Final Report
GUIDANCE FOR COMPLYING WITH FEDERAL REQUIREMENTS FOR INTELLIGENT TRANSPORTATION SYSTEM PROJECTS IN THE PUGET SOUND REGION

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<td>Center-to-Center</td>
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<tr>
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<td>Federal Highway Administration</td>
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<td>FTA</td>
<td>Federal Transit Administration</td>
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1. **INTRODUCTION**

This report provides potential project sponsors in the Puget Sound region with information on how to comply with the federal intelligent transportation systems (ITS) requirements. As a project sponsor, you need to read this report, if the answer is YES to the following two statements:

1. Your project uses funds from the federal highway trust fund (including the mass transit account) now and/or the future.
2. The project includes ITS elements.

The Transportation Equity Act for the 21st Century (TEA-21) requires that all ITS projects using federal funding must “conform” to the National ITS Architecture and ITS technical standards. (An overview of the National ITS Architecture is found in Section 2.4 of this report.) The implementation of this requirement is found in Federal Highway Administration (FHWA) Rule and Federal Transit Administration (FTA) Policy, which took effect on April 8, 2001. The Puget Sound Regional Council has taken the lead in ensuring compliance with the new federal ITS project requirements for the Puget Sound region, which includes King, Kitsap, Pierce, and Snohomish Counties.

This report explains how these new regulations affect jurisdictions, agencies or consortiums wishing to use federal funds to plan, design and/or deploy a project with ITS components. An approach and related guidance for project sponsors on how they can ensure compliance with the new federal ITS requirements is provided in this document. The key federal requirement for an ITS project funded with federal money is demonstrating that a systems engineering analysis was performed during the design of the project. The systems engineering analysis process includes the following seven elements that must to be addressed to ensure a project conforms to the federal ITS requirements:

1. Description of how project fits into the Regional ITS Architecture
2. Roles and responsibilities of participating agencies
3. Requirements definition
4. Analysis of alternative system configurations and technology options
5. Procurement options
6. Applicable ITS standards and testing procedures
7. Procedures and resources necessary for operations and management of the system

The Puget Sound Regional ITS Architecture is a framework for ensuring institutional agreement and technical integration for the implementation of ITS projects within the region. While some projects may be exempt from the federal ITS requirements, project sponsors are encouraged to determine how their project can fit into the Puget Sound Regional ITS Architecture and follow the systems engineering analysis process. Compliance with the architecture will provide a path to sharing information with other transportation organizations and the general public on a regional basis. A comprehensive systems engineering analysis is typically done as a matter of course on any transportation engineering project.

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1 Intelligent transportation systems are defined as advanced information processing, communications, sensing, or control technologies. [Examples include interconnecting traffic signals, transit signal priority systems, variable message signs, closed-circuit television cameras, automatic passenger counters, and traffic signal control software.]

2 Transportation Equity Act for the 21st Century, Public Law 105-178, 112 Stat. 457, Section 5206(e)


involving the application of advanced technology. The federal ITS requirements provide another source for guidance and a convenient checklist.

This report describes the seven systems engineering elements and describes the activities and actions that need to be taken by the project sponsor to ensure the project meets the federal ITS requirements.

- Section 2 provides background information on the overall project and the National ITS Architecture to provide a context for the document.
- Section 3 provides information on if federal ITS requirements apply to your project.
- Section 4 reviews the systems engineering analysis requirements.
- Section 5 presents an example of addressing the federal ITS requirements for deploying a traffic signal control system.

FHWA and FTA will be providing additional guidance and direction on addressing the federal ITS requirements. Project sponsors should consult the US Department of Transportation ITS Website for current information (http://www.its.dot.gov/).
2. **BACKGROUND**

2.1 **Project Overview**

The Puget Sound region has been at the forefront of deploying ITS applications. Until the Seattle Model Deployment Initiative – Smart Trek, the majority of ITS applications in the region had primarily served the interests of individual state, regional, county, and local jurisdictions or modes. The Smart Trek project led the effort to link and integrate these various applications into a comprehensive, integrated transportation management and information system. This report is the final deliverable of a project entitled the Development of the Puget Sound Regional ITS Architecture. This project built upon these past efforts to define the technical and institutional relationships required among transportation related organizations to move their separated transportation technology systems into an integrated whole in the Puget Sound region. The project activities included the following:

1. Completed an inventory of existing and planned ITS projects throughout the Puget Sound region.
2. Developed a strategy for the integration of individual ITS components within the region.
3. Developed a Puget Sound Regional ITS Architecture.
5. Recommended an approach for mainstreaming ITS into the regional transportation planning and programming process.
6. Developed guidance for compliance with the federal ITS requirements.
7. Conducted an extensive regional outreach effort to obtain the input of local, county, regional, and state stakeholders.

The Regional Council, Washington State Department of Transportation (WSDOT), and Sound Transit sponsored the project.

2.2 **Stakeholder Outreach**

Two stakeholder advisory groups provided guidance and direction for this project. The Regional ITS Advisory Panel (Advisory Panel) fulfilled this role for the development of the overall Regional ITS Integration Strategy, architecture, and mainstreaming process. The Advisory Panel consists of representatives from federal, state, county, and local transportation agencies and private sector organizations engaged in providing transportation services and consulting. The Regional Transit Technology Group (RTTG) performed this function for the development of the more detailed transit architecture. The RTTG includes members from all the regional transit agencies.

Besides the dialogue with the Advisory Panel, the following discussion group meetings were held with key stakeholder groups:

- Freight Systems Improvement Team
- Traffic Control System Managers
- Emergency Management Coordinators
- Advanced Traveler Information System Developers
- Regional Transit Technology Group

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5 For information on the Smart Trek project, consult their website at http://www.smarttrek.org/
The purpose of these meetings was to collect and summarize information about agency roles and responsibilities, identify and discuss operational issues, and identify the potential future need for operational and technology agreements. The discussions were also used to confirm and gather additional information about existing systems and plans for the expansion of existing systems and/or the deployment of new ITS applications.

The five discussions group meetings were held to inform the members of these groups about the Regional ITS Architecture project and to seek input to help shape the planning process. While the discussion group members represented a wide-range of interests and levels of familiarity with ITS, there were several over-arching themes – or gaps identified in the current regional ITS deployment – that emerged from all the groups that were consistent across most of the sessions. The detailed results are contained in the Puget Sound Regional ITS Architecture Discussion Groups Summary. ¹

In addition, briefing sessions with transportation system managers were conducted with representatives from cities, counties, WSDOT, and transit agencies to gather their input and to determine their acceptance of the recommended Regional Integration Strategy and architecture. Specific sessions included meetings with:

- WSDOT staff from the Advanced Technology Branch, Northwest Region, and Olympic Region
- Eastside traffic managers including representatives from Bellevue, Redmond, and Kirkland
- Snohomish County traffic managers including representatives from Snohomish County, Lynnwood, and Everett
- King County traffic engineer
- City of Seattle traffic engineer
- Pierce County traffic engineer
- City of Tacoma traffic engineer

Draft copies of concept documents and the Integration Strategy were distributed to over 50 transportation managers in the region for review and comment during the project.

Stakeholders involved in the regional transportation planning and programming processes were consulted in the development of ways to mainstream ITS into the transportation planning and programming in the region. These stakeholders included WSDOT including headquarters, Olympic Region, and Northwest Region; transit agencies; local agencies; Sound Transit; FHWA; and FTA. In April 2001, the Regional Council held a workshop to explain to major stakeholders the requirements of the new federal ITS requirements. The recommended process for incorporating ITS into the regional transportation programming process was the direct result of these efforts.

### 2.3 Regional Process for Ensuring Compliance With the Federal ITS Requirements

The Regional Council will be modifying the regional Transportation Improvement Program (TIP) process to incorporate checking for compliance with the federal ITS requirements. ²

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Council will add this element to the screening of transportation projects during the regional TIP development process. The ITS compliance screening would only apply to projects that include ITS elements and meet the applicability requirements of the federal ITS requirements. The overall approach is based on “self-certification” by project sponsors affirming that they will comply with the ITS requirements. In this way, the project sponsor is taking responsibility for meeting the federal ITS requirements for their project. An official that could commit the organization to compliance (i.e., Public Works Director, Transportation Director) would be required to authorize the certification. The self-certification would take place at two points in the project development cycle.

1. **Planning**: At the planning level, the project sponsor would provide a short description of how their ITS project would fit into the Regional ITS Architecture and agree to conduct a systems engineering analysis for the project during the design phase. If the project were not currently addressed in the Regional ITS Architecture, the Regional Council would work with the project sponsor to modify the Regional ITS Architecture to encompass the project.

