# Evaluating the Safety Effects of Sinusoidal Centerline Rumble Strips

*Montana Department of Transportation*

*Project Status Update*

*July 8, 2024*

PennState
College of Engineering

*Larson Transportation Institute*

# Meeting Agenda

- Introductions
  - MDT Panel Chair and Members
  - Research Project Manager
  - Research Team
- Current Status (Tasks 1 through 4 complete)
- Proposed Approach for Task 5: Supplemental Data Collection
- Upcoming Research Team Requests to MDT
- Schedule of Future Activities
- Discussion

# Research Problem Statement

- Centerline rumble strips are low-cost safety countermeasure to reduce high-severity crossover crashes and total crash frequency.
  - Provide audible and tactile feedback to drivers.
  - Feedback increases noise.
- Sinusoidal pattern reduces exterior noise but offers similar in-vehicle feedback as conventional rumble strips.
- Purpose: To evaluate safety effectiveness of sinusoidal centerline rumble strips.
  - Employ observational before-after study design → over 600 miles of sinusoidal centerline installations in 2021.
- Outcome: Inform future deployment of centerline rumble strips in Montana.

# Study Objectives

- Quantify safety performance of sinusoidal centerline rumble strips (SCRS) and conventional CRS.
  - Estimate crash modification factors (CMFs) using Empirical Bayes (EB) study design
    - Total crashes (all types and all severities)
    - Fatal+injury crashes (all crash types)
    - Target crashes
      - Single-vehicle run-off-road
      - Off-road left
      - Head-on
      - Sideswipe opposite direction
    - Fatal+injury target crashes
      - Single-vehicle run-off-road
      - Off-road left
      - Head-on
      - Sideswipe opposite direction
  - Use "matching" method to identify reference group sites most similar to SCRS (treatment) sites → more accurate assessment of true safety effect.
  - Disaggregate analysis to differential safety effects by roadway features.
- Benefit-cost analyses to compare SCRS to conventional CRS.

# Proposed Approach

| | |
|---|---|
| **Task 1: Kick-off Meeting (October 1, 2021 – October 31, 2021)**<br>Schedule and hold kick-off meeting via teleconference<br>Preparation of meeting minutes | Start Date: Jan 19, 2022 – complete Feb. 19, 2022 |
| **Task 2: Literature Review (October 1, 2021 – December 31, 2021)**<br>Identify relevant domestic literature from published research reports, journal articles, and other documents<br>Summarize literature review findings in technical memorandum #1 | March 19, 2022 – complete May 7, 2022 |
| **Task 3: Develop Data Collection Plan (January 1, 2022 – March 31, 2022)**<br>Identify data collection sites, relevant dependent and independent variables, sample size requirements, data collection protocols and evaluation criteria<br>Develop data collection plan for MDT review and approval | July 19, 2022 (Draft) – complete Sept 26, 2022 |
| **Task 4: Compile Electronic Data for "Before" Period (April 1, 2022 – June 30, 2022)**<br>Obtain electronic roadway inventory and crash data from MDT during period before sinusoidal rumble strips are implemented<br>Merge data into an analysis database to support research | October 19, 2022 – complete May 16, 2024 |
| **Task 5: Collect Supplemental Data Elements (July 1, 2022 – September 31, 2022)**<br>Obtain additional data elements using Google Earth and video photolog<br>Merge data into analysis database | January 19, 2023 -- ?? |
| **Task 6: Summarize "Before" Data Collection (October 1, 2022 – December 31, 2022)**<br>Summarize data collection protocols and activities<br>Summarize findings in technical memorandum #2 | April 19, 2023 -- ?? |
| **Task 7: Collect "After" Period Data (January 1, 2023 – June 30, 2025)**<br>Obtain annual traffic volume and crash data during period after sinusoidal rumble strips are implemented<br>Merge data into analysis database | October 19, 2025 |
| **Task 8: Complete Safety Analysis (July 1, 2025 – September 30, 2025)**<br>Develop CMFs for sinusoidal rumble strips<br>Perform cost-benefit analysis for implementation of sinusoidal rumble strips<br>Summarize findings in technical memorandum #3 | January 19, 2026 |
| **Task 9: Draft Final Report (July 1, 2025 – September 30, 2025)**<br>Draft final report of research findings and implementation plan<br>Webinar presentation of research findings to MDT technical panel<br>Summary of presentation discussion and research team response to comments | January 19, 2026 |
| **Task 10: Final Report (October 1, 2025 – December 31, 2025)**<br>Prepare PowerPoint presentation of research findings for MDT use<br>Final report of research findings<br>Prepare all other final deliverables | End Date: April 19, 2026 |

