Towards a More Interactive Asset Management Paradigm for Local Agencies

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ABSTRACT

The purpose of a formal pavement management program (PMP) is to establish and maintain a uniform definition and procedure for the application of various maintenance strategies to extend the overall expected life cycle of the city's roadways in the most economical and efficient manner. However, many small jurisdictions do not have the financial resources or staff to develop an in-house PMP with the most desirable capabilities.

To fulfill this need, Iowa Pavement Management Program has been working with small local agencies since 1999 collecting data on their road network. This project explores ways that the local agency can use the data to determine the condition of their roadways to better plan for their maintenance and improvement needs.

INTRODUCTION

The State of Iowa has nearly 115000 mainline miles of highways, roads, and streets and more than 26000 bridges. The Iowa DOT has jurisdiction over the Primary Road System which consists of more than 802 miles of the Interstate System, about 3576 miles of numbered US Routes and 4572 miles of numbered Iowa Routes. The 99 counties in Iowa have responsibility over 90000 miles of the Secondary Road System. The 947 cities have more than 14700 street miles. The city streets are essential to connecting residents and businesses and in the movement of goods to its final destination. Iowa is a predominantly rural state with more than 80% of all road networks in the state in the jurisdiction of counties and local agencies. As a result many of these local agencies do not have the financial resources or staff to develop an in-house PMP, so once in a while they employ qualitative and subjective method for determining pavement condition. This ad-hoc approach does not provide a way to track pavement performance over time.

The purpose of a pavement management system (PMS) is to support the management, planning, and programming needs of transportation agencies (cities, counties, and the state) and regional governments by providing pavement management information supporting both project level and network level pavement management activities. This purpose is accomplished by first and foremost having a state of the science data collection program.

Data Collection

The Iowa DOT funded data collection for the counties' non federal aid eligible (FAE) paved roads from 2002 through 2005. Starting in 2006, distress data collection was funded for federal aid eligible roadways in specific portions of Iowa only. The decision to participate in the data collection effort was left to individual metropolitan planning organizations (MPO) and regional planning affiliations (RPA). However, in 2013, the Iowa DOT began collecting every paved road in the state and by the end of 2014, every paved road in Iowa would have been collected.

Pavement distress data is the measure of the road surface deterioration caused by traffic, environment, and aging. Distress can be measured by type, severity, and extent of breakdown of pavement. Distress direction is collected in one direction on two-lane highways and two directions on multi-lane highways. Data is collected every hundredth of a mile for 100 percent of the network. Each hundredth of a mile section is identified by street/route name, county, city and latitude and longitude using a differential global positioning system (DGPS). Distresses collected include cracking, potholes, patches, rutting, and ride and are aggregated to predefined pavement management sections in both urban and rural areas. The data collection is fully automated using an Automated Road Analyzer (ARAN) van. Table 1 shows all the distresses collected while Table 2 will show only the distresses that was used in the project. For the distresses with severities, the project team aggregated the severity to a single number to represent the impact of that distress.

Table 1: All the distresses collected as part of the data collection

Name	Description
STREET	Full street name
DIR	Direction (5-primary, 6-secondary)
BEGIN_GLAT	Latitude co-ordinate at beginning of 10 m interval
BEGIN_GLON	Longitude co-ordinate at beginning of 10 m interval
END_GLAT	Latitude co-ordinate at end of 10 m interval
END_GLON	Longitude co-ordinate at end of 10 m interval
DATE	Collection date
PAVE_T	Pavement Type (0-asphalt, 1-concrete, 2-surface treated, 3-gravel,4-CRCP, M-milled, C-construction)
LIRI	Average left IRI (-1.00) if invalid
RIRI	Average right IRI (-1.00) if invalid
LRUT	Average left rut (-1.00) if invalid
RRUT	Average right rut (-1.00) if invalid
ALLIG_M	Area of medium serverity alligator cracking
ALLIG_H	Area of high serverity alligator cracking
TRANS_L	Total length of low severity transverse cracking
TRANS_M	Total length of medium severity transverse cracking
TRANS_H	Total length of medium severity transverse cracking
LONG_L	Total length of low severity longitudinal cracking - non wheelpath
LONG_M	Total length of medium severity longitudinal cracking - non wheelpath
LONG_H	Total length of high severity longitudinal cracking - non wheelpath
LONG_WP_L	Total length of low severity longitudinal cracking - wheelpath
LONG_WP_M	Total length of medium severity longitudinal cracking - wheelpath
LONG_WP_H	Total length of high severity longitudinal cracking - wheelpath

