- Establishing the physical infrastructure required to support the program
- Ongoing efforts to integrate with regional long-range planning efforts and to continually “keep an eye on the ball” towards implementing the regional operational concept over the long term.

### 2.2.1 ROLES AND RESPONSIBILITIES

As noted above, roles and responsibilities in signal operations can have many nuances. Roles can vary from a central agency operating all signals or creating signal timing plans for other cities in the region, to a level playing field where each jurisdiction operates, times, and maintains its own signals. Some common configurations are:

- **Single Agency Develops Timing Plans:** DRCOG leads signal timing efforts in the Denver area, creating signal timing plans which are reviewed and implemented by various jurisdictions.
- **Single Agency Times and Operates with Input from Partners:** King County operates partner agencies’ signals with their oversight and approval. King County applies the parameters of the partner agencies to the timing plans that the County develops. If for some reason the parameters do not fit within the timing plan, King County will follow up with the agency to jointly identify a workaround. In Pima County, Arizona, the City of Tucson takes the lead on signal timing efforts, timing signals for seven other agencies and creating a regional transportation model used for various improvements.
- **One Operator, One System:** Monroe County, New York is unique among this group in that the metropolitan area is on a single signal timing system operated by the county, allowing for quick implementation of timing changes and a seamless transportation system.

Roles and responsibilities to be assigned in regional signal coordination typically include the following:

- **Timing Plan Development Lead:** Individual organization or group charged with developing and maintaining signal timing plans for the study area. This may be several agencies cooperating to synchronize signals across jurisdictional boundaries, or may be a single regional entity.
- **Lead Operator(s):** Agencies with primary signal control responsibilities, including primary responsibility for implementing timing plan changes in response to changing conditions. May be one or several agencies operating coordinated signals within a given corridor or area.
- **Partner:** Agencies with secondary control to implement timing plan changes (such as during off hours), or agencies who have agreed to turn over operation of some signals to a lead operator under certain conditions.
- **Contract Agency:** Agency that contracts with a lead operator or partner for operation or maintenance of traffic signals in their jurisdiction. A contract agency may perform data collection or otherwise contribute to development of signal timing plans, but does not typically operate signals.
- **Other Stakeholder:** Other stakeholders may include freight, transit and emergency management agencies that may have unique operational needs for signal timing. In some cases, a stakeholder agency may be willing to contribute resources for signal equipment and communications upgrades, such as when needed to accommodate transit signal priority equipment.
- **Facilitator:** MPO or other regional group that facilitates the regional signal coordination program, including funding and program management.

The roles and responsibilities of each participating agency, and an individual identified as the primary contact, should be documented in a Memorandum of Agreement. Agreements are discussed in more detail in Section 2.5.5.

### 2.2.2 SIGNAL TIMING APPROACHES

Traffic control system options range from individual isolated signals to fully actuated systems that adjust timing based on predicted traffic flow. A time-based system sets pre-determined signal timing programs based on previously collected traffic data and forecasts. Various time-of-day programs can be used for peak-hour traffic and off-peak conditions, and signals are generally coordinated between systems using time synchronization. Traffic responsive systems can adjust signal timing according to real-time traffic volume data, but are difficult to synchronize with other systems and require accurate traffic-counting instrumentation.

Oakland County in southeast Michigan uses an adaptive traffic control system based on SCATS (Sydney Coordinated Adaptive Traffic System), which adjusts timings system-wide based on traffic volumes and speeds. Monroe County operates a Sperry adaptive signal control system, which controls signals for the entire county and negates the need for coordination between multiple systems.

Tucson, Montgomery County, and DRCOG all use time-based signaling plans and synchronize timing plans between agencies using the WWV atomic clock time broadcast. Monroe County and Tucson both base their signal timing plans on region-wide SYNCHRO models. Each has various time-of-day plans as well as special event plans that can be implemented for parades or expected surges in traffic.

In the Puget Sound region, a few agencies including Bellevue and Kent have implemented traffic responsive control. A few others, including Renton and Lynnwood, use traffic adjusted or actuated control. Most of the signals along the ITS Plan key corridors are interconnected within jurisdictional boundaries and are running time-of-day plans. The challenge lies with developing coordinated timing plans across borders. The next task of the RCTO will seek to identify regional signal timing guidelines for cross-jurisdictional coordination.

### 2.2.3 REGIONAL CONNECTIVITY

There are essentially two elements to regional connectivity. First, the physical communications infrastructure is required to interconnect signals and ITS field devices for monitoring and control via a traffic management center. This provides local connectivity. Regional connectivity requires the second element, which is a connection between centers that allows for the sharing of device data and video images from across the region. In looking at other regions, there is a variety of communications infrastructure in use:

- Tucson, which uses time-based signal coordination, uses leased phone lines to receive data and video feeds and is hoping to build its own fiber-optic infrastructure in the near future.
- Monroe County's system is connected through coaxial cable.
- Systems in the Denver region are not physically interconnected, but DRCOG is working toward center-to-center connectivity to allow various systems to communicate directly. DRCOG is currently looking at a pilot center-to-center project that would include video and data sharing over a secured website.

