Leveraging Technology to Develop and Implement a Pavement Marking Management System in Florida

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According to the Federal Highway Administration (FHWA), more than half of all traffic fatalities occur at night—even though three-quarters of travel occurs in daylight hours (*1*). When factoring in miles driven, the fatality rate at night is triple that of daytime. Although factors such as alcohol and fatigue contribute to this rate, pavement markings that provide appropriate visibility levels and facilitate safe nighttime driving have been shown to reduce crashes (*1*). Retroreflective markings reflect the light from a vehicle's headlamps back to the driver's eyes.

This retroreflectivity, or retroreflection, typically comes from the application of small glass spheres that are partially embedded into the pavement marking material.

Problem

Pavement markings are an important aspect of a safe transportation system, conveying vital roadway warnings and guidance information to the traveling public. It is therefore beneficial to maintain acceptable visibility levels on pavement markings in all weather and lighting conditions. To ensure that these levels are maintained adequately, the retroreflectivity must be periodically monitored and quantified accordingly.

Historically, retroreflectivity of in-service pavement markings has been measured with handheld devices and visual inspections. Visual surveys are considered subjective and handheld measurement is tedious and potentially hazardous, however.

All the monitoring data must be managed effec-

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Retroreflectivity of pavement markings increase their visibility and safety. Florida DOT's pavement marking management system assists in the timely maintenance of these markings.

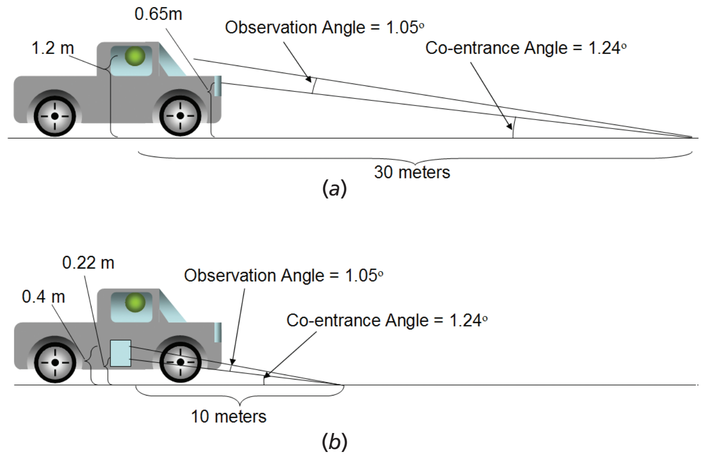

FIGURE 1 Standard 30-m geometry (*a*) and one-third scale (*b*).

tively and systematically, and because of this, it is essential to design and implement a comprehensive system for pavement marking management. Such a system would provide useful and objective information for more consistent, cost-effective, and data-driven decision making.

Solution

Consequently, the Florida Department of Transportation (DOT) focused on noncontact, sensor-based technology capable of assessing pavement markings continuously at highway speeds with improved safety and efficiency (*2–4*). The use of mobile technology for measuring retroreflectivity has allowed Florida DOT to develop and implement a pavement marking management system (PMMS) to improve the safety and nighttime visibility of its roadways. This approach offers Florida DOT an efficient, less-subjective methodology to identify conditions that are detrimental to roadway safety and to strategize ways to mitigate solutions, including the selection of appropriate materials and application techniques.

Florida Retroreflectivity Data Collection

Florida DOT's mobile system measures the retroreflectivity according to the "30-m geometry" described in ASTM E1710 (*5*). The 30-m geometry consists of the following assumptions: a typical passenger vehicle headlamp height of 0.65 m (2.1 ft), a driver eye height of 1.2 m (3.9 ft), and a distance of 30 m (98 ft) between the headlamps and the ground-based retroreflectance target. To reduce the size of the measuring device, a proportional scale is used: one-third of the 30-m geometry, shown in Figure 1 (above). Detailed description of Florida's system and other related information can be found elsewhere (*2–4*).

As with any testing using subject-driven, instrumented devices, the major concerns of the end usefulness of the resulting data are accuracy and precision. Although a level of uncertainty is always inherent to any measurement process, it also must be appropriately quantified or assessed. Florida DOT conducted a comprehensive study to assess the precision of its system in terms of repeatability and reproducibility (*3*). The overall pooled standard deviation was determined to be 12.0 mcd/m^2/lux within a device and 18.8 mcd/m^2/lux between devices. The overall pooled coefficient of variance was estimated to be 2.8% within a device and 4.7% between devices. More details can be found elsewhere (*3*).