BLOCK_M	Area of medium severity block cracking
BLOCK_H	Area of high severity block cracking
PATCH_G	Area of patching in "Good" condition
PATCH_B	Area of patching in "Bad" condition
PATCH_CNT	Number of patches
POTHOLE	Number of potholes
DCRACK_M	Number of joints affected with moderate severity D-cracking
DRACK_H	Number of joints affected with high severity D-cracking
JSPALL_M	Number of moderate severity transverse joint spalls
JSPALL_H	Number of high severity transverse joint spalls
LT_FT_SEV1	Absolute number of faults in interval in the left wheel path (> or = 3 mm, < 6 mm)
LT_FT_SEV2	Absolute number of faults in interval in the left wheel path (> or = 6 mm, < 9 mm)
LT_FT_SEV3	Absolute number of faults in interval in the left wheel path (> or = 9 mm, < 12 mm)
LT_FT_SEV4	Absolute number of faults in interval in the left wheel path (> or = 12 mm)
RT_FT_SEV1	Absolute number of faults in interval in the right wheel path (> or = 3 mm, < 6 mm)
RT_FT_SEV2	Absolute number of faults in interval in the right wheel path (> or = 6 mm, < 9 mm)
RT_FT_SEV3	Absolute number of faults in interval in the right wheel path (> or = 9 mm, < 12 mm)
RT_FT_SEV4	Absolute number of faults in interval in the right wheel path (> or = 12 mm)

Table 2: Distresses used in the project

Name	Description
ALLIG_M	Area of medium serverity alligator cracking
ALLIG_H	Area of high serverity alligator cracking
TRANS_L	Total length of low severity transverse cracking
TRANS_M	Total length of medium severity transverse cracking
TRANS_H	Total length of medium severity transverse cracking
LONG_L	Total length of low severity longitudinal cracking - non wheelpath
LONG_M	Total length of medium severity longitudinal cracking - non wheelpath
LONG_H	Total length of high severity longitudinal cracking - non wheelpath
LONG_WP_L	Total length of low severity longitudinal cracking - wheelpath
LONG_WP_M	Total length of medium severity longitudinal cracking - wheelpath
LONG_WP_H	Total length of high severity longitudinal cracking - wheelpath
DCRACK_M	Number of joints affected with moderate severity D-cracking
DRACK_H	Number of joints affected with high severity D-cracking
JSPALL_M	Number of moderate severity transverse joint spalls
JSPALL_H	Number of high severity transverse joint spalls

Data Visualization

For local government officials, the ability to visualize the road network is very crucial as typically they will go to the field to drive it. The ability to compare two roads becomes quite subjective when a side by side comparison is not possible. Figures 1-4 show network wide map of the city for transverse cracking through the years. This allows the city officials to find out right away the segments that are consistently bad. In addition, with their knowledge of maintenance and improvement projects, they can immediately pick out road segments that are worst performers in spite of the investments and that allows them to explore other alternatives.

