# Iowa Pavement Marking Management System: Initial Phases

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**ABSTRACT**

The importance of roadway pavement markings to motorists and pedestrians needs no reinforcement among the staff at the Iowa Department of Transportation (Iowa DOT). With an annual pavement marking program of approximately $2 million dollars and another $750,000 invested in maintenance of durable markings each year, the Iowa DOT is seeking every opportunity to provide all year markings in acceptable condition under all weather conditions. The goal of this study was to analyze existing pavement marking practices and to develop a prototype Pavement Marking Management System (PMMS). A practical and integrated PMMS would allow for more accurate development of annual marking needs, as well as provide guidance on durable pavement marking applications and overall marking strategies on a statewide basis.

**Key words: beads—durable marking—operations—paint—pavement marking**

## PROBLEM STATEMENT

The importance of roadway pavement markings needs no reinforcement among the staff at the Iowa Department of Transportation (Iowa DOT). With an annual pavement marking program of approximately $2 million dollars and another $750,000 invested in maintenance of durable markings each year, the Iowa DOT is seeking every opportunity to improve marking performance and minimize costs. A discussion of DOT concerns follows.

The DOT is concerned with pavement marking durability and with finding marking materials which will perform over a 12-month period (or over the winter as a minimum). Having a paint crew in each of the six districts has worked well from an operations perspective. However, given that Iowa is a snow-plow state, the winter maintenance operations present significant challenges in holding these waterborne markings over the winter. In contrast, contractor-applied durable or recessed markings have been found to be more durable, in most cases, but at a considerably higher cost than DOT-applied waterborne paint. As an example, DOT crews are applying waterborne paint at $0.025 per foot compared to durable materials which start at $0.70 per foot and can go up to over $3.00 per foot.

The DOT is also concerned with having the resources to maintain durable markings. With each construction season, the number of miles of durable markings increase on the DOT system as they are a popular item for new roadway projects. This places a considerable financial burden on the DOT as they have to budget for the maintenance of these markings over a two- to four-year cycle. Also, with durable markings being part of the standard bid items, the DOT wants to provide guidance to the districts on where these more expensive materials should be placed and where they will be maintained.

The Iowa DOT established a Pavement Marking Task Force (hereinafter referred to as “Task Force”) which was responsible for facilitating this research effort and for providing linkage with DOT staff and resources.

## RESEARCH OBJECTIVES

The objectives of this research were to analyze existing pavement marking practices and to develop recommendations and a prototype Pavement Marking Management System (PMMS) which would allow for more accurate development of annual marking needs and guidance on the use of durable and traditional markings. These objectives were incorporated into the following project Task Force objectives:

1. Develop a statewide inventory of durable pavement marking installations.
2. Utilize retroreflectivity measurements to determine actual marking performance.
3. Develop and publish guidelines for the application of durable markings.
4. Present recommendations to the Highway Division Management Team (HDMT) regarding appropriate funding for statewide markings.
5. Use retroreflectivity data to coordinate activities between conventional and durable marking programs to maximize the effective use of funds for both programs.

This report summarizes existing marking practices, as well as key findings and recommendations from objectives 1 through 3 above.

## KEY FINDINGS

This section provides a summary of key project findings. These findings represent a collaborative effort through working with the project Task Force. Task Force members represented a variety of positions within the Iowa DOT:

| | |
|---|---|
| Will Zitterich | Office of Maintenance, Chair |
| Ron Beane | Office of Maintenance |
| Mark Black | District 2 Maintenance |
| Mark Bortle | Office of Construction |
| Tim Crouch | Office of Traffic & Safety |
| Joe Putherickal | Office of Materials |
| Pat Rouse | District 1 Paint Crew |
| Dan Sprengeler | Office of Traffic & Safety |
| Steve Wilson | District 6 Highway Division |
| Kurtis Younkin | Office of Traffic & Safety |

Task Force members were assisted by

| | |
|---|---|
| Neal Hawkins | CTRE, Project Investigator |
| Omar Smadi | CTRE, Co-Project Investigator |
| Zach Hans | CTRE, GIS Specialist |

The remainder of this section summarizes the key findings as they are related to each of the 3 project objectives discussed in this report.