While broadband communications infrastructure is expensive to design and construct, many jurisdictions in the region have made significant headway and region overall is quite advanced in this area. WSDOT has a robust freeway fiber network, and many local traffic agencies have at least some fiber infrastructure. WSDOT is currently leading an initiative called Traffic Busters that will provide a video and data sharing connection between 22 regional traffic management centers. However, while Traffic Busters will provide the "pipe", the region is still lacking in a strategy for connecting the many traffic signal control systems currently in use.

Ultimately, signal coordination and ITS connectivity overall is desired through a Center-to-Center (C2C) network of systems. Each agency's systems would be interconnected through C2C Standards allowing interoperability and information sharing amongst select partners. There is limited experience deploying such systems, but the beginnings of implementations are underway in Los Angeles County, California. The successful Smart Corridors project involved the development of a data exchange network server component and corridor-wide display/graphic user interface component accessible by all project partners.

Implementation of a C2C system network could follow a stepped process by providing signal coordination in levels of deployment as follows:

- Level 1: Identify key corridors, establish necessary agreements (i.e. Memorandums of Understanding, regional signal coordination parameters), and get basic communications up to speed for support of time-based coordination.
- Level 2: Along select corridor(s), coordinate traffic signals to run as one system from the public's perspective. This approach may make use of time-based coordination combined with "shared" system monitoring between agencies, or if more cost efficient

and beneficial to the traffic agencies, the corridor may be operated by a single agency. Communications is upgraded to support broadband between the field equipment and the central traffic signal system, and between the traffic agencies (if necessary).

- Level 3: Push Out/Publish Data: Establish regional data dictionary and data warehouse, to firstly publish and maintain signal timing plans between the various traffic agencies, second to alert the various traffic agencies of on-street events (i.e. incidents, system faults, etc), and third to provide public information (i.e. current roadway conditions).
- Level 4: Design, procure, implement and maintain a C2C interface between diverse systems for coordinated daily traffic operations and event management.

#### 2.2.4 INTER- AND INTRA- AGENCY COMMUNICATIONS

Inter- and intra- agency communications are exchanges of information between (inter) and within (intra) agencies. Communications between agencies can be formal or informal; in most cases a formal framework for interagency communications is absent and communications are conducted in an informal, ad-hoc basis by phone, email, or in person. While communications may take many forms, in the realm of regional signal coordination, notification of changes to signal timing plans, equipment changes, and other operational notifications are key. Some examples in other jurisdictions are the Traffic Signal Committee in Maryland, which has established standard operating procedures including a notification process. The County of Los Angeles developed a template for agreements/MOUs that are recommended for use by its partnering agencies.

The RTOC has noted a need for contact information posted at TMCs and in multi-agency signal cabinets, listing who owns/operates/maintains the signal and who to contact if any changes are made. While the RTOC members know each other well, not all of the TMC operators and signal technicians know their counterparts at other agencies. Maintenance activities such as changing out a controller can impact the timing, and engineers may not be notified. Contacts may be listed in an MOA that newer employees are not aware of. Also, it is common for citizens to not know who the operating agency is for a given signal and voice a concern to the wrong agency. Agencies will forward the correspondence to the appropriate agency, if they have a contact – but again, this is dependent on knowing who to contact. Other cities have established 3-1-1 phone numbers for one-stop non-emergency government service assistance, including citizen reporting of traffic signal outages and other transportation concerns. 3-1-1 is not currently supported by any Puget Sound jurisdictions, although a dedicated phone line could be established and promoted to the public specifically for reporting traffic operations concerns.

The group has indicated that implementing the following practices regionally would improve communications:

- Establish standard operating procedures for a communications chain for any changes that could affect signal timing: maintenance technicians to notify engineers, who notify partner agencies.
- Develop an electronic library of agreements and contact information accessible to all agencies.

## 2.3 Best Practices for Off-Hour Operations

Currently, none of the agencies in the region have 24-hour arterial operations staff. WSDOT currently has 24-hour ITS operations, with Radio staff responding to freeway incidents and notifying

travelers via DMS and HAR. For local agencies, 24-hour coverage is generally not cost effective. Most local TMCs are only staffed during extended business hours that cover the peak periods although a traffic engineer or technician may be on 24-hour call.

