Can You See Me Now? Meeting the New MUTCD Retroreflectivity Standards

By: Marc J. Rogoff, Ph.D., Augusto S. Rodriguez, CFEA, Michael B. McCarthy, P.E.[1]

INTRODUCTION

A major goal of the FHWA is to provide a safe roadway system throughout the United States. In light of this goal, development of minimum retroreflectivity levels for traffic signs and pavement markings has been one of the agency's key work programs throughout the last two decades. These efforts have resulted in a revision of *The Manual on Uniform Traffic Control Devices (MUTCD)*, pursuant to the Congressional mandate to:

> "...include a standard for a minimum level of retroreflectivity that must be maintained for pavement markings and signs, which apply to all roads open to public travel."

In essence, roadway traffic signs and pavement markings must be readable and detectable by drivers, bicyclists, and pedestrians at a sufficient distance during both day and nighttime conditions. Conferences, workshops, and an active research program have been underway since 1984 to develop minimum retroreflectivity standards for traffic signs. It has long been known that sign materials can degrade over time making them undetectable to the public. This could result in an inconvenience to the public or create

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potential safety concerns. Currently, the FHWA suggests that there are no real objective measures available for traffic engineers to determine when a roadway sign has reached the end of its useful life for nighttime visibility and should be replaced (FHWA, 2002b).

During the course of this study, a field research program was implemented to gather information on sign retroreflectivity with the objective of quantifying the potential impact to the County meeting these new recommended guidelines. Previous studies completed by FHWA suggested that signs within counties and cities would require increased compliance costs due to the fact that their signs are often older and are typically composed of less expensive sheeting signs (TransSAfety, Inc., 1998). Our objective in this study was to specifically quantify the costs of compliance for Hillsborough County.

FIELD RESEARCH

Hillsborough County utilized the TransMap Corporation's mobile tracking and data collection system to inventory the County's traffic signs. Data was collected on existing traffic signs from fall 1999 to February 2000. The data were entered into the County's Hansen Information Technologies™ system to create a data base file of 86,575 traffic signs in Hillsborough County. The traffic signs were sorted into nine sign types: Destination, Information, Markers, Regulatory, School, Stop, Street Name, Warning and Miscellaneous. Excluding the "Miscellaneous" signs, the remaining eight categories are the same descriptors used by FHWA in the MUTCD. Approximately 60 different characteristics were recorded for each sign. The resulting data set contains over four million observations on the 86,575 signs.

Consideration was given to the size of the overall population, the time limits imposed by the project scope, and the accepted level of risk. In order to obtain a manageable data sample, four sign types were chosen for analysis: regulatory, school, stop and warning. Each of the four sign classes were sorted from the larger population and treated as separate subpopulations for the purposes of this analysis and to achieve a stratified sample. The total population of the four sign types was 45,851. The sample size was 1,423. This sample size was calculated at a 95% confidence level, meaning the sample is representative ± 5% (Table 1). After identifying the sample sizes, all of the members of each class subpopulation were assigned unique, random identifier numbers. The assigned unique identifier then sorted these and the requisite number of observations was drawn out of the class subpopulations. Thus, the sample data set was a random stratified sample of the total population of regulatory, school, stop, and warning signs in Hillsborough County.

Table 1
Sample Size

Sign Type	Population (by class)	Sample Size (95% Confidence Interval)
Regulatory	19,000	377
School	1,375	300
Stop	13,160	373
Warning	12,316	373
Total	**45,851**	**1,423**

At the outset of the fieldwork, each of the 1,423 road signs selected in the stratified random sample were mapped using locational identifiers (x y coordinates) from the previously discussed County's Sign Management Database. Sector maps for the County were then prepared using various geographic information software (GIS) software modules, which are available in ArcGIS 3.3™, to locate important features (e.g., signs, streets, and township/section/range) on each map. Maps in each sector (192 in total) were then printed in 11" x 17" size format to facilitate location of each sign in the field. Prior to each day's data collection effort, the field team utilized these maps to prepare daily routes, which would optimize data collection time and reduce overall vehicle mileage.

