

# Literature search: Colors in Dynamic Message Signs

**Need statement number:** NS 730

**Date:** 7/29/2024

**Resources searched:** EBSCO Database, MnDOT Library, TRID, Transport

## Summary

Results are compiled from the databases named above. Links are provided for full text, if applicable, or to the full record citation. I completed my searches using the following terminology: dynamic message signs, variable message signs, changeable message signs, color, retroreflective, retroreflection, retroreflectivity. The results are divided into most relevant and less relevant.

## Most relevant results from the EBSCO Database

**Title:** Delay or travel time information? The impact of advanced traveler information systems on drivers' behavior before freeway work zones.

**Authors:**

Reinolsmann, Nora<sup>1,2</sup> (AUTHOR)

Alhajyaseen, Wael<sup>1,2,3</sup> (AUTHOR)

Brijs, Tom<sup>1</sup> (AUTHOR)

Pirdavani, Ali<sup>4</sup> (AUTHOR)

Ross, Veerle<sup>1</sup> (AUTHOR)

Hussain, Qinaat<sup>2</sup> (AUTHOR)

Brijs, Kris<sup>1</sup> (AUTHOR)

**Source:** Transportation Research: Part F. May2022, Vol. 87, p454-476. 23p.

**Abstract:** **Variable message signs** benefit from delay updates for strategic freeway diversions.

- Graphical displays increase rerouting by additional 25% for time-wise equal routes.
- VMS displaying total travel times are less effective than traffic delay displays.
- Repetition of traveler information is beneficial if both freeway routes have delays.
- Highlighting the contrast in traffic delays motivates drivers to take a detour.

Peak travel times contribute to congestion formation at freeway work zones. Advanced Traveler Information Systems (ATIS) can inform drivers in real-time about the delays and travel times en-route and can provide information about an alternative route to a destination. Different ATIS display strategies are available; however, road authorities lack insights into how time display methods and sign characteristics influence the driving behavior (decelerations, lateral position), the drivers' attention allocation ability and the subsequent route choice before the freeway diversion. A driving simulator study was conducted with 80 drivers in the State of Qatar to investigate drivers' behavior and voluntary route choices when encountering total travel time (default setting) or delay time updates for two freeway routes on **Variable Message Signs** (VMS) and Graphical Route Information Panels (GRIP). The GRIPs are a graphical alternative to conventional VMS that can provide drivers with a visual map of the most direct route or an alternative less congested route to a destination using different **color** schemes. The time difference ratio between the two routes was kept constant to compare the effectiveness of the information designs and investigate the drivers' attention towards the signs with an eye-tracker. The results showed that the display of zero delays for a detour did influence 74–83% of the drivers to take the alternative route when being displayed on a VMS and a GRIP with free flow attribute framing. When displaying equal total travel times, the GRIP did influence 25% more drivers to follow the alternative route than the VMS. Generally, displaying zero delays for the alternative route resulted in an efficient

attention allocation to the first ATIS location and fewer mean decelerations before the repeated ATIS location nearing the diversion. Road authorities are advised to activate the display of delay times to support efficient route choices among freeway drivers. [ABSTRACT FROM AUTHOR]

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**URL:**

**Database:** EBSCO MegaFILE

**Title:** Effects of **color** scheme and message lines of **variable message signs** on driver performance

**Authors:**

Lai, Chien-Jung<sup>1</sup> [laicj@ncut.edu.tw](mailto:laicj@ncut.edu.tw)

**Source:** Accident Analysis & Prevention. Jul2010, Vol. 42 Issue 4, p1003-1008. 6p.

**Abstract:** The advancement in **variable message signs** (VMS) technology has made it possible to display message with various formats. This study presented an ergonomic study on the message design of Chinese **variable message signs** on urban roads in Taiwan. Effects of **color** scheme (one, two and three) and number of message lines (single, double and triple) of VMS on participants' response performance were investigated through a laboratory experiment. Results of analysis showed that **color** scheme and number of message lines are significant factors for participants' response time to VMS. Participants responded faster for two-**color** than for one- and three-**color** scheme. Participants also took less response time for double line message than for single and triple line message. Both **color** scheme and number of message lines had no significant effect on participants' response accuracy. The preference survey after the experiment showed that most participants preferred two-**color** scheme and double line message to the other combinations. The results can assist in adopting appropriate **color** scheme and number of message lines of Chinese VMS. [Copyright &y& Elsevier]

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**URL:**

**Database:** EBSCO MegaFILE

**Title:** Evaluate the Understandability of Information Display Board Signs Using a Driving Simulator Experiment.

**Authors:**

Wang, Pei<sup>1</sup> (AUTHOR)

Zhang, Tingting<sup>1</sup> (AUTHOR)

Zhou, Xiao<sup>2</sup> (AUTHOR) [zhouxiao@whut.edu.cn](mailto:zhouxiao@whut.edu.cn)

Motamedi, Sanaz<sup>1,3</sup> (AUTHOR)

Chan, Ching-Yao<sup>1</sup> (AUTHOR)

**Source:** International Journal of Human-Computer Interaction. Oct2022, Vol. 38 Issue 17, p1668-1686. 19p. 2 Black and White Photographs, 6 Diagrams, 7 Charts, 5 Graphs.

