

ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)



Planning Guidance for Intelligent Transportation Systems (ITS) Devices

FINAL REPORT
VERSION 3.1

Prepared by



September 2015

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1. Executive Summary

The [ENTERPRISE Pooled Fund Study](#) developed initial planning guidance for a set of Intelligent Transportation Systems (ITS) devices, beginning in 2009. The intent of the planning guidance is to assist agencies in the decision process of deploying technology devices as well as to validate the location of deployed devices. The devices included in the initial guidance included:

- Closed Circuit Television (CCTV);
- Dynamic Message Signs (DMS);
- Highway Advisory Radio (HAR); and
- Road Weather Information Systems (RWIS).

In 2010, the planning guidance was expanded to include the following technology devices:

- Variable Speed Limit (VSL) Signs;
- Dynamic Speed Display Signs (DSDS);
- Curve Warning Systems;
- Ramp Meters; and
- Intelligent Work Zones.

ENTERPRISE has continued to identify planning guidance for additional ITS devices, and in 2013 developed planning guidance for:

- Intersection Conflict Warning Systems (ICWS)

Transportation professionals at the state/province, county, and city levels face challenges on how to handle increasing requests for the deployment of technology devices. The overall approach to the ITS planning guidance process is modeled after the [Manual on Uniform Traffic Control Devices \(MUTCD\) warrants for traffic signal installations](#). Based on this model, the ITS planning guidelines identify criterion to assist deployment decisions of technology devices.

During the initial planning guidance effort, more than 20 transportation professionals participated in testing the guidelines and some of these agencies are continuing to actively use the guidelines as part of the decision-making process for selecting device locations.

In addition to documenting guidance for these ITS devices, ENTERPRISE has continued to test and refine the guidelines as well as exploring the industry acceptance for this concept. Ideally, the ENTERPRISE Program hopes that a National or International agency will embrace the concept of technology device guidelines and carry the concept forward in order to support the ITS planning process for years to come. In July 2013, ENTERPRISE completed a project "[Supporting the Transition of ENTERPRISE ITS Planning Guidance \(Warrants\) to a Permanent Home](#)". The objective of the project was to document activities ENTERPRISE has conducted as the initial owner and maintainer of the planning guidelines to assist in identifying potential organizations that could serve as permanent owners of the guidelines.

As ENTERPRISE documented the details of each task that was involved with owning the planning guidelines, a number of options were suggested as potential organizations to transition the ownership and maintenance of the guidelines. However, after the ENTERPRISE Board reviewed the different options for one organization to maintain the planning guidelines, it was agreed that ENTERPRISE should continue to own and maintain the guidelines and partner with organizations to review the guidelines most

appropriate to their organization(s). This approach was based on the understanding that it would be easier to find agencies willing to review and comment on one or more guidelines periodically than it would be to find an organization willing to accept the entire workload of all the guidelines. Given this, ENTERPRISE developed a review process to assist with review and modifications of the guidelines.

In June 2013, the ENTERPRISE ITS planning guidelines were presented to the AASHTO Subcommittee on Traffic Engineering (SCOTE) as a first step in working with an organization to review the guidelines. SCOTE approved a resolution to participate in the review of the guidelines. The approval indicated that AASHTO SCOTE agreed to create a task force to review and provide comments to the ITS Planning Guidelines as well as advise ENTERPRISE of other AASHTO subcommittees that would be appropriate to participate in review of some of the ITS device guidelines.

ENTERPRISE has worked with SCOTE Task Force since October 2013 to support their review of the planning guidance for the ten ITS devices. It is anticipated that the SCOTE Task Force will continue to provide input to the guidelines on a periodic basis as enhancements are made to the guidelines. This document incorporates the modifications provided by SCOTE to ENTERPRISE.

NOTE: The original term “ITS Warrants” was changed to “ITS Planning Guidance” in 2014 to eliminate the statutory/legal implications association with the publication of official warrants.

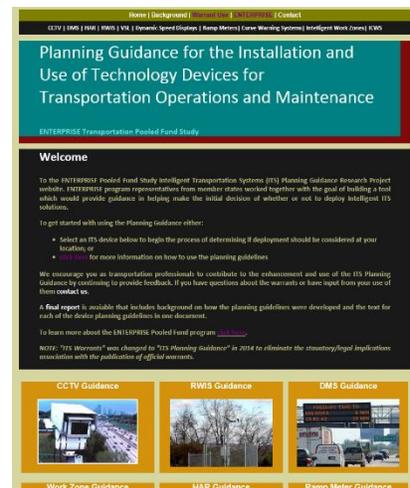
ITS Planning Guidance Website

An operational outcome of the first phase of the project was an ITS Planning Guidance website. The initial version of the website included an interactive interface where visitors could execute the guidance by ‘pointing and clicking’ to answer the planning guidance questions. Website users immediately received the results of the guidance questions (either informed that the deployment in question should be considered, not considered, or partially considered). Users were also able to request to view the criteria and decision factors that led to the planning guidance conclusions.

More than anything, the first version of the website provided an effective tool for monitoring the testing of the guidelines. Each time a visitor to the site executed a guideline (either for testing or for actual deployment analysis) the results were logged. Therefore, the project team working on the planning guidelines could poll the database and view the number of times each guideline had been executed, the results of each execution, and any feedback documented. The intent of the online tool was to serve as an effective mechanism for continued planning guidance development, testing, refinement and use by the industry.

The ITS Planning Guidance website continues to be updated in conjunction with this document as modifications are made. The website is no longer interactive since the initial refinement of the guidelines has been completed. The ITS Planning Guidance website includes background information on the development of the guidelines, instructions on how to use the guidelines, and the guidelines for the devices developed to date. The ITS Planning Guidance website is available at:

<http://enterprise.prog.org/itswarrants/>



2. Introduction

2.1 Background

The ENTERPRISE Pooled Fund Study (<http://enterprise.prog.org>) members consist of transportation agencies that fund and perform projects to address specific needs in the members' agencies that are related to advanced technologies in transportation, and that are most suited to collaborative group efforts. Each year, the ENTERPRISE members develop an annual work plan defining projects to be performed during the coming year.

In 2006, many ENTERPRISE member agencies were facing the challenge of increasing requests for the deployment of technology devices (commonly referred to as Intelligent Transportation Systems (ITS) devices). The members believed that a process of assessing whether individual devices should be considered at specific locations could help them in prioritizing device deployments. The members funded an initial phase of the planning guidance development process, which was completed in 2009, and then based on the results began developing a second phase of guidelines for additional technology devices, completed in 2010. ENTERPRISE has continued to identify additional ITS devices for planning guidance development and in 2013 developed guidelines for Intersection Conflict Warning Systems. ENTERPRISE since October 2013 has worked with SCOTE Task Force to review the guidelines. It is anticipated that the SCOTE Task Force will continue to provide input to the guidelines on a periodic basis as enhancements are made to the guidelines. This document includes all the planning guidelines that ENTERPRISE has developed.

2.2 Defining the Concept

In the fall of 2006, ENTERPRISE began to develop a limited set of planning guidelines for technology devices, modeled after the successful use of warrants by the [Manual of Uniform Traffic Control Devices \(MUTCD\)](#). In the first phases, the intent of the ENTERPRISE effort was to develop a similar set of planning guidelines for selected technology devices in order to assess the feasibility and viability of technology device guidelines.

The ENTERPRISE Pooled Fund ITS Planning Guidance project was managed and continues to be jointly managed by representatives from the Minnesota Department of Transportation (MnDOT) and the Washington State Department of Transportation (WSDOT).

In addition to the project managers, ENTERPRISE representatives and personnel from each member's agency contributed experiences, technical input and expertise from related efforts to the planning guidance development process. The specific goals of the ENTERPRISE ITS Planning Guidance Project are summarized as follows:

- To identify a small number of technology devices that would be the focus of initial planning guidance, and then based on the results and feedback, expand the focus of the initial planning guidance;
- To develop planning guidance for the installation of these devices to demonstrate the concept;

- To perform outreach to the transportation community and encourage testing and use of planning guidance;
- Based on the feedback of the planning guidance testing, to assess the feasibility of wide scale technology device planning guidance use; and
- To seek industry input on the most appropriate agency to ‘house’ device planning guidance in the future.

2.3 Current Status

The project activities have developed a set of technology device planning guidelines for ten ITS devices.

While ITS Planning Guidance was developed by the ENTERPRISE member agencies, together with the project contractor (Athey Creek Consultants), a much larger group of industry representation was involved in the process, summarized as follows:

- A workshop was conducted as part of the 2009 ITS Canada Annual meeting in which over 50 members of ITS Canada gave feedback, input, and direction to the project.
- ITS Planning Guidance was presented at numerous forums including the ITE mid-year meeting, the ITS World Congress in 2008, the National Rural ITS Conference, and to local ITS meetings and workshops.
- Additional representatives from (non-ENTERPRISE) transportation agencies tested and trialed planning guidelines on the guidance website, offering input and feedback that was considered by the development team.
- In October 2013, a webinar was held with a group of traffic safety engineers with experience in deploying Intersection Conflict Warning Systems (ICWS), to review, test, and provide input for the ICWS Planning Guidelines.
- In June 2013 the ENTERPRISE ITS Planning Guidance efforts were presented to AASHTO SCOTE as a first step in working with an organization to review the guidelines. SCOTE approved a resolution to participate in the review of the guidelines. The approval indicated that AASHTO SCOTE agreed to create a task force to review and provide comments to the ITS device planning guidance as well as advise ENTERPRISE of other AASHTO subcommittees that would be appropriate to participate in review of some of the device guidance. ENTERPRISE members have worked with the SCOTE task force to review the planning guidelines since 2013.

This document represents the efforts performed to develop the device planning guidance. Section 8 of this report contains the text of each device guideline which is also included on the ITS Planning Guidance website: <http://enterprise.prog.org/itswarrants/> .

3. Devices Selected for Planning Guidance Development

The set of devices for which planning guidance has been developed, and the associated definition of each device (as defined by this project), are summarized as follows:

- **Closed Circuit Television (CCTV)**
CCTV are defined as a video or still picture camera system used to collect images, communicate images to end users, and project images onto a video monitor, television screen, Internet display, or other monitoring equipment.
- **Dynamic Message Signs (DMS)**
DMS are defined as either fixed or portable signs capable of displaying any text message entered by an operator (either locally or remotely).
- **Highway Advisory Radio (HAR)**
HAR is defined as low power AM or FM radio transmissions where localized information is broadcast and can be heard on standard AM or FM radios. Most often, travelers are alerted to the presence of the broadcast using static or dynamic signs displaying the frequency of the transmission. The localized transmissions may cover areas that range from 5 miles to 30 miles depending upon the terrain and technologies used. The radio transmissions may be either at fixed permanent locations or mobile devices that may be temporarily located and moved as needed.
- **Road Weather Information Systems (RWIS)**
RWIS refer to in-field atmospheric and/or road weather monitoring devices that are capable of measuring conditions and reporting conditions back to a central server or a roadside device.
- **Variable Speed Limit Devices (VSL)**
VSL devices are defined as a signs capable of displaying different speed limits to travelers (in which the speed limit is either a recommended or mandatory limit) that are either manually activated or controlled by a combination of detectors and algorithms to select appropriate speeds.
- **Dynamic Speed Display Signs (DSDS)**
DSDS are defined as permanent or temporary signs that detect and display a vehicle's current speed to the driver, often the speed display indicates if the vehicle is exceeding the speed limit. Dynamic Speed Display Signs are also commonly referred to as 'Your speed is' signs, or 'Driver Feedback Signs'.
- **Ramp Meters**
Ramp Meters are defined by the Manual on Uniform Traffic Control Devices as traffic control signals that control the flow of traffic entering a freeway facility.
- **Curve Warning Systems**
Curve Warning Systems are defined as a collection of devices deployed with the goal of reducing vehicle crashes and roadway departures within horizontal curves. Technology devices may include real-time warning signs triggered by vehicle factors (e.g. speed, height, weather) and/or roadway conditions (snow, ice, and rain) at approaches to sharp curves.