While it is a fairly common practice for several regional agencies to co-locate operations, it is less common for agencies to provide coverage for others during off-hours if not co-located. In Puget Sound, the Traffic Busters program could potentially provide the connectivity needed to remotely monitor and operate another agency's signal system. Issues to be resolved would include ensuring that the off-hours operator was familiar with the other agency's system and that an agreement was established regarding operational parameters and potentially compensation.

Regional coalitions may provide the best opportunity to support regional operations on a 24-hour basis. The Niagara Frontier region of New York and the Niagara region of Ontario, Canada developed a coalition consortium of 14 agencies, authorities and municipalities covering both regions through an MOU to work towards improving regional mobility. The coalition provides its members a 24/7 Traffic Operations Center staffed by the coalition who operate selected ITS devices, disseminate information to the public and the member agencies, and provide call-out services for incident response and ITS maintenance. In California, Caltrans operates multiple 24-hour TMCs. The Bay Area's Center-to-Center (C2C) Program will enable the real-time exchange of traffic data and video between three existing ITS Smart Corridors and the Regional TMC that includes the Caltrans TMC and the 511 Traveler Information Center.

### 2.3.1 COVERAGE STRATEGIES

During hours when traffic operations centers are not fully staffed, agencies have various methods of covering operations, including fault detection with paging features or employing a staff member to monitor the system and address any issues as they occur. The Monroe County Regional Traffic Operations Center operates 24 hours a day and is able to monitor sensor and video information from roads in the region and send notification to on-call engineers who can address any urgent technical or traffic issues.

A demonstrated approach is to apportion resources from a pool to cover off-hours incidents and maintenance:

- DRCOG is working towards 24 hour incident monitoring through the Colorado DOT traffic management center (TMC). The TMC has a phone list of other agencies to contact in case of an incident.
- The new Michigan DOT TMC will have 24-hour operation using a consultant. A planned web-based freeway operations system will allow others to view cameras and conditions, and may enable integration and remote access to local systems.
- WSDOT has agreements that allow them to make changes to signal timings after hours in response to an incident or citizen concern. They immediately notify the partner agency if any changes are made.
- For equipment malfunctions, Tucson has a "page-out" feature that activates when signals go out, and the agency responsible for maintenance of those signals is called in to repair or adjust equipment. Many advanced signal systems today have alarm capabilities in case of malfunctions that can be programmed to page on-call staff for incident response.

## 2.4 Best Practices for Incident Management

Incidents can include traffic accidents, malfunctioning equipment, and natural hazards such as land slides and snow storms. Effective coordination between agencies can allow for quick responses to such incidents to reduce congestion and prevent any further complications.

### 2.4.1 DETECTION, NOTIFICATION AND RESPONSE COORDINATION

Incident management programs require a process for detecting incidents, notification of appropriate responders, the actual response activities, and clearance of the incident and associated impacts.

- **Receive 911 Notifications at TMC:** Monroe County is a responder for 911 and is able to adjust signal timing to provide capacity on alternate routes or to speed traffic through intersections. For instance, during a recent highway accident, the city was able to quickly adjust signals on parallel surface routes to allow traffic to bypass the incident. Monroe County also has roughly 70 intersection cameras in place and is steadily expanding its system. In addition, due to its single central system, Monroe has the state to coordinate with for necessary signal timing changes.
- **Implement Regional Incident Management Plan:** The Ada County Highway District (Boise Region) prepared an Incident Management Plan involving multiple regional highway and emergency responder agencies to detail information for handling incidents along various road segments. Information includes:
  - Emergency contact phone numbers
  - Standby equipment
  - Traveler information options for message signs
  - Anticipated incident impacts
  - Available ITS devices listed on plans
  - Analysis of diversion routes
- **Implement Diversion Routing Plan:** The Oregon DOT and the City of Portland coordinated efforts to effectively integrate freeway management systems with arterial systems. An Incident Management Plan was developed to route traffic efficiently away from an incident and then return back to the freeway. The plan identifies roles/responsibilities, plans and strategies, contact names, available field devices, and trigger points for actions.

A key factor in the success of any incident management plan is the operational support required to implement the plan. If designated contacts are not kept up to date or are not available to answer their phones when the incident occurs, the planned response cannot be realized.

## 2.5 Best Practices for Program Management

### 2.5.1 PERFORMANCE MEASURES AND BEFORE/AFTER ANALYSIS

Measuring the performance of signal coordination efforts allows agencies to determine the impact of improvements undertaken, which types of projects have been most cost-effective, and to evaluate which projects might be worthwhile in the future. Performance measures are also important in keeping agencies accountable to their funding sources and providing demonstrable results to the public and elected officials. While nationally the most common performance measure is citizen feedback due to the high operational cost of collecting and analyzing data, the implementation of a formal performance monitoring effort is key to a long-term successful program.