2. **Design (Prior to Construction)**: Many of the details about the ITS elements of a project are developed in greater detail during the design phase. Providing in-depth details about the project’s compliance with the new federal ITS requirements is most appropriate during the design phase, prior to construction. The project sponsor would, again, “self-certify” that the systems engineering analysis was completed and provide the Regional Council with information on the final project ITS Architecture and its relationship with the Regional ITS Architecture for the purpose of maintaining the Regional ITS Architecture. FHWA or FTA may independently request additional documentation on the systems engineering analysis before funds are released for construction.

The self-certification requirements would be in place for the update to the 2001-04 regional TIP.

### 2.4 An Overview of the National ITS Architecture

The National ITS Architecture, adopted in 1996 and updated periodically, provides a common technical and institutional framework to guide the coordinated deployment of ITS by public agencies and private organizations alike. The National ITS Architecture is not a design, rather it defines the framework around which multiple design approaches can be developed, each one specifically tailored to meet the unique needs of the region. The National ITS Architecture also defines the functions that must be performed to implement a given service, the physical entities or subsystems where these functions reside, the interfaces/information flows between subsystems, and the communication requirements for the information flows. The National ITS Architecture (The Architecture) may be found on-line at [http://www.iteris.com/itsarch/](http://www.iteris.com/itsarch/).

Although the architecture is not technology-specific, it is function-specific. The architecture is employed to structure the planning and design process along with the general functions of ITS systems. The architecture further defines these functions into two categories: physical and logical.
2.4.1 Physical Architecture

The Physical Architecture provides a framework for the physical elements of ITS systems; these elements include cars, people, computers, buses, trucks, etc. Figure 2-1, National ITS Architecture Subsystems, provides an illustration of the Physical Architecture. The physical elements are broken into large groups called subsystem categories. These are functional categories that describe what their member physical entities (subsystems) do.

The four major subsystem categories are:

1. **Traveler Subsystems**: Systems or applications that provide information to travelers (e.g., traffic conditions).
2. **Center Subsystems**: Systems or applications that process and use information to control the transportation network (e.g., signal timing).
3. **Vehicle Subsystems**: Systems or applications that provide driver information and safety on vehicle platforms (e.g., in-vehicle signing).
4. **Roadside Subsystems**: Systems or applications that process and provide vehicle system data (e.g., traffic signals).

The bubbles (or sausages) between the subsystem categories represent the communications medium. For example, the Roadway subsystem (within the “Roadside” subsystem category) could potentially be communicating with the Vehicle, the Transit Vehicle, the Commercial Vehicle, and the Emergency Vehicle subsystems (within the “Vehicle” subsystem category) via short-range wireless links.

### 2.4.1.1 Terminators

Terminators are generally defined as people, systems and the general environment that is outside the boundary of ITS but still impacting 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, a subsystem that is out of the control of the entity’s perspective is called a terminator. This is done to illustrate whom has/wants control of the proposed services.

### 2.4.1.2 Architecture Flow

An architecture flow is simply the information that is exchanged between subsystems and terminators in the Physical Architecture. These architecture flows and their communication requirements define the interfaces which form the basis for much of the ongoing standards work in the National ITS Architecture program.
Figure 2-1: National ITS Architecture Subsystems
2.4.1.3  Market Packages

While the Physical Architecture components, such as subsystems and architecture flows, provide a good tool for organizing the ITS planning and design process, they are difficult to discuss with anyone who is not familiar with the National ITS Architecture. The market packages provide an accessible, deployment-oriented perspective to the national architecture. They are tailored to fit - separately or in combination - real world transportation problems and needs. Market packages utilize one or more equipment packages that must work together to deliver a given transportation service and the architecture flows that connect them and other important external systems. In other words, they identify the pieces of the Physical Architecture that are required to implement a particular transportation service. Equipment packages group like processes of a particular subsystem together into an “implementable” package. The market packages also help in the design process by categorizing improvements and can serve as another check to make sure areas are not over or under covered.

For example, the Market Package “Regional Traffic Control (ATMS07)” is made up of the subsystems “Traffic Management” and “Roadway”, as well as the terminator “Other TM” (see Figure 2-2 on the following page). The service to be provided is regional traffic control. In order to do this, the entity must have control or access to processes under traffic management and roadway. The specific process needed is “TMC Regional Traffic Control.” This equipment package provides capabilities for analyzing, controlling, and optimizing area-wide traffic flow. These capabilities provide for wide area optimization integrating control of a network signal system with control of freeway, considering current demand as well as expected demand with a goal of providing the capability for real-time traffic adaptive control while balancing inter-jurisdictional control issues to achieve regional solutions. The terminator “Other Traffic Management Center” is linked to the equipment package "Traffic Management" through "traffic control coordination" and "traffic information coordination".
Traffic Management Center” shows that the information collected must be accessible by other traffic management centers. The architecture flow indicates that “traffic information coordination” and “traffic control coordination” will be exchanged between the “Traffic Management” subsystem and “Other Traffic Management Center” terminator.

Architecture flows represent the information flows between subsystems and terminators. These flows can be broken down further into data-flows and process specifications. This breakdown defines more and more detailed information exchanges between the subsystems and terminators. This level of detail becomes more useful in the project design and implementation stages.

2.4.2 Logical Architecture

The Logical Architecture defines the characteristics of the information being exchanged by the various ITS systems. The data that is exchanged between ITS systems needs to be concretely defined and categorized. The Logical Architecture does this. The Logical Architecture provides information regarding the definitions of the data and how it flows between systems. The Logical Architecture provides a series of specifications and detailed data flows that correspond to the elements identified in the Physical Architecture. The most common of these are Process Specifications (or P-Specs) that describe functions requirements and a complete set of inputs and outputs.

2.4.3 Interconnectivity

One of the main sources of confusion when dealing with the National ITS Architecture is interconnectivity among the elements of the architecture. No ITS applications ever work alone. At the same time, no ITS applications generally need to be contingent on other ITS applications. Most ITS applications stand-alone but are enhanced when connected to other applications.

Likewise, no section of the ITS architecture needs to be addressed before another. The architecture can be approached from any number of angles – from a high level view like subsystems or market packages or a close-up view like process specifications or data elements. It all depends on what your end-goal is or what your starting points are. Most ITS planning and design projects will start with needs, existing systems, and planned systems. The National Architecture’s multiple starting points allow planners to insert needs, planned systems, or existing systems into the process where they make sense.

Figure 2-3 shows the various components of the National ITS Architecture and their relationships.
Figure 2-3: Interconnectivity Among Components of the National ITS Architecture
3. **DO THE FEDERAL ITS REQUIREMENTS APPLY TO YOUR PROJECT?**

The first question is, “Does your project include any ITS elements?” ITS is defined as advanced information processing, communications, sensing, or control technologies.\(^8\) Examples include interconnecting traffic signals, transit signal priority systems, variable message signs, closed-circuit television cameras, automatic passenger counters, and traffic signal control software.

The next question is does the project use (or will it use) funds from the federal highway trust fund including the mass transit account. The Section 940.7 of the FHWA rule\(^9\) (shown in the text box to the right) also provides for some additional exceptions. Item (2) may be of interest to project sponsors who are updating existing systems. Finally, any ITS project that has advanced to final design by April 8, 2001 is exempt.

Destination 2030, the region’s transportation plan, states that, when possible, regional ITS projects will conform to the Regional ITS Architecture and applicable national ITS standards. Project sponsors are encouraged to use the steps recommended in this document even if they do not plan to use federal highway trust funds for their project. The use of the Regional ITS Architecture and the systems engineering analysis approach will lead to a more efficient system and will not preclude the project sponsor from using federal funds in the future, if funding conditions change for the project.

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4. **SYSTEMS ENGINEERING ANALYSIS REQUIREMENTS**

The federal ITS requirements mandate that all ITS projects be based on a systems engineering analysis. The analysis should be on a scale commensurate with the project scope - that is, the more complex the project, the more complex the analysis. The requirements for systems engineering analysis have been defined as the execution of the following seven elements:

1. Description of how the project fits into the Regional ITS Architecture
2. Roles and responsibilities of participating agencies
3. Requirements definition
4. Analysis of alternative system configurations and technology options
5. Procurement options
6. Applicable ITS standards and testing procedures
7. Procedures and resources necessary for operations and management of the system.\(^{10}\)

A comprehensive systems engineering analysis is typically done as a matter of course on any transportation engineering project involving the application of advanced technology. A traditional systems engineering process will have more activities than just the ones included above. The above list indicates the subset of activities that will meet the federal ITS requirements. However, the first item in the list - how the project fits into the Puget Sound Regional ITS Architecture - will constitute an additional effort by project sponsors. The seven elements are discussed in more detail in the following sub-sections.

