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1050.01 General

Intelligent Transportation Systems (ITS) apply advanced technologies in communications and computer science to optimize the safety and efficiency of the existing surface transportation network. In Washington State Department of Transportation (WSDOT) highway design, this goal is achieved by collecting and using traffic data to develop predictive models, regulating access to the freeway system, and providing timely information on traffic conditions to motorists. Previously, this technology was called Surveillance, Control, and Driver Information (SC&DI). In the context of highway design, ITS and SC&DI are synonymous.

The Transportation Equity Act (TEA-21) requires ITS projects to comply with the standards being developed in association with the federal government and private industry. They will be known as the National ITS Architecture. These standards are intended to ensure interoperability and efficiency to the maximum extent practicable for the many different types of ITS devices under development. The National ITS Architecture organizes a “system of subsystems” and makes managing ITS deployment easier. The Architecture helps agencies communicate complex ideas by providing a common language and definitions. One benefit of using the National ITS Architecture is that it helps identify all agencies and jurisdictions that should be included in ITS projects.

The ITS program in Washington State is known as “Venture Washington.” It focuses on the following five areas within Washington State. These areas were chosen because they each have unique characteristics and problems associated with traffic.

- Greater Puget Sound Region
- Spokane Area
- Vancouver Area
- Other Statewide Urban Areas
- Rural Areas and Intercity Corridors

An intelligent transportation system can be implemented in stages, starting with a small project for immediate benefit and then expanding the system as needed. Consider installing an ITS at any of the following locations:

- Where congestion frequently causes accidents.
- At freeway on-ramps where merging problems routinely occur.
- Where heavy traffic volumes occur between closely spaced on-ramps.
- Where the motorist would benefit from information on traffic conditions or alternative routes.

The initial stage of an intelligent transportation system can be as simple as installing a dynamic message sign that warns motorists of unusual driving conditions. Appropriate messages can be displayed on the sign using information obtained by direct observation of road conditions or by reports from law enforcement agencies.

Automated systems incorporate a traffic data collection system. The data collection system provides basic data to determine traffic volumes, vehicular speeds, and levels of congestion. The traffic data can be analyzed and used to verify the locations of traffic problems. This data can also be used in freeway computer models to predict the impacts of proposed improvements.

Design each stage of the system so that the associated technology can be used in subsequent, more sophisticated stages. For example, the stage following data collection could be the installation of closed-circuit television cameras (CCTV) to monitor freeway locations where congestion is commonplace. The CCTV monitoring is used to detect or confirm incidents noted by other forms of data collection. The installation of motorist information devices such as dynamic message signs or highway advisory radio provides a means of transmitting this information to the motorist. Eventually, as traffic congestion increases, ramp meters are installed to control the traffic flow entering the facility.

When planning a staged system, attempt to determine the ultimate communication system to the degree that underground conduit size and quantity are known and can be installed in the initial construction. Consider long-term maintenance issues and component standardization.

The Northwest Region Traffic Systems Management Center (TSMC) is an example of a traffic operations center (TOC). Because a TOC usually works best with existing radio communication, it is located adjacent to or as part of a radio communication office. In addition to the location of a TOC, consider the work force and equipment costs required to operate and maintain the entire system. The size of a TOC is dependent on the complexity of the system and can vary from a single person at a desk to a large room with advanced equipment requiring continuous staffing.

1050.02 References

23 Code of Federal Regulations (CFR), Part 940

Application of Advanced Transportation Technology Within Washington State: Discussion and Policy Recommendations, Advanced Technology Branch, WSDOT

Building Quality Intelligent Transportation Systems Through Systems Engineering, USDOT, FHWA-OP-02-046, April 2002:

www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13620.html

I-5 Seattle to Vancouver, BC, ITS Corridor Study, Advanced Technology Branch, WSDOT

I-90 Seattle to Spokane, ITS Corridor Study, Advanced Technology Branch, WSDOT

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, FHWA; as adopted and modified by Chapter 468-95 WAC “Manual on uniform traffic control devices for streets and highways” (MUTCD)