- **Intelligent Work Zones (IWZ)**
Intelligent Work Zones are defined as a collection of devices that collectively warn travelers of various hazards associated with work zones.
- **Intersection Conflict Warning Systems (ICWS)**
Intersection Conflict Warning Systems (ICWS) are defined as a traffic control device placed on major, minor or both roads of an intersection to provide drivers with a real-time, dynamic warning of vehicles approaching the intersection. ICWS are typically installed to address crash factors associated with limited sight distance and poor gap selection at stop-controlled intersections.

4. The Planning Guidance Development Process

The technology device planning guidance development process was a structured 4 step process. This process is summarized as follows:

Step 1: Definition of Purposes

The ITS technology devices described by the planning guidelines are used by transportation professionals and/or the traveling public for a variety of purposes. In order to respect the fact that devices are considered for different purposes, multiple guidelines have been developed for each device and each guideline focuses on a specific purpose for the device. As an example, for the VSL device, there are a total of four planning guidelines (four purposes) as shown in the table below.

The definition of the purposes for each device (and therefore the guidelines) were developed by the ENTERPRISE members, working together with the consultant team. It is recognized that there may be additional purposes for which planning guidelines should be developed for each device, however the members reached consensus on the initial set of purposes and guidelines for development. Table 1 summarizes the purposes addressed by each guidance.

Table 1 – Summary of Purposes Addressed by the Device Planning Guidelines

Device	Planning Guideline ID	Planning Guideline Name
CCTV	CCTV Planning Guideline #1	Traffic Observation for Signal Control Changes
	CCTV Planning Guideline #2	Traffic Incident or Event Verification
	CCTV Planning Guideline #3	Weather Verification
	CCTV Planning Guideline #4	Traveler Information
	CCTV Planning Guideline #5	Field Device Verification
	CCTV Planning Guideline #6	Intelligent Work Zone
DMS	DMS Planning Guideline #1	To Inform Travelers of Weather Conditions
	DMS Planning Guideline #2	To Inform Travelers of Traffic Conditions
	DMS Planning Guideline #3	Changing Traffic Control or Conditions
	DMS Planning Guideline #4	Special Events
	DMS Planning Guideline #5	Parking Availability
	DMS Planning Guideline #6	Transit Park and Ride Availability
	DMS Planning Guideline #7	Evacuation Routes
	DMS Planning Guideline #8	Jurisdictional Information
HAR	HAR Planning Guideline #1	Weather and Driving Conditions
	HAR Planning Guideline #2	Venue Parking
	HAR Planning Guideline #3	Changing Traffic Control & Conditions
	HAR Planning Guideline #4	Special Events
RWIS	RWIS Planning Guideline #1	Support Traveler Safety and Mobility
	RWIS Planning Guideline #2	Support Regional, Statewide or Provincial Weather Monitoring

Device	Planning Guideline ID	Planning Guideline Name
	RWIS Planning Guideline #3	Support Traveler Information
VSL	VSL Planning Guideline #1	Maximize Capacity
	VSL Planning Guideline #2	Safe Stopping Distances
	VSL Planning Guideline #3	Safe Travel Speeds for Conditions
	VSL Planning Guideline #4	Work Zones
DSDS	DSDS Planning Guideline #1	Transition Zones
	DSDS Planning Guideline #2	Posted Speed Adherence
	DSDS Planning Guideline #3	Intelligent Work Zones
Ramp Meters	Ramp Meter Planning Guideline #1	Corridor-wide Freeway Traffic Management
	Ramp Meter Planning Guideline #2	Localized Freeway Traffic Issues
	Ramp Meter Planning Guideline #3	Work Zone Activity
Curve Warning System	Curve Warning System Planning Guideline #1	Rural Two-Lane Highway Curves
	Curve Warning System Planning Guideline #2	High Risk Locations
	Curve Warning System Planning Guideline #3	Truck Rollovers on Ramps/Curves
Intelligent Work Zones*	DMS Planning Guideline #3	Changing Traffic Control or Conditions
	CCTV Planning Guideline #6	Intelligent Work Zone
	HAR Planning Guideline #3	Changing Traffic Conditions
	VSL Planning Guideline #4	Work Zones
	DSDS Planning Guideline #3	Intelligent Work Zones
	Ramp Meter Planning Guideline #3	Work Zone Activity
ICWS	ICWS Planning Guideline #1	Intersections with High Crash Frequencies or Rates
	ICWS Planning Guideline #2	Intersection Characteristics

** The Intelligent Work Zones Guidelines include a collection of other device guidelines that collectively warn travelers of various hazards associated with work zones. For example, the VSL guidelines includes one purpose focused on work zones. Therefore this guideline (VSL Planning Guideline #4: Work Zones) is included in the collection of purposes for Intelligent Work Zones.*

Step 2: Identification of Critical Factors for Each Planning Guideline

With the purposes defined for each planning guideline, the next step in the planning guidance development process was to identify the critical factors associated with whether or not a device is recommended at a specific location. These critical factors were defined to be the factors most important in determining whether or not a device is both needed and able to serve the purpose in question at the specific location.

For example, Table 2 illustrates the factors defined by the group as most critical in determining if a DSDS should be considered for the purpose of ‘Promoting speed adherence in location so speed limit reduction zones’.

Table 2 – Sample Definition of Critical Factors for DSDS Device

Device	Purpose	Critical Factors
DSDS	To promote speed limit adherence in locations of speed limit reduction zones.	1. Average speed (85 th percentile speed) compared to posted speed 2. Speed transition difference (in mph) 3. Proximity to other DSDS

Step 3: Planning Guideline Development

Once the factors were defined for each planning guideline (each purpose), the next step was to draft the text of each guideline. Using the example above, even with the definition of critical factors, there were still many decisions to be made about the parameters, cut-off thresholds, and decision points to be included in the guidelines.

The pooled fund structure of ENTERPRISE was very conducive to this portion of the planning guidance development process. Within Step 3, the planning guidelines were developed for each purpose and the draft guidelines were shared with the pooled fund members. Collectively, the members came to agree on an initial version of the planning guidelines. The initial version of the guidelines was then used in Step 4 – Testing and Adjustments.

Step 4: Preliminary Testing and Planning Guideline Adjustment

During Step 4, each of the ENTERPRISE members was asked to test the planning guidelines against technology device deployments that were:

- Being considered;
- Under development; or
- Already deployed in recent years.

By testing the planning guidelines against all three types of deployments, it provided a much larger pool of test cases, and also offered various levels of feedback. For example, agencies that tested the guidelines against devices they had already deployed were able to receive feedback from the planning guidance process and compare that to their own decision about whether they feel the device is needed where it is currently deployed.

5. How to Use the Planning Guidelines

The planning guidelines are arranged by the functions or purposes for each device, and were developed to be a series of simple yes or no questions that can be answered quickly, avoiding the complexity of collecting a lot of data before using the guidelines. In general, the intent is that the planning guidelines would require a minimal amount of data collection or information gathering and would enable a user to complete the planning guidance process in less than 30 minutes.

5.1 Planning Guideline Process

The users of the device planning guidelines are encouraged to follow three successive actions in order to determine if the device in question should be considered at the specific location being considered.

Action 1: Purpose Selection

Identify and select the most appropriate purpose(s) (function) that the device is being considered to perform at the candidate location. If the device will be used for multiple purposes, run the planning guideline analysis for each purpose.

Action 2: Consideration of Planning Guidance

For each purpose, there is a series of yes/no questions asked by the guideline. Once users complete the questions, they will have either discovered that the use of the planning guideline has concluded either:

- A) The device should be considered;
- B) The device should be partially considered (in which case users are informed that if one or more additional purposes are partially met, the device shall be considered recommended); or
- C) The device should not be considered at this location.

Action 3: Next Steps

For each device that the planning guidance process identifies it should be considered, it is advised that additional engineering and planning studies (as appropriate) be conducted for the device at the candidate location. These will include such considerations as:

- Whether there is power supply;
- Whether there is appropriate access for maintenance and operations; and
- Whether it is safe to deploy this device at this location.

Please note that the planning guidelines do not address these engineering and planning decisions, but rather simply look at whether the specific device should be considered at the location, given the need, the conditions at the location, and the potential benefits delivered by the device.

5.2 Planning Guideline Approaches

Many of the planning guidelines examine whether lower cost or less technology-oriented solutions would be more appropriate. Whenever possible, notes are included in the guidelines that may suggest alternative approaches with the intention of saving the users money and complexity.

5.3 Technology Device Planning Guidance Website

As part of the ENTERPRISE Planning Guidance initial phases, an interactive project website was created. The planning guidance website played several roles:

- Housed the latest versions of each planning guideline;
- Allowed website visitors to click boxes to answer yes/no questions about the site in question and receive a notice of whether the device is recommended at the location (as well as any feedback, notes, or qualifiers);
- Tracked the number of times each planning guideline was executed by website visitors and the results of each guideline use (i.e. tracks the number of times a guideline was used online and the number of times the device was reported should be considered, not considered or partially considered);
- Allowed visitors to enter contact information or a description of the site they performed the planning guideline on (entry of contact information is optional); and
- Provided project background information as well as planning guideline criteria information.

The interactive nature of the planning guidance website and the ability of the site to log the number of guideline trials and the outcomes of each trial provided an effective tool for future development of device planning guidelines. Guidelines could be loaded on the website and tested over the Internet by transportation professionals (note: the planning guidance website and testing was available to anyone and did not require any registration or the disclosure of any personal information). Users could enter feedback as they tested each device and the system would log whether the tester agrees with the outcome of the planning guideline.

With the development of the ICWS planning guideline in 2013 the ITS Planning Guidance website was updated. The revised website is no longer interactive since the first effort of testing and refinement has been completed for the guidelines. The ITS Planning Guidance website is available at: <http://enterprise.prog.org/itswarrants/>

6. Results of Planning Guidance Testing and Use

The structure of the ENTERPRISE Pooled Fund Study allowed for numerous agencies and individuals to test the planning guidelines. The testing involved state/provincial governments, county governments, and local city governments.

The intent of the planning guideline testing was twofold:

- To test the value of the planning guidelines in helping agencies determine if devices should be deployed and therefore testing the concept of ITS planning guidelines; and
- To test the draft versions of the planning guidelines to determine if the threshold values and specific questions are appropriate or need to be refined.

Testing the Value of Planning Guidelines and the Concept

The value of the planning guidelines was tested by agencies considering deployment of ITS devices, and by agencies that have recently deployed ITS devices. The online testing website allowed agencies to quickly answer questions about each candidate deployment location and receive an answer to whether or not the device should be considered for the location. The results of each planning guideline test were tracked for review and analysis. Verbal feedback from the test locations then verified whether the guidelines produced results that agree with local opinions.