### Objective 1—Durable Marking Inventory

*Durable Markings Database*

The DOT has road miles of durable markings, which are typically installed as part of a construction contract. The tracking of this information is less than ideal with the occasional issue of maintenance crews painting over these markings. The task force worked at developing an overall durable marking database format and inventory and at incorporating this information into a graphical GIS format. An example of this is shown on the following page in Figure 2. The Task Force developed alternative techniques for resident construction engineers to enter the durable marking data through what was termed a "section tool." This tool allows for pointing and clicking on a map to obtain the latitude/longitude limits of the durable marking as well as enter the material type and other installation details. This section tool was developed to accommodate a variety of pavement marking conditions and is shown in Figure 1.

**Figure 1. Screen shot of the section tool**

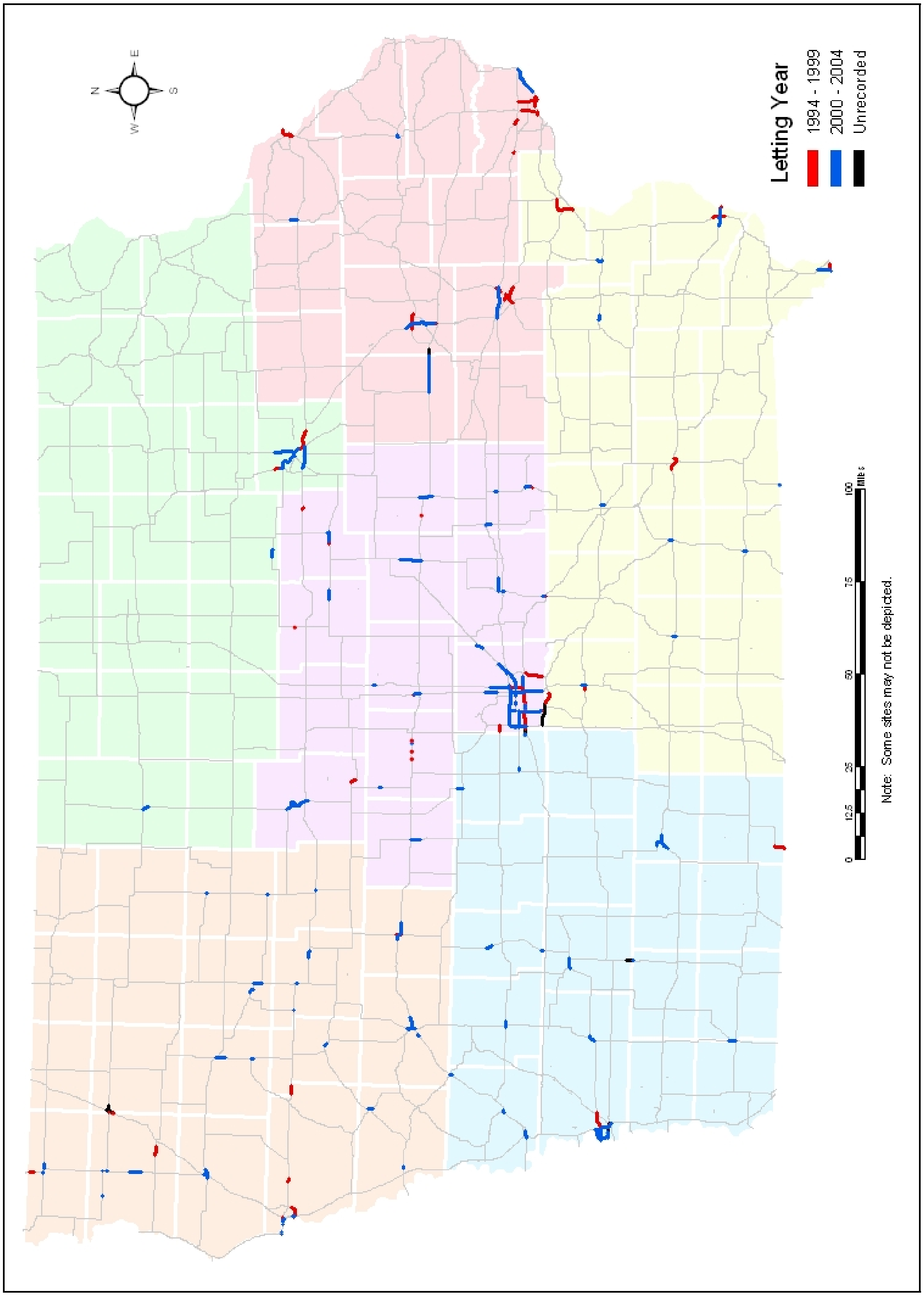



**Figure 2. Durable pavement markings inventory**

**Objective 2—Utilize Reflectivity Information and Track Performance**

A variety of issues were researched in an effort to meet the goals for this objective. A summary of these findings is presented below.