To collect data on roadway sign retroreflectivity for this project, a hand-held retroreflectometer, owned by the County, was used. The instrument is designed to measure the brightness (retroreflectivity) of road signs and materials, as seen by drivers at a distance of 100 meters (328 feet). The device measures the coefficient of retroreflection (R_A) at entrance angle of -4° and an observation angle of $+0.2^\circ$.

Prior to taking measurements, the operator calibrated the instrument, using a reference material of known retroreflectivity, which is included with the instrument package. An extension pole kit was used for signs that were out of normal reach (pole extended from five to nine feet).

The measured R_A units for each observation were displayed on the instrument's LCD panel and then up to 1,000 single readings stored in memory. The recorded data was then uploaded as a Microsoft Excel spreadsheet

These data were then read and stored in the master data file for this work assignment. Additionally, the instrument records a continuous GPS location of each retroreflectivity reading taken, data and time of the reading, identification label, and sequence number of the measurement.

A data collection instrument was developed to assist the team in manually recording observations for each sign (e.g., R_A for background, R_A for sign legend, azimuth of the sign, any viewing obstructions, and any other notable observations). These tabular data were then entered into ArcGIS for subsequent statistical analysis.

In most cases, the signs selected in the stratified random sample were easily located in the field, suggesting that the County's Sign Management Database was highly accurate. Typically, "missing signs" included those that were later found to have fallen on the ground, signs removed during road construction projects over the past several years, or were only "temporary signs" as the time the original TransMap survey was developed.

DATA ANALYSIS

The measured R_A values for each sign's legend and background were compared against the minimum recommended FHWA R_A values. If the measured value was equal or greater than the minimum R_A value for the respective sign class, then the respective sign was classified as "passed"; those not meeting the minimum value were considered to have "failed". Table 2 summarizes the percentage of traffic signs in the stratified random sample that had passed or failed these minimum recommended R_A values.

Table 2
Percentage of Signs in Random Sample Meeting Recommended Minimum R_A Values

Type of Sign	Percentage Passed or Failed	
	% Passed	% Failed
Regulatory	74.1	25.9
School	79.3	20.7
Stop	44.9	55.1
Warning	60.9	39.1

Retroreflectivity measurements taken in the field indicated that based on the minimum R_A values, over 55 percent of the white-on-red stop signs would need replacement. Obviously this is one of the most crucial groups of signs. Approximately half of the 55 percent failures of the white-on-red (stop) signs were due to the inability of the signs to meet the recommended minimum white to red contrast ratio equal to or greater than 3:1. Through research and observation sponsored by the FHWA, the determination was made that any white-on-red signs with a contrast ratio below the 3:1 value would be inadequate for service.[2] The failures appear to be an inherent problem with the accepted method of stop sign fabrication involving red silk screening over a white reflective material. Over a period of time and weathering the red silk-screening on the sign wears away allowing the white reflective material to "bleed" through, thus lowering the contrast ratio. The legend on the sign then becomes increasingly obscure.

The next crucial group of signs is the black-on-yellow/orange warning signs. Again, based on the minimum R_A values nearly 40% (39.1 percent) of the warning signs would need replacement. Similarly, almost 26% (25.9 percent) and 21% (20.7 percent) of the regulatory and school signs respectively would need replacement.

[2] Personal communication with Dr. Paul Carlson, Texas Transportation Institute, Texas A&M University System, December 15, 2003.

Although it is known that traffic signs deteriorate over time due to various environmental factors such as exposure to the sun, rain, dirt, wind, etc., we were unable, because of funding and time constraints, to measure sign failure with all of these environmental factors. Further, there is currently limited sign installation data in the County Sign Management Database to help correlate sign failure rates with sign age. We were, however, able to easily record data on sign orientation with a field compass during the course of the study. Each sign was then classified into a general exposure classification (northern, eastern, southern, and western) to discern whether there was a statistical significant correlation with sign orientation and passing/failure rates. None was determined based on compass observations, which was similar to the findings of Kirk et. al., 2001.

