Automated Variable Speeds in Rural and Urban Environments in Oregon

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Outline

1. Variable Speed Systems in Oregon
2. Variable Speed Concepts
3. Variable Speed Algorithms
4. Deployment Planning Example
5. Implementation Results
Variable Speed Systems in Oregon
Variable Speed Systems in Oregon

Oregon DOT brands their system as “ODOT RealTime”

http://www.tripcheck.com/realtime/
Statewide Variable Speed System

• **Primary Goal:** Provide an engineering solution that improves safety in high crash locations related to weather and/or congestion

• **Secondary Goal:** Consistency of deployments and operations.
Multiple Variable Speed Subsystems

- Statewide Variable Speed System
  - Congestion Responsive Subsystem
  - Weather Responsive Subsystem
  - Operator Control Subsystem
Automation Requires Integration
Regulatory vs. Advisory Speeds
# Key Differences

<table>
<thead>
<tr>
<th></th>
<th>Regulatory</th>
<th>Advisory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compliance</strong></td>
<td>• 40% exceed posted speed</td>
<td>• 75% exceed advisory speed</td>
</tr>
<tr>
<td><strong>Enforcement</strong></td>
<td>• Posted speed is directly enforceable</td>
<td>• Enforced through basic speed rule</td>
</tr>
<tr>
<td><strong>Roadway</strong></td>
<td>• &gt; 2 miles</td>
<td>• Single geometric feature, or varying conditions</td>
</tr>
<tr>
<td><strong>Public Perception</strong></td>
<td>• Tied to revenue generation?</td>
<td>• More accepting, no direct financial implications</td>
</tr>
<tr>
<td></td>
<td>• Larger responsibility to display credible speed limits</td>
<td></td>
</tr>
<tr>
<td><strong>Legal Requirements</strong></td>
<td>• Engineering study</td>
<td>• Engineering study recommended</td>
</tr>
<tr>
<td></td>
<td>• Speed zone order</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• OAR amendment for freeways</td>
<td></td>
</tr>
</tbody>
</table>
Determine Correct System

Regularly Occurring Congestion

Is the problem primarily caused by regularly occurring congestion or is it weather related?

- Yes
  - Is the variable speed primarily for the safety of the driver?
    - Yes: Use Advisory Speeds
    - No: Use Regulatory Speeds

- No
  - Weather Related
    - Will variable speeds be used in a corridor or at a specific location?
      - Corridor: Use Regulatory Speeds
      - Specific Location: Use Advisory Speeds
Variable Speed Algorithms

3 variable speed subsystems

Identifies lowest recommended speed

Subzone relationship logic

Time requirements logic
Congestion Responsive Subsystem

- Uses volume, occupancy, and speed from relevant detectors
- Performs volume and occupancy checks to determine traffic state
- Determines appropriate speed based on 85\textsuperscript{th} percentile speeds
  - Must be within 9 mph of 85\textsuperscript{th} percentile

**Diagram:****

1. **VS System**
   - **Is Congestion Responsive Subsystem enabled?**
     - Yes → **Download traffic sensor data for each station in the VS segment**
     - No → **Congestion Speed = Speed Limit**

2. **Has volume threshold been met for this station?**
   - Yes → **Calculate 85\textsuperscript{th} Percentile Station Speed**
   - No → **Is Average Station Occupancy > Occupancy Threshold?**
     - Yes → **Station Speed = Minimum Station Speed**
     - No → **Minimum Segment Speed = slowest Station Speed**

3. **Congestion Speed = Rounded Minimum Station Speed**
4. **Message Duration = Congestion Message Duration**
Weather Responsive Subsystem

- Uses visibility and road surface conditions (grip factor) from relevant RWIS
- Depends on current chain requirements for the area

### Weather Speed Lookup Tables

<table>
<thead>
<tr>
<th>Visibility</th>
<th>Grip Factor</th>
<th>Speed Limit</th>
<th>Speed Limit - 10 MPH</th>
<th>Speed Limit - 20 MPH</th>
<th>Minimum Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 500'</td>
<td>&gt; 0.70 (Dry to Wet)</td>
<td>Speed Limit</td>
<td>Speed Limit - 10 MPH</td>
<td>Speed Limit - 20 MPH</td>
<td>Minimum Speed</td>
</tr>
<tr>
<td>&lt; 500'</td>
<td>&lt; 0.30 (Very Wet)</td>
<td>Speed Limit - 10 MPH</td>
<td>Speed Limit - 20 MPH</td>
<td>Minimum Speed</td>
<td>Minimum Speed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visibility</th>
<th>Chain Condition</th>
<th>B or B1 (Towing or &gt; 10,000 lbs)</th>
<th>C (Chains Required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 500'</td>
<td></td>
<td>45 MPH</td>
<td>35 MPH</td>
</tr>
<tr>
<td>&lt; 500'</td>
<td></td>
<td>35 MPH</td>
<td>Minimum Speed</td>
</tr>
</tbody>
</table>
Operator Control Subsystem