Portland/Vancouver to Boise, ITS Corridor Study Plan, Advanced Technology Branch, WSDOT

SC&DI Design Guide, WSDOT Northwest Region

SC&DI Operations Guide, WSDOT Northwest Region

Seattle to Portland Inter-City ITS Corridor Study and Communications Plan,
Advanced Technology Branch, WSDOT

State-Wide Communications Strategic Plan, Advanced Technology Branch, WSDOT
Transportation Equity Act (TEA-21) of 1998

Venture Washington, Advanced Technology Branch, WSDOT

1050.03 Traffic Data Collection

Loop detectors (loops), which are placed in traffic lanes, are the most common devices used to collect traffic data. In general, data stations are spaced at ½-mile intervals between interchanges. Alternative methods of detection include video detection cameras, microwave detectors, and other newer technologies. This information can be augmented with cellular phone calls from motorists, Washington State Patrol (WSP) reports, and commercial traffic reporters.

The loops sense the amount of time a vehicle is over them. This is called *occupancy* and is recorded by a data station in a nearby roadside cabinet. The data station periodically transmits the data to a central computer. The information from the detection system is transmitted over leased phone lines, WSDOT phone lines, fiber optic lines, microwave transmitters, or a spread spectrum radio to a traffic operations center. The central computer translates these data into an indication of traffic congestion for incident detection and traffic flow information.

A single loop provides traffic volumes and lane occupancy from which, given some basic assumptions, speeds can be computed. Two loops spaced a known distance apart, longitudinally, provide better determinations of traffic speeds.

Closed-circuit television (CCTV) is used by the department to manage the freeway system. It is not normally used as a traffic law enforcement tool. The primary function of CCTV is to confirm or detect incidents. As a secondary function, this information can be provided to the WSP, incident response teams, maintenance forces, and the local media.

1050.04 Traffic Flow Control

During peak traffic volume periods, freeway on-ramps are metered with either roadside or overhead traffic signals. These ramp meters control or regulate the flow of traffic entering the freeway. The metering prevents the entering traffic from exceeding freeway capacity by limiting the number of vehicles that enter within a specific time period. The meters also keep long platoons of cars from merging onto the freeway. This process makes on-ramp merges safer and allows freeway traffic to move at a more efficient speed.

Ramp meters are traffic control signals and an approved traffic signal permit is required. The approval procedures for traffic signal permits are noted in Chapter 1330.

(1) Alternate Storage Methods

Consider the available area for vehicle storage on the ramp when locating a ramp meter. If the arrival rate of the entering traffic exceeds the metered flow rate, traffic queues will develop. A common concern is that this queue might extend onto the crossroads and interfere with local traffic. Chapter 1410 provides guidance on the placement of the ramp meter. This guidance, however, only addresses the required acceleration needed to merge onto the freeway. The storage area needed at the meter varies at each location and is determined separately. If it is not possible to provide an adequate storage length on the ramp, consider the following alternate methods of addressing the problem:

- Adjust the ramp metering rate to temporarily increase the rate.
- Allow two vehicles to pass the meter at a time.
- Widen to two metered lanes.
- Provide storage lanes on the crossroad.
- Provide alternate routes for local traffic.
- Provide HOV bypass lanes.

(a) Adjust the Rate

Ramp metering uses information from the detection loops to determine freeway congestion adjacent to and downstream from the ramps. Data from the loops are sent to a central computer or a local computer that adjusts the metering rate for the traffic congestion and transmits this rate to the ramp meter controllers. The ramp controllers implement the metering rate and control the signal. A ramp metering rate can be determined in two ways: remote metering and standby metering.

For remote metering, the metering rates of all ramp meter locations are determined by the local controller and adjusted by the central computer at the TOC. This is the normal mode of operation for the Seattle system. The central computer is capable of adjusting upstream metering rates on the basis of downstream conditions. A metering rate at an upstream location is decreased if traffic congestion develops downstream. Metering start and end times, as well as metering rates, can be remotely adjusted from the TOC with an override function.

