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TABLE OF CONTENTS

APPENDICES

List of Tables

List of Figures

PREFACE

P.1 INTRODUCTION

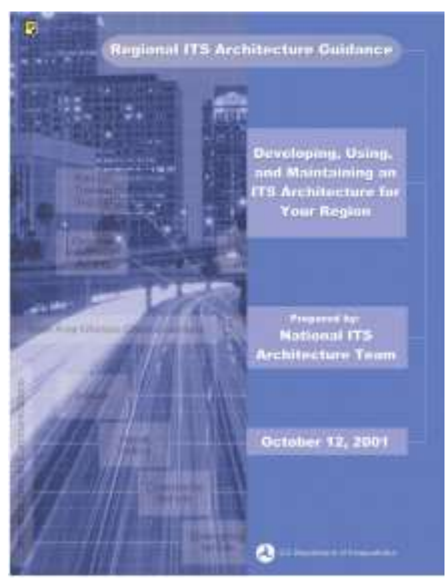
The *Salem-Keizer Intelligent Transportation System (ITS) Plan* was collectively developed by the Oregon Department of Transportation (ODOT), the City of Salem, the City of Keizer, Marion County, Polk County, the Mid Willamette Valley Council of Governments (MWVCOG), the Willamette Valley Communication Center (WVCC) and the Federal Highway Administration (FHWA). The outcome is a 20-year deployment plan of ITS projects, which includes advanced technologies and management techniques, aimed to improve the safety and efficiency of the transportation system and to improve the driving experience for travelers in the Salem-Keizer Metropolitan Area. This effort is consistent with plans put together in other regions statewide to ensure that ITS strategies used are integrated and complementary. An Executive Summary provides an overview of the plan and this Final Report includes the following detailed chapters that outline all of the steps involved in the development of this plan:

- Chapter 1: Current and Future Transportation Conditions
- Chapter 2: User Needs Assessment
- Chapter 3: Regional ITS Architecture
- Chapter 4: Operational Concept
- Chapter 5: Communication Requirements
- Chapter 6: Deployment Plan

A glossary of acronyms and a list of references used throughout the report can be found in Appendix A and B, respectively.

P.2 FHWA COMPLIANCE

In order to obtain funding for ITS projects through the Highway Trust Fund, the Federal Highway Administration (FHWA) requires those projects shall be in conformance with the National ITS Architecture by April 2005[1]. Table P-1 includes an itemized list of the FHWA criteria for developing a regional architecture and the part of the plan or plan process that complies with each criterion. The FHWA also requires that all ITS projects implemented shall adhere to the regional architecture and that the regional architecture be updated when the final design of a project varies from the regional architecture. The next section describes the ITS Plan and Regional Architecture maintenance.



[1] Title 23, Code of Federal Regulations (CFR), Highways, Chapter 1: Federal Highway Administration, Department of Transportation, Part 940: Intelligent Transportation System Architecture and Standards.

Table P-1 Salem-Keizer ITS Plan Compliance with FHWA Criteria

FHWA Criteria	ITS Plan Compliance
Architecture Scope and Region Description	✦ Chapter 1 defines the region geographically as having the same boundaries as the Mid Willamette Valley Council of Governments (See Figure 1-1) ✦ A 20-Year planning horizon was used as defined in Chapter 6. ✦ Chapter 3 describes the scope of the regional architecture.
Stakeholder Identification	✦ Chapter 2 provides a summary of the various regional key and expanded stakeholders. These stakeholders were linked to their associated ITS inventory elements in Turbo Architecture as described in Chapter 3.
System Inventory	✦ Chapter 1 describes the system inventory, which was used as input into Turbo Architecture in Chapter 3. Appendix G includes the Inventory Report from Turbo Architecture.
Needs and Services	✦ Regional user needs are documented in Chapter 2 and are mapped to the appropriate user services in Chapter 3.
Operational Concept	✦ Chapter 4 provides an operational concept that outlines stakeholder roles and responsibilities by program area.
Functional Requirements	✦ Functional requirements for the first five-year projects have been summarized in the detailed project descriptions in Chapter 6.
Interfaces/Information Flows	✦ Interfaces have been selected between subsystems and correlating architecture flows as part of the custom Turbo Architecture database in Chapter 3. Appendix H includes a detailed list of the flows. ✦ Information flows are defined in Chapter 4. ✦ Key stakeholders reviewed all interfaces and information flows.
Project Sequencing	✦ Chapter 6 identifies a project sequencing schedule, which is divided into a 5-Year Plan, 10-Year Plan, and 20-Year Plan. ✦ Additional details are provided in Chapter 6 about the major projects that fall within the 5-Year Plan.
Agreements	✦ Chapter 1 outlines existing operational agreements between agencies. ✦ Chapter 4 suggests additional potential agreements.
Standards Identification	✦ ITS standards, including identification of standards potentially relevant to the Salem-Keizer Metropolitan Area and the 5-Year Plan projects, are discussed in Chapters 3 and 6.
Using the Regional ITS Architecture	✦ As described in this Preface, the Steering Committee plans to: ▪ Continue to meet at least once per year to guide the implementation of the ITS Plan. ▪ Help with or coordinate funding applications.
Maintenance Plan	✦ ODOT and MWVCOG will be responsible for updating the regional architecture and the ITS Plan, with input from the Steering Committee.

P.3 ITS PLAN IMPLEMENTATION AND MAINTENANCE

This section outlines the lead agency roles, the regional architecture maintenance process, and the Steering Committee roles necessary for the successful implementation of this ITS Plan within the Salem-Keizer Metropolitan Area.

P.3.1 Lead Agency Roles

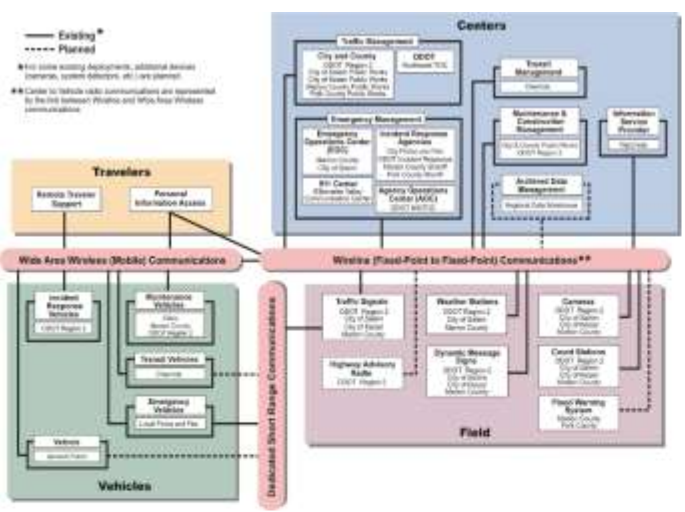
One agency should be designated to lead and facilitate ongoing deployment, coordination, education and pursuit of funding. This task will be led by the Mid Willamette Valley Council of Governments (MWVCOG), but will require coordination and participation from all of the key stakeholders. Successful implementation relies heavily on agency cooperation and committed leadership. Key responsibilities for the lead agency will include:

- Facilitate ongoing steering committee meetings
- Incorporate the ITS projects into regional project prioritization lists and planning documents
- Coordinate funding applications for ITS projects
- Coordinate and track project implementation
- Maintain the regional architecture, including the Turbo Architecture file.
- Arrange public outreach sessions as needed.

P.3.2 Regional Architecture Maintenance

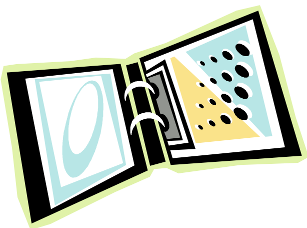
One of the keys to successful ITS plan implementation is the maintenance of the plan and architecture as ITS projects are implemented, as regional ITS needs and services evolve, and as new technologies emerge. The architecture must be maintained per federal requirements and the FHWA recommends updating the regional architecture for the following primary reasons:

- Changes in regional needs
- Addition of new stakeholders
- Changes in scope of services considered
- Changes in statewide architecture or other architectures in adjoining regions
- Addition or deletion of projects
- Changes in project priority



The architecture maintenance will be led by ODOT, who will also update the Turbo Architecture file; the Steering Committee will provide input to any changes. Significant changes to the architecture may be made at any time as deemed necessary by the lead agency and the Steering Committee; the changes will be tracked using a change log.

P.3.2.1 Project Implementation and Conformity



The implementation of ITS projects in the Salem-Keizer Metropolitan Area shall conform to the regional architecture per FHWA requirements. If the final design of an ITS project differs from the regional architecture, then the regional architecture shall be updated as described in this section. The FHWA requires a systems engineering analysis for all ITS projects on a scale commensurate to each project. The systems engineering analysis [2] shall include:

- Identification of portions of the regions ITS architecture being implemented
- Roles and responsibilities of participating agencies
- Definition of functional requirements
- Analysis of alternative system configurations and technology options to meet functional requirements
- Procurement options
- List of applicable ITS standards and testing procedures
- Operation and management procedures and resources

P.3.3 Steering Committee Roles

The Steering Committee, which consists of key stakeholders, helps foster interagency coordination and build consensus throughout the region. The continuing roles of the Steering Committee during the implementation of the ITS plan includes the following:

- Make decisions regarding project phasing. As opportunities arise (funding source, priority shift, or concurrent construction), adjust the project phasing as appropriate.
- Help with or coordinate funding applications
- Help with or coordinate project implementation
- Develop memoranda of understanding (MOUs) or intergovernmental agreements (IGA's) as required.
- Prepare plans and standards (incident management plans and standards for communication design, work zones, and data management)
- Review changes to the regional architecture

[2] Title 23, Code of Federal Regulations (CFR), Highways, Chapter 1: FHWA, Department of Transportation, Part 940: Intelligent Transportation Systems Architecture and Standards

CHAPTER

1 CURRENT & FUTURE TRANSPORTATION CONDITIONS

1.1 INTRODUCTION

The purpose of this chapter is to provide an overview of the current and future transportation system conditions in the Salem-Keizer Metropolitan Area, and develop an inventory of the physical infrastructure, operational characteristics, traffic safety elements, and travel characteristics of the transportation corridors in the study area. This inventory includes a summary of the following:

- Study area corridors
- Existing congestion locations
- High crash locations
- Transit operations
- Traffic signal control
- Intelligent transportation system (ITS) elements
- Communications network
- Emergency management
- Incident management
- Special events
- Freight movement
- Traveler information
- Relevant adopted documents

The main goal of the inventory is to establish the existing conditions in the study area along the study area corridors that will be used for building an intelligent transportation system based on regional transportation user needs.

1.2 STUDY AREA

Figure 1-1 illustrates the 20 study corridors in the study area. These corridors are located within Polk and Marion Counties, and within the City of Salem and City of Keizer. A detailed list of planned projects on each of the study corridors can be found later in this chapter. The transportation operating conditions of the key study corridors are summarized in Table 1-1. Key regional facilities located within the study area are depicted in Figure 1-2. These facilities include City halls, public works departments (engineering offices and maintenance facilities), schools, and emergency management facilities (fire stations, police stations, 911 centers, shelters, hospitals, and emergency operations centers).

Figure 1-1: Study Area Corridors

Table 1-1. Study Area Corridors

#	Corridor	Limits	Maximum Existing ADT	Maximum Future ADT
1	Interstate 5	Exit 243 Ankeny Hill to Exit 263	62,300	81,000*
2	Kuebler Boulevard/Cordon Road	Liberty Road to Hazelgreen Road	27,300	37,000*
3	Highway 22	Highway 51 (Independence Hwy) to Highway 214 (Silver Falls Hwy)	85,000	123,000*
4	Wallace Road	Highway 22 to Doaks Ferry Road	19,000	39,000
5	Salem Parkway Commercial Street Liberty Street	Interstate 5 to Highway 22	29,000	32,000
6	N. River Road Brooklake Road	Salem Parkway to Oregon 99E	26,100	41,900*
7	Lancaster Drive	Kuebler Blvd to Portland Road	35,500	37,700*
8	Commercial Street	Interstate 5 (Exit 249) to Salem Parkway	46,300	59,700*
9	Silverton Road	Portland Road to Cordon Road	24,000	25,600*
10	State Street	Front Street to Cordon Road	22,000	
11	Center Street	Hwy 22 to Cordon Road	20,500	28,500
12	Market Street	Commercial Street to Lancaster Drive	32,400	32,900
13	Chemawa Road Lockhaven Drive Hazelgreen Road	N River Road to Cordon Road	23,000	35,700
14	Broadway Street	Marion Street to N River Rd	15,900	21,200
15	Portland Road Highway 99E Fairgrounds Road	Broadway to Brooklake Road	21,300	26,900
16	$12^{th}/13^{th}$ Street SE	Commercial Street SE to Union Street	18,200	25,400
17	Hawthorne Avenue	Hwy 22 to Portland Road	19,200	29,400*
18	Liberty Road SE	Kuebler Blvd to Commercial Street	12,800	15,500
19	25^{th} Street Madrona Avenue	Mission Street to Liberty Road	15,800	20,700
20	Turner Road	Mission Street to Denver Street SE	9,200	12,900

Notes:
1. Forecasted ADT from the SKATS Regional Model for 2025.
2. Asterisk "*" indicates a forecast that was modified using growth from the 2000 to 2025 model data applied to the existing 2000 count data.

1.3 Traffic Conditions Summary

Congested corridors and high collision locations provide the greatest opportunities to implement ITS field elements that could produce a noticeable benefit to users. Table 1-1 includes a brief summary of transportation operating conditions for each study area corridor. Further discussion of existing and future recurrent congestion locations can be found in the following subsections.

Figure 1-2 Regional Facilities

1.3.1 Characters of Congestion

Congestion is typically categorized as either non-recurrent or recurrent. Non-recurrent congestion results from unexpected random events such as collisions or road debris in travel lanes. Recurrent congestion happens repeatedly at the same location, such as at key bottlenecks (like traffic signals), merge points, or weaving sections, and this recurrent condition typically occurs during peak periods. Volume-to-capacity (v/c) ratios help determine locations where traffic flows are near or at capacity on a consistent basis, indicating recurrent congestion. Travel demand forecast models provide v/c ratios by roadway link for current and future time periods. The congested levels that will be assigned for this analysis are based on v/c ratios in the Salem-Keizer Area regional model as listed in Table 1-2.

Table 1-2. Congestion Defined by Volume-to-Capacity Ratio

Congestion Level	Volume-to-Capacity Ratio
Moderate	**0.80 – 0.89**
High	**0.90 – 0.99**
Severe	**≥ 1.0**

1.3.2 Existing Recurrent Congestion

The existing (2000) travel demand model for the Salem-Keizer area was used to identify recurrent congestion locations along study area corridors during the PM peak hour. Multiple congestion locations were identified within the Salem-Keizer area these study corridors.

Recurrent congestion is primarily located along Liberty Street, Commercial Street, Madrona Avenue and Kuebler Boulevard. Figure 1-3 shows the existing (2000) recurrent congestion locations along study area corridors.

1.3.3 Future Recurrent Congestion

Figure 1-4 illustrates the magnitude of future congestion in the Salem-Keizer Area based on the SKATS 2025 regional travel demand forecast model. There is a significant level of increase in congested corridors compared to the existing (2000) conditions. Comparison of the two models indicates a rise in "severe" congestion from 11.9 miles in 2000 to 28.4 miles in 2025. This represents a 240% increase in roadway miles with a volume-to-capacity greater than or equal to 1.0 during the PM peak hour. Similarly, "high" congestion rose from 10.2 in 2000 to 15.5 miles in 2025 representing a 150% increase in roadway miles with a volume-to-capacity between 0.9 and 0.99. "Moderate" congestion rose from 5.8 in 2000 to 7.3 in 2025 representation a 125% increase in roadway miles with a volume-to-capacity between 0.8 and 0.89. The corridors that are primarily affected by the increase in congestion include: Interstate 5, Highway 22, Commercial Street, Liberty Street, Silverton Road and Lancaster Drive.

FIGURE 1-3: EXISTING CONGESTION

FIGURE 1-4: FUTURE CONGESTION

1.4 CRASH SUMMARY

Accidents contribute significantly to traffic congestion along a corridor and can have the potential to divert vehicles to other parallel roadways. ODOT has developed a Safety Priority Index System (SPIS) to identify locations with high collision rates. For every 0.10 mile section of road, a score is given based on the most recent three years of collision data with weighting for crash frequency, rate, and severity. Three or more collisions, or one or more fatal collision, must have occurred at the same location over the past three years for a location to be considered a SPIS site. Each year, ODOT identifies the top 10 percent SPIS sites and evaluates these locations for safety problems.

Additionally, ODOT uses a ranking methodology to analyze specific locations based on a three-year crash history. This process includes a designation of a “Safety Corridor” or a “Truck Safety Corridor” for any state or local highway that has a three-year average of fatal and serious injury crashes greater than the statewide average for similar kinds of roadways. Within this study area, Oregon Highway 22 between Willamette River Bridge and Highway 99 West has been designated as one of these safety corridors. Also, Interstate 5 between Highway 22 and Highway 214 has been designated as a truck safety corridor. In a safety corridor, frequent enforcement and education efforts are used to enhance the awareness of these corridors.

While a majority of collision data is collected and stored by ODOT, many times local agencies also retain their own list of accident locations that may not be based on the ODOT SPIS system. This helps to track potential corridors with safety concerns as well as statistically track increases or decreases in accident data.

The existing collision data from the City of Keizer 2001-2003 indicates an overall decrease in the total number of accidents, with peaks in collisions occurring in April, July, and December. Additionally, almost half (46%) of the accidents were designated as hit and run with no clear cause for the accident. The highest percentage (39%) of the accidents occurred on River Road, with the intersections of Chemawa, Dearborn and Lockhaven being especially problematic.

The City of Salem keeps a list that ranks the collision locations by number of occurrences, and does not factor into account severity, type of collision or number of vehicles. This ranked list can be found in Appendix C. Additional data collected from the state DMV crash database SPIS calculations indicated problematic intersections on Lancaster at Silverton Street, State Street and Durbin Street. Figure 1-5 shows the high collision locations throughout the study area by jurisdiction.

Figure 1-5: Collision Summary

1.5 TRANSIT

The Salem-Keizer Area is served by a combination of fixed route systems, dial-a-ride services and intercity bus and rail services. In this section, the different public and private transit services are discussed, as well as an overview of the scheduled upcoming transit improvements that will be conducted over the next five years.

1.5.1 Cherriots

The Cherriot's fixed route system is primarily a radial route structure in which all but six of the routes meet at the central transit station located in downtown Salem. Figure 1-6 shows the current bus routes servicing the study area. Currently there are eighty-three buses servicing the City of Salem. Almost all of the buses have global positioning system (GPS) devices in place, although they are not being used at this time. Ten buses are equipped with Automatic Passenger Counts that are measured per stop; these are run on various routes throughout the system. The data collected from the counts is sent to the bus housing facility on Dell Web Avenue.

Service is offered Monday through Saturday with frequencies varying between routes, from 15 to 60 minutes. Additionally, there are four major transit centers with covered waiting areas and other amenities. Seventy five of the eighty three buses are lift-equipped and have wheelchair positions. Each of the twenty-five routes is assigned at least one lift-equipped bus so all routes are accessible to wheelchair riders at the same time. According to average weekday ridership data from the spring of 2004, approximately 20,000 passengers ride the bus each day.

Video surveillance is present on most buses and has been extremely helpful with security issues. All of the information from the cameras is then sent to the security center at the downtown transit center and can be viewed in the case of a discrepancy. Additionally, there are many cameras in various locations in and around the downtown transit center that are viewed and archived.

1.5.2 Dial-a-Ride Services

Dial-a-Ride services are provided to offer more freedom from existing fixed routes. Typically, dial-a-ride routes are determined based on current demand with no specific, set schedule. The paratransit vehicles are a separate division contracted through OHAS (Oregon Housing and Associated Service); although some of the vehicles that are used are owned by Cherriots. "Wheels" is a nonprofit program providing paratransit services in the area. The routes are continually changing based on the demand of ridership. OHAS is responsible for the dispatch. This is a free service designated for the disabled and elderly persons in the Salem-Keizer area. Trips are scheduled on a space-available basis.

Figure 1-6: Transit summary

CherryLift also provides services to ADA-eligible riders in the Salem-Keizer area. The service is delivered by a contractor under terms set by Salem-Keizer Transit and averages 5,000 riders monthly.

Lastly, TripLink service is contracted by a Medicaid brokerage. A private firm (ATC) has teamed with the Salem Area Mass Transit District to provide specialized transportation services to Medicaid patients. The call center located off site handles the dispatch for services.

1.5.3 Intercity Bus Service

In addition to the fixed route and paratransit systems that operate within the City of Salem, other bus services provide connections to/from the City. Some of these services are public, while others are privately owned and operated. Greyhound Lines provides service to/from the City of Salem, although typically it is limited to larger destination cities. By utilizing agreements between Greyhound and other smaller service providers, many smaller rural destination points may be accessed and thus a larger number of users may be accommodated.

1.5.4 CARTS

The Chemeketa Area Regional Transportation System provides weekday public transit service connecting Salem with the cities of Dallas, Independence, and Monmouth in Polk County; Lyons and Mill City in Linn County; and Aumsville, Gates, Gervais, Hubbard, Silverton, Stayton, Sublimity, Turner and Woodburn in Marion County. This service provides approximately 12,000 rides per month.

1.5.5 SMART

The South Metro Area Rapid Transit (SMART) provides service to Wilsonville (in Washington County, OR) with three buses northbound in the morning and two in the evening. This service is primarily aimed at the workday commuter traveling between Wilsonville and Salem-Keizer, but it also serves the Barbur Transit Center in Portland where several Tri-Met bus routes connect.

1.5.6 Intercity Rail Service

Amtrak provides the Coast Starlight and Cascades trains that service the City of Salem and surrounding areas. The Cascade line offers two daily round-trip trains between Eugene and Seattle, while the Coast Starlight train operates through the Willamette Valley daily at various times.

1.6 TRANSIT IMPROVEMENTS

The existing system serves the Salem-Keizer Metropolitan Area and the surrounding areas well, but a new vision for the future of Cherriots will bring about many improvements to the system. The new vision, outlined in the Salem-Keizer Transit Strategic Business Plan involves the three C's; circulator, center, and corridor service delivery. To accomplish these goals outlying transit centers will be constructed that are served by neighborhood circulator routes. Further transfers may then be made into a corridor route for travel into downtown via large, frequent buses.

1.6.1 Corridor Improvements / Service Enhancement

At the present time, frequency improvements are scheduled on five routes within the five-year scope of the short-range plan. Service expansions at State Street and Fairview Avenue, South Commercial Street, and Lancaster Drive will improve the usability of the system. Additionally, most of the Saturday routes will be improved by increasing the frequency of service.

1.6.2 High Priority Transportation Corridor

The Broadway/River Road North corridor was selected as the most appropriate location to begin to implement changes to the transportation infrastructure to improve the movement of buses. Bus stops will be located along the middle section of the corridor. Buses designated for this lane will be equipped with emitters to utilize queue jumping, early green and/or green extension. Currently, there is funding available for this project and the next steps involve public involvement and buy-in from the cities of Salem and Keizer.

Other general transit improvements include:

- Smart Card Development;
- Streetcar feasibility studies;
- Maintenance upgrades;
- Implementation of Sunday bus service;
- Expanded Commuter Services;
- Evaluation of replacement buses (small transit buses for neighborhoods, large buses for corridor route);
- New transit centers (South Salem and Keizer); and
- Utilization of existing Automatic Vehicle Location technology.

1.7 Traffic Signals

This section describes the traffic signal equipment used at the signalized intersections in the Salem-Keizer Metropolitan Area. Figure 1-7 shows the existing and planned traffic signals in the study area with the signals color-coded by ownership for each jurisdiction. Existing signal interconnect locations are depicted on Figure 1-9.

The following subsections include details pertaining to controller and controller cabinet type, video detection, existing central signal system, and emergency vehicle preemption capabilities at traffic signals in the study area.

1.7.1 Traffic Signal Operations

Traffic signals in the Salem-Keizer Metropolitan Area are currently operated and maintained by the City of Salem and ODOT. The City of Salem is responsible for the operations and maintenance of the majority of the traffic signals in the Salem-Keizer Metropolitan Area through existing agreements with other agencies[1].

1.7.2 Oregon Department of Transportation

ODOT operates and maintains 13 traffic signals in the Salem-Keizer Metropolitan Area. Another 36 ODOT owned traffic signals in the region are operated and maintained by the City of Salem. The 13 ODOT owned and maintained traffic signals use Type 170 controllers and Wapiti W4IKS software. The 36 ODOT owned/Salem operated and maintained traffic signals use Type 170 controllers and BI Tran software.

1.7.3 City of Salem

The City of Salem operates and maintains approximately 230 traffic signals in the Salem-Keizer Metropolitan Area, including 16 Marion County signals, 14 City of Keizer signals, and 36 ODOT signals. Another 42 traffic signals are under design or planned for installation. All of the traffic signals operated and maintained by the City of Salem have Type 170 controllers and BI Tran software.

For remote access to the traffic signal controller data, the City of Salem uses the QuicNet/4 central signal system software. Of the 230 existing traffic signals, approximately 190 are direct connected to the QuicNet/4 central signal system server at the City of Salem offices via twisted wire pair. QuicNet is a central/distributed signal system that provides the City with full upload and download capabilities and a visual display of local intersection status. The QuicNet central computer does not directly control the local traffic signals, but it does allow remote access to the local traffic signal controllers. The City is planning to upgrade the traffic signal communications infrastructure to fiber optic cable as new development occurs and traffic signals are installed.

The City of Salem operates time-based coordination at many of the intersections during the AM, Midday and PM peak periods. Arterial roadways with the City of Salem use a combination of AM, Midday, and PM peak coordinated timing plans while many others operate in the free mode.

[1] The City of Salem traffic signal operations contact is Terry Hockett (503) 588-6211.

Figure 1-7: Existing/Proposed Signals

1.7.4 Video Detection

The City of Salem uses the TrafiCon video detection system for the majority of traffic signals within the City. Video cameras detect vehicles entering zones configured within the camera view and provide inputs to the traffic signal controllers for local intersection timing functions. An intersection video detection system normally consists of four to six fixed cameras mounted on traffic signal mast arms or luminaire arms. City of Salem traffic engineers are able to view images from the video detection cameras from their desktop, using communication technology and the proprietary software provided by the vendor.

In addition, the City of Salem has a current project to install video detection cameras viewing the departure side of an intersection for traffic volume counts. With these cameras, the City is expecting to be able to collect traffic volume, speed and classification information.

1.7.5 Emergency Vehicle Preemption

The majority of the traffic signals in the Salem-Keizer Metropolitan Area have full emergency vehicle preemption capability using Opticom™. Fire vehicles have the capability to preempt traffic signals, but police vehicles do not. All of the new detectors and discriminators being installed have the ability to recognize vehicle identification codes and different levels of priority requests (e.g. bus priority). Many of the existing detectors and discriminators were installed prior to this functionality being offered. The City is actively pursuing opportunities to upgrade the existing detectors and discriminators to provide vehicle identification and low priority functionality.

City of Salem traffic engineers, using the 3M priority control software, have the ability to remotely upload the preemption logs to check for valid preempts. This allows for a back-check system in the case that preemption has disrupted traffic flow during peak times of the day.

1.8 ITS Systems and Equipment

The Salem-Keizer Metropolitan Area has several existing intelligent transportation systems and ITS devices. The following sections describe existing and planned ITS systems and equipment including the Northwest Traffic Operations Center (NWTOC), existing closed-circuit television (CCTV) cameras, dynamic message signs (DMS), traffic count stations (ATR), and weather stations (RWIS). Figure 1-8 shows the locations of the existing field devices.

1.8.1 ITS Systems

The Salem-Keizer Metropolitan Area currently uses a variety of software systems to access and control field devices, and to dispatch vehicles. Table 1-3 provides a summary of the existing software systems and their primary function. Many of the software systems used today are redundant because they are proprietary to the specific vendor for the field device. Additional information about each system is provided under the field device or Northwest Transportation Operations Center description in this Chapter.

1.8.2 Northwest Transportation Operations Center (NWTOC)

ODOT currently operates a Transportation Operations Center (TOC) in the City of Salem that is a shared facility with Oregon Emergency Management (OEM) and the Oregon State Police (OSP). The Northwest Transportation Operation Center in Salem operates 24/7 and provides dispatch services, incident management support and traveler information for all of Region 2. In addition, the NWTOC provides these same services after normal business hours for all of users in Region 4 and 5.

The TOC primarily serves a support role for incident management/emergency management activities and coordinates the posting of pre-approved messages as requested by field personnel. The TOC currently has no authority to post new and unique electronic messages, activate detour routes, and implement incident signal timing plans or other management activities without prior approval from the Region Traffic Engineer. A summary of the primary functions performed by the operators is provided in the following list.

- *Incident Management* – Incident detection, response planning, resource tracking and coordination and output to the traveler information systems.
- *Emergency Management* – Includes incident management functions and the implementation of Emergency Operations Plans.
- *Traffic Management* – Control dynamic message signs, highway advisory radio, and dispatch incident responders.
- *Traveler Information* – Place and update incident alerts and road restriction messages on dynamic message signs and highway advisory radio and output to media and TripCheck.
- *Winter Operations* – Monitor the roadway conditions with CCTV and environmental sensors. Coordinate crew assignments and notifications. Place outputs to traveler information systems (HAR and DMS).
- *Maintenance Operations* – Assist maintenance manager with crew availability and location information and place call-outs.

Table 1-3. Existing Systems in the Salem-Keizer Metropolitan Area

#	System	Vendor/ Software	Operating Agency	Purpose	
1	Signal System	QuicNet	City of Salem	Traffic Signal Control	Traffic Engineers at the City of Salem have access to the traffic signal data using this system TOC operators do not have access to this system.
2	Video Detection	TrafiCon	City of Salem	Intersection Detection	Video images can be viewed at the City of Salem.
3	Dynamic Message Signs	Skyline/	ODOT	Message Sign Control	Intent is to use the Skyline software for access to all signs
4	Portable Variable Message Signs	Skyline Others DOS programs	ODOT	Message Sign Control	New PVMS are NTCIP. Intent is to use the Skyline software to control the PVMS signs.
5	Highway Advisory Radio	Highway Information Systems	ODOT	Radio Messaging	Grant money to put in HAR (11) on the coast to transmit NOAA weather or special event info. Server in Salem.
6	OSP Computer Aided Dispatch	Public Safety Systems Inc. (PSSI) CAD	OSP/ODOT	Manage Incidents	Provides link to OSP dispatch in Salem
7	Highway Traffic Conditions Reporting System	ODOT Visual Basic Application	ODOT	Feeds Info to TripCheck	
8	Road Weather Information System	SSI ScanWeb Software	ODOT	Weather Info	Server in Salem
9	Emergency Computer Aided Dispatch	HiTech Systems	Salem 911	Computer Aided Dispatch	Salem has a 911 center and separate police and fire dispatch
10	Transit Computer Aided Dispatch	Trapeze	Salem-Keizer Transit District	Transit Dispatch	Additional DOS software FleetMate for maintenance
11	Trip Link	Mobility Master and Mobilitat	ATC, private service	Paratransit service	Separate system from fixed route Cherriots Service

Figure 1-8: ITS Systems and Equipment

More detailed information on the functions of the Operations Center is documented in the *Transportation Operations Center System Concept of Operations*[2], by ODOT.

Operators in the center currently manage field devices using a variety of software packages. For variable message signs alone, the operators have multiple software packages to post messages because each manufacturer has a separate proprietary software package. However, ODOT has upgraded many of the fixed signs to be NTCIP compliant and is migrating to one software package for sign control. In addition, ODOT is currently conducting a Transportation Operations Center System (TOCS) project, which intends to integrate the functions of the advanced transportation management systems (ATMS), and the computer aided dispatch (CAD) system. The ultimate intent is to provide an integrated system interface for management of ODOT assets.

1.8.3 Closed-Circuit Television (CCTV) Cameras

Today, ODOT uses closed-circuit television (CCTV) cameras to monitor traffic at the Hayesville Interchange on Interstate 5. Two fixed mount camera are provided at this site to provide images north and south of the interchange. From the NWTOC, operators also monitor the pan-tilt-zoom camera on the radio tower at the operations center, the security cameras in the building, and the mountain pass cameras (Government Camp, Highway 22, Willamette Pass and other Statewide Pass cameras). Two additional cameras on Interstate 5 are currently under design at the Kuebler Boulevard and Mission Street Interchanges. ODOT posts images from the existing cameras on the TripCheck website, which is described later in this chapter.

The City of Salem has video images at approximately one-third of the signalized intersections (approximately 60 intersections), which are supplied from the video detection cameras. These are all fixed mount cameras, but images are generally provided on the approach section of all four legs of an intersection. All new traffic signals in the City of Salem are installed with video detection.

1.8.4 Dynamic Message Signs (DMS)

Currently, there are no existing dynamic message signs in the Salem-Keizer Metropolitan Area. However, ODOT operates and maintains fixed dynamic message signs on Interstate 5 north of Salem. All new dynamic message signs installed by ODOT are compliant with the National Transportation Communications for ITS Protocol (NTCIP). Additional signs are controlled from the NWTOC, but are outside of this project study area. Dynamic Message Signs are planned on Interstate 5 southbound near the Brooks interchange and northbound north of Albany.

[2] *Transportation Operation Center System – Concept of Operations*, Galen McGill, Patrick Hoke, Larry McKinley, ODOT, 2002.

1.8.5 Portable Variable Message Signs (PVMS)

ODOT Region 2 owns and operates several portable variable message signs. All new PVMS are being procured as NTCIP compliant, but several existing PVMS are not NTCIP compliant. Therefore, several software packages must be used to program the signs; but ODOT is migrating to one software package for PVMS sign control as the existing signs come to the end of their useful life.

1.8.6 Automatic Traffic Recorders

ODOT currently operates four automatic traffic recorders (ATR), within the Salem-Keizer study area to collect hourly volume data by lane. Three of the four ATR stations have the ability to collect speed and length data. Speed data is typically provided in 13 "Speed Bins" and length data is typically provided in two "Length Bins". ATR stations do not collect occupancy data. The four ATR stations in the study area include: North Santiam Station, Aumsville Station, Salem Bridges Station and Oak Knoll Station. Two ATRs are located on Highway 22 between Interstate 5 and Stayton and two ATRs are located on Highway 22 west of Salem between the Willamette River and 99W.

The City of Salem has a current project to install video on the downstream side of intersections to collect volume and vehicle classification information at approximately 75 locations.

1.8.7 Road Weather Information Systems (RWIS)

Marion County currently operates and maintains three weather stations in Marion County at Drakes, Prospect Hill and Elkhorn. The weather information is accessible online at http://publicworks.co.marion.or.us/operations/weather/index.asp. ODOT has a weather station alongside River Road at the Traffic Signal Services Unit facility. The City of Keizer has a weather station at their City maintenance facility behind the Keizer Fire Station. Weather and road condition information collected from these sites generally includes air temperature, pavement temperature, wind speed, wind direction, barometric pressure, and humidity.

1.9 COMMUNICATION EQUIPMENT

The communications system is one of the most critical components in the deployment of ITS infrastructure since local agencies must be able to monitor, control, and operate traffic management devices from remote locations and share information in real-time between operations centers to effectively manage the movement of passengers and goods and respond to incidents. The existing transportation related communications network in the Salem-Keizer area consists of a variety of media such as fiber optic cable, twisted-pair copper, radio, and cellular telephone. The existing agency-owned communications infrastructure is illustrated in Figure 1-9, where data is available.

Additional communications infrastructure exists, either as part of the private telecommunications infrastructure or wireless infrastructure on towers that have not been mapped to maintain security.

1.9.1 Fiber Optic Infrastructure

There is limited public agency installed fiber optic infrastructure in the Salem-Keizer area, but there are existing projects and plans that intend to install a significant amount of new fiber optic cable in the near future. ODOT is currently designing fiber optic infrastructure from the radio tower on the east side of Interstate 5 north of State Street south to Kuebler Boulevard. In addition, ODOT has plans to install fiber optic infrastructure from this radio tower site west to the Northwest TOC providing a direct connection to field devices on Interstate 5. The City of Salem is also installing fiber optic cable with all of their new traffic signal construction projects.

Local telecommunications providers in the Salem-Keizer area include ComCast and Qwest.

1.9.2 Copper Twisted-Pair Infrastructure

The City of Salem currently has copper twisted-pair (12 pair) infrastructure interconnecting approximately 190 traffic signals with the central signal system server (shown in Figure 1-9). Today, the copper twisted-pair infrastructure is used for communications between traffic signals.

1.9.3 Wireless Communications

The City of Salem and ODOT currently use wireless communications for some individual field devices. ODOT uses Code Division Multiple Access (CDMA) cell modems to communicate to variable message signs and the City of Salem uses some wireless Ethernet (unlicensed frequency) to transmit video from some traffic signals.

The City of Keizer is exploring the possibility of building a public agency wireless network with complete coverage of the City.

Figure 1-9: Communications infrastructure

1.10 EMERGENCY MANAGEMENT

This section describes the emergency management agencies in the Salem-Keizer area, as well as the strategies used for routine services typically handled by 911, police, fire, and medical agencies, and strategies for major emergencies and disasters. Roles and responsibilities and interagency relationships (for emergency management and transportation management agencies) will be discussed in Chapter 4: Operational Concept.

1.10.1 911 Center

The Willamette Valley Communication Center (WVCC) is the primary 911 Center that services the Salem-Keizer Metropolitan Area. This center is located in downtown Salem and coordinates/communicates with 18 different agencies. In the surrounding area there are two additional 911 Centers; one located in Woodburn (Norcom) and another located in Stayton (Santiam Canyon).

The 911 Center is equipped with a central CAD system to monitor police, fire and emergency vehicle dispatch. The CAD system is Geo 911, and there is also communication via VHF/UHF and an 800 Mhz mobile data network. The center takes approximately 450 calls a day and typically has anywhere from 2 to 5 call takers depending on the time of day.

1.10.2 Police/Fire/Emergency Vehicles

The City of Salem, City of Keizer, Polk County and Marion County all have various law enforcement agencies. The City of Salem and City of Keizer have police departments and Polk County and Marion County have sheriff's departments. The various police department locations can be found on Figure 1-2 earlier in this chapter.

The police departments work with a mobile data network and mobile data terminals and can monitor what other units are doing at any time. Outside communication to/from officers is currently handled through the 911 Center. Communication between officers can be accomplished through the mobile data network as a messaging system.

The City of Salem police department uses a UHF frequency system for communication, while Polk County utilizes a radio system and Marion County utilizes a VHF frequency system.

The Fire department currently does not have global positioning system (GPS) units, but would like to implement GPS. When emergency fire calls are processed the closest unit to the incident/call is typically dispatched unless other information is available through the 911 Center that would indicate a faster response from another unit.

1.10.3 Emergency Management Communications Agencies

As previously stated, a system of radio, VHF, UHF and 800 Mhz communication equipment is utilized by various agencies. The City of Salem currently utilizes an 800 Mhz communication network, while the Salem Police Department uses a UHF system. Polk County uses a radio network system and Marion County uses a VHF communication system.

1.11 Incident Management

ODOT currently staffs eleven incident responders in Region 2 that serve as the first responders to an incident. A special program funds the wages and equipment for the dedicated responders. These responders typically work from 9:00 a.m. to 6:00 p.m. and are on-call 24 hours a day, seven days a week. Each responder has designated uniforms and an incident response vehicle that they take home at night. These vehicles are equipped with a 2-line/8 character changeable message sign and will be updated with GPS and mobile data collection capabilities in the near future. Each responder also takes part in extensive on-going training.

The success of the program relies heavily on interagency coordination, training and developing an understanding about each agency's roles and responsibilities regarding response, dispatch and other communication. When an incident occurs in Salem, the incident responders coordinate with fire and police. The comprehensive incident management plan also includes information such as sign placement, flagger location, and interchange closures during and after an incident.

In the event of a major emergency, lasting eight or more hours, alternative routes have been mapped from Portland to Cottage Grove on I-5. These detours provide accessible parallel routes. Many of the coastal route detours do not have the same accessibility to detours and may have more significant impacts in an emergency event. Variable message signs play a critical role in the use of the alternate routes. Proposed locations for the next variable message signs will be northbound I-5 at North Albany and southbound I-5, north of the Brooks interchange.