4.1 **Description of How Project Fits Into the Regional ITS Architecture**

The Regional Council has completed the development of the Puget Sound Regional ITS Architecture\(^ {11}\) and a detailed ITS Transit Architecture.\(^ {12}\) The Regional ITS Architecture defines a regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects. It is designed to provide guidance and serve as a resource in the development of local ITS projects.

One of the primary federal ITS requirements is to demonstrate how your project fits into the Puget Sound Regional ITS Architecture. The recommended approach to demonstrating that a project fits into the Regional ITS Architecture is illustrated in the process flow diagram (Figure 4-1) and contains the following steps.

1. Review market packages in the National and Regional ITS Architecture to determine which market packages will best meet the requirements of your project.
2. Review the Regional ITS Integration Strategy to determine how your project could be integrated into the overall regional deployment of ITS applications. This will help you identify other organizations and ITS applications to which your project may need a connection.

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3. Determine which agencies, organizations and stakeholders beyond your own organization could be involved in the project.

4. Develop an operational concept for the project using the results of the market package review and identification of stakeholders to be included in the project. The operational concept defines the institutional relationships and the high-level information flows among the organizations required for the deployment and operation of the project.

5. Develop a project ITS Architecture diagram that indicates subsystems (entities and stakeholders), equipment packages and information exchanges using the National ITS Architecture market package definitions and diagrams as a basis. Example ITS Architecture diagrams are available as a starting point.

6. Identify any market packages, interface requirements, and information exchanges provided by the project that are not currently included in the Regional ITS Architecture.

7. Work with the Regional Council to update the Regional ITS Architecture, if required. The Regional Council will work with you to document and discuss the additional market packages, agencies, organizations, stakeholders and high-level information flows that need to be added to the Regional ITS Architecture to fully represent your ITS project.

The results of this activity feed into the rest of the systems engineering analysis effort that is to be performed during the design of the project.

Additional guidance on these steps is provided below.
Figure 4-1: Fitting into the Regional ITS Architecture

ITS Project Objectives

Market Package Review

Identify Stakeholders

Operational Concept

Compare and Update Regional ITS Architecture

Puget Sound Regional ITS Architecture

National ITS Architecture

Regional Integration Strategy

Subsystem
Equipment Package
Equipment Package
Architecture Flow
Architecture Flow
Project ITS Architecture
Terminator

Local ITS Project Design
4.1.1 Review of Applicable Market Packages

The Regional ITS Architecture is based upon the National ITS Architecture, which was described in Section 2.4. The National ITS Architecture is not a design, rather it defines the framework around which multiple design approaches can be developed, each one specifically tailored to meet the unique needs of the region or project. In the National ITS Architecture, market packages provide an accessible, deployment-oriented perspective to the National Architecture. They are tailored to fit - separately or in combination - real world transportation problems and needs. The market packages also include a depiction of the relationship and data flow between different entities providing the “service” implemented by the deployment of the market package.

The identification of which market packages are to be deployed for your project is the starting point for determining how your project will fit into the Regional ITS Architecture. For reference, Table 4-1 shows all the market packages that are encompassed by the Regional ITS Architecture. The market packages are listed by type of public sector organization. Full definitions of these and all other market packages are found on-line at the National ITS Architecture website (http://www.iteris.com/itsarch/).

Table 4-1: Puget Sound Regional ITS Architecture Market Packages

<table>
<thead>
<tr>
<th>Market Package Name</th>
<th>WSDOT</th>
<th>Commercial Vehicle Operations</th>
<th>Transit</th>
<th>Local Agencies</th>
<th>Emergency Management</th>
<th>PSRC</th>
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<td>Incident Management System</td>
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13 Glossary, US DOT, National ITS Architecture, Version 3.2
### Market Package Name | WSDOT | Commercial Vehicle Operations | Transit | Local Agencies | Emergency Management | PSRC
---|---|---|---|---|---|---
Electronic Toll Collection & X & & & & X
Emissions Monitoring and Management & & & & & &
Standard Railroad Grade Crossing & X & & X
Railroad Operations Coordination & X & X & X
Parking Facility Management & & & & X
Reversible Lane Management & & & & X
Road Weather Information System & X & & X
Regional Parking Management & & & & X
Electronic Clearance & X & X & &
CV Administrative Processes & X & & X
International Border Electronic Clearance & & & &
Weigh-In-Motion & & X & &
Roadside CVO Safety & X & X & &
On-board CVO Safety & & & & X
Hazardous Materials Management & & & & X
Emergency Response & X & & X
Emergency Routing & X & X & &
Mayday Support & & & & X

#### 4.1.2 Regional ITS Integration Strategy

The Puget Sound Regional ITS Integration Strategy\(^{14}\) provides guidance for the Puget Sound region in the management and investment of ITS applications to achieve a regionally integrated system. Accordingly, the strategy acknowledges the requirement to transition legacy systems, accommodate new systems, and provide for links to other stakeholders. The complexity of the undertaking requires multiple activities and a phased approach to meet the overall objective of an integrated system. The recommended strategy can be summarized into the following elements:

1. **Use the Smart Trek ITS Backbone as the initial mechanism for the sharing of real-time transportation system and other related information among jurisdictions and private information service providers (ISPs).**

2. **Transition to structured, emerging National Transportation Communications for ITS Protocol (NTCIP) center-to-center (C2C) protocols among transportation management systems for the future sharing of information and device control coordination.**

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3. Continue sharing of common ITS applications and systems among regional transit agencies and build links to other traffic management and other information sources.

4. Build information interfaces between transportation management systems and emergency management centers.

5. Connect local commercial vehicle regulatory functions to the Washington State deployment of the Commercial Vehicle Information Systems and Network (CVISN).

6. Use Smart Trek as basis for the deployment of a regional multi-modal traveler information system (RMTIC) and the new three-digit traveler information telephone number (511) to provide basic traveler information to the general public.

7. Accommodate the electronic flow of information to private ISPs through the deployment of a common interface standard via the ITS Backbone.

8. Build electronic links to other transportation stakeholders including ports, rail operators, clean air agency, toll agencies, and freight management organizations.

9. Capture and archive real-time transportation system data for future analysis and to support transportation planning.

Each elements of the Regional ITS Integration Strategy are discussed in detail in the report.

4.1.3 Other Stakeholders to Consider

The Puget Sound Region has many different public and private entities providing transportation related services, data management, and coordination. A convenient way to characterize these organizations is to use the center subsystem descriptions found in the Physical Architecture portion of the National ITS Architecture (see Section 2.4). Accordingly, the regional stakeholders can be categorized as follows:

- **Traffic Management (state, county, local):** The Traffic Management Subsystem operates within a traffic management center or other fixed location. This subsystem communicates with the Roadway Subsystem to monitor and manage traffic flow. Incidents are detected and verified, and incident information is provided to the Emergency Management Subsystem, travelers, and to third party providers.

- **Transit Management (transit agencies, ferry system):** The Transit Management Subsystem manages transit vehicle fleets and coordinates with other modes and transportation services. It provides operations, maintenance, customer information, planning, and management functions for the transit property. It spans distinct central dispatch and garage management systems and supports the spectrum of fixed route, flexible route, and paratransit services.

- **Emergency Management (police, fire, ambulance, etc.):** The Emergency Management Subsystem operates in various emergency centers supporting public safety including police and fire stations, search and rescue special detachments, and hazardous materials response teams. This subsystem interfaces with other emergency management centers to support coordinated emergency response involving multiple agencies. The subsystem creates, stores, and utilizes emergency response plans to facilitate coordinated response.
• **Information Service Provider (ISP):** The Information Service Provider Subsystem collects, processes, stores, and disseminates transportation information to system operators and the traveling public. The subsystem can play several different roles in an integrated ITS. In one role, the ISP provides a general data warehousing function, collecting information from transportation system operators, and redistributing this information to other system operators in the region and other ISPs. In this information redistribution role, the ISP provides a bridge between the various transportation systems that produce the information and the other ISPs and their subscribers that use the information. The second role of an ISP is focused on delivery of traveler information to subscribers and the public at large. Information provided includes basic advisories, real time traffic condition and transit schedule information, yellow pages information, ridematching information, and parking information.

• **Commercial Vehicle Administration:** The Commercial Vehicle Administration Subsystem performs administrative functions supporting credentials, tax, and safety regulations. It issues credentials, collects fees and taxes, and supports enforcement of credential requirements. This subsystem communicates with the Fleet and Freight Management Subsystems associated with the motor carriers to process credentials applications and collect fuel taxes, weight/distance taxes, and other taxes and fees associated with commercial vehicle operations. The subsystem also receives applications for, and issues special oversize/overweight and hazardous materials permits in coordination with other cognizant authorities.