*Pavement Marking Damage*

Through field inspections and discussions with staff, the Task Force categorized the majority of damage to be related to snow or maintenance blades, winter maintenance application of sand and salt, high shear from weaving or cross-over vehicular maneuvers, or installation and material failure. A discussion of some of this follows.

<u>Winter Maintenance</u>. The Task Force worked with state climatologist to review 30 years of average snowfall by each Iowa DOT district and to map this information as shown in Figure 3.

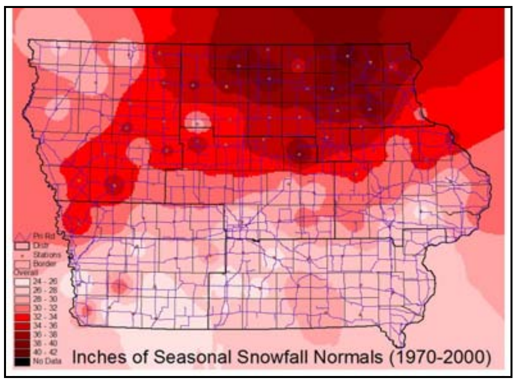
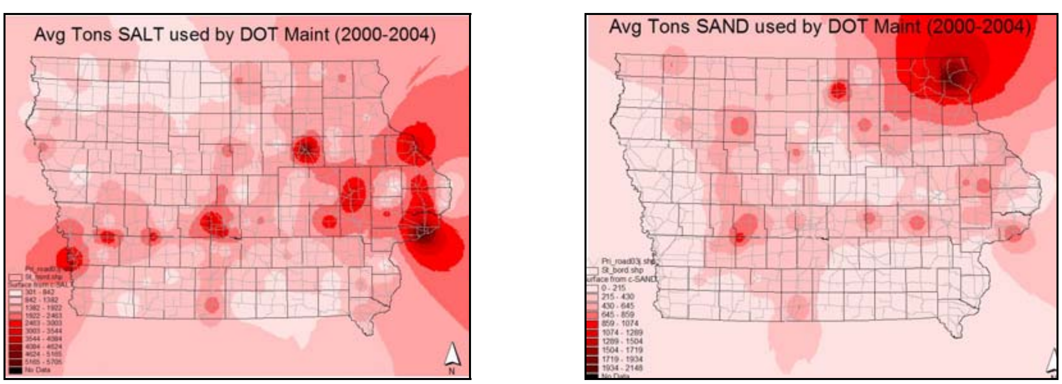



**Figure 3. Average snowfall**

The variability across the state, along with winter maintenance policies, create differences in the frequency with which individual routes are plowed each year and the opportunity for damage to surface applied markings. Existing snow plow and sanding activities are recorded on a person-hour or quantity basis and not by route/milepost. Each district develops individual winter maintenance procedures. Figure 4 depicts the average tons of salt and sand used by location over the 2000 through 2004 time period.




(a) (b)

**Figure 4. Average tons of salt (a) and sand (b) by location over 2000-2004 time period**

Edge Rut Maintenance. The Task Force found that edge rut maintenance can have a detrimental impact on marking reflectivity (edge line). Gravel is typically dumped or bladed onto the driving surface and then bladed off smoothly over the shoulder. In the summer of 2004, one District painted a white edge line and measured the reflectivity to be 400 millicandela/meter squared/lux (mcd). Within a week of painting, edge rut maintenance was performed for this stretch of roadway. Following this, the same line was measured and found to have been reduced down to a reflectivity of a little over 100 mcd. Figure 5 below depicts typical edge rut maintenance, where gravel is scraped across the white edge line. The Task Force also discussed a variety of examples where heavy traffic and/or turning movements have a significant impact on marking performance. This analysis on one year of data showed that marking performance is worse on older paved driving surfaces.

**Figure 5. Edge line damage due to shoulder maintenance**

*Measuring Reflectivity*

The Iowa DOT has established internal performance targets for markings at 300/200 mcd for initial reflectivity of white and yellow paint, respectively, and 150/100 mcd for replacement of white and yellow markings, respectively. Two methods are used to collect reflectivity information. For interstate, and some major 4-lane roadways, reflectivity is measured with the Lazerlux Van. All other measurements are completed by each District through use of handheld Delta LTL-X machines. A description of each method follows.