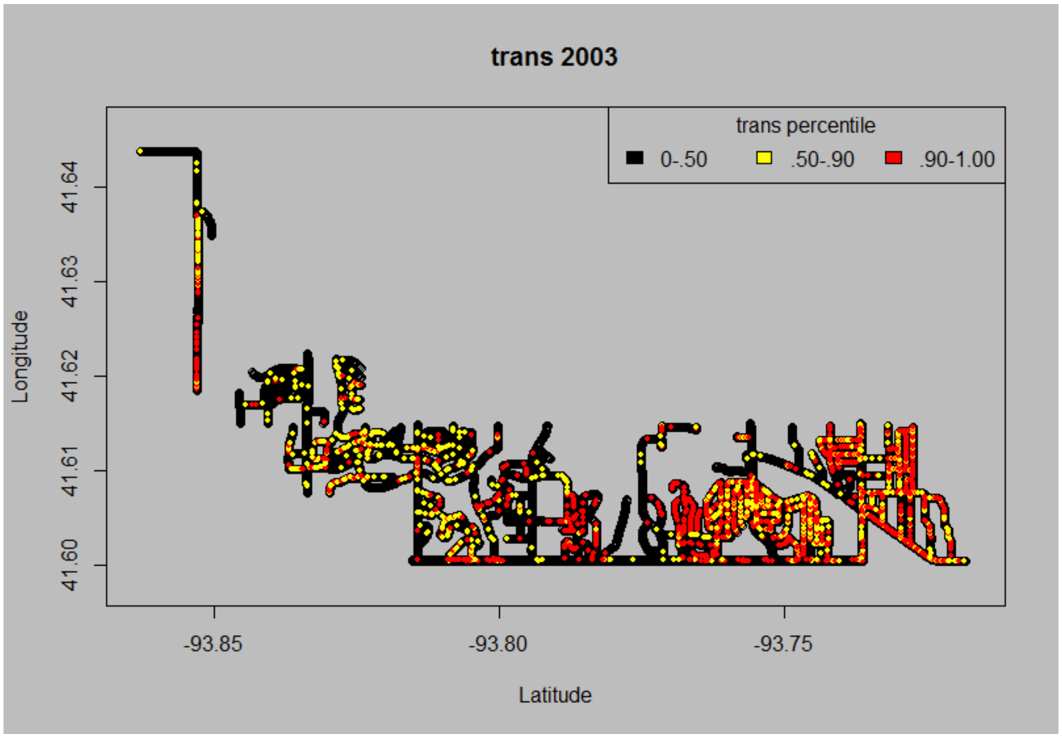

Figure 1: 2003 Total transverse cracking

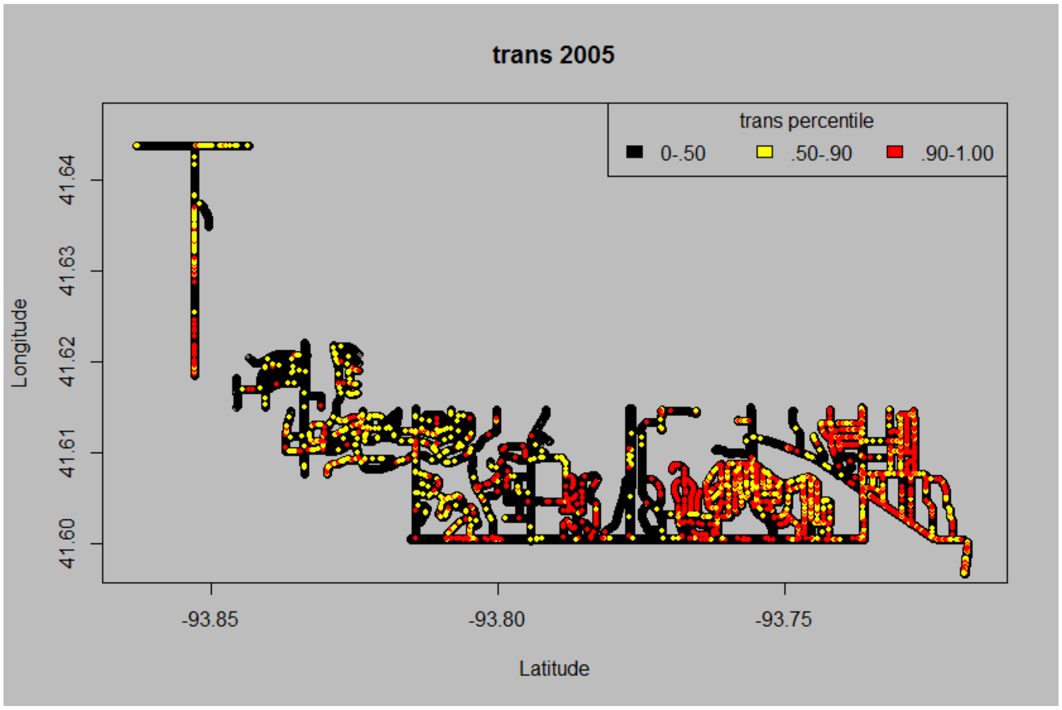

Figure 2: 2005 Total transverse cracking

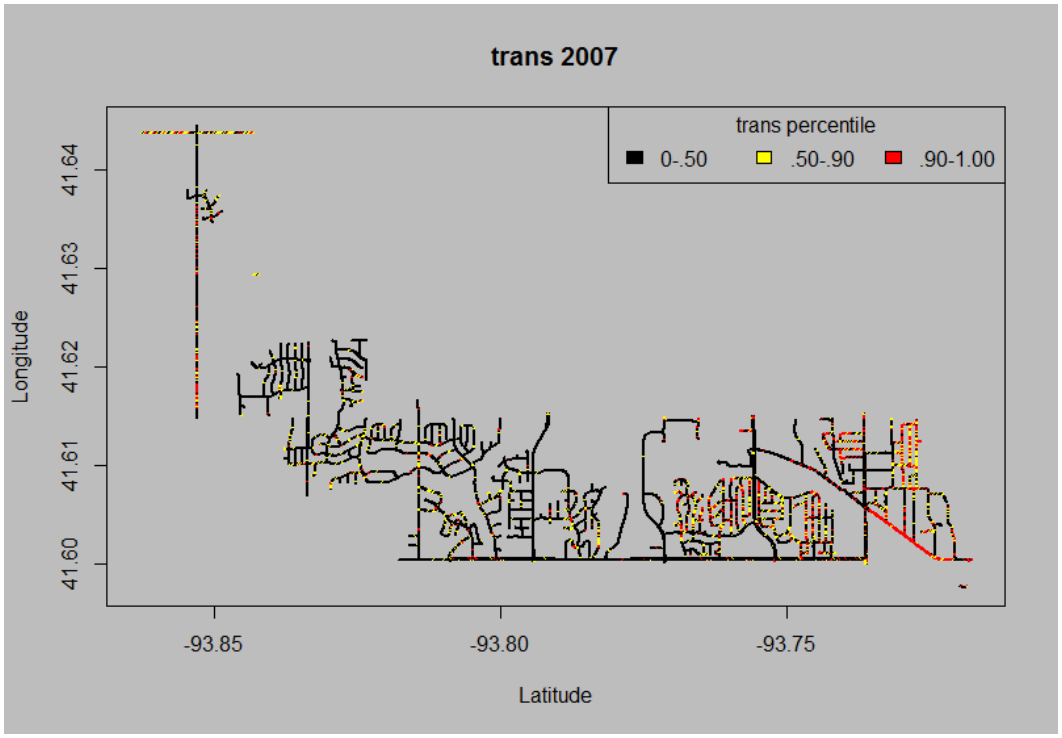

Figure 3: 2007 Total transverse cracking