Testing to Refine and Verify the Draft Planning Guidelines

The second intent of testing the guidelines was part of the overall planning guidance development process. The ‘qualitative’ nature of the device planning guideline is such that the initial drafting of guideline is a best ‘first shot’ at defining the parameters, thresholds and decision points to be used to determine if a device is justified. However, real-world practical use of the planning guideline was needed to either verify these values or refine them. From another perspective, ideally the guidelines would be supported by actual mathematical calculations to justify each calculation in the guidelines. However, these calculations are simply not known, nor are there any physical supporting evidence of such calculations. Therefore, the guidance development started with initial draft guidelines, and then the transportation industry (and the testing and feedback of initially over 20 transportation agencies) has helped refine the guidelines. The online website and ongoing feedback loop will ultimately allow any agency that chooses to contribute to the guidance process.

6.1 Multi-state Planning Guidance Testing Results

The first state agency to formally test the guidelines was the Michigan Department of Transportation (MDOT). MDOT had completed a strategic plan for ITS deployments throughout the state, including numerous locations where ITS devices are being considered. This provided a challenging test-bed to trial the guidelines against actual deployment sites. In total, the guidelines were trialed for five devices in five different locations throughout Michigan, resulting in four devices being identified as they should be considered and one device identified as it should not be considered. In each case of guideline testing, the tests allowed further development and refinement of the guidelines based on actual feedback and comments from traffic engineers familiar with the local situations.

A second set of guideline tests were conducted in Southeastern Minnesota. CCTV cameras were being considered for deployment along I-35 at the interchange of Trunk Highway 19 (near Northfield, Minnesota), and at the interchange with I-90 (near Albert Lea). In addition, the CCTV guidelines were tested at a site in the city of Rochester, Minnesota that is prone to a high number of merges and traffic congestion. These tests of the guidelines offered a perspective from rural areas and small urban areas.

North Carolina DOT in 2013 provided input on the ICWS guidelines by testing the criteria for the ICWS guidelines as the guidance was being developed against previously deployed ICWS systems in North Carolina.

The ENTERPRISE members have involved over 20 transportation agencies to assist in testing the guidelines and expects the number of test-participating agencies to continue to grow. These include rural areas such as I-35 in southern Minnesota, to small urban areas such as the city of Rochester, to major metropolitan areas such as Minneapolis, Minnesota and Seattle, Washington. Typically, each time a guideline is tested, the feedback has resulted in slight changes to the guideline (either the context of the guideline or the text describing the guideline). As a result, the guidelines have improved and now better represent the agencies that have contributed towards them.

Expressions of Support and Concerns

The testing also resulted in considerable positive feedback about the concept of ITS device guidelines. The concept has been presented to state traffic engineering, local traffic engineers, planners, and operations and maintenance personnel. There has been overwhelming support for the concept and the benefit it offers to decision makers. The only concerns expressed are best summarized as follows:

- *Concern that the guidelines are too restrictive and local experts may understand a need for a device in locations where the guidelines do not support it.* This concern is a good example of the need to continue to allow open feedback from the community to adjust guidelines when needed. It is important to consider that there will always be locations where devices are needed due to unique and specific situations. For this reason, the ITS guidelines should be one tool that engineers and planners use.
- *Concern that in locations where development is occurring and devices are being considered based on anticipated travel patterns that will exist when the new development is completed.* The concern is that devices may not currently meet the guidelines, however it would be prudent to install the devices during the construction phase. For this concern, local transportation professional should perform local engineering and analysis to determine if device installations are appropriate.

6.2 Actual Use of the Guidelines

The section presents a few examples of real-world uses of the ITS guidelines.

Virginia Department of Transportation

The Virginia Department of Transportation (VDOT) in 2010 operated approximately 41 Road Weather Information System (RWIS) devices throughout the state to monitor weather and road conditions in real-time. Each device communicated data back to VDOT offices and the weather and road condition reports were used to support VDOT maintenance activities and traveler information dissemination systems. VDOT continued to add RWIS devices as needs were understood and funding allowed. Future deployment plans for RWIS are determined through coordination with District Maintenance Offices and Regional Operations Partners.

After preliminary testing of the RWIS device guidelines, VDOT used the device guidelines as one consideration when developing deployment plans for RWIS devices. The structure of the guidelines has allowed maintenance engineers to answer the guideline questions quickly. When device deployments are proposed or requested, VDOT engineers execute the guidelines for the locations being considered.

North Dakota Department of Transportation

North Dakota DOT is not a member of the ENTERPRISE Pooled fund. However, North Dakota DOT became aware of the ITS Planning Guidance project, and used the ITS Planning Guidance website in 2010 to assist in selecting technology deployments for rural safety initiatives. The ITS guidelines were used to examine concepts for deployment, and the result of the guideline use was recommendations of simpler technology deployments. North Dakota DOT contacted the ENTERPRISE Pooled Fund to relay their experience with the ITS guidelines and commented that it was beneficial to them in prioritizing their deployment plans.

Kansas Department of Transportation

In preparation for rural safety deployments in 2010, Kansas DOT used the ITS guidelines to prioritize deployments and included an explanation of the guideline use when submitting their rural safety deployment plan. Like other uses, the ITS guidelines was just a tool to assist the decision-making process, however feedback was very positive regarding the value and effectiveness of the guidelines.

Minnesota Department of Transportation

The Minnesota DOT's [Traffic Engineering Manual](#) includes a chapter on Intelligent Transportation Systems. Within the ITS chapter a section includes a link to the ITS Planning Guidelines developed by ENTERPRISE.

7. The Future - Ongoing Planning Guidance Development and Use

The ITS guidelines have been well accepted by the transportation community. Several examples of monetary and time savings from agencies using the ITS guidelines have been documented (both ENTERPRISE and Non-ENTERPRISE member agencies). The ITS guidelines are an attempt to fill a need in the transportation industry for support in the decision making process for deploying ITS devices. Based upon the feedback from those who have been exposed to the guidelines, it appears that they help address this need.

The guidelines developed by ENTERPRISE represent a portion of the number of ITS devices in the industry. The initial concept for the guidelines was to assess the value and potential for ITS planning guidance. It was always recognized that if the ITS guidelines were agreed to be valuable (and if a group beyond ENTERPRISE adopted the ITS guidelines) that additional guidelines would be developed. Therefore, the devices selected in the first phases of the guidance development effort are not meant as an all-inclusive set of devices or guidelines, but rather were chosen to be used to test the concept of guidelines for technology devices. The ENTERPRISE members have agreed that the guidelines have been valuable and moved forward with developing guidelines for ICWS in 2013.

ENTERPRISE continues to test and refine the guidelines as well as explore industry acceptance for this concept. Ideally, the ENTERPRISE Program hopes that a National or International agency will embrace the concept of technology device guidelines and carry the concept forward in order to support traffic engineers for years to come. In July 2013 ENTERPRISE completed a project "[Supporting the Transition of ENTERPRISE ITS Planning Guidance to a Permanent Home](#)". The objective of the project was to document activities ENTERPRISE has conducted as owner and maintainer of the guidelines to assist in identifying potential organizations for transitioning the guidelines to a new owner.

As ENTERPRISE documented the details of each task that was involved with owning the guidelines, a number of options were suggested as potential organizations to transition the ownership and maintenance of the guidelines. However, after the ENTERPRISE Board reviewed the different options for one organization to maintain the guidelines, it was agreed that ENTERPRISE should continue to own and maintain the guidelines and partner with organizations to review the guidelines. This approach was based on the understanding that it would be easier to find agencies willing to review and comment on one or more guidelines periodically than it would be to find an organization willing to accept the entire workload of all the guidelines. Given this, ENTERPRISE developed a planning guidance review process to assist with review and modifications of the guidelines.

8. ITS Technology Device Planning Guidance Text

The following pages contain the ITS technology device planning guidance for:

- [Closed Circuit Television \(CCTV\)](#);
- [Dynamic Message Signs \(DMS\)](#);
- [Highway Advisory Radio \(HAR\)](#);
- [Road Weather Information Systems \(RWIS\)](#);
- [Variable Speed Limit \(VSL\) Signs](#);
- [Dynamic Speed Display Signs \(DSDS\)](#);
- [Curve Warning Systems](#);
- [Ramp Meters](#);
- [Intelligent Work Zones](#); and
- [Intersection Conflict Warning Systems \(ICWS\)](#).

As noted earlier, the guidelines are also maintained on the project website. The project website is: <http://enterprise.prog.org/itswarrants/>

ITS Guidelines offer a tool to support local transportation professionals in selecting locations for ITS device deployments. Local design standards and criterion should be the ultimate determining factor in final selection of the locations.

8.1 CCTV Planning Guidance

CCTV shall mean a video or still picture camera system used to collect images and relay images to a central monitoring location, and project images onto a video monitor, television screen, Internet display, or other monitoring equipment.

Engineering judgment should be used to assess potential implications that may result from installation of CCTV. This planning guidance does not mandate the use of CCTV.

Six (6) guidelines have been identified to capture the most common uses of Closed Circuit Television (CCTV). While there are other purposes and uses for CCTV, the guidelines developed to date have focused on the following six.

CCTV Guideline - 1: Traffic Observation for Signal Control Changes

Purpose: To visually observe traffic conditions in order to determine if alternate signal timings are appropriate before implementing alternate traffic signal timing plans remotely.

CCTV Guideline - 2: Traffic Incident or Event Verification

Purpose: To allow traffic operations personnel or emergency response teams to visually verify traffic flow and/or incidents (e.g. crashes, debris in roadway) in order to activate or dispatch appropriate response and post message to traveler information systems.

CCTV Guideline - 3: Weather Verification

Purpose: To allow maintenance dispatchers and traffic control personnel to verify weather conditions on the roadway, either to guide traveler information dissemination or to dispatch operations.

CCTV Guideline - 4: Traveler Information

Purpose: To allow travelers to understand traffic delay and road weather conditions by viewing images of the roadway from the Internet prior to departing.

CCTV Guideline - 5: Field Device Verification

Purpose: To allow traffic or maintenance operations personnel to verify operational functionality of in-field devices (such as Dynamic Message Signs, road/lane closure gates, and other devices).

CCTV Guideline - 6: Intelligent Work Zone

Purpose: To allow travelers or transportation professionals to understand construction or maintenance traffic delay by viewing images of the roadway remotely.

CCTV Guideline #1: Traffic Observation for Signal Control Changes

Purpose:	To visually observe traffic conditions in order to determine if alternate signal timings are appropriate before implementing alternate traffic signal timing plans remotely.
Device should be considered if:	<ol style="list-style-type: none">1. There are typically periods of time at least twice per week of 'loaded' cycles (i.e. where the vehicles in the queue do not all dissipate in one green cycle) that last 15 minutes or longer. AND2. The signalized intersection has sufficient cross street traffic such that visual observation is needed determining if alternate signal timings are appropriate to benefit the primary direction of flow (i.e. in order to verify that the secondary street is not backing up). AND3. The operations personnel have the ability to activate special event timing plans remotely. <p><i>Partial Guideline Criteria:</i> If either #1 or #3 above are met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

CCTV Guideline #2: Traffic Incident or Event Verification

Purpose:	To allow traffic operations personnel or emergency response teams to visually verify traffic flow and/or incidents (e.g. crashes, debris in roadway) in order to activate or dispatch appropriate response and post message to traveler information systems.
Device should be considered if:	<p>1. The candidate location encounters incidents as frequently as twice per month for arterial streets or once per month for freeways.</p> <p style="text-align: center;">AND</p> <p>2. The incidents and events that occur on freeways typically cause delay to travelers of at least 15 minutes while the incident is active and has not been cleared.</p> <p style="text-align: center;">OR</p> <p>2b. The incidents and events that occur on arterials typically cause impact travel such that the signal progression is no longer occurring and vehicles are not clearing green cycles.</p> <p style="text-align: center;">OR</p> <p>2c. Incident location verification is needed by 911 dispatchers (e.g. large complex interchange where drivers don't know where they are, closely spaced interchanges).</p> <p style="text-align: center;">AND</p> <p>3. The location encounters:</p> <ul style="list-style-type: none"> • At least 2 hours per day of peak period travel where traffic flow exceeds 1,100 veh/hr/lane; or • Conditions considered Level of Service C; or • Average annual daily traffic (AADT) of 16,800 for a 2 lane road; 33,600 for a 4 lane road; 50,400 for a 6 lane road; 67,200 for an 8 lane road.