**Abstract:** The main research question of this study was how to apply the design guidelines for traditional **Changeable Message Signs** (CMSs) to the design of the full-**color** and full-matrix LED Information Display Boards (IDBs). Three categories of messages were evaluated in this study, including (1) travel-time messages, (2) transit travel-time messages, and (3) Graphic Route Information Panels (GRIPs). A driving simulation program was developed based on real-world videos and used to evaluate the designed signs in terms of understandability and helpfulness for decision-making. A total of twenty-four local commuters participated in the driving simulator experiments. Results show that: (1) the perceived easiness of five-line travel-time message is significantly lower than the baseline three-line message, (2) the perceived helpfulness of the transit logo is significantly higher than the generic symbol, and (3) there is no significant difference between the drivers' comprehension of the three-line message and the single-link GRIPs. [ABSTRACT FROM AUTHOR]

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**Full Text Word Count:** 12477

**URL:**

**Database:** EBSCO MegaFILE

## Most Relevant Results from the TRID Database

**Title:** Effects of Full Matrix **Color Changeable Message Signs** on Legibility and Roadway Hazard Visibility.

Authors: Chrysler, Susan T; Carlson, Paul J; Brimley, Brad; Park, Eun Sug.

Source: Transportation Research Record: Journal of the Transportation Research Board, Issue 2617, 2017, pp 9-18

<https://trid.trb.org/view/1438308>

Abstract: Transportation agencies are considering public-private partnerships as they struggle to fund infrastructure and operations improvements. The national Manual on Uniform Traffic Control Devices (MUTCD) allows acknowledgments of private sponsors on static signs. The legibility and visibility impacts of including logos of sponsors on **changeable message signs** (CMSs) were examined. Thirty drivers participated in a closed-course study during daytime and nighttime conditions. Full-sized full matrix **color** LED signs were used to display travel time and safety reminder messages with and without sponsor acknowledgment logos. Single- and dual-phase messages were tested. The measures of effectiveness were legibility distance for target words on the signs and roadway hazard object detection distance. Legibility distances of the CMS messages were notably greater than those of **retroreflective** traffic signs and well above the MUTCD threshold of 30 ft/in. During the day, the median legibility index was approximately 60 ft/in. At night, the index was approximately 45 ft/in. Sponsor logos had no significant effect on the legibility distances of travel time signs. Sponsor logos had a small effect on the legibility distance of safety message signs with a blue background but not on those with a black background. The use of sponsor logos marginally affected object detection for certain object locations. The results of this study, coupled with an earlier driving simulation evaluation showing no cognitive distraction due to logos, support the use of sponsorship acknowledgment signs on CMSs. An open road evaluation is planned before statewide implementation is enabled.

**Title: An automated sign **retroreflectivity** condition evaluation methodology using mobile LIDAR and computer vision.**

Authors: Ai, Chengbo; Tsai, Yichang (James).

Transportation Research Part C: Emerging Technologies, Volume 63, 2016, pp 96-113

<https://trid.trb.org/view/1396586>

Abstract: Traffic sign **retroreflectivity** condition is one of the most critical factors impacting nighttime driving safety. The federal rule on minimum traffic sign **retroreflectivity** incorporated in the 2009 Manual on Uniform Traffic Control Devices (MUTCD) issued by the Federal Highway Administration (FHWA) is compelling transportation agencies to evaluate how to comply. As the traditional manual methods have become financially and/or practically infeasible, there is an urgent need for an effective and efficient **retroreflectivity** evaluation method. This paper investigates the possibility and proposes a methodology for automatically evaluating traffic sign **retroreflectivity** condition using mobile light detection and ranging (LIDAR) and computer vision. The proposed methodology uses (a) the traffic sign detection and **color** segmentation methods that are introduced for the first time to evaluate the **retroreflectivity** of different traffic sign **color**s separately in an automated manner; (b) the proposed theoretical-empirical LIDAR retro-intensity normalization scheme to more reliably model the radiometric responses of traffic sign captured in the mobile LIDAR data; (c) the population-based condition assessment method for the first time to statistically quantify the **retroreflectivity** condition of traffic signs rather than an four-point average. An experimental test was conducted on 35 Type I Engineer Grade stop signs. The result shows that the proposed methodology can produce a promising outcome with consistent **retroreflectivity** evaluations based on handheld retroreflectometer measurements; the proposed methodology can, also, better identify traffic signs with non-homogeneous deteriorated **retroreflectivity**. The reliable **retroreflectivity** evaluation results make the proposed methodology an appealing alternative for transportation agencies to use to comply with the FHWA's requirement.