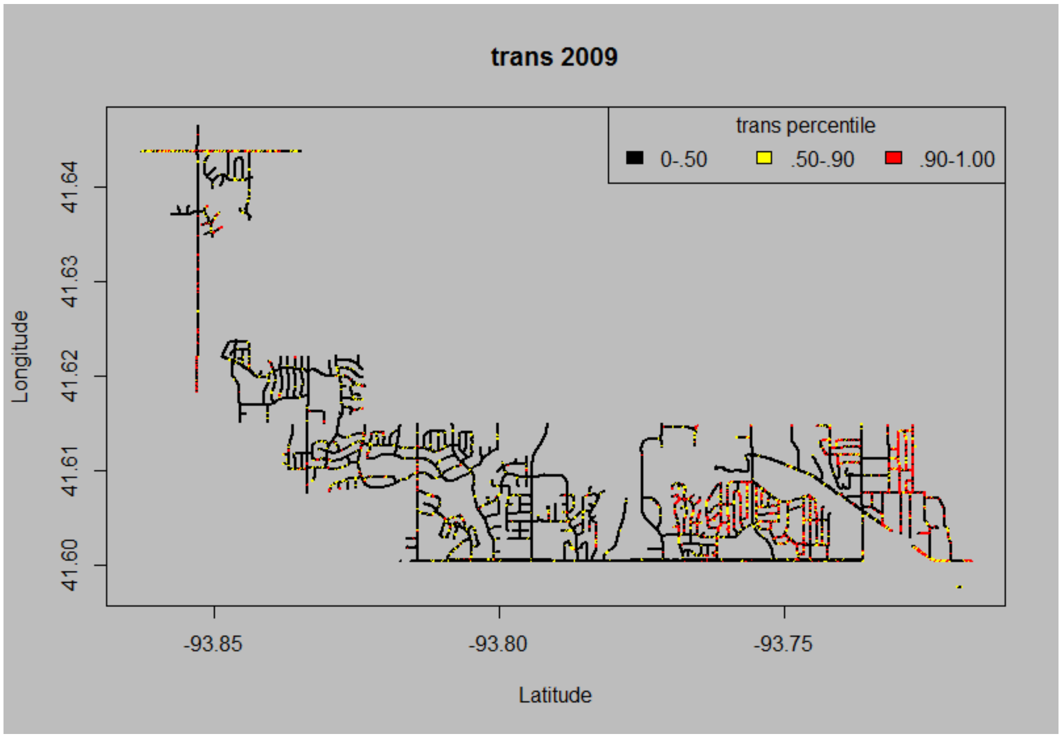

Figure 4: 2009 Total transverse cracking

It can be seen from the figures that the road segments at the western edge and southern edge of town seems to be kept up better than most parts because they are the most travelled roads in the city.