CCTV Guideline#3: Weather Verification

Purpose:	To allow maintenance dispatchers and traffic control personnel to verify weather conditions on the roadway, either to guide traveler information dissemination or to dispatch operations.
Device should be considered if:	<ol style="list-style-type: none">1. The location typically encounters at least 10 weather events each season. <p style="text-align: center;">AND</p> <ol style="list-style-type: none">2. Weather events have a significant impact to travelers at this location (due to such circumstances as either: local terrain, lack of alternate routes, winding or steep routes), and it is a location that travelers are frequently concerned about. <p style="text-align: center;">AND</p> <ol style="list-style-type: none">3. If there are<ul style="list-style-type: none">• No nearby weather sensors reporting real-time conditions; or• No regular manual observations and reports of visibility, precipitation, or pavement temperatures, or• Nearby weather sensors would be enhanced through the capability of visual observation. <p><i>Partial Guideline Criteria:</i> If #1 And #3 above are met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

CCTV Guideline #4: Traveler Information

Purpose:	To allow travelers to understand traffic delay and road weather conditions by viewing images of the roadway from the Internet prior to departing.
Device should be considered if:	<p>1a. The location visible by the camera image has a history of congestion on a regular basis (i.e. each commuter day is a candidate for congestion).</p> <p>OR</p> <p>1b. The location is prone to weather situations that travelers would not otherwise be forewarned about (e.g. spots where fog regularly forms, bridges that ice early, mountain passes with weather that differs from approaches).</p> <p>OR</p> <p>1c. The location is in a remote area that receives considerable traffic volume due to commercial vehicle traffic or recreational traffic.</p> <p>AND</p> <p>2. The majority of travelers to the area have Internet access in proximity to the area where camera images are of value to travelers prior to departure.</p> <p>Partial Guideline Criteria: If either #1a, #1b, or #1c above are met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

CCTV Guideline #5: Field Device Verification

Purpose:	To allow traffic or maintenance operations personnel to verify operational functionality of in-field devices (such as Dynamic Message Signs, road/lane closure gates, and other devices).
Device should be considered if:	<ol style="list-style-type: none">1. The proper operations of the device can be remotely monitored by a camera. <p style="text-align: center;">AND</p> <ol style="list-style-type: none">2. The failure of the device presents a safety hazard. <p style="text-align: center;">OR</p> <ol style="list-style-type: none">3. The camera operation would avoid unnecessary trips to verify functionality of the field device. <p>Guideline Criteria: If #1 And #2 above are met, Or if #3 above is met, the guideline should be considered. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

CCTV Guideline #6: Intelligent Work Zone

Purpose:	To allow travelers or transportation professionals to understand construction or maintenance traffic delay by viewing images of the roadway remotely.
Device should be considered if:	<p>1a. The alignment or traffic control that is visible by a camera image is expected to change periodically during the construction period.</p> <p>OR</p> <p>1b. The construction zone encounters periods of queues or delays for at least 30 minutes each day.</p> <p>AND</p> <p>2. The construction zone is in a location where there is not a convenient alternate route for the majority of traffic to deviate from the typical route.</p> <p>Guideline Advice: Consideration should be given to temporary/portable cameras in work zone areas.</p>

8.2 DMS Planning Guidance

DMS are defined as either fixed or portable signs capable of displaying any text message entered by an operator (either locally or through remote access).

The Manual on Uniform Traffic Control Devices (MUTCD) contains the national standards governing all traffic control devices. Dynamic Message Signs (described as Changeable Message Signs in the MUTCD) are one traffic control device covered by the MUTCD (MUTCD 2009 Edition Chapter 2L. Changeable Message Signs. In MUTCD Section 2L:

- Section 2L.01 addresses the description of Changeable Message Signs;
- Section 2L.02 addresses applications of Changeable Message Signs;
- Section 2L.03 addresses legibility and visibility of Changeable Message Signs;
- Section 2L.04 addresses design characteristics of Changeable Message Signs;
- Section 2L.05 addresses message length and information of Changeable Message Signs;
- Section 2L.06 addresses installation of permanent Changeable Message Signs.

The Planning Guidelines presented in this section are intended to be an additional tool to assist agencies in the decision process of selecting when and where to deploy DMS technologies, based upon the experiences of agencies that have previously deployed DMS.

Engineering judgment should be used to assess potential implications that may result from installation of DMS. This planning guidance does not mandate the use of DMS.

The guidelines do not distinguish between types of DMS (portable, overhead, roadside). Rather the intent of the guidelines are to contribute to the understanding of the need for some type of DMS. Detailed design would contribute to the selection of the specific DMS type.

Eight (8) guidelines have been identified to capture the most common uses of Dynamic Message Signs (DMS). While there are other purposes and uses for DMS, the guidelines developed to date have focused on the following eight purposes.

DMS Guideline - 1: To Inform Travelers of Weather Conditions

Purpose: To provide road weather information to drivers so that the drivers can choose whether to continue travel on the route or whether to adjust their speed, route of travel, or divert from the trip in anticipation of an upcoming weather hazard.

DMS Guideline - 2: To Inform Travelers of Traffic Conditions

Purpose: To provide current traffic status information (incidents, congestion, travel time, road work) to drivers so that drivers can choose to divert to avoid the situation, to reduce driver anxiety, and to reduce crashes involving drivers encountering unexpected stopped traffic.

DMS Guideline - 3: Changing Traffic Control or Conditions

Purpose: To notify drivers in advance of special changing traffic conditions and roadway configuration changes associated with road construction or maintenance in order to reduce driver confusion that could result in a crash.

- DMS Guideline - 4: Special Events**
Purpose: To provide parking or alternate route information about special events or major venues to drivers in order to reduce congestion and delays due to unnecessary "circling the block" or non-participating drivers being caught in traffic.
- DMS Guideline - 5: Parking Availability**
Purpose: To provide real time parking availability information to drivers to avoid unnecessary "circling the block" looking for parking spots.
- DMS Guideline - 6: Transit Park and Ride Lot Availability**
Purpose: To provide real time parking availability information to drivers regarding transit park and ride lots.
- DMS Guideline - 7: Evacuation Routes**
Purpose: To provide evacuation route information to drivers during disaster or homeland security events.
- DMS Guideline - 8: Jurisdictional Information**
Purpose: To provide jurisdictional specific information to drivers at or near borders between two jurisdictions.

DMS Guideline #1: To Inform Travelers of Weather Conditions

Purpose:	To provide road weather information to drivers so that the drivers can choose whether to continue travel on the route or whether to adjust their speed, route of travel, or divert from the trip in anticipation of an upcoming weather hazard.
Device should be considered if:	<ol style="list-style-type: none"> 1. If the location is prone to weather situations that travelers would not otherwise be forewarned about (e.g. spots where fog regularly forms, bridges that ice early, mountain passes with weather that differs from approaches). <li style="text-align: center;">AND 2. If there is available road weather information for the area downstream of the candidate DMS location. <li style="text-align: center;">AND 3. If there is the capability (either manually by staff members or automated through a condition reporting system) to create event specific descriptions of weather conditions to be displayed on the DMS. <li style="text-align: center;">AND 4a. If there is a need to disseminate event specific descriptions (rather than a lower technology approach such as activating a flashing warning sign that says "Weather Alert When Flashing"). <li style="text-align: center;">OR 4b. If there are options for either alternate routes or services, that might be described on the DMS, where travelers may wait out conditions. <li style="text-align: center;">OR 4c. If flashing beacon signs have been tried and not proven to generate responses from travelers. <li style="text-align: center;">AND 5. If weather events contribute to a significant number of crashes or road closures such that there are major impacts to travelers.

	<p>Guideline Advice: If the only guideline being met for a DMS is the weather information guideline, then it is recommended that the lesser technologies are considered before deploying full DMS capabilities.</p> <p>Partial Guideline Criteria: If either #1 or #5 above are met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>
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DMS Guideline #2: To Inform Travelers of Traffic Conditions

Purpose:	To provide current traffic status information (incidents, congestion, travel time, road work) to drivers so that drivers can choose to divert to avoid the situation, to reduce driver anxiety, and to reduce crashes involving drivers encountering unexpected stopped traffic.
Device should be considered if:	<ol style="list-style-type: none"> 1. If the target area is monitored by CCTV cameras, traffic detectors, or another method of monitoring the conditions, or are travel times for the downstream stretch of road. AND 2. Events occurring in the area unexpectedly impact or impede traffic (e.g. close a lane, encounter slow traffic in one or more lanes, or events on the shoulder) an average of at least two times per month. AND 3a. If there are acceptable alternate routes with capacity to accept vehicles that may deviate based upon the information. OR 3b. If the location is a stretch of road where no alternate route are possible and travelers would benefit from information describing the cause and/or extent of delays in order to relieve driver anxiety or confusion. OR 3c. If there are horizontal or vertical curves that create safety issues when traffic is stopped unexpectedly. AND 4. The route being considered for the DMS has on average <ul style="list-style-type: none"> • At least 2 hours of peak period travel where traffic flow exceeds 1,100 veh/hour/lane; or • Experiences conditions considered Level of Service C; or • Experiences average annual daily traffic (AADT) of 16,800 for a 2 lane road; 33,600 for a 4 lane road; 50,400 for a 6 lane road; 67,200 for an 8 lane road.

Partial Guideline Criteria:

If #2 above is met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.