Of particular importance is the expected increase in construction projects on Interstate 5 that are programmed for the next 3-6 years. The lack of communication and coordination between construction zones is especially problematic with respect to the information dissemination to the traveling public. An additional security issue includes the state capitol building in downtown Salem in the event of a terrorist emergency.

1.12 Special Events

The Salem-Keizer area has many recurring special events throughout the year that attract additional trips. These events provide significant revenues to the city of Salem and the surrounding economies, but have negative impacts on the existing transportation system. The city of Salem has an event coordinator that plans many of these events that include baseball games, events at Riverfront Park and the State Fair. Specialized local event timing plans have been established to accommodate the increased traffic demand at these locations. Some annual events that impact the transportation system in the area are discussed below.

Keizer Volcanos

The Keizer Volcanoes are a minor-league baseball team that attracts many fans. The stadium is located off of I-5 on Radiant Drive. The season runs from the middle of June through Labor Day with about 35 scheduled home games and the possibility of playoffs.

Riverfront Park

Salem's downtown Riverfront Park and outdoor amphitheatre hosts a variety of events. It also houses the Riverfront Carousel with hand carved wooden horses and the A.C. Gilbert Discovery Children's Museum. Additionally, numerous other local festivals and events such as the Bite of Salem and the World Beat Festival take place at this location.

Bush's Pasture Park

This 24-acre park located on 880 Mission Street SE, just south of the central business district, hosts many different events, perhaps most notably, the Salem Art Fair and Festival that typically attracts over 100,000 participants in July of every year. It also is home to the Cascade Surge Soccer team at McCulloch Stadium.

Enchanted Forest/Thrill Ville Theme Parks

The amusement parks located just south of Salem off of I-5 have water slides, roller coasters and offer fun for all ages. During the summer months between Memorial Day and Labor Day, these parks attracts over 200,000 visitors.

Fairgrounds

The fairgrounds are located off of I-5 near the intersection of Lana Avenue and 17th Street. The fairgrounds and Expo Center host many different events throughout the year, including the Oregon State Fair. The state fair is held for two weeks before Labor Day and attracts about 450,000 people over the 12-day period.

1.13 Freight

Freight movements in the Salem-Keizer Metropolitan Area include movements on the State Highway Freight System and the railroad tracks through the city. Existing designated freight routes in the Salem area include Interstate 5 and Highway 22 east of Interstate 5. Freight routes are designated to facilitate efficient and reliable interstate and intrastate truck movements. These are primarily state highways that carry a significant tonnage of freight by truck and/or serve as the primary interstate and intrastate highway freight connections to ports, intermodal terminals, urban areas and other states. Benefits include slightly increased mobility standards, measured by maximum volume to capacity ratios, and pavement conditions that are maintained at higher conditions. ODOT has recently drafted a Freight Route Analysis Project (FRAP)[3] that includes recommendations for revisions to the freight system. Based on the FRAP, Salem Parkway, Highway 22 west of Salem and Highway 99W are recommended additional freight routes.

[3] DRAFT Freight Route Analysis Project (FRAP) Staff Report, September 1, 2004.

1.14 Ferries

Marion County Public Works maintains and operates two shuttle ferry services across the Willamette River that provides an alternative way to travel between Newberg and Salem. The Wheatland service operates a mile north of the SKATS region near Willamette Mission Park. This service is the largest and busier of the two ferry services available, with about 225,000 trips annually. This ferryboat can carry 9 vehicles and 42 passengers per trip. The maximum wait time is typically 10 to 15 minutes. The ferry is operational all year long, depending on weather and equipment conditions.

The second ferry is the Buena Vista and it operates five miles downstream from the SKATS area, and carries about 9,000 trips per year. This ferryboat can transport 4 autos and 29 passengers per trip. It operates 5 days a week from April through October. The maximum wait time for this service is also 10 to 15 minutes depending on the types of vehicles onboard.

1.15 Traveler Information

The Oregon Department of Transportation (ODOT) provides most of the traveler information for the Salem-Keizer area. ODOT provides real-time traveler information through the TripCheck website, and 511. ODOT's TripCheck website (www.tripcheck.com) includes two camera images, road conditions, weather information, incident maps, and construction activity for the Salem-Keizer area. ODOT continues to add information to TripCheck as new equipment is deployed.

In late 2003, ODOT implemented 511, the new national traveler information number, throughout the state to provide various types of real-time traveler information. The 511 system is accessible to travelers over the phone through touch-tone dialing or voice activation.

Traveler information is also provided to the public on the Marion County public works website. http://publicworks.co.marion.or.us/operations/roadclosures/closures.asp. The Marion County road closure website includes Marion County, Salem and ODOT road closures in addition to current emergencies and conditions, and the operating status of the ferries.

1.16 Summary of Relevant Documents

A number of regional studies and plans have been compiled in the Salem-Keizer Metropolitan Area that relate to ITS applications. A review of these documents was conducted to identify potential connections to other agencies and/or planned projects in the study area. This section provides a summary of the key points from the documents reviewed.

1.16.1 1999 Oregon Highway Plan

The 1999 Oregon Highway plan developed by ODOT provides refined goals and policies of the Oregon Transportation Plan as well as a vision for the future of the state highway system and a system analysis of state highway needs and implementation strategies. The highway plan breaks ODOT's highway responsibility into 11 major categories, including modernization, preservation, bridge, maintenance, operations, safety, special programs, construction support, planning, administration and central services. Intelligent Transportation Systems is one of the five goals included in the Oregon Highway Plan. This policy states that a broad range of ITS services will be considered to cost-effectively improve safety and efficiency and will reflect the user service priorities developed in the Oregon ITS Strategic Plan. This policy highlights the following ITS services for consideration throughout Oregon:

- Incident Management
- Pre-Trip Traveler Information
- En-Route Driver Information
- Public Transportation Management
- Traffic Control (Arterials and Freeways)
- Emergency Notification and Personal Security
- Route Guidance
- Emergency Vehicle Management
- Commercial Vehicle Electronic Clearance
- Commercial Fleet Management

1.16.2 Oregon Transportation Plan Update

This plan is a 20 year multi-modal plan for the state of Oregon that serves many functions, including addressing the state and local transportation systems, system needs, system priorities, and investment strategies. Oregon's population continues to grow; this paired with changing demographical and geographical trends, has significant impacts on the transportation system. Trends show a more ethnically diverse, geographically centered and older population. Based on these trends and other transportation challenges such as economy, environment, safety, and funding the following draft goals have been developed:

- Mobility and accessibility
- Economic vitality
- Sustainability
- Management of the system
- Safety and Security
- Funding of the system
- Coordination and cooperation

This plan is currently a work in progress with a public review of the draft scheduled for the summer of 2005.

1.16.3 I-5 State of the Interstate Report

In the *I-5 State of the Interstate Report – 2000*, ODOT provides comprehensive data regarding the existing physical and operating conditions on I-5, a general future travel demand forecast, and an assessment of freeway performance if no improvements are made through 2020. Early action improvements are projects that have been identified through deficiency analysis to improve the operation and or safety of the corridor. These projects for improvements in the study area are listed below:

- *Interstate 5 at Kuebler Interchange:* Replace the loop ramp with added superelevation and modify the exit ramp intersection approach to a lesser skew (less than 15 degrees) and tighten curb radius.
- *Interstate 5 at Chemawa Interchange:* Move guardrail and widen shoulder on northbound entrance ramp
- *Interstate 5 at Brooklake Interchange:* Lengthen southbound entrance acceleration lane by 33 meters and address capacity problems at ramp terminals.

1.16.4 Planned Projects in Salem-Keizer Metropolitan Area

Table 1-4 shows funded and unfunded infrastructure and signal projects for the study corridors, as well as some general transit improvements that may have a potential connection to the implementation of ITS deployments in the future. More detailed descriptions of these projects can be found in the following plans or reports. Additionally, many of the reports outline project recommendations for low, medium, and high priorities. For the purpose of this review, only high priority project recommendations were listed.

Statewide Transportation Improvement Program (STIP), 2004-2007: This program is the Oregon Department of Transportation's short term capital improvement program that provides funding and scheduling information for transportation improvements.

City of Salem Transportation System Plan (TSP), 2001: This plan contains policy information and descriptions of transportation investments that will take place over the next 20 years.

SKATS Regional Transportation System Plan (TSP), 2002: This regional plan is a cooperative effort between SKATS, ODOT, the Cities of Salem and Keizer, Marion and Polk County and the Salem Area Mass Transit District and outlines the priority transportation improvements necessary for the region.

SKATS Transportation Improvement Program (TIP), 2004-2007: The SKATS TIP identifies the transportation projects within the region that are expected to use federal and state funds during the next four years. These projects may overlap many of the improvements outlined in the STIP.

Marion County Transportation System Plan (TSP), Draft 2005 Update: This plan provides a comprehensive list of 20-year transportation improvements in Marion County to maintain the safety and efficiency of the transportation system to an acceptable level.

Table 1-4. Planned Projects on Study Area Corridors

Study Corridor	Project	Report/Plan
Interstate 5	Install traffic signals and turn lanes at Brooklake ramp intersections	Marion County Draft TSP
	Replace Marietta Street Bridge (I-5 interchange and Kuebler Ramp)	SKATS TSP
	I-5 Phase lllb: Hwy 22 to Kuebler Interchange widen to 6 lanes	
	1-5 Phase lV: Kuebler Interchange to Delaney road widen to 6 lanes	
	I-5 N. Santiam-Kuebler Blvd, widen to 6 lanes replace 6 bridges	STIP (2004-2007)
	I-5 Kuebler-Illahee Crossing widen to 6 lanes	
Kuebler Blvd/Cordon Road	Construct a left turn lane on Cordon Rd at Pennsylvania Ave	Marion County Draft TSP
	Construct a left turn lane on Cordon Rd at Herrin Rd	
	Construct a left turn lane on Cordon Rd at Hayesville St	
	Construct a left turn lane on Cordon Rd at Carolina St	
	New interchange at ORE 22 and Cordon Road	
	Traffic signal interconnect at Turner and I-5	SKATS TSP
	Widen to 4 lanes Commercial St to I-5	
	Traffic signal interconnect: Silverton to State Street	STIP (2004-2007)
	Install new actuated and interconnected traffic signals at Kuebler and 36th	
	Minor realignment of the intersections of Gaffin and McCleay	
Highway 22	Pedestrian Improvements path at Lancaster Street	STIP (2004-2007)
Wallace Road	Traffic signal interconnect Edgewater to Glen Creek	SKATS TSP
	Increase the radius of WB offramp from Highway 22 to Wallace Road (more lanes)	City of Salem TSP
	Expand intersection at Glen Creek Road NW	Salem CIP
Salem Parkways & Liberty Street	Traffic signal interconnect from Salem Parkway to 25th Street along Hyacinth Street	City of Salem TSP
N River Road/Brooklake Road	Structural overlay from Chemawa Road to North Santian Interchange	STIP (2004-2007)
	Widen travel lanes and add paved shoulder from River Rd to Interstate 5	Marion County Draft TSP

Table 1-4. Planned Projects on Study Area Corridors (continued)

Study Corridor	Project	Report/Plan
Lancaster Drive	Traffic signal interconnect on Sunnyview Road from Lancaster Drive to Cordon Road	City of Salem TSP
	Traffic signal interconnect Hagers Grove Rd to Cordon Rd	STIP (2004-2007)
	Lancaster/Market Street NE, additional turn lanes for NB and WB movement	City of Salem TSP
	New signal at Lancaster and Carson Road	STIP (2004-2007)
	Realign curves and widen to 3 lanes (Highway 22 to Kuebler Blvd)	Salem CIP
Commercial Street	North and southbound left turn lanes @ Wiltsey Street	SKATS TSP
Silverton Road	Traffic signal interconnect Brown to Cordon	STIP (2004-2007)
	Traffic signal interconnect Lancaster to 45th	
	Traffic signal interconnect Lockhaven (River Rd N to I-5)	
Center Street	Traffic signal interconnect 12th to Hawthorne	STIP (2004-2007)
Market Street	N River Road to Rickman Rd pedestrian improvements	SKATS TSP
Chemawa Rd/Lockhaven Dr	Bridge replacement over Claggett Creek	STIP (2004-2007)
	Traffic signal interconnect from Fred Meyer to Shangri La	SKATS TSP
Broadway Street	Left turn lanes from SB Oregon 99E to Howell Prairie Rd	Marion County Draft TSP
Portland Rd/Hwy 99E/Fairgrounds Rd	Left turn lane from northbound 99E to Boones Ferry road	STIP (2004-2007)
	Traffic signal interconnect Erixon to Lana	SKATS TSP
	Traffic signal interconnect with Hayesville and Chemawa	
	Install new actuated and interconnected traffic signals at Kale Street	STIP (2004-2007)
12th/13th St SE	12th Street Pedestrian Promenade	SKATS TSP
	Traffic signal interconnect Hines and Hoyt	
	Traffic signal interconnect Mission to Hoyt	STIP (2004-2007)
Hawthorne Avenue	Widen to 2 travel lanes with center turn lane Portland Road to Sunnyview Road	Salem CIP
Liberty Road SE	Widen to add left-turn lanes on all approaches at Madrona Aveneue SE	STIP (2004-2007)
25th Street/Madrona Avenue	Madrona and Liberty Road left turn refuges and signal upgrade	STIP (2004-2007)
Turner Road	No improvements at this time	
Transit Improvements	Transit garage retrofit	STIP (2004-2007)
	Preventative maintenance	
	Transit station construction (South Salem and Keizer)	
	Streetcar feasibility study	
	High Priority Transportation Corridor Implementation N River Road/Broadway	

Table 1-4. Planned Projects on Study Area Corridors (continued)

Study Corridor	Project	Report/Plan
Bridge Improvements	Bridge Replacement Capitol Street Bridge at Mill Creek Bridge Replacement Center Street Bridge at Mill Creek Bridge Replacement Summer Street Bridge at Mill Creek Bridge Replacement Commercial Street Bridge at Pringle Creek Bridge Replacement Liberty Street Bridge at Pringle Creek Bridge Replacement 14th Street Bridge at Shelton Ditch	Salem CIP

City of Salem Capital Improvement Program: This plan consists of a variety of projects to improve the City of Salem's multi-modal transportation system. The community has not approved a transportation general obligation bond since 1995. Given the lack of bond funding, the majority of street improvement projects proposed for funding in this issue are to be constructed using Transportation System Development Charges.

1.16.5 Oregon ITS Strategic Plan (1997-2017)

ODOT developed the Oregon ITS Strategic Plan to set a vision and goal for ITS in Oregon. The plan includes a summary of existing ITS infrastructure, high priority user services, and ITS implementation strategy, timeframe and associated costs. Both regional and statewide projects are included for implementation in the short (1997-2002), mid (2002-2007) and long term (2007-2017). Some of the projects that have been identified for Region 2 over the next 15-year are outlined below.

- Install Photo Violation Detection (Short-term)
- Regional Traffic Management Center (TMC) (Short-term)
- Incident Dispatch and Response (short-term)
- Automatic Incident Detection System (Medium Term)
- Variable Message Signs (Medium-term)
- Installation of CCTV Surveillance Cameras (Long-term)

The list of statewide projects is quite lengthy and encompasses many aspects of ITS, such as transportation operations, traffic and incident management, traveler information, emergency response, and traveler safety.

1.16.6 Salem-Keizer Transit Strategic Business Plan

The Salem-Keizer Transit District developed the strategic plan in an effort to define what their mission means in practice and how can best be accomplished. The main component of the service program over the next five-year period is the conversion of the current radial pulse pattern of service to what has been coined the "3C" system of neighborhood circulators, outlying transit centers, and high-frequency corridor routes. This shift will potentially provide greater capacity, flexibility and efficiency by enabling the system to attract more riders, adapt to the changing communities and improve mobility to more neighborhoods. Additionally, Intelligent Transportation Systems (ITS) technology is programmed to improve service speed, quality of the transit experience and improved information for riders.

CHAPTER 2

User Needs Assessment

2.1 Introduction

This chapter provides a summary of transportation system user needs for the Salem-Keizer Metropolitan Area gathered from project stakeholders. Personal key stakeholder interviews and expanded stakeholder questionnaires contributed to a comprehensive list of user needs for the region. This chapter also includes a summary of the interviews and questionnaires that were conducted and an assessment of regional strengths, weaknesses, opportunities, and challenges. The assessment of current and future transportation user needs in the Salem-Keizer area provides the backbone for the development and evaluation of potential ITS projects.

The *Stakeholders and System Users* section describes details from the interviews and questionnaires. The *Summary of User Needs* section highlights the user needs identified by stakeholders organized by the following areas of interest:

- Travel and Traffic Management
- Public Transportation Management
- Emergency Management
- Maintenance and Construction Management
- Information Management

2.2 Stakeholders and System Users

To ensure the success of the *Regional ITS Operations & Implementation Plan for the Salem-Keizer Metropolitan Area*, a coalition of stakeholders and system users was created to gather input and build consensus. Efforts were taken to include a variety of interested stakeholders into the development of the plan, due to the broad array of positive impacts and benefits that ITS provides to the community. Personal interviews with key stakeholders targeted numerous subjects, while questionnaires focused primarily on gathering the big picture user needs from expanded stakeholders. After the completion of the interviews and questionnaires, a workshop for both the key and expanded stakeholders was held to discuss and verify the transportation needs that had been identified previously and to determine any additional needs.

2.2.1 *Personal Interviews*

Key stakeholders with decision-making authority regarding matters such as ITS implementation and institutional coordination were interviewed personally. The interviews were conducted to identify user needs, regional transportation problems, institutional relationships, and obstacles to

ITS implementation. Each interview lasted approximately one hour, the notes taken during the interviews can be found in Appendix D. One or more representatives from the following agencies were interviewed:

- ODOT Region 2
- Salem Public Works Dispatch 9-1-1 Center
- City of Salem
- City of Keizer
- Cherriots
- Marion County
- Polk County

2.2.2 Expanded Stakeholder Questionnaire

An online questionnaire was developed and e-mailed to the project's expanded stakeholders to determine user needs, agency coordination and perceived problems with the transportation system. The questionnaire was sent to public agencies indirectly involved with the project. Questionnaire recipients included the following:

- Marion County (Public Works, Engineering, Operations and Maintenance)
- Emergency Management (Marion and Polk County)
- Red Cross, Emergency Services
- Police (Salem, Keizer)
- Fire Department (Salem, Keizer)
- Salem-Keizer School District (Security)

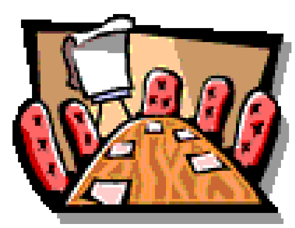
Of the 18 questionnaires sent, there was one response. This response can be found in the Appendix E, along with a complete list of questionnaire recipients and a copy of the questionnaire.

2.2.3 User Needs Assessment Workshop

A user needs assessment workshop was conducted with a group of key and expanded stakeholders to discuss and finalize the existing list of transportation needs. The workshop participants included representatives from some of the agencies listed above and contributed to an expanded collection of user needs for the Salem-Keizer Metropolitan Area.

The workshop included a presentation that provided project background information, an overview of the plan process, general ITS uses, and a summary of the previous needs identified from stakeholder interviews. After the presentation, a group discussion was conducted to gain consensus on the existing list of needs and to identify additional needs. The discussion was organized by the following interest areas:

- Traffic Operations and Management
- Emergency Management and Incident Management
- Traveler Information and Information Management
- Public Transportation Management
- Maintenance and Construction Management



A preliminary list of needs was also classified into functional areas, similar to those outlined above and placed on a poster for a project scoring exercise. Each participant was given five dots to place in the areas that represented the most critical need from their perspective. The outcome of this workshop was a comprehensive list of prioritized, user needs for the region that will be used as input for the subsequent steps of the planning process. The workshop invitation, presentations, workshop handout and meeting minutes can be found in Appendix F.

2.3 Project Mission Goals & Objectives

Key project stakeholders developed a mission statement and accompanying goals and objectives to guide the development and deployment of intelligent transportation systems in the Salem-Keizer Metropolitan Area.

2.3.1 Mission Statement

To enhance economic productivity by improving the safety, efficiency, and reliability of our existing and future transportation system using enhanced operations, advanced technologies, coordinated management techniques and real-time information.

2.3.2 Goals

Improve the safety, efficiency and reliability of our transportation system.

<u>*Objectives*</u>

- Reduce frequency, duration, and effects of incidents.
- Reduce emergency response times.
- Reduce recurrent congestion.
- Coordinate incident/emergency response with other local and regional agencies.
- Improve the management and operations during incidents and emergencies.

Enhance management of the transportation system to improve maintenance and operations efficiencies.

<u>*Objectives*</u>

- Reduce the number of stops.
- Reduce overall vehicle hours of delay.
- Reduce incident related capacity restrictions.
- Increase average vehicle occupancy.
- Reduce intermodal transfer time.
- Reduce fuel consumption and environmental impacts.
- Provide weather information to coordinate snow and ice removal.
- Enhance management and maintenance of vehicle fleets.
- Provide more efficient response to customer complaints.
- Reduce operating costs by improving maintenance and operations processes.

Improve traveler mobility.
Objectives

- Reduce recurrent and non-recurrent congestion related delay.
- Improve travel time for all transportation system users including transit vehicles, commuters, freight, and tourists.
- Improve travel time reliability.
- Improve transit travel time reliability.

Provide improved traveler information and access to the information.
Objectives

- Provide real-time multi-modal transportation system information to travelers.
- Provide real-time information about construction activities.
- Provide incident information.
- Provide real-time road condition and weather information.
- Provide one location where customers can access all regional and local traveler information.
- Provide accessible traveler information to all users of the transportation system.
- Provide one central location for dissemination of all traveler information.

Secure/develop a continuing commitment to ITS deployment by utilizing public-public and public-private partnerships
Objectives

- Deploy systems that fit in with future improvements and can be coordinated and integrated with other agencies.
- Deploy systems with a high benefit-to-cost ratio and maximize the use of existing infrastructure.
- Deploy systems with minimal maintenance and operational support requirements.
- Integrate deployments with other local and regional projects.
- Share infrastructure and operations resources between local and regional agencies.
- Build consensus among the Steering Committee members.
- Follow a phased plan and implement projects with high likelihood of success.
- Evaluate ITS projects using before and after surveys to document and promote the benefits and educate the public.
- Use data collection devices to document and track the transportation system performance.
- Educate decision makers, operators, planners and engineers using outreach, project benefit summaries, training and workshops.

2.4 SUMMARY OF USER NEEDS

This section contains paraphrased statements that summarize the user needs gathered from the interviews and questionnaires. User needs are categorized by the following areas of interest: Travel & Traffic Management, Public Transportation Management, Emergency Management, Maintenance & Construction Management and Information Management. Some needs may apply to multiple categories and any similar user need statements are likely the result of comments from separate stakeholders. The transportation user needs outlined in this section will then be mapped into the national ITS architecture user services (Chapter 3) prior to determining applicable ITS projects for the Salem-Keizer Metropolitan Area.

2.4.1 Travel and Traffic Management Needs

Travel and traffic management user needs and deficiencies were identified in this section and categorized into the following areas of interest: traffic operations and management, incident management, and traveler information.

2.4.1.1 Traffic Operations and Management Needs

- Need ability to automatically collect vehicle counts with classification
- Need more count stations
- Need to use automatic traffic recorders for detour route plans
- Need to install cameras
  - at all new intersections
  - Interstate 5 interchanges
  - West Salem bridges
  - Mission Street
  - Cordon Road
  - Lancaster Road
  - Salem Parkway
- Need means to show traffic congestion on key corridors
- Need the ability to share access to video images and data devices
- Need to set up an incident management plan/tool for using Willamette River Bridge for reverse traffic in the event of one bridge closure
- Need real-time construction mapping information
- Need mapped height and weight restrictions for possible diversion routes
- Need to communicate height and weight restrictions to the detour route (for incidents or pre-planned construction)
- Need to integrate systems between local transportation and emergency agencies
- Need to support "unrestricted freight mobility"

- Need to address safety and blocking issues at rail crossings
- Need to provide additional information regarding flood monitoring and slide monitoring
- Need advanced traffic control
- Need to provide railroad crossing occupation
- Need to communicate closures due to events held at the Capitol
- Need to provide information on Capitol closures to public and emergency responders
- Need parking management at the convention center
- Need advanced notification about parking for convention center
- Need a parking management plan and advanced signage to communicate parking information
- Need to manage parking structures downtown

2.4.1.2 Incident Management Needs

- Need improved detour route management
- Need a common communication link
- Need to provide advanced information to travelers (variety of media and provide other choices)
- Need to enhance the incident management program
- Need to provide additional video coverage
- Need to provide traveler information for incidents on Commercial Avenue
- Need to provide incident classification information (fender bender vs. major)
- Need to separate severity of accidents to filter the page notification
- Need to provide incident detection
- Need to provide infrastructure to support detection/traveler information
- Need to have tool to indicate traffic speeds on the roadside so that a page can be sent when traffic slows or stops
- Need to distribute information to the media
- Need signal interconnect on Cordon Road to automatically switch to an emergency signal timing plan
- Need to provide advanced information to east / west travelers intersecting Cordon Road in the event of a detour
- Need to get air bag deployment data from private sector vendors
- Need to investigate crime scenes quicker and more efficiently
- Need to define what needs to be included in accident investigations

2.4.1.3 Traveler Information Needs

- Need real-time, accessible traveler information
- Need to install VMS at:
  - Lancaster
  - Cordon (I-5 detour route)
  - Silverton Road
  - Highway 22 East
  - River Road northbound at Brooklake Road
  - 99W/Highway 22 intersection
- Need to utilize and implement dynamic message signs, highway advisory radio, Internet, Cable TV, in-vehicle, 511, radio for distribution of traveler information.
- Need a quality image for TripCheck, current cameras are black and white
- Need to integrate information from multiple sources (construction, incidents, public transit, congestion, alternate routes)
- Need to include parking information on highway advisory radio in Salem
- Need to be able to broadcast messages to cellular phones
- Need to be able to link traffic information to xm radio for use with existing xm traveler information channel

- Need traveler information for the Willamette River Bridges due to limited alternate route options
- Need to be able to access information about operational status of ferry systems
- Need to be able to post images on internet (ODOT TripCheck)
- Need weather stations at:
    - West Salem Hill
    - Fall City
    - Grand Ronde

2.4.2 Public Transportation Management Needs

- Need to utilize automatic vehicle locaters (AVL) on Cherriots fixed-routes
- Need to implement Mobile Data on paratransit
- Need to support the High Priority Transportation Corridor
- Need to implement transit signal priority along bus routes
- Need to incorporate transit arrival information
- Need a uniform CAD interface from fixed route to paratransit
- Need to provide support for the regional trip planner
- Need to disseminate information about the operational status of ferry from Salem
- Need ferry information on TripCheck
- Need advanced signage to indicate ferry is closed
- Need security cameras to remote sites and safety management on ferry

2.4.3 Emergency Management Needs

- Need to facilitate preemption by vehicle ID
- Need to share incident information between 911, police, fire and transportation
- Need the ability to communicate with Salem Police Department
- Need to get data from Mayday systems (private sector data feed)
- Need to deploy vehicle tracking on fire department vehicles
- Need to provide real-time information to mobile data devices
- Need to enhance evacuation management
- Need to have information related to road closures, major accidents, and detour information available to 911 center
- Need to share incident information between computer aided dispatch (CAD) systems.
- Need evacuation plan in case of a major rail event involving hazardous materials
- Need some plan for terrorist attacks and Capitol mall security issues
- Need to notify public about road closures and affects on rail in the event of a terrorist attacks
- Need to be able to share digital video to first responders
- Need to have video dispatch center
- Need a link between the region's Emergency Operations Center (EOC) and Agency Operations Center (AOC)

2.4.4 Maintenance and Construction Management Needs

- Need to implement in-vehicle geo-coding of maintenance items (potholes, tree-limbs, signs)
- Need to provide a central source for construction information/construction zone coordination
- Need to enhance construction zone management to improve safety (video on site)
- Need to improve construction activity information (e.g. monitor delays, provide travel time information)
- Need to put all construction information in one location
- Need to provide operators at the TOC with construction activity information
- Need to provide RWIS information to TripCheck
- Need a better application of weather data, processing, road surfaces, and black ice automation
- Need better traffic control and advance signing in construction zones
- Need better maintenance planning

2.4.5 Information Management Needs

- Need to install sufficient communications infrastructure to support future bandwidth requirements
- Need to install communications over the bridges
- Need to provide the NWTOC with access to all weather stations
- Need a cable channel dedicated to travel/incident management
- Need an automatic notification system for the media
- Need communication between City of Salem and ODOT Traffic Operations Center
- Need a filter mechanism to filter out "extra" information so that you only see/hear the information you need.

2.5 Strengths, Challenges and Opportunities

Throughout the interviews and the development of the existing and future conditions chapter of the report, the project team identified strengths, weaknesses, opportunities, and challenges that may affect the deployment of ITS projects in the Salem-Keizer Metropolitan Area. Each of these areas represents information that is valuable to developing an ITS plan that is tailored to fit the specific characteristics of the study area.

Table 2-1. Regional Challenges

Challenges	Suggested Preventative Measures
• Lack of available resources and funding	• Identify other creative non-traditional funding opportunities
• Lack of high speed communications to field devices	• Minimize the required resources by deploying ITS technologies that meet ITS standards and are easy to operate and maintain.
• Limited interagency connectivity	• Focus on deploying technologies that enhance the informational flow between agencies and provide a common communication interface.
• Willamette Bridges – limited alternatives	• Develop alternative route/plan that could be used in an emergency event
• ITS education	• Clearly demonstrate the benefits of ITS in an outreach and education program and by collecting before and after data from ITS deployments
• Finding on-going funding sources • Funding operations and maintenance • Supporting freight mobility (provide reliable travel times)	• Focus on long and short-term evaluation of ITS implementation to support funding needs and demonstrate benefits that building new infrastructure can't provide (i.e non-recurring congestion such as incidents and special events).

Table 2-2. Regional Strengths

Strengths	Suggestions to Capitalize on Strengths
• Northwest Transportation Operation Center • ODOT's Incident Response Team • Salem central signal system and communications infrastructure • Regional interest in communications • Support for ITS exists at all levels	• Integrate the TOC with regional transportation agencies and determine a strategy for regional traffic operations, management, and information sharing. • Document the success of the incident response team to showcase preliminary benefits of communications between emergency responders and transportation agencies. • Utilize the construction of fiber optic cable around the area to coordinate with other jurisdictions and accelerate the deployment of ITS field equipment • Maintain this support through continued outreach, education and identification of funding sources

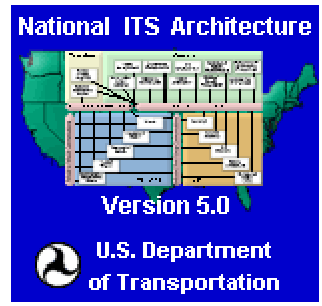
Table 2-3. Regional Opportunities

Opportunity	Suggested Action Plan
• Existing Salem video detection • Planned Capital Improvement Projects: New signals and communications I-5 Widen to 6 lanes (Highway 22 to Kuebler Blvd) OTIA projects Transit Improvements Fiber optic infrastructure projects Salem video data collection project	• Utilize existing cameras as a low-cost "early winner" project by displaying camera images on ODOT's TripCheck website. • Capitalize on new construction projects and install communications infrastructure (i.e. conduit) and other ITS equipment defined in this plan. • Integrate planned transit improvements with the deployment of ITS technologies.

CHAPTER 3

REGIONAL ITS ARCHITECTURE

3.1 INTRODUCTION



This chapter provides a summary of the National ITS Architecture[1] and how it applies to the deployment of intelligent transportation systems in the Salem-Keizer Metropolitan Area. This includes definitions of National ITS Architecture terminology, the Salem-Keizer Metropolitan area ITS systems inventory, descriptions of the user services and market packages selected by the Steering Committee to meet the needs of the Salem-Keizer area transportation network, and applicable ITS standards.

3.1.1 Why Develop an ITS Architecture?

The U.S. Department of Transportation (U.S. DOT) developed the National ITS Architecture to ensure that intelligent transportation systems deployed around the country can communicate with each other and share information to maximize the return of investment on ITS. The architecture is a framework that describes the functions of system components, how these components interconnect, the organizations involved, and the type of information to be shared.

For example, if a transportation agency wants to clear incidents faster, the architecture defines a function to monitor roadways and identifies the interconnection and information flows between the roadway, the traffic management center, and the emergency management center needed to provide responders with incident information. The architecture provides the framework for the process, but does not define how this is done with technology or management techniques.

The reasons for developing a regional ITS architecture tailored to the Salem-Keizer Metropolitan area include the following:

- Develop a framework for institutional agreements and technical integration for organized ITS project deployment that meets local transportation user needs.
- Build consensus among regional stakeholders about resource and information sharing and activity coordination.
- Meet federal funding requirements.

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[1] *National ITS Architecture, Version 5.0*. U.S. Department of Transportation. April 1, 2004. http://itsarch.iteris.com/itsarch/. Accessed April 19, 2005.

The Federal Highway Administration (FHWA) published a final rule[2] that all agencies seeking federal highway trust funding for ITS projects must develop a regional architecture that is compliant with the National ITS Architecture. The Federal Transit Administration (FTA) published a similar policy[3] that applies to federal funding from the mass transit account of the highway trust fund.

The Regional ITS Architecture must include the following elements:

- **Description of the Region**: Included in Chapter 1 and Turbo Architecture
- **Identification of Stakeholders**: Included in Chapter 2 and Turbo Architecture
- **Operational Concept**: Included in Turbo Architecture and Chapter 4
- **Interface Requirements and Information Exchanges**: Included in Turbo Architecture
- **Identification of ITS Standards**: Included in Section 3.4 and Turbo Architecture
- **Sequence of Projects Required for Implementation**: Presented in Implementation Plan (Chapter 6)

3.2 REGIONAL ITS ARCHITECTURE DEVELOPMENT APPROACH

The Salem-Keizer Regional ITS Architecture was developed based upon the regional transportation network infrastructure, the user needs identified by stakeholders through interviews, questionnaires, and the user needs assessment workshop, and the *Regional ITS Architecture Guidance*[4]. *Turbo Architecture*[5], a software tool designed to support development of regional and project architectures based on the National ITS Architecture, was used to document the Salem-Keizer Regional ITS Architecture. This *Turbo Architecture* database is intended to be a living document that will be updated by the key stakeholders as regional needs change over time. The Salem-Keizer Turbo Architecture file will be managed by the Mid Willamette Valley Council of Governments (MVCOG) with support from ODOT.

The following steps, illustrated in Figure 3-1, were followed in the development of the regional architecture:

- **Stakeholder Input**: Key and expanded stakeholders, who are listed in Chapter 2, provided input throughout the architecture development process to obtain regional consensus.

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2 *Intelligent Transportation System Architecture and Standards: Final Rule*, U.S. Department of Transportation, Federal Highway Administration, FHWA Docket No. FHWA-99-5899, Jan. 8, 2001.

3 *Federal Transit Administration National ITS Architecture Policy on Transit Projects: Notice*, Federal Transit Administration, FTA Docket No. FTA-99-6147, Jan. 8, 2001.

4 National ITS Architecture Team. *Regional ITS Architecture Guidance: Developing, Using, and Maintaining an ITS Architecture for Your Region*. Prepared for U.S. Department of Transportation, Federal Highway Administration, and Federal Transit Administration. FHWA-OP-02-024. Oct. 12, 2001.

5 *Turbo Architecture, Version 3.0*, developed by Iteris for the U.S. Department of Transportation, Federal Highway Administration, 2004.

- **Systems Inventory**: Existing and planned ITS system elements, described in Chapter 1, were input into the architecture. The *Turbo Architecture* inventory report for the regional architecture can be found in Appendix G.
- **Map User Needs to User Services**: The transportation user needs, documented in Chapter 2, were mapped to user services to ensure the architecture meets the regional needs.
- **Market Package Selection**: Market packages were selected based on the systems inventory and user needs.
- **Interconnect and Information Flow Customization**: Information flows between subsystems were customized to ensure that the architecture reflects existing and planned regional interconnects.

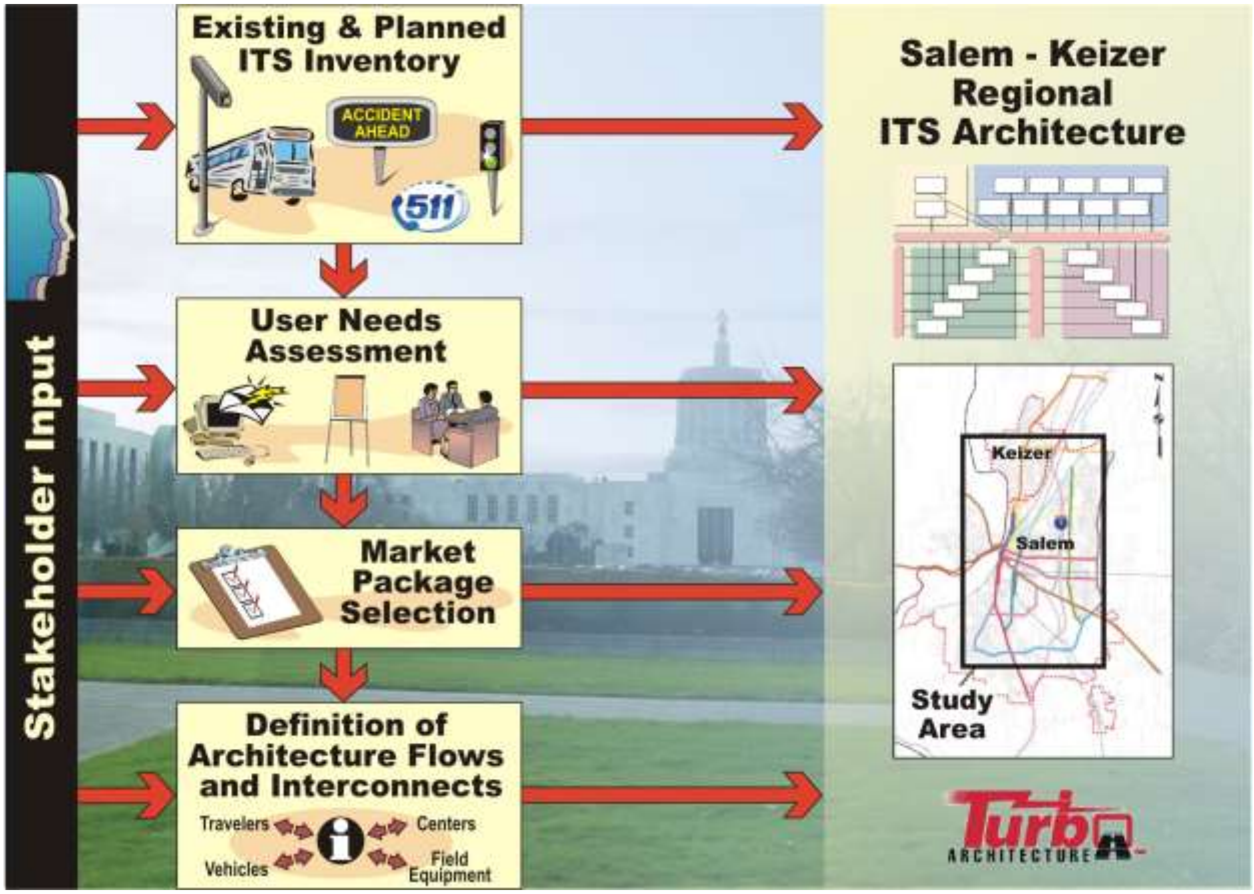

Figure 3-1. Regional ITS Architecture Development Process

The Salem-Keizer regional architecture has been constructed to be compliant with the existing Oregon statewide architecture. The Salem-Keizer regional architecture provides more detail about the stakeholders and the system elements in the region, while the Oregon statewide architecture provides a higher level view of ITS in Oregon. Common elements existing in both architectures and identify interfaces between the two architectures.