Data Reduction

To be able to make decisions in a consistent manner, the ability to integrate and summarize data in a practical way becomes very crucial and a vital step towards a comprehensive picture of network level pavement condition. Since the data comes in small chunks of a 100^{th} of mile, there is need to aggregate the data to manageable segmentation such as the street level. In addition, there is need to make sure that that aggregation represents same pavement or surface type. For instance, an asphalt street is expected to behave differently from a concrete street.

Another reason for the segmentation is to be properly represent the maintenance practices of the agency. For instance, they will never fix a road one 100^{th} mile section at a time, typically they will do maintenance at the block level because there are hidden costs to closing the street for maintenance. It cost the same to close the street to fix a small section as it costs to fix the entire street hence the need to not have to close the street again for small sections, if they can avoid it.

Figure 5 shows the longitudinal cracking through the years grouped by street and surface type while Figure 6 shows Figure 5 facetted by surface type, where 0 is asphalt and 1 is concrete. From the figures, it can easily be seen that there was a noticeable spike in 2007 that was taken care of by 2009.

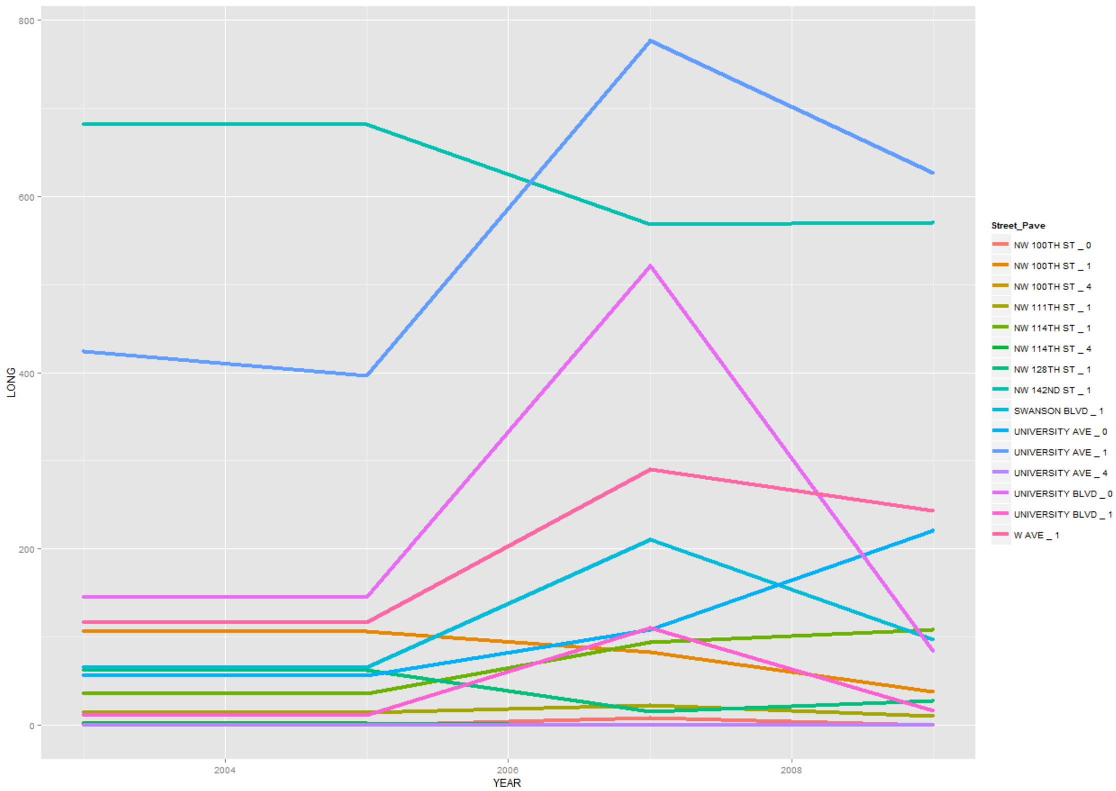

Figure 5: Longitudinal Cracking 2003 - 2009

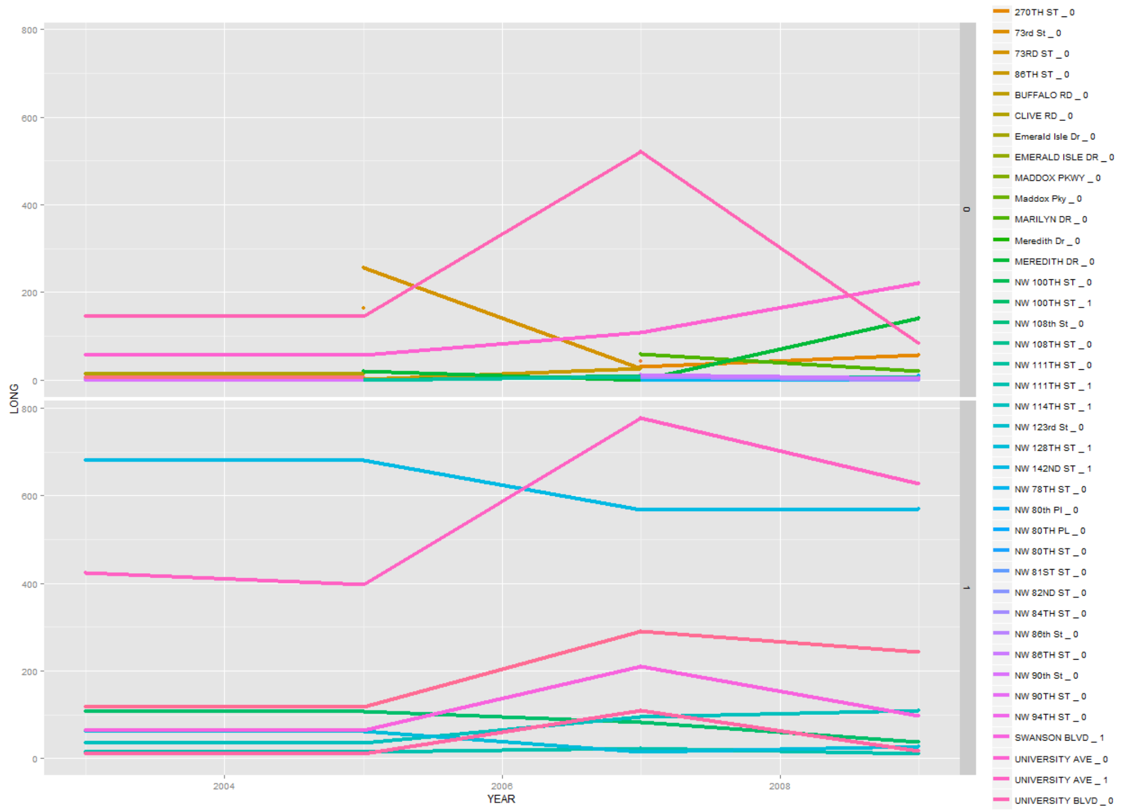

Figure 6: Longitudinal Cracking 2003 - 2009 faceted by surface type

Pavement Condition

So far the discussion has been at the distress level. It can get unwieldy to look at each distress variable. Most of the distress variables by themselves cannot trigger a treatment (maintenance or improvement strategy). Hence, the need to represent each pavement segment by a composite index that helps to capture its overall condition with respect to the rest of the network. This provides a quick number to represent the network overall. Asset managers in the local government can use that number to set targets for where they want their pavements to be at. It is impossible to fix every road, hence the need for a number that can capture the investments in the road network from year to year.

Based on how the Iowa Pavement Management Program calculates its condition index, we borrowed the weights used for each distress variable. But instead of calculating a condition index at the segment level, we calculated it at the individual raw data (100th of mile) segments then aggregated to the pavement segment level by surface type. For simplicity, we didn't use all the variables that the IPMP used to calculate the condition index, CPI. Figures 7-10 show the network condition 2003 through 2009.