# Task 5 Update:
# Supplementary Data Collection

# Supplemental Data Overview

- Not provided in the dataset but are critical variables in the crash prediction model
- Can be collected using resources such as Pathpoints and open resources such as Google imagery
  - Examples: Horizontal curvature, roadside data, presence of a countermeasure

# Supplementary Data Elements

| Variables | Tools used |
|---|---|
| Shoulder type | Pathpoints Videolog |
| Shoulder width | Pathpoints Videolog |
| Radius and Degree of curvature | ArcGIS, Civil 3D, Google Earth |
| Presence of Rumble Strips | Google Earth |
| No. of driveways | Google Earth |
| Roadside Hazard Rating (RHR) | Pathpoints Videolog |
| Presence of ‘Curve Warning’ sign | Pathpoints Videolog / Google Earth |
| Presence of ‘Stop Ahead’ sign | Pathpoints Videolog / Google Earth |
| Presence of ‘Signal Ahead’ sign | Pathpoints Videolog / Google Earth |
| Presence of ‘Turn Lane’ | Pathpoints Videolog / Google Earth |

# Horizontal Curvature

- Degree of curvature:
  - Import GIS files for state routes into Civil 3D and enable the geolocation feature in Civil 3D to identify Google Map beneath
  - Identify segments as 'Line' or 'Curve' segments
  - Calculate deflection angle for curve as the difference in bearings of successive tangent segments
- Radius:
  - Length of curve = Distance between PC and PT
  - Radius = Length of curve / Deflection angle (radians)

# Rumble Strips Presence

- Centerline RS:
  - Locations of sinusoidal RS are known (MDT)
  - Locations of traditional RS can be identified in Google Earth Street view images
- Shoulder RS: Locations are provided in MDT database

Sinusoidal CLRS

Traditional CLRS

# Roadside Hazard Rating (RHR)

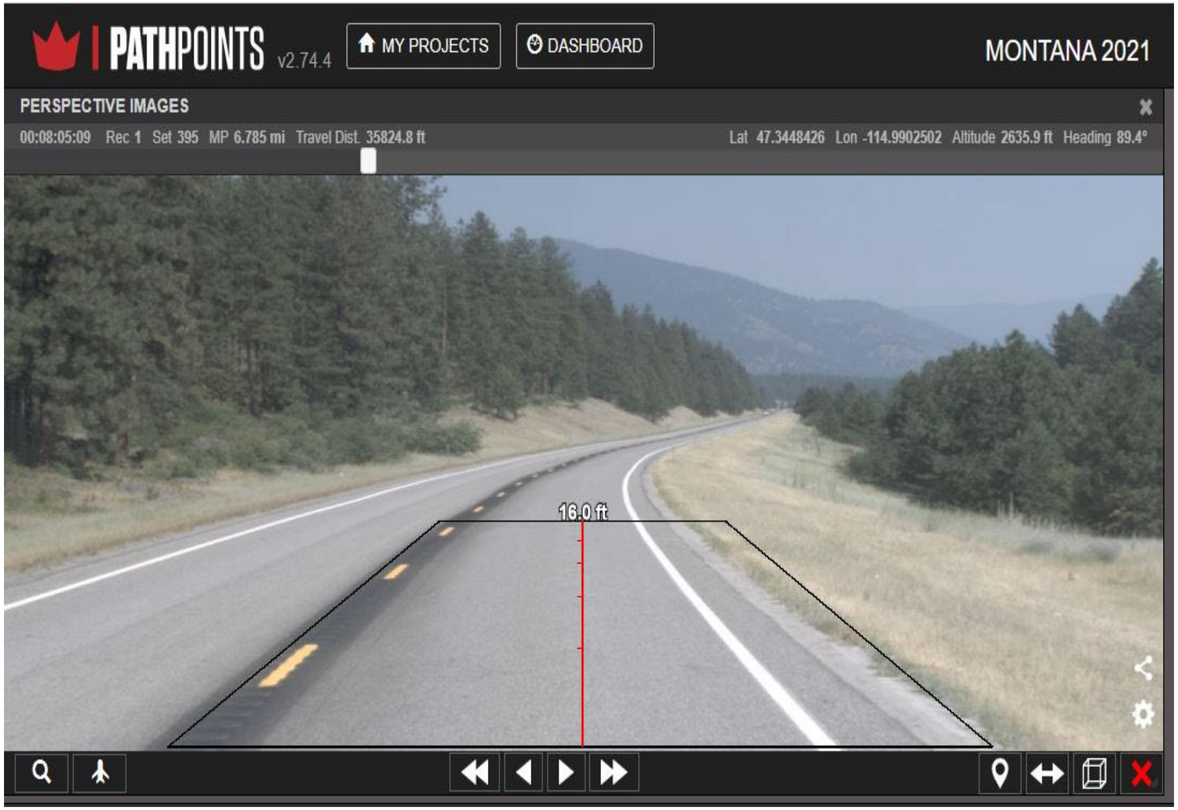
- Qualitative measure of crash potential for roadway designs on two-lane rural highways
- Visually inspection of roadside of roadway segments
  - Rating ranges from 1 (least hazardous) to 7 (most hazardous) based on Zeeger et al (1986)