3.3 NATIONAL ITS ARCHITECTURE OVERVIEW

The National ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems. It is a mature product that reflects the contributions of a broad cross-section of the ITS community (transportation practitioners, systems engineers, system developers, technology specialists, etc.). The architecture defines:

- The functions (e.g., gather traffic information or request a route) that are required for ITS applications.
- The physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle).
- The information flows that connect these functions and physical subsystems together into an integrated system.[6]

The purpose of a Regional Architecture is not to specify specific technologies that will be used in ITS deployments, but rather to define the functions that the technologies should perform. The architecture provides structure for defining general ITS functional requirements during the planning and design process. Key terms and concepts related to the National ITS Architecture are discussed below.

3.4 Salem-Keizer Regional ITS Architecture

This section includes further descriptions of the National ITS Architecture user services, subsystems, and market packages that were selected for the Salem-Keizer Metropolitan Area. Additional details may be found in the Salem-Keizer Turbo Architecture database.

3.4.1 User Services

User services describe what functions intelligent transportation systems should perform from the user's perspective. Users encompass a broad range including groups such as the traveling public, transportation agency personnel, emergency management personnel, and commercial vehicle operators. Although a user service is a functional requirement of the system, it does not describe where components fit into the architecture or how the service will be implemented. Selection of user services provides a high-level means of identifying the services to provide that address the regional user needs and problems. To simplify the range of requirements in a broad area of services, the user services are logically grouped into the following eight user services bundles.

- Travel & Traffic Management
- Public Transportation Management
- Electronic Payment
- Commercial Vehicle Operations
- Emergency Management
- Advanced Vehicle Safety Systems
- Information Management
- Maintenance & Construction Management

Table 3-1 includes the 33 nationally defined user services and indicates the ones selected by the Steering Committee based on the regional user needs documented in Chapter 2. A description of each user service may be found on the National ITS Architecture website[7].

[6] US DOT, National ITS Architecture, Version 5.0

[7] *User Services Bundles and User Services*. U.S. Department of Transportation. Nov. 3, 2003. itsarch/iteris.com/itsarch/html/user/userserv.htm. Accessed March 24, 2004.

Table 3-1. User Service Bundles and User Services

User Services Bundles and User Services	User Need Areas						
	Traffic Operations & Management	Incident Response	Traveler Information	Public Transportation Management	Emergency Management Operations	Information Management	Maintenance & Construction Management
Travel & Traffic Management							
Pre-Trip Travel Information			✓				
En-Route Driver Information		✓	✓	✓	✓		
Route Guidance		✓	✓	✓	✓		
Ride Matching & Reservation			✓	✓			
Traveler Services Information			✓				
Traffic Control	✓		✓	✓	✓	✓	
Incident Management	✓	✓	✓		✓		
Travel Demand Management	✓		✓	✓			
Emissions Testing & Mitigation							
Highway Rail Intersection	✓						
Public Transportation Management							
Public Transportation Management			✓	✓			
En-Route Transit Information			✓	✓			
Personalized Public Transit				✓		✓	
Public Travel Security				✓			
Electronic Payment							
Electronic Payment Services				✓			
Commercial Vehicle Operations							
Commercial Vehicle Electronic Clearance	✓						
Automated Roadside Safety Inspection							
On-Board Safety & Security Monitoring							
Commercial Vehicle Administrative Processes	✓						
Hazardous Material Security & Incident Response	✓	✓					
Freight Mobility	✓		✓				✓
Emergency Management							
Emergency Notification & Personal Security	✓	✓			✓		
Emergency Vehicle Management		✓			✓		
Disaster Response & Evacuation	✓	✓			✓		
Advanced Vehicle Safety Systems							
Longitudinal Collision Avoidance							
Lateral Collision Avoidance							
Intersection Collision Avoidance	✓						
Vision Enhancement for Crash Avoidance							
Safety Readiness							
Pre-Crash Restraint Deployment							
Automated Vehicle Operation							
Information Management							
Archived Data Function	✓			✓		✓	
Maintenance & Construction Management							
Maintenance & Construction Operations	✓			✓			✓

3.4.2 Physical Architecture for Salem-Keizer

The physical architecture provides a framework for the physical elements of ITS systems. It consists of subsystems, equipment packages, terminators, architecture flows, and architecture interconnects, which are all described in this section. Figure 3-2 illustrates the high-level physical architecture customized for the Salem-Keizer metropolitan area. The intent is to show the existing and planned subsystems in the region, and the types of communications links between them.

3.4.2.1 Subsystems

A subsystem represents a grouping of processes defined in the logical architecture that may be defined by single entities. There are 19 subsystems in the physical architecture that are assigned to four overarching classes that correspond to the physical world as described in Table 3-2 and illustrated in Figure 3-2.

Table 3-2. Subsystem Classes

Subsystem Class	Function	Real World Examples
Centers	Systems or applications that process and use information to control the transportation network.	✦ ODOT Northwest Transportation Operations Center (NWTOC) ✦ 911 Centers
Field	Provide direct interface to the roadway network, vehicles traveling on the roadway network, and travelers in transit.	✦ Dynamic Message Signs ✦ Highway Advisory Radio ✦ Weigh-in-Motion Stations
Vehicles	Use the roadway network and provide driver information and safety systems.	✦ Cherriots Buses ✦ Emergency Response Vehicles
Travelers	Systems or applications that provide information to travelers.	✦ TripCheck Website ✦ 511 Traveler Information Number

3.4.2.2 Equipment Packages

Equipment packages group similar processes of a subsystem together into an implementable package that addresses user services. The equipment packages are considered the building blocks of the physical architecture subsystems. Table 3-3 lists several examples of equipment packages in the National ITS Architecture.

Table 3-3. Sample Equipment Packages

Equipment Package	Process Specifications (PSpecs)	User Service Addressed
Roadway Basic Surveillance	✦ Process Traffic Sensor Data ✦ Process Traffic Images	Traffic Control
Transit Center Tracking and Dispatch	✦ Manage Transit Vehicle Operations ✦ Update Transit Map Data	Public Transportation Management
Emergency Evacuation Support	✦ Manage Emergency Response ✦ Provide Operator Interface for Emergency Data ✦ Provide Evacuation Coordination	Disaster Response and Evacuation

Figure 3-2. Salem-Keizer High Level Physical Architecture

3.4.2.3 Terminators

Terminators are generally defined as people, systems and the general environment that are outside the boundary or control of ITS, but still impact ITS systems. Interfaces between subsystems and terminators need to be defined, but there are no ITS-related functional requirements associated with terminators. Since regional architectures are usually developed from a specific agency(s) perspective, an entity that impacts ITS but is out of the bounds of the primary agency's perspective is called a terminator. This is done to illustrate ownership/ control of the proposed services. Examples of terminators include "Transit Vehicle Operator", "Other Traffic Management" (such as a traffic management center that is outside of the study area but that still interacts with entities within the study area), and "Financial Institution" (such as a bank that holds revenues from transit fares or toll collection).

3.4.2.4 Architecture Flows

An architecture flow is the information that is exchanged between subsystems and terminators in the physical architecture. These flows and their communication requirements are used to define the interfaces which are the basis for much of the ongoing standards development in the National ITS Architecture program. The current US DOT guidelines require that a Regional ITS Architecture be developed at a sufficient level of detail to show subsystems and architecture flows. Appendix H includes all of the architecture flows identified in the Salem-Keizer Metropolitan Area Regional ITS Architecture.

3.4.2.5 Architecture Interconnects

Architecture interconnects, also called information interconnects, are the communications paths that carry architecture flows between the subsystems and terminators. These interconnects are typically grouped into one of the four categories listed in Table 3-4. Chapter 5 provides a detailed summary of the communications requirements for the Salem-Keizer Regional ITS Architecture.

Table 3-4. Architecture Interconnects

Interconnect	Function	Real World Example
Fixed-Point to Fixed-Point Communications	Uses a communications network to link stationary entities.	✦ Fiber optic connection between a traffic management center and a CCTV camera
Wide Area Wireless Communications	Uses wireless devices to link users and infrastructure-based systems.	✦ Mobile telephone used to access traveler information
Dedicated Short Range Communications	Uses short to medium range (300-1000 feet) wireless communications channels to link vehicles and the infrastructure.	✦ Radio waves between a roadside transmitter and a vehicle
Vehicle to Vehicle Communications	Uses a wireless system to link communications between vehicles.	✦ Future vehicle collision avoidance systems

3.4.3 Market Packages

Market packages are deployment-oriented groupings of physical architecture entities that address specific user services. The user services identified in Section 3.3.1 are too broad in scope to aid in the planning of actual deployments. Market packages are made up of one or more equipment packages that work together to deliver a transportation service and the architecture flows that connect them with subsystems and terminators. Figure 3-3 illustrates a sample market package that includes subsystems (the large rectangular boxes), the equipment packages (the small rectangular boxes), the terminators (the ovular boxes), and the architecture flows (the arrows).

Market packages for the Salem-Keizer metropolitan area were selected early in the ITS plan development process to stimulate ideas about regional needs that may not have been previously identified. Table 3-5 lists the market packages selected by the Steering Committee and includes both existing market packages already deployed and planned market packages that will be deployed within the next 20 years as part of this plan. Eight broad categories of interest are used to group the 85 market packages and a description of each market package may be found on the National ITS Architecture website[8].

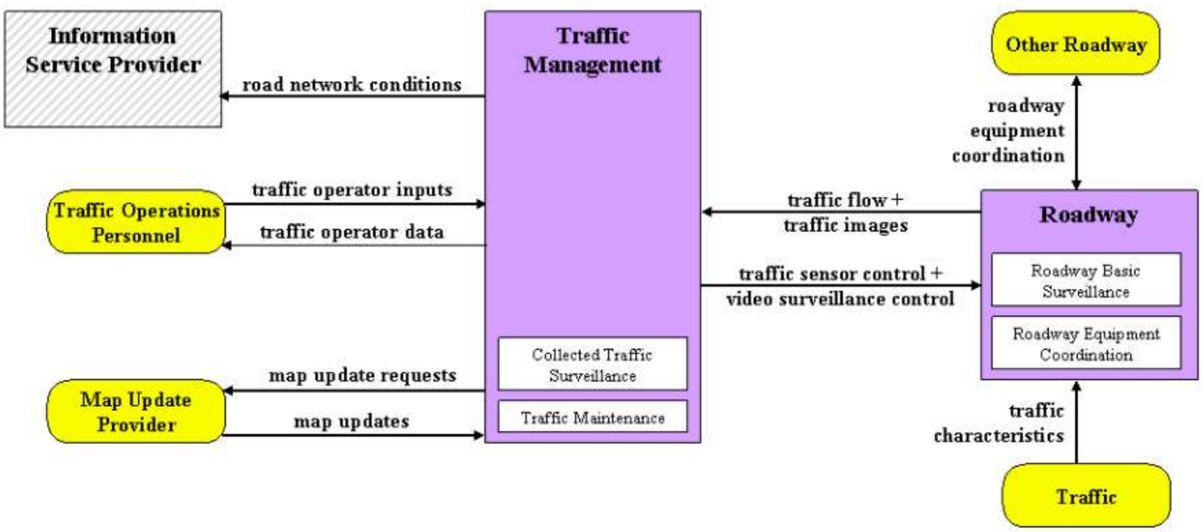

Figure 3-3. Sample Market Package Graphic: Network Surveillance

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8 *Market Packages*. U.S. Department of Transportation. Nov. 3, 2003. itsarch/iteris.com/itsarch/html/user/userserv.htm. Accessed March 24, 2004.

Table 3-5. Existing and Planned Market Packages (Page 1 of 3)

Market Packages (E = Existing, P = Planned)	**Key Stakeholders**							
	ODOT	City of Salem	City of Keizer	Marion County	Polk County	MWVCOG	Cherriots	Emergency Management
Archived Data (AD) Management								
AD1: ITS Data Mart	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**E**
AD2: ITS Data Warehouse						**P**		
AD3: ITS Virtual Data Warehouse								
Advanced Public Transportation Systems (APTS)								
APTS1: Transit Vehicle Tracking							**P**	
APTS2: Transit Fixed-Route Operations							**P**	
APTS3: Demand Response Transit Operations							**E**	
APTS4: Transit Passenger & Fare Management							**P**	
APTS5: Transit Security							**E**	
APTS6: Transit Maintenance							**E**	
APTS7: Multi-Modal Coordination	**P**	**P**	**P**	**P**			**P**	
APTS8: Transit Traveler Information							**P**	
Advanced Traveler Information Systems (ATIS)								
ATIS1: Broadcast Traveler Information	**P**	**P**	**P**	**P**			**P**	
ATIS2: Interactive Traveler Information	**E**	**P**	**P**	**P**			**P**	
ATIS3: Autonomous Route Guidance								
ATIS4: Dynamic Route Guidance	**P**	**P**	**P**	**P**			**P**	
ATIS5: ISP Based Route Guidance	**P**							
ATIS6: Integrated Transportation Mgmt/Route Guidance								
ATIS7: Yellow Pages & Reservation	**P**	**P**						
ATIS8: Dynamic Ridesharing	**P**						**P**	
ATIS9: In Vehicle Signing	**P**	**P**	**P**	**P**			**P**	
Advanced Traffic Management Systems (ATMS)								
ATMS1: Network Surveillance	**E**	**E**	**P**	**P**	**P**		**E**	
ATMS2: Probe Surveillance	**P**	**P**					**P**	
ATMS3: Surface Street Control	**E**	**E**	**E**	**P**	**P**			
ATMS4: Freeway Control	**P**							
ATMS5: HOV Lane Management								
ATMS6: Traffic Information Dissemination	**E**	**P**	**P**	**P**	**P**		**P**	
ATMS7: Regional Traffic Control	**P**	**P**	**P**	**P**	**P**			
ATMS8: Traffic Incident Management System	**E**	**E**	**E**	**E**	**P**			**E**
ATMS9: Traffic Forecast & Demand Management	**E**	**P**	**P**	**P**	**P**	**E**		
ATMS10: Electronic Toll Collection								
ATMS11: Emissions Monitoring & Management								
ATMS12: Virtual TMC & Smart Probe Data								
ATMS13: Standard Railroad Grade Crossing	**E**	**E**	**E**	**E**	**E**			
ATMS14: Advanced Railroad Grade Crossing								
ATMS15: Railroad Operations Coordination	**P**	**P**	**P**					
ATMS16: Parking Facility Management		**P**						
ATMS17: Regional Parking Management		**P**						
ATMS18: Reversible Lane Management	**P**	**P**						
ATMS19: Speed Monitoring								

Table 3-5. Existing and Planned Market Packages (Page 2 of 3)

Market Packages (E = Existing, P = Planned)	**Key Stakeholders**							
	ODOT	City of Salem	City of Keizer	Marion County	Polk County	MWVCOG	Cherriots	Emergency Management
ATMS20: Drawbridge Management								
ATMS21: Roadway Closure Management				**P**	**P**			
Advanced Vehicle Safety Systems (AVSS)								
AVSS1: Vehicle Safety Monitoring								
AVSS2: Driver Safety Monitoring								
AVSS3: Longitudinal Safety Warning								
AVSS4: Lateral Safety Warning								
AVSS5: Intersection Safety Warning	**P**	**P**	**P**	**P**				
AVSS6: Pre-Crash Restraint Deployment								
AVSS7: Driver Visibility Improvement								
AVSS8: Advanced Vehicle Longitudinal Control								
AVSS9: Advanced Vehicle Lateral Control								
AVSS10: Intersection Collision Avoidance	**P**	**P**	**P**	**P**				
AVSS11: Automated Highway System								
Commercial Vehicle Operations (CVO)								
CVO1: Fleet Administration								
CVO2: Freight Administration								
CVO3: Electronic Clearance	**E**							
CVO4: CV Administrative Processes	**E**							
CVO5: International Border Electronic Clearance								
CVO6: Weigh-in-Motion	**E**			**P**				
CVO7: Roadside CVO Safety								
CVO8: On-Board CVO & Freight Safety & Security								
CVO9: CVO Fleet Maintenance								
CVO10: HAZMAT Management	**P**	**P**						**P**
CVO11: Roadside HAZMAT Security Detection & Mitigation	**P**	**P**	**P**	**P**	**P**			**P**
CVO12: CV Driver Security Authentication								
CVO13: Freight Assignment Tracking								
Emergency Management (EM)								
EM1: Emergency Call-Taking & Dispatch								**E**
EM2: Emergency Routing								**P**
EM3: Mayday Support	**P**							**P**
EM4: Roadway Service Patrols	**E**							
EM5: Transportation Infrastructure Protection								
EM6: Wide-Area Alert	**E**							**E**
EM7: Early Warning System								
EM8: Disaster Response & Recovery	**P**	**P**	**P**	**P**	**P**		**P**	**P**
EM9: Evacuation & Reentry Management	**P**	**P**						**P**
EM10: Disaster Traveler Information	**P**	**P**	**P**	**P**	**P**			**P**

Table 3-5. Existing and Planned Market Packages (Page 3 of 3)

Market Packages (E = Existing, P = Planned)	**Key Stakeholders**							
	ODOT	City of Salem	City of Keizer	Marion County	Polk County	MWVCOG	Cherriots	Emergency Management
Maintenance & Construction (MC) Management								
MC1: Maintenance & Construction Vehicle & Equipment Tracking	**P**	**P**		**P**				
MC2: Maintenance & Construction Vehicle Maintenance								
MC3: Road Weather Data Collection	**E**	**P**		**E**				
MC4: Weather Information Processing & Distribution	**E**	**P**		**P**				
MC5: Roadway Automated Treatment								
MC6: Winter Maintenance	**P**	**P**		**P**				
MC7: Roadway Maintenance & Construction	**E**	**E**	**E**	**E**				
MC8: Work Zone Management	**P**	**P**	**P**	**P**	**P**			
MC9: Work Zone Safety Monitoring	**P**	**P**	**P**	**P**	**P**			
MC10: Maintenance & Construction Activity Coordination	**P**	**P**	**P**	**P**	**P**			

3.5 ITS STANDARDS

This section presents some general information on common ITS standards and their relevance to the implementation of ITS systems, both nationally and for the Salem-Keizer Metropolitan area. The US DOT supports the development of standards for specific systems through the ITS Standards Program, which has cooperative agreements with six standards development organizations[9].

Intelligent transportation systems depend on the ability to integrate many advanced technologies; ITS standards enhance this integration through interoperability and interchangeability. ITS standards contribute to interoperability by specifying consistency and compatibility between different ITS systems and components, including interconnects, interfaces, hardware and software. This allows agencies to deploy systems and technologies that can exchange information efficiently. These standards also promote interchangeability and assist in the selection and maintenance of ITS systems including: equipment replacement, system upgrades and system expansions.

As the development and testing of ITS standards progresses, requirements may be developed for their use on ITS projects that are accepting federal funding. Currently, there are no such federal mandates for ITS standards; however, there are many benefits of using standards and the US DOT strongly encourages their use as soon as possible. In some cases, agencies may have already procured systems that were developed prior to the development of the ITS standards, or

[9] Standard Development Organizations include: AASHTO, ITE, NEMA, ASTM, IEEE, SAE

that conform to another set of standards. In all cases, system engineering analysis[10] should be conducted to determine where ITS standards applications are feasible. The primary focus is on implementing standards on current and future projects so agencies interface ITS systems consistently and travelers can utilize technologies more efficiently. The sooner that the standards become recognized as an essential part of the deployment process, the sooner that the benefits can be recognized by agencies and travelers. Although standardizing may cost more initially, the long term benefits and cost savings can be substantial.

As of January 2005 there are 75 published standards with approximately 45 more approved, in ballot or under development. The U.S. Department of Transportation maintains an up-to-date, online summary on the status of ITS standards[11]. This web site provides an explanation of key standards and provides additional contact information for more details. ITS standards are under active development; information is being updated regularly at the US DOT web site and should be consulted for the latest information.

3.5.1 Standards and the National ITS Architecture

ITS standards define how system components operate within the National ITS Architecture. The National ITS Architecture links standards to market packages as a starting point for determining which ITS Standards may be applicable to a region. The Turbo Architecture database includes recommended/relevant standards for each architecture flow between elements. This information may be output as customized reports for specific architecture elements (such as, all of the potentially relevant standards for exchanging information between the ODOT NWTOC and OSP CAD).

3.5.2 Common Standards

Although the standards development effort is broad and many standards are still under development, there are a series of common standards that define terms, message sets and foundation standards that apply to many market packages. These standards form the basis for interoperability among systems by defining a common set of terms and message sets. Key standards that should be adopted and used by regional jurisdictions in the development of ITS applications are included in Table 3-6. These key baseline standards are critical for the deployment of a wide range of market packages because they establish the common vocabulary that allows different systems to speak with each other.

[10]Title 23, Code of Federal Regulations (CFR), Highways, Chapter 1: FHWA, Department of Transportation, Part 940: Intelligent Transportation Systems Architecture and Standards

[11] ITS Standards. US Department of Transportation. Site accessed April 8, 2005 http://www.standards.its.dot.gov/resource4.htm#gen

Table 3-6. Key Standards Recommended for the Salem-Keizer Region

Standard Development Organizations	Applicable Architecture Interfaces	Key ITS Standards Recommended for Salem-Keizer Regional ITS Architecture
AASHTO ITE NEMA	Traffic Management Centers to Other Centers	✦ National Transportation Communications for ITS Protocol (NTCIP) –
	Traffic Management Center to Field Devices	
	Roadside Signal Controllers	✦ Advanced Transportation Controller (ATC)
	Transit Center to Other Centers and Vehicles	✦ Transit Communications Interface Profile (TCIP)
ITE	Traffic Management Center to Other Centers	✦ Traffic Management Data Dictionary (TMDD) ✦ Message Sets for External Traffic Management Center Communications (MS/ETMCC)
IEEE	Emergency Management Center to Other Centers	✦ Standard for Incident Management Message Sets (IMSS) for Use by Emergency Management Centers
	General	✦ Standard for Data Dictionaries for Intelligent Transportation Systems
ASTM	Archived Data Management Center Interfaces	✦ Standard Guide for Archiving and Retrieving ITS-Generated Data
ASTM IEEE	Vehicle to Roadside	✦ Dedicated Short Range Communications (DSRC)
SAE	Traveler Information (Information Service Provider (ISP) Interfaces)	✦ Advanced Traveler Information Systems (ATIS) Data Dictionary ✦ Advanced Traveler Information Systems (ATIS) Core Message List and Data Dictionary
	Location Referencing	✦ Location Referencing Standards

3.5.3 National Transportation Communications for ITS Protocol

National Transportation Communications for ITS Protocol (NTCIP) provides communications protocols and data definitions for two different types of ITS communications. The first type of ITS communications is between two transportation management centers (or systems) and is called center-to-center (C2C). The second type is called center-to-field (C2F) and is the link from a transportation management system or center to a field device like a traffic signal or dynamic message sign.[12]

[12] *NTCIP: The National Transportation Communications for ITS Protocol Online Resource*. AASHTO, ITE, and NEMA. March 22, 2005. www.nctip.org. Accessed March 24, 2005

✦ **Center-to-Center Standards:** ODOT is planning on utilizing XML[13] for center-to-center communication, as opposed to either DATEX[14] or CORBA[15]. Many standards for XML have already been developed and are used widely in the IT industry. Message sets and data dictionaries for ITS utilizing XML are currently being converted from DATEX message sets by the Standard Development Organizations (SDO's).

✦ **Center-to-Field Standards:** For C2F applications, NTCIP offers the potential for interchangeability and interoperability of equipment from different suppliers on the same system. This family of standards provides both the rules for communicating (called protocols) and the vocabulary (called objects) necessary to allow electronic traffic control equipment from different manufacturers and transportation management centers to operate with each other as a system.[16] Key C2F standards that should be adopted and used by regional jurisdictions are included in Table 3-7.

Table 3-7. Key Center-to-Field Standards

NTCIP Standard	Name	Description
NTCIP 1201	Global Object Definitions	Provides the vocabulary—commands, responses and information—necessary for general device management, including those objects required for device identification, time-based schedule configuration, and event log configuration.
NTCIP 1203	Object Definitions for Dynamic Message Signs (DMS)	Defines data that is specific to dynamic message signs including all types of signs that can change state, such as blank- out signs, changeable signs, and variable signs.
NTCIP 1204	Object Definitions for Environmental Sensor Stations & Roadside Weather Information Systems	Defines those objects used to describe ambient conditions (including air pressure, wind, temperature, precipitation, sunlight, visibility, and air quality) and pavement conditions (including surface and subsurface temperature, moisture, treatment, etc.)
NTCIP 1205	Data Dictionary for Closed Circuit Television (CCTV)	A database for closed circuit television systems. The format of the database is identical to other NTCIP devices and uses Abstract Syntax Notation One (ASN. 1) representation. Targeted devices include cameras, lenses, video switches, and positioning controls for aiming and identification, such as videotext overlays.
NTCIP 1206	Data Collection and Monitoring Devices	Specifies object definitions that may be supported by data collection and monitoring devices, such as roadway loop detectors.

[13] eXtensible Markup Language (XML): a universal structured data transfer methodology that is currently widely used in e-business and e-government applications.
[14] DATa EXchange Between Systems (DATEX): one of the two approved NTCIP standards for center-to-center communications.
[15] Common Object Request Broker Architectures (CORBA): one of the two approved NTCIP standards for center-to-center communications.
[16] U.S. Department of Transportation. *Intelligent Transportation Systems, Standards Fact Sheet*. October 1999, AASHTO/ITE/NEMA TS 3.1, National Transportation Communications for ITS Protocol (NTCIP) Overview.

NTCIP Standard	Name	Description
NTCIP 1207	Ramp Meter Controller Objects	Specifications for objects that are specific to ramp metering controller operations.
NTCIP 1208	Object Definitions for Video Switches	Deals with the data needed to control a video switch enabling multiple monitors to view multiple video feeds.
NTCIP 1209	Transportation System Sensor Objects	Object definitions that are specific to and guide the data exchange content between advanced sensors and other devices in an NTCIP network. Advanced sensors include video-based detection sensors, inductive loop detectors, sonic detectors, infrared detectors, and microwave/radar detectors.
NTCIP 1210	Objects for Signal Systems Master	Defines the objects necessary to manage a field master.
NTCIP 1211	Objects for Signal Control Priority	Defines the management information base for Signal Control and Prioritization (SCP) Systems. It defines individual parameters that represent the configuration, status, and control information that is unique to an SCP and also defines specific groupings of these parameters and others to address the operational configuration, monitoring, and control of the device/entity in a baseline system configuration.

3.5.4 Transit Communications Interface Profiles (TCIP)

The Transit Communications Interface Profiles (TCIP)[17], a subset of NTCIP are communications standards for interfaces between subsystems involving transit elements such as public transportation vehicles, transit management centers, other transit facilities, and other ITS centers and subsystems. TCIP standards provide conformance requirements for automated information exchange, mechanical and electrical interfaces, data integrity and required message set. Most of these standards are still in draft form so they have not been put to use by most ITS transit vendors. As transit projects are developed, a systems engineering approach will need to be used to determine whether compliance with TCIP standards is feasible.

[17] Transit Communications for ITS Protocols (TCIP), Institute of Transportation Engineers. http://www.ite.org/standards/tcip.asp

CHAPTER 4

OPERATIONAL CONCEPT

4.1 INTRODUCTION

This chapter provides the operational concept for the Salem-Keizer Metropolitan area. The operational concept defines each stakeholder agency's current and future roles and responsibilities in the implementation and operation of the regional transportation system. It provides a high-level overview of the way the region's systems and stakeholders will work together to provide ITS services. This chapter includes discussion about many of the components that contribute to the high level operational concept database and the corresponding input into the Turbo Architecture database including: operational concept approach and overview, agency roles and responsibilities, information flows and pictorial flow diagrams for each of the program areas of ITS services included in this plan.

4.1.1 Operational Concept Approach

Interviews were conducted with key stakeholders to determine existing and planned relationships between different public agencies. Ongoing discussions with the Steering Committee regarding market package and user service selection, and previously defined user needs contributed information used to develop the operational concept for the Salem-Keizer region. The purpose of the interviews was to discuss existing problems and opportunities for interagency coordination and shared resources for the future. The results discussed in this chapter do not represent all of the potential interactions, but does present key relationships, coordination, and information flows that can be incorporated into the Salem-Keizer regional ITS plan.

The Salem-Keizer operational concept has been split into several different operational concepts; with each one covering a particular aspect of the transportation system. Operational concepts will be defined for each of the following ITS areas:

- Regional Traffic Control
- Traveler Information
- Incident Management
- Public Transportation Services
- Maintenance and Construction
- Archived Data

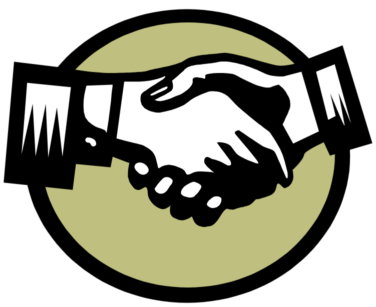
4.2 Operational Concept Overview

The following section outlines the different components that contribute to the operational concept for the Salem-Keizer region. The deployment of ITS projects is unique; many of the benefits are seen when ITS projects are implemented together on a region-wide basis, rather than on an individual basis. As a result, the implementation of ITS projects requires coordination and ongoing cooperation between various agencies within a region.

4.2.1 Operational Concept Database

The operational concept database was created from input from key stakeholders regarding existing and future relationships between agencies. The High-Level Operational Concept database consists of agency roles and responsibilities and information flows between agencies. These two areas are discussed in more detail in the section below. Each relationship and information flow was characterized as existing (the relationship/information flow is operational), planned (the relationship/information flow is planned) or consider (the relationship/information flow will be considered in the future). This database can be used to develop the framework for setting up inter-agency agreements within the Salem-Keizer Region and is included in Appendix I.

4.2.2 Agency Roles and Responsibilities



Key Stakeholder agencies within the Salem-Keizer Region currently interact with each other on various levels. The purpose of the operational concept database is to capture these existing relationships, as well as to look to the future at potential relationships that could be incorporated into the regional ITS architecture plan and affect the functional success of future ITS deployments. Table 4-1 defines eight different relationships that are used to characterize relationships between public agencies in the High-Level Operational Concept Database.

Table 4-1. Agency-to-Agency Relationships

Relationship	Definition	"From/To" Example
Independent	Parties operate independently with no interaction	No interaction (e.g. existing relationship between Oregon State Police and the City of Salem).
Consultation	One party confers with another party, in accordance with an established process, about an anticipated action and then keeps that party informed about the actions taken. No electronic sharing of information.	FROM agency provides information on activities to interested TO agencies (e.g. existing relationship from the City of Salem to the local police and fire agencies).
Cooperation	The parties involved in carrying out the planning, project development and operations processes work together to achieve common goals or objectives. No electronic sharing of information.	Both agencies cooperate in the development and execution of common plans, projects, and operational procedures (e.g. existing relationship between the City of Salem and the NWTOC).
Information Sharing	The electronic exchange of data and device status information between parties, for the purposes of coordinated operations, planning, and analysis.	FROM agency will provide status, data, and/or video information from the FROM agency's field devices to the TO agency (e.g. planned ODOT's detector data to the City of Salem)
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	FROM agency is allowed by the TO agency to control the TO agency's field devices—(e.g. planned City of Salem control of ODOT cameras).
Only Operational Responsibility Shifted	One party operates the field equipment of a second party on a full time basis.	FROM agency will operate the field devices of the TO agency (e.g. County operates a City's traffic signals but the City is responsible for maintenance and repairs.)
Only Maintenance Responsibility Shifted	One party maintains the field equipment of a second party.	FROM agency maintains the field devices of the TO agency, but the TO agency is responsible for operations.
Full Responsibility Shifted	One party has full responsibility for the field equipment of a second party including operations and preventative and emergency maintenance.	FROM agency operates and maintains the field devices of the TO agency (e.g. existing City of Salem operates and maintains Marion County's traffic signals)

4.2.3 Information Flows

Information flows represent the different types of information that can be shared or exchanged between agencies, roadside devices, or vehicles within the Salem-Keizer region. There are two types of information flows: center to center and center to field. A center to center information flow occurs when information is exchanged between agencies' centers. A center to field information flow is characterized by an information flow (e.g. data) being sent directly to an agency's center from or to a field device.

Other important functional information flows include request or control. Requests for information, (e.g. signal timing plan) may occur from one agency's center to another agency's field devices. The information flows included in the High-Level Operational Concept Database are defined in Table 4-2.

Table 4-2. Information Flow Definitions

Information Flows	Definition	"From/To" Example
Data	The dissemination of data gathered from one party's field devices to another party. Data can include, but is not limited to, traffic, weather, parking, transit data etc	FROM agency sends data to the TO agency's field devices and centers
Video	The dissemination of live video and still images from one party's field camera's to another party	FROM agency sends live video and still images to the TO agency (e.g. planned roadway information data/video flows from the City of Salem Traffic Management to Cherriots Transit Operations Center)
Status	The ability for one party to monitor another parties field devices, and receive such information as current signal timing/response plan, current message sets, etc.	FROM agency sends status information on its devices to the TO agency (e.g. planned signal status information from the City of Salem to NWTOC)
Request	The ability for one party to solicit either data or a command change, such as DMS messaging or signal timings, from another party.	FROM agency requests information or action from the TO agency (e.g. existing request for resource from the Willamette Valley 911 center to local police vehicles)
Control	The ability for one party to control another party's field devices. Control can include but is not limited to, changing DMS messaging, changing traffic signal timings, camera control, etc.	FROM agency issues control instruction to the TO agency's field devices (e.g. planned control of ODOT's dynamic message signs by the City of Salem)

4.2.4 Roles and Responsibilities

In addition to the operational concept database, detailed roles and responsibilities are included for each of the key stakeholders in the Turbo Architecture database. The report output from the Turbo file includes these roles and responsibilities that are classified according to the list below:

- Design: Includes the design of equipment and systems required under each program area
- Operations: Includes agency roles in operations of equipment and systems in each functional area after implementation
- Operational Planning: Includes agency roles in defining operational planning process and procedures to support ongoing operations and future expansion of each program area
- Maintenance: Includes agency roles in maintenance of equipment and systems in each program area.
- Construction: Includes the construction or installation of equipment and systems required under each program area. This category also includes requirements for integration of the old systems with the new systems.
- System Development and Integration: Includes the responsibility for development of new software interfaces and integration between systems to support each program area.

4.2.5 Program Area Operational Concepts

The operational concept for each program area includes flow diagrams, description of the program area, applications of the program area and detailed roles and responsibilities that have been input into the Turbo Architecture file. The flow diagrams depict relationships and information flows that were developed to illustrate relationships between agencies, roadside devices and other factors that influence the operations of each program area.

4.3 REGIONAL TRAFFIC CONTROL

4.3.1 Description

The operational concept for regional traffic control represents a broad view of interagency coordination and information exchanges that contribute to the success of the region-wide implementation of ITS services related to traffic management. Figure 4-1 illustrates the operational concept for regional traffic control within the Salem-Keizer region.

The city and county field devices and traffic management centers have been grouped together because they operate similarly; the majority of the roadside devices are operated and maintained by the City of Salem. Roadway information, as indicated on the flow diagram, from field devices or centers may include:

- Incident information
- Construction information
- Congestion information
- Weather information

The diagram also indicates shared video images, requests for resource, status information and control of field devices between corresponding agencies.

4.3.2 Applications of the Program Area

Communications between the city and county traffic management centers and the ODOT NWTOC represent one component of this program area. Other planned information flows include: flood and slide monitoring, railroad crossing occupation information, and parking status information. These changes to the regional system will contribute to more efficient operations of the transportation network and reduced delays for travelers and emergency responders.

4.3.3 Roles and Responsibilities

Currently, there is existing coordination between the city and county traffic management and ODOT's field devices. The city of Salem operates and maintains many of the traffic signals that are owned by ODOT, City of Keizer and Marion County within the study area. Additional shared responsibilities are planned between emergency management, ODOT, and city/county traffic operations centers. Detailed roles and responsibilities are shown in Appendix J.

FIGURE 4-1

4.4 Traveler Information

4.4.1 Description

Traveler information includes the coordination and dissemination of information that affects travel within the Salem-Keizer region. Traveler information includes planned information, such as special events and construction activities and unplanned events, such as incidents and detour routes. Traveler information is collected and then distributed to the individual traveler via cell phones, websites, PDA's, kiosks, or other media sources. This information can be used to make informed travel decisions and contribute to decreased delays caused by congestion, incidents or construction. Figure 4-2 illustrates the operational concept for traveler information within the Salem-Keizer region.

4.4.2 Applications of the Program Area

The primary source of traveler information in the Salem-Keizer region is currently ODOT's TripCheck website and the 511 traveler information telephone system. Other planned sources for traveler information dissemination include city and county websites and Cherriots transit website. The operational status of the ferries, real-time transit arrival and departure information, weather information, special events, parking and road closure information will be incorporated into the proposed regional en-route traveler information system. Additionally, there are many existing cameras in Salem and Keizer that could potentially post images on the City of Salem and TripCheck websites to illustrate real-time traffic conditions throughout the study area.

4.4.3 Roles and Responsibilities

A key responsibility of the regional agencies involved with providing information includes maintaining and operating user interfaces that are easily accessible and provide current, up to date traveler information. It is equally important for operating agencies to remove outdated traveler information when it is no longer applicable. For example, messages on electronic message signs about a crash ahead should be remove as soon as the incident is cleared from the roadway. Detailed roles and responsibilities are shown in Appendix J.

Figure 4-2

4.5 INCIDENT MANAGEMENT

4.5.1 Description

Incident management includes all of the information flows and agency relationships for involvement in emergency and incident response. The scenarios covered by this program area are broad in scope and include minor incidents on local streets to major region-wide emergencies that cross city and county jurisdictional boundaries. Coordination is needed for both planned and unplanned events to increase agency awareness and work towards a common goal of improving the safety of the public and minimizing effects on traffic flow. The key agencies include: the city and county emergency management and vehicles, Oregon State Police, 911 Center, ODOT NWTOC and incident response vehicles. Each agency contributes to the regional success of incident management. Figure 4-3 illustrates the operational concept for incident management within the Salem-Keizer region.

4.5.2 Applications of the Program Area

Existing relationships between the city and county traffic management centers and emergency management personnel could be enhanced through information exchanges, such as data or video images. Other useful information includes data and vehicle location for emergency and incident response vehicles to assist with efficient emergency dispatch and shared incident information between city/county traffic management, ODOT NWTOC and the Mid-Willamette Valley 911 Center.

4.5.3 Roles and Responsibilities

Incident management requires a broad range of agency coordination at many different levels. Each agency has the responsibility to install, operate and maintain individual systems that will contribute to the overall management of the regional traffic system and also to coordinate with other appropriate agencies by providing information and controlling field devices and systems as appropriate. Detailed roles and responsibilities are shown in Appendix J.

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FIGURE 4-3

4.6 Maintenance and Construction Management

4.6.1 Description

The maintenance and construction management program area includes weather-related information and construction, work zone, and routine maintenance activities. The information exchange relies on real-time information and planned delays due to roadway construction. Public agencies utilize this information to assist in planning and reducing impacts to local and regional road networks. This program area includes city and county public work agencies, ODOT NWTOC, roadside equipment that is owned and operated by city/county/ODOT and information providers, including the media and internet websites. Figure 4-4 illustrates the operational concept for maintenance and construction management within the Salem-Keizer region.

4.6.2 Applications of the Program Area

Currently the city of Salem is equipped with GPS on some maintenance vehicles for tracking routine maintenance needs; future use of this technology will extend to tracking pothole repairs. A statewide construction website will offer a source of information for planned construction events within the state as well as the local Salem-Keizer region. Construction and/or weather related information flows to emergency management centers and Cherriots Transit Management from the city/county/ODOT traffic operations centers are also planned.

4.6.3 Roles and Responsibilities

The statewide construction website relies on local agencies providing up to date information about planned construction activities. The city and county public works will also be responsible for installing, operating and maintaining field devices and on-board equipment that will enhance maintenance and construction operations. Detailed roles and responsibilities are shown in Appendix J.

Figure 4-4

4.7 PUBLIC TRANSPORTATION SERVICES

4.7.1 Description

Within the Salem-Keizer region, Cherriots operates fixed-route services and Oregon Housing and Associated Services (OHAS) operates demand-responsive paratransit service. This program area focuses on improving transit services through coordination and implementation of ITS technologies, such as transit signal priority, CAD interface integration between paratransit and fixed route service and the use of automatic vehicle location to provide real-time arrival and departure information. Figure 4-5 illustrates the operational concept/informational flows for public transportation services within the Salem-Keizer region.

