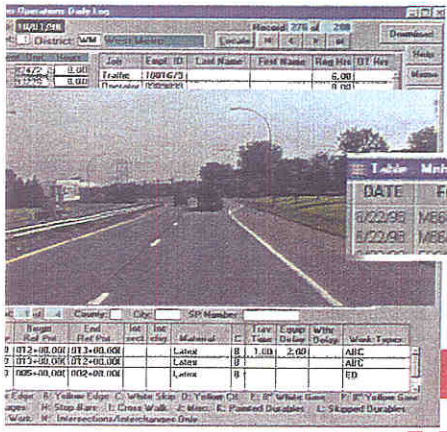
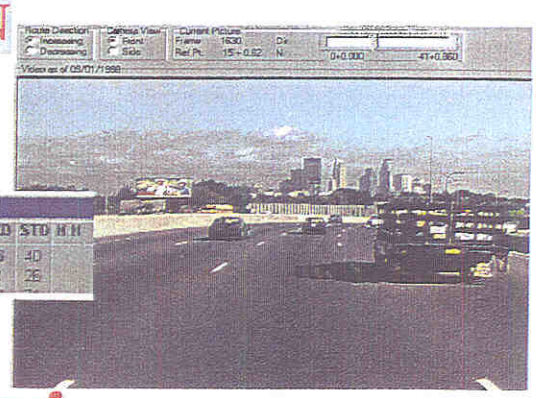
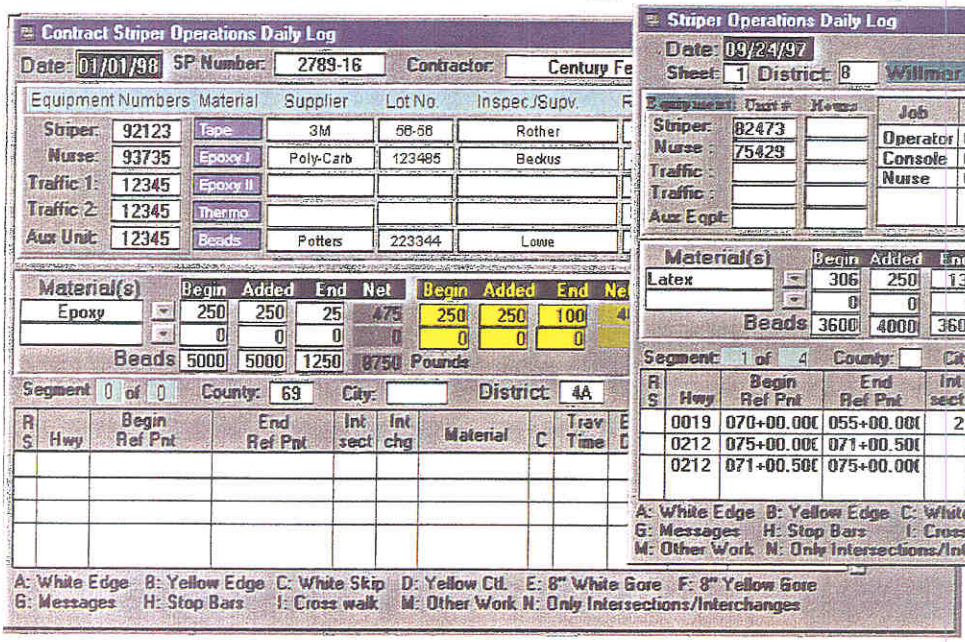
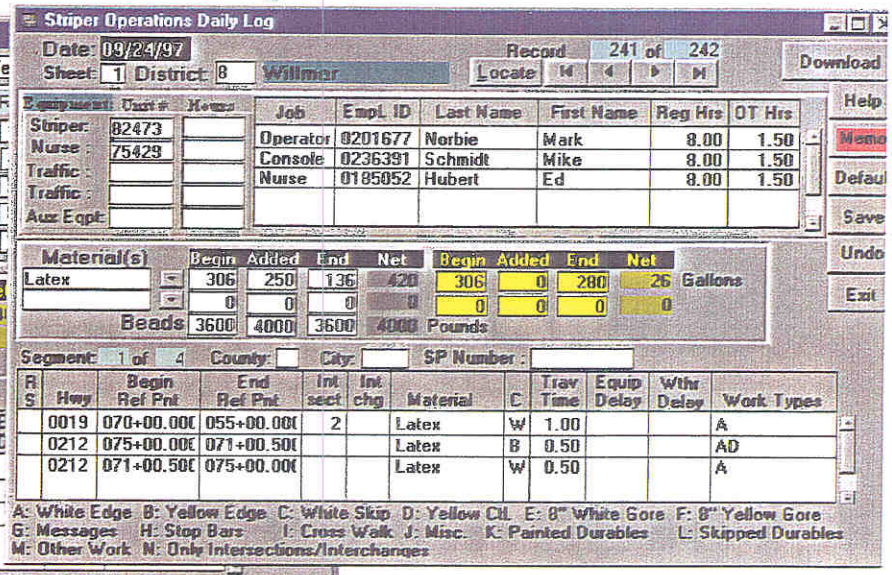
MINNESOTA DEPARTMENT of TRANSPORTATION