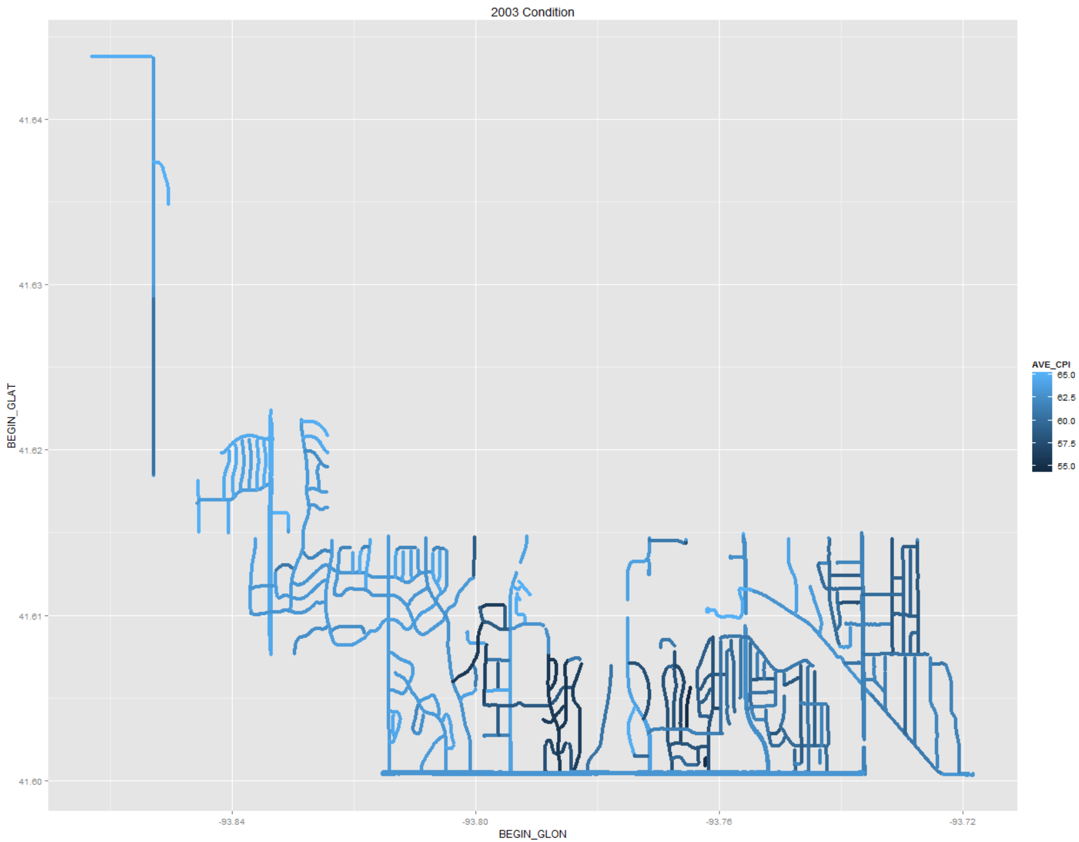

Figure 7: 2003 Condition Index

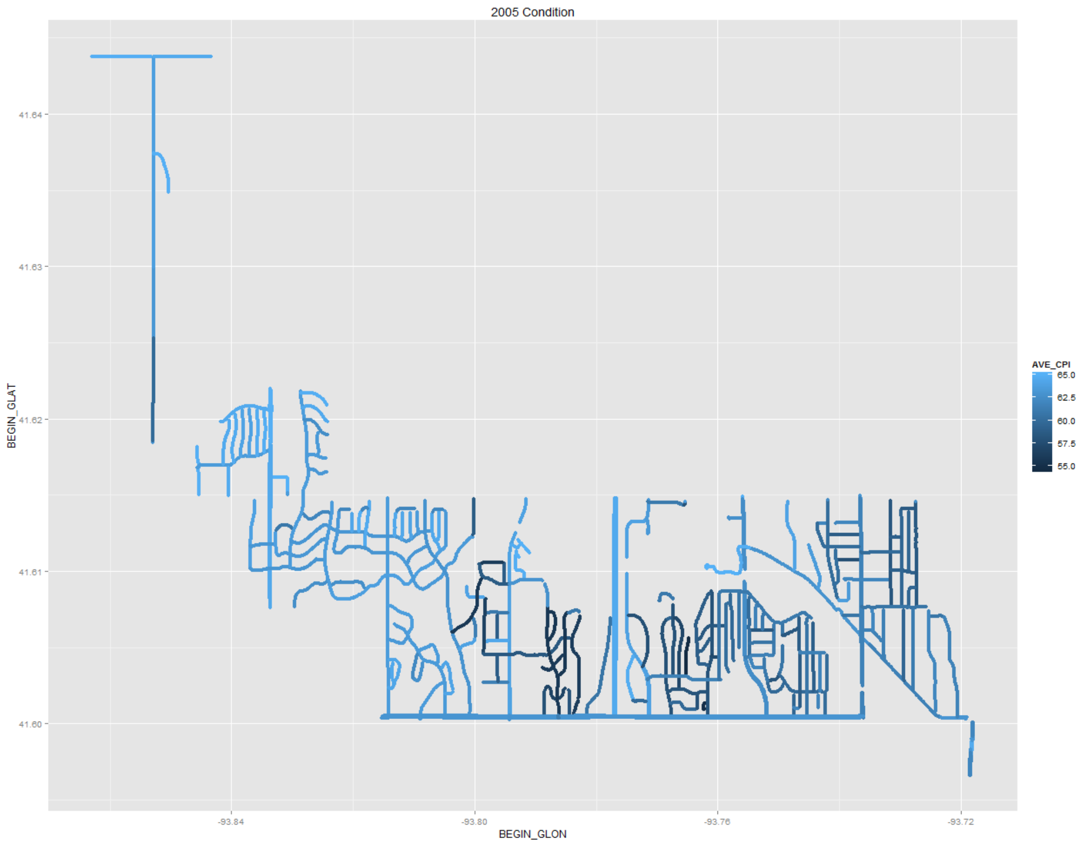