DMS Guideline #3: Changing Traffic Control or Conditions

Purpose:	To notify drivers in advance of special changing traffic conditions and roadway configuration changes associated with road construction or maintenance in order to reduce driver confusion that could result in a crash.
Device should be considered if:	<ol style="list-style-type: none"> 1. The candidate location is upstream of an area with construction or maintenance activities that are expected to cause at least 15 minutes of delay to the mainline traffic. <li style="text-align: center;">AND 2. If the candidate location is upstream of traffic control or construction/ maintenance activities that are expected to change more frequently than once every 60 days. <li style="text-align: center;">AND 3. If the posted work zone speed limit is greater than 45 MPH. <p>Notes:</p> <p><i>A. If question #2 is not met (activities do not change frequently), lower cost static signage is recommended.</i></p> <p><i>B. Portable DMS vs. permanent DMS should be considered based on the expected duration of events impacting the area.</i></p> <p>Partial Guideline Criteria:</p> <p>If #2 above is met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

DMS Guideline #4: Special Events

Purpose:	To provide parking or alternate route information about special events or major venues to drivers in order to reduce congestion and delays due to unnecessary "circling the block" or non-participating drivers being caught in traffic.
Device should be considered if:	<p>1. If the location contains a venue that houses ticketed events (typically with rapid and tight arrival patterns for a specified start time).</p> <p style="text-align: center;">AND</p> <p>2a. If the event venue typically houses at least two weekday (M-F) ticketed event per week (including seasonal sporting events that only occur during the season).</p> <p style="text-align: center;">OR</p> <p>2b. If the event venue typically houses at least 10 events per year attracting 30,000 visitors or more.</p> <p style="text-align: center;">AND</p> <p>3. If the setting of the venue is such that mainline traffic (not attending the event) is impacted by the conditions.</p> <p style="text-align: center;">AND</p> <p>4. If there are alternate parking or traffic options that could be displayed on signs to direct visitors to more preferred options.</p> <p>Guideline Advice: Placement of DMS signs should consider the intent of each sign. For example, further upstream signs are more effective at helping non-visitors to the venue avoid traffic congestion while signs closer to the venue are effective for directing drivers to open capacity.</p> <p>Alternate parking options should be considered. For example, at large rural venues alternate parking options may not be available.</p> <p>Partial Guideline Criteria: If either #1 and either #2a or #2b above are met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

DMS Guideline #5: Parking Availability

Purpose:	To provide real time parking availability information to drivers to avoid unnecessary "circling the block" looking for parking spots.
Device should be considered if:	<ol style="list-style-type: none">1. If the area contains ample parking to handle the regular visitors, either during commuter periods or special events. AND2. If the area contains a set of similar parking garages (similar parking costs) each with generally comparable ingress and egress and access to events (i.e. parking facilities are all generally equal options to select from). AND3. If visitors regularly are unable to find parking, and 'circling the block' occurs for more than 15 minutes during the AM commuter period or prior to special events, as visitors seek out parking spaces.

DMS Guideline #6: Transit Park and Ride Lot Availability

Purpose:	To provide real time parking availability information to drivers regarding transit park and ride lots.
Device is should be considered if:	<ol style="list-style-type: none">1. If the area contains park-and-ride lots that fill to capacity on either a regular basis or during regularly occurring events (e.g. inclement weather, sporting events). <p>AND</p> <ol style="list-style-type: none">2. If alternate park-and-ride lots are available (either upstream or downstream) that do not typically fill to capacity.

DMS Guideline #7: Evacuation Routes

Purpose:	To provide evacuation route information to drivers during disaster or homeland security events.
Device should be considered if:	<ol style="list-style-type: none">1. If the area is a major metropolitan area or has nearby icons that increase the likelihood of requiring an evacuation (e.g. nuclear reactor, major attraction, hurricanes, wildfire, etc). <p>AND</p> <ol style="list-style-type: none">2. If the area evacuation procedures allow for traffic movements and/or the use of roads that otherwise are not available to the public (e.g. contra-flow lanes). <p><i>Partial Guideline Criteria:</i> If #2 above is met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

DMS Guideline #8: Jurisdictional Information

Purpose:	To provide jurisdictional specific information to drivers at or near borders between two jurisdictions.
Device should be considered if:	<p>1. If there are differing rules or regulations between adjacent jurisdictions.</p> <p>AND</p> <p>2a. If display of differing rules or regulations on static signs would either not attract enough attention.</p> <p>OR</p> <p>2b. If the rules or regulations change frequently (e.g. load restrictions).</p> <p><i>Partial Guideline Criteria:</i> If #1 above is met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

8.3 HAR Planning Guidance

Highway Advisory Radio (HAR) refers to low power AM or FM radio transmissions where localized information is broadcast and travelers are alerted to the presence of the broadcast using static or dynamic signs. The localized transmissions may cover areas that range from 5 miles to 30 miles depending upon the terrain and technologies used. The radio transmissions may be either at fixed permanent locations or mobile devices that may be temporarily located and moved as needed.

Engineering judgment should be used to assess potential implications that may result from installation of HAR. This planning guidance does not mandate the use of HAR.

Four (4) guidelines have been identified to capture the most common uses of HAR. While there are other purposes and uses for HAR, the guidelines developed to date have focused on the following four.

HAR Guideline - 1: Weather and Driving Conditions

Purpose: To provide road weather information and/or regulatory restriction information (e.g. chain requirements) to drivers in rural areas to alert them to impending conditions.

HAR Guideline - 2: Venue Parking/Route Guidance

Purpose: To provide parking or route guidance information around major venues where unfamiliar travelers can benefit from verbal explanations (e.g. airports, National Parks, tourist attractions).

HAR Guideline - 3: Changing Traffic Conditions

Purpose: To notify drivers in advance of special changing traffic conditions and roadway such as those configurations associated with road construction or maintenance, traffic incidents or recurring congestion.

HAR Guideline - 4: Special Events

Purpose: To notify travelers about special events (either prior to the event start date or during the event), alerting travelers to the impacts of these events on traffic, and to guide event attendees to the event.

HAR Guideline #1: Weather and Driving Conditions

Purpose:	To provide road weather information and/or regulatory restriction information (e.g. chain requirements) to drivers to alert them to impending conditions.
Device should be considered if:	<p>1. If the location is upstream and within 4 hours driving proximity to locations that are prone to weather situations that travelers would not otherwise be forewarned about (e.g. spots where fog regularly forms, bridges that ice early, mountain passes with weather that differs from approaches).</p> <p style="text-align: center;">AND</p> <p>2a. If there is a need to disseminate a detailed report (such as those possible using HAR recordings) as opposed to flashing beacons or DMS.</p> <p style="text-align: center;">OR</p> <p>2b. If weather events contribute to a significant number of crashes or road closures such that there are major impacts to travelers (this may include 1 or more annual closures or crashes on freeways or 10 or more crashes or closures annually on arterials).</p> <p><i>Partial Guideline Criteria:</i> If #1 and #3 above are met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered. Otherwise it should not be considered at this time.</p>

HAR Guideline #2: Venue Parking/Route Guidance

Purpose:	To provide parking or route guidance information around major venues where unfamiliar travelers can benefit from verbal explanations (e.g. airports, National Parks, tourist attractions).
Device should be considered if:	<ol style="list-style-type: none">1. The venue is visited by at least 10,000 visitors per day (either year-round or seasonally). <p style="text-align: center;">AND</p> <ol style="list-style-type: none">2a. If there are parking and drop-off/pick-up options that are not inherently simple enough to disseminate using static or DMS sign displays. <p style="text-align: center;">OR</p> <ol style="list-style-type: none">2b. If there are parking options and real-time parking availability information available for dissemination. <p style="text-align: center;">OR</p> <ol style="list-style-type: none">2c. If there are more than one primary access routes to the venue covered by the range of the HAR device (i.e. one HAR device would support all approaches vs. multiple signs being needed). <p><i>Partial Guideline Criteria:</i> If #2a, #2b, or #2c above are met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

HAR Guideline #3: Changing Traffic Conditions

Purpose:	To notify drivers in advance of special changing traffic conditions and roadway configurations such as those associated with road construction or maintenance, traffic incidents or recurring congestion.
Device should be considered if:	<p>1a. The candidate location is upstream of an area with traffic control changes (e.g. lane closure, crossover, contra flow) where travelers would benefit from a verbal explanation.</p> <p>OR</p> <p>1b. Where you want to redirect a significant portion of traffic, or convey a message to them.</p>

HAR Guideline #4: Special Events

Purpose:	To notify travelers about special events (either prior to the event start date or during the event), alerting travelers to the impacts of these events on traffic, and to guide event attendees to the event.
Device should be considered if:	<ol style="list-style-type: none">1. The temporary event is expected to attract more than 600 vehicles in any one hour period. AND2a. There is a route of travel for event attendees that creates considerably less impact on traffic than other approaches (i.e. if event attendees can be directed to this route it will minimize impacts). OR2b. There is an optional route for non-event traffic to avoid the impacts of this event. AND3. The message(s) that need to be relayed to the travelers are too complex to convey on a portable changeable or static sign (better relayed through spoken reports).

8.4 RWIS Planning Guidance

Road Weather Information Systems (RWIS) refer to in-field atmospheric and/or road weather monitoring devices that are capable of measuring conditions and reporting conditions back to a central server or a roadside device. RWIS are comprised of Environmental Sensor Stations (ESS) in the field.

Engineering judgment should be used to assess potential implications that may result from installation of RWIS. This planning guidance does not mandate the use of RWIS.

Three (3) guidelines have been identified to capture the most common uses of RWIS. While there are other purposes and uses for RWIS, the guidelines developed to date have focused on the following three.

RWIS Guideline #1: Support Traveler Safety and Mobility

Purpose: To provide site specific atmospheric and road surface condition reports to the agencies responsible for responding to weather events in order to promote safe travel and maintain travelers' mobility.

RWIS Guideline #2: Support Regional, Statewide, or Provincial Weather Monitoring

Purpose: To monitor weather and road surface conditions on a regional, statewide, or provincial grid in order to support wide area weather monitoring and/or modeling and weather prediction in support of snow and ice management activities.

RWIS Guideline #3: Support Traveler Information Systems Through RWIS at Key Locations

Purpose: To gather real-time data describing atmospheric weather and road surface conditions in order inform travelers of the conditions, either through pre-trip traveler information systems or through en-route information dissemination systems.

RWIS Guideline #1: Support Traveler Safety and Mobility

Purpose:	To provide site specific atmospheric and road surface condition reports to the agencies responsible for responding to weather events in order to promote safe travel and maintain travelers' mobility.
Device should be considered if:	<p>1a. The location surrounding the candidate site typically experiences 3 or more crashes related to weather events each year.</p> <p style="text-align: center;">OR</p> <p>1b. The location surrounding the candidate site has experienced crashes related to weather events above the typical crash rate or 1 or more fatalities per year in crashes occurring during weather events.</p> <p style="text-align: center;">OR</p> <p>1c. The location surrounding the candidate site is prone to weather events frequently causing difficult driving conditions (e.g. treacherous roads in winter storms, seasonal or storm related flooding, pockets of fog).</p> <p style="text-align: center;">AND</p> <p>2a. The number of weather events that would be measured and reported at the location is typically more than 10 per year.</p> <p style="text-align: center;">OR</p> <p>2b. The area surrounding the site experiences rare weather events that cause serious operational problems that often last multiple days (e.g. one major ice storm).</p> <p style="text-align: center;">AND</p> <p>3. There is not another weather and road surface monitoring station that provides access to the data.</p> <p>Note: <i>In using the guidelines, it is recommended that the agency research whether any other agencies (National Park System, National Weather Service, Department of Natural Resources, Department of Aviation) has weather and/or road condition monitoring stations and make the data publicly available.</i></p>

RWIS Guideline #2: Support Regional ,Statewide, or Provincial Weather Monitoring

Purpose:	To monitor weather and road surface conditions on a regional, statewide, or provincial grid in order to support wide area weather monitoring and/or modeling and weather prediction in support of snow and ice management activities.
Device should be considered if:	<p>1. The candidate region, state, or province typically encounters 10 or more inclement weather events each year.</p> <p style="text-align: center;">AND</p> <p>2a. The transportation agency responsible for maintenance in the region, state, or province has (or is planning) the ability to utilize grid weather reports (either manually or with the help of a decision support system) to influence their treatment of conditions.</p> <p style="text-align: center;">OR</p> <p>2b. The transportation agency responsible for traveler information in the region, state, or province operates (or is planning to operate) a region-wide traveler information system including weather reports throughout the area.</p> <p style="text-align: center;">AND</p> <p>3. The transportation agency responsible for maintenance and the agency responsible for traveler information in the region has examined and/or tested current perpetual data sources (e.g. NWS) and determined that these sources do not fully meet the needs for the region.</p>

RWIS Guideline #3: Support Traveler Information Systems Through RWIS at Key Locations

Purpose:	To gather real-time data describing atmospheric weather and road surface conditions in order inform travelers of the conditions, either through pre-trip traveler information systems or through en-route information dissemination systems.
Device should be considered if:	<p>1. The number of crashes occurring during weather events in the area surrounding the RWIS site (roughly 20 mile radius) is more than 5 per year.</p> <p style="text-align: center;">AND</p> <p>2. If there are unique geography conditions at the site that prohibit the prediction of accurate weather from such systems as NWS forecasts.</p> <p style="text-align: center;">AND</p> <p>3a. The area in consideration is prone to fog or other local (non regional) visibility restrictions (defined as 10 or more events per year where fog presents dangerous driving conditions).</p> <p style="text-align: center;">OR</p> <p>3b. The area in consideration is near an attraction or other draw (winter recreation area, college, resort area) that attracts visitors traveling at least 1 hour to reach the destination.</p> <p style="text-align: center;">OR</p> <p>3c. The area is along a regular commuter path.</p> <p style="text-align: center;">OR</p> <p>3d. The route does not have an alternate route.</p>

8.5 Variable Speed Limit Planning Guidance

For purposes of the ITS planning guidance process, Variable Speed Limit (VSL) devices are defined as a signs capable of displaying different speed limits to travelers (in which the speed limit is either a recommended or mandatory limit) that are either manually activated or controlled by a combination of detectors and algorithms to select appropriate speeds.

