Oregon DOT Weather-Responsive Active Traffic Management

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ABSTRACT

The Oregon Department of Transportation (ODOT) is deploying a standardized variable speed system based on real-time weather and traffic data. The primary goal is to improve safety in high crash locations.

Variable speeds can be set by current weather conditions, traffic congestion, or manually by an operator. Depending on the site specific needs, any or all of these controls can be used independently. The weather responsive system uses current chain-up requirements and data from roadway weather sensors measuring roadway grip factor, surface condition classification, and visibility to set an appropriate speed and post advisory messages on VMS.

The first variable speed system in Oregon is being completed on an urban freeway in the Portland area. Design is in progress for a variable speed system on two rural highways through the popular Mt. Hood winter recreation area. Planning work is complete for a rural freeway across a mountain pass in Southern Oregon and a rural highway in Central Oregon.

BACKGROUND

The Oregon Department of Transportation (ODOT) is currently creating a statewide variable speed system that can cater to all highway types throughout Oregon. The primary goal of the system is to provide an engineering solution that improves safety in locations where there is an increase in crashes resulting from weather and/or congestion. Many independent variable speed systems are currently or soon will be in operation throughout Oregon. As more projects are being planned, ODOT wishes to create one system that can process real-time data and provide an automated response appropriate for the measured condition, independent of location.

The statewide variable speed system is composed of three subsystems: congestion responsive, weather responsive, and operator control (Figure 1). These subsystems work together to determine the appropriate speed to display on every sign in a variable speed corridor. Real-time data is required to operate a variable speed system.

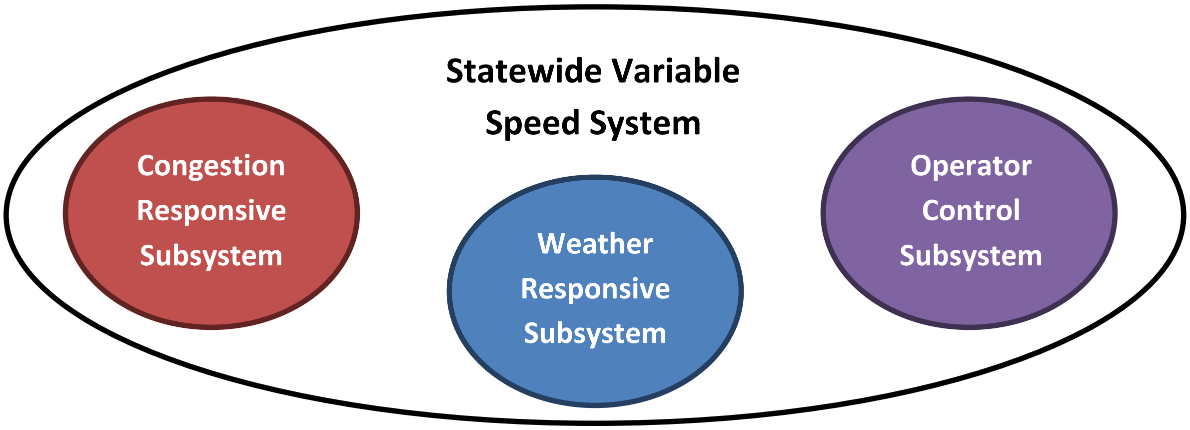

Figure 1: Statewide Variable Speed System Overview

The **weather responsive subsystem** uses data from a device that provides grip factor (relative friction of the roadway), visibility, and roadway surface classification. Using these three factors along with any current chain-up conditions, an appropriate weather speed and advisory message is generated.

The **congestion responsive subsystem** uses average traffic speeds and volumes that are collected via inductive loops and radar on intervals as small as 20 seconds. From this data, 85^{th} percentile speeds are estimated to determine an appropriate congestion speed to display.

The **operator control subsystem** allows an operator to manually choose a speed to be displayed. When a speed is chosen, a command priority of absolute or recommended speed must be selected. Absolute speeds ignore all other speeds being generated by other subsystems. Recommended speeds display the slowest speed from any of the subsystems. Pre-determined responses for ten scenarios are provided detailing situations and the corresponding speed that an operator can implement. Additional pre-determined responses may be created later but require approval from the state traffic engineer.

When multiple subsystems are generating speed messages for a single sign, the message with the lowest speed value will be displayed unless there is a speed being generated from the operator control system with a command priority of absolute. For the purposes of this paper, we will primarily focus on the weather responsive subsystem.