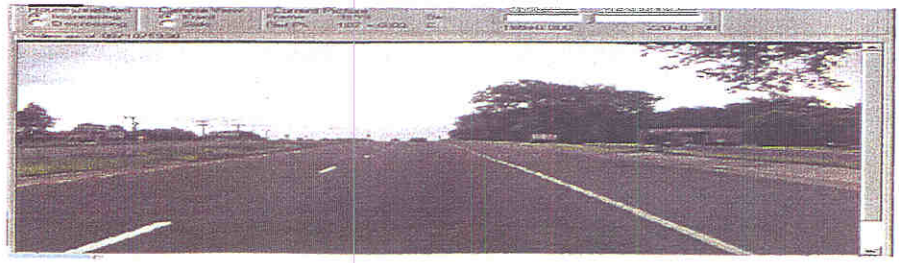
Pavement Marking Management System





Reference Manual

June 1999



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Overview of the Pavement Marking Management System

A number of forces have driven the creation of the Pavement Marking Management System (PMMS) and are ensuring its continued existence. The PMMS system in essence provides a pool of data that can be developed and deployed to resolve complex problems facing transportation agencies. The Pavement Marking Management System is information technology, which can be viewed as putting in place a system that will allow its users to make data driven decisions.

information technology applications are enabling agencies to reduce cost through improved operating efficiency. Some systems were not considered key elements, which was especially true for pavement markings, until the passage of the appropriations act of 1993 (i.e., the ISTEA bill). One of the central parts of ISTEA, which is aimed at improving highway safety, is the establishment of a minimum value for pavement marking retroreflectivity.

Pavement markings play an essential role in the safe and efficient movement of traffic, especially during hours of darkness. It is a well-known fact that in order for pavement markings to be seen at night they must be retroreflective. Glass beads, which are imbedded into the marking material, make pavement markings retroreflective. Retroreflectivity is the technical term used when describing how a vehicle headlight illuminates a pavement marking. It is technically wrong to describe pavement markings as being “bright,” but for simplicity this term will be used in this manual.

One of the original driving forces behind the development of PMMS is the Federal Highway Administration (FHWA) legislative mandate to set minimum retroreflective values for pavement markings. With this in mind, responsible agencies are stepping up efforts to develop new processes so that minimum values can be maintained.

The Minnesota Department of Transportation, with the help of FHWA, jointly developed this system. The aim was to develop a comprehensive system that will track the useful life of pavement markings. PMMS will track all of the following:

- Installations-
  location, date, line, type and quantity of material
- inventory
- Retroreflectivity
- Record specific action steps
- Costs-
  employee, equipment, material
- Suppliers

At this time, there is no standard/guideline for minimum retroreflectivity values on public roads. However, FHWA is expecting to start the rule-making process to establish threshold values in 1999. In the next update to the Manual on Uniform Traffic Control *Devices,* FHWA will provide pavement marking retroreflectivity guidance. Although no such guidance currently exists, many transportation agencies have for some time focused efforts toward reducing the loss of visibility of pavement markings during the hours of darkness.

Special instruments (i.e., retroreflectometers) are needed to collect pavement-marking retroreflectivity. They are used to determine how bright the markings appear at night to motorists. All reflectometers are designed to read pavement markings within specified geometric ranges. FHWA has determined that 30-meter geometry replicates typical driving experiences and has adopted it for their rule-making processes. This geometry conforms to what an average passenger automobile driver sees when viewing 30 meters ahead of the vehicle at night. Various manufacturers are producing a wide range of both handheld and mobile retroreflectometers. Handheld reflectometers are used by placing the meter over markings at specified intervals. Once the total number of handheld readings at each interval is collected and averaged, an entire segment average is determined. Mobile instruments measure retroreflectivity of pavement markings while driving at highway speeds. An onboard computer is responsible for collecting and analyzing the retroreflectivity data. No matter which instrument is used, an averaging of all the readings taken over a specified segment length should be done. Averaging the measurements, whether mobile or handheld, normalizes the variability present in all markings.

