Dynamic Part-Time Shoulder Use Triggers

105\textsuperscript{th} Purdue Road School
Bastian Schroeder – Kittelson and Associates
March 5, 2019
Overview

Triggers for Dynamic Part-Time Shoulder Use (expected late 2019)
Performance Based Practical Design

- Modifying the traditional “top down, standards first” approach to a “design up” approach
- Project decisions are based on critical examination of geometric elements
- Utilizes relevant, objective data to inform decisions – engineering judgement
- Choices made to serve project priorities while trying to make cost effective decisions
- Project savings Benefit System Needs
Transportation Systems Management and Operations Strategies (TSMO)

- Work Zone Management
- Traffic Incident Management
- Service Patrols
- Special Event Management
- Road Weather Management
- Transit Management
- Freight Management
- Traffic Signal Coordination
- Traveler Information
- Ramp Management
- Managed Lanes
- Part-Time Shoulder Use
- Active Traffic Management
  - Dynamic Speed Limits
  - Dynamic Lane Assignment
  - Queue Warning
  - Dynamic Part-Time Shoulder Use
What is Part-Time Shoulder Use?
What is Part-Time Shoulder Use?

• Various names
  – Shoulder running
  – Hard shoulder running
  – Temporary shoulder use
  – Part-time shoulder use

• Same meaning: use of the left or right shoulders of an existing roadway for travel during certain hours of the day.
  – Transportation Systems Management and Operations (TSMO) strategy for addressing congestion and reliability issues
  – Preserves shoulder as shoulder during most hours of day
What is Part-Time Shoulder Use? (continued)

- It adds capacity only when needed
- It keeps the shoulder intact for most hours of the day
- Do what is physically and financially possible
  - Support decisions with analysis
- A decision to use the shoulder part-time may defer major and costly widening.
Types of Part-Time Shoulder Use

- **Bus-on-Shoulder (BOS)** – open only to buses, usually at driver’s discretion
- **Static part-time shoulder use** – open to passenger vehicles during predetermined hours of operation
- **Dynamic part-time shoulder use** – open to passenger vehicles based on need and real-time conditions

Shoulder use typically implemented on freeways; but can be applied to arterials
Bus On Shoulder (BOS) in Minneapolis-St. Paul

Source: Metro Transit
Left-Shoulder Bus on Shoulder (BOS) in Chicago

Source: Pace Bus
Bus on Shoulder (BOS) on US 9 Arterial in New Jersey

Source: TCRP Report 151
Static Shoulder Use – US 2 in Washington State

Source: Google Maps
Static Shoulder Use – I-66 in Virginia (Made Dynamic in 2015)

Dynamic signs over shoulder; but fixed hours of operation.

Source: Virginia Department of Transportation
Dynamic Shoulder Use – I-66 in Virginia

Source: Virginia Department of Transportation
Shoulder Use on I-70 Mountain Corridor, Colorado

Source: Colorado Department of Transportation
Dynamic Shoulder Use – I-35W in Minneapolis

Source: Minnesota Department of Transportation
Where is Part-Time Shoulder Use in U.S.?

There are many international applications as well.

Source: Kittelson & Associates, Inc.
A resource to assist State DOT’s considering part time shoulder use.

It is a guide, not a standard, directive or policy.

Comprehensive
  – Limited information on operations: when to open and close shoulder

Current Research: “Triggers” for Dynamic Shoulder Use
Project Objectives

• Guide agencies to implement Dynamic Part-Time Shoulder Use (D-PTSU)
• Prepare internal FHWA white paper synthesizing current practices (complete)
  – Domestic and International
• Prepare guidebook document with “Triggers” for D-PTSU (expected late 2019)
Concept of Operational-Based Trigger

Uncongested Conditions

Predict Breakdown

Open Shoulder*

Prevent Congestion

- Historical Data
- Predictive Models
- Best Practices
- Facility-specific needs

* Assuming there are no issues with maintenance, law enforcement, environmental conditions, etc.
Concept of Operational Trigger

- Volume Per Lane
- Speed
- Time
- Shoulder
- Speed
- Trigger
- Sweep Time
- Open Shoulder
- Capacity Per Lane
- Demand/Lane
- Time

U.S. Department of Transportation
Federal Highway Administration
Levels of PTSU

- Low level - Static
- Medium level(s)
- High level – Fully dynamic
- Increasing real-time responsiveness to traffic
- Increasing Instrumentation and Automation
- Increasing agency capabilities/maturity
Types of Triggers

- Static (time-of-day) based operation
- Dynamic - Traffic volumes above/below a certain threshold.
- Dynamic - Vehicle operating speeds below/above a certain threshold.
- Combinations
- Triggers are used to both open and close the shoulder
Trigger Selection

Volume-Based Trigger

Speed-Based Trigger

Volume (veh/h/ln) vs. Clock Time

Breakdown (06:25 AM)

Speed

Volume

Speed (mi/h)

Volume (veh/h/ln) vs. Clock Time

25 min.

