SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2017

ODOT Research Unit
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I. PROBLEM NUMBER AND TITLE

17-021_TSHF Quantifying the Performance of Low-Noise Rumble Strips

II. RESEARCH PROBLEM STATEMENT

Roadway departure crashes account for 66% of all highway fatalities in Oregon, the majority of which happen on rural highways. Rumble strips, either on the shoulder or on the center-line, are a low-cost countermeasure which have been shown to significantly reduce roadway departure crashes. The noise and vibration generated by the rumble strips alerts drivers when they are departing the traveled way. In Oregon, these are either milled-in or installed with raised durable striping. Previous research indicates that on rural 2-lane roadways, shoulder rumble strips (SRS) reduce run-off-road (ROR) fatal injury crashes by 33% and all ROR crashes by 15%. Center-line rumble strips (CRS) have been shown to reduce head-on and sideswipe crashes by 30%. Even though they are inexpensive to install, easy to maintain, and have a very long service life, it is not always possible to install rumble strips on many roadway segments due to noise concerns. Residents living adjacent to highways have complained to ODOT regarding the noise generated by traditional milled-in rumble strips. As a result, rumble strips are not currently installed on many roadway segments – even where there is documented evidence of lane departure crashes.

A newer sinusoidal pattern design produces a lower noise profile and may be a solution. There is an opportunity to scientifically quantify the noise differentials between traditional and sinusoidal milled rumble strips (see Figure 1). It is generally believed that sinusoidal rumble strips generate the necessary in-vehicle vibration and noise and reduced roadside noise, however, little to no research has been conducted to date. Further, although ODOT has expressed interest in experimenting with the sinusoidal design, there has been issues in finding contractors willing/able to include the modified rumble strips in their work.

Figure 1. Traditional Rumble Strip (left) Sinusoidal Rumble Strip (right)

III. RESEARCH OBJECTIVES

The proposed study will evaluate the feasibility of using sinusoidal as a substitute for traditional milled rumble strips on highway segments with lane departure crash problems. A quantitative and empirical comparison of the in-vehicle noises and vibrations and roadside noises of sinusoidal and traditional rumble strips will give an indication as to whether the sinusoidal pattern can potentially be used as a substitute for the traditional pattern in areas with lane crash problems.

IV. WORK TASKS, COST ESTIMATE AND DURATION

The specific tasks including estimated costs and duration to be undertaken for the study are as follows:

Task 1: Brief Literature Review (2 months, $10,000)
Conduct a brief literature review on the topics key to this study such as possible rumble strip patterns, driver performance, in-vehicle haptic and audible feedback, and roadside noise proliferation.

Task 2: Contractor and Agency Outreach (2 months, $10,000)
Conduct a survey of transportation agencies to determine current understanding and the state of practice in milled-in rumble strip patterns. In addition, the research team will conduct a survey of contractors to identify the issues that are blocking them from embracing the new strip designs.

Task 3: Experimental Designs and Pilot Study (4 months, $45,000)
Two experiments: (1) ***A probe vehicle test*** - three test vehicles (one passenger car, one pickup/SUV, and one heavy vehicle) will be instrumented to record the interior noise and vibration that is generated when contact is made with sinusoidal and traditional SRS; (2) ***A roadside test*** – portable noise sensors will be positioned adjacent and perpendicular to the roadway at different distances to determine the sound proliferation adjacent to the roadway over time for each treatment type. The experimental design will include the performance measurements needed, the instrumentation plan, and a schedule for conducting the experiments. Data collection instruments will include accelerometers mounted to the steering column and a Knowles Electronics Manikin for Acoustics Research (KEMAR) to reflect noise measurements as perceived by the human ear both in the car and adjacent to the roadway. The research team will perform a pilot study to demonstrate the feasibility of the experimental study. Mike Kimlinger is confident that we will be able to find a demonstration site(s) for the experiment. *Note*: If additional resources are available and directed by the TAC, experiments for bicycle-suitability of the sinusoidal pattern could also be designed and conducted.

Task 4: Data Acquisition (6 months, $55,000)
Probe vehicle data will be collected for incursions with each treatment, at a range of test speeds for each vehicle type at two locations (e.g. one location with a wide open adjacent land such as typical in Eastern Oregon and one with dense trees near the coast). Due to safety concerns, only shoulder designs will be tested though results will be applicable to centerlines.

Task 5: Data Reduction and Analysis (5 months, $30,000)
Analyze the data collected to determine if the in-vehicle response of contact with each treatment type is comparable and if the roadside noise profile of each treatment is comparable. This data will also be used to calibrate and validate a finite element modeling project that is being led by OSU to begin later this year. The addition of actual measurements will dramatically improve the robustness of that study.

Task 6: Final Report (2 months, $20,000)
Prepare and submit a final report which describes the research study, conclusions, and recommendations.

Research Administration ($7,000)

Total project time: 12 months Total project budget: $177,000

V. IMPLEMENTATION
A successful research project will help ODOT revise its current policies as they relate to roadway departure crashes. Sinusoidal rumble strips can be added as a low-cost countermeasure in addressing this critical crash type in areas where noise is a concern. Guidelines in manuals such as the ODOT Traffic Manual and the ODOT Traffic Line Manual will be modified to reflect the research results as warranted. The Traffic Standard Engineer and Traffic Services Engineer will be responsible for implementing this change.

VI. POTENTIAL BENEFITS

If the research project results confirm that sinusoidal rumble strips can be used as a substitute for traditional pattern design, the research will provide significant benefit to ODOT and other local jurisdictions within the state of Oregon. Highway safety would clearly be improved by reducing roadway departure crashes and the associated fatalities and injuries while nearby residences would not experience as much roadside noise. As these treatments have a high cost-benefit return ratio, the ODOT roadway departure plan estimates upwards of a 90:1 cost benefit ratio if only fatal and serious injuries are considered, this improvement would mean possible installation at more sites.

VII. SUBMITTED BY

Stage 1 Submitter	***Stage 2 Submitter***	***ODOT Champion***
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