- **Identify and Utilize Traffic Data Sources for Performance Measure Analysis:** There is a significant amount of near-real-time freeway data collected by WSDOT in the region, but significantly less for arterials. Near-real-time traffic data is helpful in validating software model results, permitting fine-tuning for future use as well as for “powering” decision support and performance monitoring tools. The Performance Measure System (PeMS) project collects historical and real-time freeway data from freeways across California in order to compute freeway performance measures. The graphical user interface displays flow maps and a “dashboard” of performance measures, tabular and raw data available with user ID.<sup>2</sup>
- **Identify and Commit to Regional Performance Measures:** DRCOG recently completed a state-of-the-practice analysis of performance measures, with the next steps of design, construction and evaluation of technologies to collect data for the identified performance measures. For the pilot program, DRCOG and its partner agencies will focus on the performance measures of queue lengths, corridor travel times, and traffic volumes. It was felt that these measures provide value to three core user groups: signal system operators, the public and elected officials.<sup>3</sup>
- **Make Performance Reporting a Priority:** In the Denver Region, DRCOG’s releases a yearly report of travel, fuel, and user savings from various new projects. These reports are available to the public at <http://www.drcog.org/index.cfm?page=TrafficSignalProgram>. SEMCOG also reported that before and after travel time runs were performed for their 1000 signal retiming project. The results were extrapolated to calculate annual time and fuel savings. The availability of near-real-time data from field devices provides a source for both periodic programmatic performance analysis while also providing support for operator decision making and communicating conditions information to the public.
- **Use Asset Management Tools to Track Progress:** SEMCOG is implementing a traffic signal inventory database that will keep track of all of the region’s signals, including the make/model, operating characteristics (coordinated, centrally controlled, etc.) and the date of the most recent retiming. This tool will improve progress reporting and monitoring of the signal timing program.

In their Peer Exchange meeting with the RTOC, DRCOG emphasized heavily the importance of performing before/after analysis of traffic coordination projects. Documenting the results of these projects helps DRCOG to demonstrate the need for continued program funding, as well as provides a resource for identifying the most effective improvements.

## 2.5.2 TRAINING

Training may be required for agency staff in the implementation and support of coordinated signal timing plans. Training opportunities are generally found through courses that are supported by the FHWA, ITE and other transportation organizations, and academic institutions. Some agencies may retain a consultant to produce a handbook or guidelines to assist agencies too.

- **Share Knowledge:** In the Los Angeles region, the Los Angeles County provides specific training for partnering agencies on many subjects, including signal timing plan optimization and operations/maintenance support of systems. As part of the ITS Survey that was completed by the RTOC members, training needs and “special skills” were identified by each agency.

<sup>2</sup> Source: <http://pems.eecs.berkeley.edu/?dnode=State>

<sup>3</sup> Source: *Performance Measures for Traffic Signal Operations Final Report*, prepared by Felsburg Holt & Ullevig for Denver Regional Council of Governments; November 2008.

### 2.5.3 ADVOCACY

Effective signal coordination efforts often come about through the advocacy efforts of a lead agency. The presence of an effective advocate can help in securing funding, increasing public support, and gaining the cooperation of various local agencies.

- **Designate program ambassadors:** Having a single agency (Tucson DOT) advocating for funding and coordination has been useful in encouraging cooperation between agencies in Pima County.
- **Be able to explain the benefits of the program in simple language:** As a public outreach effort, DRCOG released a brochure entitled “Why Is the Signal Always Red?” which is intended to educate the public on the basics – and importance – of traffic signal timing.
- **Be visible:** In Springfield, MO a video about the Traffic Management Center was shown on the city’s public access television. The results of travel time studies were also disseminated to the public to show that even though traffic volumes have increased over time, travel times have remained constant. The TMC is located in a public facility, which allows any member of the public a view of traffic management in action. Presentations at city council meetings help build political support.<sup>4</sup>

### 2.5.4 PROJECT PRIORITIZATION AND FUNDING

Effective methods of prioritization can help focus efforts on the most urgent and/or cost-effective signal coordination projects. This can also help in securing Federal funding for capital investments.

A number of funding sources are available. In addition to local funding, the federal government makes money available through the Surface Transportation Program (STP) and CMAQ (Congestion Mitigation and Air Quality) programs.

The STP provides flexible funding that may be used by States and localities for project on any Federal-aid highway, including the NHS, and transit capital projects. The CMAQ program provides funding for projects and programs in air quality non-attainment and maintenance areas for ozone, carbon monoxide (CO), and particulate matter which reduce transportation emissions. The STP program has more total funding and CMAQ may have more onerous requirements to satisfy air quality concerns, although CMAQ funding has been used in many regions for signal timing projects. However, the CMAQ program may also fund 100% costs for signal timing projects, where STP is hard to obtain greater than 80% federal support. The use of either funding though will greatly depend upon the regional MPO. Other agencies have successfully applied the following practices:

#### **Use a Regional Model to Set Priorities**

- Southeast Michigan applies a set of “operational factors” to its regional SYNCHRO model to determine corridors needing retiming. SEMCOG performs the project prioritization.
- Like Southeast Michigan, DRCOG uses its regional SYNCHRO model to prioritize corridors for optimization.