Engineering judgment should be used to assess potential implications that may result from installation of VSL. This planning guidance does not mandate the use of VSL.

Four (4) guidelines have been identified to capture the most common uses of Variable Speed Limit devices. While there are other purposes and uses for VSL, the guidelines developed to date have focused on the following four.

VSL Guideline #1: Maximize Capacity

Purpose: To maximize capacity by maintaining uniform travel speeds that are optimal for the current volume of traffic, and prevent the roadway system from becoming 'unstable' and reaching congested conditions.

VSL Guideline #2: Safe Stopping Distances

Purpose: To encourage travel at speeds that are conducive to stopping safely for stopped or slowed vehicles (e.g. crashes, stalls, other incidents).

VSL Guideline #3: Safe Travel Speeds for Conditions

Purpose: To maintain safe travel speeds during periods when road and/or driving conditions may be impacted.

VSL Guideline #4: Work Zones

Purpose: To post varying speed limits for construction zones in order to only slow traffic when necessary, or to maintain consistent travel speeds to promote safety.

VSL Guideline #1: Maximize Capacity

Purpose:	To maximize capacity by maintaining uniform travel speeds that are optimal for the current volume of traffic, and prevent the roadway system from becoming 'unstable' and reaching congested conditions.
Device should be considered if:	<ol style="list-style-type: none">1. The typical peak hour volume of the freeway corridor exceeds 1,100 vphpl. AND2. The route segment has a history of reduced travel speeds of 40 mph or less for a least one hour on typical days (55 mph posted speed). AND3. There is a regularly occurring speed differential of at least 10 mph of travel speed below the posted speeds between the upstream and downstream locations of the segment (e.g. a downstream bottleneck location has typical speeds that are slower than an upstream location). (1)

VSL Guideline #2: Safe Stopping Distances

Purpose:	To encourage travel at speeds that are conducive to stopping safely for stopped or slowed vehicles (e.g. crashes, stalls, other incidents).
Device should be considered if:	<ol style="list-style-type: none">1. The freeway peak hour volume exceeds 1100 vphpl. AND2. The rear end, lane-change, or side-swipe crash rate for the segment is higher than expected for the local area. AND3. It has been observed that there is a significantly higher rate of secondary crashes on the candidate segment than other similar roadway segments. AND4. There is a regularly occurring significant speed differential of at least 10 mph of travel speeds below posted speeds between the upstream and downstream locations of the segment (e.g. a downstream bottleneck location has typical speeds that are slower than an upstream location). (1)

VSL Guideline #3: Safe Travel Speeds for Conditions

<p>Purpose:</p>	<p>To maintain safe travel speeds during periods when road and/or driving conditions may be impacted.</p>
<p>Device should be considered if:</p>	<ol style="list-style-type: none"> 1. The area in consideration is a segment or corridor (typically a minimum of 2 miles or longer) and not an isolated spot location (such as a bridge or a vertical curve) where other technologies may be more appropriate. <p style="text-align: center;">AND</p> <ol style="list-style-type: none"> 2a. The area regularly experiences adverse conditions (e.g. snow, water on the road, fog, wind, blowing snow, animal migrations) that result in traffic congestion, slow downs, low visibility or safety hazards for travelers. <p style="text-align: center;">OR</p> <ol style="list-style-type: none"> 2b. The area experiences rare conditions that result in traffic issues, but the resulting traffic issues are known to impact large numbers of vehicles (e.g. locations with crashes that occur every 1-2 years but results in incidents, impacting numerous vehicles). <p style="text-align: center;">OR</p> <ol style="list-style-type: none"> 2c. The geography or geometry of the area pose a known risk for traffic issues when traveled by vehicles at varying travel speeds. <p style="text-align: center;">AND</p> <ol style="list-style-type: none"> 3. The critical crash rate for the segment or corridor is higher than expected for similar segments within the state, based upon the judgment of local engineers. For example: is the stretch of road a known location for high crash rates. <p style="text-align: center;">AND</p> <ol style="list-style-type: none"> 4. The area experiences regular speed differentials of at least 10 mph of travel speeds between drivers that are believed to contribute to crashes. (Speed differentials may be due to vehicles traveling slow for various reasons (e.g. commercial vehicles with chains limiting speed, cautious or unfamiliar drivers traveling considerably slower than other drivers), weather conditions that may not be obvious to all travelers (black ice, freezing conditions, water on the roadway, fog, heavy winds, blowing dust), or other factors). (1)

VSL Guideline #4: Work Zones

Purpose:	To post varying speed limits for construction zones in order to only slow traffic when necessary, or to maintain consistent travel speeds to promote safety.
Device should be considered if:	<ol style="list-style-type: none"><li data-bbox="407 438 1414 648">1. The schedule of the construction activities being performed AND the design of the work zone are such that the vehicles are not required to be slowed to the same speed 24 hours per day. For example, if vehicles are slowed to a speed during the day when workers are present, but when work is not occurring the absence of workers and layout of the construction zone (lane width, geometries, structure) would allow higher speeds. <p data-bbox="456 688 493 716">OR</p> <ol style="list-style-type: none"><li data-bbox="407 762 1403 863">2. The construction zone already exists and there is a noticeable differential in the speed of vehicles as they progress through the work zone (where travelers would benefit from slowing earlier). <p data-bbox="407 905 1370 1005">Note: Many locations include additional fines for speeding in work zones, and the design of any variable speed limit system must consider this aspect before determining if variable speed systems are appropriate for work zones.</p>

8.6 Dynamic Speed Display Signs Planning Guidance

For the purposes of the ITS planning guidance process, Dynamic Speed Display Signs (DSDS) are defined as permanent or temporary signs that detect and display a vehicle's current speed to the driver, often the speed display indicates if the vehicle is exceeding the speed limit. Dynamic Speed Display Signs are also commonly referred to as 'Your speed is' signs, or 'Driver Feedback Signs'.

Engineering judgment should be used to assess potential implications that may result from installation of DSDS. This planning guidance does not mandate the use of DSDS.

Three (3) guidelines have been identified to capture the most common uses of Dynamic Speed Display Signs (DSDS) devices. While there are other purposes and uses for DSDS, the guidelines developed to date have focused on the following three.

DSDS Guideline #1: Transition Zones

Purpose: To promote speed limit adherence in locations of speed limit reduction zones.

DSDS Guideline #2: Posted Speed Adherence

Purpose: To promote speed limit adherence in locations prone to vehicles exceeding the posted speed limit.

DSDS Guideline #3: Intelligent Work Zones

Purpose: To promote speed adherence in locations where posted speeds have temporarily been reduced for construction, maintenance or other traffic control.

DSDS Guideline #1: Transition Zones

Purpose:	To promote speed limit adherence in locations of speed limit reduction zones.
Device should be considered if:	<ol style="list-style-type: none">1. The 85th percentile speed (as determined by a speed study) at a location within the lower speed limit area exceeds the posted speed limit by at least 10 mph. (2) AND2. The zone experiences a posted speed limit reduction of at least 10 mph. AND3. There are no other Dynamic Speed Display Signs along the route encountering the speed transition, within 5 miles in either direction (excluding DSDS within school zones). (3) <p>Note: Signs tend to be most effective where there are two lanes or less in one direction of travel.</p>

DSDS Guideline #2: Posted Speed Adherence

Purpose:	To promote speed limit adherence in locations prone to vehicles exceeding the posted speed limit.
Device should be considered if:	<ol style="list-style-type: none">1. The 85th percentile speed (as determined by a speed study) exceeds the posted speed limit by at least 10 mph, or by at least 5 mph in a school zone. (4) (2) <p style="text-align: center;">AND</p>2a. The area is within 500 yards of a major pedestrian generator (e.g. school, park, library, senior center, office building). (5) <p style="text-align: center;">OR</p>2b. The area is primarily a residential area or a heavily traveled pedestrian area. (5) <p style="text-align: center;">AND</p>3. The posted speed limit is 35 mph or less. (4) <p style="text-align: center;">AND</p>4. There are no other Dynamic Speed Display Signs along the route within a 5 mile in either direction of the proposed sign (excluding DSDS within school zones). (3) <p>Note: Signs tend to be most effective where there are two lanes or less in one direction of travel.</p>

DSDS Guideline #3: Intelligent Work Zones

Purpose:	To promote speed adherence in locations where posted speeds have temporarily been reduced for construction, maintenance or other traffic control.
Device should be considered if:	<ol style="list-style-type: none">1. The work zone is currently in operation and observations suggest that the 85th percentile speed at a location within the work zone exceeds the posted speed limit by at least 10 mph. <p>OR</p> <ol style="list-style-type: none">2. The work zone area includes hazardous roadway conditions, such as a temporary unusually tight curve, or a rough road surface, requiring extra driving precaution. <p>Note: Signs tend to be most effective where there are two lanes or less in one direction of travel.</p>

8.7 Ramp Meter Planning Guidance

Ramp Meters are defined by the Manual on Uniform Traffic Control Devices as traffic control signals that control the flow of traffic entering a freeway facility.

The planning guidelines for ramp meters are presented as one tool to assist agencies in selecting deployment locations, and are not a replacement for the planning or design process. Also, prior to deploying a ramp meter System, ensure the basic requirements of the MUTCD (2009 Edition Chapter 4I. Traffic Control Signals for Freeway Entrance Ramps) have been met at the location of concern.

Engineering judgment should be used to assess potential implications that may result from installation of ramp meter. This planning guidance does not mandate the use of ramp meters.

Three (3) guidelines have been identified to capture the most common uses of Ramp Meters. While there are other purposes and uses for Ramp Meters, the guidelines developed to date have focused on the following three.

- Ramp Meter Guideline #1: Corridor-wide Freeway Traffic Management**
Purpose: To address the need for a 'zone' of Ramp Meters along a stretch of freeway (typically considered in 3-6 mile segments).
- Ramp Meter Guideline #2: Localized Freeway Traffic Issues**
Purpose: To address the need for an isolated Ramp Meter deployment, that is not part of an overall corridor ramp metering approach.
- Ramp Meter Guideline #3: Work Zone Activity**
Purpose: To meter on-ramp traffic during road work activities to improve safety and/or consistent traffic flow.