The industry's collective understanding of how pavement markings function has grown exponentially over the past 10 years. And, with the advent of various pavement marking management systems the ability to actively manage pavement markings is adding to responsible agencies cornucopia of managerial tools.

Installations

In order to effectively manage pavement markings, agencies must have complete information about their pavement marking installations. This could be considered the hear-l of this system. To make data driven pavement-marking decisions managers need complete installation information. With this type of information, managers/supervisors can identify problem areas, determine maintenance schedules, and effectively plan budgets.

In order for this level of decision-making to be possible, processes that track complete and accurate installations must be incorporated. Critical components that should be tracked include location, date, specific line, material type, and quantity of material used at time of installation. The location should track from reference point to reference point, or some such common beginning and end points, where the markings were installed. Each line (e.g., centerline, edgeline, lane line, etc.) should be tracked by installation date. Material type indicates what type of line was installed. Some of the most

common types are latex, tape, thermoplastic, or epoxy. Many agencies will call for multiple material types within the same locations, which is not a problem for PMMS. Example, agencies will specify tape for the lane lines (skips) and will use epoxy for the edgelines. Again, PMMS is capable of tracking multiple material installations. Tracking materials is one of the foundations that this system was designed to track.

Inventory

Many of the decision options that PMMS can provide depend on accurately tracking pavement-marking installations. Without this type of process, developing an inventory could be very expensive. PMMS approaches this by tracking daily installations. This is one of the principle reasons that both maintenance and contracted input screens were developed. One major problem with tracking any inventory is that the database (i.e., the inventory) is usually out of date by the time it is entered into a data base. PMMS inventory will never be out of date if markings are tracked as they are installed.

Retroreflectivity

If pavement markings are to be seen at night they must be retroreflective. Retroreflectivity refers to the principle of light being directly returned to its source. In automobiles the light source is the headlight of the vehicle. Again, special instruments that have been designed to read at a specific geometry measure this light intensity. A central part of PMMS is the requirement that field inspection for retroreflectivity be completed.

The type of reflectometer used to measure markings does not matter. Agencies will specify the process for field inspections, and the Manual on Uniform *Traffic* Control Devices (MUTCD) will provide guidance on retroreflectivity values and reflectometer geometry. Many of these factors will vary from region to region and State to State. A central focus of PMMS is the ability to track pavement markings so that the various pavement marking's life cycles can be determined.

Collecting retroreflactivity with either mobile or handheld meters can be time consuming and expensive. Before determining which process to use agencies should consider:

- Average Daily Traffic (ADT) count for the area to be measured
- Length of segment
- Location of line to be measured (i.e., centerline vs. edgeline)
- Number of readings that are required per segment
- Traffic control requirements

PMMS is designed to allow inspectors to collect retroreflectivity data and store it in tables for future reference.

Record Specific Action Steps

Once life cycles can be established for each type of marking used, the responsible agency will have many options. The ability to determine when or how often markings are in need of maintenance is first and foremost. PMMS will give an agency the ability to record specific action steps. In addition to enabling effective maintenance, PMMS offers agencies the following benefits.

- PMMS can provide an agency with data to set striping priorities
- It can provide information for the analysis of persistent problems
- This system records steps taken or not taken for defense against tort liability claims

These benefits cannot be gained without timely, efficient, and comprehensive recording practices. The memo field in either the maintenance or construction daily log offers agencies the opportunity to record and store this information. Agencies should consider including some of the following in the memo field.

- If an area was reported as being deficient, record the source of the information as, for example, agency employee, private citizen, public official, contract, or in-house inspectors
- Record specific actions taken, for example, location reinspected and retroreflectivity readings taken, or additional traffic control devices applied
- Record when and by whom the situation was reviewed

costs

It is more important today than ever to have the ability to track costs. PMMS is designed to provide agencies/authorities with the data they need to manage striping costs. It makes sense to replace only pavement markings that need replacement, or in other words, only markings that are at the end of their useful life. Pavement markings themselves are only one part of the cost equation. PMMS allows agencies the opportunity to track employee, equipment, and material costs, which are key parts of developing pavement-marking cost.

Suppliers

Tracking suppliers, and more specifically, material batch numbers, can answer many questions when problem installations are uncovered. Past experience has shown that failures can be tracked to specific batches of material. An advantage of tracking areas in this detail becomes clear when you can uncover other areas with the same material that may also reveal a failure.