4.7.2 Applications of the Program Area

Transit signal priority is planned on many signalized corridors in the Salem-Keizer Metropolitan area, specifically on the high priority transportation corridor on North River Road. Transportation agencies owning signals will control, operate and maintain traffic signals with equipment (software and detection hardware) to support transit priority. Cherriots will equip busses with priority equipment to request priority at traffic signals. Additional flows include the transmittal of real-time traveler information to the Cherriots website and transit security surveillance images from the busses to transit center.

Users can access the Cherriots website for real-time traveler information. Planned information flows from the city/county traffic management centers and emergency management provide construction, incident and weather information that may affect scheduled routes and transit arrivals and departures.

4.7.3 Roles and Responsibilities

Cherriots and OHAS are primarily responsible for the daily operation, maintenance, design and implementation of field devices used to support their agencies' services. Additional coordination with the City of Salem is required for the operations, maintenance, design and installation of traffic signal priority devices and the exchange of roadway information that may influence the transit services, such as incidents, construction or weather information. Detailed roles and responsibilities are shown in Appendix J.

4.8 ARCHIVED DATA

4.8.1 Description

The purpose of the data warehouse is to provide a centralized, electronic database that facilitates information/data sharing between agencies within the Salem-Keizer region. As illustrated in Figure 4-6, data will be shared between the regional data warehouse and other public agencies within the Salem-Keizer region.

4.8.2 Applications of the Program Area

Data from the following agencies will be collected, stored and archived: City of Salem, City of Keizer, Marion County, Polk County, Cherriots transit management, Emergency management and ODOT's traffic management systems. Types of data that will be exchanged may include traffic count data, weather data, incident data and transit data. ODOT has a policy not to store video images due to institutional and privacy issues. The capability to store select images should be considered for the purpose of detailed traffic analysis.

4.8.3 Roles and Responsibilities

The Mid Willamette Valley Council of Government (MWVCOG) will lead the development, design, operations and maintenance of a regional data warehouse within the Salem-Keizer region. Each agency will participate in data exchange to/from the warehouse and create their corresponding user interface for sharing information. Detailed roles and responsibilities for this program area are shown in Appendix J.

Figure 4-5

Figure 4-6

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CHAPTER 5 COMMUNICATION REQUIREMENTS

5.1 INTRODUCTION

This chapter outlines a communication plan for the Salem-Keizer Metropolitan Area that will support transportation requirements for data and video transmission.

The basic purpose of the communication network is to provide the communication links between various end points on the network (e.g. field devices and centers). These end points are distributed across the region and can include everything from a camera to a central traffic signal system server to a 911 call center.

The communication network defined in this chapter will support communication required for ITS deployment between selected points in the region as identified in the deployment plan (Chapter 6). It will provide a backbone communication system, as well as a distribution network to reach the individual devices or control locations.

5.1.1 Methodology for Developing Salem-Keizer Communication Plan

The methodology used to develop this communication plan follows a bottom-up approach. The analysis begins with a definition of the current communication requirements, then overlays the future requirements and proposed technologies that should be supported. Based on the defined communication requirements (current and potential), a communication model for the entire network is developed. This model establishes the general configuration of the communication network and the basic protocols that will be supported. The final stage of the communication plan development determines how the plan is applied to the actual deployment of the communication network, e.g. how is the implementation phased.

The communication plan should be considered a living document that is updated on a regular basis, as the communication needs change, to follow improvements in technology, and to reflect the implementation of various portions of the network.

5.1.2 Communication Plan Guidelines

A number of guiding principles have been used in the development of this communication plan. These principles must also be considered during the detailed design:

- **Reliability**: The system must provide a high level of reliability, achieved through the use of components with a high mean time between failures (MTBF) (i.e. 8-10 years), combined with a redundancy in the network design. Included in this category is an ease of operations and maintenance of the network by agency staff. A more detailed discussion of Operations & Maintenance (O&M) is provided in section 5.6 of this chapter.

- **Growth**: The network must be expected to grow gracefully. This requires the incorporation of a reasonable amount of unused capacity (i.e. 40% to 50%) and a design approach that allows extra capacity to be provided by upgrading the transmission equipment.
- **Standards**: Communication protocols and component selection must use widely accepted standards that minimize ongoing operations and maintenance costs.
- **Flexibility**: The network configuration must be designed to maximize flexibility to accommodate future changes, rearrangements and equipment changes.
- **Decentralized**: As the network supports several agencies, it must be configured around several centers of control, and allow the control location to be changed according to current needs.

5.1.3 Application of the Communication Plan

This chapter defines a high-level planning approach to ITS communication for the Salem-Keizer Metropolitan Area. This plan provides the guidelines to be used in the development of the detailed design for each section of the communication network. As the opportunity arises to construct a section of the network, through funding or provision of facilities by a third party, the detailed design for that section will be completed.

The regional plan addresses the configuration and implementation approach, but it does not determine exact routing, equipment selection and capacities. These aspects of the communication network are best finalized during detailed design as a section of the network is implemented, allowing the most up to date requirements to be incorporated in sizing, and current transmission equipment to be selected. In municipal networks, cost effective facility routing and equipment locations can be selected if the implementation considers the plans for road reconstruction and construction or renovation of buildings that can be used for communication equipment. The approach summarized in the following three subsections is recommended for each detailed design:

5.1.3.1 Pre-Design Planning Review

Before the start of the detailed design, typically at the same time as the documents are prepared to seek funding for the design, a brief pre-design planning review should be prepared. This document should typically be no more than two pages and should address the following topics:

- Key elements of the design that are required by the communication plan. These should include provisions for future growth and for geographic areas beyond the scope of a particular detailed design.
- Aspects of the design that will not follow the communication plan, with justification for these changes.

The purpose of the pre-design planning review is to ensure that the concepts and principles of the communication plan are considered in the detailed design. For example, if a road is being reconstructed, and it is known to be on a planned backbone communication route, this approach will ensure that the detailed design (even if it is only a small section of the ultimate backbone) provides for the future needs. These provisions could accommodate the future capacity with the initial installation or provide conduit and equipment mounting space for future installation.

5.1.3.2 Final Planning Review

After the completion of the detailed design of the specific network segment, the pre-design planning review should be finalized to include any changes that have been made during the detailed design. The final planning review should document any provisions made in the detailed design to support the communication plan (for instance, spare capacity, routing or configuration considerations). It should also justify deviations that have been made to the communication plan.

An important aspect of the final planning review is to identify if there is a need to update the master communication plan, either in whole, or in part.

5.1.3.3 Communication Plan Updates

As sections of the network are implemented, and as technology and communication requirements change, the communication plan should be updated as required. At any given time, the "current" communication plan should consist of the plan itself, and any planning reviews that have been conducted. A current list should be maintained with the communication plan, and updated as required.

5.2 Existing Communication Infrastructure

Chapter 1: Current & Future Transportation Conditions includes a section on existing communication infrastructure. This section identifies existing equipment and infrastructure that is owned and maintained by ODOT, Polk County, Marion County, City of Salem, City of Keizer and Cherriots. This existing infrastructure is illustrated in Figure 5-1 and summarized in this section.

In addition to the existing infrastructure, each agency was asked about their near-term plans and future vision for communications—independent of the new requirements defined in this regional ITS planning effort. The results of these discussions are included in this section as well.

5.2.1 Fiber Optic Infrastructure

There is limited public agency installed fiber optic infrastructure in the Salem-Keizer area, but there are existing projects and plans that intend to install a significant amount of new fiber optic cable. ODOT is currently designing fiber optic infrastructure from the radio tower on the east side of Interstate 5 north of State Street south to Kuebler Boulevard. In addition, ODOT has plans to install fiber optic infrastructure from this radio tower site west to the Northwest TOC providing a direct connection to the field devices on Interstate 5. The City of Salem is also installing fiber optic cable with all of their new traffic signal construction projects and has plans for new fiber optic cable south of the City of Salem offices to Mission Street and east to Interstate 5. Once these plans are fully implemented a center-to-center data and video exchange agreement could be established between the ODOT Northwest TOC and the City of Salem using agency owned fiber optic cable.

Figure 5-1. Salem-Keizer Metropolitan Area Existing Communications Infrastructure

5.2.2 Copper Twisted Pair Infrastructure

The City of Salem currently has copper twisted-pair (12 pair) infrastructure interconnecting approximately 190 of the 230 traffic signals with the central signal system server. Today, the copper twisted-pair infrastructure is used for communications between traffic signals. Generally, all copper twisted pairs in the downtown area are currently in use. Outside the downtown area, there is two to four pair available for use.

Currently fifteen traffic signals are without communications; although construction projects will reduce this number to six traffic signals within the next few months. The remaining traffic signals utilize a variety of communications methods. In particular, thirteen traffic signals are supported by leased telephone lines.

The current central signal system, BI-Trans QuicNet/4.1, utilizes two pairs of twisted copper per communications channel (one pair for transmit and one pair for receive) and therefore utilizes all of the twisted pair capacity. The City of Salem has successfully deployed a variety of Ethernet-over-Copper devices on a limited basis and has obtained bandwidths of 4 Mbps at distances of 9,200 feet and 1.6 Mbps at distances of 30,000 feet through two separate pilot projects. Expansion of this technology throughout the Salem-Keizer area offers the potential to deploy ITS field devices using the existing communications infrastructure on an interim basis until fiber optic cable is installed.

5.2.3 Wireless Network Infrastructure

The City of Salem and ODOT currently use wireless communications for some individual field devices. Code Division Multiple Access (CDMA) cell modems are used by ODOT to communicate to portable dynamic message signs and the City of Salem to communicate with seven traffic signals.

The City of Salem has deployed IEEE 802.11b (11 MBPS) technology at a number of traffic intersections to support traffic controller data and CCTV communications. In addition, IEEE 802.11b is used for communications across the river between West Salem and Salem.

5.2.4 Leased Infrastructure Alternatives

Local telecommunications providers in the Salem-Keizer area include ComCast, Qwest and AT&T. These agencies own fiber optic cable in the Salem-Keizer area that may be available for lease. However, access points to a telecommunications providers' fiber optic cable are generally limited to only a few sites within the City. To access the telecommunication providers' fiber optic cable the public agency would need to install the "last mile" of cable from the point of presence (POP) to the field devices or transportation operations center. In addition, a large telecommunication provider such as Qwest or SBC, is not in the business of leasing fiber to only provide communications to the limited number of transportation management centers and field communications hubs that is typical in an ITS network[1]. To lease their infrastructure would require a much greater commitment to access points, such as Statewide, then what is envisioned for the Salem-Keizer Metropolitan Area.

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[1] Based on meeting with AT&T sales representatives on February 25, 2005 with Dennis Jorgensen, ODOT and Jim Peters, DKS Associates.

5.3 COMMUNICATION REQUIREMENTS

This section considers the end devices and centers to be supported on the network and the associated requirements for local communication facilities. All of these devices and centers, considered as a group, form the communication requirements for the region, which must be supported by the communication network. The following deployment plan chapter (Chapter 6), discusses the proposed ITS projects in more detail and illustrates the ITS field device locations in Figures 6-1 through 6-6.

5.3.1 Requirements for Existing and Planned Devices

The network must be designed to support the various communication needs of the region; now, in the near future, and for the long term. This section describes the current and future requirements for communication that the network must accommodate, including the planned devices identified in the deployment plan.

The detailed design of any section of the network should support all current requirements, and provide for future requirements. Where the exact deployment of the planned equipment is not finalized, or in those cases where there is a significant incremental cost, the provision for these future requirements may be limited to the following:

- Installation of appropriate cable sizes, or the installation of underground conduit for future cable installation
- Sizing of equipment enclosures, cabinets, and facility rooms to accommodate the future requirements
- Sizing provisions for power to include the load for future equipment
- Choice of transmission systems that will allow modular expansion to support the anticipated future requirements

5.3.1.1 Traffic Signals

Traffic signals in the region are operated by two separate agencies as shown in Table 5-1; the City of Salem operates the vast majority of the signals in the project area. Included in the 230 traffic signals operated and maintained by the City of Salem are 14 signals owned by the City of Keizer, 16 signals owned by Marion County, and 36 signals owned by ODOT. Additionally, ODOT operates and maintains 13 traffic signals in the project area.

Table 5-1. Regional Traffic Signals

Agency	Number of Signals Operated	Controller Types	Software	Communication
City of Salem	230	170	BI-Trans with QuicNet 4.1 Central Software	190 of 230 signals are directly connected to the BI-Trans server using copper twisted pair. Remaining signals use either CDPD cell phone modems, IEEE 802.11b, telco phone lines. Six remote traffic signals do not have communications.
ODOT	13	170	Wapiti W4IKS	None
TOTAL	243			

Current Requirements

The City of Salem is the only agency in the Salem-Keizer Metropolitan Area that currently has remote communications to their traffic signals. Their current network configuration uses two twisted pairs per communication channel to connect the QuicNet central computer at the City of Salem to the traffic signal controllers. Each channel (two pairs) can theoretically support up to thirty-two traffic signal controllers as shown in Figure 5-2, however most agencies (including the City of Salem) employ much smaller signal groupings in order to ensure adequate bandwidth is available. QuicNet is a central/distributed signal system that provides the City with full upload and download capabilities and a visual display of local intersection status. The QuicNet central computer does not directly control the local traffic signals, but it does allow remote access to the local traffic signal controllers for status information and upload/download capabilities. Communication to the local controller is accomplished using EIA/TIA-232 communication, commonly referred to by its original name, RS-232.

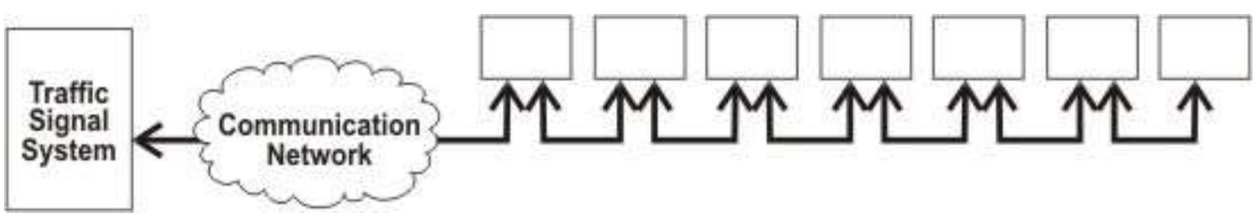

Figure 5-2. Traffic Signal Communication

Future Requirements

It is expected that ODOT, in addition to the City of Salem, will have remote access to traffic signals via a central traffic signal system. ODOT's access to the City of Salem traffic signals would likely be limited to activating and deactivating an incident management coordinated timing plan from the Northwest TOC. Within the timeframe of this plan, the traffic signal controllers will likely be upgraded to advanced transportation controllers (ATC) to support future functionality such as direct IP communication to the controller, higher speed upload/download capability, advanced signal control features such as transit signal priority and adaptive signal control and more intelligent recovery methods after signal preemption. The future ATC controllers will support the National Transportation Communications for ITS Protocol (NTCIP) and allow the agencies to install software from a variety of vendors on the same hardware platform.

NTCIP protocols will allow RS-232 or Ethernet communication to each controller. The data loading is dependant on the manufacturer's implementation of the protocol, but many of the ATC controllers today support communications up to 57.6 kbps today. Therefore, 57.6 kbps is a good basis for network design considering the current signal controllers communicate at 1200 bps.

Communication Provisions

The communication protocols used by traffic signal controllers can be supported by a variety of communication media including fiber optics, twisted pair, wireless or a combination of the three. The City of Salem has established a policy of installing fiber optic cable to support all newly constructed signalized intersections. The communication design should provide for two fibers for each group of six controllers, connected in series. Limiting the number of signals in each group to six will allow for more than enough bandwidth to accommodate the additional overhead required for NTCIP protocols. If Ethernet communications are employed, the number of traffic signals assigned to a single group can be increased substantially, upwards of 20 signals per group, depending upon the physical media employed. Whereas wireline media can support over 20 signals per group, wireless communications are dependent upon the establishment of line-of-sight between all transmitter and receiver locations.

It may be advantageous for the City of Salem to reorganize their controller communications groups as fiber optic cable trunk lines are constructed. This measure could allow the City to reroute existing copper twisted pairs to communication hubs in order to ensure all signals have direct or indirect access to the fiber optic trunk line. Signals that are not on a current fiber path may be connected to this path using the existing twisted pair cable as required, or through wireless Ethernet networking where appropriate. In either case, fibers should be reserved in the main fiber ring to accommodate those additional signals in the future.

Detailed design should anticipate additional intersections that may be installed. Where additional signals are likely, the number of signalized intersections sharing a common channel should be reduced to allow for future signalized intersections.

The City of Salem has successfully connected serial-to-ethernet converters to their existing Type 170 controllers on a limited basis to support locations where traffic controller data and CCTV video is required. The potential exists to expand the Ethernet-over-Copper technology to other portions of the region. By installing a serial-to-ethernet converter, Ethernet switch and Ethernet-over-Copper Digital Subscriber Line Access Multiplexer (DSLAM) that can withstand the extreme environmental conditions found in the a typical traffic control cabinet, the existing copper twisted pairs can be used to provide broadband capabilities to the field and allow for successful deployment of higher bandwidth ITS field devices such as CCTV cameras prior to the installation of fiber optic cable.

5.3.1.2 Transit Signal Priority (TSP)/Emergency Vehicle Priority (EVP)

Transit signal priority is an ITS technology that extends the green phase of a traffic signal or truncates conflicting phases to turn on the green early to accommodate transit vehicles that are behind schedule. Emergency Vehicle Priority is an ITS technology that preempts the current phase of a traffic signal in order to provide a green signal to properly equipped emergency vehicles.

There are no TSP systems currently deployed in the Salem-Keizer area, however there are plans to deploy TSP on the major corridors in the region. The majority of the traffic signals in the Salem-Keizer Metropolitan Area have full emergency vehicle preemption capability using Opticom™. Fire vehicles have the capability to preempt traffic signals, but police vehicles do not. All of the new detectors and discriminators being installed have the ability to recognize vehicle identification codes and different levels of priority requests (e.g. bus priority). Many of the existing detectors and discriminators were installed prior to this functionality being offered. The City is actively pursuing opportunities to upgrade the existing detectors and discriminators to provide vehicle identification and low priority functionality.

City of Salem traffic engineers, using the 3M priority control software, have the ability to remotely upload the preemption logs to check for valid preempts. This allows for a back-check of the system to monitor for illegal preemption requests from after market emitters and to monitor the preemption activity.

<u>Future Requirements</u>

Most TSP and EVP systems use local communication between a roadside sensor and the traffic signal controller. The roadside sensor identifies the location of a transit or emergency vehicle within a particular zone and provides signal priority or preemption as required. The length of the zone is established through configuration of the detector on each leg of a traffic signal controlled intersection.

In some municipalities a more centralized monitoring approach has been used, where the locations of the transit vehicles are tracked, and the signal priorities are changed system-wide in response to the congestion experienced by these vehicles. Such systems require automatic vehicle location technology for transit vehicles with frequent communications (up to second-by-second) between the transit vehicles and the central transit system. They also require fast, reliable communication between the transit management system and the central traffic signal system and near-real-time communications to the traffic signals.

<u>Communication Provisions</u>

The most likely scenario for implementation of TSP, and communications from the transit vehicle to the traffic signal, is with a dedicated short range communication (DSRC) technology. This approach takes advantage of the existing Opticom™ deployed at the majority of intersections. DSRC will not affect the overall communication network design because it is deployed on an intersection by intersection basis.

Within the timeframe of this plan, the centralized approach to TSP may become a reality. This approach requires real-time (up to second-by-second) communications between the transit vehicle and the transit management system, between the transit management system and the central traffic signal control system and between the traffic signal control system and the traffic signals. Wireless mesh or radio are the two most likely candidates for transmitting the vehicle location information. Center-to-center communications should be provided via fiber optic cable with redundant paths between centers. Traffic signal communications should be per the recommendations of the traffic signal section in this chapter.

5.3.1.3 CCTV Video

CCTV monitoring requires transmission of a video signal, as well as a data channel for camera control. Camera control, pan/tilt/zoom (PTZ) and focus, is carried on an RS-232, RS-422 or RS-485 data channel, which can be digitized in an internet protocol (IP) video stream or carried as a separate low speed data channel.

Current Requirements

Today, ODOT uses closed-circuit television (CCTV) cameras to monitor traffic at the Hayesville Interchange on Interstate 5. Two fixed mount cameras are provided at this site to provide images north and south of the interchange. From the NWTOC, operators also monitor the pan-tilt-zoom camera on the radio tower at the operations center, the security cameras in the building, and the mountain pass cameras. Two additional cameras on Interstate 5 are currently under design at the Kuebler Boulevard and Mission Street Interchanges. ODOT posts images from the existing cameras on the TripCheck website, which is described later in this chapter.

The City of Salem has video images at approximately one-third of the signalized intersections (approximately 60 intersections), which are supplied from the video detection cameras. These are all fixed mount cameras, but images are generally provided on the approach section of all four legs of an intersection. All new traffic signals in the City of Salem are installed with video detection.

Future Requirements

In addition to video detection cameras being installed at all new traffic signals, approximately twenty-nine PTZ CCTV deployment locations have been identified throughout the Salem-Keizer area. The analog video signals interfaced at a typical control center are shown in Figure 5-3. In recent years the quality of digital CCTV cameras that output a video data stream has approached a level that is comparable to traditional analog video signals.

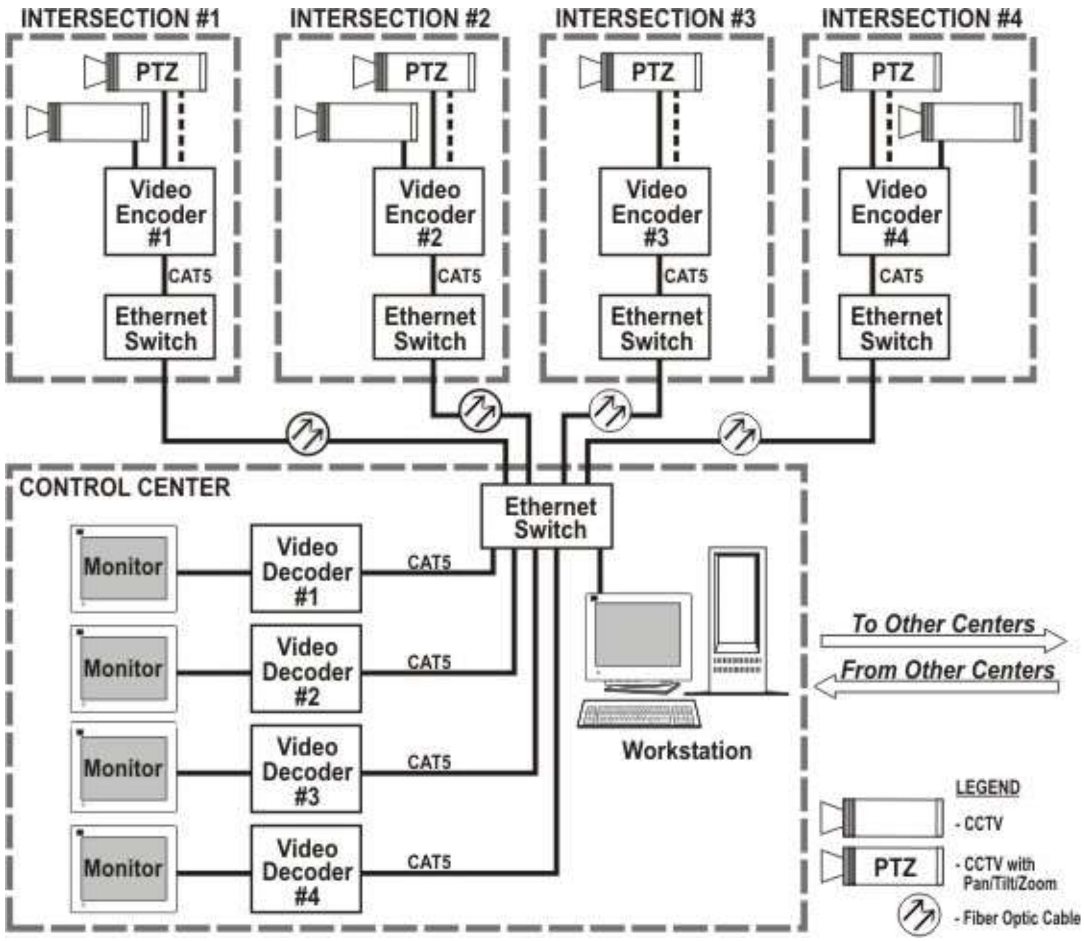

Figure 5-3. CCTV Video

<u>Communication Provisions</u>

CCTV video can be carried as an analog or digitized signal. The camera control channel can be transmitted as either serial data or be included in the UDP/IP data stream with the digital video.[2] There are several methods available to transmit the video, but digital IP video is recommended because it provides the most flexible network design for sharing video with other agencies and the Internet.

Analog transmission methods could initially be used for deployment of the communications network. However, as the number of ITS elements increases, digital transmission will become

[2] Transmission Control Protocol (TCP) is a protocol developed under contract from the U.S. Department of Defense to internetwork dissimilar systems. This is the protocol of the Internet and the global standard for communications. The TCP/IP suite provides two methods for data transport, TCP and User Datagram Protocol (UDP). TCP is used for everything that must arrive at its destination in perfect form while UDP is used in cases where reliable delivery is not required. There is less processing of UDP packets than there is for TCP. In particular UDP does not use a handshake protocol between origination point and destination point to start a session, it just sends out data packets. UDP is widely used for streaming audio and video, voice over IP (VoIP) and videoconferencing, because there is not time to retransmit erroneous or dropped packets.

more economical. This is because more digital channels can be added at a lower cost compared to analog systems. Also, connecting different field devices over a digital network over a digital network enables more flexibility for implementing automatic measures to route data traffic around network nodes experiencing hardware or software failures. This automatic failure recovery is referred to as fault tolerance.

If an analog video system were to be deployed, it would require some form of field aggregation of the video feeds within communication hubs. Otherwise, each field camera would require a single strand of fiber between the camera itself and the Traffic Management Center. Simply put, this is an inefficient use of the communications medium. Conversely if a digital video system were to be deployed in the Salem-Keizer area, the communications hub would still be required to function as an aggregation point however it would also serve the equally important role of providing fault tolerance in the event of unexpected network outages.

DKS recommends providing four fiber strands at every ITS field element location. The first pair of fiber strands would be used for an Ethernet link supporting the video encoding and camera control requirements. The second pair of fiber strands would be reserved for future requirements. Digital video encoders have improved their compression algorithms to a point where high quality video can be transmitted with as little as 1Mbps of bandwidth however for planning purposes, DKS recommends provisioning 8 Mbps of bandwidth for each CCTV camera.

5.3.1.4 Automatic Traffic Recorders

Automatic traffic recorders (ATR) are used to collect traffic volume, speed and occupancy data at a given location. These may utilize existing detection at a signalized intersection or be installed at a remote site with dedicated equipment.

Current Requirements

ODOT ATR’s within the Salem-Keizer study area collect hourly volume data by lane. Three of the four ATR stations have the ability to collect speed and length data. Speed data is typically provided in 13 “Speed Bins” and length data is typically provided in two “Length Bins”. ATR stations do not collect occupancy data.

Traffic volumes collected from these sites today provide 24-hour count data that provides changes in volume by time-of-day and by time-of-year.

Future Requirements

The deployment plan (Chapter 6) includes additional ATR deployments to monitor critical traffic congestion points and collect traffic volume and speed data for future planning and congestion information mapping. The majority of ATR deployments shown in the plan assume 24-hour volume information. However, automatic traffic recorders that utilize existing vehicle detection at traffic signals could be utilized to provide turn movement counts at signalized intersections. This would not affect the communications requirements, but would affect the data storage requirements.

Communication Provisions

The low data requirements of automatic traffic recorders can be supported with copper twisted pair, fiber optic cable, wireless or a dial-up phone line. Often these devices communicate directly with a traffic signal controller, and the fiber strands or copper pairs provisioned for a traffic signal controller will also support the automatic traffic recorders. In the case of a stand-alone automatic traffic recorder, the data could be connected to the Ethernet network if it is near a communications hub. For remote ATR's, leased dial-up phone lines are adequate.

5.3.1.5 Weather Stations (RWIS)

Weather stations, also called roadway weather information systems (RWIS), are used to collect and monitor weather and road conditions that are pertinent to motorists and to maintenance personnel responsible for the roadway operations. Typically weather stations collect temperature, wind speed, wind direction, precipitation, humidity and road surface temperature.

Current Requirements

Marion County currently operates and maintains three weather stations in Marion County at Drakes, Prospect Hill and Elkhorn. The weather information is accessible online at http://publicworks.co.marion.or.us/operations/weather/index.asp. ODOT has a weather station alongside River Road at the Traffic Signal Services Unit facility. The City of Keizer has a weather station at their City maintenance facility behind the Keizer Fire Station. Weather and road condition information collected from these sites generally includes air temperature, pavement temperature, wind speed, wind direction, barometric pressure, and humidity.

Future Requirements

Several additional RWIS locations have been identified as part of the deployment plan (Chapter 6).

Communication Provisions

The low data requirements of a typical RWIS station can be supported with either copper twisted pair or fiber optic cable. ODOT's RWIS stations support TCP/IP for Ethernet networks and serial line internet protocol (SLIP) for RS-232 serial data over 56 kbps dial-up. Both configurations can be converted to fiber. However, if CCTV cameras are desired at the weather station, then fiber optic cable is the recommended transmission medium. Specifically, two fiber strands are needed per RWIS location (one to support the RWIS and a spare for redundancy). In the event the proposed RWIS locations are remote and less than 10,000 feet from the fiber ring, then CCTV video and RWIS data could be transported over copper twisted pair using HDSL technology deployed as part of the ITS network. For locations farther than 10,000 feet from the fiber ring a leased line from a private sector telecommunication provider may be necessary.

5.3.1.6 Dynamic Message Signs (DMS)

A dynamic message sign (DMS) is an electronic sign used to post messages that are variable (any message) or changeable (one of several fixed messages). Traffic management personnel typically use DMS to provide information to motorists about changes in the local road conditions.

Current Requirements
Currently, there are no existing dynamic message signs within the Salem-Keizer Metropolitan Area. However, ODOT operates and maintains fixed dynamic message signs on Interstate 5 north of Salem. All new dynamic message signs installed by ODOT are compliant with the National Transportation Communications for ITS Protocol (NTCIP). Additional signs are controlled from the NWTOC, but are outside of this project study area.

Future Requirements
ODOT plans additional DMS on Interstate 5 southbound near the Brooks interchange and northbound north of Albany.and the deployment plan (Chapter 6) includes additional DMS's throughout the region. ODOT's new DMS installations are NTCIP compliant and user configurable for 56K dial-up and UDP/IP over Ethernet. Communication requirements are similar to the traffic signal controllers, and several signs may share a single serial data communication channel depending on device location.

Communication Provisions
DKS recommends providing four fiber strands at each DMS location (two to support the DMS unit and two for redundancy).

5.3.1.7 Highway Advisory Radio (HAR)

The purpose of HAR is to provide supplemental information to motorists about traffic advisories, construction and maintenance operations, adverse weather or environmental conditions, route diversions and special events. HAR uses low-power roadside transmitters that operate in AM or FM frequencies licensed by the Federal Communications Commission (FCC). The typical operating range on a HAR transmitter is two miles although ODOT has achieved ranges of up to eighteen miles in some instances. HAR is not intended to replace required permanent signs or temporary signs used for construction or maintenance operations. Local agencies wishing to establish a HAR site must apply to the Oregon State Traffic Engineer. Following approval by the state, the HAR owner subsequently applies to the FCC for permission to operate in the AM or FM frequency spectrum.

ODOT HAR transmitters are equipped with an Ethernet port, so when fiber optic cable is available these sites will be able to communicate with the Traffic Operations Centers using Ethernet communications protocols. Currently all ODOT HAR sites are remotely accessed via leased telephone lines and communicate using Dual Tone Multi-Frequency (DTMF) and voice.[3]

Current Requirements
There is no existing HAR in the project area.

[3] Dual Tone Multi-Frequency (DTMF), the system used by touch-tone telephones. DTMF assigns a specific frequency (consisting of two separate tones) to each key so that it can easily be identified by a microprocessor. In the case of HAR, the microprocessor is located within the HAR transmitter.

Future Requirements
Additional HAR sites are planned by ODOT to provide additional travel advisory information in advance of key interchanges. The deployment plan (Chapter 6) includes additional detail about this project.

Communication Provisions
HAR systems are currently being introduced to the market that will allow traffic management personnel to alter or replace HAR broadcast messages remotely from a traffic management center or other remote location using TCP/IP protocols. DKS Associates recommends provisioning four fiber strands per HAR location to support this capability (two for the HAR station and two for redundancy). If the HAR site is remote, a leased phone line is adequate.

5.3.2 Transit Subsystems

A number of systems are available for "next bus arrival", providing time and/or routing information to transit riders for the next bus to arrive. Many of these systems operate using wireless technologies, but they could also use the wireline communication network if it is available. It is also possible that at strategic points in the region, there will be communication links to the transit vehicles. Although the final link to the vehicle would use wireless technology, the communication backbone would support the link between the wireless antenna site and the control center.

Current Requirements
There are limited current requirements for transit communications. Security video at the transit management center is viewable at the security center and at the Dellweb maintenance facility. Communications between the transit center and the maintenance facility support several business network needs. The link between the transit center and the maintenance facility is being implemented with a transit agency owned wireless network.

Future Requirements
Potentially two new transit centers could be constructed during the life of this plan (one in the Keizer Station vicinity and one in south Salem). The transit agency will require security video at these sites and communications infrastructure to support the distribution of this video to the transit management and maintenance centers. In the Summer of 2005, Cherriots is deploying mobile data terminals on paratransit vehicles and implementing a pilot project to provide "next bus" arrival information on a few routes. Both deployments are planned to be supported by wireless communications.

Communication Provisions
Communications to the planned transit centers should be considered in long term planning of the Salem-Keizer communication network. Actual sites for these centers have not been selected at the time of this print, but general locations are known. Spare fibers and access points should be considered during detailed design of communications infrastructure.

Four fibers should be allocated for future transit links to transit centers and from field hubs to support roadside signs of future wireless communications to vehicles.

5.3.3 Center-to-Center Requirements

A key element of a regional ITS operation is the use of center-to-center links to support the sharing of video and data, and in some cases allow for the complete control of another operations center from a backup location. Center-to-center communications should be provided between a variety of locations including transportation management centers, transportation maintenance centers, emergency operations centers (EOC's), transit management centers and 911 centers. The following centers in the Salem-Keizer Metropolitan Area should be interconnected:

- Northwest Transportation Operations Center (ODOT)
- City of Salem Traffic Operations Center
- Marion County Public Works
- City of Keizer Public Works
- Polk County Public Works
- Cherriots Transit Management Center
- Mid-Willamette Valley Council of Governments
- Willamette Valley Communications Center
- City of Salem Police Department
- City of Keizer Police Department
- City of Salem Fire Department
- City of Keizer Fire Department
- Polk County Sheriff's Department
- Marion County Sheriff's Department

Future Requirements

Although there are no plans to develop formal transportation operations centers other than the existing Northwest Transportation Operations Center in downtown Salem, other agency locations should be considered as centers and served with appropriate center-to-center communication links because the information sharing requirements will be the same. Agencies without the physical space designated to a TOC will utilize workstations to provide similar functionality (viewing video, processing information and responding accordingly). Existing and planned centers and their potential needs for a communications link are summarized in Table 5-2

Table 5-2. Center to Center Links

Centers	Purpose	Type of Link
City of Salem and ODOT NWTOC	Allow shared monitoring of cameras and control of traffic signals during incidents.	Ethernet
Transit Management Center and Traffic Management Centers	Share bus location information for vehicle probe project. Share video. Support centralized management of TSP.	Ethernet
Traffic Management Centers and 911 Center	Allow sharing of information during emergency situations. Allow video monitoring and traffic congestion information	Data and video on Ethernet. Voice communications for backup
Traffic Management Centers and Emergency Operations Centers	Allow sharing of traffic condition information (video and data) during emergency situations	Ethernet

Communication links throughout the network, including Center-to-Center and Center-to-Field links, should conform to National Transportation Communications for ITS Protocol (NTCIP) standards. NTCIP is a family of standards that provides both the rules for communicating (called protocols) and the vocabulary (called objects) necessary to allow electronic traffic control equipment from different manufacturers to operate with each other. The NTCIP Standards Framework is divided into five levels – Information, Application, Transport, Subnetwork and Plant. In addition to defining the data protocols and objects common to the ITS industry, the five NTCIP levels incorporate the seven layers of the Open System Interconnection (OSI) model used to standardize the protocols included in networking equipment found in the Information Technology industry. A brief description of each NTCIP level is provided below.

- Information Level – Information standards define the meaning of data and messages and generally deal with transportation related data as opposed to data concerning the communications network. This level is not part of the OSI model.
- Application Level – Application standards define the rules and procedures for exchanging information data. The rules may include definitions of proper grammar and syntax of a single statement, as well as the sequence of allowed statements. Protocols found in this level include FTP, SNMP and STMP. These standards are roughly equivalent to the Session, Presentation and Application layers of the OSI model.
- Transport Level – Transport standards define the rules and procedures for exchanging the Application data between point "A' and point "X" on the network, including any necessary routing, message assembly/disassembly and network management functions. Protocols found in this level include TCP/IP, and UDP/IP. These standards are roughly equivalent to the Transport and Network layers of the OSI model.
- Subnetwork Level – Subnetwork standards define the rules and procedures for exchanging data between two adjacent devices over some communications media. Protocols found in this level include ATM, Ethernet, SONET, PMPP and PPP. These standards are roughly equivalent to the Data Link and Physical layers of the OSI model.
- Plant Level –The plant level includes the communication infrastructure over which NTCIP communications standards are to be used. Physical media included in this level includes fiber optic cable, coaxial cable, copper twisted pair cable, and wireless communications.

<u>Communication Provisions</u>

During detailed design, the exact communications provisions between centers should be determined. Fiber optic cable and wireless communications are the most viable candidates. If fiber optic cable is selected for a particular center-to-center link, then six fibers should be included in the main fiber runs to accommodate each center-to-center link. If wireless communications is selected for a particular center-to-center link, then a FCC licensed frequency band capable of supporting broadband bandwidth over given distance is recommended.

5.4 Communication Network Architecture

In order to select a network architecture that is best suited to the needs of the region, it is important to consider the available options. This section describes the possible configurations and communication protocols at a higher level, including brief consideration of the strengths and weaknesses of each option. A typical communication network is divided into the following three basic elements, as shown in Figure 5-4. Communication Network Elements

- **Backbone**: The communication backbone is capable of carrying all types of the data traffic in the system. The backbone interconnects a number of nodes, which are central locations where the information can be inserted onto or removed from the backbone.
- **Distribution**: The distribution portion of the network provides a connection between the backbone node and a group of ITS devices or buildings. In the case of fiber optic cable, the distribution portion typically has fewer fiber strands compared to backbone portions. Distribution electronics are commonly collocated with the backbone node equipment in a communication hub.[4]
- **Local**: The local portion of the network or "drop" that connects an end device or building to a distribution cable or directly to a node on a backbone. For fiber optic networks, local portions typically have fewer fiber strands compared to distribution portions. For example, a hypothetical ITS network could have a 96 strand fiber backbone with 12 strand distribution cables that allocate two fiber strands for each traffic controller cabinet.