Ramp Meter Guideline #1: Corridor-wide Freeway Traffic Management

Purpose:	To address the need for a ‘zone’ of Ramp Meters along a stretch of freeway (typically considered in 3-6 mile segments).
Device should be considered if:	<p>1a. <i>Control Factors.</i> During the AM or PM Peak Period, the Zone in consideration has at least 30 minutes per commute day (measured in 5 minute increments) where the demand is equal to or exceeds 95% of the downstream capacity, according to the following equation?</p> $MV + OR > (ER + MC) * .95$ <p>Where: MV = Upstream Mainline Volume (in veh/5 min.) OR = The sum of On-Ramp volumes of ramps within the zone (in veh/5 min.) ER = The sum of Exit Ramp Volumes within the zone (in veh/5 min.) MC = Downstream Mainline Capacity (in veh/5 min.)</p> <p>OR</p> <p>1b. Platoons from signalized intersections are recognized to adversely impact <i>ALL</i> on-ramps feeding the freeway segment under consideration. For example if hourly volume, based on maximum 30 second volume readings projected to hourly volumes, exceed 1100 vph. (regardless of overall hourly volume).</p> <p><i>Note: Overall hourly volume entering from arterials may be relatively low (e.g. 700 vph. However, during periods when platoons arrive, if 30 second readings of volumes represent 1100 vph or greater, this factor is considered met.</i></p> <p>AND</p> <p>2. <i>Safety Factors.</i> There is one or multiple area(s) within the zone where crashes are understood to exceed the typical crash rate (at the ramp gore point or within 500 feet in either direction of the gore point) for the metropolitan area. (6)</p> <p>AND</p> <p>3. <i>Functionality Factors.</i> Volumes at ramps being considered for meters, within the zone, fall within the range of 240 – 900 vphpl during peak periods. (7)</p>

Ramp Meter Guideline #2: Localized Freeway Traffic Issues¹

<p>Purpose:</p>	<p>To address the need for an isolated Ramp Meter deployment, that is not part of an overall corridor ramp metering approach.</p>
<p>Device should be considered if:</p>	<p>1a. The freeway operates at speeds less than 50 mph for a duration of at least 30 minutes for 200 or more calendar days per year. (6)</p> <p>OR</p> <p>1b. There is a high frequency of crashes (collision rate along the freeway exceeds mean collision rate in the subject metropolitan area) near the freeway entrances because of inadequate merge area or congestion? (6)</p> <p>OR</p> <p>1c. The ramp meter will contribute to maintaining a specific level of service (LOS) identified in local transportation plans and policies. (6)</p> <p>OR</p> <p>1d. The ramp meter will contribute to maintaining a higher level vehicle occupancy through the use of HOV preferential treatments as identified in the region's transportation system management (TSM) plan. (6)</p> <p>OR</p> <p>1e. The ramp meter will contribute to balancing demand and capacity at a system of adjacent ramps entering the same freeway facility. (6)</p> <p>OR</p> <p>1f. The ramp meter will mitigate predictable sporadic congestion on isolated sections of freeway because of short peak period loads from special events or from severe peak loads of recreational traffic. (6)</p> <p>AND</p> <p>2a. The Total Mainline-Ramp Design Hour Volume (mainline volume plus ramp volume) exceeds the following: (8)</p> <ul style="list-style-type: none"> • Two mainline lanes in one direction – 2,650 (vph); • Three mainline lanes in one direction – 4,250 vph;

¹ The majority of the localized freeway traffic issues guideline was originally developed by ITS Engineering and Constructors, Inc. on behalf of Arizona Department of Transportation, published as 'Ramp Meter Design, Operations, and Maintenance Guidelines'.

	<ul style="list-style-type: none"> • Four mainline lanes in one direction – 5,850 vph; • Five mainline lanes in one direction – 7,450 vph; • Six mainline lanes in one direction – 9,050 vph. <p>OR</p> <p>2b. The total volume of the sum of traffic in the right most lane and the ramp exceed 2100 vph during the design hour. (8)</p> <p>OR</p> <p>2c. Platoons from signalized intersections are recognized to adversely impact the ramp in consideration. If hourly volume, based on maximum 30 second volume readings projected to hourly values, exceed 1100 vph. (regardless of overall hourly volume). (9)</p> <p><i>Note: Overall hourly volume entering from arterials may be relatively low (e.g. 700 vph). However, during periods when platoons arrive, if 30 second readings of volumes represent 1100 vph or greater, this factor is considered met.</i></p> <p>AND</p> <p>3. <i>Functionality Factors.</i> Volumes at ramps being considered for meters fall within the range of 240 – 900 vphpl during peak periods. (7)</p> <p>Note: <i>The length and geometry of the ramp is a factor in the final decision of whether to deploy a ramp meter. The current guideline for ramp meters does not address this factor, as it is believed the analysis of the ramp will be a part of the preliminary and final design. The focus of the guideline is on whether or not a ramp meter is needed, not on whether a ramp meter can be designed at the location, as that would be determined during the design process.</i></p>
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Ramp Meter Guideline #3: Work Zone Activity

Purpose:	To meter on-ramp traffic during road work activities to improve safety and/or consistent traffic flow.
Device should be considered if:	<p>1a. <i>Capacity Factors</i>. There is a temporary reduction in capacity of through lanes due to either a reduction in the number of lanes, or a reduction in the width of lanes of traffic, causing a backup of traffic during peak periods.</p> <p>OR</p> <p>1b. <i>Geometric Factors</i>. There is a temporary change in the geometry or length of the acceleration lane that will potentially have a negative impact on ramp traffic merging with the mainline traffic.</p> <p>OR</p> <p>1c. <i>Behavior Factors</i>. There is a desire to discourage the use of the ramp during the period of road work.</p>

8.8 Curve Warning System Planning Guidance

Curve Warning Systems are defined as a collection of devices deployed with the goal of reducing vehicle crashes and roadway departures within horizontal curves. Technology devices may include real-time warning signs triggered by vehicle factors (e.g. speed, height, weather) and/or roadway conditions (snow, ice, and rain) at approaches to sharp curves.

The planning guidelines for curve warning systems are presented as one tool to assist agencies in selecting deployment locations, and are not a replacement for the planning or design process. Also, prior to deploying a Curve Warning System, ensure the basic requirements of the MUTCD ([2009 Edition Chapter 2C. Warning Signs and Object Markers](#)) have been met at the location of concern.

Engineering judgment should be used to assess potential implications that may result from installation of Curve Warning Systems. This planning guidance does not mandate the use of Curve Warning Systems.

Three (3) guidelines have been identified to capture the most common uses of Curve Warning System Devices. While there are other purposes and uses for Curve Warning Systems, the guidelines developed to date have focused on the following three.

Curve Warning System Guideline #1: Rural Two-Lane Highway Curves

Purpose: To provide additional warnings beyond static advisory curve warning signs to warn drivers of actions required to reduce risks associated with rural two lane curves.

Curve Warning System Guideline #2: High Risk Locations

Purpose: To influence driver behavior in horizontal curves where an excessive level of crashes are occurring.

Curve Warning System Guideline #3: Truck Rollovers on Ramps/Curves

Purpose: To influence the behavior of commercial vehicle operators driving on ramps/curves.

Curve Warning System Guideline #1: Rural Two-Lane Highway Curves

Purpose:	To provide additional warnings beyond static advisory curve warning signs to warn drivers of actions required to reduce risks associated with rural two lane curves.
Device should be considered if:	<p>1. The Radius of Curvature is less than 1,000 ft. <i>Research conducted by Texas Transportation Institute found the risk of crashes on curves increases significantly when the radius of curvature is less than 1,000ft.</i> (10)</p> <p style="text-align: center;">AND</p> <p>2a. The horizontal curve is considered part of a visual trap (i.e. the beginning of the horizontal curve immediately follows a vertical curve and is hidden from the line of sight, or where the main road curves but a minor road (and sometimes utility lines) continue on the tangent). (11)</p> <p style="text-align: center;">OR</p> <p>2b. There is an observed pattern of vehicles entering the curve at speeds that are faster than safe speeds. For example, the 85th percentile speed exceeds the recommended or posted speed limit.</p> <p style="text-align: center;">OR</p> <p>2c. There are typically 2 or crashes on the curve each year. (12)</p> <p style="text-align: center;"><i>Note: if there has been at least one crash in the last year on the horizontal curve, a lower technology solution may be appropriate. Freeborn County (Minnesota) Safety Study identified high risk curves to have a combination of a visual trap, a low radius of curvature and at least one previous crash.</i> (11)</p> <p style="text-align: center;">AND</p> <p>3. The highway is a 2-lane highway (1 lane each direction). (11)</p> <p style="text-align: center;">AND</p> <p>4a. The Speed Limit on the Highway is 55 MPH or greater. (11)</p> <p style="text-align: center;">OR</p> <p>4b. The Speed Differential (difference between the regulatory speed limit and the advisory speed limit) is 25 MPH or greater. (10)</p>

Curve Warning System Guideline #2: High Risk Locations

<p>Purpose:</p>	<p>To influence driver behavior in horizontal curves where an excessive level of crashes are occurring.</p>
<p>Device should be considered if:</p>	<p>1a. <i>Crash Rate Factor</i>. The Crash Rate (crashes per million vehicle miles traveled) within the vicinity of the curve exceeds 1 crash per million vehicle miles traveled, when computed over a 3 year period.</p> <p style="padding-left: 40px;">Calculation: $CR = (\# \text{ of crashes} * 10^6) / (\text{Length} * \text{ADT} * 365 \text{Days} * 3 \text{ years})$. (13)</p> <p style="text-align: center;">OR</p> <p>1b. The Curve has been identified as a location with a high probability for crashes, using the locally accepted crash analysis (e.g. one of the top 10 locations in the state most prone to curve related accidents, or on a list of areas most prone to crashes).</p> <p style="text-align: center;">AND</p> <p>2a. <i>Speed Factor</i>. The number of vehicles that has been observed to enter the curve at speeds that are considered unsafe is more than expected, based on the judgment of local engineers. (e.g., high profile vehicles entering rural curves at speeds believed to be unsafe the 85th percentile speed exceeds the recommended or posted speed).</p> <p style="text-align: center;">OR</p> <p>2b. There is evidence of near misses and/or rapid deceleration either within the curve or in the approach to the curve. (e.g. pavement skid marks, scrapes along guard rails)</p>

Curve Warning System Guideline #3: Truck Rollovers on Ramps/Curves

Purpose:	To influence the behavior of commercial vehicle operators driving on ramps/curves.
Device should be considered if:	<p>1. <i>Crash Frequency Factor.</i> The ramp/curve has a history of at least one truck rollover crash every 5 years. (12)</p> <p>OR</p> <p>1b. <i>Crash Impact Factor.</i> The roadway geometry, traffic pattern, or location of the ramp/curve is in a location where a rollover would have an unusually large impact, either to the driver of the vehicle or to other drivers or the local network.</p> <p>AND</p> <p>2a. <i>Speed Factor.</i> Vehicles have been observed to enter the ramp/curve at speeds that are unsafe. (e.g. trucks entering ramps at unsafe speeds).</p> <p>OR</p> <p>2b. There is evidence of near misses and/or rapid deceleration either within the ramp/curve or in the approach to the ramp/curve. (e.g. pavement skid marks, scrapes along guard rails)</p>

8.9 Intelligent Work Zone Planning Guidance

Intelligent Work Zones are defined as a collection of planning guidelines from other devices (DMS, CCTV, HAR, VSL, DSDS, Ramp Meter) that collectively warn travelers of various hazards associated with work zones.