- Manual speed selection by segment or corridor
- Can be recommended or absolute control
- Automatic time expirations
- Non-engineer operators have 10 pre-approved responses
Pre-approved Operator Responses

- If automatic systems are not responding adequately, operator can recommend lower speeds.
- Anything else requires state traffic engineer approval.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Speed</th>
<th>Command Priority</th>
<th>Duration (Default)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing Water / Spots of Ice</td>
<td>Posted Speed - 10</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>Black Ice / Packed Snow Significant Traction Problems</td>
<td>Posted Speed - 20</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>Black Ice / Packed Snow Significant Traction Problems Not Resolved in Above Condition</td>
<td>Minimum Slow Speed</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>Ice / Packed Snow Plus Low Visibility</td>
<td>Minimum Slow Speed</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>Condition B or B1 Chain Requirement in Effect</td>
<td>45</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>Condition C Chain Requirement in Effect</td>
<td>35</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>Visibility Less Than 500 Feet</td>
<td>Posted Speed - 10</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>High Winds</td>
<td>Posted Speed – 10</td>
<td>Recommended</td>
<td>30 min</td>
</tr>
<tr>
<td>Work Zones Based on Approved Temporary Speed Zone Order</td>
<td>Speed Zone Order Value</td>
<td>Recommended</td>
<td>1 week</td>
</tr>
<tr>
<td>False Sensor Readings</td>
<td>Posted Speed</td>
<td>Absolute</td>
<td>48 hours</td>
</tr>
</tbody>
</table>
Deployment Planning

• Do your systems engineering analysis first.
• Use the right tool to solve the problem.
Legal Stuff

- Oregon Administrative Rules:
  - OAR 734-020-0018 requirements for public roads
  - OAR 734-020-0019 criteria for interstate freeways

- Engineering study must consider and document:
  - Same factors a prudent driver considers including congestion, road conditions, visibility, and weather
  - Boundaries of the variable speed zone
  - Location of each sign
  - Set of algorithms
  - Speed change intervals
  - Means, responsibilities, and procedures for changing speed
  - Means, responsibilities, and procedures for keeping records
Planning Example: I-5 Siskiyou Pass
Crashes by Roadway Condition
Crash Analysis

- Few crashes are because people are exceeding the speed limit
- Most crashes are driving speed exceeding conditions
  - 89% on ice or snow
Signing Placement

- 3 subzones:
  - Uphill approaching summit
  - Summit area
  - Downhill
- Multiple traffic detectors
- Multiple weather stations
- Supplemental VMS
  - Also southbound, not shown
US 26 / OR 47
Staley’s Junction

- Regulatory variable speed
- Short: 2/3 mile
- Goal: improve side street safety and mobility
System Performance

- Lower vehicle speeds: average and 85th percentile
- Less side street delay, shorter queues
- Low volume makes crash analysis difficult
- No complaints

<table>
<thead>
<tr>
<th></th>
<th>Vehicles</th>
<th>Posted Speed</th>
<th>Average Speed</th>
<th>85% Percent Exceeding</th>
<th>Pace Limits</th>
<th>Percent In Pace</th>
<th>Maximum Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGES</td>
<td>231</td>
<td>50 MPH</td>
<td>47</td>
<td>52</td>
<td>43-53</td>
<td>82%</td>
<td>58</td>
</tr>
<tr>
<td>AVERAGES</td>
<td>217</td>
<td>45 MPH</td>
<td>44</td>
<td>48</td>
<td>39-49</td>
<td>81%</td>
<td>56</td>
</tr>
<tr>
<td>AVERAGES</td>
<td>282</td>
<td>40 MPH</td>
<td>35</td>
<td>41</td>
<td>32-42</td>
<td>75%</td>
<td>50</td>
</tr>
<tr>
<td>AVERAGES</td>
<td>278</td>
<td>35 MPH</td>
<td>31</td>
<td>37</td>
<td>26-36</td>
<td>68%</td>
<td>46</td>
</tr>
<tr>
<td>AVERAGES</td>
<td>316</td>
<td>30 MPH</td>
<td>23</td>
<td>29</td>
<td>20-30</td>
<td>66%</td>
<td>38</td>
</tr>
</tbody>
</table>

TABLE 7
STALEY’S JCT. VSL ANALYSIS BY POSTED SPEED SUMMARY
June 12 & July 24, 2011
OR217 Active Traffic Management

- Urban expressway
- 135,000 AADT
- Advisory variable speed
- 7.4 miles
- 7 speed subzones
- Subzones tied together to reduce speed in steps
- Goal: improve safety and reliability
- Also has weather responsive
Early Results

Before and After Travel Time Reliability, OR-217 NB Left Lane

- Average Buffer Index before VAS = 48.8%
- Average Buffer Index after VAS = 27.64%
- Before = July 2012 midweek days
- After = Midweek days from the past three weeks
Thank you

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