National Committee on
Uniform Traffic Control Devices

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Item No.: 24B-CAV-01

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

COMMITTEE / TASK FORCE:	Connected and Automated Vehicles JTF
ITEM NUMBER:	24B-CAV-01
TOPIC:	Uniform Lane Line Contrast Pattern
ORIGIN OF REQUEST:	CAV JTF and Markings TC ADS Task Force.
AFFECTED SECTIONS OF MUTCD:	Section 5B.02 Markings Section 3A.03 Colors

DEVELOPMENT HISTORY:

Approved by CAV JTF:	06/27/2024 and 01/08/2025
Approved by MTC:	06/27/2024 and 01/08/2025
Approved by NCUTCD Council:	01/10/2025

This is a recommended change to the MUTCD that has been approved by the NCUTCD Council. This proposal does not represent a revision of the MUTCD and does not constitute official MUTCD standards, guidance, or options. It 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:

The 11th Edition of the MUTCD has additional references for pavement marking contrast practices but remains silent on establishing or referencing a uniform contrast pattern. In comments to the 11th Edition MUTCD rulemaking, the automated vehicle industry provided a specific preference for contrast markings. In addition, two recent studies have been published that provide new information and pertinent research results.

These new sources of information are described below to support a proposed provision to develop a uniform pavement marking contrast pattern for lane lines. During a CAV JTF web meeting, a summary of these materials was presented and the question was asked: Is there enough material to develop a proposal to standardize contrast pavement marking patterns in the US? While unanimous support was provided, it was also agreed to limit the scope to lane lines for now[1].

DISCUSSION:

Pavement markings can be contrasted with black material to improve their daytime visibility. Section 3A.03 of the 11th Edition provides the following option: “Black markings may be used in combination with the colors mentioned in Paragraph 1 to enhance the contrast with a light-colored pavement.” In most applications, contrast markings are used on concrete pavements, but they can also be used on asphalt pavements knowing that the pavement color can fade to a

light grey in southern climates. Black is mostly used to supplement lane lines, but in some cases, edge lines are also supplemented with black material. This proposal is focused exclusively on the lane line application.

There are at least 7 different lane line contrast patterns used in the US[2]. Of those 7, the majority are either a bordered (thin black lines paralleling the outside edge of a lane line) or lag (black material of the same dimensions of the lane line following and immediately behind the lane line) contrast pattern[3].

A recent safety study showed that contrast lane lines reduce crashes 5 to 29 percent, depending on the number of lanes - the more lanes, the more effective the lane line contrast patterns appear to be[4]. This study evaluated the safety performance of both the bordered and lag contrast patterns and found from the human driver perspective there was no statistical difference between the safety performance of the two patterns (this study was not focused on vehicle technologies).

During the 11th Edition rule-making process, the Automated Safety Council (ASC) submitted comments related to TCD design and uniformity practices that would be beneficial for vehicle technologies entering the US fleet at a high rate (currently there are about 75 million vehicles in the US equipped with forward looking cameras and essentially all new vehicles sold in the US starting in 2025 will have forward looking cameras)[5]. In the ASC letter, the following suggestion was provided, “Contrast markings in which a black lane line of the same dimension immediately follows a normal white lane line, improves machine vision system recognition in glare conditions.” The letter goes on to describe how the thin black lines used to make up the bordered contrast pattern are too thin for the machine vision systems to “see”.

The CAV JTF hosted a web mtg on June 13, 2024, where a representative of the ASC presented the evolution of vehicle camera capabilities and how the evolution impacts some specific TCD detection distances[6]. This presentation confirmed that vehicle cameras of today and next generation cameras provide greater detection when lag contrast patterns are used. The key factor is the width of the black material and pixels of the vehicle camera. Higher resolution cameras of tomorrow will have similar performance as today’s cameras, except the higher resolution cameras provide consistently longer detection distances.

In conclusion, there is data showing that 7 contrast patterns are used in the US. From a human driver perspective, the two most common patterns show no difference in terms of safety benefits (they are both positive). From a vehicle machine vision perspective, the lag pattern is favored. Therefore, the following changes to the MUTCD are recommended to improve safety for legacy drivers and ready roadways for vehicles equipped with machine vision technologies.

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1 NCUTCD CAV JTF web meeting, May 28, 2024.
2 Evaluation of Wet-Weather and Contrast Pavement Marking Applications. TxDOT Research 5008-2, 2007.
3 Contrast Pavement Marking Practices, NCHRP Synthesis 613, 2023.
4 Crash Modification Factors for Contrast Pavement Markings on Light-Colored Pavement, FHWA-ICT-22-101, August 2022.
5 Automotive Safety Council (ASC) response to 11th Edition rulemaking.
6 NCUTCD CAV JTF web meeting, June 13, 2024.

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].

PART 3. MARKINGS

CHAPTER 3A. GENERAL

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 **The widths and patterns of longitudinal lines shall be as follows:**

A. Normal line—4 to 6 inches wide.

B. Wide line—at least twice the width of a normal line.

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.

Support:

07 Black markings used with broken lane lines on light colored pavements have been shown to improve safety during daytime conditions when they are used in a bordered or lag contrast pattern (see Figure 3A-XX).