This is exactly the type of information that managers/supervisors need when determining system needs. Another use for such information is to compare suppliers

against one another. This type of information can lead to quality improvement in an overall pavement marking program.

PMMS Software Structure

The PMMS software is a Windows" based Paradox@ data base scripted program. The software is designed for Windows version 95/98 or NT version 4.0 or higher. The software is designed as a **"run-time"** application, and is therefore a royalty free program. In other words, installing Paradox is not required to install and add information to the program. However, in the scripted format the program will only allow user to input the information. To fully utilize the program users will need to have a full version of Paradox, or another comparable data base program. Paradox is a commercially available program, which can be run within any Windows environment. This program assumes nothing about an operator's level of computer knowledge. We have strived to develop a program that can be used by even the most novice computer user.

Entering information into the program is accomplished by entering the data directly into a scripted form. This program has been designed so that all relevant data can be entered directly into one of two screens: the daily maintenance, or contracted screen.

This program takes advantages of many Windows programming options. Keep in mind that you can use the right mouse button on parts of data input screen. Although you can move through the menus to do most things in the PMMS program, using the right click on your mouse will reveal additional menus that can save time. Highlighting (i.e., left clicking in the appropriate box) the **District, Job,** or **Empl. ID** portions of the input screen, and then right clicking the mouse button will allow access their sub-menus. Each of these sub-menus can be chanaed to fit specific needs.

System Requirements

Component	Description/Comments
Microprocessor	486 or higher
RAM	6MB (8MB is recommended.) Performance will increase with more memory.
Hard disk	A hard disk is required. System files installed using this minimum Paradox installation requires approximately 8 MB.
Video monitor	EGA or higher
Microsoft Windows	Version 95, 98, or later NT 4.0
Mouse	Although not required, a mouse is strongly recommended. Some design features can be accessed only with a mouse.

Overview of Conducting Field Surveys

Conducting field surveys of the condition of pavement marking is not easy. Many aspects need to be considered prior to conducting field surveys. For example, markings are considered new within 14 days of installation, with all excess glass beads removed. When or how long after installation should retroreflectivity tests be taken? The fact is that it depends on the type of marking. Some markings can be read immediately after installation, and some should be allowed to brighten before their retroreflectivity is determined. Performance contracts for pavement markings are showing up throughout the United States across the country. And many of these contracts specify when readings will be taken.

Other items that should be considered prior to field inspection:

- How many readings should be taken?
- Will the readings be done with a mobile or handheld reflectometet?
- Determine how much of the line needs to be read (i.e., total samples)?
- How many times, or at what intervals, will readings be taken?

There are many factors (e.g., road surface, safety needs, alignment, material type) to be considered before pavement markings are installed. There is no one part or link in a pavement marking value chain that is more important then any other. One of the underlying premises of PMMS is that field inspections, or more specifically, the retroreflectivity of pavement markings, must be collected.

The following is included for consideration purposes only, and is not intended to take the place of any specific agency or organization specifications. It is provided as information to those agencies that have not performed field inspections. Agencies may also want to consider the following standards

ASTM Standards

- E284 Terminology of Appearance
- E809 Practice for Measuring Photometric Characteristics of Retroreflectors
- D4061 Test Method for Retroreflectance of Horizontal Coatings
- E 1710 Pest Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry using a Portable Retroreflectometer

Other Standards

- CEN/TC226 WG2 Horizontal Signalization
- PrEN 1436:1994 Road Equipment. Horizontal signalization. Road marking performance for road users

Test Method for Determining the Retroreflectivity of Pavement Markings

The following specifies a procedure that can be used to evaluate the retroreflective performance of horizontally applied (in-service) pavement markings. This test procedure is only intended for field measurement. Because the entrance and observation angles of the retroreflectometer affect the readings of pavement markings the entrance and observation angles (geometry) shall be specified. Evaluation of pavement markings shall be done within specified zones and time intervals. Criteria are included for determining inspection zones that appear, by visual or mobile instrument inspection, to fall below the specified minimum performance value.

Retroreflective field data can be collected with either portable (i.e., handheld) or mobile reflectometers. The Engineer has the option of determining whether the readings shall be done at night or during daylight, but in either case the readings will be done in dry conditions. Data shall be collected in the direction of traffic, when ambient temperature conditions are compatible with specifications for the instrument. When encountering pavement markings that separate opposing traffic (i.e., centerline, lane line, skip lines, etc.), the Engineer may request that pavement markings be evaluated in both directions, and that the centerline be measured for each stripe.

This process is an improvement over visual inspections because it allows collection of data that can be used to objectively determine the retroreflective qualities of the installation. We do not intend to discourage visual inspections, especially visual inspections done at night. Visual nighttime inspections are encouraged because they may reveal deficient areas that should be inspected.