#### **Obtain a Dedicated Pool of Funds**

<sup>4</sup> Source: *Case Studies of Regional Traffic Signal Timing Programs*; prepared by Science Applications International Corporation (SAIC) for the Federal Highway Administration; 2004

- Orange County Transportation Authority; San Bernardino Valley Regional Governments (SANBAG); Los Angeles County MTA; Maricopa Association of Governments (Phoenix area); Southwestern Pennsylvania Commission (Pittsburgh area) all have dedicated funding sources for their programs.
- DRCOG's \$3 million program is fully funded by CMAQ, which gives it leverage with local agencies and has helped to encourage cooperation. Funding for traffic signal timing and coordination in Southeast Michigan is also 100 percent CMAQ funds.

#### 2.5.5 AGREEMENTS

Depending on the region and specific situations, agencies may use formal (such as MOUs) or informal "handshake" agreements when coordinating signal timing. While formal agreements can help to solidify relationships and keep agencies accountable to one another, informal agreements can allow for quick decisions and greater flexibility when implementing projects.

Interagency agreements vary considerably between programs. Monroe County has an MOU with the State of New York that allows the county to create signal timing plans for state highways in the region. Tucson, Denver, and Montgomery County all use informal agreements between agencies for signal timing efforts, and all three have found this method to be sufficient. In addition, Tucson operates and maintains the regional transportation model at no cost to other agencies.

Part of the agreement should include frequent contacts and follow-up to ensure that timing plans are closely monitored and adjusted with consensus. Plans should be developed for flexibility so that small adjustments can be accommodated. The agreement should state performance goals and a commitment to and process for performance reporting against stated goals.

The RTOC has indicated that formal agreements are generally preferred, especially in terms of building support from the decision makers who must sign the agreements.

#### 2.5.6 ROADBLOCKS

Limited funding and communication issues have generally been the main roadblocks to implementing the ideal system in various regions. There are a variety of roadblocks that may delay or halt signal timing coordination projects. These can be of a technical nature or non-technical, institutional issues.

The technical roadblocks generally relate to equipment or systems that do not provide required functionality or compatibility. Fortunately, there are many options to resolving these issues problems, since single system integration is not the only solution to implementing coordinated signal timing plans. Emerging standards will provided some promise of interoperability between different vendors. Coordination between different systems or incompatible controllers can be accomplished through a common time source. However, the combined financial clout of the many signal system customers in the region should not be overlooked in regards to influence that the region as a whole could have in requiring interoperability from system vendors. For example, jurisdictions could jointly adopt procurement language requiring demonstrated interoperability with neighboring systems as a condition of purchase.

The non-technical roadblocks can be resolved, but require at a minimum a willingness to engage in cooperation and open communications to accomplish signal coordination across jurisdictional boundaries, as well as buy-in from decision makers and elected officials. Political concerns that are raised by elected leaders and constituents (for example, local residents do not want freeway traffic routed through city streets) can derail a project. These are best addressed by being prepared to

explain the benefits and outcomes of the project, such as how the adverse impacts of such an incident are reduced by managing the traffic in a more controlled manner. Using softer terms like alternate routes instead of detours may be more palatable for some constituents, as experience has found not all freeway traffic will divert upon receiving such advisory information.

Funding availability is also seen as a common institutional roadblock. Signal coordination projects can compete very well for competitive highway funding, as most experiences have resulted in benefit-cost ratios of over 10:1. However, there must be an awareness of such benefits to open up funding opportunities. Regional programs with dedicated funding for such projects provide the best opportunity for funding.

## 2.6 Best Practices for Stakeholder Coordination

### 2.6.1 TRANSIT SIGNAL PRIORITY

The ability to time traffic signal phases to favor public transit vehicles can help improve passenger flow by providing higher average speeds to the vehicles with the highest capacity. This can be accomplished by using a vehicle-mounted transponder which requests signal priority at the approaching intersection and can be useful in either an exclusive right-of-way, such as a bus rapid transit line or light rail line, or in shared lanes used by conventional buses or streetcars.

- **TSP should be a cooperative effort between traffic and transit:** Such projects have been successfully implemented in the Portland, Oregon area, Los Angeles and Arlington County Virginia with favorable results. Each project has been unique in its level of system integration, but involved participation from both transit and highway based agencies.

King County Metro's successful TSP program involves very close coordination with local traffic agencies.