• **Fleet and Freight Management:** The Fleet and Freight Management Subsystem provides the capability for commercial drivers and dispatchers to receive real-time routing information and access databases containing vehicle and cargo locations as well as carrier, vehicle, cargo, and driver information. In addition, the capability to purchase credentials electronically shall be provided, with automated and efficient connections to financial institutions and regulatory agencies, along with post-trip automated mileage and fuel usage reporting. The Fleet Management Subsystem also provides the capability for Fleet Managers to monitor the safety of their commercial vehicle drivers and fleet. The subsystem also supports application for hazardous materials credentials and makes information about hazardous materials cargo available to agencies as required.

Table 4-2 illustrates the potential regional stakeholders by center subsystems. It should be noted that information service providers (ISPs) could be either public or private organizations. An agency can be an ISP by simply having a website that provides transportation information. Many organizations listed under traffic and transit management act as ISPs. They are not represented under the ISP category.
### Table 4-2: Potential Regional Stakeholders by Center Subsystems

<table>
<thead>
<tr>
<th><strong>Traffic Management</strong></th>
<th><strong>Emergency Management</strong></th>
<th><strong>Information Service Providers</strong></th>
<th><strong>Commercial Vehicle Administration</strong></th>
<th><strong>Fleet and Freight Management</strong></th>
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<tr>
<td><strong>State</strong></td>
<td>Ambulance Services</td>
<td>Agency Operated ISPs</td>
<td>Burlington Northern Santa Fe</td>
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<td>WSDOT NW Region</td>
<td>Hospitals</td>
<td>Private ISPs</td>
<td>Union Pacific</td>
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<td>WSDOT Olympic Region</td>
<td>Local Fire</td>
<td>Smart Trek</td>
<td>Shipping Companies</td>
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<td><strong>Counties</strong></td>
<td>Local Police</td>
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<td>Trucking Companies</td>
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<td>Other Emergency Response</td>
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<td>Mt. Rainier National Parks</td>
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4.1.4 Develop a Project Operational Concept

The operational concept defines the relationships among the organizations required for the deployment and operation of the project. Relationships between agencies embody two main components: 1) what roles and responsibilities does each agency play in the agency-to-agency relationship and 2) what kinds of data are shared as part of the information exchange. These two components are detailed below in Table 4-3.

Table 4-3: Potential Relationships and Information Exchanges

<table>
<thead>
<tr>
<th>Agency to Agency Relationships</th>
<th>Information Exchanges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultation: One party confers with another party, in accordance with an established process, about an anticipated action and then keeps that party informed about actions taken.</td>
<td>Video: The dissemination of live video and still images from one party’s field cameras to another party.</td>
</tr>
<tr>
<td>Cooperation: The parties involved in carrying out the planning and/or project development processes work together to achieve a common goal or objective.</td>
<td>Data: The dissemination of data gathered from one party’s field devices to another party. Data can include, but is not limited to, traffic data, weather data, parking data, transit data, etc.</td>
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<tr>
<td>Coordination: The comparison of the transportation plans, programs, and schedules of one agency with related plans, programs, and schedules of other agencies and adjustment of plans, programs and schedules to achieve general consistency.</td>
<td>Command: The ability for one party to control a second party’s field devices. Command can include, but is not limited to, changing VMS messaging, changing traffic signal timings, camera control, etc.</td>
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<tr>
<td>Information Sharing: The exchange of data, and device status information between parties, for the purpose of coordinated responses, planning, and analysis.</td>
<td>Request: The ability for one party to solicit either data, or a command change, such a VMS messaging or signal timings, from another party.</td>
</tr>
<tr>
<td>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.</td>
<td>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.</td>
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<tr>
<td>Operations: One party fully operates field equipment of a second party, typically because the second party does not have a control center.</td>
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<td>Maintenance: One party maintains the field equipment of a second party.</td>
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</table>

The operational concept is based upon the selection of market packages that best meet the project requirements and the identification of other agencies that will participate in the project. Each market package description identifies which entities (i.e., subsystems) are involved in the deployment of the market package. For example, if a local traffic management center wishes to share traffic information and video images with the WSDOT Transportation System Management Center (TMSC), the market package that best addresses this idea is the Regional Traffic Control. Regional Traffic Control provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy. The operational concept would capture the institutional relationship and high-level data...
flows between the two organizations that are cooperating in the deployment of the project. This example is illustrated in the Figure 4-2 below.

Many market packages do not require interaction with other organizations, and can be generally implemented as stand-alone applications locally. In these cases, the market package itself defines the operational concept for deployment. However, several market packages have been identified as requiring jurisdictional interaction and the need to define operational concepts. These market packages are:

- Regional Traffic Control
- Regional Parking Management
- Multi-Modal Coordination (Transit Signal Priority)
- Transit Fare Management
- Transit Data Management
- Transit Traveler Information
- Incident Management
- Data Archiving
- Rail Crossing Coordination

In several cases, multiple traffic, transit, and emergency management agencies will need to form relationships with each other to define specific roles and responsibilities for the deployment of the market packages required by the project.
A matrix or diagram detailing the relationships between entities including other agencies and jurisdictions plus the identification of which high-level information flows will be supported defines the operational concept for the project. Additional information on this topic is found in Section 4 of the Regional ITS Architecture document. In addition, searchable market package databases have been developed detailing existing, planned and potential relationships between jurisdictions for the following market packages:

- Regional Traffic Control
- Regional Parking Management
- Multi-Modal Coordination (Transit Signal Priority)
- Transit Fare Management
- Transit Traveler Information

These databases can be accessed from the Regional Council’s website at [http://www.psrc.org/](http://www.psrc.org/) or in Appendix A of the Puget Sound Regional ITS Architecture report.

### 4.1.5 Develop a Project ITS Architecture

Using the selected project market packages and operational concept, a project ITS Architecture diagram should be assembled for your project. The diagram should depict following items:

- **Subsystems**: “The principle structural element of the Physical Architecture. There are nineteen subsystems in the National ITS Architecture (see Section 2.4), which are grouped into four classes: Centers, Roadside, Vehicles, and Travelers. Example subsystems are the Traffic Management Subsystem, the Vehicle Subsystem, and the Roadway Subsystem. These correspond to existing things in the physical world: respectively traffic operations centers, automobiles, and roadside signal controllers.”

- **Equipment Packages**: “The building blocks of the Physical Architecture subsystems. Equipment Packages group like processes of a particular subsystem together into an ‘implementable’ package.”

- **Architecture Flow Between the Subsystems**: “Information that is exchanged between subsystems and terminators in the Physical Architecture. Each architecture flow contains one or more data flows from the Logical Architecture.” Architecture flows are at the next level of detail beyond the five high-level information flows noted above.

An example link from a city traffic management center to a state traffic management center for the purpose of sharing of information and video is shown below in Figure 4-3.

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The descriptions of the equipment packages from the National ITS Architecture combined with the architecture flows between the subsystems provides an excellent starting point for defining functional requirements. The National ITS Architecture contains databases, which allow the user to link these items back to the Logical Architecture when used to develop detailed functional requirements and specifications (See Section 4.3 below). Information exchanges and interface requirements are primarily defined by the architecture flows.

Diagrams were developed for a wide range of organizations throughout the region. Some depict existing operations and others provide illustrations of how a local or county jurisdiction might define its project ITS Architecture for compliance with the Regional ITS Architecture. These diagrams should provide a useful starting point and checklist for these efforts and are contained in the Regional ITS Architecture document. Example diagrams include the following:

- Washington State Department of Transportation
- Typical County with Traffic Operations Center
- Typical City with Traffic Operations Center
- Typical Traffic Management Center-to-Center Interface

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• Detailed Transit Architecture (one for each agency in the region)
• ITS Backbone
• Regional Multi-Modal Traveler Information Center (RMTIC)
• Local Link to Commercial Vehicle Information Systems and Network (CVISN)
• Typical Emergency Management Service Provider
• Archived Data Management

4.2 Roles and Responsibilities of Participating Agencies

The Regional ITS Architecture provides both a technical and institutional framework for the deployment of ITS in the Puget Sound region. Institutional integration involves coordination between agencies and jurisdictions to achieve seamless operations and interoperability.

According to the federal ITS requirements, the engineering analysis that needs to be done to ensure conformance, must include an identification of the participating agencies roles and responsibilities. The roles of the project sponsor as well at that of other stakeholders should be clearly defined. The operational concept developed for the project (See Section 4.1.4) will identify these key relationships.

Additionally, where agreements (memorandum of understanding, formal agreement, etc.) are needed – these should be identified and described in the engineering analysis. For example, a traffic management center to traffic management center connection (market package called Regional Traffic Control) would likely involve sharing traffic information or system control capabilities between agencies. Limits of authority, operational discretion, and liability need to be defined for the owner agency as well as other participating agencies. In the case of a Transit Signal Priority, roles and responsibilities of the transit agency and the signal control operating agency need to be defined and will likely require a formal agreement.