Lazerlux Van. The Iowa DOT has one Lazerlux Van which takes continuous readings on Interstate and major 4-lane highways. At the time of the study, the van was not equipped with GPS equipment, thus relying on route and milepost for reference. The van also relied on problematic floppy disks to transfer readings to other computers for analysis or storage. The Van is equipped with a 30 m geometry lazerlux reflectometer which samples markings every second and averages the results based on tenth mile segments. Each segment is then averaged for a specific route, using the mileposts as the beginning and end points of reference. The van is capable of taking readings from either side of the vehicle at an average speed of 55mph. Machine calibration is performed routinely at least once per day or when erratic measurements are observed. Calibration blocks are used for this process. In general, the Lazerlux van is a centralized process which covers the entire state. The crew consists of a driver and an operator who codes reading data by type of line, material, and location. Figure 6 shows a picture of the van.

**Figure 6. Lazer Lux Van**

Handheld Units. In the spring of 2004, the Iowa DOT purchased 3 additional handheld Delta LTL-X machines for a total of 6 (one per district). Each unit has the ability to record a GPS latitude and longitude with each reading along with the default of entering in the location through route and milepost. In 2003, District 1 began using these units as part of normal paint operations and positioned the unit roughly 2 miles behind the paint machine. As the paint became dry to the touch, an initial reflectivity was recorded and relayed to the paint operators. This constant calibration process became an invaluable tool in maintaining consistency and in dealing with the change in a number of conditions and weather throughout each day. In fact, District 1 found that after adjusting truck speed, paint and bead rates, and paint tips they were still not meeting their initial reflectivity goal. They examined the beads to find they lacked a coating needed for waterborne paint. Without the reflectivity feedback, the crew may have painted all summer with the wrong beads. The hand devices are 30-meter geometry machines and can be set to sample or average samples at a variety of settings. These units also have calibration blocks for validation. Figure 7 shows a picture of the device in use. The Iowa DOT Office of Maintenance has developed a standard protocol for Districts to follow regarding how often and how many readings to take when measuring roadway segments.

**Figure 7. Handheld Delta LTL-X machine**

*Analysis Tools*

The 2004 spring retroreflectivity data were used to depict marking condition information in a visual format using route and milepost as a reference. Some difficulties were discovered when using the route and milepost data due to the GIS background mapping which stops each route at the county borders. Figure 8 shows the data points collected with the handheld (left) machine and van (right) methods.

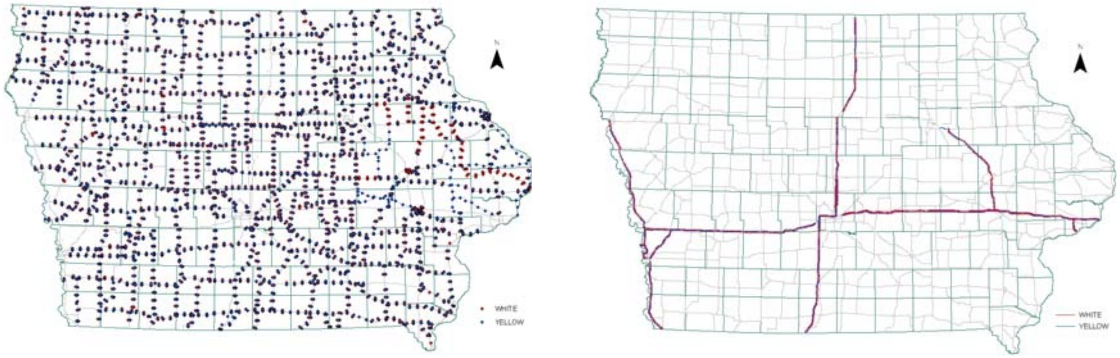



**Figure 8. Data points collected with the handheld (left) machine and van (right) methods**

Additional interpretation issues arise when route segments are concurrent with other routes and milepost references are confused. Through working with DOT staff, a series of four plots were used to evaluate early spring marking conditions on a statewide and district level. Figure 9 provides a sample of the GIS plots generated for 2004 reflectivity data. Similar plots were generated for each district at a more detailed scale. The plots are categorized to show reflectivity information as follows: Yellow Center Line, White Edge Line, White Dashed Center Line, and Yellow Edge Line.