### 2.6.2 EMERGENCY MANAGEMENT

Effective traffic signal coordination can result in improved ability to manage emergencies. Traffic Operations Centers are able to change signal timing on surface roads in order to manage traffic flows in the event of a major accident or other emergency which affects the capacity of a highway or roadway. This can also help to provide information and prioritized access to emergency responders using pre-set emergency signal plans and signal preemption.

- **Establish Traffic and Emergency Data Sharing:** Monroe County is a responder for 911 and can adjust signal timing and coordinate emergency responses based on camera and sensor data. Tucson also receives feeds from 911 and State highway equipment, allowing a similar response.
- **Establish Operating Agreements with Responders:** WSDOT has a joint operations policy statement (JOPS) with the Washington State Patrol for cooperative operations to improve incident clearance times, share roadway surveillance and incident data, and improve safety in work zones, ferries and for freight.

### 2.6.3 FREIGHT

Cooperation with freight carriers can help to improve flow of freight along arterial roads, helping to improve both economic activity and air quality by reducing idling and congestion.

- **Adjust signal timing to improve freight safety:** Vancouver, Washington is in the process of improving a major freight corridor in the Port of Vancouver in order to accommodate the transfer of long wind towers from cargo ships to regional highways. This effort includes timing traffic signals at two busy intersections to prevent the towers from blocking traffic during a green cycle, as well as creating an entire lane without vertical obstructions.
- **Consider Freight ITS Improvements:** The Miami-Dade MPO developed a Freight Plan to address the region's freight mobility needs. The plan identified a list of project recommendations to support the program's goals. The projects included several traffic signal operational improvements and other related ITS elements. Signal timing improvements along key arterials to improve the flow of trucks across jurisdictional boundaries was a key element of the plan. A single county-wide signal system helps support the proposed operational changes.

### 3. STRATEGIES FOR PUGET SOUND REGION

In order to develop a strategic RCTO that supports regional signal operations, all affected agencies must share a common vision with goals and objectives. Before the strategies can be implemented, a Concept of Operations must be established that can support the final plan.

#### 3.1 Concept of Operations

A concept of operations establishes the roles and responsibilities between organizations including responsibilities for operations and maintenance of equipment, and also the levels of electronic information and device control sharing among the entities. Essentially, the concept of operations defines what information is electronically gathered and manipulated by which agency, and how it is shared with other agencies to the benefit of all. Because the concept of operations defines information sharing links between agencies, it is also a starting point for defining ITS communications requirements, for example, more bandwidth will be required to link two agencies that wish to send streaming video to each other, compared to two agencies who simply wish to share signal timing plan data.

It is recognized that relationships between agencies embody two main components: 1) what roles and responsibilities does each agency play in the relationship, and 2) what kinds of information are shared. Seven types of roles or responsibilities are used to describe agency-to-agency relationships. They are listed as follows from lowest to highest level of interaction:

- **Consultation:** One party confers with another party, in accordance with an established process, about an anticipated action and then keeps that party informed about actions taken.
- **Cooperation:** The parties involved in carrying out the planning and/or project development processes work together to achieve a common goal or objective.
- **Coordination:** The comparison of the transportation plans, programs, and schedules of one agency with related plans, programs, and schedules of other agencies and adjustment of plans, programs and schedules to achieve general consistency.
- **Information Sharing:** The electronic exchange of data, and device status information between parties, for the purpose of coordinated responses, decision support, planning, and analysis.