Section 5 of the Regional ITS Architecture document\(^{17}\) provides a checklist of potential issues for consideration in the development of an agreement. These should be considered during a project’s planning and design stage and any agreements that are needed or have already been developed should be identified during the systems engineering analysis. Inter-agency agreements often result in certain system design requirements (e.g., firewalls may need to be included in a design for a system where information or control is shared; communications will need to be designed to support the sharing or information.). Therefore, to avoid the need for design changes down the road, it is important to highlight and resolve any relevant issues, and formalize these into an agreement, as early as possible in the project development process.

4.3 Requirements Definition

In a traditional systems engineering analysis, a project’s system requirements must be defined before project design and deployment takes place. The “Requirements Definition” is an activity that has been identified in the federal ITS requirements as being a necessary component of the systems engineering analysis.

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System requirements lead the way in design by providing a framework for the project – they include:

- **Functional Requirements** (What is to be accomplished by the project.)
- **Performance Requirements** (How the functions will be executed, i.e., how fast and how often.)
- **Technical Requirements** (What equipment, standards, mechanical, etc., are required for accomplishing the functions.)

Requirements should be developed for each major component of the project including center, field, vehicle, traveler, and communications hardware, software and equipment. The project ITS architecture (Section 4.1.5) can help with the development of requirements.

The National ITS Architecture provides some tools that should be used in developing the system requirements. The Physical Architecture can be used to address the issues surrounding where the required functions need to be performed. The Physical Architecture is based on subsystems and the information flows between them. The project ITS architecture diagram can capture these requirements. User Services and User Service Requirements from the Logical Architecture portion of the National ITS Architecture (see Section 2.4) can be used to define the functional requirements of a system. The National ITS Architecture also provides links to ITS technical standards that Architecture can be used in defining technical requirements. The National ITS Architecture website (http://www.iteris.com/itsarch/) provides an excellent means of accessing this information.

### 4.4 Analysis of Alternative System Configurations and Technology Options

Evaluation of different configurations and technology options is an essential activity in any systems engineering analysis. An analysis of alternative system configurations and technologies ensures that the system meets the desired objectives within the available budget and schedule, while maximizing the quality of the system. Depending on the nature of the project, potential system configuration and technology options will vary greatly, but the analysis should be commensurate with the scale of the project.

The alternative system configuration analysis should give an overview of each option and discuss design factors (both advantages and disadvantages) such as redundancy, expandability, cost, etc. for each. The analysis should document how each option would meet the requirements of the project.

A technology evaluation should also be performed. Often the technology of a system is dependant on the system configuration, so it may be prudent to have a recommended system configuration established prior to starting the technology evaluation. The technology evaluation should identify potential equipment options and for each option, the review should address the following factors:

- **Cost**: The equipment unit costs and quantities need to be examined.
- **Functionality**: Does the equipment meet the identified functional requirements? If no, can the system objectives still be met without the specific function(s)? Does the technology provide additional functions (not identified in the system requirements) that are beneficial now or in the future?
- **Schedule**: What is the lead time required for ordering equipment? Will selection of technology bring forward or delay the schedule?
• **Maintenance**: Does the technology typically require a significant level of effort or cost to maintain? Investigate other implementations of the technology and gather information on maintenance requirements? What is the typical life span of the technology?

• **Expandability and Adaptability**: Technology expandability needs to be reviewed. Does the technology provide additional capacity that can be used in the future? Can additional applications be added? Can the device handle additional interfaces/connections with other equipment?

• **Standards**: Does the selected technology conform to national ITS technical standards?

• **Security**: Security of devices, software and communications should be addressed (i.e., is it needed and what does the technology offer?).

### 4.5 Procurement Options

Many agencies currently procure ITS using existing procurement vehicles that were designed for traditional road and bridge design and construction. There are only rare examples of procurement processes designed specifically for ITS. Often, traditional procurement processes do not adapt well to ITS, which can require more flexibility to suit the uncertain and iterative nature of ITS.

For example, one of the most common contributory reasons for many ITS software development project failures is that they were procured using construction procurement methods. Construction procurements require low-bid (rather than qualifications-based) selections, have difficult change-order processes, and include liability and completion clauses that do not apply well to software development. These aspects of construction procurements, among others, resulted in the issuance of a US DOT memorandum to all FHWA Division Administrators noting that ITS software development should never be procured as a “low bid” (memorandum can be found at http://www.its.dot.gov/Technical/memo-a.htm).

Of course, there are many other types of ITS projects such as field device implementation, communications system implementation, and implementation of software that require little customization. The key difference among the various types of ITS procurements is the degree of uncertainty in the project outcome. The relationship between uncertainty and procurement is the focus of this discussion and the key to successful procurements.

Even without procurement processes designed specifically for ITS, existing procurement methods can be applied that better respond to the needs of ITS projects. This section describes why ITS projects can have uncertain outcomes, and the available procurement methods that can be used given various levels of uncertainty.

#### 4.5.1 ITS Projects – Certain or Uncertain Outcomes?

ITS is different from traditional road and bridge projects. The key differences relate to the following factors:

• **Maturity of the Technology**: Technologies for ITS are relatively new and rapidly changing. In contrast, roads and bridges have been constructed for millennia, with a long history of lessons learned. The technology that is thought to be implemented at the beginning of an ITS project may change by the end. The outcome is not certain.
A related factor is that ITS can be implemented quickly (and should be due to the rapid change in technology). Roads and bridges take decades from concept to implementation. Because the technology changes so little, road and bridge projects can withstand a long implementation cycle. Quick technology changes and short cycle times require responsive management processes, including procurement processes.

- **Design Criteria and Standards**: Because ITS is new and dynamic, there are few, if any, design or process criteria and standards to guide implementation. Contrast this to the dozens of manuals available for traditional transportation projects. This means that there are many more decisions required of the design team than are required for roads and bridges. Since there are so many options to choose from, the outcome is not certain. With many decisions required, and with each new decision affecting each subsequent decision, the management processes for ITS must be responsive to an incremental implementation approach.

- **Ability To Innovate**: Because the technology industry is constantly introducing new technologies, new software solutions and new concepts, ITS sparks our imaginations and spurs innovation. In the past decade, a large number of ITS projects were innovative. ITS projects commonly include new software, components that have never been integrated before, new communications methods and new institutional processes. Innovations, by their very nature, are uncertain. It is not possible to predict the final design requirements, the actual final software and hardware outcome, or the usefulness of the innovation in any institutional context. Innovative ITS projects require management processes that are adaptable and responsive to changes as the projects evolve.

These features of ITS projects are no different from technology projects implemented in other sectors of the economy. However, these features are drastically different from traditional public sector transportation projects. Sectors that focus on software, systems and technology implementations have specifically developed procurement processes in place. Ideally, the public transportation sector would also adopt new procurement processes for ITS. However, the law-making process introduces a major barrier to doing so.

Even without a specially designed procurement process for ITS, agencies can use existing procurement processes already available to them that can adapt to the needs of ITS. Most agencies are not aware of the range of procurement vehicles available to them, as they have not needed to use them. The following section outlines the basics of procurement methods at public transportation agencies across the United States.

4.5.2 Procurement Methods Available Under the US Code

The US Codes outline how traditional road and bridge projects must be procured. The following is a condensed and simplified description of the available methods. Key concepts in the law that is pertinent to ITS are:

- **Method of Award**: How the contractor is selected. There are three basic criteria: solely cost-based, solely qualifications based, and combinations of cost and qualifications. The method of award is tied to the US Codes for the various procurement types.

  The method of award used in the law matches the nature of the item being procured. When the items are fixed, clearly understood and easily defined, the method of award is based on cost. In
addition, when purchasing durable goods (which are readily defined) cost is often the sole criteria.

When the contrary is true, as for planning projects, or when the item being procured is not a durable good, such as intellectual property, or person-hours, then the method of selection is based on qualifications.

ITS projects are typically combinations of goods and services. If it is not possible or advisable to sever the goods from the services, then a combined qualifications and cost-based selection should be conducted.

• **Contract Type**: The method of payment including, fixed price, cost plus fixed fee, and cost reimbursement. Method of payment is not tied to the US Codes for the various procurement types. However, some state and local laws do tie the two together.

The contract type connects to the item being procured. If the item or outcome is easily defined - is “fixed” – then the contract type can be fixed price. If not, other methods should be considered. Cost plus fixed fee contracts are intended to provide an incentive to complete the work at a lower cost, as the fee will not change.