WEATHER RESPONSIVE VARIABLE SPEED SYSTEM

Weather responsive variable speed systems are most appropriate in locations that experience these conditions:[1]

- Adverse weather conditions with traffic problems, slowdowns, or safety hazards
- Higher than expected crash rates
- Regularly occurring safe speed requirements at least 10 mph below the posted speed
- Conditions where stopping distance exceeds the sight distance

The goal of a weather responsive variable speed system is to improve safety and mobility throughout the corridor and maintain smooth flow during unfavorable weather conditions by notifying drivers of adverse weather and road conditions. Even when adverse weather conditions are detected by drivers, knowing a safe operating speed for conditions is not always apparent.

Weather Sensors and Placement

To detect an adverse weather or roadway condition, weather sensors must be installed on the corridor. Roadway weather sensors should be installed in a location where they can accurately measure roadway conditions, in an area representative of the local climate, in an area that does not require a lane closure for maintenance access, and should have suitable power and communications. The primary purpose of the weather sensors is to measure the level of grip of the roadway surface (also called grip factor), roadway surface classification, and visibility. These measurements will be used by the weather responsive variable speed system to change speeds. For evaluation and fine-tuning, additional weather variables may be measured including air temperature and rainfall intensity.

In corridors that span many miles, it may not be practical to locate a weather sensor in every variable speed segment. Typically, the weather sensor located the shortest distance away from each segment will be assigned to that segment but this may vary due to items such as localized weather conditions and elevation. Figure 2 shows an example of a variable speed corridor with the relationship between weather sensors and signs. A corridor with consistent weather conditions should have weather stations every 20 to 30 miles; however, a corridor with significant elevation changes or varying weather conditions could require weather sensors installed every few miles. At a minimum, two weather sensors should be installed per variable speed corridor to provide redundancy should one weather sensor fail.

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[1] *Guidelines for the Use of Variable Speed Limit Systems in Weather*. Federal Highway Administration, Safety Program, Aug. 2012.