The percentage of traffic signs not meeting minimum R_A values in the stratified random sampling was used to project the number of signs which would need replacement Countywide. Table 3 is a summary of the projected sign replacement costs for Hillsborough County based on the County's current contract replacement costs under two different cost replacement scenarios: $60.00 per sign for private vendor fabrication and County installation and $125.00 per sign for private vendor fabrication and installation. Prices were based on standard signs under 12 square feet surface area and using Type III High Intensity sheeting materials. As shown, County cost for nearly 17,300 (17,262) signs are projected at slightly more than $1,000,000 ($1,035,750 County installation), and $2.1 million ($2,157,812 vendor installation).

Table 3
Projected Hillsborough County Sign Replacement Costs

Sign Type	Countywide Sign Population	% Below Minimum	# of Signs	Replacement Cost at $60.00	Replacement Cost at $125.00
Regulatory	19,000	25.9	4,920	$ 295,178	$ 614,954
School	1,375	20.7	284	$ 17,048	$ 35,517
Stop	13,160	55.1	7,251	$ 435,041	$ 906,336
Warning	12,316	39.1	4,808	$ 288,483	$ 601,005
	45,851		**17,262**	**$ 1,035,750**	**$ 2,157,812**

CONCLUSIONS

While measurement of retroreflectivity is not an exact science and is a complex interaction of the driver, vehicle, roadway, and the sign itself, the minimum retroreflectivity values provided by the FHWA provide transportation policy makers with objective guidelines for sign replacement. The field research program conducted by the County suggests that its Sign Management Program database appears to be quite accurate. Most, if not all, of the signs in the random sample could be easily located in the field using the GIS coordinates and accompanying street names. Further, the retroflectomer was easy to operate in the field, proved to be extremely reliable, and the software enabled quick downloading of the R_A recorded measurements.

POLICY DIRECTIONS FOR THE COUNTY

Traffic sign management is a critical element in the County's transportation program. Given the wide variation of County roadway conditions, types of vehicles, and the driving ability of a rapidly aging driving population, maintenance of traffic signs and nighttime visibility will continue to be an important safety consideration for the County, the driving public and pedestrians.

Currently, the County maintains an inventory of general stock (stop, yield, speed limit signs, etc.) and a specialty traffic signs (street names, specific information) through implementation of the HANSEN inventory system. Work for the County's Sign Shop Group is generated through work orders, as a result of an investigation, through a citizen request, or as a repair work order. Work orders for new signs and new contract installations are currently processed through this software system, which enables the County's sign inventory to be revised. The specialty signs are either fabricated in-house or those requiring special graphics or multiple colors are purchased through term contracts. On new County roadway projects, installation of the required signage is purchased through term contracts. Discarded and old signs are taken to the Roadway Maintenance Department where a recycling contractor picks them up.

The County's current HANSEN system enables staff to track the cost and material usage for roadway signs. Along with the current sign inventory in the HANSEN sign database, the County is well on its way towards development of an integrated Sign Management System. Further, the current inventory system utilizes a GPS location reference system to track the location of individual signs.

To improve the usefulness of the existing sign inventory system, the County is considering the following basic improvements, as recommended by the FWHA in its report, *An Implementation Guide for Minimum Retroreflectivity Requirements for Traffic Signs*:

- Providing information on the installation date for each sign;
- Sign inspection (an assessment of the quality of the sign based on nighttime and daytime visual inspections and retroreflectivity measurements) and maintenance records (date sign was inspected or maintained along with service performed);
- Photo images of each sign (either digitally captured or linked to a video disc based photo log) and

- Assessment of microcomputer/pen-based/tablet technologies to enable data entry in the field and thereby minimize keyboard entry. This would also provide real time data for field crews

Additionally, implementation of a routine sign inspection and maintenance program is an essential element of a sign management program. While the County has an active program, available staff resources within the last few years have been stretched and some maintenance and pro-active inspection has been deferred. As a consequence of this study, county staff is requesting additional budget to replace signs of each failing category in the projected proportion over the next four years. Replacement of the failing stop signs is the first priority with funding from the current operating budget, but the schools and warnings will be next in support of its expanding Bicycle Ped program and school safety.