# RHR Assignment Criteria

| RHR | Clear Zone Width (ft) | Side Slope (V:H) | Recoverable? | Guardrail | Exposed objects |
|---|---|---|---|---|---|
| 1 | 30 ft or more | 1:4 or flatter | Yes | Not present | None |
| 2 | 20 to 25 ft | About 1:4 | Yes | Not present | None |
| 3 | About 10 ft | Between 1:4 to 1:3 | Marginally | Not present | None |
| 4 | 5 to 10 ft | Between 1:4 to 1:3 | Marginally | 5 to 6.5 ft away | about 10 ft away |
| 5 | 5 to 10 ft | About 1:3 | No | 0 to 5 ft away | 6.5 to 10 ft away |
| 6 | less than 5 ft | About 1:2 | No | Not present | 0 to 6.5 ft away |
| 7 | less than 5 ft | 1:2 or steeper | No | Not present | Cliff or vertical cut |

Note:
1. Clear zone starts at the edge of the traveled way and includes shoulder
2. All distances taken from the edge of the traveled way

# Estimating RHR for a Roadway Segment




Example section taken from Pathpoints videolog

- Right side:

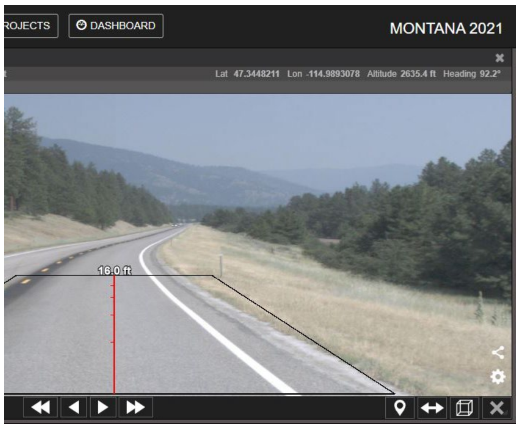
Clear zone ~ 20 ft,
Slope ~ 1:4,
Recoverable
→ RHR = 2

- Left side:

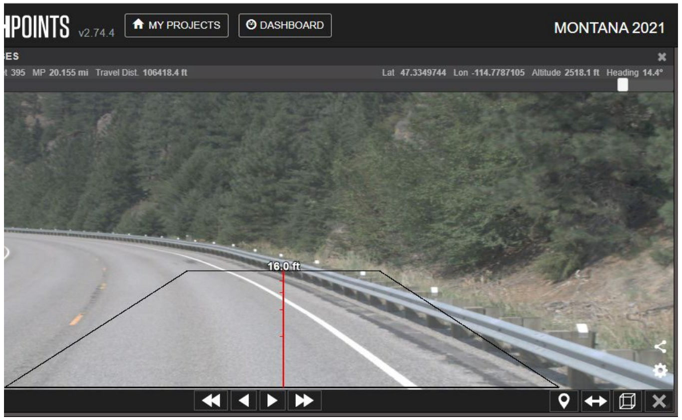
Clear zone ~ 10 ft
Slope ~ 1:3
Marginally recoverable
Exposed object about 10 ft away
→ RHR =4

- Recommend highest RHR be used.

