National Committee on
Uniform Traffic Control Devices

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Item No.: 24B-MKG-01

NCUTCD PROPOSAL FOR CHANGES TO THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

COMMITTEE / TASK FORCE:	Markings Technical Committee
ITEM NUMBER:	24B-MKG-01
TOPIC:	Pavement Marking Line Widths for Driving Automation Systems and Improved Visibility
ORIGIN OF REQUEST:	Markings TC and CAV JTF
AFFECTED SECTIONS OF MUTCD:	Section 3A.04

DEVELOPMENT HISTORY:
Approved by Markings TC: 06/27/2024
Approved by NCUTCD Council:

This is a proposal for recommended changes to the MUTCD that has been developed by a technical committee or joint task force of the NCUTCD. The NCUTCD is distributing it to its sponsoring organizations for review and comment. Sponsor comments will be considered in revising the proposal prior to NCUTCD Council consideration. This proposal does not represent a revision of the MUTCD and does not constitute official MUTCD standards, guidance, or options. If approved by the NCUTCD Council, the recommended changes will be submitted to FHWA for consideration for inclusion in a future MUTCD revision. The MUTCD can be revised only through the federal rulemaking process.

SUMMARY:
NCUTCD recommend changes to the MUTCD developed by the Markings Technical Committee (MTC) Automated Driving Systems (ADS) RFI Task Force was sent to FHWA in January 2020 (19B-MKG-02). The changes identified related to line width for normal and wide lines were not incorporated into the 11th edition of the MUTCD. This proposal submits similar language to the 19B-MKG-02 recommended language.

DISCUSSION:
In January 2020, the NCUTCD recommended changes to Section 3A.04 to FHWA. The 11th edition of the MUTCD did not address the NCUTCD recommendation. The FHWA explanation relative to proposed amendments to Section 3A.04 addressed their reasons for retaining the 2009 language. It did not address the NCUTCD recommended changes.

The NCUTCD CAV Task Force helps the NCUTCD understand how connected and automated driving technologies might impact the MUTCD. One of the key objectives of the NCUTCD CAV

Task Force was to develop relationships with the vehicle industry so that the communication can improve, and both the highway and vehicle industries can collaborate more effectively in visioning a robust transportation system where both human-led vehicles and connected and automated vehicles can operate in a safe and efficient manner.

At the January 2018 NCUTCD meeting, the Markings Technical Committee formed a Task Force in anticipation of the FHWA's ADS RFI, which was designed to obtain input on roadway infrastructure requirements needed to support automated driving systems. The top finding from FHWA's ADS RFI was the need for more uniform and quality in pavement markings and other traffic control devices to support automated driving systems. Another finding from the ADS RFI was that FHWA should take a national lead in developing an understanding of how the roadway infrastructure can adapt to support automated driving systems. As a result, FHWA conducted a series of National Dialogue sessions throughout the second half of 2018 to obtain additional input. One of the key takeaways from the infrastructure-themed National Dialogue meeting was that highway infrastructure standards need to be updated to respond to automated driving systems.

The MTC RFI ADS Task Force worked with the NCUTCD CAV Task Force to review available research and engage with the automotive industry to develop specific recommendations that support automated driving systems as well as provide additional guidance and safety for human-led vehicles. Throughout the second half of 2018 and the first half of 2019, the MTC ADS RFI Task Force engaged with a variety of stakeholders to develop a thorough understanding, as well as solicit feedback and comment. Stakeholders included the AASHTO Committee on Traffic Engineering, ATSSA, the Automated Safety Council, the Auto Alliance, as well as input from six machine vision companies that provide technologies that detect and read pavement markings to provide automated driving features such as lane departure warning, lane keep assist, and lane centering. The results of these efforts were used to form the proposed MUTCD language that was presented to the MTC in June 2019. The MTC discussed and then voted unanimously to approve the proposed recommendations, as shown below, to go to Sponsors for comments.