Further, in light of the sign replacement recommendations discussed in the paragraphs above, the County will be implementing a pro-active inspection and maintenance program covering the following major aspects:

- Condition of the sign face to evaluate major cracking, peeling or blistering of the retroreflective laminate sheeting materials causing problems such as discoloration, streaking, or fading of each sign face;
- Visibility of the sign with respect to roadside vegetation or new structures that may be blocking the driver's view of the sign;
- Dirt or other substance on the sign;

- Graffiti and/or vandalism;
- Orientation and structural stability of the sign support system; and
- Ability to meet recommended minimum retroreflectivity guidelines.

The FHWA is working on providing additional guidance to agencies for the implementation of the provisions of the new rule.

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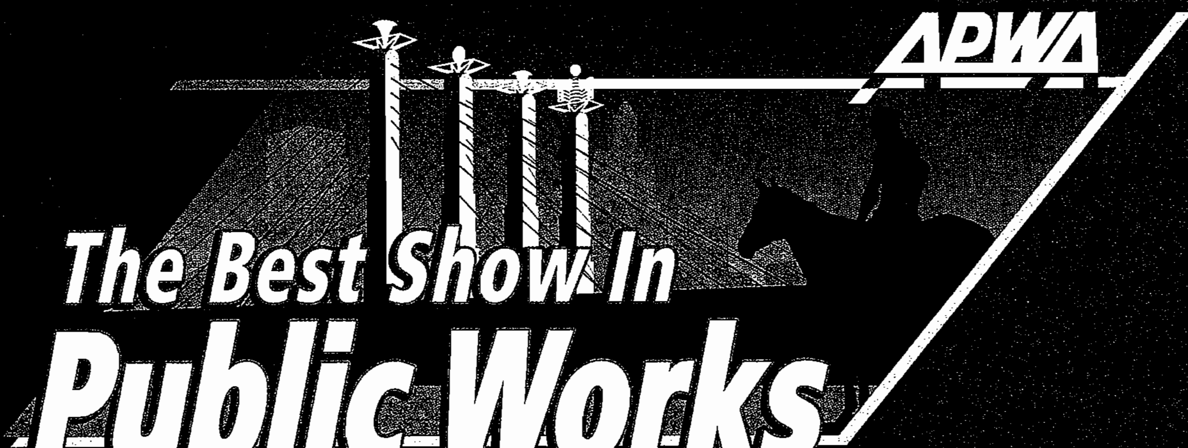

Program & Show Guide

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2 – 3 p.m.

Chapter/National Leaders Exchange

Room 2214

Chapter Leaders—this is your opportunity to meet with the APWA President and Board Members for an informal discussion. There is no agenda for this meeting... just a time to express your concerns/ideas/questions and get straightforward answers.

2 – 3 p.m.

PWHS Board of Trustees

Room 2212

2 – 4:30 p.m. 0.25 CEU

Super Session

Room 4100B

What Does It All Mean?

Speaker: Joseph Coates, President, Consulting Futurist, Inc., Washington, DC

Here's your chance to continue the conversation begun during Monday's General Session: The Future and Public Works—The Next 30 Years. This time, though, we want to hear from you! Now it is your turn to interpret the trends you've learned about and compare your interpretation to those of your public works colleagues from around the globe. Futurist Joseph Coates will be your expert facilitator on this journey, from looking for meaning to strategic thinking about the future.

