**Research Problem Statement**

**Research Problem Title:**

Center Line Buffer Areas

**Statement of Problem**

Roadway Departure crashes account for half of all fatalities every year (1). From 2016 to 2018, more than 18,000 fatalities resulted from roadway departures (2) with more than 5,000 fatalities being the unfortunate result of head-on crashes (3). These crashes occur primarily on undivided, high speed, rural roads with vehicles traveling in opposite directions often separated only by a center line pavement marking and possibly a rumble strip. Typically, double yellow center line markings consist of two 4-inch lines separated by a 4-inch space (4), however the 2009 Manual on Uniform Traffic Control Devices (MUTCD) indicates that a double line is two parallel lines separated by a “discernible space” (5). Increasing the space between the two lines making up a double yellow center line is a potential way to provide a buffer space between vehicles traveling in opposite directions and combatting potential head-on crashes, referred to as a center line buffer area. This poses the question at what width do road users interpret the two lines as separate single yellow lines. This is an important distinction as single lines have a different meaning in the 2009 Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) than double lines and therefore different meanings in accordance with state and local statutes and ordinances. Further questions arise when considering a center line buffer area application (e.g., will road users correctly comprehend the markings as a buffer space, or is there a certain width buffer that users begin to incorrectly interpret this space as a lane). Practical marking patterns for center line buffer areas, including those with passing zones (one-direction and two-direction), need to be developed and investigated and developed to determine how road users perceived the marking patterns.

The objectives of this research are as follows.

1. Evaluate driver perception of the width of the space between the two lines which make up a double line to determine A) when they are perceived as being two separate lines) and B) which spacing and line markings minimize driver mis-perception that the buffer is a center left-turn lane or refuge?
2. Evaluate pavement markings for passing and no passing zones to determine how they are perceived by road users in rural areas.

**Summary of Existing Literature**

*State of Practice*

Section 3A.06 of the 2009 MUTCD indicates that the standard “normal line” is between 4 to 6 inches wide and the standard double line is “two parallel lines separated by a discernible space.”

Although the 2009 MUTCD does not contain provisions specific to center line buffer areas, it does contain provisions for the use of center line pavement markings and other longitudinal pavement markings. Some examples and/or applications are as follows:

* Section 3B.01 Yellow Center Line Pavement Markings and Warrants Paragraph 09
  + “Center line markings shall be placed on all paved urban arterials and collectors that have a traveled way of 20 feet or more in width and an ADT of 6,000 vehicles per day or greater. Center line markings shall also be placed on all paved two-way streets or highways that have three or more lanes for moving motor vehicle traffic” (5).
* Section 3B.03 Other Yellow Longitudinal Pavement Markings Paragraph 06
  + “If a continuous flush median island formed by pavement markings separating travel in opposite directions is used, two sets of solid double yellow lines shall be used to form the island as shown in [Figures 3B-2](https://mutcd.fhwa.dot.gov/htm/2009/part3/part3b.htm#figure3B02) and [3B-5](https://mutcd.fhwa.dot.gov/htm/2009/part3/part3b.htm#figure3B05). Other markings in the median island area shall also be yellow, except crosswalk markings which shall be white (see [Section 3B.18](https://mutcd.fhwa.dot.gov/htm/2009/part3/part3b.htm#section3B18))” (5).
* Section 3B.03 Other Yellow Longitudinal Pavement Markings Paragraph 03
  + “If a two-way left-turn lane that is never operated as a reversible lane is used, the lane line pavement markings on each side of the two-way left-turn lane shall consist of a normal broken yellow line and a normal solid yellow line to delineate the edges of a lane that can be used by traffic in either direction as part of a left-turn maneuver. These markings shall be placed with the broken line toward the two-way left-turn lane and the solid line toward the adjacent traffic lane as shown in Figure 3B-7” (5).

The Federal Highway Administration (FHWA) released a Rural Roadway Departure Countermeasure Pocket Guide offering center line buffer areas as a countermeasure for reducing head-on crashes. This publication deemed the use of center line buffer areas appropriate in no-passing zones where there is enough right-of-way and substantial traffic volume. To enhance the center line buffer area, rumble strips can be deployed within the buffer area (6).

There was limited information identified through State MUTCD supplements on the implementation of center line buffer areas. However, some State supplements help to clarify how States may define normal lines and double lines in terms of width and spacing:

* The Texas DOT classifies a wide line as at least twice the width of a normal line (7).
* The Maryland DOT states the width of a normal line is 5 inches wide on a state owned, operated, and maintained roadway (8).
* The Delaware DOT specifies that double lines are two parallel lines set 6 inches apart. State-maintained roadways have a normal line width of 5 inches and a wide line width of 10 inches (9).