Standby metering, also called local control, is used when communications with the central computer are interrupted or when that computer is not in service. In these cases, each ramp meter determines a metering rate for its on-ramp according to local traffic conditions or by a predetermined rate based on a time of day table. These time of day tables are developed to predict averages of the actual traffic volume peaking characteristics of the on-ramp. In standby metering, each ramp meter operates independently without coordinating with other controllers.

Single-lane metering rates normally vary between 4 and 15 vehicles per minute (240 and 900 vehicles per hour). If a ramp has heavier traffic volumes and queue storage is not adequate, several of the alternate methods can be considered.

(b) Allow Two Vehicles

The metering capacity can be increased by allowing two vehicles to enter during each green cycle. This can increase a single-lane ramp meter maximum capacity to about 1100 vehicles per hour. This procedure is a temporary, operational solution and is not a recommended design practice.

(c) Widen the Ramp

The metering capacity can be increased by widening the ramp to install additional lanes. Widening a single-lane on-ramp to create two lanes can double the metered traffic volume to 1800 vehicles per hour, provided no downstream traffic congestion develops. Changes in ramp access to the freeway might require an interchange justification report (see Chapter 550).

(d) Use Storage as Turn Lanes

If adequate storage length cannot be provided on the ramp, it might be possible to provide storage as turn lanes on the crossroad and adjust the ramp terminal traffic signal timing to limit freeway access movements.

(e) Divert Ramp Traffic

Diversion of some ramp traffic to local arterial streets might be desirable, assuming a suitable alternate route is available. When diversion occurs, modification of traffic signal timing and coordination plans on the alternative routes might be necessary. Coordinate efforts with the local agency and, if appropriate, initiate public meetings to identify needs and impacts.

(f) Provide HOV Bypass Lanes

Wherever possible, provide bypass lanes for high-occupancy vehicles (HOV) around the traffic queue at the ramp meter. The HOV bypass allows transit vehicles to maintain schedules and indirectly provides an incentive for carpooling (see Chapter 1410).

1050.05 Motorist Information

Motorist information includes dynamic message signs, highway advisory radio, telephone traffic information lines, commercial radio and television messages, and Internet access for personal computers. These are all used to transmit traffic conditions to freeway users. The motorist information system is also used to alert drivers to short-term construction and maintenance activities that might affect normal travel patterns. It can also be used to suggest alternative travel routes.

(1) Dynamic Message Signs

Dynamic message signs (DMS) are used to provide motorists with current road and traffic conditions. Accidents, incidents, construction and maintenance activities, reversible lane status, traffic congestion, and traction device requirements are examples of this information. Because motorists receive many distractions while driving, consider the location of the DMS. The best location for a DMS is on a tangent section of roadway with few roadside distractions. Overhead installations have more visual impact. When possible, use sign bridges, cantilever sign structures, or bridge mounts on existing overcrossings for DMS. Use the message displays and sign location requirements contained in the *Manual on Uniform Traffic Control Devices* and Chapter 1020.

(2) Highway Advisory Radio

The highway advisory radio (HAR) system uses car radios to provide information to motorists. Warning signs, usually with flashing beacons, direct motorists to select a specific AM radio station for information. HAR has an advantage over DMS because longer messages with more detailed information can be relayed to the motorist. The major disadvantages are that not all vehicles have radios that can receive HAR frequencies, and some motorists might not use the radio for this information. HAR works best when used in conjunction with DMS.

HAR locations and assigned radio frequencies are restricted to prevent interference with other frequencies in use. HAR message content is restricted by federal regulations, and WSDOT restricts HAR messages to noncommercial voice information pertaining to roadway and mountain pass conditions, major traffic incidents, and travel advisories.

(3) Additional Public Information Components

A telephone number can be provided to give the same prerecorded messages as the HAR and can also include transit and carpool information. A computer-generated flow map can be developed, using the data collection system, to graphically depict actual traffic flows within a geographical area. The flow map can be made accessible to the public by providing links to a WSDOT website.

