Evaluating the Safety Effects of Sinusoidal Centerline Rumble Strips

Kick-off Meeting Minutes

Tuesday, February 22, 2022
11:00 am to 12:30 pm Mountain Time
Via Zoom

Attendees:

- Eric Donnell (PSU)
- Vikash Gayah (PSU)
- Chad DeAustin (MDT)
- Damien Krings (MDT)
- Gabe Priebe (MDT)
- Jody Bachini (MDT)
- Joe Radonich (MDT)
- Natalie Villwock-Witte (Western Transportation Institute)
- Patricia Burke (MDT)
- Pete Servel (MDT)
- Vaneza Callejas (MDT Research Project Manager)
- Marcee Allen (FHWA)

Meeting summary:

1. Introductions
    a. Panel Chair:
        i. Gabe Priebe
    b. Panel Members:
        i. Jody Bachini
        ii. Patricia Burke
        iii. Joe Radonich
        iv. Matt Ulber
        v. Marcee Allen – FHWA
        vi. Pete Servel
        vii. Damien Krings
    c. Other Interested Parties at MDT:
        i. Chad DeAustin
        ii. Natalie Villwock-Witte
    d. Research Team:
        i. Eric Donnell
        ii. Vikash Gayah
    e. Research Project Manager:
        i. Vaneza Callejas

2. Project Management (Callejas)

a. Vaneza reviewed all project roles – she will serve as a liaison to facilitate project/meetings/logistics
b. MDT technical panel in charge of all technical components of the project

3. Review of Project Scope (Donnell and Gayah)
    a. Eric Donnell reviewed the project scope of work and schedule with meeting participants.
    b. Question received about the length of the “after” period. Research team indicated that three years of after data will be considered (2022, 2023, and 2024).
    c. MDT indicated that SCLRS were installed at locations without additional changes being made to the site.
    d. After this project, just a minority of routes will have no CLRS or SCLRS of any type, which may influence reference group site selection. Gabe wonders how this might impact analysis. Eric indicated that the before period (no SCLRS or CLRS) could be used as a reference group in order to develop the safety performance functions needed for the Empirical Bayes analysis. Research team can also consider comparing SCLRS to conventional CLRS and will share this approach in the Task 3 data collection and analysis plan.
    e. MDT panel indicated that, under stakeholder engagement, research team should reference “Montana Traffic & Safety Bureau” instead of “Safety Section.”
    f. Gabe indicated that 99% of SCLRS were installed during 2021 construction season -- three segments need to be striped in Spring 2022. However, temporary striping exists at these locations. For this reason, the research team can use 2022 as the start year for the “after” period for the safety evaluation.
    g. Research team asked if crash data would be available by end of June of each year? MDT indicates this is a reasonable assumption.
    h. MDT indicated that linear referencing system (LRS) changed during the last year. Research team asks for clarification on this. However, MDT suggests that the old data will be updated to use the new LRS. It was also clarified that the updated LRS will not impact how crash data are characterized or appended to roadway inventory and traffic volume data. New system should go live in April of this year with consistent format for all data.
    i. LTIS road log can be used to identify/confirm changes/reconstruction dates for roadway segments to ensure consistency and most accurate data for use in this project. MDT will look into granting research team access to this system.
    j. Research team will wait until April 2022 for new data system to go live before compiling before period data. MDT will provide data sample and data dictionary before April for research team to become more familiar with data system and expedite before data period collection.

k. MDT panel indicated that, about halfway through installation of SCLRS, construction teams changed specifications. This created a significant difference in feedback received from the SCLRS and might influence safety performance. Research team will receive list of where the different specs were used and will try to evaluate differences in safety performance based on different specifications.
l. Technical panel discussed need to schedule and use conference room for meetings related to this project.

4. Project Schedule Review (Donnell and Gayah)
    a. Donnell noted that project start date is January 19, 2022, instead of assumed start date of October 1, 2021 in the proposal. The presentation materials included updated project timeline, with end date of July 2026.

5. Discussion: the discussion items occurred throughout the meeting, which are captured in the "Review of Project Scope" section above.

Action Items

- Patricia Burke will send research team a sample of new data format with data dictionary in March 2022.
- MDT will work with internal team to determine if research team can be granted access to LTIS system in order to identify any major construction activities that took place at candidate study sites.
- MDT will provide research team with list of CLRS and SCLRS sites.

Evaluating the Safety Effects of Sinusoidal Centerline Rumble Strips

Montana Department of Transportation

Research Project Kick-off Meeting

February 22, 2022

PennState
College of Engineering

Meeting Agenda

- Introductions
  - MDT Panel Chair
  - MDT Panel
  - Research Project Manager
  - Research Team
- Research Project Management
- Research Approach
- Research Project Timeline
- Discussion

Research Team Introduction

Eric Donnell, Ph.D., P.E.