1400 veh/h/ln crossed (06:00 AM)
Trigger Selection

- Variations in capacity
- Variability in Demand
- Sweep time
- Rate of increase in the traffic flow
- Geometry of the specific facility
Agency Questions (Use Cases)

• Would D-PTSU be an appropriate strategy in a location where no part-time shoulder use (even static) is currently in place?
• Should D-PTSU be considered in a location where static part-time shoulder use is in place?
• How can an agency better optimize the operation of an existing D-PTSU installation?
Analysis Approaches

- **Demand-to-Capacity Patterns**
  - Sensor Data
- **Empirical Performance Data**
  - Probe Data
- **Macroscopic Trigger Optimization**
  - HCM Modeling
- **Microscopic Trigger Refinement**
  - Microsimulation
- **Monitoring and Adjustment**
  - Real Time
## Demand-to-Capacity Patterns

<table>
<thead>
<tr>
<th>Base Number of Lanes</th>
<th>Base Capacity (pc/h/ln)</th>
<th>Capacity with PTSU added* (pc/h/ln)**</th>
<th>Ratio of PTSU vs. Base PTSU d/c** Ratio Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4,000-4,400</td>
<td>5,600-6,000</td>
<td>1.40 – 1.36</td>
</tr>
<tr>
<td>3</td>
<td>6,000-6,600</td>
<td>7,600-8,200</td>
<td>1.27 – 1.24</td>
</tr>
<tr>
<td>4</td>
<td>8,000-8,800</td>
<td>9,600-10,400</td>
<td>1.20 – 1.18</td>
</tr>
</tbody>
</table>

* Assumes shoulder capacity of 1,600 pc/h/ln
**d/c = demand to capacity (ratio). pc/h/ln = passenger cars per hour per lane. PTSU = part-time shoulder use.
Empirical Performance Data (Example I-66)

Static PTSU Only – AM Peak (6-10AM)

Dynamic PTSU (flexible operations)
Before and After Performance (Example I-66)

Static PTSU Only
- AM Peak (6-10AM)

Dynamic PTSU (flexible operations)
Empirical Performance Data - Breakdown Distribution

Key:
- Speed-flow data
- Pre-breakdown interval
- Maximum-Likelihood estimation (no time offset)
- Product-Limit estimation (no time offset)
- Maximum-Likelihood estimation (15 min offset)
- Product-Limit estimation (15 min offset)

Graph showing:
- Speed (mi/h) vs. Flow rate (veh/h/ln)
- Breakdown probability

Histograms:
- Number of Breakdowns by Day of Week
- Number of Breakdowns by Hour of Day

Bar charts show:
- Frequency of Breakdowns by day and hour.
• Breakdowns are frequent and predictable (e.g. every morning between 7am and 9am, but no breakdowns other times),
  – Fixed time-of-day trigger may sufficient
• Breakdowns are seasonal (not a daily occurrence), variable (breakdown in the mornings but also in some afternoons, and sometimes on the weekends), or random (result of incidents, weather, special events)
  – Speed-based trigger may be most adequate
• Breakdowns are frequent and reasonably predictable based on cyclical traffic patterns (e.g. breakdown every morning peak),
  – Volume-based trigger may be appropriate
• Combination of Triggers cover multiple applications
• Opening the shoulder too early results in increases in capacity before it is needed, resulting in potentially higher speeds, and potentially reduced safety.

• Opening the shoulder too late may result in congestion and potentially reduced safety

• A trigger volume that is set too low can result in false positives; i.e., traffic volumes are increasing but will never reach capacity.
Project Timeline

- Technical work completed in early 2019
- Webinar in mid-2019
- Publication in late-2019
QUESTIONS?
Contact Information

• Jim Hunt jim.hunt@dot.gov
• Greg Jones GregM.Jones@dot.gov
• Pete Jenior pjenior@kittelson.com
• Bastian Schroeder bschroeder@kittelson.com
• David Hale david.k.hale@leidos.com