The FHWA adopted several of the proposed changes as part of the 11th Edition. The requirement of dotted edge line extensions at acceleration and deceleration lanes (Section 3B.07, Standard; Figures 3B 8-10) is a positive step towards highway system harmonization. FHWA addressed its decision to retain language in Section 3A.04 Functions, Widths, and Patterns of Longitudinal Pavement Markings Standard: 02A, Normal Line and B. Wide line, by referencing its own NPA proposal to apply the 6" normal and 10" wide line standard "be used for freeways, expressways, and ramps as well as for all other roadways with speed limits greater than 40 mph." No mention was made of the NCUTCD approved language that applied those changes "for Interstate, freeway, expressway and corresponding ramp interchange markings and for edge lines on all other roadways with posted or statutory speeds of 55 mph or more and an ADT of 6,000 vehicles per day or greater…".

The proposed recommendations are beneficial to human drivers and the full spectrum of driving automation system technologies referenced by FHWA in the 11th Edition. The proposal is in line with efforts by FHWA and AASHTO to take a safe systems approach to roadway safety. Lane keeping technologies are rapidly becoming ubiquitous in today's motor vehicles. These recommendations are technology neutral and will provide safer, more robust pavement marking

detection rates resulting in fewer vehicles unintentionally leaving their lane (roadway departure crashes make up over half of all fatalities and serious injury crashes in the US).

The safety benefits from these technologies have been shown to have a much higher impact on reducing roadway departure crashes than existing infrastructure treatments such as rumble strips (for instance, a study from 2016 showed the potential to reduce fatal crashes by 29 percent once these technologies are more prevalent). And the technology is already making its way into the vehicle fleet. In 2017, 60 percent of new vehicles sold in the US were equipped with lane departure technologies.

The proposed changes represent items mentioned, described, and/or referenced as it relates to pavement markings that support automated driving technologies—particularly the camera / machine vision systems that detect and track pavement markings for ADS features such as lane departure warning, lane keep assistance, and lane centering control. These technologies form the foundation of guidance systems used by current SAE Level 2 automated systems as well as the future, more advanced automated systems (SAE Levels 3 through 5). Engagements (meetings, presentations, and surveys) with automotive OEMs and manufacturers of ADS technologies have resulted in a vetted consensus list of priority uniformity needs that can best be addressed through changes to the MUTCD. It is expected that the proposed changes will increase safety of human drivers as well as increase the reliability of automated driving systems. For instance, FHWA research has shown that 6-inch wide edge line markings on two-lane highways can reduce fatal and injury crashes by 15 to 35 percent. Furthermore, research has shown that specific features of automated driving systems such as lane departure warning and lane keep assist, can reduce roadway departure crashes by nearly 50 percent.

The Task Force has reviewed available research, including NCHRP 20-102(6) research, to establish recommendations for pavement marking characteristics that provide adequate machine vision detection for ADS features such as Lane Departure Warning (LDW) and Lane Keep Assist (LKA), which are already providing benefits in terms of reduced roadway departure crashes and projected to have drastic impacts on these types of crashes as more vehicles with such equipment enter the fleet (by 2025 most new car sales will include LDW and approximately half will include LKA). The recommendations are “vehicle technology neutral” as well as “markings product neutral” and provide broad societal benefits.

Additional Information:

- Harper, C. D., Hendrickson, C. T., Samaras, C. Cost and benefit estimates of partially-automated vehicle collision avoidance technologies. Accident Analysis & Prevention, 95, 104–115. 2016
- Responses to the FHWA ADS RFI: https://www.federalregister.gov/documents/2018/01/18/2018-00784/automated-driving-systems
- FHWA Automation National Dialogues: https://ops.fhwa.dot.gov/automationdialogue/index.htm
- Swedish Pavement Marking & Lane Departure Warning Study – 2010: http://vti.diva-portal.org/smash/get/diva2:670435/FULLTEXT01.pdf
- Roads that Cars Can Read, EuroRAP, 2011: http://www.eurorap.org/wp-content/uploads/2015/04/20110629-Roads-That-Cars-Can-Read-June-2011.pdf, and http://www.eurorap.org/wp-content/uploads/2015/03/roads_that_cars_can_read_2_spread1.pdf
- Marking the Way Towards a Safer Future (2013): https://trid.trb.org/view/1286269