Often, ITS software and systems projects are procured as cost plus fixed fee with a cap. The cap is often an arbitrary budget number, because very uncertain projects cannot be estimated for cost at their outset. As the project design and implementation progresses, the cost becomes clearer. For projects with uncertain outcomes, capping the cost plus fixed fee amount may not be flexible enough because the cap creates a de facto fixed price contract. If the project is uncertain and the intent is to supply an incentive to complete under budget, the cap should be at the very upper limit of the possible final budget.

One way to manage uncertainty in ITS projects and budgets is to consider a **Task Order** structure. Task Orders are described, below.

• **Ability to Combine Goods and Services**: Generally, there are limits in the law on the amount of “hard” goods that can be purchased under services contracts and vice-versa.

Many ITS projects are combinations of goods and services. A central control system includes software development (services) and the computing and communications equipment (goods). The ability to combine goods and services is often a key to successful ITS deployments.

The procurement methods described in the US Code are defined below.

• **Engineering And Design Services**: This type of procurement is defined in the US Code as:

  "**Professional services of an architectural or engineering nature, as defined by State law..."**

  "**Such other professional services of an architectural or engineering nature, or incidental services...including studies, investigations, surveying, and mapping, tests, evaluations, consultations, plans and specifications, value engineering, construction phase services..."**

  o The method of award is qualifications-based.
  o The contract type (method of payment) is not restricted.
  o The amount of hard goods that can be procured is restricted to less than 10 percent of the contract value.
There are no licenses required for software and systems engineering. Therefore, Engineering and Design Services is not the required method for procuring ITS that relies primarily on those services. However, Engineering and Design Services is often an appropriate procurement method that.

- **Construction:** This type of procurement is defined in the US Code as:
  
  “…the supervising, inspecting, actual building, and all expenses incidental to the construction or reconstruction of a highway…”

  - The method of award is cost-based, and always must be low bid.
  - The contract type (method of payment) is not restricted in the US Code.
  - Combining services and construction is highly restricted. Only services directly related to the construction – and no design services – can be included.

Many ITS projects should not be defined as construction. Some ITS projects, those that share the certainty that road and bridge projects do, can be defined as construction. Today, most field device projects are successfully procured as construction projects. The exception is when an experimental device, communications, or other uncertainty is introduced. If this is the case, consider procuring the uncertain elements separately.

- **Common Rule:** The US Code allows agencies (other than the federal agencies) to procure projects that are not defined as construction (per the US Code) using their own laws and rules. In addition, if no federal Funds are included in the project, agencies can use their own procurement methods. Most agencies have adopted some form of the American Bar Associations Model Procurement Code. There are three common categories under that code:

  - Construction – Federal law constrains the definition of construction, so most agencies use the same definition as the US Code. State and local agency construction laws are often even more restrictive than the US Code requirements.
    - The method of award is cost-based, and always must be low bid.
    - The contract type (method of payment) is not restricted in the US Code, but is often restricted due to State and local laws.
    - Services outside of those directly related to the construction cannot be included.

  - Goods – Commodities such as paper and sand.
    - The method of award is cost-based, and always must be low bid.
    - The contract type (method of payment) is not restricted in the US Code, but is often restricted due to State and local laws.
    - No services other than warranties, minor installation, and other items directly related to provision of the goods can be included.

  - Services – Services are defined as procurements that are neither goods nor construction. Includes engineering, meeting planning, network management and others. Sometimes, State and local law further defines professional and non-professional services categories. Professional services are those that require a license in the particular jurisdiction and can
include engineering, barbers and therapists. Non-professional services are those that are not defined as professional services.

- The method of award for services can be either qualifications alone, or cost and qualifications, depending on local law. It is never cost alone.
- The contract type (method of payment) is not restricted in the US Code, but is often restricted due to State and local laws.
- The amount of goods that can be purchased under a services contract varies greatly from agency to agency. In general, there are usually no explicit legal restrictions if the goods are not considered part of construction or protected by labor and trade laws. Rather, the restrictions are policy-based.

There are a variety of procurement methods available. Procurement methods available under the Common Rule can be very flexible and appropriate for ITS. Most agency staff are surprised at what is allowed under law. A common trap is to assume that the current process is “law” or “policy” or somehow required and the only process available to you. Just because procurements have always been done a certain way does not mean that they always must be. Ask how your agency, or other departments within your agency, procures systems such as phones, computers, information technology services and other items comparable to ITS.

4.5.3 Additional Tools

For all types of procurements (except usually construction), two tools are available that can be very useful in helping manage dynamic, quick turn-around, uncertain ITS projects that require many decisions.

- **Indefinite Quantity Contracts**: Indefinite Quantity Contracts (IQC) are used to procure both goods and services. They help reduce the time from advertising to notice to proceed by pre-qualifying and signing contracts with one or many contractors to supply required goods or services with no guaranteed minimum. Because the process of advertising, awarding and contracting is completed, when a service or good is required, they can be procured expeditiously by simply defining the service or good and agreeing on the price.

- **Task Order Contracts**: Task Order Contracts are used when the project goal can be reasonably well defined, but the processes and methods used to accomplish the goal cannot be clearly defined up front.

For example, a project can be procured to implement a freeway management system on a specific portion of freeway, including central control software. The project can be divided into small tasks to help reduce uncertainty, and to better manage overall costs. For example, the first task might be to confirm the needs and the project vision, goals and objectives. The next might be a high-level ITS architecture and functional requirements. The following tasks could then be written to focus on various aspects of the system and requirements to further define them. Once requirements are well understood, tasks to write functional and testable modules of the system software could be written. The number of tasks depends on the scope and complexity of the work. Most ITS projects benefit from using a Task Order approach.
4.5.4 Applying Procurement Method Concepts

The key to selecting the appropriate procurement method for ITS is to match the method to the level of project uncertainty.

Key guidelines to remember is that ITS systems and software, and innovative ITS projects should not be procured as construction, and should not be low bid.

Always ask, “What are we buying? Is it tangible or intangible property?”

- Fixed Outcome = Fixed Price = Cost-Based Selection
- Uncertain Outcome = Flexible Costs = Qualifications-Based Selection

Many ITS projects are combinations of uncertain and fixed outcomes, and should either be divided into more than one procurement, or procured using combinations of qualifications and cost.

Applying the appropriate procurement process to an ITS project is no guarantee of success. ITS projects demand more time and attention than traditional road and bridge projects. Because there are many decisions that must be made, the agency must play an active part in the design and development process. Success in ITS requires change in how projects are managed and in the traditional contractor-client relationship.

4.6 Applicable ITS Standards and Testing Procedures

Technical standards facilitate deployment of interoperable systems at local, regional, and national levels without impeding innovation as technology advances and new approaches evolve. “ITS standards are specifications that define how transportation system components interconnect and interact within the overall framework of the National ITS Architecture. They specify how different technologies, products, and components interconnect and interoperate among the different systems so that information can be shared automatically.”

ITS standards contain and specify the technical details on how to build and integrate ITS systems and components consistently. The key point is that standards provide the spectrum of technical detail that enables the design and deployment of an integrated ITS system throughout the region. Standards allow different systems to speak to each other in a common language, using common data elements, well-defined data structures or ”messages”, and well-understood protocols or rules for data exchange and sharing. In addition, the use of standards in “stand-alone” projects will help promote interoperability among project components and any future connections to other systems.

Several working groups composed of public and private sector stakeholders within standards development organizations are developing ITS standards. The process is partially supported by the US Department of Transportation. There are seven standards development organizations actively participating in ITS standards development activities:

- AASHTO (American Association of State Highway and Transportation Officials)
- ANSI (American National Standards Institute)
- ASTM (American Society for Testing and Materials)
- IEEE (Institute of Electrical and Electronics Engineers)

US DOT maintains an up-to-date summary on the status of ITS standards on its website at [http://www.its-standards.net/](http://www.its-standards.net/). Also, Section 7 of Puget Sound Regional ITS Architecture\(^\text{19}\) provides a summary of market packages that are applicable to the region and the relevant standards associated with each. The Regional ITS Architecture further discusses the need for and use of the following standards:

- **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 suite of data interface standards for the transit industry.

To meet the federal ITS requirements, it is recommended that the market packages selected for the project be crosschecked with relevant standards. Applicable standards and protocols should be highlighted during the systems engineering analysis.

Testing Procedures and Documentation should be clearly described within the systems engineering analysis. Testing of all ITS components and communications equipment should be described and associated responsibilities of the project owner, consultants, and contractors identified. Testing will take account of equipment (tested at each site) and communications (field-to-center and center-to-center). Once individual system components are tested, system integration tests should be performed. Execution and supervision of final testing and acceptance of installed systems should take place. This activity will also include a description of start-up and operating requirements and all associated documentation.