**Title: Specifications Of a Universal **Variable Message Sign****

Author: Alferdinck, Jwam.

Source: Tno Technische Menskunde Tm, Issue TM-01-C045, 2001, 38 p.

<https://trid.trb.org/view/730824>

Abstract: The Netherlands Transport Research Centre (AVV) is preparing functional specifications for the universal **variable message sign** (VMS), which shall be used as traffic signaling. It is of major importance that traffic signs are presented uniformly. In order to draft well-founded requirements, research was needed on the recognition distance of traffic signs, the backing board dimensions, and the allowed colour differences and reflections. In a laboratory matrix signs were simulated with images of traffic signs in various resolutions and in normal and inverted (white symbols on a black background) conditions. With 12 observers the recognition distance was determined. Information from literature was used to draft proposals for the requirements for the backing board dimensions and the allowed colour differences and reflections. Some of the conclusions made are: In order to recognise traffic signs at a distance of 200 m on a matrix sign with optimal optical properties, the height of circular and triangular signs should be at least 133 and 148 m, respectively. Arrows should have a minimal length of 49 cm. For displaying these signs a matrix sign is needed with a size of 1.5 x 1.7 m (h x w) and a light point distance of maximal 32 mm. For an aesthetic image the light point should be no more than 16 mm; The required resolution of a matrix sign does not depend on the recognition of the displayed traffic sign, but on its aesthetic properties; Concerning recognition there is no restriction for the use of inverted signs; A backing board with a width of 50 cm, measured from the side of the display surface, ensures sufficient legibility and conspicuity. and distracting reflections in signs can be avoided by establishing

requirements for diffuse and specular reflections, which can be measured according to standardised methods. For related work see ITRD E206643.

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## Relevant Results from the Web

### Title: [Exploring the applicability of the CAM18sl brightness prediction](#)

Abstract: Recently, a **color** appearance model, CAM18sl, has been published. The model can predict the **color** perception (hue, **colorfulness**, brightness) of self-luminous stimuli seen against neutral backgrounds varying in luminance. In this paper, the applicability of CAM18sl to situations different from the one for which it was originally developed is explored. The brightness perception predicted by this model (expressed in “bright”) is compared with the outcome of the CIE Unified Glare Rating (UGR) for luminaires, the limiting luminance values for **Variable Message Signs** as indicated in the European standard for outdoor situations, the visual gloss (VG) formula to characterize the gloss of objects, the CIE grey-scale calculation for self-luminous devices, and the predicted brightness value of illuminated objects according to CIECAM02. Although the application domains mentioned above are very distinct, it appears that the predicted brightness perception of the CAM18sl model correlates well with the outcome of the particular and dedicated metrics. It seems that, for brightness perception, CAM18sl can be considered as a general model applicable for a wide range of applications. This could lead to a reduction of a number of application-specific metrics.

### Title: [Research on the influence of light source characteristics on traffic visual distance in foggy areas at night](#)

Abstract: Adverse weather such as fog will reduce drivers' visual recognition ability, and important visual information in the driving will be weakened and even lost, which brings risks to driving safety. This paper sets out to explore causes for the decline in driving visual ability in foggy sections at night based on drivers' visual recognition demand mechanism. The purpose is to study the influence of light source characteristics on visual distance under open traffic conditions. Through an outdoor visual recognition test, data were collected on the visual recognition distances of 12 car drivers to standard gray small targets, under different light source characteristics and meteorological visibility conditions. Results revealed that the latter conditions, along with illuminance and correlated **color** temperature affected drivers' visual recognition ability in low meteorological visibility sections at night. At the same illuminance and meteorological visibility, a light source with high correlated **color** temperature could improve visual distance. The multivariate power function model of meteorological visibility, illuminance at the target and driver's visual distance in foggy areas were obtained by fitting. The research methods and conclusions could provide technical reference for improving traffic visual distance at night, and thus help lay a foundation for road construction and traffic control technology in foggy areas.