- TRB Automated Vehicle Symposium, 2014 – Present: http://www.automatedvehiclessymposium.org/proceedings
- Meetings with, and presentations by, the Auto Alliance, the Automotive Safety Council and Original Equipment Manufacturers
- Connected and Autonomous Vehicle Technology, Determining the Impact on State DOT Maintenance Programs, Shauna Hallmark, Omar Smadi, Jon Markt, et.al. NCHRP Report 1084, 2024: Connected and Autonomous Vehicle Technology: Determining the Impact on State DOT Maintenance Programs | Blurbs New | Blurbs | Publications (trb.org).
- Pavement Marking Demonstration Projects, FHWA-HRT-12-048, November 2013: https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/12048/12048.pdf
- Road Markings for Machine Vision. NCHRP 20-102(6). Final Report Pending: https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4004

RECOMMENDED MUTCD CHANGES:

The following present the proposed changes to the current MUTCD within the context of the current MUTCD language. Proposed additions to the MUTCD are shown in blue underline and proposed deletions from the MUTCD are shown in ~~red strikethrough~~. Changes previously approved by NCUTCD Council (but not yet adopted by FHWA) are shown in green double underline for additions and ~~green double strikethrough~~ for deletions. In some cases, background comments may be provided with the MUTCD text. These comments are indicated by [bracketed white text in shaded green]. Deletions made by a technical committee or task force after initial distribution to sponsoring organizations are shown in ~~highlighted red strikethrough and Helvetica text~~. Additions made by a technical committee or task force after initial distribution to sponsoring organizations are shown in underline blue and Helvetica text.

Section 3A.04 Functions, Widths, and Patterns of Longitudinal Pavement Markings

Standard:

01 **The general functions of longitudinal lines shall be as follows:**

- **A. A double line indicates maximum or special restrictions.**
- **B. A solid line discourages or prohibits crossing (depending on the specific application).**
- **C. A broken line indicates a permissive condition.**
- **D. A dotted lane line provides warning of a downstream change in lane function.**
- **E. A dotted line used as a lane line or edge line extension guides vehicles through an intersection, a taper area, or an interchange ramp area.**

02 **If used in accordance with Chapter 3B, ~~T~~the widths and patterns of longitudinal lines shall be as follows:**

- **A. Normal line—**
  1. **~~4 to~~ 6 inches wide for Interstate, freeway, expressway and corresponding ramps markings;**
  2. **6 inches for edge lines on all other roadways with a posted or statutory speed of 55 mph or more and an ADT of 6,000 vehicles per day or greater;**
  3. **4 to 6 inches in all other cases.**
- **B. Wide line—at least ~~twice the width of~~ 4 inches wider than a normal line but not to exceed 12 inches in width.**
- **C. Double line—two parallel lines separated by a discernible space. The pavement surface shall be visible between the lines in the same way that it is visible outside the lines, except where contrast markings are used in combination with the double line (see Section 3A.03).**
- **D. Broken line—normal width line segments separated by gaps.**

E. Dotted line—noticeably shorter line segments separated by shorter gaps than used for a broken line. The width of a dotted line extension shall be at least the same as the width of the line it extends.

Guidance:

03 To be recognized as a double line rather than two separate, disassociated single lines, the discernible space separating the parallel lines of a double line should not exceed two times the line width of a single line.

Support:

04 The width of the line indicates the degree of emphasis.

05 Increasing edge line width from 4 inches to 6 inches has been shown to be a beneficial countermeasure to enhance safety at locations with a history of run-off-the-road crashes (see Section 3B.09). Wider normal lines with a 6-inch width instead of the minimum 4-inch width can be beneficial to both human drivers and driving automation systems (see Section 5B.02).

Guidance:

06 Broken lines should consist of 10-foot line segments and 30-foot gaps, or dimensions in a similar ratio of line segments to gaps as appropriate for traffic speeds and the need for delineation.

07 A dotted line used as a lane line (see Section 3B.07) should consist of 3-foot line segments and 9-foot gaps. A dotted line for line extensions within an intersection, taper area, or interchange ramp area (see Section 3B.11) should consist of 2-foot line segments and 2-foot to 6-foot gaps.

Support:

08 Section 5B.02 contains information on pavement marking considerations for driving automation systems.