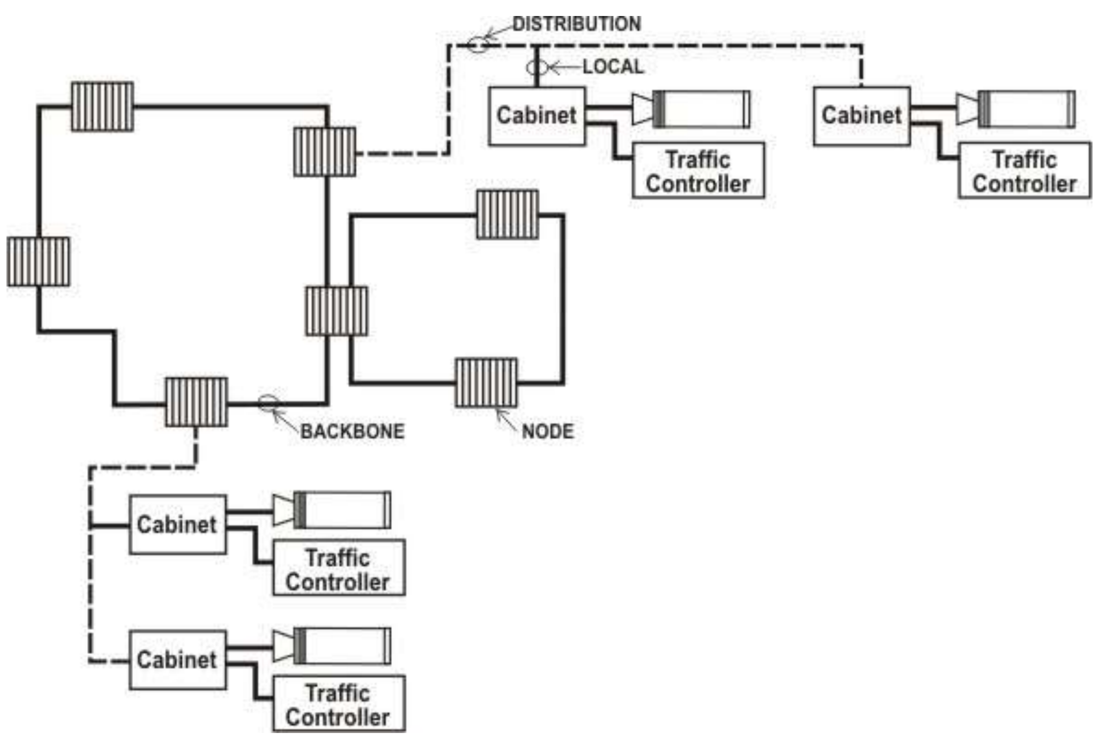

Figure 5-4. Communication Network Elements

[4] For the purposes of this document, the terms node and hub may be considered interchangeable.

The network must be designed to support data and video requirements to a wide variety of locations throughout the region. With particular types of communication equipment the video can also be converted to a data stream and carried on a common transmission medium, but for planning purposes it is typically more flexible to consider two independent networks:

- **Data:** The communication network to carry the data signals will consist of a high-speed backbone and local distribution that will feed the individual signals to the backbone.
- **Video**: The video network will carry single video channels and multi-channel video signals, generally to a control center. Single channel video will typically be carried in the distribution network, and video on the backbone usually combines a number of video signals into one multi-channel video signal.

There are a number of aspects of any network architecture that need to be considered:

- **Communication Technology Options – Plant Level:** At the outside plant level, the network architecture considers the links between elements in the network. There are a number of technologies that can be used to connect locations on the network, either cables or wireless links.
- **Physical Topologies:** The devices, centers and other facilities on a communication network can be connected in a number of different physical configurations or topologies, including star, ring, and/or mesh networks.
- **Backbone Communications Technology Options – Sub-network Level:** A key aspect of the network architecture is the type of transmission system used in the backbone to interconnect network nodes. Examples include ATM, SONET and Gigabit Ethernet (GigE) technologies. In newly constructed networks generally a single backbone transmission system is selected for the entire network.
- **Distribution Communication Technology Options – Sub-network Level:** There are a number of communication technologies that should be supported by the architecture for distribution systems such as Ethernet, RS-232/485, or propriety. Although it reduces complexity to minimize the number of distribution technologies, it is better not to design physical facilities that limit the use of a wide range of technologies.

5.4.1 Communication Technology Options – Plant Level

The plant level considers the physical plant used to interconnect points on the network. In traditional networks this would include the cable (fiber or twisted pair) between devices, but in recent years, the introduction of wireless technologies has also allowed wireless equipment to provide a plant level link. This section summarizes plant level options.

Twisted Pair

Twisted pair cable was the original physical plant used for communication networks. The widespread use of this technology by the telephone companies has resulted in robust cables that require little maintenance when installed correctly.

The most significant drawback of twisted pair plant is the narrow bandwidth it can provide. In recent years this disadvantage has been addressed through the use of Digital Subscriber Line (DSL) technology. There are two types of DSL service commonly deployed in the field –

Asymmetric Digital Subscriber Line (ADSL) and High Bit-rate Digital Subscriber Line (HDSL). ADSL is the most popular form of xDSL technology. The key to ADSL is that upstream and downstream bandwidth is asymmetric, or uneven. In practice, the bandwidth from the provider to the user (downstream) will be the higher speed path. This is in part due to the network provider's desire to accommodate the typical Internet usage pattern where the majority of data is being sent to the user (programs, graphics, sounds and video) with minimal upload capacity required (keystrokes and mouse clicks). ADSL downstream speeds typically range from 768 Kb/s to 9 Mb/s. Upstream speeds typically range from 64Kb/s to 1.5Mb/s although most deployments tend to be towards the lower end of this spectrum. ADSL's upstream data rate is typically not high enough to support full motion video transmissions and is therefore not recommended for use in the City's ITS program.

HDSL delivers 1.544 MBPS of bandwidth in each direction over two copper twisted pairs. Because HDSL provides the equivalent of T1 speed, telephone companies have been using HDSL to provision local access to T1 services whenever possible.[5] The operating range of HDSL is limited to 12,000 feet (3657.6 meters) without the use of signal repeaters.
A third type of Digital Subscriber Line technology has recently gained attention in the United States call SHDSL. Symmetric High Bit-rate Digital Subscriber Line (SHDSL) is the first standardized multi-rate symmetric DSL and is a product of the International Telecommunications Union – Telecommunications (ITU-T) standards body. SHDSL is designed to transport rate-adaptive symmetrical data across a single copper pair at data rates of 192 Kbps to a range of 20,000 feet or 2.3 Mbps to a range of 10,000 feet.

SHDSL equipment has recently been introduced to the ITS market which provides up to 9.2 Mbps of bandwidth using Ethernet communications protocols to a distance of 9,500 feet using two pair of 24 AWG copper twisted cable.[6] This is sufficient to support broadband ITS field devices such as CCTV cameras. If more copper pairs are available, then the distance and bandwidth capacities increase significantly. Using the example of the 24 AWG copper twisted cable, increasing the number of pair from two to four provides 14.2 Mbps of bandwidth at 9,500 feet. Increasing the copper twisted pair from four to eight provides 27.2 Mbps of bandwidth at 9,500 feet.

The Salem-Keizer area has a significant copper twisted pair network in place. In particular, the City of Salem has a good quality twisted pair network that operates the vast majority of the traffic signal system. In many cases it may be feasible to deploy Ethernet-over-Copper equipment on an interim basis in order to support high bandwidth ITS field devices until fiber optic cable is installed.

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[5] Other HDSL applications include Private Branch Exchange (PBX) network connections, digital loop carrier systems, interexchange Point-of-Presence (POP) connections for internet/intranet access, internet servers, and private data networks.

[6] In February and March 2005 DKS Associates conducted a 60 day field trial in Livermore CA comparing the SHDSL equipment manufactured by Tut Systems and Actelis Networks. Tut Systems provided performance data showing 9.2 Mbps to a range of 9,500 feet using two pair of 24AWG copper cable. Actelis Networks provided performance data showing 7.2 Mbps to a range of 9,500 feet using two pair of 24 AWG copper cable. Actual field observations obtained during the field trial were in line with the performance statistics advertised by each manufacturer.

Coaxial Cable
Coaxial cables were introduced to provide increased bandwidth and are still widely used to carry broadband video services by the cable television industry. In intelligent transportation systems they are used typically to make video connections where the cable is 500 feet or less in length, which does not require any transmission equipment.

Although coaxial cables can be used to transport video images for greater distances, the transmission of unmodulated analog video signals (i.e. baseband) required in ITS networks is carried more efficiently on fiber optic cable.

Fiber
Fiber optic cable has become the preferred choice of physical plant installations for ITS networks. Fiber optic systems can carry very large bandwidth on a single fiber, and cost effective transmission systems are available for CCTV video signals. Fiber has the advantage of low signal loss, allowing signals to be carried large distances without repeaters. Equipment is available that can carry a signal with any of the protocols described in this document between any two points in the region without repeaters. In recent years the cost of fiber optic cable has decreased, and it costs far less than a twisted pair of equivalent capacity.

Wireless
As the road allowances have become increasingly congested with cable plant, wireless systems have increased in suitability. Recent developments are making these systems more cost effective and increasing the bandwidth that they can carry.

Many options exist for low speed systems that do not require FCC licensing to operate. These systems typically operate in the 900MHz, 2.4GHz and most recently 5.8GHz frequency bands and employ Frequency Hopping Spread Spectrum techniques where the transmitter and receiver rapidly switch frequencies that allow other users to occupy the same frequency band without interference.[7] While license free systems frequently offer a relatively inexpensive and simplified deployment compared to licensed frequency systems, the popularity of the license free frequency band has saturated the 900 MHz and 2.4GHz bands. In the last few years significant research and development efforts have been made by telecommunication equipment manufacturers to provide wireless broadband access over licensed and license-free frequencies. This effort has intensified with the issuance of the IEEE 802.16, which addressed standards for manufacturing Ethernet compliant wireless metropolitan area networking devices.

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[7] Spread Spectrum is a data transmission modulation technique by which the transmitted signal is spread over a bandwidth wider than the information bandwidth. Spread Spectrum radio communications was developed originally used by the military because the radiated signals are distributed over a wider range of frequencies and then collected onto their original frequency at the receiver making them difficult to jam or intercept. Spread Spectrum frequency bands are designated by the FCC and require no user license. Currently three license free Spread Spectrum frequency bands have been assigned by the FCC – 902 MHz to 928 MHz, 2.4 GHz to 2.4835 GHz and 5.725 GHz to 5.85 GHz. There are two Spread Spectrum transmission techniques – Frequency Hopping and Direct Sequence. Frequency Hopping Spread Spectrum is a technique by which the frequency band is divided into a number of channels and the transmission hops from channel to channel in a pre-specified sequence. Direct Sequence Spread Spectrum is a technique by which the transmitted signal is spread over a particular frequency range.

When compared to the high cost of cable installation, wireless systems are a viable option. Based on our DKS Associates' experience in designing both fiber optic CCTV systems and wireless CCTV systems, constructing fiber optic cable systems typically costs ten times more than a similar system using wireless communications. In the short term, it is expected that wireless systems can provide the greatest cost benefit for low speed links in congested areas, and could be considered for short haul communication to ITS devices. However in the mid to long term, equipment conforming to IEEE 802.16 will become more prevalent, resulting in high bandwidth ITS field devices being supported with license-free wireless communications.

Leased Lines

Another plant level option is to lease communication services from a third party. Leased links require ongoing monthly charges, but do not require a large capital outlay for installation. They are often used effectively to serve remote devices where it would be too costly to install a dedicated cable.

As a point of reference, a leased 56K Frame Relay connection can often cost between $200/month and $300/month, while a T-1 line can often run anywhere from $500/month to over a $1,000/month. A DS-3 typically costs approximately 10 times more than a T-1 line. However, these costs can vary drastically from region to region and between service providers, and should be verified during detailed design.

Leased Fiber

Fiber can be leased from telecommunication providers in the region. Unused fibers contained in cables owned by the private sector telecommunications provider can be segregated and leased exclusively for ITS use.

Although leased fibers incur monthly charges ranging from $300/month to $1,000/month depending on the location and distance, they provide the full benefit of the fiber optic cable without the capital construction costs. Utilization of leased fiber may be particularly advantageous for phased network implementation, with the leased segments being replaced by new construction as network deployment proceeds.

5.4.2 Physical Topologies

There are a number of physical topologies that can be used to interconnect locations on a communication network. This section introduces some example network topologies, including star, ring, mesh, and hybrid.

Star

Star configurations refer to a topology where each device has one connection to a central point as shown in Figure 5-5. Also called a "home run," these links provide the sole communication path from the device to any other point in the network. This approach is often used in distribution networks, where each device has a single channel back to a node on the backbone. Local links are typically star configurations, as well, between the distribution cable and the end device.

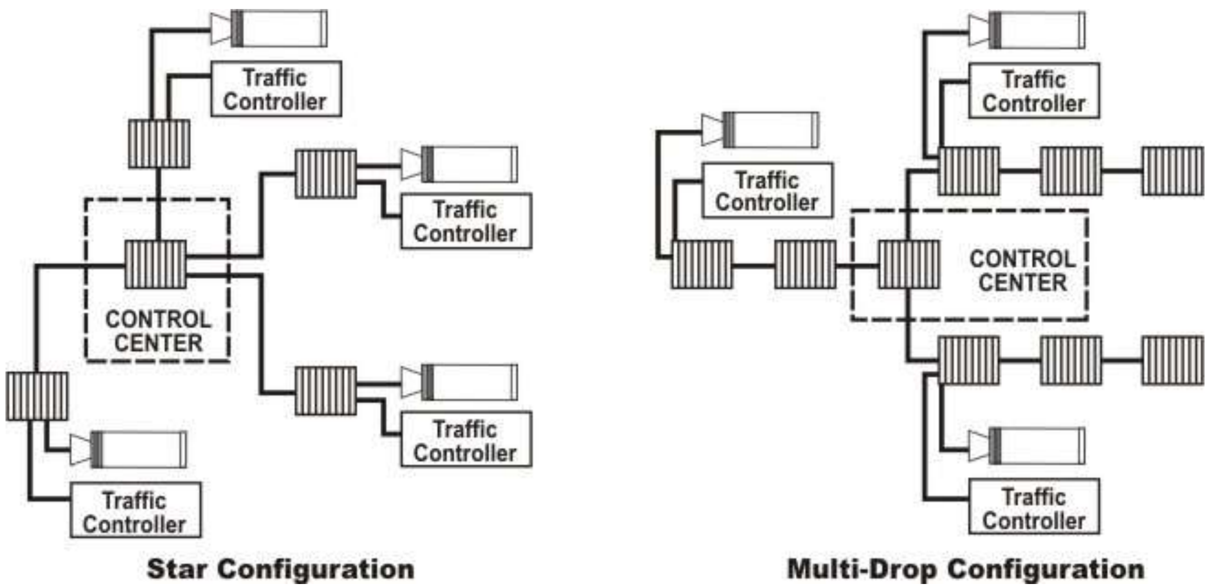

Figure 5-5. Generic Star and Multi-Drop Configuration

With some systems, more than one device can share a channel. If these devices are served in series (as illustrated in Figure 5-5) they can be called a multi-dropped star, where a number of devices share one communication path.

The main advantage of this topology is it allows for the greatest control of the network since all circuits are connected to a central location. In addition, star topologies tend to provide the fastest performance since all nodes are connected to the central location. Disadvantages of the configuration include more susceptibility to disruptions due to link failures, e.g. cable severed in the field, and a more extensive communications infrastructure for point-to-point links.

Ring

Ring configurations connect a number of devices or locations in a ring. This approach is often used in backbone networks that connect a number of nodes together as shown in Figure 5-4. Each node has two connections: primary and secondary. In this configuration illustrated in Figure 5-6, the failure of a single communication path or a single node allows the remainder of the devices to communicate without interruption. The use of rings in distribution networks is also possible, although there are a fewer number of types of distribution electronics available to do this.

Fault tolerance is accomplished through the use of the Spanning Tree Protocol (IEEE 802.1d) or Rapid Spanning Tree Protocol (IEEE 802.1w), protocols designed for looped Ethernet networks. Since Ethernet has traditionally been found in a star or a bus network, it was not originally designed to be a ring network. This worked well in a local area network environment, primarily when a broadcast message was sent, since a broadcast message was received by each connected device from only one link, or path. With a ring or meshed network, a connected device could receive and forward the same broadcast message from multiple links or paths. In some instances the forwarding of identical messages elicits even more messages and subsequent forwarding from other devices. This process eventually "snowballs" into a broadcast storm. A severe broadcast storm can block all other network traffic. Broadcast storms can usually be prevented by carefully configuring a network to block redundant links, thus preventing loops in the network and avoiding broadcast storms. The Spanning Tree Protocol is primarily utilized to prevent "broadcast storms" in multiple path networks. Based on a "Root Switch", the protocol continuously monitors all links on the network and automatically re-routes traffic in the event one link or several links fail.

In order to employ Spanning Tree Protocols while maintaining the ability to deploy Ethernet switching products from multiple manufacturers, DKS recommends employing Ethernet switching equipment that fully complies with IEEE 802.1d or IEEE 802.1w standards and does not utilize proprietary Spanning Tree algorithms. In order to minimize the fault recovery times to as little as 5 milliseconds and support up to 80 Ethernet switches in a single ring, compared with IEEE 802.1d/IEEE 802.1w fault recovery times that approach 60 seconds on rings supporting up to 31 Ethernet switches, many Ethernet switching manufacturers have developed proprietary Spanning Tree Protocols that do not conform to IEEE standards. However in order to take advantage of these features, then Ethernet switching equipment from a single manufacturer is required.

The chief advantage of this topology is in the area of fault tolerance. Since communications are not focused entirely on one location. Another advantage of a ring topology is geographic coverage. In most cases the data transmission present at each network nodes regenerates the received signal which allows for a wider geographic coverage of the network. The primary disadvantage of a ring topology is the whole network can be impacted by a cable cut is the primary and secondary loops occupy the same conduit bank.

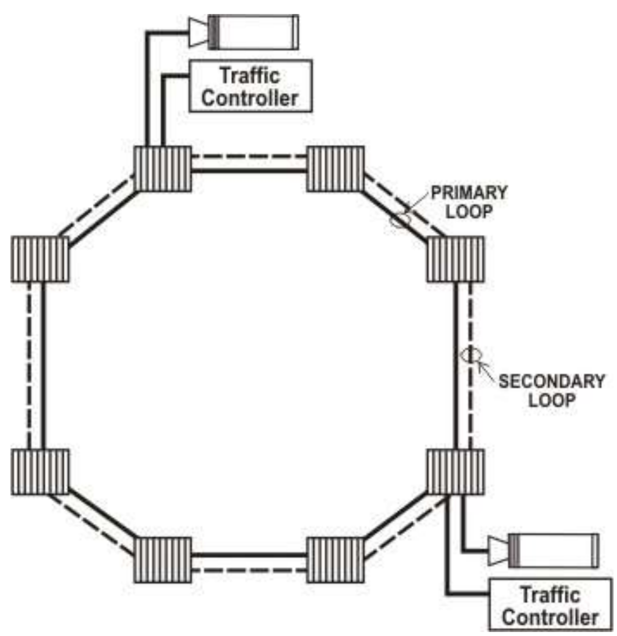

Figure 5-6. Generic Ring Configuration

Mesh
In some backbone technologies, particularly TCP/IP, the equipment can accept many different connections (instead of just primary and secondary), and the firmware on the communication equipment can select the routing of the traffic between any two points on the network (as compared to the ring where the hardware determines the routing). With this capability, a mesh configuration can be established where any number of connections may exist between any two points in the network, as shown in Figure 5-7.

This configuration can provide multiple redundant paths, and allows the system to balance traffic between the nodes in real time. It also provides increased flexibility and growth options for the network. This configuration also provides advantages in a system where there are multiple control points. The virtual traffic management center (TMC) concept, where ITS operations are conducted and monitored from multiple ad-hoc locations, would be well supported by this configuration. The disadvantage of this topology is complexity. Mesh networks require a high level of technical expertise to manage effectively.

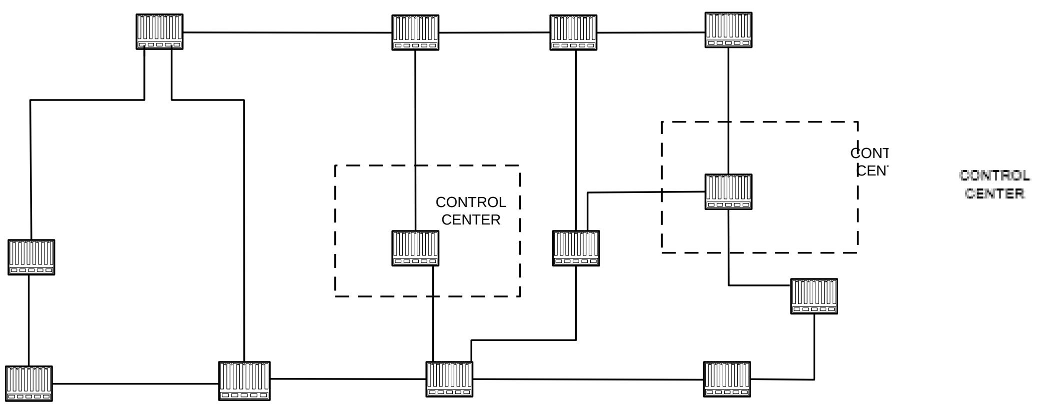

Figure 5-7. Generic Mesh Configuration

Hybrid
A hybrid network combines one or more of the previously discussed technologies into a single network. The most common topology is a hybrid with a star distribution network and a mesh or ring backbone. Hybrids combine the advantages of ring and star topologies to provide relatively high performance with an increased level of redundancy.

A hybrid approach is also typically used in backbones where a ring or mesh has a node that is connected by a spur in a star configuration as shown Figure 5-8. In this case the node on the spur has access to the backbone bandwidth, but does have the redundancy that a node on the ring or mesh would have. This configuration also provides advantages in a system where there are multiple control points. The virtual TMC concept would also be well supported by this configuration.

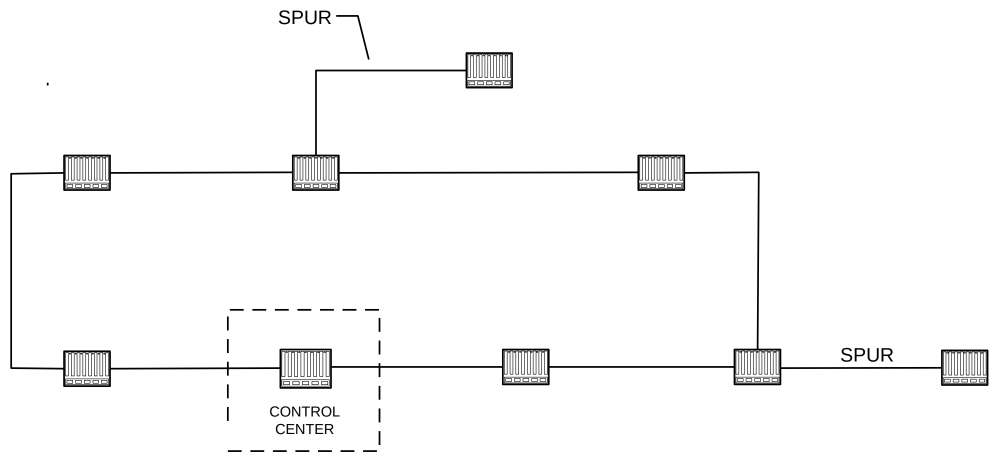

Figure 5-8. Generic Hybrid Configuration

Another hybrid network is a redundant star as shown in Figure 5-9. In this configuration, each device is connected in a star configuration, but two channels are provided to make the connection. The two channels are contained in the same transmission media, providing redundancy should the electronics on one of the end points fail. Since the communication path is common, however, this does not provide any redundancy to communication path failures such as cable cuts.

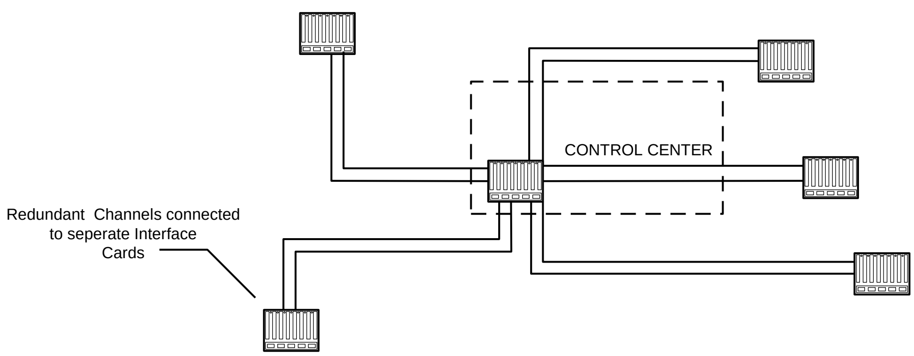

Figure 5-9. Generic Redundant Star Configuration

5.4.3 Backbone Communication Technology Options

The most significant decision in the design of the communication network is the selection of the data backbone technology. The selection must consider the current needs, industry standards, and the developing standards.

At this time there are only three technologies that are widely used, which also have a well established base of standards: ATM, SONET and Gigabit Ethernet. Other backbone systems exist, but they either do not have a full range of accepted standards, or there is not a variety of vendors providing interoperable equipment.

Asynchronous Transfer Mode (ATM)
Asynchronous Transfer Mode (ATM) backbones saw their greatest growth prior to the introduction of 100 and 1,000 Mbps Ethernet transmission. This equipment provided high speed connectivity and easily supported TCP/IP (Ethernet) transmission, making it a popular candidate for use in networks that had a high volume of TCP/IP traffic. The equipment provided routing and supported mesh configurations. ATM also provided the first variable bit rate solutions for transmission of video signals.

With the improvement of speeds provided on Ethernet equipment and new advances in digital video, the implementation of new ATM networks has virtually stopped. With the advent of Gigabit Ethernet (1,000 Mbps), TCP/IP traffic no longer requires conversion to ATM protocols for transmission at higher speeds. The most common digital video transmission protocols are also now based on TCP/IP protocol.

Synchronous Optical Network (SONET)
SONET technology is the traditional choice of telecommunication providers, for whom voice transmission makes up the majority of the traffic. The highly reliable system is based on the provision of established channels that are constantly open between each end point in the system.

The standards for SONET are firmly established and widely followed, and provide for the transport of serial data streams of 1.544 Mbps (T-1) or higher in a number of protocols. Data services operating at lower speeds or different protocols can be accommodated by adding communication components connected to the SONET network. Transmission equipment supporting pure implementations of SONET is interoperable between vendors.

SONET standards do not provide for Ethernet connections or data channels with lower speeds than 1.544 Mbps. Some vendors do provide multiplexers that will accept these protocols and transport them using SONET protocols and data rates, but these products are not “pure” SONET, and are not interoperable between vendors because each multiplexer must communicate with another multiplexer made by the same vendor.

An implementation of SONET in the backbone network for the region that would support TCP/IP (Ethernet) and low speed data would require routers at every node to convert the Ethernet signals into data channels that can be carried by SONET. It would also require multiplexers to combine the low speed data channels for ITS applications into a T-1 signal that can be carried by the SONET multiplexer. These additions require a number of other components as shown in Figure 5-10 resulting in a very complicated network, increasing capital cost and complexity in network maintenance.

The inherent requirement for SONET to assign all channels in a permanent manner can make the system inefficient, unless the transmission requirements are continuous and consistent, and the switching is done outside the backbone network. This is the case in a traditional telecommunication network.

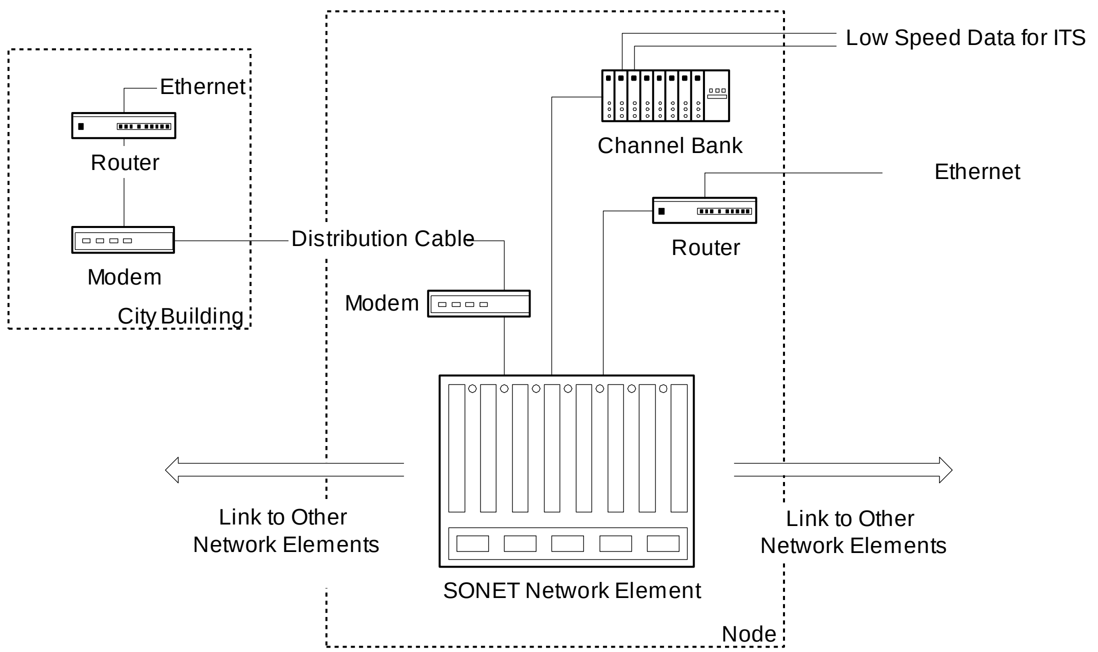

Figure 5-10. Required Equipment for SONET Backbone

Ethernet Family

A third network architecture that is increasing in use as the backbone in ITS networks is based on Ethernet. Although invented in 1976, Ethernet has evolved over time to support larger bandwidths of over 1000 Mbps. While Gigabit Ethernet (GigE) with bandwidth of 1000 Mbps is beginning to be deployed for ITS applications today, research is underway for higher bandwidth Ethernet switches that will support up to 10 Gbps. The increased bandwidth is achieved by continuously refining the Dense Wavelength Division Multiplexing (DWDM) algorithms programmed into the Ethernet switches. DWDM works by combining and transmitting multiple signals simultaneously at different wavelengths on the same fiber. In effect, one fiber is transformed into multiple virtual fibers. The increased speeds are achieved by increasing the number of available wavelengths on a single fiber strand. More available wavelengths contribute to more avenues for the data to get from point "A" to point "B" thereby increasing the overall performance of the Ethernet switch. Given the continued investment into Ethernet by the networking industry, it is reasonable to believe that the Salem-Keizer ITS network may deploy Ethernet equipment that is capable of well over 10 Gbps during the network's lifetime. Standard TCP/IP protocols are used throughout the network, and the components are widely available and interoperable between vendors.

Ethernet provides a number of advantages:

- Based on established standards.
- Provides direct TCP/IP connectivity for center-to-center connectivity.
- Allows a standard IP addressing scheme, and subnetting.
- Supports Virtual Private Networking (VPN).
- Maintains the simple communication configuration.
- Supported by standard Network Interface Cards (NIC) and drivers, allowing direct

connection to the backbone.

- Equipment is interoperable between a number of vendors, and compatible with the equipment and systems installed in the region's facilities.
- The extensive use of Ethernet in communication networks worldwide ensures that it will continue in the future.

Under an Ethernet configuration, a serial hub or terminal server device provides the low speed EIA/TIA 232 communication for existing ITS devices using EIA/TIA 232 communication, but this provides flexibility by allowing each port to be addressed with an IP address. Many new ITS devices may be procured with the Ethernet protocol in place of RS-232/422/485 and no serial hub or terminal server device is required. The routers are not required to convert the Ethernet traffic to other protocols for transport. The equipment at a node is greatly simplified as shown in Figure 5-11.

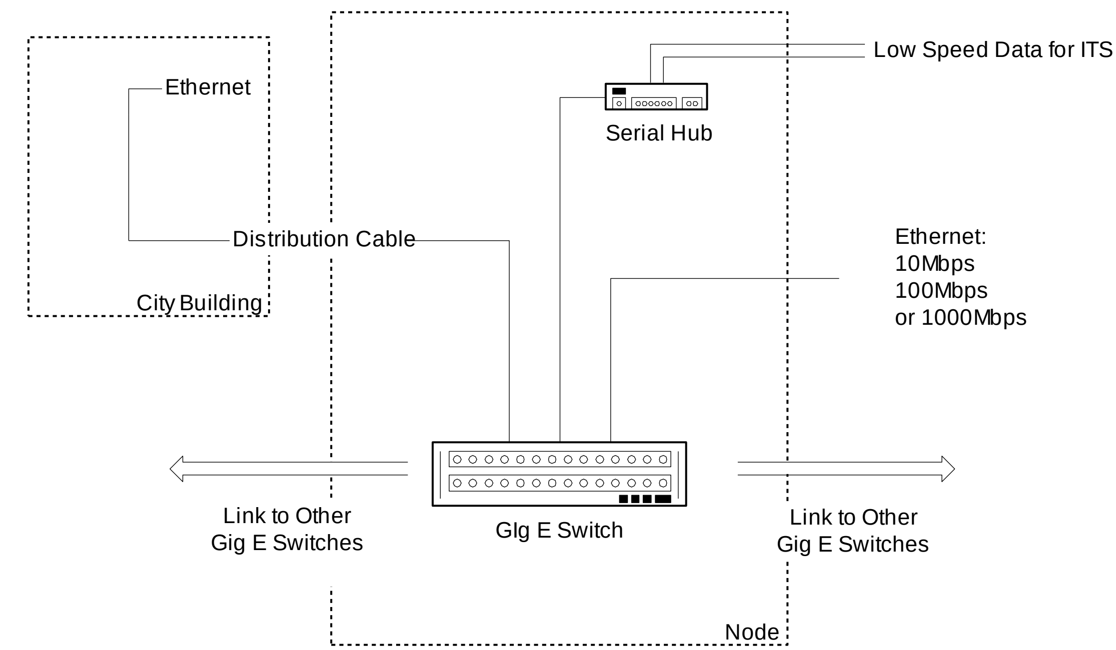

Figure 5-11. Required Equipment for Gigabit Ethernet Communication

5.4.4 Distribution Communication Technology Options

The options for communication in the distribution network are driven mainly by the communication protocol used by the ITS device. Most distribution networks support these protocols directly; however, some distribution systems convert signals in a number of protocols into a common channel that can be easily carried on the backbone network.

RS-232/422/485

The traditional low speed protocol used by ITS devices is RS-232. This protocol is still widely used, and is one of the two low speed protocols recognized by NTCIP as a standard. RS-422 and RS-485 are similar protocols, and are often found in the circuits used for camera control. These all provide low speed communication, typically operating at 9600 bps or 19,200 bps.

Each of these low-speed protocols was originally designed for twisted pair communication, but is now widely supported by fiber optic components. Although RS-232 is actually a point-to-point protocol, it can be supported as a multi-dropped protocol with certain fiber optic transceivers. RS-422 and RS-485 have similar interface requirements except that RS-422 is generally point-to-point and RS-485 is a multi-drop protocol.

In addition to simple point-to-point and multi-drop transmission, there are many options to combine and transport multiple RS-232/422/485 signals on the distribution network. Video/data transceivers are also available that will carry these protocols and video signals over fiber so that a pair of transceivers can provide the video signal from a camera and the camera control data channel.

Some distribution networks use redundancy, and there are data transceivers that can be connected in a ring over fiber to provide redundancy in case of a fiber failure.

Communication for the ITS subsystems requires the provision of low speed links to the controllers for each device. A number of controllers can typically share each low speed channel, and with NTCIP compliant controllers, functions such that vehicle detection and dynamic message sign control signals can share the same channel.

As shown in Figure 5-12, the low speed channels can be carried on the distribution cable from the node to the device using fiber optic modems. These modems will carry the signal over a pair of fibers connected in series so that the same pair of fibers can serve a number of modems. When the signals are carried to the node, a modem converts the optical signal to an electrical signal that can be connected to node equipment.

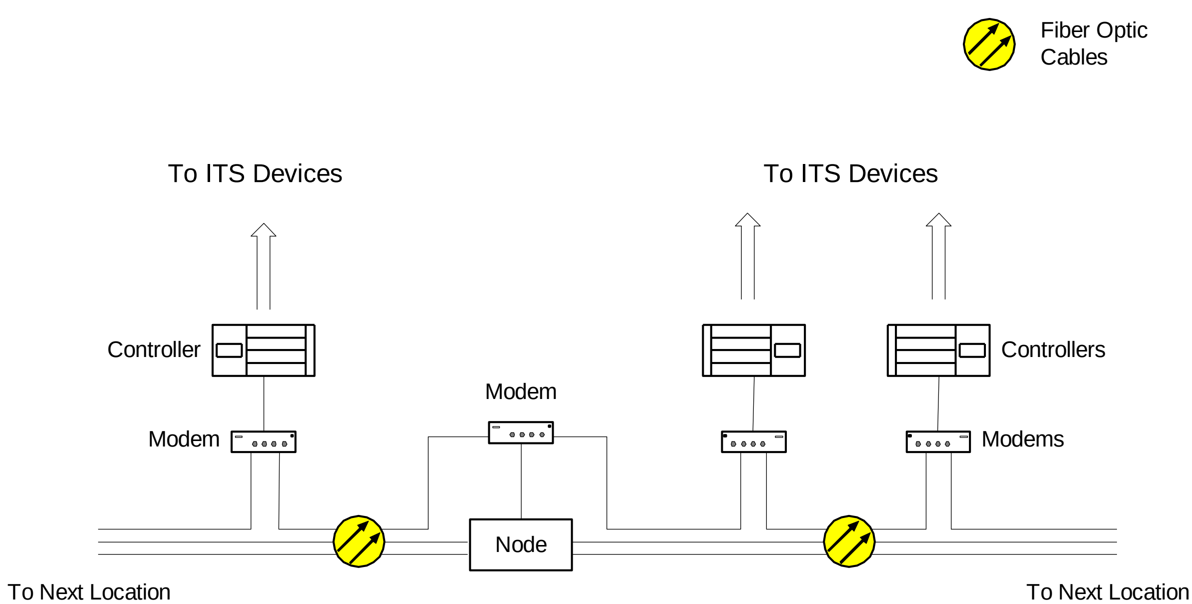

Figure 5-12. ITS Distribution – RS-232

Video Transmission

There are two economical methods of carrying the video signals from the field cameras to a control center: simple analog video transmission over fiber optic cables or digitized video carried by the backbone transmission equipment.

Analog video signals can be carried economically approximately 30-40 miles and provide a full motion video signal. Such transmitters could also carry the camera control signal as described above. Analog video signals differ from digitized video signals in that digital video signals are compressed. Consequently digital video signals require less bandwidth compared to analog video signals.

A number of video signals can be multiplexed and transported over a single fiber. Such systems typically combine from four to twelve signals on one fiber, but systems with as many as 128 signals are available. These systems become economical when there are few fibers available or the transmission distances are greater.

Individual camera signals would be carried on single channel transmission systems to a node location. At the node, a number of camera signals will be multiplexed into one signal that can be carried over a fiber to the control center, as shown in Figure 5-13.

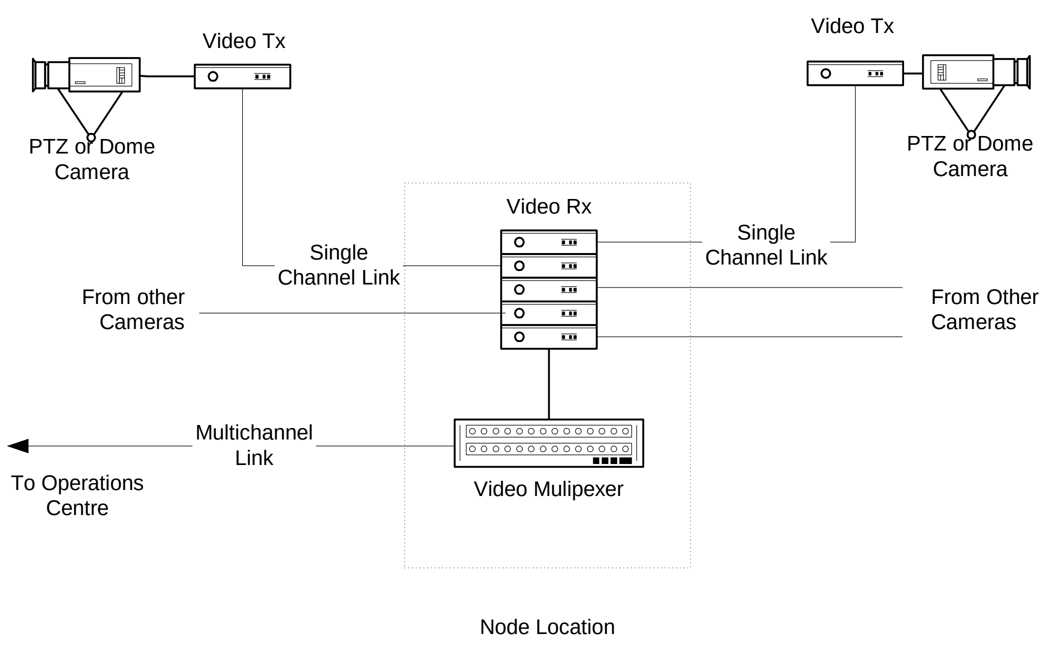

Figure 5-13. Video Links

The trend in the ITS industry is towards digital video transmission equipment that will carry digitized video signals over a TCP/IP network ("IP Video") as shown in Figure 5-14, and the quality of the video images can be equivalent to analog systems. There is significant development occurring in this area, with improved quality using less bandwidth, and the systems are becoming more cost effective.