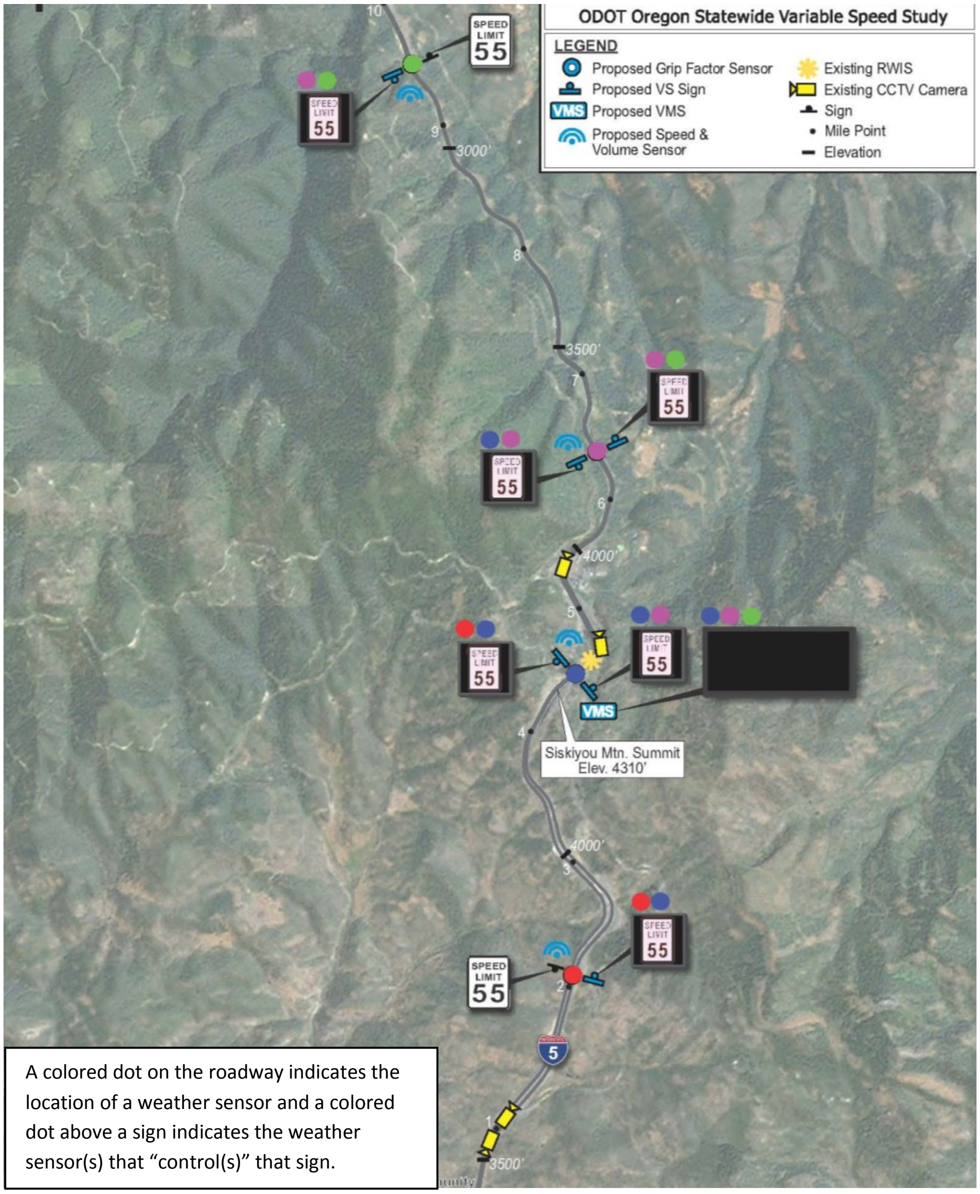


Figure 2: Example of Weather Sensor and Sign Relationships

Weather-Responsive Logic

The weather responsive variable speed subsystem will activate during times of adverse weather conditions. To notify drivers of adverse weather conditions, the weather responsive variable speed subsystem will produce messages to be displayed on the variable speed signs and the variable message signs located throughout the corridor. In order to produce a message, an unfavorable weather or roadway condition must be detected. The detection and responsive decision logic is illustrated in Figure 3.

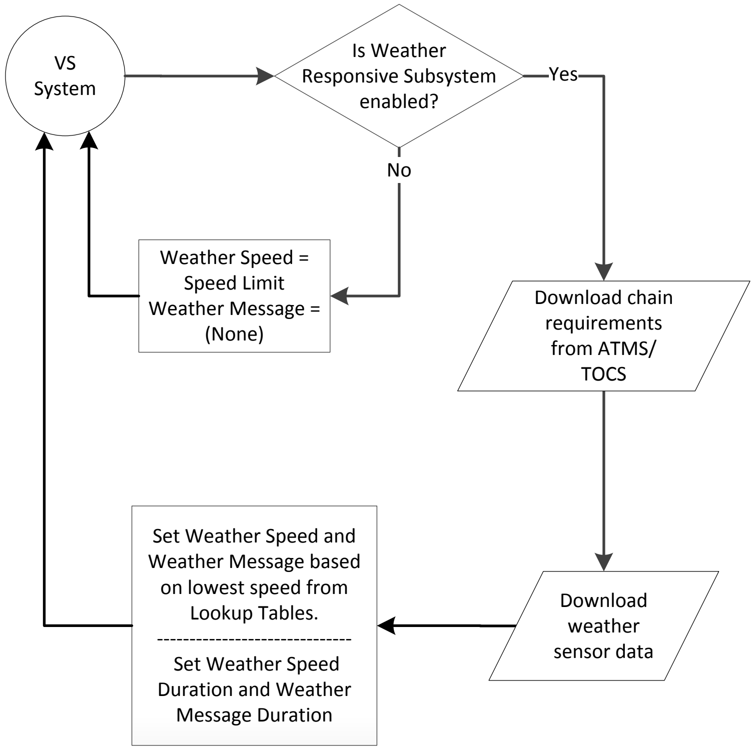
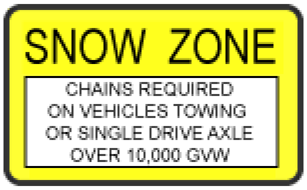


Figure 3: Weather Responsive Variable Speed Subsystem Flow Chart for Each Segment

During inclement weather months, ODOT inputs the appropriate chain conditions in the Advanced Traffic Management System (ATMS) or Traffic Operations Center Software (TOCS) that are used at the Traffic Management Operations Center (TMOC) or Traffic Operations Center (TOC).

The decisions for what speed to use according to the visibility, grip factors, and chain requirements are shown in Table 1. The visibility and grip factors come directly from the weather sensors. The chain requirements come from ATMS or TOCS:

A: You must have chains or traction tires in or on your vehicle and they must be the right size for your vehicle and of sufficient number to comply with the Minimum Chain Requirements.