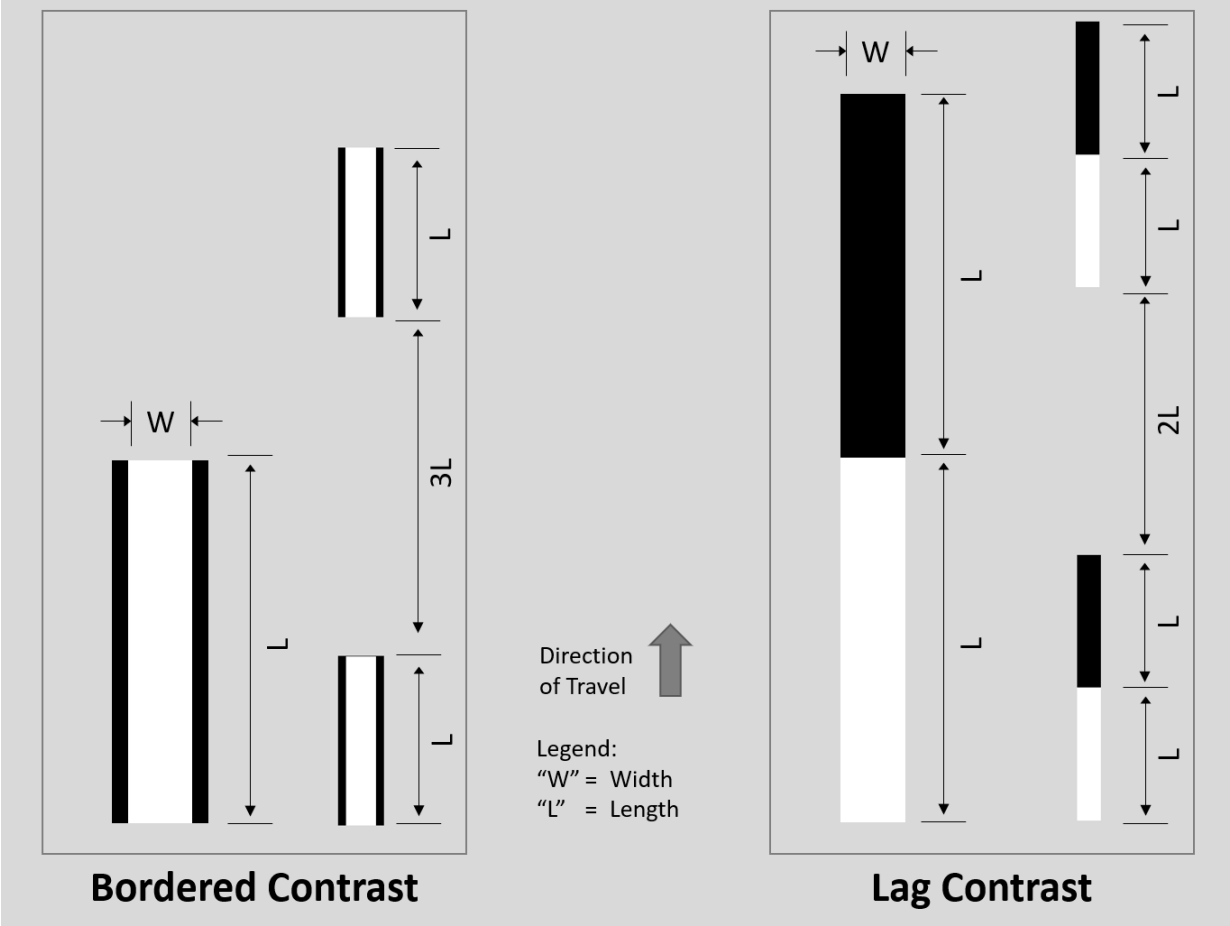
Guidance:

~~07~~08 *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~~09 Section 5B.02 contains information on pavement marking considerations for driving automation systems.

Figure 3A-XX. Bordered and Lag Contrast Pattern



Updated Figure

PART 5. TRAFFIC CONTROL DEVIOCE CONSIDERATIONS FOR AUTOMATED VEHICLES

CHAPTER 5B. PROVISIONS FOR TRAFFIC CONTROL DEVICES

Section 5B.02 Markings

Support:

01 Driving automation systems use sensors, algorithms, and processing to locate, read, and comprehend pavement markings. Location, condition, uniformity, design characteristics, and consistent application all have some effect on the ability of driving automation systems to perform this function. Certain pavement marking applications and practices have been shown through research to better support driving automation system technology, while also benefitting, or at least not detracting from, the performance of the human operator.

Guidance:

Agencies seeking to better accommodate driving automation system to support AVs, while also potentially benefitting human drivers, should consider:

A. Normal width longitudinal lines of at least 6 inches in width (see Section 3A.04).

B. Edge lines of at least 6 inches in width (see Sections 3A.04 and 3B.09).

C. Dotted edge line extensions along all entrance and exit ramps, all auxiliary lanes, and all tapers where a deceleration or auxiliary lane is added (see Section 3B.11).

D. Chevron markings in the neutral areas of exit gores to distinguish them from travel lanes (see Section 3B.25).

E. Raised pavement markers only as a supplement to, rather than as a substitute for, pavement markings (see Sections 3B.16 and 3B.17).

F. ~~Uniform contrast markings on light-colored pavements to create greater contrast~~. Supplementing broken white lane lines with a lag pavement marking contrast pattern consisting of black material with the same dimensions of the lane line ~~and immediately following the lane line~~. (see Section 3A.04).

G. Broken lines with uniform marking and gap length (see Section 3A.04).