## Less relevant results From the EBSCO Database

### Title: [Influence of text luminance, text colour and background luminance of variable-message signs on legibility in urban areas at night.](#)

#### Authors:

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Li, Y<sup>1</sup> (AUTHOR)

Xing, L<sup>3</sup> (AUTHOR)

Qiu, Z<sup>1</sup> (AUTHOR)

Zhang, X<sup>1</sup> (AUTHOR)

**Source:** Lighting Research & Technology. May2021, Vol. 53 Issue 3, p263-279. 17p.

**Abstract:** Variable-message signs, which are an important type of traffic sign, have been widely used in traffic control. This study examines the influence of text luminance, text colour and background luminance of variable-message signs on legibility in urban areas under night-time vision. First, the background luminance of variable-message signs in typical urban areas is investigated, tested and classified as high, medium or low depending on the obtained values (3.0, 1.0 or 0.1 cd/m<sup>2</sup>, respectively). Second, a calculation model is established for the experimental visual recognition distance under different visual acuity conditions, the experimental luminance interval is determined based on psychophysical magnitude perceived, and a legibility experiment is performed using Landolt-C rings. Finally, the reasonable luminance interval (minimum [replacement] luminance), optimal luminance and changing trends of luminance for red, green and yellow colours under different background luminances are obtained such that the legibility requirement is satisfied. The results indicated that different colours have different luminance interval and optimal luminance under different background luminances. This study is of great importance in determining the reasonable luminance of variable-message sign texts and improving the safety and efficiency of road traffic. In the future, these research results are expected to serve as guidelines for variable-message sign setup and management. [ABSTRACT FROM AUTHOR] *Copyright of Lighting Research & Technology is the property of Sage Publications, Ltd. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts.)*

**URL:**

**Database:** EBSCO MegaFILE

**Title:** Skyline Products Case Study Explores Colorado Department of Transportation's (CDOT) Use of Skyline Variable Speed Limit Signs for I-70 Glenwood Canyon Corridor Project

**Authors:** PR Newswire

**Source:** PR Newswire US. 10/20/2020.

**Abstract:** COLORADO SPRINGS, Colo., Oct. 20, 2020 /PRNewswire-PRWeb/ -- Skyline Products, which produces the industry's most advanced and reliable ITS-Grade® **dynamic message signs** (DMS), released today a case study that explores the use of Skyline Products variable speed limit (VSL) signs by the Colorado Department of Transportation (CDOT). The installation of Skyline's LED variable speed limit signs is part of a project to enhance CDOT's Intelligent Transportation Systems (ITS) infrastructure along I-70 in the Glenwood Canyon corridor. [ABSTRACT FROM PUBLISHER]

**URL:**

**Database:** EBSCO MegaFILE

## Less Relevant Results from the Web

**Title:** [Legibility research of highway signage typefaces: A critical review and a potential design-centred approach](#)

**Abstract:** With the increasing prevalence of the automobile, the transmission of information through the visual means of signage became critical owing to the safety problems that followed the growth of the highway system and the continuous increase in traffic. This paper presents a review of research on the legibility of highway signs and discusses the key studies of the legibility of typefaces used on them. It



examines in particular the legibility of the Latin typefaces in English language used on US highway signs, focusing on the most significant findings on the characteristics of typefaces and the features that most affect legibility. The paper also discusses the methodological approaches used to examine legibility in conditions of driving and suggests that future research should pursue the application of findings in the field of reading research and be informed by design knowledge.

**Title: [Analysis of traffic signs information volume affecting driver's visual characteristics and driving safety](#)**

**Abstract:** To study the influence of traffic signs information volume (TSIV) on drivers' visual characteristics and driving safety, the simulation scenarios of different levels of TSIV were established, and 30 participants were recruited for simulated driving tests. The eye tracker was used to collect eye movement data under three-speed conditions (60 km/h, 80 km/h, and 100 km/h) and different levels of TSIV (0 bits/km, 10 bits/km, 20 bits/km, 30 bits/km, 40 bits/km, and 50 bits/km). Principal component analysis (PCA) was used to select indicators sensitive to the influence of TSIV on the drivers' visual behavior and to analyze the influence of TSIV on the drivers' visual characteristics and visual workload intensity under different speed conditions. The results show that the fixation duration, saccade duration, and saccade amplitude are the three eye movement indicators that are most responsive to changes in the TSIV. The driver's visual characteristics perform best at the S3 TSIV level (30 bits/km), with the lowest visual workload intensity, indicating that drivers have the lowest psychological stress and lower driving workload when driving under this TSIV condition. Therefore, a density of 30 bits/km is suggested for the TSIV, in order to ensure the security and comfort of the drivers. The theoretical underpinnings for placing and optimizing traffic signs will be provided by this work.