### 4.7 Procedures and Resources Necessary for Operations and Management of the System

Critical aspects of ITS projects are the need to operate and manage the system once it is installed. The identification of the procedures and resources necessary for operations and management of the system is an important aspect of the project design. Elements to consider include the following:

1. Daily Operating Procedures
2. Operations Training
3. System Monitoring
4. Center Equipment Maintenance
5. Field Equipment Maintenance
6. Spare Equipment Stockpiles
7. Maintenance Activity Tracking
8. Equipment Maintenance Training
9. Maintenance Facilities and Related Tools
10. Data Management
11. Performance Requirements

12. Equipment Upgrades
13. Software Upgrades
14. Staffing Requirements
15. Development of Consensus for Operations That Will Impact Multiple Jurisdictions
16. Development and Approvals of Inter-Agency Agreements

For each of the above, an analysis should be performed to determine staffing and resource levels and budgets to ensure efficient and continuous operation of the system.
5. **Example: Deploying a Traffic Signal Control System**

This section provides an example of how a project sponsor can meet the federal ITS requirements. For this example, the deployment of a traffic signal control system was selected. The example does not include a full systems engineering analysis, but illustrates how the National and Regional ITS Architectures relate to the planning and design of a signal control system project.

5.1 **Overview of Illustrative Project**

The example selected for this exercise is the installation of a computerized central traffic signal control system. For the purpose of this example, the “City” has defined the following objectives shown in Table 5-1.

<table>
<thead>
<tr>
<th>Table 5-1: Objectives For Illustrative Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide ability to control traffic signals from a central location</td>
</tr>
<tr>
<td>2. Provide ability to monitor roadway conditions with sensors and cameras</td>
</tr>
<tr>
<td>3. Provide ability to implement transit signal priority (TSP)</td>
</tr>
<tr>
<td>4. Support traffic signal preemption for emergency vehicles</td>
</tr>
<tr>
<td>5. Provide ability to display messages on dynamic message signs</td>
</tr>
<tr>
<td>6. Provide ability to share information with neighboring city and state traffic management centers including video</td>
</tr>
<tr>
<td>7. Support ability to store data collected by the traffic signal system for future analysis</td>
</tr>
<tr>
<td>8. Support ability to provide traveler information on a website</td>
</tr>
</tbody>
</table>

Besides just providing traffic signal control, the illustrative project calls for the central system to control sensors, cameras, and dynamic message signs on the arterial roadway in the city. The deployment of TSP equipment adds an additional challenge and the need to work with the local transit agency. The objectives also include the desire to share information, including video, with neighboring jurisdictions. Finally, providing information gathered by the traffic control system to the Internet adds more requirements beyond just signal control.

5.2 **Fitting Into the Regional ITS Architecture**

One of the primary federal ITS requirements is to demonstrate how your project fits into the Puget Sound Regional ITS Architecture. The approach to demonstrating that a project fits into the Regional ITS Architecture contains the following steps:

1. Review market packages in the National and Regional ITS Architectures to determine which market packages will best meet the requirements of your project.

2. Review the Regional ITS Integration Strategy to determine how your project could be integrated into the overall regional deployment of ITS applications. This will help you identify other organizations and ITS applications to which your project may need a connection.

3. Determine which agencies, organizations and stakeholders beyond your own organization could be involved in the project.
4. Develop an operational concept for the project using the results of the market package review and identification of stakeholders to be included in the project. The operational concept defines the institutional relationships and the high-level information flows among the organizations required for the deployment and operation of the project.

5. Develop a project ITS architecture diagram that indicates subsystems (entities and stakeholders), equipment packages, and information exchanges using the National ITS Architecture market package definitions and diagrams as a basis. Sample ITS architecture diagrams are available as a starting point.

6. Identify any market packages, interface requirements, and information exchanges provided by the project that are not currently included in the Regional ITS Architecture.

7. Work with the Regional Council to update the Regional ITS Architecture, if required.

8. The results of this activity feed into the rest of the systems engineering analysis effort that would be performed during the design of the project.

5.2.1 Review Market Packages

The next step is to determine which market packages would be appropriate for inclusion in the illustrative project. Using the list of illustrative project objectives (Table 5-1) as a guide, market packages included in Puget Sound Regional ITS Architecture (Table 4-1) and the National ITS Architecture should be matched against these objectives. The resulting list of applicable market packages for this example project with a definition of the selected market package is found in Table 5-2.

Table 5-2: Illustrative Review of Market Packages for a Signal Control System

<table>
<thead>
<tr>
<th>ILLUSTRATIVE PROJECT OBJECTIVES</th>
<th>MARKET PACKAGE NAME</th>
<th>DEFINITION FROM NATIONAL ITS ARCHITECTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide ability to control traffic signals from a central location</td>
<td>Surface Street Control</td>
<td>This market package provides the central control and monitoring equipment, communication links, and the signal control equipment that support local surface street control and/or arterial traffic management.</td>
</tr>
<tr>
<td>Provide ability to monitor roadway conditions with sensors and cameras</td>
<td>Network Surveillance</td>
<td>This market package includes traffic detectors, other surveillance equipment, the supporting field equipment, and wire line communications to transmit the collected data back to the Traffic Management Subsystem.</td>
</tr>
<tr>
<td>Provide ability to implement transit signal priority</td>
<td>Multi-Modal Coordination</td>
<td>This market package establishes two-way communications between multiple transit and traffic agencies to improve service coordination. More limited local coordination between the transit vehicle and the individual intersection for signal priority is also supported by this package.</td>
</tr>
<tr>
<td>Support traffic signal preemption for emergency vehicles</td>
<td>Emergency Routing</td>
<td>This market package supports dynamic routing of emergency vehicles and coordination with the Traffic Management Subsystem for special priority on the selected route(s). The Emergency Vehicle would also optionally be equipped with dedicated short-range communications for local signal preemption.</td>
</tr>
<tr>
<td>ILLUSTRATIVE PROJECT OBJECTIVES</td>
<td>MARKET PACKAGE NAME</td>
<td>DEFINITION FROM NATIONAL ITS ARCHITECTURE</td>
</tr>
<tr>
<td>---------------------------------</td>
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<td>------------------------------------------</td>
</tr>
<tr>
<td>Provide ability to display messages on dynamic message signs</td>
<td>Traffic Information Dissemination</td>
<td>This market package allows traffic information to be disseminated to drivers and vehicles using roadway equipment such as dynamic message signs or highway advisory radio.</td>
</tr>
<tr>
<td>Provide ability to share information with neighboring city and state traffic management centers including video.</td>
<td>Regional Traffic Control</td>
<td>This market package advances the Surface Street Control and Freeway Control Market Packages by adding the communications links and integrated control strategies that enable integrated Inter-jurisdictional traffic control. This market package provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy.</td>
</tr>
<tr>
<td>Support ability to store data collected by the traffic signal system for future analysis.</td>
<td>ITS Data Mart</td>
<td>This market package provides a focused archive that houses data collected and owned by a single agency, district, private sector provider, research institution, or other organization. This focused archive typically includes data covering a single transportation mode and one jurisdiction that is collected from an operational data store and archived for future use.</td>
</tr>
<tr>
<td>Support ability to provide traveler information on a website</td>
<td>Broadcast Traveler Information</td>
<td>This market package provides the user with a basic set of ATIS services; its objective is early acceptance. It involves the collection of traffic conditions, advisories, general public transportation, toll and parking information, incident information, air quality and weather information, and the near real time dissemination of this information over a wide area through existing infrastructures and low cost user equipment (e.g., FM subcarrier, cellular data broadcast).</td>
</tr>
<tr>
<td>Support ability to provide traveler information on a website</td>
<td>Interactive Traveler Information</td>
<td>This market package provides tailored information in response to a traveler request. Both real-time interactive request/response systems and information systems that &quot;push&quot; a tailored stream of information to the traveler based on a submitted profile are supported. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route to include phone, kiosk, Personal Digital Assistant, personal computer, and a variety of in-vehicle devices.</td>
</tr>
</tbody>
</table>

As Table 5-2 indicates, the traffic signal system control project can become more complex when the requirements include sharing information with other jurisdictions, agencies, and the general public. It also indicates how the Regional and National ITS Architectures can be of assistance in defining the project.
5.2.2 Review the Regional ITS Integration Strategy

The next activity is to review the regional ITS integration strategy to determine how the project could fit into the overall vision of deploying an integrated system throughout the region. Critical to the deployment of an integrated regional ITS system is the specification and development of electronic interfaces for the full exchange of system status information and control data. These interfaces enable the regional sharing of data and information for the purposes of transportation network status and for the future sharing of ITS devices among the transportation management systems operated by local, county, state, and transit organizations. In this case, the choice of an ITS standards-based signal control system using the National Transportation Communications for ITS Protocol (NTCIP) center-to-center protocol for the exchange of information with other traffic and transit management centers would be attractive. However, an agreement with other agencies on the use of the technical standard would be required. Additional information on this topic is found in Section 3 of the Puget Sound Regional ITS Integration Strategy report.\(^{20}\)

5.2.3 Determine Stakeholders

The review of the market packages and illustrative project objectives indicate the need for agreements and information exchanges between the City Traffic Management group and the following organizations:

- **Transit Management Organization**: implementation of transit signal priority.
- **Other City Traffic Management Organization**: sharing of information and video images.
- **State Traffic Management Organization**: sharing of information and video images.
- **Emergency Management Organization**: implementation of emergency signal preemption.