A significant advantage of IP Video over analog video is flexibility. Analog video signals are typically transmitted over dedicated circuits whereas compressed digital video can be converted to data packets that are suitable for transmission over TCP/IP based networks. This flexibility allows ITS network operators to store, duplicate, and transmit (i.e. multicast) identical video streams to multiple users on the network.

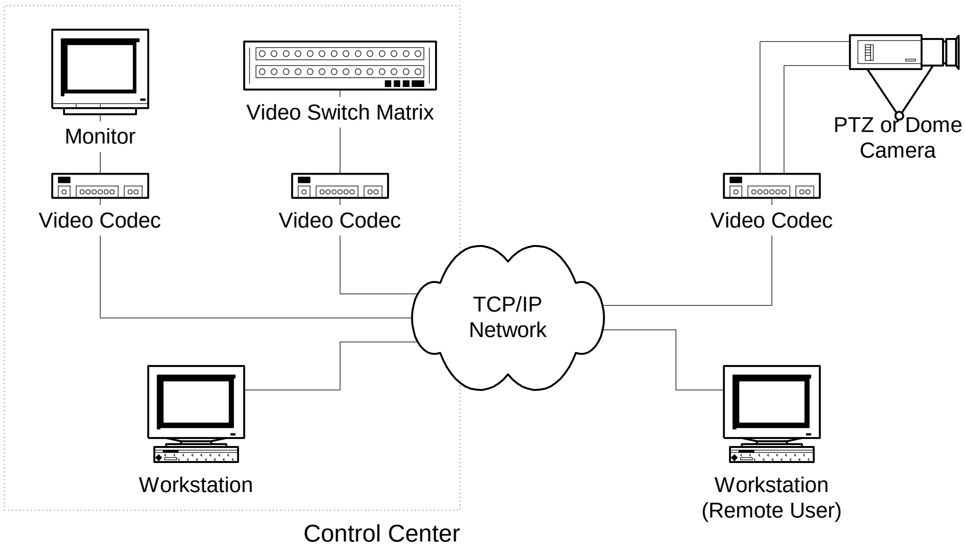

Figure 5-14. TCP/IP Network

Ethernet

With the proliferation of Ethernet (TCP/IP) communication in most computing equipment, this protocol is now appearing as an option in many ITS devices. Ethernet is a shared network providing a much wider bandwidth link to each device. (10 Mbps Ethernet typically provides up to 2 Mbps of actual throughput and 100 Mbps or "fast Ethernet" provides over 22 Mbps). Ethernet protocols also offer the ability to set transmission priorities to the different types of video and data traffic on the network. This allows the ITS network operator to control the Quality of Service (QoS) given to each application using the network.

Ethernet is the second low speed protocol standardized under NTCIP, and is gaining use in this area because the increased connection speed is needed to support the overhead required by the NTCIP protocol. With Ethernet being the defacto standard for office networks and the Internet, it is clear that Ethernet equipment will be available for many years to come.

Where the backbone network is Gigabit Ethernet, the use of Ethernet for the distribution can result in a very simple and flexible network. Small serial hubs can be used to convert RS-232/422/485 signals to Ethernet traffic so that the network can support all data requirements. If IP video is also implemented, all network traffic can be carried as an Ethernet signal as shown in Figure 5-15.

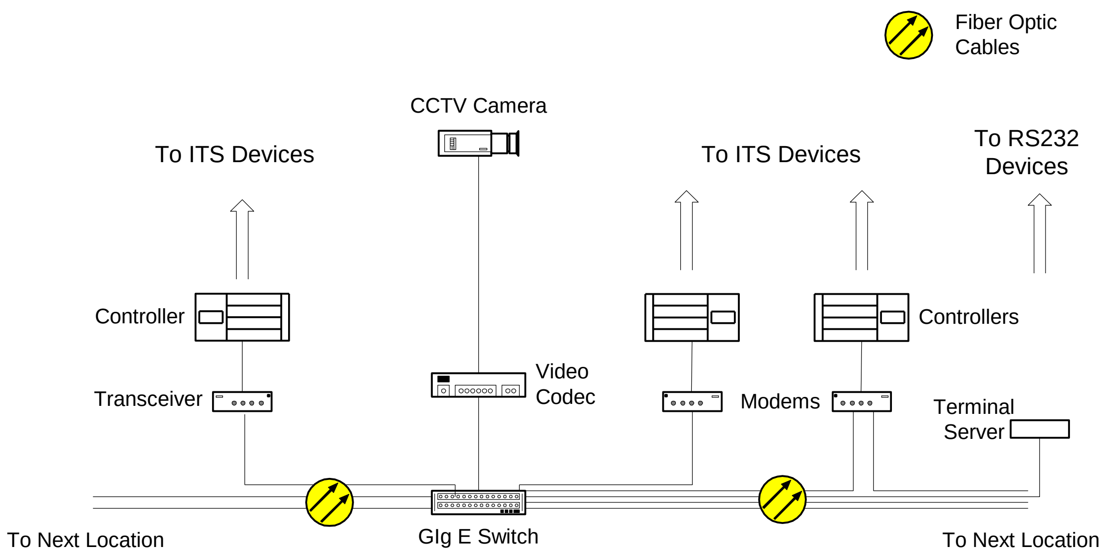

Figure 5-15. ITS Distribution

Wireless

Wireless communication is being used for distribution services for an increasing number of systems due to its advantage of not requiring a physical cable installation. Most wireless systems will carry RS-232/485 communication and can be used interchangeably with a pair of fibers and interconnecting fiber as described above.

Ethernet communication can also be accomplished over wireless links, and standards such as IEEE 802.16s are evolving to the point that wireless Ethernet communication manufacturers will begin production of equipment that can provide wireless broadband Ethernet coverage throughout the Salem-Keizer Metropolitan Area. IEEE 802.16a is a sister standard of the widely used IEEE 802.11 wireless Ethernet standard. Whereas IEEE 802.11 is commonly deployed in office buildings and has an effective operating coverage of approximately 300 feet from the network access point, IEEE 802.16a operates in the 2-11 GHz licensed and unlicensed frequency bands and is specifically focused on deployment where operating coverage in excess of seven miles.

Microwave transmission is an option in many ITS networks, including the Salem-Keizer. Unlike IEEE 802.16a, microwave communication requires visual line-of-sight between transmitter and receiver and frequency spectrum allocation from the Federal Communications Commission (FCC). However microwave communication would be especially effective in areas with large bandwidth requirements that are located on flat terrain and away from the fiber optic backbone.

Regardless of whether licensed or unlicensed frequencies are employed, encryption of the data at the transmitter with decryption at the receiver is recommended for all wireless applications where risk of interception and/or unauthorized manipulation is not desired. Data encryption can decrease overall data throughput anywhere from 15 to 40 percent depending on the type of wireless technology and encryption algorithm and techniques employed.

5.5 COMMUNICATION PLAN RECOMMENDATIONS

This section describes the communication plan recommendations, and the process used to reach these recommendations. This methodology starts with the areas to be connected, addresses the configuration to be used, and develops a logical plan to serve the entire area.

At this stage of the process, this plan provides a high-level conceptual design of the network. Therefore, as the alternative technologies, architectures and approaches were considered, detailed cost estimating was not performed. Recommendations are based on industry experience, and a higher-level analysis combining the ability to meet requirements, cost, technical maturity, availability of equipment and services and a number of other factors.

It is highly recommended that this plan be considered a guide, and not a final design. It is further recommended that as each network segment enters planning and detailed design, all options be considered for connecting centers and field devices, including:

- Building new fiber optic cable.
- Utilizing existing twisted pair or other copper plant.
- Utilizing existing wireless communication links.
- Leasing communication services from private providers.
- Building and/implementing new wireless communication links.

Finally, as discussed in Section 5.1, it is recommended that this plan be updated regularly, as various segments of the network are built, and if and as overall design philosophy changes.

Physical Topology

Section 5.4 discussed the common physical topologies employed in data communications. Among the topologies discussed, DKS Associates believes a hybrid physical topology is best suited for ITS operations in the Salem-Keizer Metropolitan Area. Employing a hybrid topology will allow member agencies to fully utilize their existing and planned network infrastructure in a manner that can benefit and complement others. Specific recommendations are listed below:

- **Establish broadband Ethernet communications using the existing copper twisted pair network on an "interim basis" until fiber optic cable is made available through new construction or leasing.** This would allow for the deployment of high bandwidth ITS field devices such as CCTV cameras. Instead of waiting for fiber optic infrastructure funding, Salem-Keizer ITS stakeholders could begin deploying measures to address traffic congestion in the area.

- **Construct communication hubs at key locations to facilitate high speed communications between the field and traffic management centers.** Ideally the communication hubs would be located on the fiber optic ring and serve as transition point for ITS data and video signals from copper twisted pair, wireless or other medium to the fiber optic ring. Since much of the fiber optic ring is not in existence, the communication hubs would be located where ITS corridors intersect with each other. In the absence of fiber optic cable, detailed design efforts will focus on maximizing the bandwidth at these locations by provisioning as many copper twisted pairs as possible between the communication hub and the nearest TOC. If copper twisted pair cable is not available for Communication Hub-to-TOC communications, then wireless communications will be examined.

- **Establish high-speed Center-to-Center communications using fiber optic cable connections or Ethernet-over-Copper equipment.** The primary Center-to-Center link is expected to be between the City of Salem TOC and NWTOC. There are multiple fiber optic projects in the planning stages that will result in a dedicated fiber link between the two agencies. For other traffic management centers or nodes, DKS recommends establishing links to the City of Salem or NWTOC using fiber optic cable or Ethernet-over-Copper if possible. As a last option, DKS recommends exploring the potential for establishing a licensed microwave network in the area that is capable of transporting multiple CCTV data streams.

5.5.1 Communication Technology

This section provides a summary of recommendations for physical infrastructure and communication technology to support the deployment of ITS field devices and center-to-center information exchange requirements as identified in the deployment plan.

Plant Level

At the plant level, the preferred technology is fiber optic cable. The fiber may be owned by one of the agencies or leased as dark fibers from others such as Qwest or Comcast. As each network segment goes to detailed design, both leased and new build options should be analyzed and a final decision made on a case-by-case basis. Regardless of whether the physical plant is leased or agency owned, DKS recommends all Salem-Keizer ITS stakeholders be granted access to the entire network. This will ensure technology issues do not hamper the ability of Salem-Keizer traffic management staff to efficiently address the traffic congestion and incident management issues. From a maintenance perspective, DKS Associates recommends Salem-Keizer ITS stakeholders be held responsible for maintaining the ITS infrastructure placed in their jurisdiction.

<u>Single Mode (SM) vs. Multimode (MM) Fiber</u>

Although multimode fiber transmission could be used for links with short lengths (generally the distribution from a node to the field devices) this would require the use of a hybrid SM/MM fiber cable that would be a custom order. DKS Associates recommends the system utilize only SM fiber.

This approach will standardize the transmission components and allow the procurement of the widely available SM fiber. It will also ensure that all of the spare fibers in a cable could be used for any application. (In a hybrid cable spare MM fibers cannot be used for the longer distance links).

While fiber is the recommended technology for any new construction, other more cost effective distribution options may also be reviewed during detailed design, including using existing twisted pair plant and/or wireless links as discussed hereafter. Since multiple departments are requesting access to the fiber optic cable, DKS Associates concurs with the City of Salem and

ODOT standard fiber optic trunk line of 96 strands. This would support the current requirements and provide ample room to allow the fiber ring to support future requirements.

Use of Existing Twisted Pair for Distribution

The existing twisted pair cable in the City of Salem may be used for the distribution from the communication hub to the field device. The copper twisted pair network is currently used to transmit serial and Ethernet data between the BI-Trans/QuicNet 4.1 central server at the City of Salem and each of the traffic controllers deployed in the field.

Many central traffic signal control system manufacturers including McCain, the makers of BI-Trans, are currently developing versions of their product that communicate using Ethernet data packets as opposed to serial data. Increasing the deployment of serial-to-Ethernet converters will allow the City of Salem to reallocate the existing twisted pair from the Type 170 traffic controller to a digital subscriber line (DSL) modem.[8] The deployment would include a high data-rate digital subscriber line (SHDSL) modem and a field hardened Ethernet switch in each traffic signal controller cabinet. This upgrade would allow the City to free up pairs that could then be used to support deployment of other ITS field devices such as CCTV cameras and dynamic message signs.

To complete the SHDSL deployment, DKS Associates recommends establishing communications hubs at selected locations with access to both copper twisted pair and the fiber backbone. The purpose of the communications hub is to serve as the interface between the fiber network and the copper twisted pair network. To that end, each hub will typically be equipped with a digital subscriber line access multiplexer (DSLAM), Ethernet switch and fiber termination panel to perform this function. DKS estimates the communications hub equipment could be housed in a dedicated Type 332 traffic control cabinet. Figure 5-16 illustrates a typical SHDSL configuration in an ITS environment.

[8] When deploying serial-to-Ethernet converters both ends of the circuit are required to have conversion equipment manufactured by the same company to ensure interoperability.

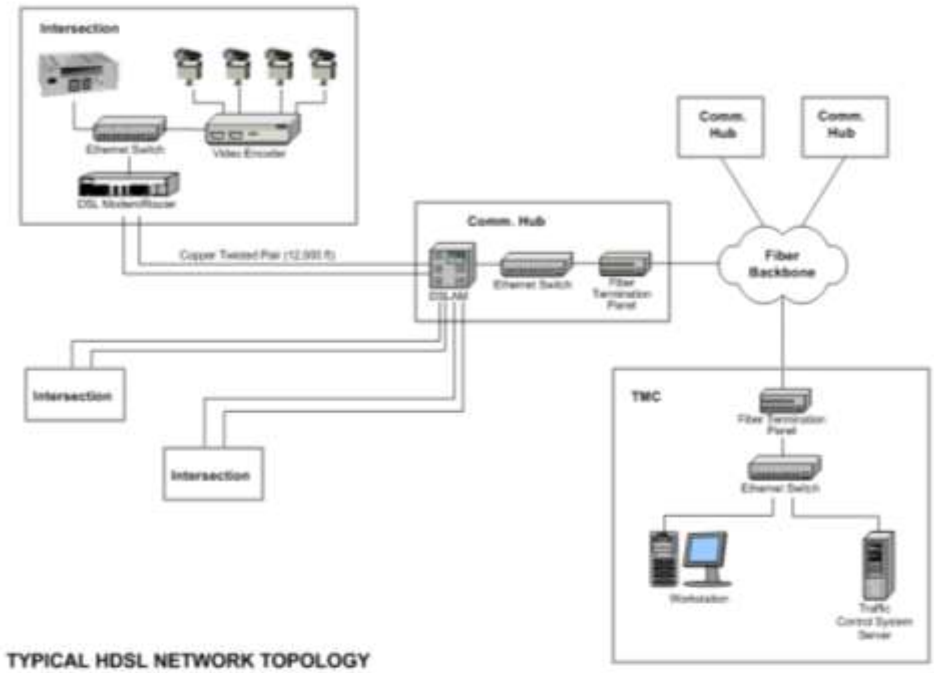

Figure 5-16. Typical HDSL Network Topology

Wireless Distribution

Wireless communication is also a viable option for distribution services between the node and the field device. Since high capacity wireless systems (SONET OC-3 at 155 Mbps) can typically cost over $60,000 per link, it is not anticipated that they would be the primary selection for backbone transmission although less expensive, lower speed wireless systems could be used as back-up Center-to-Center links for redundancy purposes. However, wireless systems could be considered to provide links for sections of the Salem-Keizer that do not have access to the backbone via fiber or copper twisted pair, or to link sections through environmentally sensitive areas or those with particularly difficult obstacles.

The choice of wireless or wireline transmission for specific areas should be determined during detailed design, and will be based on the local site conditions and facility availability.

Recommendation:

Expand the fiber optic network where feasible. Deploy Ethernet-over-Copper equipment on an interim basis in order to deploy high bandwidth ITS field devices in advance of fiber optic cable. For remote locations and/or sites without direct access to the fiber optic cable or copper twisted pair, consider using the wireless communications.

Video Transmission

It is recommended that the video signals on the network be transported as digitally encoded video. In order to give key stakeholders maximum flexibility in determining the location from which ITS operations are controlled, analog video must be converted to IP data at some point in the network.[9] By using IP video transmission throughout the network the video can be easily routed to users at any point on the network.

With multiple agencies covering the region, it is expected that several video images will be of interest to more than one agency. In these circumstances one video image is commonly required at more than one control center. With digital video this is accomplished simply by sending the IP stream to a select group of users on the network with one transmission. This process is known as multicasting[10]. Instead of multicasting, analog systems require distribution amplifiers and additional video channels between control centers.

IP video transmission should adhere to a current Motion Picture Expert Group (MPEG) standard. At this time, the most common MPEG standards are MPEG-1, MPEG-2 and MPEG-4. MPEG-1 produces video quality slightly below the quality of most conventional VCR videos and is therefore no longer widely used. MPEG-2 was developed for all major TV standards including NTSC and HDTV.

MPEG-4 is based on MPEG-1, MPEG-2 and Apple QuickTime technology and is designed to require considerably less bandwidth than MPEG-1 and MPEG-2. The initial MPEG-4 standard, MPEG-4 SP (Simple Protocol) was finalized in 1998. MPEG-4 SP was intended for low bandwidth applications such as dial-up internet access. In 2000 MPEG-4 Version was ratified as an international standard. Since 2000 several incremental enhancements to this standard were introduced including Advanced Simple Protocol (ASP) and Advanced Video Coding (AVC). MPEG-4 ASP improves upon MPEG-4 SP in that the ASP algorithm is better able to compensate for changes to the picture caused by the movement of objects. MPEG-4 AVC, also referred to as MPEG-4 Part 10 and H.264, was recently introduced. AVC improves upon ASP by offering significantly greater compression. MPEG-4 AVC is capable of providing DVD-quality video under 40 percent of the bit rate of MPEG-2 and is considered promising for full-motion video over wireless and Ethernet-over-Copper connections.

MPEG-4 supports traditional video display devices and also allows standard web browsers to view the video stream over an Ethernet connection to the backbone network. MPEG-2 typically produces a higher quality video signal than MPEG-4 and is better suited to instances where bandwidth is not an issue (i.e. where agency owned fiber is available). MPEG-4 is better suited for instances where bandwidth and/or fiber optic cable is at a premium (i.e. where leased lines are employed).

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9 Analog transmission cannot be used since it requires a separate network and video receivers at the user's location. Since these receivers cannot be moved easily to accommodate the "virtual control center", the video is converted to IP traffic that can easily be directed to the user's IP address, no matter where they are connected in the network.

10 Most IP traffic uses unicasts, where traffic is sent from one sender to one receiver on the network. With video, the traffic can be multicast, meaning video sent from one sender to a select group of receivers on the network in one transmission. This reduces network traffic by sending the data only once to two or more receiving locations. A third transmission mode, broadcast, sends from one address to all other addresses on the network. Broadcast transmission is typically only used for short messages to all devices, and must be used with caution if the receiving devices must respond to the broadcast command, as they can easily overload the communication network.

Digital video compression is an area undergoing constant innovation. ODOT has employed a mixture of MPEG-2 and MPEG-4 encoders statewide. Generally speaking, ODOT deploys MPEG-2 encoders at locations with fiber optic connections where bandwidth is not limited and MPEG-4 ASP encoders at locations with copper or wireless connectivity. As larger quantities of MPEG-4 AVC encoders enter the market, ODOT expects to transition away from MPEG-4 ASP to MPEG-4 AVC. DKS Associates recommends the Salem-Keizer stakeholders carefully review the video encoding technology on a regular basis to ensure the ITS network is employing compression technology that best fits their needs.

Backbone

Gigabit Ethernet transmission is recommended for backbone transmission. The primary reasons for this recommendation are as follows:

- GigE is well suited for all network topologies employed in the Salem-Keizer area such as ring (fiber ring) and star (possible HDSL deployment using existing copper twisted pair network).
- GigE switching equipment suitable for deployment in traffic control cabinets is becoming available in the marketplace.
- GigE provides flexible bandwidth allocation, which will allow key stakeholders to establish temporary traffic management centers as necessary.
- GigE will support transmission of the recommended IP video without any additional transmission equipment.
- GigE will directly support NTCIP standards for center-to-center communication, as well as NTCIP communication over Ethernet to field devices.
- GigE is mid-span compatible[11] between vendors, allowing different agencies to select different hardware for their portion of the network, and allowing open procurement.
- GigE provides quality of service (QoS) levels that can assign a priority (or QoS) to data from different ports. This allows prioritization of the services to be provided if the network is operating in a failure mode or peak traffic period. The IEEE 802.1.p standard delineates eight categories for prioritizing traffic at the Data Link layer of the OSI model. At this time many Ethernet equipment manufacturers do not strictly follow IEEE 802.1p. Instead they employ two or three categories of traffic prioritization, which are typically proprietary in nature. Therefore, ITS networks desiring a high level of QoS should strongly consider standardizing on a single Ethernet switch manufacturer within the communication hub and Traffic Operations Centers.

Recommendation:

Convert analog video to digital. Digital video provides the greatest flexibility for sharing video between multiple agencies. Consider the installation of digital video cameras as the quality improves.

[11] When equipment is mid-span compatible, products from different vendors will function fully when inter-connected.

Reasons GigE is recommended over SONET
SONET transmission offers very fast switchover to redundant rings and dedicated channel capacity to any point in the network. However, it does not provide the advantages of GigE in the following areas:

- A pure SONET implementation does not support TCP/IP traffic that is specified in the NTCIP standards, or the low speed data channels. In these cases, additional channel banks or multiplexing/encoding hardware would be required.
- Proprietary SONET implementations will support video, Ethernet and low speed data directly, but once a type of equipment is selected for the ring, the same vendor must be used elsewhere. This could be a problem in multi-agency networks.
- SONET networks set up channels and reserve bandwidth between points on the network. Where the data requirements change, particularly as routing for video is changed, the channels would have to be re-routed through the nodes. Standard SONET implementations do not do this automatically, or in a user-friendly manner; it must be completed through changes at the network management system.
- Generally, SONET has a higher cost per node, particularly when the equipment required to convert the low speed RS-232 signals for transport on the SONET network are included.
- Overall cost and complexity of SONET network (due to the points discussed above) is not justified by regional redundancy requirements.

ATM
Asynchronous Transfer Mode (ATM) is a network technology based on transferring data in cells or packets of a fixed size. The small, constant cell size allows for the efficient transmission of video, audio and data on the same network. ATM equipment is expensive to procure and requires a high level of training to operate and maintain compared to Ethernet and is not recommended for ITS networks.

Recommendation:
Use Ethernet for links between field devices and communication hubs. Utilize GigE for Hub-to-TOC communications and Center-to-Center communications. In the mid to long term, consider 10GigE where the extra bandwidth is required and as prices of the equipment become more cost effective.

Distribution
At this time, the recommended protocol for distribution to most devices is RS-232 communication, but all detailed design should support a migration to Ethernet. This recommendation is based on the large installed base of RS-232 traffic signal controllers, and the fact that Ethernet based controllers using NTCIP protocols are only just now becoming available. As new versions of controllers are made available in the market, Ethernet communication should be considered, as it will likely become the standard in the future.

To provide RS-232 distribution to field devices over the GigE network, small terminal servers or serial hubs should be used. These devices are up-linked to the Ethernet network on the backbone, and provide a number of RS-232/485/422 ports, each addressable with a unique IP address. The central computer would communicate over the Ethernet network to the serial hub, where the data would be converted. From the hub to the end device, fiber optic links, wireless links or twisted pairs could be used as determined in detailed design.

Where possible, field nodes would be co-located at video camera locations, allowing video to be encoded and directly inserted on the backbone. When this is not possible, the video signal must be carried on the distribution network. It is recommended that the video image be converted to IP video at the base of the pole, and transported using video transceivers to the node. This approach eases a later migration to Ethernet.

Recommendation:
Migrate to IP addressable field devices as they become available. In the interim, provide terminal servers to support the Ethernet transmission standard.

5.5.2 Map of Proposed Communication System

Figure 5- illustrates the existing and proposed ITS equipment, centers, communication hubs, and the existing and proposed communication network infrastructure. The following sections briefly describe some details of the proposed network.

Figure 5-17. Map of Proposed Salem-Keizer ITS Network

Backbone Routes
The communication links identified in this plan will likely be constructed in phases, either as funding becomes available or in coordination with roadway improvement projects. One way to cost effectively support this phased construction process may be to build new fiber within the boundaries of a specific construction project and utilize leased services, Ethernet-over-Copper or wireless for hub to hub and/or hub to center connectivity.

When fiber cable is installed on any of these routes, sufficient fibers to support the ultimate network should be included, even if the current build is only a section of the backbone.

Standard Network Node Bandwidth Allocation
To determine bandwidth requirements, the standard field node configuration assumed would consist of the equipment listed in Table 5-2. The bandwidth requirements are based on a worst case scenario where the data sources listed in the table are assumed to be operating at maximum bandwidth at all times. DKS recommends designing the ITS network to be capable supporting the maximum possible bandwidth.

When performing detailed design, DKS Associates recommends following a design philosophy of distributing the bandwidth evenly between backbone nodes. This approach often allows for a common design approach to be applied to the system, simplifying the network configuration and maintenance.

Table 5-2. Standard Node Requirements

Communication Channel	Type	Description	Maximum No. of Channels Required	Approximate Maximum Bandwidth
CCTV Cameras	Video	One video camera per node	1	8 Mbps
CCTV Camera Control	RS-232/422/485	One common channel for all cameras	1	9.6 kbps
Traffic Signal Control	RS-232 or Ethernet	Up to six intersections per channel	2	56 kbps
System Detectors	RS-232 or Ethernet	Up to six detectors per channel	1	9.6 kbps
DMS	RS-232 or Ethernet	Up to four signs per channel	1	9.6 kbps
Other (HAR, RWIS)	RS-232		1	9.6 kbps
Total				8.095 Mbps

5.6 Maintenance & Operations

Figure 5-18 indicates the primary components of a generic regional communication network, and will be used to illustrate some of the maintenance and operations issues related to the communication network.

This figure assumes a network configuration in which agency specific fiber may be located in the same bundle or sheath as fiber that is utilized for the regional communication backbone. It also assumes that shared regional communication equipment (such as hubs, routers, multiplexers, transmitters and receivers) may be located in one agency's cabinet. Under this scenario, a number of different maintenance and operational issues need to be addressed and a series of recommendations are included in this section.

5.6.1 Fiber and Equipment Design

Communication equipment such as fiber optic cable, splice cabinets and enclosures, hubs, routers, multiplexers and modems should be standardized to the extent possible. In addition, local agencies should utilize standard equipment for their portion of the communication network that follows the standards of the backbone communication network. This supports bulk equipment purchasing, stocking of spare equipment, training of operations and maintenance personnel, network expansion and overall interoperability.

In cases where multiple agencies share portions of the same fiber optic cable plant, DKS Associates recommends the establishment of cooperative agreements between all involved parties. These agreements will formalize the fiber optic cable strand assignments for each agency and delineate the operational responsibilities, maintenance responsibilities and documentation responsibilities of each stakeholder. Frequently agreements of this nature require all parties to document the location of all cable, splices and end electronics in a common manner, typically using a single database.

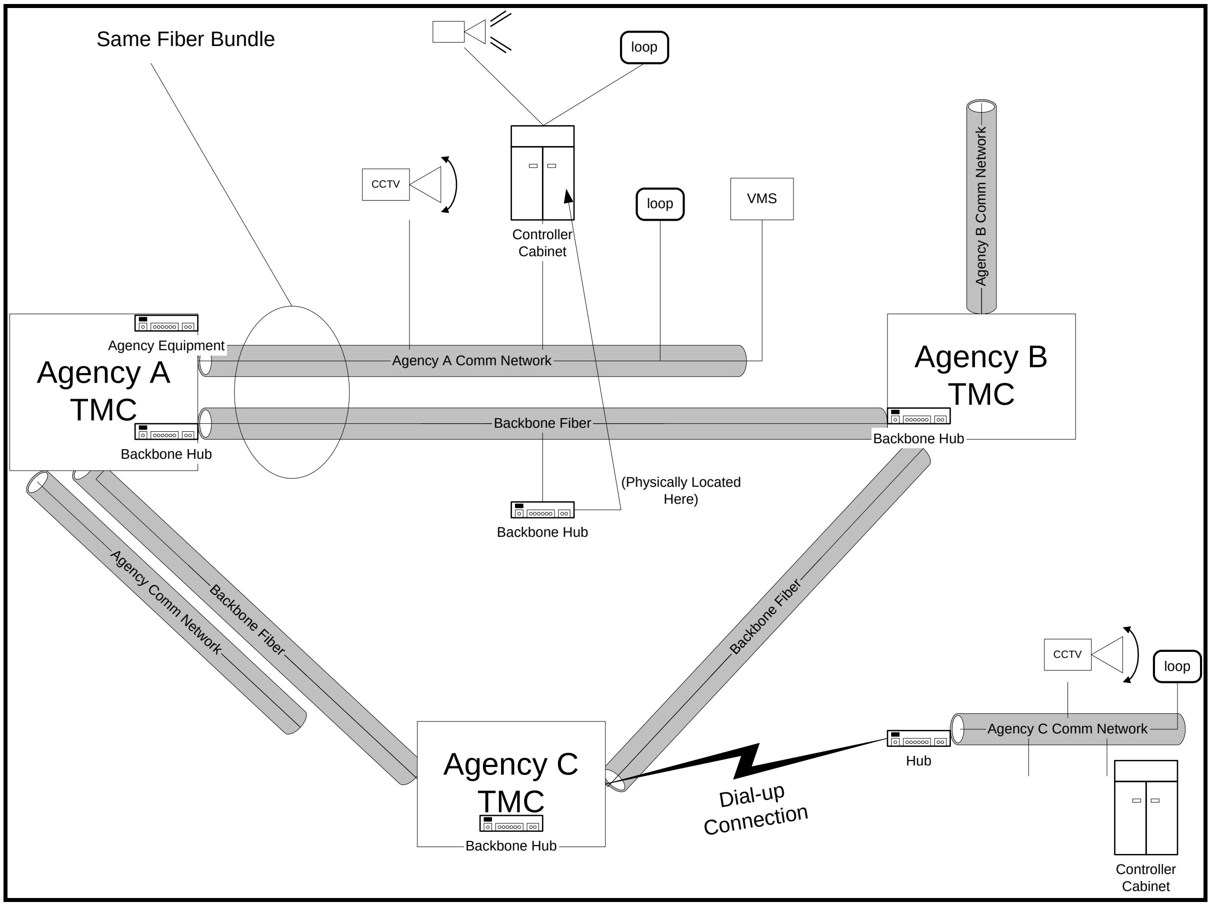


Figure 5-18. Conceptual Communication Network

5.6.2 Operations and Maintenance (O&M) of Communication Equipment

Many agencies have found that the cost of maintaining their own fiber optic networks—including equipment, training, and allocated staff—can be prohibitive. The rate of equipment or cable failure is so low that the trained personnel often do not get the opportunity to use the training on a small system, making them ineffective when repairs are needed. Often a group of regional agencies have pooled their resources, developed necessary agreements, and either selected a lead agency or a preferred contractor to maintain the network.

Any final maintenance agreements will need to address the issues in the following subsections.

5.6.2.1 O&M of Agency Dedicated Fiber

This agreement should identify each agency's responsibility for maintaining and operating fiber that connects to their own field devices.

5.6.2.2 O&M of Backbone Fiber

This agreement should identify each agency's responsibility for maintaining and operating fiber that is used for the regional communication backbone.

5.6.2.3 O&M of Equipment Located in Agency Facilities

This agreement should identify each agency's responsibility for operating and maintaining equipment that is located in an agency's facility (such as the TOC). It is assumed that both agency specific communication equipment, as well as backbone communication equipment, will be included in agency facilities, and the responsibilities for operating and maintaining both sets of equipment need to be established.

5.6.2.4 O&M of Equipment Located in Agency Field Devices

This agreement should identify each agency's responsibility for operating and maintaining equipment that is located in an agency's field device (such as a controller cabinet or splice vault). It is assumed that both agency specific communication equipment, as well as backbone communication equipment, will occasionally be included in agency field devices, and the responsibilities for operating and maintaining both sets of equipment need to be established.

5.6.3 Service Level Agreements

Once an agency (or group of agencies) has been determined as the lead agency (ies) for ongoing maintenance and operations of the network, agreement needs to be reached on level of service. Service level agreements (SLA's) include issues such as response time for a network outage to be repaired, prioritization of bringing equipment/fibers back on-line after an outage and availability of the network (acceptable amount of downtime per year).

5.6.4 Utilization of Dial-Up and Leased Line Connections

Some agencies currently use (or may plan to use) leased line connections to field devices. Opportunities to replace these connections with agency-owned infrastructure and/or purchase bulk telecommunication services from service providers should be examined, and regional rules-of-thumb developed.

CHAPTER 6 DEPLOYMENT PLAN

6.1 INTRODUCTION

This chapter provides an overview of the ITS deployment plan for the Salem-Keizer Metropolitan Area and includes details about the ITS projects, such as how and when projects will be deployed. A key goal of this plan is to integrate existing technology based systems, incident management, traffic signals and communication infrastructure and develop a program for the future that will tie all of these technologies together into a coordinated, functional system that will serve the region's transportation system. The success of many of these projects relies heavily on integration with other projects, shared resources and coordination between agencies.

The projects included in the deployment plan were developed based on collaboration from the project Steering Committee. A project deployment schedule is provided based on a timeline of a 0 – 5 Year Plan, a 6 – 10 Year Plan, and an 11 – 20 Year Plan. Additional details are provided for some of the significant projects scheduled for deployment within the first five years.

6.1.1 Deployment Plan Workshop

On June 28, 2005, a workshop was held to discuss strategies for ITS deployment in the Salem-Keizer Metropolitan Area. The workshop included the project's key stakeholders (agency staff) as well as expanded stakeholders including additional agency staff (e.g. maintenance, emergency services and planning). The main purpose of the workshop was to obtain consensus regarding the projects included in the deployment plan.

The workshop began with a short presentation to summarize the project to date and highlight how the user needs collected earlier in the project were used to determine deployment plan projects. Workshop participants then participated in one of the following breakout groups:

- Traffic Management, Traveler Information, Public Transportation Services
- Emergency Management, Archived Data Management, Maintenance and Construction Management

Participants were given the opportunity to participate in discussion related to the specific topic area, ask questions and provide comments regarding modifications to the project list or project phasing. The group reconvened at the end of the meeting to summarize comments from each session. Appendix K includes the workshop invitation, presentation, handout, and meeting minutes.

6.2 Deployment Projects

The ITS deployment projects for the Salem-Keizer Metropolitan Area are summarized in Table 6-1. The table includes the following details for each project:

- Project Number (for reference)
- Lead Agency
- Project Title
- Project Description
- Priority (High, Medium, or Low)
- Relativity to Planned Projects
- Project Dependencies
- Capital Costs/Operation &Maintenance Costs/Staff Costs
- Expected Benefits
- Technical and Institutional Feasibility

The project numbers are used for reference purposes only and although they generally follow the ranking developed by the steering committee, do not solely indicate project priority. Within this table, the projects are described under one of the following eight applicable categories:

- Traffic Management (TM)
- Traveler Information (TI)
- Emergency Management (EM)
- Public Transportation Services (PT)
- Communications (CO)
- Archived Data Management (AD)
- Maintenance and Construction Management (MC)
- Program Evaluation and System Management (PM)

Each project was assigned a priority of high, medium, or low based on a scoring exercise to determine project rankings (criteria included safety/crash prevention, traffic volumes/congestion, key traveler decision location, user needs, statewide consistency, relativity to other planned projects, short term-funding availability, and support of other plan projects), input from the Steering Committee, cost, expected benefits, technical and institutional feasibility and equitable distribution of projects. The corridors in the study area were also prioritized based on forecasted traffic volumes and the number of collisions and given corresponding high, medium and low designations. The high, medium, and low priorities relate to a 20-year schedule that includes a 5-Year Plan (0 – 5 Years), 10-Year Plan (6 – 10 Years), and a 20-Year Plan (11 – 20 Years), respectively. Figure 6-1, 6-2, 6-3, 6-4, 6-5 and 6-6 show equipment and infrastructure deployment locations for many of the ITS projects and depicts how they fit in with the 5-Year, 10-Year, and 20-Year Plans.

The cost estimates included with each project are based on past ITS project experience in the State of Oregon and costs found through various ITS resources available through the Federal Highway Administration (FHWA) and ITS America. A complete list of these cost resource documents is included in Appendix B. The cost associated with each project includes mark-up for design, mobilization, and contingency. The operations and maintenance (O&M) costs for each project represent an annual estimated cost once the project has been deployed. The additional staff costs represent an annual estimated cost of staff required to support the projects (e.g. incident responders and TOC operators).