*Relevant Research*

*\*Note: This review was focused on buffer-separated lanes of opposing traffic and did not include buffer-separated same-direction traffic such as preferential lanes.*

Overall, there is not substantial research evaluating the efficacy of different types of center line buffer areas. However, studies performed by Texas DOT, Texas A&M, University of Minnesota, and a research group in Queensland, Australia, indicate that center line buffer areas could be a cost-effective countermeasure for reducing head-on collisions and some results, as summarized below, suggest that the width and spacing of center line buffer pavement markings may influence drivers’ behavior.

A National Cooperative Highway Research Project (NCHRP) Project 17-66 developed Report 995 providing guidance for the selection of appropriate countermeasures for opposite direction crashes (10). One countermeasure, center line buffer areas, was found to significantly reduce fatalities. A cross-sectional study used a regression-type model to examine existing roads in Texas with center line buffers. For two lane highways, the center line buffer showed a reduction in opposite-direction crashes of about 15%. No significant effect was shown on four-lane highways. Crash Modification Factors (CMFs) were developed for center line buffer areas 2 ft, 4 ft, and 6 ft in width.

The University of Minnesota (sponsored by Minnesota Department of Transportation) performed a study using a driving simulator to evaluate the effectiveness of different experimental center line treatments. The two most effective methods found to keep drivers further from the center line were 1) 14-foot lanes with both longitudinal rumble strips and 4-inch-wide dashes marking the center line, and 2) 12-foot lanes with 4 ft buffer marked by 4-inch-wide dashes (11).

According to a study in Queensland, Australia, between 2007 and 2013, 31% of fatal and serious injury crashes were “crossing center line crashes.” In Queensland, wide center line treatments (or center line buffers) are implemented similarly to regular center lines; a dashed line is placed where passing is permitted, and a solid line is placed where passing is not permitted. A before-and-after study was conducted on Bruce Highway in Queensland to assess the effectiveness of wide center line treatments. The study concluded that all types of crashes were reduced after widening the center line to 1.0 m (12).

**Potential Research Approach**

The general approach to addressing the research objective is to conduct a state-of-practice review followed by laboratory testing to evaluate driver perception of single lines vs double lines.

It is recommended that the focus of this study is on comprehension and perception rather than a detailed safety analysis, as the safety implications of center line buffers have already been studied by NCHRP 17-66 (10).

*Task 1 – Kick-off Meeting and Project Management*

The research team will attend a kickoff meeting with the TOCOR and TCD PFS panel. The research team will work with the TCD PFS and other stakeholders to ensure a common understanding of the research objective and obtain input on existing research information available and existing guidelines available in various states and jurisdictions.

*Task 2 – Literature Review*

The research team will review and synthesize literature regarding research that has been performed on center line buffer areas. Additionally, relevant information in the MUTCD and any other standards and guidance available online from States and other jurisdictions will be summarized. Specific areas of interest will include pavement marking widths, spacing widths, and whether passing is indicated as permissible with center line buffers and if yes, how.

*Task 3 – Development of Work Plan*

The research team will develop and submit a work plan summarizing the findings of the literature review and describing the proposed approach to conducting the project tasks. The project will consist of two parts:

* *Part 1 – State-of-Practice and Practitioner Discussions*
* *Part 2 – Laboratory Study*

*Task 4 – State-of-Practice and Practitioner Discussions*

It is possible that the findings of the online review of standards and guidance may not reflect the full scope of what is being implemented. Therefore, the research team will conduct a detailed state-of-practice review that involves reaching out to State and local practitioners via email and/or holding discussions via teleconference to obtain a full picture of what is currently being done, including any supporting documentation. The team will hold conversations, as appropriate, with select stakeholders in order to obtain additional information such as reasoning for selected practices, subjective feedback on effectiveness and/or their experiences in general, and any other relevant information. In areas with active implementations, the team will also determine if States have gathered any crash data internally or if there is potential to gather historical crash data on sites where this has already been implemented.

*Task 5 – Laboratory Comprehension Testing and Analysis*

The research team will use the findings from the State-of-Practice review and practitioner discussions to refine the laboratory study approach. Participants will be presented with various images and/or videos and will be asked questions pertaining to their perceptions including, but not limited to, spacing of lines and when they are perceived as being two lines, and when they think they are allowed to cross or pass. Other information, as identified in the work plan, may also be gathered. The analysis will be completed in accordance with the work plan.

*Task 6 – Final Report and Presentation*

The research team will develop a final report that describes the research approach and results and provides a discussion of the findings. The team will present their findings to the TCD PFS members.

**Chance of Successful Evaluation**

High

There is a high likelihood that there will be some characteristics related to the implementation of center line buffer areas that will produce effective guidance to make sure that treatments are applied in a uniform and consistent manner. The laboratory study will likely provide some perspectives related to comprehension and perception of wide buffer areas.

Upon completion of the project, there may be a need for field testing to verify any potential guidance that is produced.

**References**

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