To standardize the testing, including the data-collection activities, Florida DOT developed a test method for measuring retroreflectivity of pavement marking materials (*6*). A standard naming convention was included to identify each pavement stripe, regardless of the number of lanes. This test method also normalizes the data acquisition system, operational procedure, and reporting, as well as equipment calibration and precision.

Florida PMMS

All pavement marking retroreflectivity measurements are stored in a comprehensive database accessible via intranet and a web-based interface. It also includes other vital roadway information, such as feature codes from Florida DOT's Roadway Characteristics Inventory database (average daily traffic, speed limit, pavement type, and more). The database stores pavement marking data in 0.1-mi increments and includes the ability to store and retrieve 40 years of data. Some of the additional features include a mobile-friendly, web-based interface to query and filter the retroreflectivity data based on set criteria.

The information in the web-based interface is cross-referenced with video image files and data mapping with a geographic information system (GIS) application using linear reference system information (Figure 2, page 50). The GIS map uses dif-

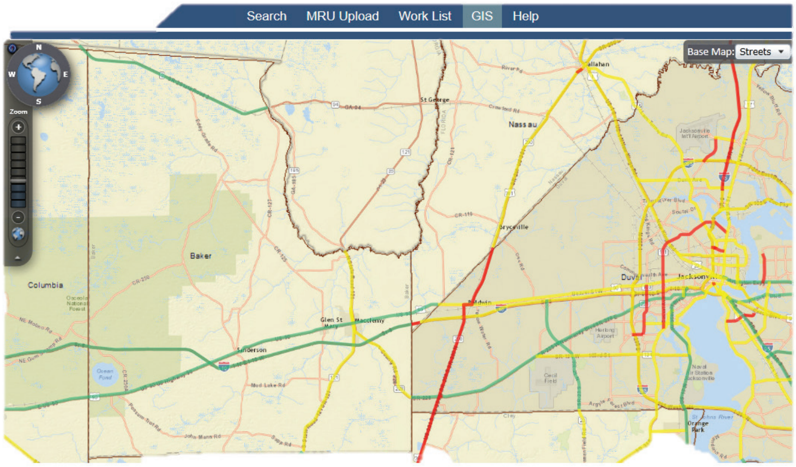

FIGURE 2 GIS viewer application of a county roadway section.

ferent colors for different ranges of retroreflectivity values as defined by the user and allows the user to download the retroreflectivity data for any given roadway as an Excel file.

Application

In 2012, Florida DOT implemented PMMS. The primary objective of the system is to evaluate and manage the statewide pavement marking retroreflectivity in a systematic and efficient manner. A total of 25,000 lane-miles of pavement markings are evaluated annually, with a primary emphasis on yellow center lines and white line (edge and skip) markings. Moreover, to ensure the reliability of the retroreflectivity data, Florida DOT conducts independent field quality assurance testing.

In addition to providing data in the PMMS database and allowing immediate access, a notice is sent upon completing the survey on any given county. Moreover, at the end of each survey year, Florida DOT issues an annual report with essential information on the condition of the Florida State Highway System pavement markings collected that year. The comprehensive PMMS database, county completion notification, and annual facts and figures reports on statewide pavement marking performance are examples of the rich information the PMMS provides to Florida DOT districts to make data-driven decisions and to manage statewide pavement markings cost-effectively and in a timely manner.

Benefits

The Florida PMMS offers an efficient, safer, and less-subjective methodology to monitor and assess the safety and night visibility of the state's roadway system. It ultimately results in a more effective and strategic use of state funds through informed decision making and by ensuring the safety of the traveling public.

Florida TaxWatch recently honored the PMMS with a Productivity Award and highlighted this work, noting that it "significantly and measurably increases productivity and promotes innovation to improve the delivery of state services and save money for Florida taxpayers and businesses." PMMS creates an estimated savings of more than $1.7 million each year versus the traditional approaches.

With the advance in autonomous vehicle and connected vehicle technologies, the information contained in the PMMS may also be valuable to the latest national research effort on the effect of different performance characteristics of pavement markings on the ability of machine vision systems to detect and recognize pavement markings.

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Suggestions for Research Pays Off topics are welcome. Contact Stephen Maher, Transportation Research Board, Keck 486, 500 Fifth Street, NW, Washington, DC 20001; 202-334-2955; smaher@nas.edu.