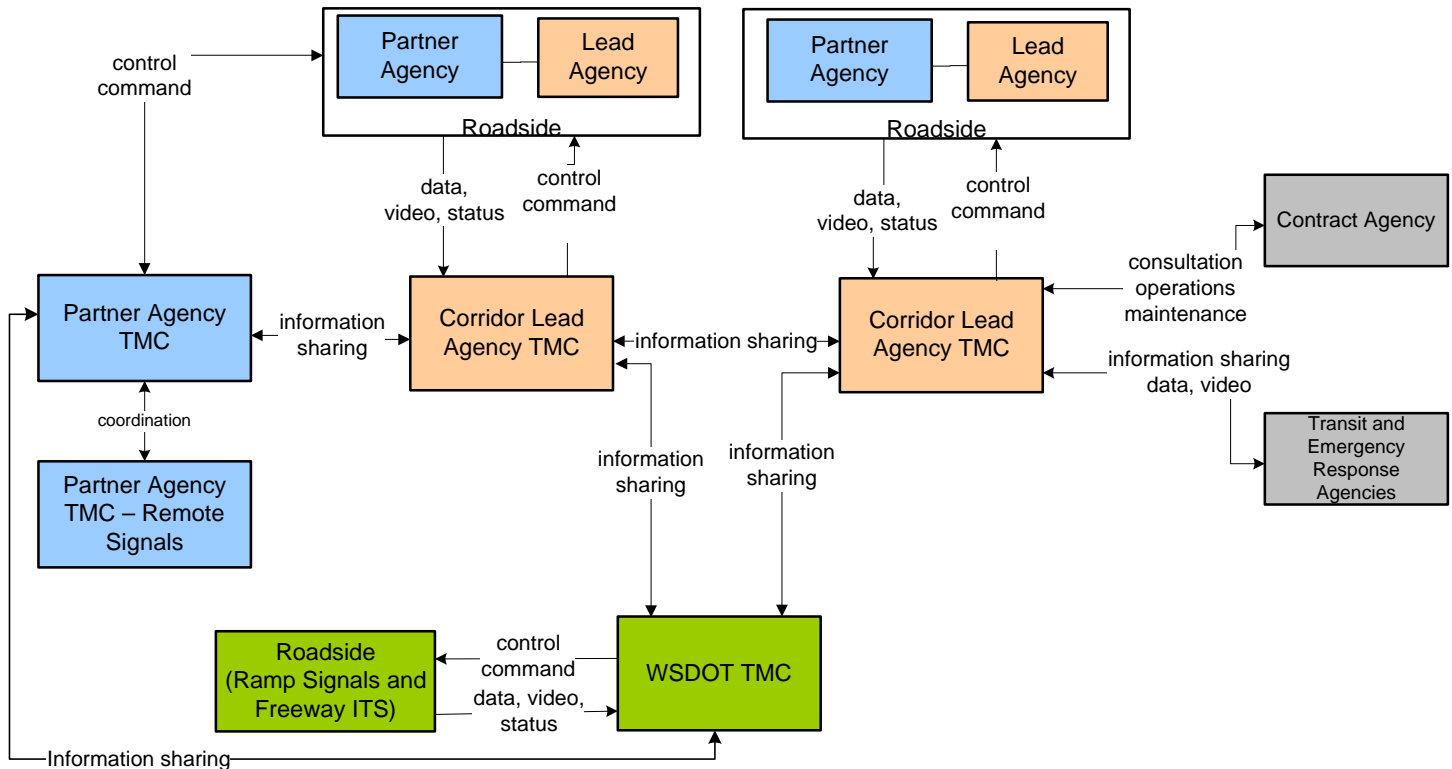
- **Control Sharing:** The ability, through operational agreements, to allow for one party to control another party's field devices to properly respond to incident, event, weather, or traffic conditions.
- **Operations:** One party fully operates field equipment of a second party, typically because the second party does not have this capability and contracts for the service.
- **Maintenance:** One party maintains the field equipment of a second party.

Along with these seven roles and responsibilities are associated information types that are typical for agency-agency exchange. Five primary types of electronic information exchanges were identified:

- **Video:** The dissemination of live video and still images from one party's field cameras to another party.
- **Data:** The dissemination of data from one party to another party. Data can include, but is not limited to, traffic data, weather data, parking data, transit data, etc., and along with video, provides key information that is needed to support operational decision making.
- **Command:** The ability for one party to control field devices. Command can include, but is not limited to, changing DMS messaging, changing traffic signal timings, camera control, etc.
- **Request:** The ability for one party to solicit either data, or request a change, such a DMS messaging or signal timings, from another party.
- **Status:** The ability for one party to monitor field devices, and receive such information as current signal timing/response plan, current message sets, etc.

The following is the suggested concept for multi-jurisdictional corridor operations in the Puget Sound region:

Puget Sound Regional Council  
 REGIONAL CONCEPT OF TRANSPORTATION OPERATIONS:  
 BEST PRACTICES



**Figure 1: Regional Signal Coordination Concept**

The concept identifies a lead agency, partner agencies and contract agencies. The lead agency would typically be the agency with the most signals on the corridor. The lead agency would develop daily and incident timing plans using global parameters that were agreed to by all parties. Partner and contract agencies would provide data collection and performance analysis support. While ideally all of the corridor’s signals would be on a single system and operated by the lead agency, a partner agency may still operate the signals along a segment of the corridor and coordinate with the lead agency. There will likely be multiple “lead agencies” across the region depending on the geographic basis of the projects being implemented. Information sharing links between the various TMCs and WSDOT could be provided by Traffic Busters.

To summarize, the following roles and responsibilities would be established:

- **Corridor Lead Agency:** Primary role in operating corridor, including developing and implementing signal timing plans with input from partners; day-to-day operations; before and after analysis; and responding to inquiries from the public.
- **Partner Agency:** The partner agency would continue to operate signals that are not centrally controlled or that are spaced at such a distance from other corridor signals that there is not a need for coordination. The partner agency would still have the ability to control signals their signals that are operated by the lead agency.
- **WSDOT:** WSDOT will continue to operate its freeway ramp signals, but may consider converting their controllers to another model that can be operated by a local agency, as long as WSDOT can continue to monitor the signals without the addition of multiple

workstations. WSDOT may take the role of the lead agency or a partner agency, but is shown separately in the diagram because of its unique position in the region.