1050.06 Systems Engineering

Conduct a systems engineering analysis on a scale commensurate with the project scope. As a minimum, include the following in the systems engineering process:

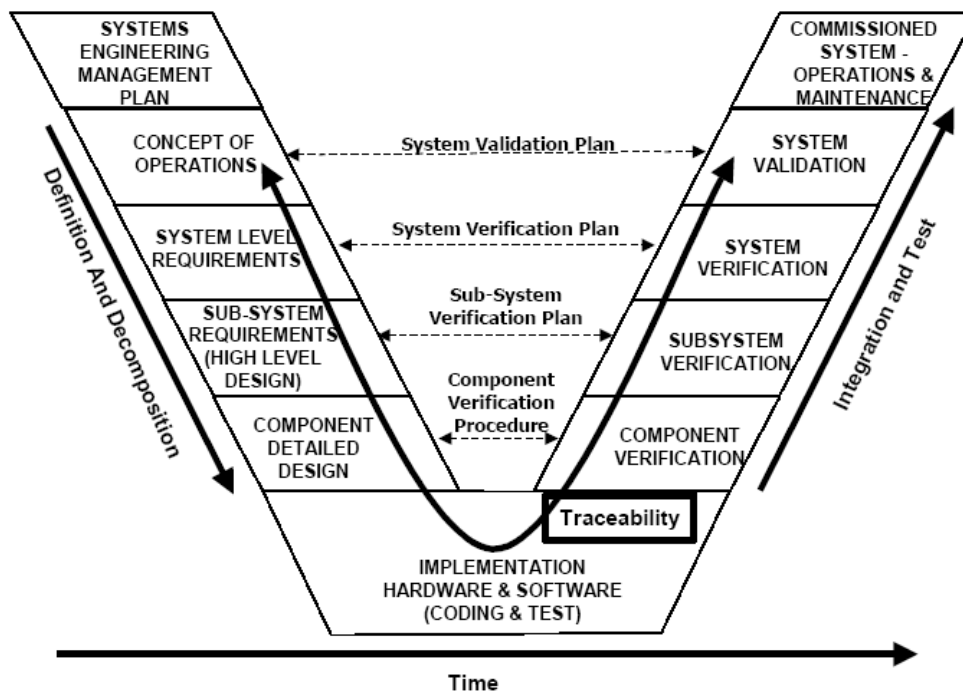
- Identify portions of the regional ITS architecture being implemented. Refer to the ITS architecture or regional planning document.
- Identify the roles and responsibilities of participating agencies.
- Define requirements.
- Provide an analysis of alternative system configurations and technology options to meet requirements.
- Identify procurement options.
- Identify applicable ITS standards and testing procedures.
- Delineate procedures and resources necessary for operations and management of the system.

For additional information, refer to USDOT's *Building Quality Intelligent Transportation Systems Through Systems Engineering*:

www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13620.html

Systems engineering is a structured process for arriving at a final design of a system. The “V” diagram in Exhibit 1050-1 provides a pictorial description of systems engineering.

An ITS project begins in the upper left side of the “V” diagram and progresses down the “V” and up the right side. Upon reaching the upper right corner, reverse the process to ensure a project is being completed that meets the initial requirements.



Systems Engineering “V” Diagram
Exhibit 1050-1

During the “Component Level Design,” specific subsystems and/or components (such as wireless communications, VMS, ESS, cameras, or software) should be identified as requiring specialized knowledge and skills. These issues should be coordinated between the Project Engineer and the region Traffic Engineer.

Construction oversight and approvals are taken care of in the systems engineering process as you validate/verify the right side of the “V” diagram with the left side. The key to successful construction oversight is traceability. Trace each step on the right side of the “V” diagram back to a requirement on the left side.

Systems engineering costs are to be estimated and incorporated in the construction engineering (CE) and project engineering (PE) portions of the construction estimate. It is estimated that the total cost to conduct systems engineering is 15% of the ITS construction estimate.