30-Meter Measurement Geometry

Instrument geometry is specified because it is a primary driver in determining retroreflective values. Thirty meters has been selected because it most closely correlates an average automobile drivers vision geometry. Instruments used to measure the retroreflective properties of pavement markings shall conform to the following measurement geometry(s):

- The entrance angle (the angle between the illumination axis and the retroreflector axis) shall be $\geq 88.50^{\circ}$ and $\leq 88.76^{\circ}$, and the observation angle (the angle between the illumination axis and the observation axis) shall be $\geq 1.0^{\circ}$ and $\leq 1.05^{\circ}$. The co-viewing angle (the complement of the entrance angle) shall be $\geq 2.29^{\circ}$ and $\leq 2.50^{\circ}$.

All readings taken, or the coefficient of retroreflected luminance, shall be expressed as the metric equivalent $(mcd/m^2/lux)$.

Scheduling for Data Collection and Reporting

Field evaluations (data collection) should not be started until the markings have been in-service for a minimum of 2 weeks. The 2-week minimum time frame is very dependent on the type of material that is being installed. Data collection should be completed within 6 weeks of installation (weather permitting). Waiting any longer could jeopardize the ability of some marking material to meet minimum values. This is especially true for areas with high volumes of traffic or areas where vehicles make numerous turning movements.

After field evaluations are completed, a written report shall be submitted to the Engineer Contained within the report shall be:

- State project number
- The test date
- Average of the readings at each test location
- Standard deviation (one deviation)
- Geographical location of the test site(s), including distance from the nearest permanent site identification (such as a reference point/mile marker)
- Identification of the pavement marking material tested: type, color, age, and transverse location on the road
- Identification of the retroreflectometer
- Remarks concerning the overall condition of the line, such as carryover of asphalt, snowplow damage, uneven distribution of beads, etc.

Method for Determining Portable Reflectometers Measurement Zones, and Minimum Sampling Rates

The evaluation of longitudinal pavement markings shall be made after identifying the zone(s) to be measured. Any installation less than 300 meters (1000 feet) shall be considered a zone. One zone of measurement should be identified for installations that fall between 300 meters and 1.5 kilometers. Any installation greater than 1.5 kilometer shall have a minimum of one zone selected for each kilometer of striping. The 300 meters shall be continuous in length. The random segment(s) may be selected after a visual inspection. A minimum of 26 readings on each line will be taken within each test zone. When reading broken lines (skip stripes), every other skip shall be read, with no more then three readings taken on any one skip stripe. A minimum of two readings should be taken on individual skip lines, and they should be taken approximately 500 millimeters (20 inches) from each end of the skip. On continuous lines, break the measurement zone into a minimum of ten 30-meter (IOO-foot) areas, and space the 25 readings a minimum of 33 feet apart but no more than 100 feet apart. The Engineer may determine that more samples shall be taken.

Note: After the initial evaluation, regardless of the results, the-Engineer can define new checkpoint areas if they are considered critical for road safety.

Method for Determining Dynamic (Mobile) Measurement Zones, and Minimum Sampling Rates

Mobile instruments shall conform to specified geometry and shall be capable of reporting both $mcd/m^2/lux$ average and standard deviation for each line and each segment. When reading longitudinal lines, the minimum interval for averaging both, a segment's individual $mcd/m^2/lux$ readings and the segment's standard deviation will be no less than 100 feet; however, all of the individual readings shall be used when determining a zone's overall average. Inspectors shall not group together, in any one report, two lines or two color lines in the same data file. When collecting data on longitudinal continuous lines, readings shall be collected at a minimum rate of not more than 8 feet apart. When collecting data on longitudinal broken lines, readings shall be collected at a minimum rate of not more than 5 feet apart.

Repeatability of the mobile instrument shall be considered acceptable if the instruments deviation within the same inspection zone is $\pm 10\%$. The maximum acceptable deviation for measurements made by two different instruments manufactured by the same manufacturer, within the same zone of measurement, shall not be greater than $\pm 15\%$. The calibration of the instrument shall conform to the manufacturers instructions. Mobile instruments shall measure a minimum of 20% of each installed line. And, reading entire segments of installed lines should be considered.

Note: Upon evaluation, despite the results of the inspection, the Engineer can define additional inspection areas if they are considered, critical for road safety.

Symbols and Legends

For each contract, the zone of measurement can be considered **as** the contract length. Inspectors shall take and report a representative sample of each type of symbol.