- **Contract Agency:** The contract agency is one that does not operate signals and instead contracts with a lead agency for these services. The contract agency may provide data collection or other input for decision support and the development of timing plans.
- **Transit and/or Emergency Response:** Transit and emergency response agencies are often interested in access to data and video. Travel time and traffic count data can be of particular interest for transit service planning. These agencies may also have data that is of interest to traffic agencies.
- **Roadside:** “Roadside” is a general term to denote field ITS devices, including signals, cameras, message signs, etc., that comes from the National ITS Architecture. Agencies may have varying levels of access and control to roadside devices depending upon the corridor operating agreement.

## 3.2 Strategies

The RTOC has identified 25 key corridors for development. ITS, communications, and signal timing improvements will be identified for each of these corridors. However, there are many, many more multi-jurisdictional arterial corridors in the region. Beyond the capital improvements identified for the RITISP, the question remains how regional corridors should be operated.

Through conversations with the RTOC Operations Subcommittee, the following strategies have been identified for moving forward with coordinated signal and ITS operations.

- **Promote Full Corridor Communications:** Corridor improvement projects should be constructed for interconnectivity and to enable remote operation by any agency along the corridor – specifically, allowance for broadband communications along the entire corridor needs to be included in each project. The ITS Plan projects will identify “gaps” in communications and for other roadway improvement projects such as widening, etc, traffic engineers should encourage that fiber infrastructure automatically be included if not already existing.
- **Develop Operating Plan for Corridor:** Multi-jurisdictional signal coordination projects undertaken by RTOC members should identify by segment, which signals that will work together on the same control system, which will be coordinated using time-based coordination, and which can remain independent due to distance. Long corridors may be split into multiple segments based upon travel patterns and operational capabilities.
- **Provide All-Agency Camera Access:** Corridor traffic camera access will be provided to agencies as needed to support operations.
- **Keep the Lines Open:** To ensure effective communications, each agency should establish a “communications tree” and contact list so that everyone knows who to contact at partner agencies. All agreements and contact lists would be posted to an electronic library for access by all parties.
- **Data Collection and Documentation:** Projects implemented under the banner of Regional ITS or Regional Signal Coordination should plan and budget for before-and-after analysis of the project outcomes. Projects may seek additional operations funding

to ensure adequate staffing to perform the required data collection and performance analysis.

These strategies are being incorporated into the ITS Plan project descriptions and cost estimates.

The following are other potential initiatives for the RTOC group to undertake:

- **Regional C2C Strategy:** Several agencies, including WSDOT, are looking at upgrading/replacing signal systems in the near future. As a group, the RTOC has much more leverage with vendors to make interoperability a priority in the region. Cooperatively developing requirements for new systems to interface with others in the region and including this language as part of system procurements could begin to set C2C in motion. A first implementation of C2C will soon be underway between WSDOT and the City of Seattle as part of the SODO Integrated Corridor Management effort.
- **Regional Decision Support System:** A regional decision support system would utilize traffic data collected from field devices to provide intelligent decision support to operators, and would be a means of maximizing the usefulness of the available data. A regional decision support system could be a next step after successfully implementing some level of regional data sharing. The support system could provide the statistical data analysis to help the RTOC and PSRC with project prioritization, performance measurement, and before/after project analysis.
- **Incorporation of Operations in Long Term Planning:** Operations is often overlooked in long-term planning and budgeting efforts, including staff training and growth, equipment replacement and projects to support the regional strategy. While this may require a shift in the conventional capital improvement focus, operations should be incorporated into local and regional long-term transportation plans.
- **Dedicated Funding:** There is currently no secured funding source for regional signal coordination and/or the ITS corridor projects. Other agencies have found that the only way to sustain an ongoing timing improvement program is through dedicated funding via the regional Metropolitan Planning Organization (MPO). To secure the future of the program, the RTOC would need to work with PSRC to identify a strategy for long term funding and project prioritization.
- **Outreach and Advocacy:** The RTOC group has taken advantage of several opportunities to present the group's activities to local and national groups. However, individual participants should seek opportunities to "make the case" for signal improvement and ITS projects to their city councils and other elected officials, particularly in the context of how regional projects also have many local benefits.
- **Resource Sharing:** Through the communications portal opened by Traffic Busters, there may be opportunities to foster TMC resource-sharing during off hours, where partner agencies may agree to pool resources for the purpose of offering extended hours of operation.