*Database*

The Iowa DOT has two separate databases for pavement marking information which consist of reflectivity information (both van and handheld data) and paint application information. The van reflectivity information is read directly into the database through a spreadsheet format. Handheld data are retrieved from each machine electronically and then entered into a CITRIX interface which assists in formatting the data fields. The CITRIX interface also provides the formatting for the daily paint log information which is entered into a separate database. The Task Force spent time outlining the components of a potential Pavement Marking Management System. A focus was placed on existing and future inventory information consisting of pavement marking, pavement condition, and operations. The operations database does not exist and would represent factors such as the difficulty for crews to place markings in certain areas, heavy weaving or turning areas, areas requiring significant traffic control or night-time operations. The pavement condition data already exist from the DOT pavement management system, and it was shown how this can be merged with marking data.

Collecting data strictly on a route and milepost basis creates a number of problems in interpreting the information given concurrent routes and GIS issues at county borders. This effort identified alternative tools to locate segments for paint or reflectivity readings along with the tracking of durable markings. The Task Force examined pavement marking data input and developed a common listing of data input items.

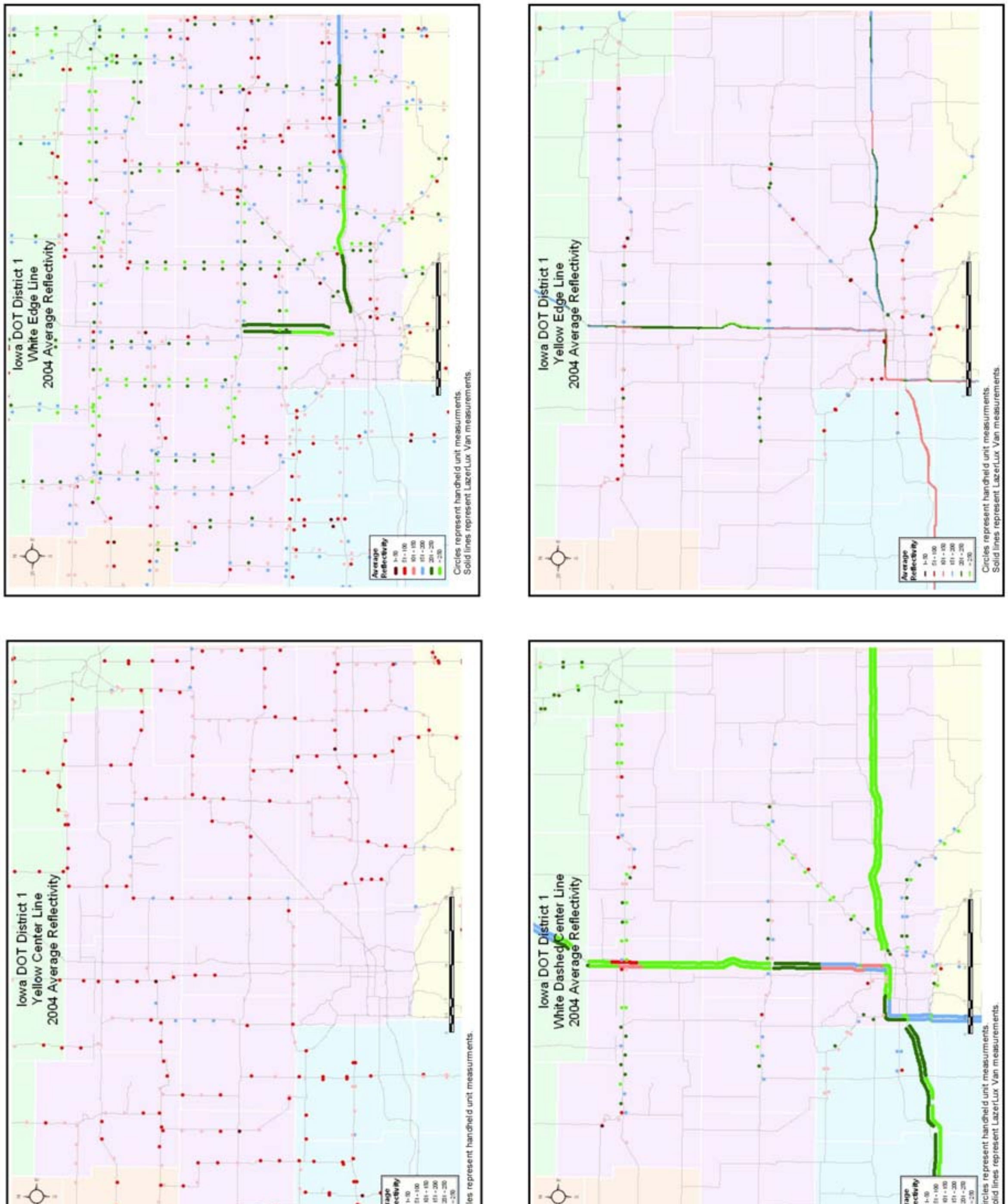



**Figure 9. GIS plots for 2004 reflectivity data showing four types of lines**

*Field Test*

The Task Force spent considerable effort in beginning a 3-year test along Highways 5 and 65 within the Des Moines metro (which is the only known test of its size and quality nationwide) to evaluate two types of durable waterborne paints and glass beads. Since the materials were put down using DOT crews, this demonstration has already provided valuable knowledge regarding how to install these new products. A picture of painting during the field demonstration is shown in Figure 10. The reflectivity results to date have shown very good results with expectations that these materials will continue to evolve into providing 3 seasons of service life. The task force is also considering how to groove pavement as part of initial construction to accommodate recessing of the pavement markings.

**Figure 10. Painting white edge line during the Highways 5 and 65 field demonstration**

*Tracking Performance*

In 2004, the Iowa DOT was just beginning to collect information when markings were installed and when they will be measured in the future. A comparison of good performance information was not available for this initial phase of this study.