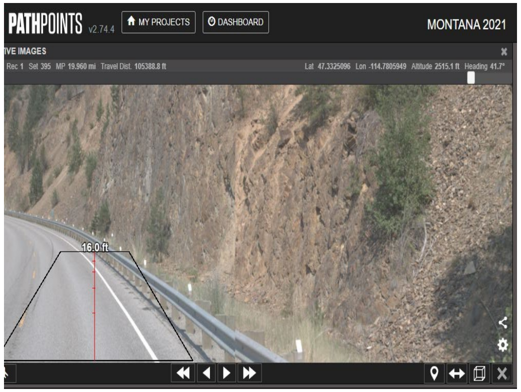
# RHR Examples



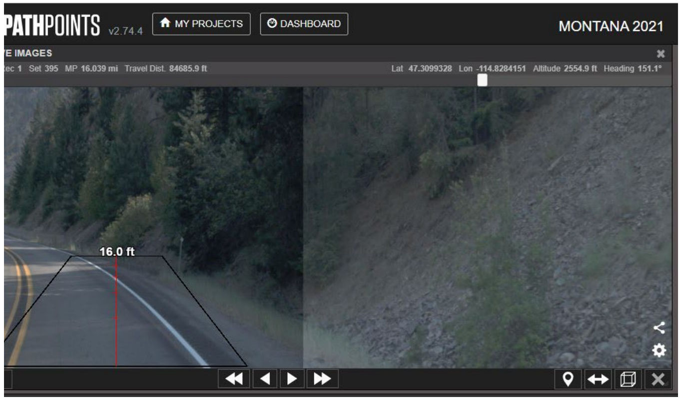

RHR =2




RHR =4

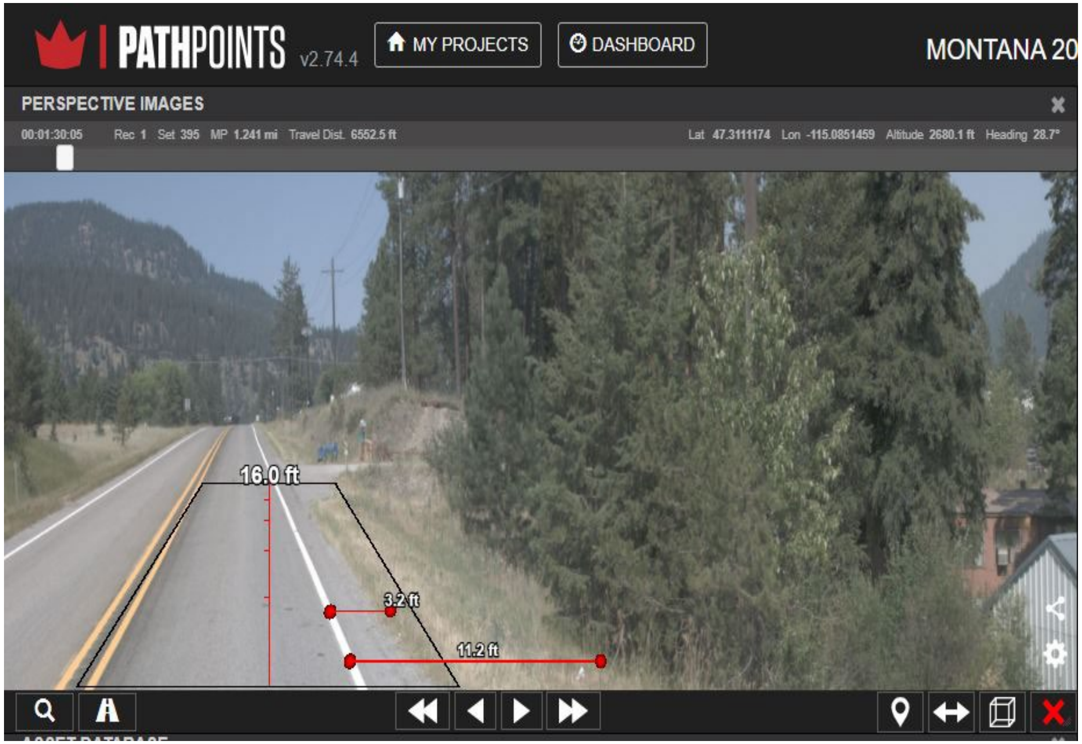



RHR =5




RHR =6

# Shoulder Type and Width




- **Shoulder type**: Paved or unpaved
  - Identified by visual inspection of Pathpoints videolog
- **Shoulder width**: Estimated using the "Width Measure" feature in Pathpoints

# Driveway Density

- Use Google Earth image to count number of access points on both sides of a roadway segment
- Driveway density (DD) =
  # Access Points / Length of the segment

# Presence of Warning Signs

- Curve warning, Stop ahead, Signal ahead
  - Locate the feature (curves, intersections) in Google Earth
  - Use Google Street View to verify the presence / absence of the warning sign


Curve warning sign


Stop ahead sign

# Presence of Turn Lane

- Locate intersections in Google Earth
- Use Google Street View to verify the presence / absence of turn lane

# Upcoming Research Team Requests

- "After" Period Crash Data
  - 2022 through 2024 (inclusive)
- Review Task 5 Supplemental Data Collection Plan
  - Draft in August 2024
  - Includes estimated time to complete supplemental data collection

# Thank you!