Professor of Civil Engineering

Tenure as Penn State Faculty Member: 17 years

Role in Project: Principal Investigator

Vikash Gayah, Ph.D.

Associate Professor of Civil Engineering

Tenure as Penn State Faculty Member: 9 years

Role in Project: co-Principal Investigator

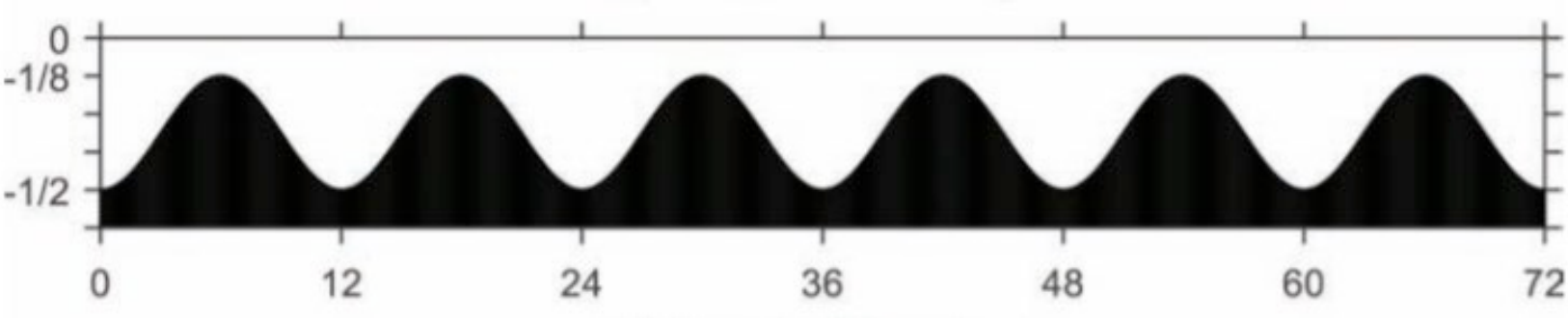
Research Problem Statement

- 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.

Background

- Approximately one-half of fatal crashes in U.S. are result of roadway departure.
- Mitigation strategies are:
  - Keep vehicles in travel lane.
  - Reduce crash potential when vehicle departs lane.
  - Minimize crash severity.
- Centerline rumble strips are low-cost "proven" countermeasure:
  - ↓ total crashes (40%) and ↓ fatal+injury target crashes (64%) on urban two-lane roads.
  - ↓ total crashes (9%), ↓ fatal+injury crashes (12%), ↓ total target crashes (30%), and ↓ fatal+injury target crashes (44%) on rural two-lane roads.

What are Sinusoidal Rumble Strips?



Sinusoidal rumble strip example from Indiana (Mathew et al., 2018).
[Pattern depth is on vertical axis and wavelength is on horizontal axis, in inches]

Source: Terhaar, et al. *Sinusoidal Rumble Strip Design Optimization Study.* Minnesota Department of Transportation, 2016.