Engineering judgment should be used to assess potential implications that may result from installation of intelligent work zones devices. This planning guidance does not mandate the use of intelligent work zones.

Six (6) guidelines have been identified to capture the most common uses of Intelligent Work Zone Devices from the other device guidelines that have been developed. For example, the VSL guidelines includes one purpose focused on work zones. Therefore this guideline (VSL Planning Guideline #4: Work Zones) is included in the collection of purposes for Intelligent Work Zones. While there are other purposes and uses for Intelligent Work Zones as well as existing system components to consider, the guidelines developed to date have focused on the following six.

DMS Guideline #3:	Changing Traffic or Control Conditions Purpose: To notify drivers in advance of special changing traffic conditions and roadway configuration changes associated with road construction or maintenance in order to reduce driver confusion that could result in a crash.
CCTV Guideline #6:	Intelligent Work Zone Purpose: To allow travelers or transportation professionals to understand construction or maintenance traffic delay by viewing images of the roadway remotely.
HAR Guideline #3:	Changing Traffic Conditions Purpose: To notify drivers in advance of special changing traffic conditions and roadway configurations associated with road construction or maintenance.
VSL Guideline #4:	Work Zones Purpose: To post varying speed limits for construction zones in order to only slow traffic when necessary, or to maintain consistent travel speeds to promote safety.
DSDS Guideline #3:	Intelligent Work Zones Purpose: To promote speed adherence in locations where posted speeds have temporarily been reduced for construction, maintenance or other traffic control.
Ramp Meter Guideline #3:	Work Zone Activity Purpose: To meter on-ramp traffic during road work activities to improve safety and/or consistent traffic flow.

DMS Guideline #3: Changing Traffic Control or Conditions

Purpose:	To notify drivers in advance of special changing traffic conditions and roadway configuration changes associated with road construction or maintenance in order to reduce driver confusion that could result in a crash.
Device should be considered if:	<ol style="list-style-type: none">1. The candidate location is upstream of an area with construction or maintenance activities that are expected to cause at least 15 minutes of delay to the mainline traffic.<p style="text-align: center;">AND</p>2. If the candidate location is upstream of traffic control or construction/maintenance activities that are expected to change more frequently than once every 60 days.<p style="text-align: center;">AND</p>3. If the posted work zone speed limit is greater than 45 MPH. <p>Notes:</p> <ol style="list-style-type: none">A. <i>If question #2 is not met (activities do not change frequently), lower cost static signage is recommended.</i>B. <i>Portable DMS vs. permanent DMS should be considered based on the expected duration of events impacting the area.</i> <p>Partial guideline Criteria:</p> <p>If #2 above is met, the guideline is considered 'Partially Met'. If one or more additional purposes are partially met at this location for this device, the device should be considered.</p>

CCTV Guideline #6: Intelligent Work Zone

Purpose:	To allow travelers or transportation professionals to understand construction or maintenance traffic delay by viewing images of the roadway remotely.
Device should be considered if:	<p>1a. The alignment or traffic control that is visible by a camera image is expected to change periodically during the construction period.</p> <p>OR</p> <p>1b. The construction zone encounters periods of queues or delays for at least 30 minutes each day.</p> <p>AND</p> <p>2. The construction zone is in a location where there is not a convenient alternate route for the majority of traffic to deviate from the typical route.</p> <p>Guideline Advice: Consideration should be given to temporary/portable cameras in work zone areas.</p>

HAR Guideline #3: Changing Traffic Conditions

Purpose:	To notify drivers in advance of special changing traffic conditions and roadway configurations such as those associated with road construction or maintenance, traffic incidents or recurring congestion.
Device should be considered if:	<ol style="list-style-type: none">1. The candidate location is upstream of an area with traffic control changes (e.g. lane closure, crossover, contra flow) where travelers would benefit from a verbal explanation; <p style="text-align: center;">OR</p> <ol style="list-style-type: none">2. Where you want to redirect a significant portion of traffic, or convey a message to them.

VSL Guideline #4: Work Zones

Purpose:	To post varying speed limits for construction zones in order to only slow traffic when necessary, or to maintain consistent travel speeds to promote safety.
Device should be considered if:	<ol style="list-style-type: none"><li data-bbox="407 438 1417 648">1. The schedule of the construction activities being performed AND the design of the work zone are such that the vehicles are not required to be slowed to the same speed 24 hours per day. For example, if vehicles are slowed to a speed during the day when workers are present, but when work is not occurring the absence of workers and layout of the construction zone (lane width, geometries, structure) would allow higher speeds. <p data-bbox="456 688 493 716">OR</p> <ol style="list-style-type: none"><li data-bbox="407 762 1403 863">2. The construction zone already exists and there is a noticeable differential in the speed of vehicles as they progress through the work zone (where travelers would benefit from slowing earlier). <p data-bbox="407 905 1370 1005">Note: Many locations include additional fines for speeding in work zones, and the design of any variable speed limit system must consider this aspect before determining if variable speed systems are appropriate for work zones.</p>

DSDS Guideline #3: Intelligent Work Zones

Purpose:	To promote speed adherence in locations where posted speeds have temporarily been reduced for construction, maintenance or other traffic control.
Device should be considered if:	<p>1a. The work zone is currently in operation and observations suggest that the 85th percentile speed at a location within the work zone exceeds the posted speed limit by at least 10 mph.</p> <p>OR</p> <p>1b. Hazardous roadway conditions, such as a temporary unusually tight curve, or a rough road surface, requiring extra driving precaution.</p> <p>Note: Signs tend to be most effective where there are two lanes or less in one direction of travel.</p>

Ramp Meter Guideline #3: Work Zone Activity

Purpose:	To meter on-ramp traffic during road work activities to improve safety and/or consistent traffic flow.
Device should be considered if:	<p>1a. <i>Capacity Factors</i>. There is a temporary reduction in capacity of through lanes due to either a reduction in the number of lanes, or a reduction in the width of lanes of traffic, causing a backup of traffic during peak periods.</p> <p>OR</p> <p>1b. <i>Geometric Factors</i>. There is a temporary change in the geometry or length of the acceleration lane that will potentially have a negative impact on ramp traffic merging with the mainline traffic.</p> <p>OR</p> <p>1c. <i>Behavior Factors</i>. There is a desire to discourage the use of the ramp during the period of road work.</p>

8.10 Intersection Conflict Warning System Planning Guidance

Intersection Conflict Warning Systems are defined as a traffic control device placed on major, minor or both roads of an intersection to provide drivers with a real-time, dynamic warning of vehicles approaching or waiting to enter the intersection. ICWS are typically installed to address crash factors associated with limited sight distance and poor gap selection at stop-controlled intersections.

Initial Guidance:

- This planning guidance provides guidance for the use of an ICWS device, regardless of the device configuration. If an ICWS is considered, the device configuration will be selected by the engineer. (Note: Design guidance for ICWS developed by ENTERPRISE and other relevant resources can be found at: [Design and Evaluation Guidance for Intersection Conflict Warning Systems.](#))
- This planning guidance does not mandate the use of ICWS. ICWS is one of several safety treatments that may be considered to improve safety at intersections.
- ICWS 1- Intersections with High Crash Frequencies or Rates (Reactive Approach) and ICWS-2 – Intersection Characteristics (Proactive Approach) may be used together or as stand-alone approaches for consideration of ICWS. Intersections meeting planning guidance criteria may not necessarily be selected for deployment of ICWS; these could be used to help agencies prioritize intersections for ICWS deployment.
- To optimize the effectiveness of ICWS by reducing the likelihood of continuous alert activation, the following maximum ADT volumes should be considered.
 - Major Road ADT typically does not exceed 12,000. (17)
 - Minor Road ADT typically does not exceed 3,000. (17)
- Engineering judgment should be used to assess potential implications that may result from installation of ICWS at candidate intersections.

Two (2) guidelines have been identified to capture the most common uses of ICWS. While there are other purposes and uses for ICWS as well as existing system components to consider, the guidelines developed to date have focused on the following two.

ICWS Guideline #1:	Intersections with High Crash Rates Frequencies or Rates (Reactive Approach) Purpose: To influence driver behavior at stop-controlled intersections (typically 45 mph or greater posted speed on the major road) where right-angle crashes are the predominant crash type.
ICWS Guideline #2:	Intersection Characteristics (Proactive Approach) Purpose: To influence driver behavior at stop-controlled intersections (typically 45 mph or greater posted speed on the major road) where conditions are such that the intersection could be susceptible to right-angle crashes.

ICWS Guideline #1: Intersections with High Crash Rates (Reactive Approach)

Purpose:	To influence driver behavior at stop-controlled intersections (typically 45 mph or greater posted speed on the major road) where right-angle crashes are the predominant crash type.
Device should be considered if:	<p>1. Crashes or Crash Rate at the intersection are higher than expected over a 5-year period for a region, with agency-specific thresholds as determined by using one of the following:</p> <p style="margin-left: 40px;">a) The 5-year Crash Rate (per million entering vehicles) is higher than an agency-defined threshold for the Average Crash Rate in a region.</p> $\text{Crash Rate} = \frac{N \times 10^6}{(\sum \text{ADT}) \times 5 \text{ years} \times 365 \text{ days (22)}}$ <p style="margin-left: 40px;">Where, N = the total number of crashes at the intersection during a 5-year period $\sum \text{ADT}$ = the sum of average daily traffic entering the intersection</p> <p style="margin-left: 40px;">OR</p> <p style="margin-left: 40px;">b) The total number of crashes over a 5-year period exceeds an agency-defined threshold that is higher than expected in a region.</p> <p>AND</p> <p>2. One or both of the following conditions is observed at the intersection:</p> <p style="margin-left: 40px;">a) Limited sight distance</p> <p style="margin-left: 80px;">AND/OR</p> <p style="margin-left: 40px;">b) Poor gap acceptance for the minor road driver is observed at the site (e.g. actual crashes and/or near misses)</p>

ICWS Guideline #2: Intersection Characteristics (Proactive Approach)

<p>Purpose:</p>	<p>To influence driver behavior at stop-controlled intersections (typically 45 mph or greater posted speed on the major road) where conditions are such that the intersection could be susceptible to right-angle crashes.</p>
<p>Device should be considered if:</p>	<ol style="list-style-type: none"> 1. One or both of the following conditions is observed at the intersection: <ol style="list-style-type: none"> a) Limited sight distance <p style="text-align: center;">AND/OR</p> <ol style="list-style-type: none"> b) Poor gap acceptance for the minor road driver is observed at the site (e.g. actual crashes and/or near misses) <p style="text-align: center;">AND</p> <ol style="list-style-type: none"> 2. One or more of the following conditions are present at the intersection. These conditions have been found to be associated with a higher frequency of right-angle crashes at stop-controlled intersections. (18) The combination of conditions present at the intersection should be assessed using engineering judgment. <ul style="list-style-type: none"> • The intersection skew angle is greater than 15 degrees. (18) • A horizontal curve and/or vertical curve is present at the intersection. (18) (19) • A railroad crossing is present on one of the minor leg approaches to the intersection. (20) • Commercial development is present in one or more of the intersection quadrants. (21) • The minor leg approach does not have a STOP sign within 5 miles prior to the intersection. (22) • Crashes or Crash Rate at the intersection are trending higher than expected over a 5-year period for a region.

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