1050.07 Documentation

The entire systems engineering process is to be documented in the Project File. If the project is a stand-alone ITS project, the systems engineering documentation is to be filed with the ITS Design File. If the ITS project is part of a larger project, the systems engineering documentation is to be filed with the Design Documentation Package for the project: www.wsdot.wa.gov/design/projectdev/

Completion of the “ITS Project Systems Engineering Review Form,” Exhibit 1050-2a, meets the FHWA requirement for systems engineering documentation. Exhibit 1050-2b provides instructions for completing the form.

Systems engineering documentation is to be approved by the region Traffic Engineer or authorized representative. Completion of each phase of the systems engineering is to be reported to the region Traffic Engineer.

This form, or a reasonable facsimile, must be completed for all ITS projects.

It is to be submitted to FHWA with the construction authorization request for all federal oversight projects that include ITS. Otherwise, it is to become part of the project record and maintained by the project sponsor.

Name of Project:

Regional ITS Architecture:

1. **Identify the portions of the Regional ITS Architecture being implemented:
Is the project consistent with the architecture? Are revisions to the architecture required?**

2. **Identify the participating agencies and their roles and responsibilities:**

3. **Definition of Requirements:**

4. **Analysis of alternative system configurations and technology options to meet requirements:**

5. **Procurement options:**

6. **Identification of applicable ITS standards and testing procedures:**

7. **Procedures and resources necessary for operations and management of the system:**

ITS Project Systems Engineering Review Form
Exhibit 1050-2a

1. Identify the portions of the Regional ITS Architecture being implemented:

Identify which user services; physical subsystems, information flows, and market packages are being completed as part of the project and how these pieces are part of the regional architecture.

2. Identify the participating agencies, their roles and responsibilities, and concept of operations:

For the user services to be implemented, define the high-level operations of the system, including where the system will be used, functions of the system capabilities, performance parameters, the life cycle of the system, and who will operate and maintain the system. Establish requirements or agreements on information sharing and traffic device control responsibilities. The regional architecture operational concept is a good starting point for discussion.

3. Requirements definitions:

Based on the above concept of operations, define the “what” and not the “how” of the system. During early stages of the systems engineering process, they will be broken down into detailed requirements for eventual detailed design. The applicable high-level functional requirements from the regional architecture are a good starting point for discussion. A review of the requirements by the project stakeholders is recommended.

4. Analysis of alternative system configurations and technology options to meet requirements:

The analysis of system alternatives should outline the strengths and weaknesses, technical feasibility, institutional compatibility, and life cycle costs of each alternative. The project stakeholders should have input in choosing the preferred solution.

5. Procurement options:

Some procurement (contracting) options to consider include: consultant design/low bid contractor, systems manager, systems integrator, task order, and design/build. The decision regarding the best procurement option should consider the level of agency participation, compatibility with existing procurement methods, role of system integrator, and life cycle costs.

There are different procurement methods for different types of projects. If the project significantly meets the definition of construction, then construction by low-bid contract would be used. If the project significantly meets the definition of software development/hardware acquisition, in other words an information technology project, then follow the acquisition processes outlined in the WSDOT *Purchasing Manual*. This option includes services for systems integration, systems management, and design.

Contact the WSDOT HQ Traffic Operations Division for additional guidance and procurement options.

6. Identification of applicable ITS standards and testing procedures:

Include documentation on which standards will be incorporated into the system design and justification for any applicable standards not incorporated. The standards report from the regional architecture is a good starting point for discussion.

7. Procedures and resources necessary for operations and management of the system:

In addition to the above concept of operations, document any internal policies or procedures necessary to recognize and incorporate the new system into the current operations and decision-making processes. Resources necessary to support continued operations, including staffing and training must also be recognized early and be provided for. Such resources must also be provided to support necessary maintenance and upkeep to ensure continued system viability.

ITS Project Systems Engineering Review Form Instructions
Exhibit 1050-2b