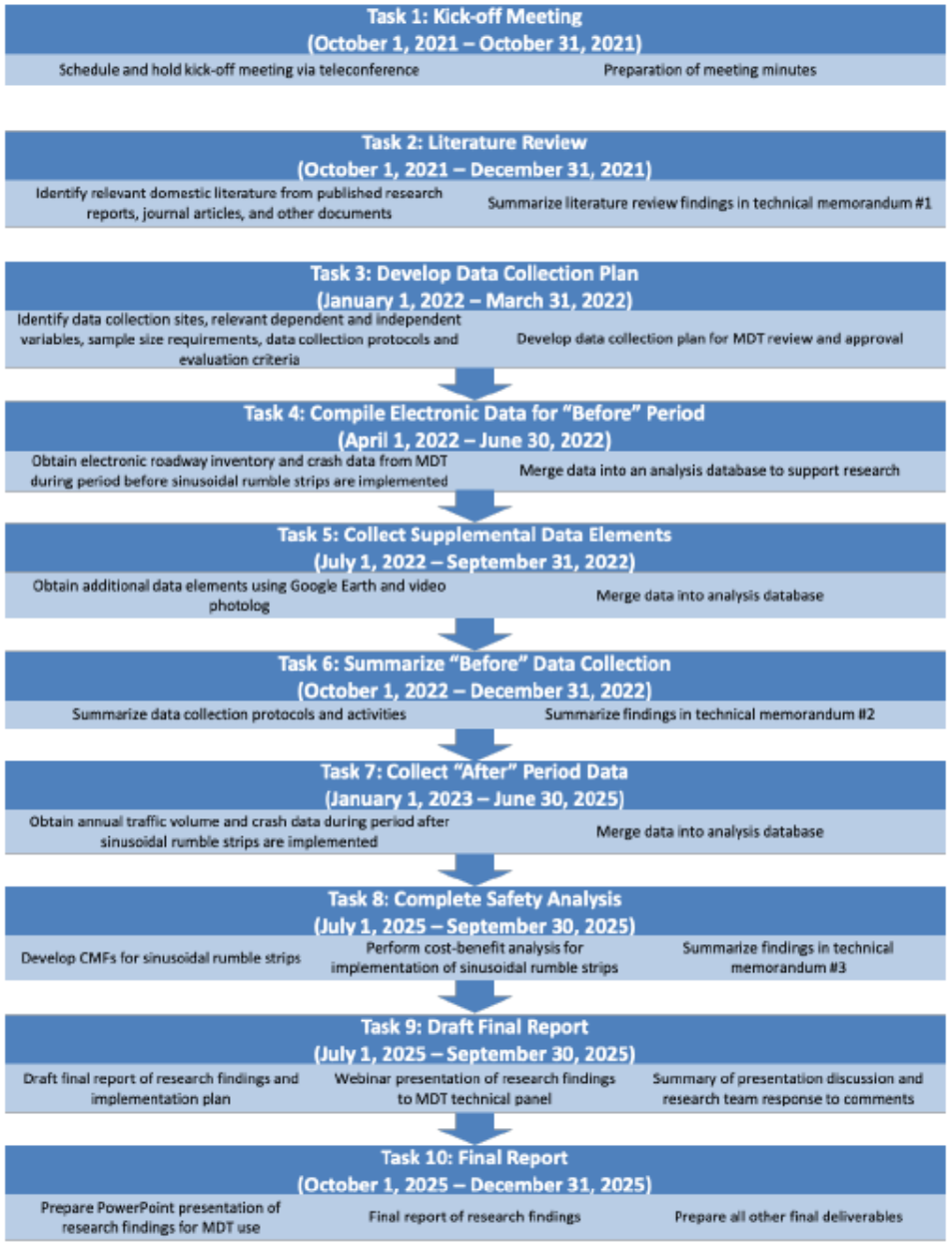
Study Objectives

- 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.

Benefits of Proposed Approach

- Compare CMFs from SCRS and CRS.
  - Similar CMF → consider noise propagation
  - Different CMFs → disaggregate analysis to prioritize implementation & resource allocation
    - Degree of curvature
    - Cross-section width
    - Season
    - Other site-specific conditions

Proposed Approach



→ Start Date: January 19, 2022

→ March 19, 2022

→ July 19, 2022 (Draft)

→ October 19, 2022

→ January 19, 2023

→ April 19, 2023

→ October 19, 2025

→ January 19, 2026

→ January 19, 2026

→ End Date: April 19, 2026

Research Plan

- **Task 1: Kick-off Meeting**
  - Within two weeks of award
  - Deliverables: Distribute meeting agenda in advance and meeting minutes after kick-off meeting
- **Task 2: Literature Review**
  - Review domestic and international literature
    - Co-authored NCHRP 641
  - Include SCRS and CRS implementation and study design methodology
  - Deliverable: Technical memorandum #1 (two months after NTP)

Research Plan (cont'd)

- **Task 3: Data Collection and Analysis Plan**
  - Define dependent and independent variables
  - Data sources and collection periods
  - Measures of effectiveness
  - Anticipated sample sizes
  - Proposed analysis methods
  - Deliverables: Draft data collection and analysis plan (6 months after NTP) and final data collection plan (8 months after NTP)

Proposed Data Elements and Information Sources

Data Description	Elements	Information Source(s)	Collection Period (Before/After)
Crash Data	Crash type Severity Crash sequence Date of crash Crash location (e.g., route/milepost)	Electronic crash reporting system	Before and after periods
Traffic Data	Average annual daily traffic Posted speed limit	Electronic roadway inventory files	Before and after periods
Roadway Cross-section Data	Lane width Shoulder type and width Pavement surface type	Electronic roadway inventory files	Before period only (no change during analysis period)
Horizontal Alignment Data	Curve presence Radius and length of curve (if available)	Google Earth	Before period only (no change during analysis period)
Roadside Hazard Rating	Subjective roadside hazard rating (on a scale of 1 to 7)	Video photolog review	Before period only (no change during analysis period)
Treatment Installation Dates	Dates of sinusoidal rumble strip installation	MDT	Before period
Presence of Other Safety Improvements at Treatment and Comparison Sites	Shoulder rumble strip presence Traffic control devices Others as identified during video review	Video photolog review	Before and after periods
Access Density	Number of driveways on each roadway segment	Google Earth	Before and after periods

Anticipated Sample Size

- Assuming:
  - SCRS installed on 620 miles of roadway.
  - Crash data available for 5 years before and 3 years after SCRS installation.
  - CMF for SCRS is similar to CRS.