2 – 2:50 p.m. 0.1 CEU

Education Sessions

15 Steps to Public Works Greatness

Speaker: Robert Hyde, PE, Director of Public Works/City Engineer, City of Anacortes, WA

Room 4100A

The Public Works Director of Anacortes, Washington, is issuing a "call to arms" for public works professionals to lead their organizations into greatness! Based on his 20 years of military experience in the U.S. Navy Civil Engineer Corps and recent successful completion of APWA's Accreditation process, he has identified 15 steps that will take you and your agency up the ladder into the highest realms of professionalism and leadership.

10,000 Rain Gardens Public Outreach Campaign

Speaker: Lynn A. Hinkle, President, ASTRA Communications, Kansas City, MO

Room 4201A

Kansas City discovered you can plant the seeds for stormwater management and water quality by convincing residents that to "keep up with the Jones," they better have a rain garden. Using the same savvy media techniques that politicians use to get elected, the 10,000 Rain Gardens campaign created a tsunami of public support, and galvanized a regional effort to apply green solutions throughout the watershed.

A Wake Up Call: Flooding in New Orleans—Predicted But Not Prevented

Speakers: Col. Jeffrey Bedley, Commander, Hurricane Protection Office, U.S. Army Corps of Engineers, New Orleans, LA; Gasper Chifici, Vice President, PBS&J, Encinitas, CA; Bill Hinsley, Senior Project Manager, PBS&J, Metarie, LA

Room 2105

Learn about the complexities involved in rebuilding New Orleans and for managing the potential for floods in an urban area. The area's flood plan consists of four elements: levees to contain flood water; floodways to provide an outlet for excess water; channel improvements and stabilization; and tributary improvements. Engineering solutions will be affected by both political and environmental factors. Join this discussion of where we are and where the process is going.

Benefits of Student Interns in Infrastructure Management

Speakers: Angie Hager, EIT, Staff Engineer, Infrastructure Planning & Programming and Pat Kennedy, PE, Senior Engineer, Street Maintenance, Department of Public Works, City/County of Denver, CO

Room 4202B

The City and County of Denver, Colorado, is using student interns from a local university to collect and input inventory and distress data on a wide range of infrastructure elements and to participate in bridge and other asset inspections. Several research projects on infrastructure management have also been accomplished. Learn how this partnership benefited the students, the local government, and the university.

Broadband from Your Streetlights?

Speaker: William Roger Buell, PE, Director of Public Services, Grand Blanc Township, MI

Room 2104B

Hear from a local right-of-way manager who managed a large municipality's response to a provider's approach to deploying broadband wireless Internet service via antennas on streetlight poles. Learn about the regulatory aspects, agreements, costs, successes and pitfalls associated with this type of deployment.

Can You See Me Now? Meeting the New MUTCD Retroreflectivity Standards

Speakers: Michael B. McCarthy, PE, Traffic Division Director, Hillsborough County, FL; Augusto S. Rodriguez, CFEA, Senior Project Manager, Ayres Associates, Inc., Tampa, FL; Marc J. Rogoff, PhD, Project Director, SCS Engineers, Tampa, FL

Room 4204B

Hillsborough County, Florida, conducted a field research study to assess the potential impact of the proposed MUTCD retroreflectivity standards and quantify the potential costs of compliance. While measurement of retroreflectivity is not an exact science, objective guidelines for sign replacement were derived from the study. Examine this agency's model for collecting sign inventory data, evaluating a sign management program, and estimating the cost of compliance.

Challenges of Diversity in Dealing with Emergency Response

Speaker: Robert C. Chandler, PhD, Chair, Communication Division, Center for Communication and Business, Pepperdine University, Malibu, CA

Room 4202A

Volunteers participating in emergency response activities may face a number of diversity issues. When coordinating mass care, sheltering, food preparation, and distribution functions, volunteers must display sensitivity to the cultural, ethnic, religious, and language attributes of the affected population. Learn the importance of applying the three R's to every response activity: Rules, Routine, and Respect.