B1: You must use chains if your vehicle is rated 10,000 pounds gross vehicle weight (GVW) or less and is towing. You must use chains on any single drive axle vehicle rated over 10,000 pounds GVW whether towing or not. Chains must also be used on the trailer or vehicle being towed as described under Minimum Chain Requirements.

B: You must use chains if your vehicle is towing or rated more than 10,000 pounds gross vehicle weight (GVW). Chains must also be used on a trailer or vehicle being towed as described under Minimum Chain Requirements.

C: You must use chains if your vehicle is towing or is rated over 10,000 pounds GVW. Chains must also be used on a trailer or vehicle being towed as described under Minimum Chain Requirements. If your vehicle is rated 10,000 pounds GVW or less and is not towing you must use chains or traction tires.

Table 1: Weather Speed Lookup Tables

Grip Factor / **Visibility**	**> 0.70**	**0.70 > X > 0.30**	**< 0.30**
> 500'	Speed Limit	Speed Limit - 10 MPH	Speed Limit - 20 MPH
< 500'	Speed Limit - 10 MPH	Speed Limit - 20 MPH	Minimum Speed

Chain Condition / **Visibility**	**B or B1**	**C**
> 500'	45 MPH	35 MPH
< 500'	35 MPH	Minimum Speed

When a chain condition is present, and a weather event is being detected by a Road Weather Information System (RWIS) sensor, the slowest generated speed of the two shall be used. The weather responsive variable speed subsystem also generates messages for variable message signs based on grip factor, visibility, and surface classification as shown in Table 2.

Table 2: Weather VMS Message Lookup Table

Visibility	Classification \ Grip Factor	> 0.70	0.70 > X > 0.30	< 0.30	Chain Requirement
> 500'	Moist or Wet	(None)	 USE CAUTION	 USE CAUTION	(None)*
	Frosty, Snowy, Icy, or Slushy	(None)	ICE USE CAUTION	ICE USE CAUTION	(None)*
< 500'	Moist or Wet	LOW VISIBILITY USE CAUTION	 USE CAUTION	 USE CAUTION	(None)*
	Frosty, Snowy, Icy, or Slushy	LOW VISIBILITY USE CAUTION	ICE USE CAUTION	ICE USE CAUTION	(None)*

*Snow zone chain requirement messages for VMS will come from ATMS/TOCS

Table 1 and Table 2 are configurable, but require prior approval from the State Traffic Engineer.

The weather sensors will provide values of grip factor, classification, and visibility at regular intervals. These regular intervals shall be user defined with a default of five minutes. Depending on the volatility and accuracy of the data being reported, some simple averaging or data smoothing may be warranted. Ideally, if an inclement weather condition is being accurately detected, a message should be generated and sent to the signs as quickly as possible. For this reason, Federal Highway Administration (FHWA) recommends that speed values should be recalculated at intervals of 60 seconds or less.[2]

Advisory and Regulatory Speeds

Speeds displayed by variable speed systems may be advisory speeds or regulatory speeds. Both advisory and regulatory speed systems, based on weather, congestion, or a combination of both, are used or planned for use in Oregon in different applications. Whether to implement an advisory or regulatory system depends on a variety of factors, including the length of the variable speed zone, the conditions warranting the system, input from law enforcement, roadway classification and ownership, and statutory requirements.

2 *Guidelines for the Use of Variable Speed Limit Systems in Weather*. Federal Highway Administration, Safety Program, Aug. 2012.

Typically, variable speed signs are either used as a small insert area in a larger static sign or combined to create a sign entirely composed of LEDs. The small insert areas typically only display the variable speed numerals on the sign within the static legend text and background as shown in Figure 4. When the entire sign area is composed of LED pixels, it is commonly called a full matrix sign.

Figure 4: Examples of Variable Speed Limit Sign (left) and Variable Advisory Speed Sign (right) using LED Inserts

SYSTEM DEVELOPMENT

The first variable speed system in Oregon is being completed on an urban freeway in the Portland area and will feature the weather-responsive, congestion-responsive, and operator control systems. Additional features include a queue warning system and a travel time system. Design is in progress for a variable speed system on two rural highways through the popular Mt. Hood winter recreation area. Planning work is complete for a rural interstate freeway across multiple mountain passes in Southern Oregon and a rural highway in Central Oregon.

Future considerations for the variable speed system include online logging and reporting for public users, a live connection to TripCheck with real-time speeds, a smartphone app, and additional weather controls if evaluations show these would be useful. As time progresses, various parameters within the variable speed system will be updated to match conditions and desired responses based upon project evaluations.

AUTHORS

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