Table 6-1. Deployment Projects (1 of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
Program Management (PM)								
SK-PM-01	Program Management & System Evaluation	This project will include the management and system evaluation of the Salem-Keizer ITS program. Work will be ongoing and be performed by local agency staff and project consultants.	H, M, L	This project is relative to all projects in the deployment plan		$0/ $50,000	• Efficient management of program • Improved schedule adherence for project deployment and tracking of funding	This project will be a part of every project deployed in this program.
Traffic Management (TM)								
SK-TM-01 (City of Salem)	Metropolitan Area Wide Video Deployment	This project will deploy fixed and pan-tilt-zoom video cameras to monitor traffic conditions, emergency events, optimize signal timings, view high accident locations, monitor flood and slide zones, and provide roadway condition information to travelers.			The current video images have detection zones that are not appropriate to show to the general public. Modifications to the images may need to occur before posting on TripCheck		•Reduced incident detection times •Improved safety and efficiency •Increased traveler information	The City of Salem has successfully deployed many cameras througout the metropolitan area.
		Highway 22, Lancaster Drive, Commercial St, Kuebler/Cordon Road, Salem Parkway, Interstate 5	H			$2,100,000/ $46,000		
		North River Rd, Hawthorne Ave, Center St, Portland Rd	M			$1,470,000/ $31,000		
		Wallace Rd, Chemewa Rd, Silverton Rd, Market St, Broadway St, 25th St, State St, 12th/13th SE, Turner Rd, Liberty Road SE	L			$1,554,000/ $32,000		
SK-TM-02 (ODOT, City of Salem)	Incident Management Plan for West Salem Bridges	This project will provide traffic management and traveler information tools (cameras, advisory radio, moveable barriers) and a specific plan outlining roles, responsibilities and procedures for handling an emergency bridge closure on Marion/Center Street bridges.	H,M,L	SK-TI-01		$1,082,000/ $19,000	•Increased capacity and throughput during incident conditions •Reduction in congestion and delay due to incidents •Improved safety and efficiency	
SK-TM-03 (ODOT)	Incident Response Program Enhancements	This project builds on the current ODOT incident response program to support incident management on state, count and city roadways. This project will equip incident response vehicles with GPS to enhance dispatch. It will also provide additional incident response vehicles and personnel.	H	STIP Key #12939		$494,000/ $40,000/ $240,000	•Increased capacity and throughput during incidents •Reduced congestion and delay due to incidents •Reduced incident response times •Improved safety and efficiency •Supports freight mobility	Region 2 currently has a successful incident response program

Table 6-1. Deployment Projects (2 of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
SK-TM-04 (ODOT, City of Salem, Marion County, City of Keizer)	Detour Route Management	This project supports incident management in Region 7 and expands the existing detour route plans. Improvements will include the mapping of detour route plans in GIS, incident signal timing plans, electronic message signs, and congestion monitoring to support incident responders and management of the roadway network during incidents. Additional improvements on detour routes will include communications to field devices (traffic signals, vehicle detection, message signs and cameras). High priority corridors have been selected in the event of an I-5 closure and include: •Cordon Road •Salem Parkway/Commercial/Mission	H	SK-TI-01 SK-TM-01		$400,000/ $8000	•Increased capacity and throughput during incident conditions •Reduction in congestion and delay due to incidents •Improved safety and efficiency	
SK-TM-05 (City of Salem)	Traffic Data Collection System	This project will deploy vehicle detection equipment around the metropolitan area to automate the collection of vehicle count, speed and classification information	H,M,L	STIF Key # 13066 SK-TM-05	Requires communication from the field devices to the City of Salem traffic management center	$210,000/ $10,000	•More effective traffic mangement •Availability of additional volume data •Improved transportation planning/modeling	City of Salem has a current project to deploy video detection for collecting vehicle count and classification information
SK-TM-06 (ODOT)	Arterial Congestion Map	This project will deploy an arterial congestion map based on system detector data and future floating car data from GPS devices to show travel speeds on roadways througout the region. The City of Salem has a current project to install a significant number of system detector locations that could be used for measuring congestion. It is assumed that GPS data from transit vehicles or future vehicle infrastructure integration projects will provide a more accurate measurement in the future.	M	SK-TM-10	Depends on the installation of system detectors within the City of Salem	$313,000/ $5000	•Reduced congestion and delay •Customer satisfaction •Provides motorists with pre-trip travel information to make informed travel decisions	Project supports traffic congestion monitoring and traffic counting for planning purposes
SK-TM-07 (ODOT, City of Salem)	Advanced Rail Warning System	Deploy railroad crossing train detection to determine rail crossing occupation and duration. This information will be provided to the NWTOC and the 911 center to notify emergency responders of response routes that are blocked or will soon be blocked. This information would also be provided to motorists approaching the crossing to enable them to select an alternate route.		None	None		•Enhanced safety •Real-time railroad occupation information •Reduced emergency response times •Reduced delay	Requires coordination with railroad for occupation information. Project can be deployed at each crossing independently
		City of Salem (Commercial Street, Liberty Street, Broadway St, Silverton Rd)	M			$133,000/ $5,700		
		City of Salem (Center St, State St, Madrona Ave)	L			$143,000/ $8250		
		Transmit advanced crossing occupancy information to the public via message signs or in-vehicle navigational systems	L			$14,000/ $2500		

Table 6-1.Deployment Projects (3 of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
SK-TM-08	Coordinated Emergency Management System	This system would be used for major emergencies to coordinate response and management of the event between multiple agencies. Today agencies respond to their respective EOCs and do not share the same electronic interface to the emergency condition description, status, etc. This system would provide a common interface for emergency managers to coordinate response to an emergency event across jurisdictions.	M			$65,000	•Improved emergency response times •Enhanced communication between jurisdictions/agencies	
SK-TM-09 (City of Salem)	Center to Center Integration - ODOT, Salem, Keizer, Marion County, Polk County	This project will implement center-to-center communications between the ODOT NWTOC and other traffic management centers at the City of Salem, City of Keizer, Marion County and Polk County. The center-to-center project could use the ODOT Transportation Operations Center Software as the primary interface but will require some integration to provide a system interface between the City of Salem traffic signal system and the operations center software.	M		Depends on center to center communication infrastructure deployment	$205,000	•Information sharing capabilities •Back-up capabilities •More effective traffic management, incident management and maintenance management •Safety and efficiency improvements	Requires communications between the local transportation centers and the NWTOC
SK-TM-10 (City of Salem)	Salem Traffic Management Center Upgrade	This project will upgrade the existing City of Salem traffic management center to provide a designated space to manage traffic in the Salem metropolitan area.	L		Depends on space availability for expansion in current facility	$361,000/ $2,050/ $60,000		
SK-TM-11 (City of Salem)	Downtown Salem Parking Management	This project will provide real-time parking information in downtown Salem. Dynamic message signs will be installed and highway advisory radio (HAR) messages will be used to direct motorists to facilities with available parking. This project assumes the parking status at multiple parking facilities will be monitored, with a particular emphasis on the areas near the Salem Convention Center.	M			$448,000/ $3,000	•Reduced congestion and air pollution near parking lots •Reduced fuel consumption •Reduced driver frustration	This project can be deployed independently. Other similar projects have been completed around the county. Initially, the implementation will be focused on the area around the Salem Convention Center
SK-TM-12 (City of Salem)	Central Signal System Upgrade	The City of Salem's central computer for traffic signal control will be due for replacement within the timeframe of this plan. This project will define and procure a new central signal system to provide additional functionality including: * Advanced signal control * Support for camera control * Automated incident response signal timing plans * Signal status integration with the operations centers * Arterial Congestion Mapping	M	SK-TM-01, SK-TM-10, CO-02		$600,000/ $2530	•Reduction in stops, fuel consumption, and vehicle delay •Improved travel time on major arterials •Enhanced information sharing capabilities •Supports arterial management projects	
SK-TM-13 (City of Salem)	Adaptive Signal Timing Project	Deploy adaptive signal timing on select signalized corridors in the region with the highest levels of congestion and the most fluctuation in volumes	L	SK-TM-12		$1,400,000/ $15,000	•Improved efficiency of signalized corridors	Adaptive signal timing projects have been implemented successfully in other Oregon cities.

Table 6-1. Deployment Projects (4 of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
SK-TM-14 (Marion County)	Flood Warning System	This project will deploy a system to monitor rising water on the roadway and alert transportation managers of high water. This project will include cameras to monitor the common flood areas and dynamic message signs to provide advanced notification to motorists.	L			$400,000/ $12,500	•Improved safety	
SK-TM-15 (Marion County)	Slide Monitoring System	This project will deploy a system to monitor frequent slide zones to identify landslides onto the roadway. The project will include cameras to monitor common slide areas and could include dynamic message signs and road closure systems to manage traffic.	L			$273,000/ $7,500	•Improved safety	
SK-TM-16 (ODOT)	Advanced Vehicle System - Mayday to TOCS	Provide for information flow from vehicle Mayday systems to the TOC (notification of airbag deployment).	H	SK-EM-02	Requires an interface to the mayday system vendors data	$24,000/ $1,900	•Reduced emergency response times •Availability of collision characteristics to emergency/medical staff	Data from the mayday systems will be transmitted to ODOT in 2005.
SK-TM-17 (ODOT)	Advanced Vehicle System – Vehicle Navigation System	This project would use a network of short range communications from the roadside to vehicles to transmit regional traveler information to in-vehicle navigation systems.	L	SK-TI-01	Depends on the ability to collect traveler information	$32,000/ $1000	•Reduced delay •Increased traveler information	This project may be implemented as part of a nationwide vehicle infrastructure integration project
SK-TM-18 (Marion County)	Isolated Intersection Safety Warning System	This project would deploy devices at high crash locations to warn drivers of changing conditions such as "tee" intersections or sharp horizontal curves	L			$660,000/ $11,000	•Improved safety •Reduced collisions •Reduced vehicle speeds	
SK-TM-19 (Marion County)	Wheatland and Buena Vista Ferry Traveler Information System	This project will provide the operational status of the ferries via arterial message signs that are located at key traveler decision points and highway advisory radio (HAR) messages.	L			$280,000/ $6000	•Provides motorists with traveler information	
SK-TM-20 (Marion County)	Weigh-in-Motion Facility	This project will deploy weigh stations in Marion County	L			$24,000/ $1950	•Support freight mobility •Increase transportation system efficiency and capacity	

Table 6-1. Deployment Projects (5 of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
Traveler Information (TI)								
SK-TI-01 (ODOT)	En-Route Traveler Information	Dynamic message signs, city and county websites and highway advisory radio (HAR) will be deployed in the Salem-Keizer metropolitan area to notify motorists of incidents, detour routes, construction and other traveler information.	H		Depends on the deployment of appropriate field devices to collect real-time traveler information and the ability to provide up to date information to dissemination sources		•Real-time traveler information gives motorists the ability to make informed travel decisions •Reduced congestion and delay •Customer satisfaction	Requires an interface between other agencies traffic data and video collection systems in the Salem-Keizer Metropolitan area to TripCheck, the 511 system, highway advisory radio and other traveler information dissemination systems
		Deploy dynamic message signs on the following corridors:						
		Highway 22, Lancaster Drive, Commercial St, Kuebler/Cordon Road, Salem Parkway, Interstate 5	H			$980,000/ $26,000		
		North River Rd, Hawthorne Ave, Center St, Portland Rd	M			$1,050,000/ $20,000		
		Wallace Rd, Chemawa Rd, Silverton Rd, Market St, Broadway St, 25th St, State St, 12th/13th SE, Turner Rd, Liberty Road SE	L			$1,050,000/ $20,000		
		Deploy Highway Advisory Radio	H			$30,000/ $1000	•En-route information that allows users to make informed travel decisions •Reduced congestion and delay •Customer satisfaction	Eugene has implemented highway advisory radio (HAR) with a wide coverage area and can be used as a resource during design and constuction. Depending on the type of transmission, FCC licensing is required and broadcasts are then permitted on a specific range of frequencies.
SK-TI-02	Cable TV Traveler Information Channel	This project will provide camera images and other traveler information to cable TV companies to display on a channel in the Salem-Keizer metropolitan area.	H	SK-TM-01	Depends on the ability to provide quality images for public viewing	$26,000	•Improved pre-trip traveler information	Agreements with television company may result in reduced airtime costs
SK-TI-03	Broadcast Traveler Information	A dedicated traffic condition radio channel will be provided in the Salem-Keizer metropolitan area to provide traffic condition information.	L	SK-TI-01	Depends on the ability to provide up to date information	$245,000/ $75,000	•Improved en-route traveler information	
SK-TI-04	Interactive Traveler Information	This project will allow the motorist to request specific traveler information, utilize dynamic ridesharing, and provide yellow page and reservation services prior to a trip or en-route using wide area wireless connections.	L			$218,000/ $128,000/	•Enhanced mobility •Customer satisfaction	

Table 6-1. Deployment Projects (6 of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
Communication (CO)								
SK-CO-01 (ODOT, City of Salem)	Metropolitan Area Communications	This project will phase in new fiber optic communications cable throughout the metropolitan area to provide high speed communications between management centers and centers and field devices (i.e. cameras). Fiber optic communications will be installed in three different phases over the 20-year plan.	H M L	Most of the projects in this plan are dependent on these communication improvements	While the communication network can be expanded independent to the other projects in this plan, it is more likely that the infrastructure will be installed as part of other projects in the plan.	$840,000/ $32,000 $700,000/ $20,000 $980,000/ $20,000	•Connection between agencies will allow for multi-jurisdictional control, management, coordination, and information sharing •Connection to ITS field devices allows for innovative strategies such as incident management and arterial management	
SK-CO-02 (City of Salem)	Communications to Isolated Signalized Intersections	This project will provide communications to all signalized intersections in the metropolitan area that are currently isolated from the central signal system computer.	M	STIP Key # 11110, 12601, 12604, 12930, 12625		$445,000/ $14,000	•More effective traffic/incident management •Improved safety and efficiency •Ability to monitor and control traffic control systems in real-time from a remote location	Sections of traffic signal interconnect can be added to the main system when other nearby projects are constructed
Public Transportation Services (PT)								
SK-PT-01 (Cherriots)	Paratransit Mobile Data Devices	This project will deploy mobile data devices that will provide the capability to monitor fuel usage, mileage, passengers, and trips. This project will also include AVL on paratransit vehicles for enhanced dispatch.	H	Cherriots is currently outfitting all 50 paratransit vehicles with MDT equipment		$384,000/ $10,500	•More efficient dispatch •Customer satisfaction •Improved customer mobility	
SK-PT-02 (Cherriots)	Maintenance Management System	This system will support electronic tracking of equipment inventory, and automatic scheduling of transit maintenance.	M	This system is currently being deployed by Cherriots		$63,000/ $600	•More efficient allocation of transit resources •Improved maintenance management	
SK-PT-03 (Cherriots, ODOT, City of Salem)	Transit Signal Priority	The project will include installing transit priority emitters on select coaches and upgrading traffic signal controllers along the selected corridors. The first phase will include the High Priority Transportation Corridor (Broadway/River Road). Future phases of this project will expand transit signal priority capabilities to other corridors in the region.	H	STIP Key #12115,12117	Requires the installation of transit detection equipment on the transit fleet.	$130,000/ $1000	•Reduced transit delay •Enhanced transit service •Increased ridership •Increased schedule reliability	TriMet and the City of Portland have successfully deployed the technology on several corridors in the City of Portland

Table 6-1. Deployment Projects (7of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
SK-PT-04 (Cherriots)	Automated Vehicle Location (AVL) System	Install automated vehicle location (AVL) devices on the Cherriots Transit fleet and integrate transit vehicle locations with the existing computer aided dispatch (CAD) system. This project will support future deployments for transit arrival information, enhanced transit signal priority capabilities, automated passenger counting systems, and using transit vehicles to estimate roadway congestion.	H			$697,000/ $19,000	•More efficient allocation of transit resources •Operating cost savings •Improved transit reliability	TriMet and Lane Transit District can be used as resources. TriMet has already successfully implemented AVL and CAD and LTD is currently researching systems for acquisition.
SK-PT-05 (Cherriots)	Real-Time Transit Arrival Information	This project will provide real-time transit arrival and departure information to riders. The project will provide traveler information via an updated Cherriots website, integration with the Regional Trip Planner, electronic message signs at selected stops, cell-phones and PDA's.	H,M,L	Six transit stops have been selected for a pilot deployment of electronic message signs.	Automated vehicle location (AVL) must be installed on the transit feet in order to provide real-time schedule information	$275,000/ $36000	•Real-time transit information to aid riders with en-route planning •Improved customer satisfaction	TriMet has successfully implemented real-time customer information displays in the Portland metropolitan area using simple wireless communications.
SK-PT-06 (Cherriots)	Transit Center Security	Cherriots has two new transit centers planned for the future; one in Keizer and one in South Salem. This project will provide security camera images at both sites and communications infrastructure for remote monitoring of the images.	M	STIP Key # 12567,13336	Depends on construction/location of new transit centers and the communication connectivity between the buses and these locations	$420,000/ $12,000	•Increased security for riders	Cherriots currently has existing cameras on many of the buses and at the transit center located downtown.
SK-PT-07 (Cherriots)	Transit Computer Aided Dispatch (CAD) Integration Project	This project will integrate the various CAD systems used today by transit providers in the Salem-Keizer metropolitan area.	M,L	SK-PT-08, SK-PT-01		$420,000/ $4000	•More efficient allocation of transit resources •Improved dispatch	Cherriots will need to coordinate with private and public paratransit agencies that offer services in Salem.
SK-PT-08 (Cherriots)	Transit Management & Maintenance Center Integration	Project would provide communications between the transit management center in downtown Salem and the maintenance management center at CellMet.	M	CO-01		$280,000/ $4000	•More efficient allocation of transit resources •Improved maintenance management	
Archived Data Management (AD)								
SK-AD-01 (MVCOG)	Archived Data Management System	This project will enhance the traffic data collection system and provide a central storage facility to archive data. The central data storage facility will collect transportation related data from multiple agencies and provide the data in formats that can be used to manage and study existing transportation systems or to plan new ones.	L	This project is related to all projects that deploy field devices and systems to collect transportation related data	This project is dependent on interagency communications and the deployment of field devices to collect data	$540,000/ $7000	•Improved resources for regional modeling, research, anyalsis, planning and design •Reduced cost of data collection	This project will make use of data already collected or planned from collection with the deployment of field devices. ODOT's TOCS software package may be able to supply an information brokerage system. Portland State University's database system may be able to provide data storage and access (portal.its.pdx.edu)

Table 6-1. Deployment Projects (8 of 9)

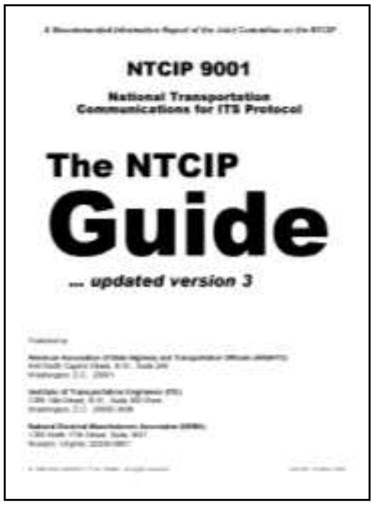
Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
Emergency Management (EM)								
SK-EM-01 (Salem Police Dept)	Real-Time Information to mobile data devices	Provide real-time traffic information to emergency responder's mobile data devices	M	SK-EM-02, SK-EM-03	None	$110,000/ $4400	•Improved real-time traffic conditions information •Reduced emergency response times	Many emergency response vehicles already include in-vehicle mobile data devises
SK-EM-02 (ODOT, Mid-Willamette Valley 911 Center, City of Salem)	Intra-Agency Information (Data/Video) Sharing	This project will provide a two-way information flow (video images from the roadway cameras, related weather and construction information) between traffic management, 911 center, police, fire and Emergency Operations Centers.	M	SK-TM-01 SK-MC-03, SK-MC-04	Software interfaces will be required at the 911 and emergency dispatch and transportation operations centers	$600,000/ $5600	•Improved real-time traffic conditions •More efficient allocation of emergency response resources •Reduced emergency response times	ODOT and the Bureau of Emergency Communications are currently working on a proof-of-concept for 911 center integration. Evaluation of this proof-of-concept will help with 911 and emergency dispatch center integration in the Salem-Keizer metropolitan area
SK-TM-03 (Mid-Willamette Valley 911 Center, ODOT, City of Salem)	911 Computer Aided Dispatch Interface	This project will provide a direct interface with the 911 Computer Aided Dispatch system to automatically post traffic-related incidents and to provide traffic congestion and video information.	M			$250,000/ $1,500	•Real-time incident information •Enhanced information sharing between agencies	
SK-EM-04 (ODOT)	Hazardous Materials Management	This project will detect and classify security sensitive hazardous material information in trains and commercial vehicles traveling through the Salem-Keizer metropolitan area to coordinate emergency response availability.	M	SK-EM-02		$53,000/ $530	•Improved safety for motorists and emergency responders •More efficient allocation of emergency response resources	Requires coordination with commercial vehicle companies and rail operators.
SK-EM-05	Responder Video System	Provide emergency/incident responders with video cell phones and develop a link to the TOC to link video to other agencies.	M	SK-EM-02	None	$21,000/ $15,700	•Improved public safety • More efficient allocation of medical and emergency response resources	Current video cell phone technology can be used; however some public jurisdictions have existing policies in place prohibiting the use of cell phones with cameras, due to privacy issues.
SK-EM-06	Dynamic Routing of Emergency Vehicles	This project will automatically calculate the ideal route between two points based on real-time roadway congestion, construction, and incident information.	L	SK-EM-02	Depends on real-time traffic information availability and also requires a communication between the regional traffic management centers and the 911 centers. Automatic vehicle locators on emergency vehicles are required for dynamic route guidance.	$420,000	•Reduced emergency response times	As the Mid-Willamette 911 Center is connected to the regional communication network, real-time traffic information will be readily available.
SK-EM-07	Traffic Signal Preemption by Vehicle ID	Implement preemption equipment to provide traffic signal preemption by specific vehicle ID.	L	None	None	$490,000	•Reduced delays •Reduced emergency response times	Technology is readily available. Upgrade work is minimal.

Table 6-1. Deployment Projects (9 of 9)

Project # (Lead Agency)	Project Title	Project Description	Priority	Relativity to Planned Projects	Project Dependencies	Capital Costs/ O&M Costs/ Staff Costs	Expected Benefits	Technical and Institutional Feasibility
Maintenance and Construction Management (MC)								
SK-MC-01 (ODOT, City of Salem, Marion County)	Work Zone Safety Systems and Monitoring	This project will provide portable cameras, variable speed limit signs and speed detection devices to monitor and control traffic conditions in construction work zones. It will also deploy technology within work zones that will reduce motor vehicle conflicts with workers by warning workers of vehicles entering work zones.	H	OTIA Projects	None	Funded with construction projects	• Improved construction zone safety and efficiency • Heightened safety awareness through driver feedback • Maintain freight mobility	These systems could be incorporated in the transportation management plans being developed as part of the OTIA program
SK-MC-02 (ODOT, City of Salem, Marion County)	Maintenance and Construction Coordination System	Deploy a construction activity information site that contains details about region-wide/statewide maintenance and construction activities by public agencies, and utility companies. The system will include active construction, planned construction, weight and width restrictions, travel times in work zones and other information necessary to manage traffic mobility in Oregon.	H	OTIA Projects	Requires data and information from public and private agencies throughout the region	$100,000/ $1000	• Information sharing between agencies • More efficient allocation of maintenance resources • Real-time information to travelers • Reduced delay • Supports freight mobility	This system supports the statewide goal for unrestricted freight mobility. With relatively minor modifications, the ODOT Highway Transportation Conditions Reporting System will support the implementation
SK-MC-03 (ODOT, City of Salem, Marion County)	Construction Zone Traveler Information Systems	This project will provide travel time information through work zones using electronic message signs, the internet, and highway advisory radio (HAR).	H	SK-TI-01, SK-TI-02	Depends on the ability to collect traveler information	$315,000/ $20,000	• Improved construction zone safety and efficiency • Heightened safety awareness through driver feedback	
SK-MC-04 (ODOT, City of Salem, Marion County, City of Keizer)	Roadway Weather Information System	Weather stations with roadway temperature, wind speed, humidity, and precipitation sensors will be installed at the following locations:		SK-TI-01	None		• Real-time weather and pavement conditions • More efficient allocation of maintenance resources during inclement weather	Weather stations have been implemented successfully throughout Oregon
		West Salem Hill East of Cordon Rd on Hwy 22	M			$250,000/ $6500		
		Grand Ronde Falls City	L			$250,000/ $6500		
SK-MC-05 (City of Salem, Marion County)	Maintenance Vehicle Tracking	This project will track maintenance vehicles to enhance dispatch of personnel and equipment to daily events and for management of the transportation network during winter storms	L		Requires the installation of GPS/AVL equipment on maintenace vehicles	$779,000/ $20000	• More efficient allocation of maintenance resources	Other states have deployed similar systems that can be used as models for the region
SK-MC-06 (City of Salem, Marion County)	Maintenance Event Logging System	Log maintenance requirements through an automated system to record items that require maintenance as personnel identify them daily.	L		Requires the installation of GPS/AVL equipment on maintenace vehicles	$94,000/ $1000	• More efficient allocation of maintenance resources	

6.2.1 ITS Standards and Operational Guidelines

Chapter 3 discusses the probable need for and use of the following ITS standards as part of the ITS deployment program in the Salem-Keizer Metropolitan Area:



- **Common Standards:** Standards that define terms, data elements, and message sets.
- **National Transportation Communications for ITS Protocol (NTCIP):** ITS standards that apply to the majority of interfaces between traffic and transit management systems and devices.
- **Transit Communications Interface Profiles (TCIP):** A number of data interface standards for the transit industry.

However, these standards are currently in various stages of development and acceptance, and many are not yet approved by the Standards Development Organizations (SDO's). Standards not yet approved are not widely utilized by equipment, communication and software vendors. However, to meet the federal ITS requirements, it is recommended that each deployment project selected for near-term deployment be crosschecked with relevant standards as the project moves beyond this initial planning phase.

Applicable standards and protocols should be highlighted during the systems engineering analysis and—upon approval by the lead deployment agency—the appropriate standards should be utilized during detailed design, equipment selection and implementation. Particular attention should be paid to the identification of system-to-system standards that allow for the mutual sharing of information. Relevant standards for the 5-Year Plan deployment projects have been identified as part of the overall description of major projects as detailed in Section 6.4. The *National ITS Architecture* provides a good starting point for the identification of relevant standards.

In addition to relevant standards, there is also a significant need for operational guidelines for the various types of ITS field equipment scheduled for deployment by state and local agencies over the next 20 years. Operating guidelines may include examples of proven and effective practices as well as documented procedures for ensuring consistency and proper implementation, operation and maintenance of the ITS equipment. Most ITS equipment is deployed as part of a system and relies on integration with other field devices and communications to centers (i.e. traffic management or 911 centers). It is essential that the equipment functions efficiently within the system. Established operational guidelines can assist the various agencies with avoiding inconsistent or incorrect applications of the equipment and contribute to an integrated, cost-effective ITS system.

6.3 Deployment Plan Schedule

Table 6-2 lists the deployment plan schedule for the proposed projects, grouped by area of interest. As described previously, the schedule follows a 5-Year Plan, 10-Year Plan, and 20-Year Plan and relates to the priority assigned to each project in Table 6-1. Since priorities and institutional objectives change over time, the deployment plan schedule should be re-evaluated after the 5-Year Plan has been completed. In addition, the deployment plan schedule does not necessarily coincide with each of the local agency funding cycles. As the ITS plan is incorporated into local agency planning documents and project lists, the Deployment Plan schedule should be adjusted as appropriate.

Table 6-2. Deployment Plan Schedule

		5-Year Plan					10-Year Plan					20-Year Plan									
Ref. No.	Project Title / Years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SK-PT-01	Paratransit Mobile Data Devices	■																			
SK-PT-02	Maintenance Management System	■	■																		
SK-PT-03	Transit Signal Priority		■	■			■	■			■	■			■	■			■	■	
SK-PT-04	Automatic Vehicle Location (AVL) System		■	■	■		■					■									
SK-PT-05	Real-Time Transit Arrival Information		■			■		■		■		■		■		■					
SK-PT-06	Transit Center Security							■	■							■	■				
SK-PT-07	Transit Computer Aided Dispatch (CAD) Integration Project											■	■								
SK-PT-08	Transit Management and Maintenance Center Integration	■	■																		
Emergency Management																					
SK-EM-01	Real-Time Information to MDTs						■	■	■												
SK-EM-02	Intra-Agency Information Sharing						■	■													
SK-EM-03	911 Computer Aided Dispatch Interface									■	■	■									
SK-EM-04	Hazardous Materials Management														■	■					
SK-EM-05	Resonder Video System						■	■													
SK-EM-06	Dynamic Routing of Emergency Vehicles											■	■								
SK-EM-07	Traffic Signal Preemption by Vehicle ID							■	■			■	■								
Archived Data Management																					
SK-AD-01	Archived Data Management System											■	■	■							
Maintenance and Construction Management																					
SK-MC-01	Maintenance and Construction Coordination System	■	■																		
SK-MC-02	Work Zone Management and Safety Monitoring Systems	■	■	■	■	■															
SK-MC-03	Construction Traveler Information						■	■													
SK-MC-04	Roadway Weather Information Systems (RWIS)							■	■			■	■								
SK-MC-05	Maintenance Vehicle Tracking													■	■	■					
SK-MC-06	Automated Maintenance Logging System																■	■	■		

■ Proposed Implementation

Table 6-2. Deployment Plan Schedule

Ref. No.	Project Title	5-Year Plan					10-Year Plan					20-Year Plan									
	Years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SK-PM-01	Program Management and System Evaluation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Traffic Management																					
SK-TM-01	Metropolitan Area Wide Video Deployment	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
SK-TM-02	Incident Management Plan for West Salem Bridges			■	■	■	■														
SK-TM-03	Incident Response Program Enhancements	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SK-TM-04	Detour Route Management			■	■				■	■				■	■						
SK-TM-05	Traffic Data Collection System	■	■				■	■				■	■			■	■			■	■
SK-TM-06	Arterial Congestion Map													■	■						
SK-TM-07	Advanced Rail Warning System						■	■				■	■					■	■		
SK-TM-08	Coordinated Emergency Management System						■	■	■												
SK-TM-09	Center to Center Integration - ODOT, Salem, Keizer, Marion County, Polk								■	■											
SK-TM-10	Salem Traffic Management Center Upgrade											■	■								
SK-TM-11	Downtown Salem Parking Management						■	■													
SK-TM-12	Central Signal System Upgrade								■	■	■										
SK-TM-13	Adaptive Signal Timing Project																		■	■	■
SK-TM-14	Flood Warning System						■					■					■				
SK-TM-15	Slide Monitoring System						■					■					■				
SK-TM-16	Advanced Vehicle System - Mayday to TOCS	■																			
SK-TM-17	Advanced Vehicle System - Vehicle Navigation System															■	■		■	■	
SK-TM-18	Isolated Intersection Safety Warning System													■	■			■	■		
SK-TM-19	Weigh-in-Motion Facility											■	■								
Traveler Information																					
SK-TI-01	En-route Traveler Information		■	■				■	■				■	■			■	■			
SK-TI-02	Cable TV Traveler Information Channel			■	■																
SK-TI-03	Broadcast Traveler Information											■	■								
SK-TI-04	Interactive Traveler Information																	■	■		
SK-TI-05	Wheatland and Buena Vista Ferry Traveler Information System											■	■								
Communications																					
SK-CO-01	Metropolitan Area Communications	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SK-CO-02	Communications to Isolated Signalized Intersections	■	■				■					■									

■ Proposed Implementation

6.4 5-YEAR PLAN PROJECTS

This section provides more details regarding many of the significant 5-Year Plan projects. A table describing each project includes the following information:

- Project Title
- Project Number (for reference)
- Purpose
- Existing Problems
- Stakeholders
- Description
- Communication Requirements
- ITS Standards
- Project Dependencies
- Goals Supported
- Benefits
- Cost
- Phased Plan
- Associated Market Packages
- Potential Funding Sources

6.4.1 Potential Funding Sources for 5-Year Plan Projects

A variety of potential funding sources should be considered for the implementation of projects throughout the Salem-Keizer Metropolitan Area. Funding sources are necessary for capital costs, as well as continued operations and maintenance costs to ensure the success of the regional deployment plan that has been outlined in this chapter. The following list presents some possible funding sources:

- State ITS Funds (ODOT)
- Federal ITS Grants
- System Development Charge (SDC)
- State Transportation Improvement Program (STIP)
- Federal Homeland Security
- Private Sector Partnership

6.4.2 ITS Standards for 5-Year Plan Projects

It is recommended that each ITS project selected for near-term deployment be crosschecked against relevant standards. Accordingly, each of the 5-Year Plan project descriptions in Section 6.4 includes identification of relevant standards. ODOT already adheres to some applicable ITS standards as described herein.

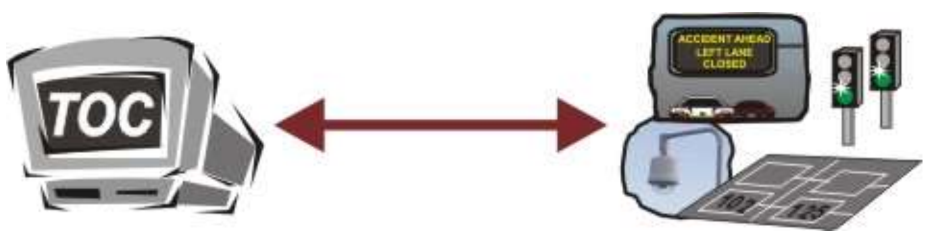
6.4.2.1 ITS Standards in Use by ODOT

Of the traffic agencies in the Salem-Keizer area, ODOT has spent the most time analyzing, approving and utilizing ITS standards because they have the most experience with ITS implementations around Oregon. The following practices highlight ODOT's experience with the adoption of ITS standards:

- ODOT is currently using most of the approved message set and data definition standards when available and applicable, particularly:
  - ***ITE TM 1.03: Standard for Functional Level Traffic Management Data Dictionary (TMDD)***
  - ***ITE TM 2.01: Message Sets for External TMC Communications (MS/ETMCC)***

- **Center-to-Center Standards:** ODOT is planning on utilizing XML[1] for center-to-center communication, as opposed to either DATEX[2] or CORBA[3]. Many standards for XML have already been developed and are used widely in the IT industry. Message sets and data dictionaries for ITS utilizing XML are currently being converted from DATEX message sets by the Standard Development Organizations (SDO's).

- **Center-to-Field Standards:** Most field device NTCIP standards are still in development. ODOT is currently utilizing ***NTCIP 1203: Object Definitions for Dynamic Message Signs*** and will continue to review all other relevant NTCIP standards when deploying new field devices.



[1] eXtensible Markup Language (XML): a universal structured data transfer methodology that is currently widely used in e-business and e-government applications.
[2] DATa EXchange Between Systems (DATEX): one of the two approved NTCIP standards for center-to-center communications.
[3] Common Object Request Broker Architectures (CORBA): one of the two approved NTCIP standards for center-to-center communications.

METROPOLITAN AREA WIDE VIDEO DEPLOYMENT

SK-TM-01

Purpose

To provide continuous video coverage of congested locations to motorists and assist incident detection and data collection efforts

Existing Problems

- Recurrent traffic congestion
- High incident locations at specific intersections
- Limited monitoring capabilities
- Lack of traveler information

Stakeholders

Primary:
- City of Salem
- ODOT

Description

This project will post existing City of Salem camera images on ODOT's TripCheck traveler information website. The City of Salem currently has many cameras throughout the study area that are used at the traffic management center to monitor traffic conditions. The first phase of this project will involve modifying the images so they can be posted for public viewing and includes the deployment of new pan-tilt-zoom cameras on the specified 0-5 year corridors. Future phases of this project will deploy more pan-tilt-zoom cameras at other key intersections in the City of Salem, the City of Keizer and Marion County. In many of the downtown locations, fixed cameras should be used due to extensive tree coverage that limits the long-distance viewing capabilities. The cameras will be used to monitor the roadway for congestion, trouble spots, incidents, equipment failures, traffic signal operations and to provide roadway condition information to travelers.

Project Dependencies

Existing cameras images have marked vehicle detection zones (lines) that affect the image that would potentially be posted on TripCheck. One option involves building a separate communication link to each camera to send the image back to the City of Salem traffic operation center on a different channel. This image could then be posted on TripCheck without the detection zones.

Relevant ITS Standards

- ITE TM 1.03, TM 2.01
- NTCIP 1101, 1102, 1103, 1201, 1205 1209, 1210, 1211

METROPOLITAN AREA WIDE VIDEO DEPLOYMENT

SK-TM-01 Page 2 of 2

Communication Requirements

High speed communications are required between the cameras, the City of Salem Traffic Management Center and the ODOT NWTOC.

Goals Supported

- Improve the safety, efficiency, and reliability of the transportation system.
- Deploy systems with a high benefit-to-cost ratio and maximize the use of existing infrastructure
- Improve traveler mobility
- Provide improved traveler information and access to the information

Cost

$2,100,000	Project Deployment
$48,000	Annual Ops & Maintenance

Benefits

- Ability to monitor and control traffic control systems in real-time from a remote location.
- Reduced incident detection times
- Improved safety and efficiency
- Increased traveler information

Phased Plan

0 – 5 Years: Project Deployment

Associated Market Packages

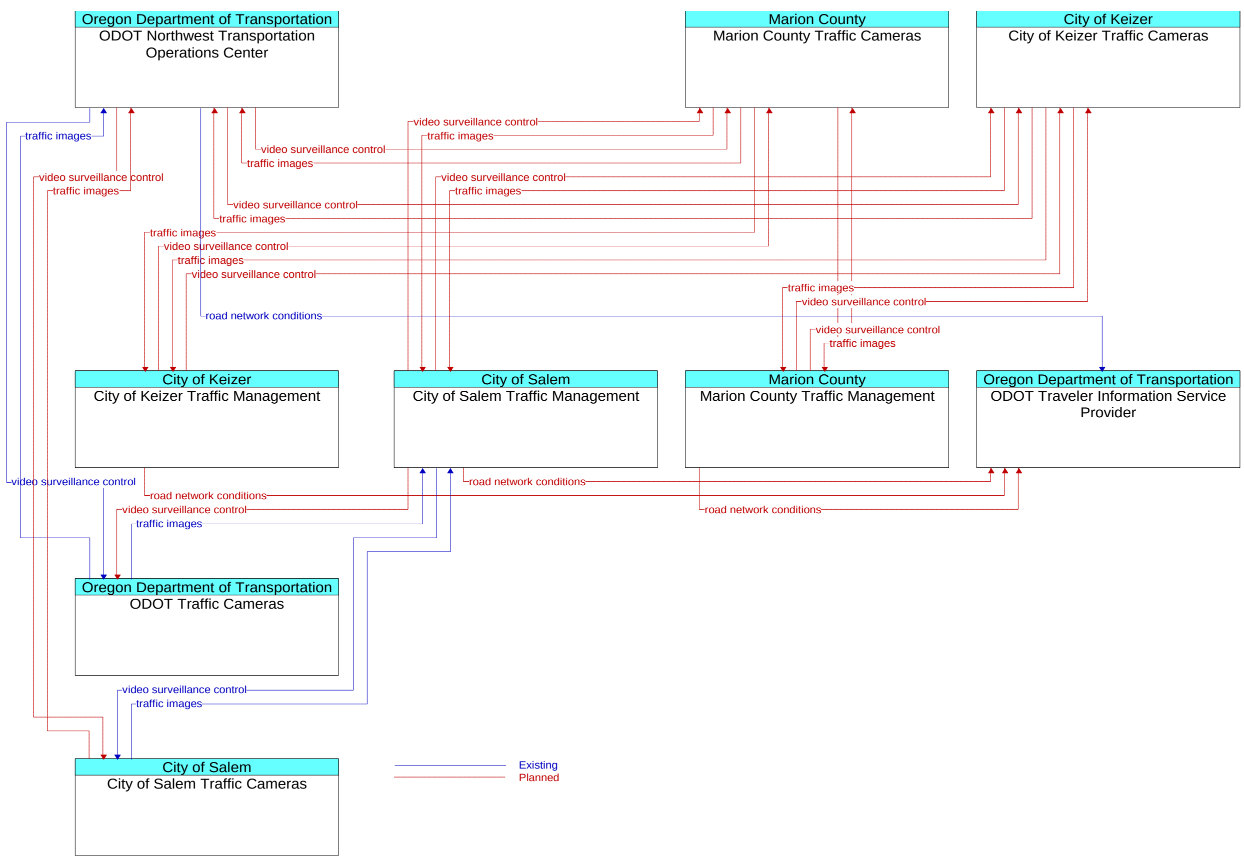
- ATMS1 Network Surveillance
- ATMS6 Traffic Information Dissemination

Possible Funding Sources

This project has many funding options including statewide ITS funds, federal ITS funds, or the Statewide Transportation Improvement Plan (STIP). A policy for real-time system management is included in the City of Salem's Transportation System Plan which may also allow funding (where available) to come from local agency budgets or system development charges (SDC). Local City budgets and SDC funding may be utilized if the benefits of this project can be directly tied to capacity improvements on the roadway.

METROPOLITAN AREA WIDE VIDEO DEPLOYMENT

Architecture Interconnects and Flow Diagrams



DKS Associates
TRANSPORTATION SOLUTIONS

Oregon Department of Transportation

MAINTENANCE AND CONSTRUCTION COORDINATION SYSTEM

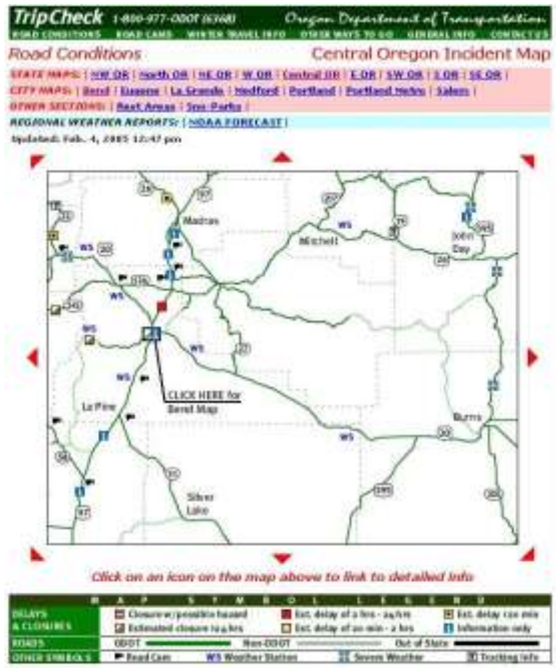
SK-MC-02

Purpose

The purpose of this project is to improve traffic mobility throughout the State of Oregon by providing a central source for all current and planned maintenance and construction activity.