Crash type	Assumed CMF Value*	Minimum Crash Rate (Crashes/Year/Mile)
Total crash frequency	0.91	0.27
Fatal + injury crash frequency	0.88	0.15
Total single-vehicle run-off-road (SVROR), off-road left, head-on, and sideswipe opposite direction crashes	0.70	0.02
Fatal and injury SVROR, off-road left, head-on, and sideswipe opposite direction crashes.	0.56	0.01

** Values obtained from NCHRP Report 641*

Data Analysis

- Empirical Bayes (EB) study design consists of 3 steps:
  - *Step 1*: Predict safety performance of roadway with sinusoidal centerline rumble strips would have been in the after period had they not been installed.
  - *Step 2:* Estimate actual safety performance was in the after period with the installation of sinusoidal centerline rumble strips.
  - *Step 3:* Compare the results of *Step 1* and *Step 2*.
- Step 1: Safety performance function (SPF) for reference group (RG)
  - Approach 1: Identify RG using functional class and number of lanes
  - Approach 2: Identify RG using propensity scores matching
- Step 2: Expected number of crashes had no treatment been applied
  - Combines SPF and reported crash frequencies
- Step 3: Safety effect estimate and standard error

Research Plan (cont'd)

- **Task 4: Compile "Before" Period Data for Treatment and Reference Group Sites (3 to 5 years)**
  - Treatment sites: SCRS and CRS
  - Reference group sites: "Conventional" selection and propensity score matching
- **Task 5: Supplemental Roadway Inventory Data Collection**
  - Satellite imagery or video photologs
  - Driveway density and horizontal curvature
  - Roadside hazard rating
  - Other site-influencing features

Research Plan (cont'd)

- **Task 6: Technical Memorandum of Before Period Data**
  - Summarize Task 4 and 5 data collection activities
  - Deliverable: Technical memorandum #2 (15 months after NTP)
- **Task 7: Collect "After" Period Data for Treatment and Reference Group Sites (3 years)**
  - Update analysis database with crash and traffic volume data.
  - Assume crash data will be available by June 1st of following year.

Research Plan (cont'd)

- **Task 8: Complete Safety Analysis**
  - At least 10 CMFs
  - Consider disaggregating CMF by season and roadway features
  - Perform benefit-cost analysis of SCRS and CRS
  - Deliverable: Technical memorandum #3 (47 months after NTP)
- **Task 9: Draft Final Report and Presentation**
  - Report of literature review, data collection and analysis findings.
  - Powerpoint webinar briefing.
  - Deliverables: Draft final report and webinar 48 months after NTP
- **Task 10: Final Report and Presentation**
  - Updated final report and Powerpoint briefing.
  - Deliverables: Final report and presentation 51 months after NTP

Communications Plan

- Frequent deliverables for MDT review (Task 1, 2, 3, 6, 8, 9, and 10) and follow-up discussion
- Monthly progress reports
- Stakeholder engagement:
  - Montana State Highway Traffic Safety Section: safety data requests and review of deliverables
  - MDT Research Division: coordinating interactions with research team and MDT team
  - Montana Design and Construction professionals: research dissemination and implementation

Project Schedule

Task	2021	2022				2023				2024				2025			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1: Kick-off Meeting	√*																
Task 2: Literature Review	√																
Task 3: Develop Data Collection/Analysis Plan		√															
Task 4: Compile "Before" Period Crash and Electronic Roadway Inventory Data for Treatment and Reference Group Sites			√														
Task 5: Collect Supplemental Roadway Inventory Data for Treatment and Reference Group Sites				√													
Task 6: Prepare Technical Memorandum Summarizing "Before" Period Analysis Data					√												
Task 7: Collect and Compile "After" Period Crash and Traffic Volume Data for Treatment and Reference Group Sites Annually							√ (2022)				√ (2023)				√ (2024)		
Task 8: Complete Safety Analysis																√	
Task 9: Draft Final Report and Presentation																√	
Task 10: Final Report																	√
√* Task 1 kick-off and kick-off meeting meetings will be completed by October 31, 2021.																	

Value Added Opportunities

- Compare CMFs for SCRS and CRS
  - At least 10 CMFs
  - Identify where and when SCRS should be used as opposed to CRS (via disaggregate analysis)
- Benefit-cost ratio for SCRS and CRS

Project Risk and Mitigation Plan

- Implementation dates of treatment (SCRS and CRS) sites
- All “before” data available at project outset
- All “after” data available no later than June of following year
- Limited reference group (sites without rumble strips)

Discussion

- Availability of SCLRS and CLRS construction information
  - Locations and dates of implementation
- Roadway inventory (including traffic volume)
  - "Before" period data
  - Roadway reconstruction information (if applicable)
- Crash data
  - "Before" period data at SCLRS and CLRS sites
  - Exclude construction year
  - Reference group sites

Thank you!