5.2.4 Develop an Operational Concept

The operational concept defines the relationships among the organizations required for the deployment and operation of the project. Relationships between agencies embody two main components: 1) the agency-to-agency relationship defines what roles and responsibilities each agency has, and 2) the kinds of information exchanges that occur between each agency. Based on the project objectives, identified market packages, other subsystems (vehicles and roadway), and stakeholders, Table 5-3 was developed to define both types of interactions between stakeholders and other subsystems. A graphic of the matrix is also provided in Figure 5-1.

To illustrate, Table 5-3: Illustrative Operational Concept Matrix for a Signal Control System shows:

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
<th>RELATIONSHIP</th>
<th>INFORMATION</th>
<th>COMMENTS</th>
</tr>
</thead>
</table>
| City Traffic Management Center | Roadway | Operations Maintenance | Command Request | • Signal Control  
• Link to Sensors and Cameras |

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
<th>RELATIONSHIP</th>
<th>INFORMATION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway</td>
<td>City Traffic Management Center</td>
<td>Information Sharing</td>
<td>Data Status Video</td>
<td>• Link from Field Equipment</td>
</tr>
<tr>
<td>City Traffic Management Center</td>
<td>Transit Management Center</td>
<td>Information Sharing</td>
<td>Data Request Status</td>
<td>• Share Information for Transit Signal Priority (TSP)</td>
</tr>
<tr>
<td>Transit Management Center</td>
<td>City Traffic Management Center</td>
<td>Information Sharing</td>
<td>Data Request Status</td>
<td>• Share Information for Transit Signal Priority (TSP)</td>
</tr>
<tr>
<td>Transit Management Center</td>
<td>Roadway</td>
<td>Information Sharing</td>
<td>Data Request Status</td>
<td>• Provide Information to Signal Control to Enable TSP</td>
</tr>
<tr>
<td>Roadway</td>
<td>Transit Management Center</td>
<td>Information Sharing</td>
<td>Data Status</td>
<td>• Provide Information on TSP operations</td>
</tr>
<tr>
<td>Transit Vehicle</td>
<td>Roadway</td>
<td>Information Sharing</td>
<td>Request</td>
<td>• Request for Priority by Transit Vehicle</td>
</tr>
<tr>
<td>Emergency Vehicle</td>
<td>Roadway</td>
<td>Information Sharing</td>
<td>Command</td>
<td>• Command for Preemption for Emergency Vehicle</td>
</tr>
<tr>
<td>City Traffic Management Center</td>
<td>Other Agency Traffic Management Center</td>
<td>Information Sharing</td>
<td>Data Request Status Video</td>
<td>• Exchange of Information and Video</td>
</tr>
<tr>
<td>Other Agency Traffic Management Center</td>
<td>City Traffic Management Center</td>
<td>Information Sharing</td>
<td>Data Request Status Video</td>
<td>• Exchange of Information and Video</td>
</tr>
<tr>
<td>City Traffic Management Center</td>
<td>Personal Information Access (website)</td>
<td>Information Sharing</td>
<td>Data</td>
<td>• Send information and images to website</td>
</tr>
<tr>
<td>Personal Information Access (website)</td>
<td>City Traffic Management Center</td>
<td>Information Sharing</td>
<td>Data Request Status</td>
<td>• Request information</td>
</tr>
</tbody>
</table>
Figure 5-1: Illustrative Operational Concept For Traffic Signal Control System
5.2.5 Develop a Project ITS Architecture

Based upon the market package review and operational concept, the project ITS Architecture diagram can be assembled. The diagram should include each of the jurisdictions identified in the operational concept, the subsystems identified in the market package review, any relevant equipment packages and the detailed information (architecture) flows required to meet the project objectives. The individual market package diagrams found in the National ITS Architecture provide the information on the relevant equipment packages and architecture flows. Only the equipment packages and architecture flows to be supported by the project should be included.

The project ITS architecture diagram for the illustrative traffic signal control system project is provided in Figure 5-2. To the center of the diagram is the City Traffic Management Center (TMC). The primary information flows are between City TMC and the Roadway for the control of field equipment. The City TMC also shares traffic information and video with other TMCs (left and upper corner) and enables the sharing of information for transit signal priority with the Transit Management Center. In this diagram, the Transit Management Center has a direct link to the Roadway to provide information to traffic signal controllers to enable TSP. This architecture reflects the approach to TSP implementation being used by King County Metro where TSP interface units are installed in the traffic signal cabinets and a direct link from the transit management center to the roadside equipment is provided. Both transit and emergency vehicles have the ability to request priority from the traffic signal controllers in this diagram. Finally, the City TMC provides information to travelers via the Personal Information Access subsystem. In this case, the information is provided via a website.
Figure 5-2: Illustrative Project ITS Architecture Diagram For Traffic Signal Control System

- **State Traffic Management Center**
  - TMC Regional Traffic Control

- **Other City Traffic Management Center**
  - TMC Regional Traffic Control

- **Personal Information Access**
  - Personal Basic Information Reception
  - Personal Interactive Information Reception

- **City Traffic Management Center**
  - TMC Signal Control
  - TMC Multi-modal Coordination
  - Collect Traffic Surveillance
  - Traffic Maintenance
  - TMC Traffic Info Dissemination
  - TMC Regional Traffic Control
  - Traffic Data Collection
  - ITS Data Repository
  - Basic Information Broadcast
  - Interactive Infrastructure Information

- **Transit Management Center**
  - Transit Center Multi-modal Coordination
  - Traffic Control Priority Request
  - Signal Control Data
  - Traffic System Data

- **Roadway**
  - Roadway Signal Controls
  - Roadside Signal Priority
  - Roadway Basic Surveillance
  - Roadway Traffic Info Dissemination

- **Transit Vehicle**
  - Emergency Vehicle

- **Legend**
  - Subsystem
  - Equipment Package
  - Architecture flow

- Communications:
  - Traffic information for transit
  - Traffic control priority status
  - Sensor and surveillance control
  - Roadway information system data
  - Signal control data
  - Broadcast information
  - Traveller information
  - Traveller request
  - Local signal priority request
  - Local signal preemption request (command)
5.2.6 Does the Project Fit Into the Regional ITS Architecture?

Because the illustrative project only selected market packages already included in the Regional ITS Architecture and supports the Regional ITS Integration Strategy, it clearly fits into the Puget Sound Regional ITS Architecture. At this point, the project sponsor would have addressed all the requirements for demonstrating compliance at the planning level check point in the transportation improvement plan review process.

5.3 Systems Engineering Analysis Considerations

As the project enters the design phase, the systems engineering analysis would be completed as an expected project design activity, but also in response to the federal ITS requirements. The remaining six elements required for the systems engineering analysis would be typically performed as part of a new signal control system design effort or any other transportation technology project. Some key points for selected elements are discussed below.

The high-level roles and responsibilities of participating agencies are defined by the operational concept. Once the design phase begins, the project sponsor should work to detail and formalize these understandings. For this illustrative project, issues to resolve could include:

- Access protocols to camera and traffic information.
- Selection of technical standards for the exchange of camera images and traffic information.
- Selection of TSP control strategy.
- Maintenance responsibilities for roadside TSP equipment.

System requirements lead the way in design by providing a functional, performance, and technical description of the project. The project ITS architecture provides a convenient starting point for this analysis effort. For traffic signal system projects, peers at other local agencies that have recently deployed newer systems are another source of information.

The definition of system requirements will allow a trade-off analysis to be conducted for alternative system configurations and technology options. The requirements provide the evaluation criteria for comparing each option. In selecting new signal systems, future maintenance requirements should be specifically considered.

Standards Development Organizations with support from US DOT are rapidly moving toward the development of national ITS technical standards. At this time, US DOT has not formally adopted through the federal rulemaking process any ITS technical standard that is required for deployment. However, each project sponsor should give serious consideration to requiring these standards to ensure future interoperability and ease of integration with other systems in the region. For a signal system, the key standards of interest are the NTCIP center-to-center and center-to-field protocols. The selection to use NTCIP standards will have a significant impact on the definition of system requirements. Additional information on these standards is found in Section 7 of the Regional ITS Architecture document and on the US DOT ITS Standards website (http://www.its-standards.net/).

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