Existing Problems

- Lack of centralized source for current and planned maintenance and construction activity information
- Many construction projects restrict heavy, wide or tall commercial vehicles resulting in detours for commercial vehicles
- No ability to identify active construction projects on potential detour routes



Stakeholders

Primary:
- ODOT

Secondary:
- Marion County
- City of Salem
- City of Keizer
- Utilities
- Trucking Industry
- Other Statewide public agencies and utilities.

Description

Develop a construction activity information site that contains details about region-wide/statewide maintenance and construction activities by public agencies and utility companies. The system will include active construction, planned construction, weight and width restrictions, travel times in work zones and other information necessary to manage traffic mobility in Oregon. This central database of construction and maintenance activity will provide transportation managers with the ability to monitor construction activity and schedules and ensure there is always an east-west and north-south route into and out of the State of Oregon for goods movement.

Communication Requirements

Interface to make entries to this system will be provided through a standard web browser.

MAINTENANCE AND CONSTRUCTION COORDINATION SYSTEM

SK-MC-02

Project Dependencies

None

Goals Supported

- Improve the safety and efficiency of our transportation system
- Provide improved traveler information and access to the information
- Integrate regional ITS projects with local and regional partners
- Monitor transportation performance measures

Benefits

- Improved traffic mobility
- Improved freight mobility
- Information sharing between agencies
- More efficient allocation of maintenance resources
- Real-time information to travelers
- Reduced delay

Relevant ITS Standards

- ASTM E2259-03
- SAEJ2353, J2354, J2529
- ITE TM1.03, TM2.01

Associated Market Packages

- ATIS02: Interactive Traveler Information
- MC07: Roadway Maintenance and Construction
- MC10: Maintenance and Construction Activity Coordination

Phased Plan

0 – 5 Years: Project Deployment

Cost

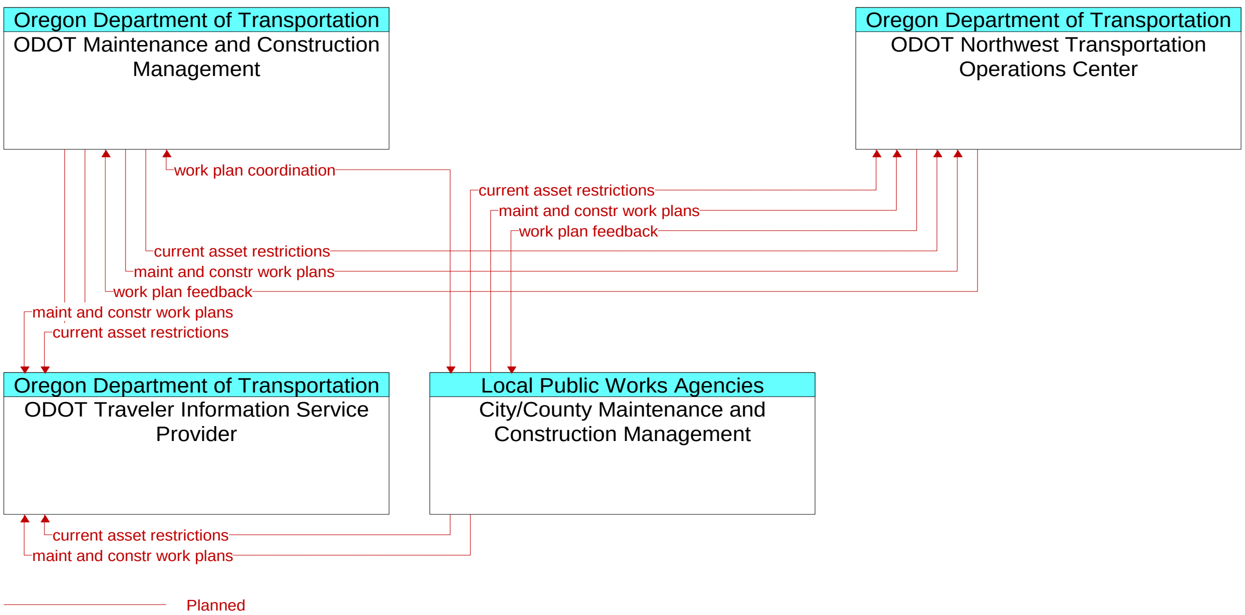
$100,000	Project Deployment
$1,000	Annual Ops & Maintenance

Possible Funding Sources

This project has many funding options including statewide ITS funds, federal ITS funds, or the Statewide Transportation Improvement Plan (STIP).

MAINTENANCE AND CONSTRUCTION COORDINATION SYSTEM

Architecture Interconnects and Flow Diagrams



EN-ROUTE TRAVELER INFORMATION

SK-TI-01

Purpose

To provide a source of integrated traveler information for travelers en-route throughout the Salem-Keizer Metropolitan Area.

Existing Problems

- Limited availability of accessible, pre-trip and en-route real-time traveler information.

Stakeholders

Primary:
- ODOT
- City of Salem

Secondary:
- Cherriots
- City of Keizer
- Marion County
- Polk County

Description

This project will include the deployment of dynamic message signs (DMS), enhanced Salem-Keizer area traveler information on the TripCheck website and 511 and highway advisory radio (HAR) in the Salem-Keizer Metropolitan Area to notify motorists of incidents, detour routes, construction, weather or other traveler information. In addition to these deployments, traveler information will be coordinated/sent to TripCheck and 511 and will be downloadable to mobile phones and personal digital assistants (PDA's).

Project Dependencies

This project depends on the deployment of appropriate field devices to collect real-time traveler information and the ability to provide up to date information to the dissemination sources.

Relevant ITS Standards

- ITE TM 1.03, TM 2.01
- IEEE IM
- NTCIP 1101, 1102, 1103, 1201, 1205,1209, 1210, 1211, 2101, 2102, 2103, 2104, 2201

EN-ROUTE TRAVELER INFORMATION

SK-TI-01 Page 2 of 2

Communication Requirements

Each agency that has traveler information to disseminate will need to support communications between the field devices and the traffic management centers. Center-to-center network connections will support the exchange of traveler information between the transportation agencies and dissemination sources.

Additional communications will be needed for the deployment of field devices (DMS and HAR) and will depend upon the location.

Goals Supported

- Improve the safety, efficiency, and reliability of the transportation system.
- Improve traveler mobility
- Provide improved traveler information and access to the information

Benefits

- Real-time and static traveler information.
- Pre-trip planning capabilities and en-route information that allow travelers to make informed travel decisions.
- Reduced congestion and delay.
- Customer satisfaction

Cost

$980,000	Project Deployment
$12,500	Annual Ops & Maintenance

Phased Plan

0 – 5 Years: Project Deployment will include HAR and the deployment of DMS on the following corridors at key decision points:

- Highway 22
- Lancaster Drive
- Commercial Street
- Kuebler/Cordon Road
- Salem Parkway
- Interstate 5

Associated Market Packages

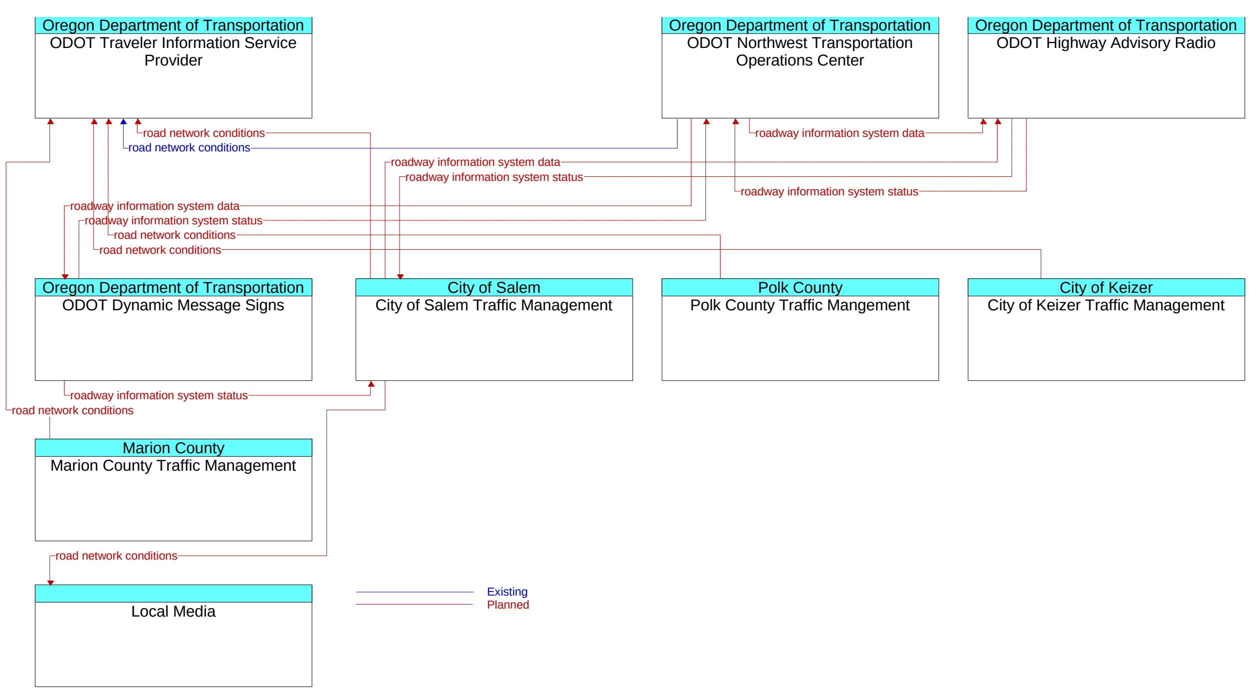
- ATMS6 Traffic Information Dissemination
- EM10 Disaster Traveler Information
- ATIS1 Broadcast Traveler Information
- ATIS2 Interactive Traveler Information

Possible Funding Sources

This project has many funding options including statewide ITS funds, federal ITS funds, or the Statewide Transportation Improvement Plan (STIP).

ENROUTE TRAVELER INFORMATION

Architecture Interconnects and Flow Diagrams



DETOUR ROUTE MANAGEMENT

SK-TM-04

Purpose

To support incident management in the Salem-Keizer Metropolitan Area

Existing Problems

- Lack of traffic management resources when travelers are diverted from I-5
- Limited infrastructure to notify the public of the detour/use of alternative route.
- Need for improved inter-agency coordination

Stakeholders

Primary:
- ODOT
- City of Salem
- Marion County

Secondary:
- City of Keizer
- Emergency Management

Description

This project includes improvements to the existing detour plan for Cordon Road including: GIS mapping of the detour route, incident signal timing plans, electronic message signs, CCTV cameras for congestion monitoring and interagency communications and coordination to support incident responders and management of the roadway network during incidents. An operational plan discussing specific roles and responsibilities of each agency and their control of the associated field devices will also be developed.

The priority corridor is Kuebler Boulevard/Cordon Road. Another corridor that may be used as an alternate route is Salem Parkway/Commercial/Mission Street.

Project Dependencies

An incident management operational plan must be developed for each corridor to clearly establish roles and responsibilities of each agency prior to the occurrence of an incident.

Relevant ITS Standards

- IEEE IM
- ITE TM 1.03, TM 2.01
- NTCIP 1101, 1102, 1103, 1201, 1203, 1204, 1205, 1206, 1209, 1301, 2001, 2101, 2102, 2103, 2104, 2201, 2202

DETOUR ROUTE MANAGEMENT

SK-TM-04

Communication Requirements

Communications are required between the field devices and City of Salem traffic management center and the ODOT NWTOC.

Goals Supported

- Improve the safety, efficiency, and reliability of the transportation system.
- Improve emergency response times
- Improve traveler mobility
- Provide improved traveler information and access to the information

Benefits

- Reduction in congestion and delay due to incidents.
- Increased capacity and throughput during incident conditions.

Cost

$1,800,000	Project Deployment
$30,000	Annual Ops & Maintenance

Phased Plan

0 – 5 Years:	Project Deployment
6-10 Years:	Project Deployment

Associated Market Packages

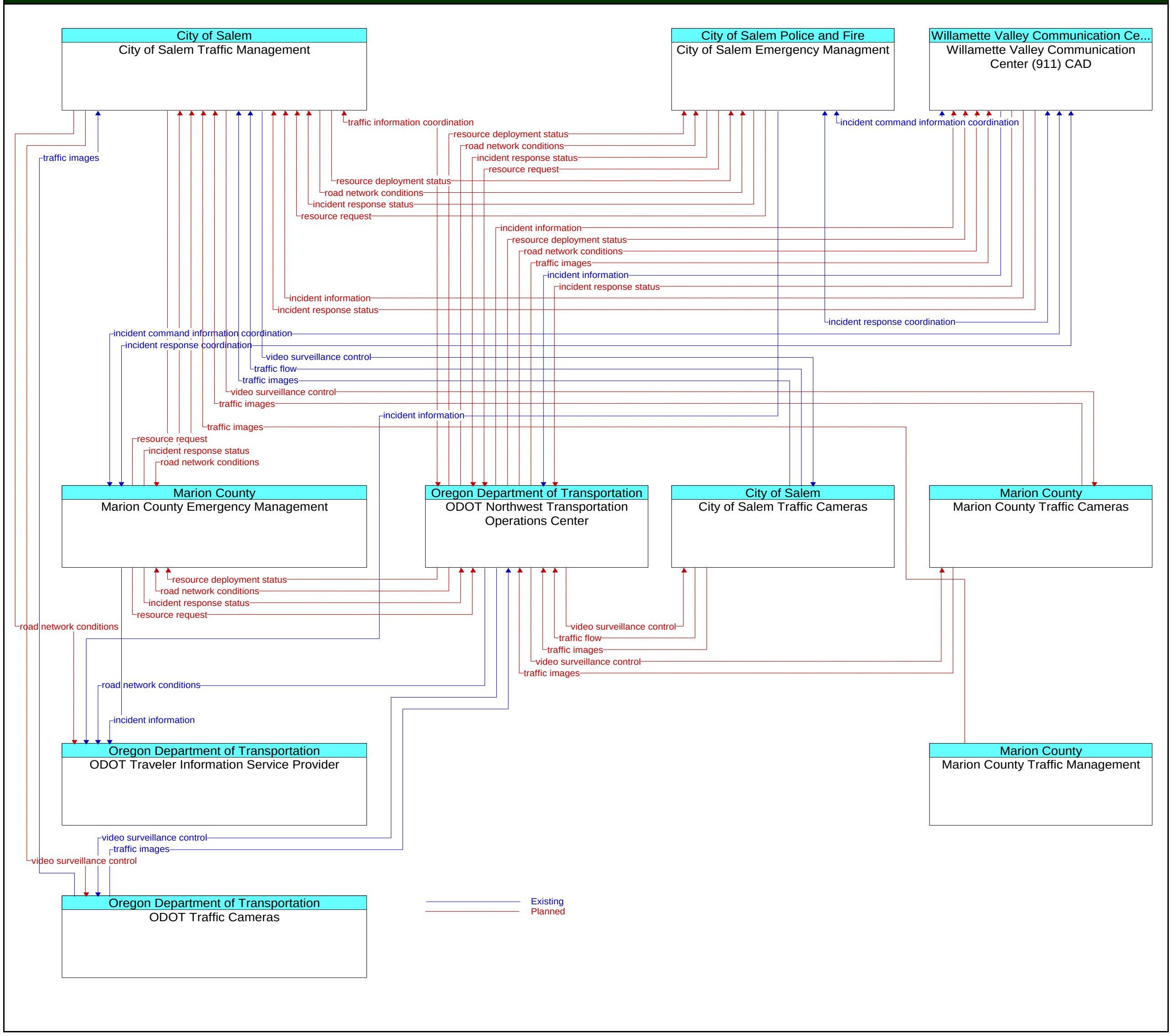
- ATMS06 Traffic Information Dissemination
- ATMS08 Traffic Incident Management System

Possible Funding Sources

This project has many funding options including statewide ITS funds, federal ITS funds, or the Statewide Transportation Improvement Plan (STIP). The multi-agency jurisdiction of this project presents a good example where partnerships may be formed to obtain funding.

DETOUR ROUTE MANAGEMENT

Architecture Interconnects and Flow Diagrams



REAL-TIME TRANSIT ARRIVAL INFORMATION

SK-PT-05

Purpose

To enhance the service of public transportation and provide real-time transit traveler information at transit centers and bus stops in the Salem-Keizer Metropolitan Area.

Existing Problems

- Need to provide transit arrival/location information to travelers
- Variable transit travel times due to congestion
- Need accessible, real-time transit information

Stakeholders

Primary:
- Cherriots

Description

This project will provide real-time transit arrival and departure information to riders via an updated Cherriots website, integration with the Regional Trip Planner, electronic message signs at selected stops, cell-phones and PDA's.

Project Dependencies

Automated vehicle location (AVL) must be installed on the transit fleet in order to provide real-time schedule information.

Relevant ITS Standards

- SAE J2353, J2354, J2369
- NTCIP 1401, 1403,1404,1405,1406,1407

REAL-TIME TRANSIT ARRIVAL INFORMATION

SK-PT-05 Page 2 of 2

Communication Requirements

Communications will be required between each real-time information display and the Cherriots dispatch center. A wireless connection will provide the most cost-effective method of establishing communications.

Communications will be required between the transit vehicles and the transit management center to transmit vehicle location information.

Goals Supported

- Improve traveler mobility
- Provide improved traveler information and access to the information
- Provide multi-modal transportation information to travelers

Benefits

- Real-time transit information to aid riders with en-route planning
- Improved customer satisfaction

Cost

$137,000	Project Deployment
$13,500	Annual Ops & Maintenance

Phased Plan

0 – 5 Years:	Deploy electronic message signs at six locations along the High Priority Transportation Corridor (Broadway/N River Road)

Associated Market Packages

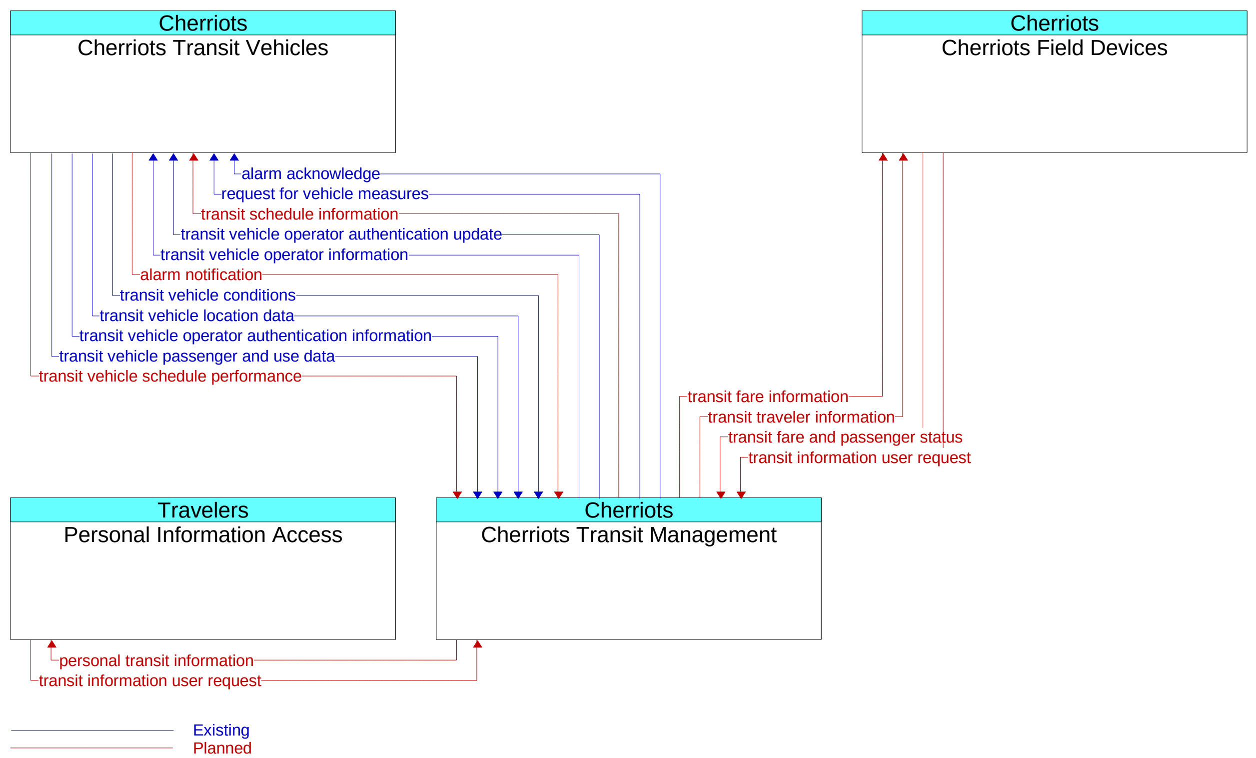
- APTS08: Transit Traveler Information

Possible Funding Sources

This project has many funding options including statewide ITS funds, federal ITS funds, or the Statewide Transportation Improvement Plan (STIP).

REALTIME TRANSIT ARRIVAL INFORMATION

Architecture Interconnects and Flow Diagrams



TRANSIT SIGNAL PRIORITY

SK-PT-03 Page 1 of 2

Purpose

To improve transit travel time reliability on corridors with traffic signals.

Existing Problems

- Corridors experience changing levels of congestion that affects bus travel arrival time reliability.
- Transit vehicles may not fully benefit from coordinated signal corridors because they service bus stops between intersections.

Stakeholders

Primary:
- Cherriots
- City of Salem
- ODOT
- City of Keizer
- Marion County

Description

The project will include the installation of transit priority emitters on select coaches and traffic signal controller software upgrades along the selected corridors to support transit signal priority. The first phase will include the High Priority Transportation Corridor (Broadway/River Road). Future phases of this project will expand transit signal priority capabilities to other corridors in the region that have been selected based on levels of current traffic congestion and transit ridership.

Project Dependencies

This project depends on the installation of transit detectors on the transit fleet and traffic signal software that supports transit signal priority.

Relevant ITS Standards

- IEEE 1455 – 1999
- ITE TM 1.03, TM 2.01
- NTCIP 1202, 1206, 1209, 1211, 1401, 1405

TRANSIT SIGNAL PRIORITY

SK-PT-03 Page 2 of 2

Communication Requirements

A communications interface will be needed between each transit vehicle and each traffic signal along a transit priority corridor. Potential interfaces include preemption equipment used by emergency response, loops embedded in the pavement that detect bus presence, radio frequency tags and readers or a central management system that requests priority based on vehicle locations.

Cost

$130,000	Project Deployment
$1,000	Annual Ops & Maintenance

Phased Plan

0 – 5 Years: High Priority Transportation Corridor; Broadway/N River Road
Lancaster Drive
South Commercial Street

6-10 Years: Portland Road
12th/13th Couplet
Market Street
Liberty/Commercial Couplet
Silverton Road

11-20 Years: Salem Parkway
Wallace Road
Center Street
Liberty Road

Goals Supported

- Enhance management of transportation system to improve maintenance and operations efficiencies
- Improve the reliability of the transportation system

Benefits

- Reduced transit delay.
- Improved schedule adherence and reliability.
- Reduced operational costs.
- Enhanced transit service.
- Increased ridership

Associated Market Packages

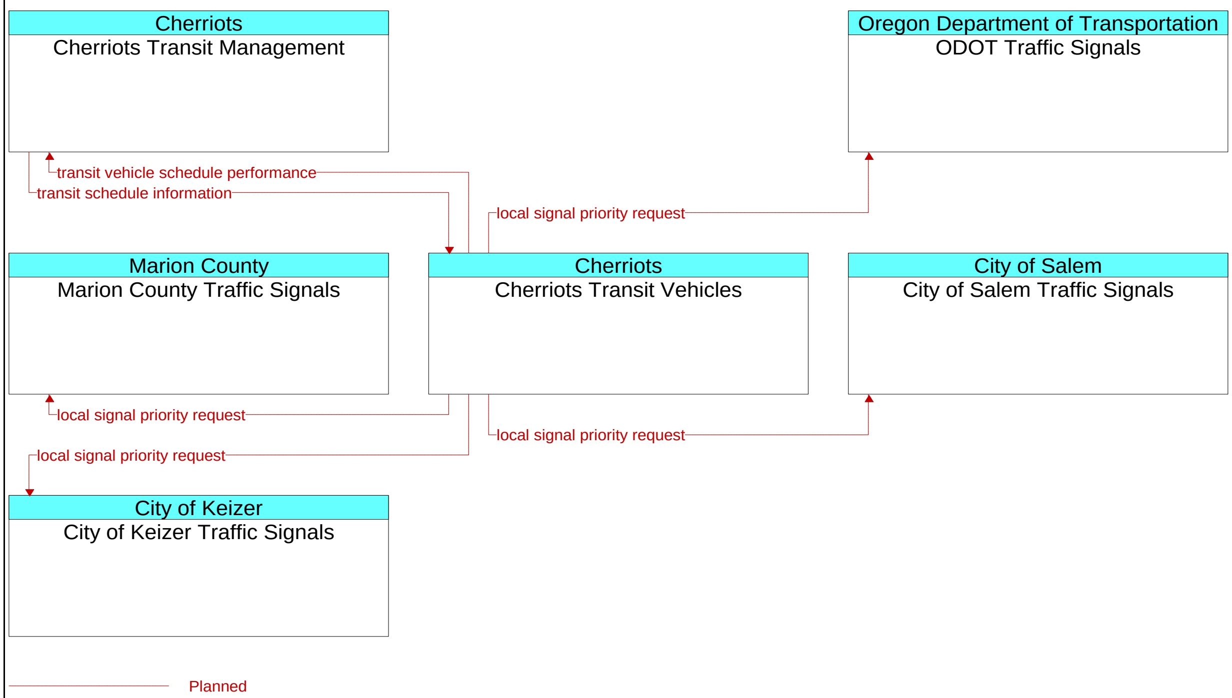
- APTS7 Multi-modal Coordination

Possible Funding Sources

This project has many funding options including statewide ITS funds, federal ITS funds, or the Statewide Transportation Improvement Plan (STIP).

TRANSIT SIGNAL PRIORITY

Architecture Interconnects and Flow Diagrams



INTRA-AGENCY INFORMATION SHARING

SK-EM-02

Purpose

To enhance communications and coordination between traffic management and emergency management agencies.

Existing Problems

- Need for improved coordination and communication between traffic agencies and emergency management agencies
- Lack of transportation related information (incident status, construction status, etc.) available to emergency responders.
- Continuing need to maintain and/or reduce emergency response times.

Stakeholders

Primary:
- ODOT
- Cities of Salem and Keizer
- Marion and Polk Counties
- Emergency Management

Description

This project will provide a two-way information flow (video images from the roadway cameras, related congestion, incident, weather and construction information) between traffic management, 911 center, police, fire and Emergency Operations Centers. This project will support dynamically routing emergency vehicles based on real-time transportation conditions.

Project Dependencies

New software enhancements will be required at the 911 center, emergency management center and traffic management centers to integrate transportation related information (congestion, incidents, construction zones, etc) with the computer aided dispatch (CAD) software.
Dynamic emergency vehicle routing depends on the availability of vehicle location information.

Relevant ITS Standards

- NTCIP 1201, 1209
- ITE TM 1.03, TM 2.01

INTRA-AGENCY INFORMATION SHARING

SK-EM-02

Communication Requirements

High speed center-to-center communications are required between emergency management centers and transportation management centers to support the exchange of real time transportation and emergency related information.

Cost

$600,000	Project Deployment
$5,600	Annual Ops & Maintenance

Phased Plan

6-10 Years:	Project Deployment

Goals Supported

- Improve the safety, efficiency, and reliability of the transportation system.
- Improve traveler mobility
- Share infrastructure and operations resources between local and regional agencies

Benefits

- Reduced emergency response times
- More efficient allocation of emergency response resources
- Improved real-time traffic conditions
- Enhance interagency communication and coordination

Associated Market Packages

- EM02 Emergency Routing
- ATMS06 Traffic Information Dissemination

INCIDENT RESPONSE PROGRAM ENHANCEMENTS

SK-TM-03

Purpose

To continue to provide efficient multi-agency response to incidents, to reduce incident detection and response times, and to reduce the amount of time that traffic is disrupted.

Existing Problems

- Recurrent traffic congestion
- Limited incident responders in ODOT Region 2 and the Salem-Keizer Metropolitan Area
- Limited monitoring and incident detection capabilities
- Lack of means to disseminate real-time alternate route information

Stakeholders

Primary:
- ODOT

Description

Region 2 currently has a successful incident management program that services the Salem-Keizer Metropolitan Area. This project will build on the current incident response program to support incident management on state, county and city roadways. It will equip incident response vehicles with GPS to enhance dispatch capabilities and will also provide additional incident response vehicles and personnel.

Project Dependencies

Full use of the incident management operational plan depends on the deployment of field devices and communications in the region

Relevant ITS Standards

- NTCIP 1205,1207, 1208,1209

INCIDENT RESPONSE PROGRAM ENHANCEMENTS

SK-TM-03

Communication Requirements

Requires wireless communications to response vehicles for vehicle location information

Goals Supported

- Improve the safety, efficiency, and reliability of the transportation system.
- Improve traveler mobility

Benefits

- Reduced incident detection times
- Reduced incident response times
- Supports freight mobility
- Reduced congestion and delay due to incidents
- More efficient allocation/dispatch of incident responders

Cost

$494,000	Project Deployment
$42,000	Annual Ops & Maintenance
$240,000	Staff Costs

Phased Plan

0 – 5 Years:	Project Deployment

Associated Market Packages

- ATMS01 Network Surveillance
- ATMS06 Traffic Information Dissemination
- ATMS08 Traffic Incident Management System

Possible Funding Sources

This project has many funding options including statewide ITS funds, federal ITS funds, or the Statewide Transportation Improvement Plan (STIP).

6.5 Deployment Plan Costs

Table 6-3 summarizes the estimated capital costs, annual operations/maintenance, and additional annual staffing costs for full implementation of the 20-Year Plan with an overall capital cost of 29.7 million dollars. To maximize the benefits of ITS projects in the Salem-Keizer Metropolitan Area, an on-going commitment must be made to the operations and maintenance of equipment and software and to consistent staffing for effective system operation. Figure 6-7 illustrates the 20-year plan cost categorized by program area.

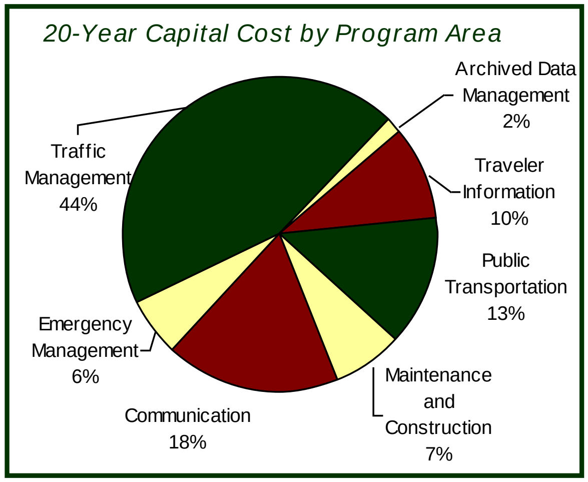


Figure 6-7. 20-Year Cost by Program Area

Table 6-3. Estimated Capital and Annual Operations/Maintenance Costs for 20-Year Plan

Implementation Stage	*Estimated Implementation Capital Costs*	*Estimated Annual Operations & Maintenance Costs**	*Estimated Annual Staffing Costs*
5-Year Plan: 0 – 5 Years	$6,997,000	$214,000	$240,000
10-Year Plan: 6 – 10 Years	$9,660,000	$266,000	$0
20-Year Plan: 11 – 20 Years	$13,067,000	$359,000	$60,000
TOTAL	**$29,724,000**	**$839,000**	**$300,000**

* Annual operations and maintenance costs are per year for the associated stage.

6.5.1 Deployment Plan Costs for 5-Year Plan

Table 6-4 includes a breakdown of the capital costs and annual operations and maintenance (O&M) costs by agency for the 5-Year Plan, which totals 7 million dollars. As shown in Figure 6-8, the costs are distributed among different agencies in the Salem-Keizer region. Some of the projects scheduled for deployment in the first 5 years have multi-jurisdictional components. The costs have been divided among the different agencies based on the anticipated portion of usage. For example, each agency will be using fiber optic cable so the total cost of the communication network has been split among Marion County (15%), the City of Salem (55%) and ODOT (30%). Other shared projects for the first phase of implementation include detour route management and the incident management plan for the west Salem bridges.

Table 6-4. Estimated Agency Costs for 5-Year Plan

Project Elements	Estimated Costs Capital	Estimated Costs Annual O&M
Oregon Department of Transportation (ODOT)		
✦ Incident Management Plan for West Salem Bridges	$546,000	$9500
✦ Incident Response Program Enhancements	$494,000	$182,000
✦ Detour Route Management	$150,000	$6,750
✦ Communication Network	$252,000	$3,600
✦ Maintenance and Construction Coordination System	$100,000	$1000
✦ En-Route Traveler Information	$980,000	$12,500
ODOT Total:	***$3,614 ,000***	***$221,850***
City of Salem		
✦ Metropolitan Area Wide Video Deployment	$2,100,000	$48,000
✦ Detour Route Management	$150,000	$6750
✦ Incident Management Plan for West Salem Bridges	$546,000	$9500
✦ Communication Network	$462,000	$9,900
City of Salem Total:	***$3,258,000***	***$64,650***
Cherriots		
✦ Transit Signal Priority	$130,000	$1000
✦ Automated Vehicle Location (AVL) System	$655,000	$19,000
✦ Real-Time Transit Arrival Information	$135,000	$13,500
Cherriots Total:	***$920,000***	***$33,500***

Table 6-4. Estimated Agency Costs for 5-Year Plan (cont)

Project Elements	Estimated Costs: Capital	Estimated Costs: Annual O&M
Marion County		
✦ Communication Network	$126,000	$1800
✦ Detour Route Management	$100,000	$4500
✦ Flood Warning System	$405,000	$18,000
✦ Slide Warning System	$273,000	$11,000
Marion County Total:	***$904,000***	***$35,300***
Shared Projects Between Several Agencies		
✦ Incident Management Plan for West Salem Bridges	$1,092,000	$19,000
Shared Agencies Total:	***$1,092,000***	***$19,000***

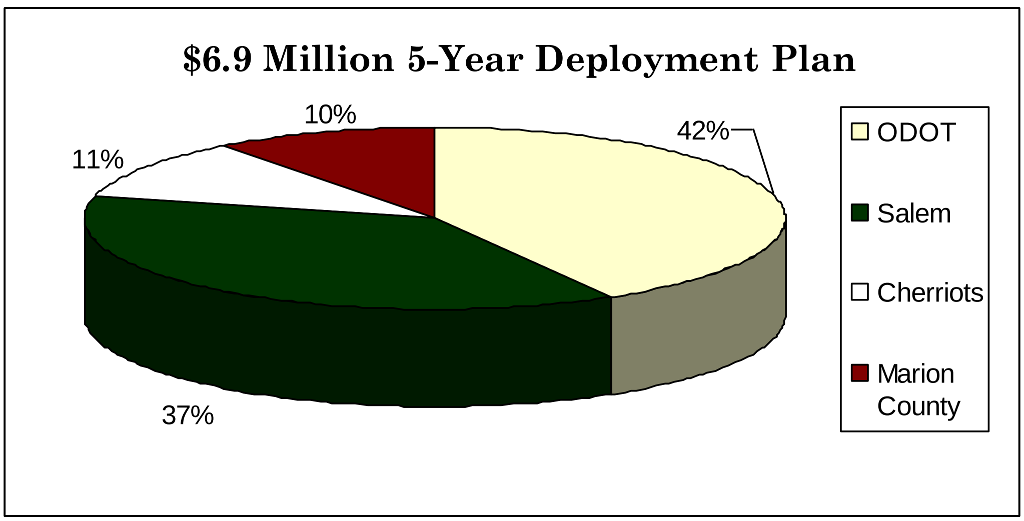


Figure 6-8. Estimated 5-Year Deployment Plan Cost by Agency

Appendix A: Glossary of Acronyms

List of Acronyms

AD	Archived Data Management
ADA	American Disability Act
ADT	Average Daily Traffic
AOC	Agency Operation Center
APC	Automated Passenger Counting
APTS	Advanced Public Transportation System
ARC	American Red Cross
ASTM	American Society for Testing and Materials
ATC	Advanced Traffic Controller
ATIS	Advanced Traveler Information Systems
ATM	Asynchronous Transfer Mode
ATMS	Advanced Traffic Management System
ATR	Automatic Traffic Recorder
AVL	Automated Vehicle Location
AVSS	Advanced Vehicle Safety System
C2C	Center to Center
C2F	Center to Field
CAD	Computer-Aided Dispatch
CARTS	Chemeketa Area Regional Transportation System
CCTV	Closed Circuit Television
CIP	Capital Improvement Plan
CO	Communications
CORBA	Common Object Request Broker Architecture
CVO	Commercial Vehicle Operations
DATEX	Data Exchange Between Systems
DFD	Data Flow Diagram
DMS	Dynamic Message Sign
DMV	Department of Motor Vehicles
DSRC	Dedicated Short Range Communication
DSL	Digital Subscriber Lines
DSLAM	Digital Subscriber Line Access Multiplexer
EM	Emergency Management
EMS	Emergency Management Services
EOC	Emergency Management Services
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FRAP	Freight Route Analysis Project
FTA	Federal Transit Administration
FTP	File Transfer Protocol
GIS	Geographical Information System
GHz	Gigahertz

GigE	Gigabit Ethernet
GPS	Global Positioning System
HAR	Highway Advisory Radio
IM	Information Management
IMMS	Incident Management Message Sets
IEEE	Institute of Electrical and Electronics Engineers
IGA	Inter-governmental Agreement
IP	Internet Protocol
ISP	Information Service Provider
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
IVR	Interactive Voice Response
K	Kilobits per Second
MC	Maintenance & Construction
MCM	Maintenance & Construction Management
MDT	Mobile Data Terminal
MHz	Megahertz
MOU	Memoranda of Understanding
MPEG	Motion Picture Expert Group
MS/ETMCC	Message Set External Traffic Management Center Communication
MWVCOG	Mid-Willamette Valley Council of Governments
NOAA	National Oceanic and Atmospheric Administration
NTCIP	National Transportation Communication for ITS Protocol
NWTOC	Northwest Transportation Operation Center
O & M	Operations and Maintenance
ODOT	Oregon Department of Transportation
OEM	Oregon Emergency Mangement
OHP	Oregon Highway Plan
OHAS	Oregon Housing and Associated Services
OVCTS	Oversize Vehicle Closure Telephone System
OSI	Open System Interconnection
OSP	Oregon State Police
OTIA	Oregon Transportation Investment Act
NIC	Network Interface Card
PDA	Personal Digital Assistant
PMPP	Point to Multipoint Protocol
PPP	Point to Point Protocol
PM	Program Management
PoP	Point of Presence
PTS	Public Transportation Services
PTZ	Pan-Tilt-Zoom
PVMS	Portable Variable Message Sign
QoS	Quality of Service
RF	Radio Frequency
RTP	Regional Transportation Plan
RWIS	Road Weather Information Systems
Rx	Receiver
SCP	Signal Control and Prioritization
SDC	System Development Charge
SDO	Standards Development Organizations

SKATS	Salem-Keizer Area Transportation Study
SLIP	Serial Line Internet Protocol
SMART	South Metro Area Rapid Transit
SONET	Synchronous Optical NETwork
SPIS	Safety Priority Index System
STIP	Statewide Transportation Improvement Program
TCP/IP	Transmission Control Protocol/Internet Protocol
TDM	Transportation Demand Management
TEA-21	Transportation Equity Act for the 21st Century
TI	Traveler Information
TIP	Transportation Improvement Program
TOC	Transportation Operations Center
TM	Traffic Management
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
TSP	Transportation System Plan
Tx	Transmitter
USDOT	United States Department of Transportation
V/C	Volume-to-Capacity
VMT	Vehicle Miles Traveled
VPN	Virtual Private Network
WVCC	Willamette Valley Communication Center
XML	Extensible Markup Language

Appendix B: References

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