**Objective 3—Application Matrix**

*Development of an Application Matrix*

The Task Force developed a Longitudinal Pavement Marking application matrix based upon meeting drivers needs, consideration of roadway type, pavement service life, the performance of materials, and cost. This initial matrix shown in Figure 11 reflects the fact that very little historic information exists today to track material performance over a range of conditions on DOT roadways. However, this information can be collected and used to consider modifications to the application matrix over time.

| LONGITUDINAL PAVEMENT MARKINGS | | | | | |
|---|---|---|---|---|---|
| Remaining Pavement Surface Life | Primary 2 & 3 - Lane | Primary 4+ - Lane | | Interstate | |
| | RURAL + URBAN ≤ 55 mph | RURAL | URBAN High Traffic | < 50,000 ADT | > 50,000 ADT |
| | 7,811 centerline miles (75% of total) | 1,059 centerline miles (10% of total) | 556 centerline miles (5% of total) | 1,000 centerline miles (9.6% of total) | 45 centerline miles (0.4% of total) |
| ≤ 2 yrs | **Waterborne** | **Waterbourne** | **Durable Waterborne**, Waterborne, | **Waterborne** | **Durable Waterborne,** Waterborne |
| 3 - 5 yrs | **Durable Waterborne**, Waterborne | **Durable Waterborne,** Waterborne | **Durable Waterborne,** Waterborne, Epoxy, Polyurea | **Durable Waterborne** | **Durable Waterborne**[E&R] Polyurea[E&R] Epoxy[E&R] |
| $5^+$ yrs | **Durable Waterborne**, Waterbourne, Epoxy, Polyurea | **Durable Waterborne**, Waterbourne, Epoxy, Polyurea | *__Durable Waterborne__[E] *Epoxy, *Polyurea, *Tape | **Durable Waterborne**, Epoxy, Polyurea | **Tape**[E&R] Durable Waterborne[E&R] Epoxy[E&R] Polyurea[E&R] |

E = Enhancements could include reflectorized rpm's, wider markings, supplemental strips of wet reflective tape, roadway lighting, larger beads, paint additives, or other forms of enhanced illumination.

R = Recessed marking within a groove which is milled into the driving surface.

* = Where the characteristics such as heavy volumes, weaving, high speeds, or other conditions exist, markings within this category may be treated similar to Interstate Urban with > 5 years of life.

**Figure 11. Longitudinal Pavement Marking application matrix**

## CONCLUSIONS

This research provided a significant investigation into existing Iowa DOT pavement marking practices, evaluation of potential new durable waterborne paint and bead combinations, development of a pavement marking application matrix, and short and long-term recommendations for implementation and operation of a Pavement Marking Management System for the Iowa DOT. Future phases currently underway include the final implementation and operations tasks. The work of the Iowa DOT Pavement Marking Task Force has made a significant contribution to DOT paint practices in terms of tracking performance, quality, and management of retroreflectivity on a statewide basis.