Figure 8: 2005 Condition Index

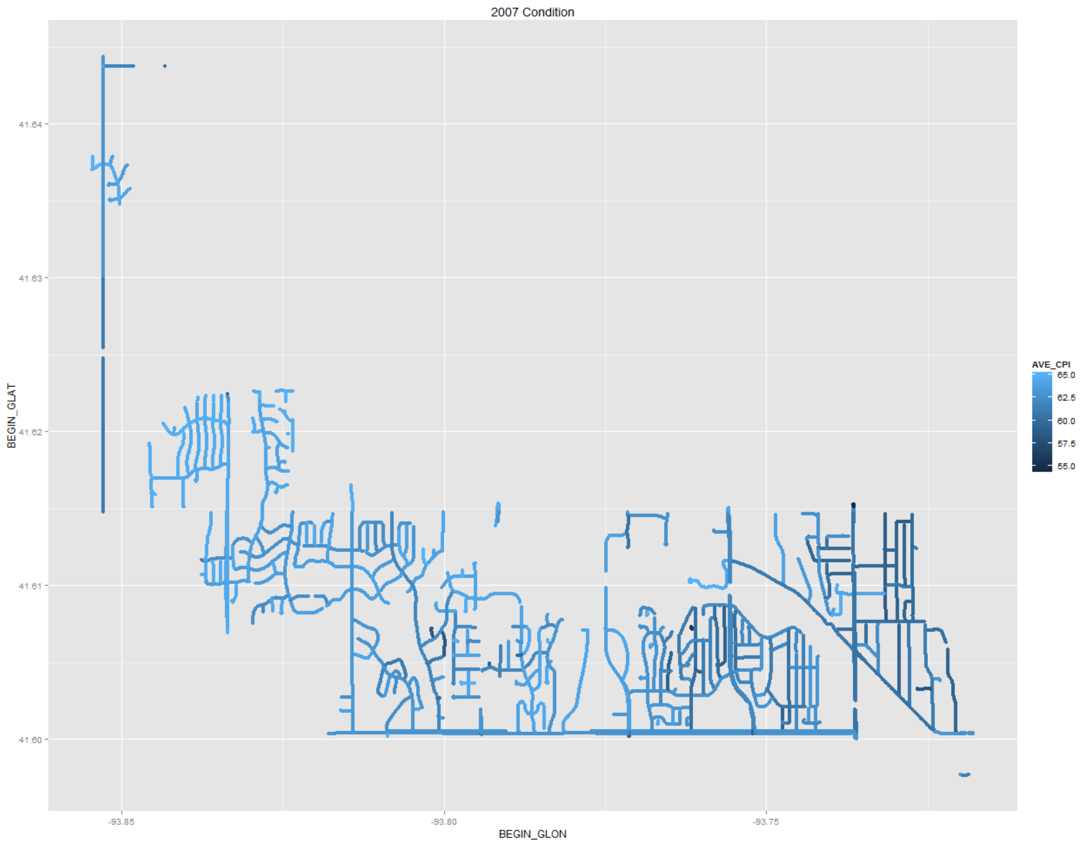

Figure 9: 2007 Condition Index

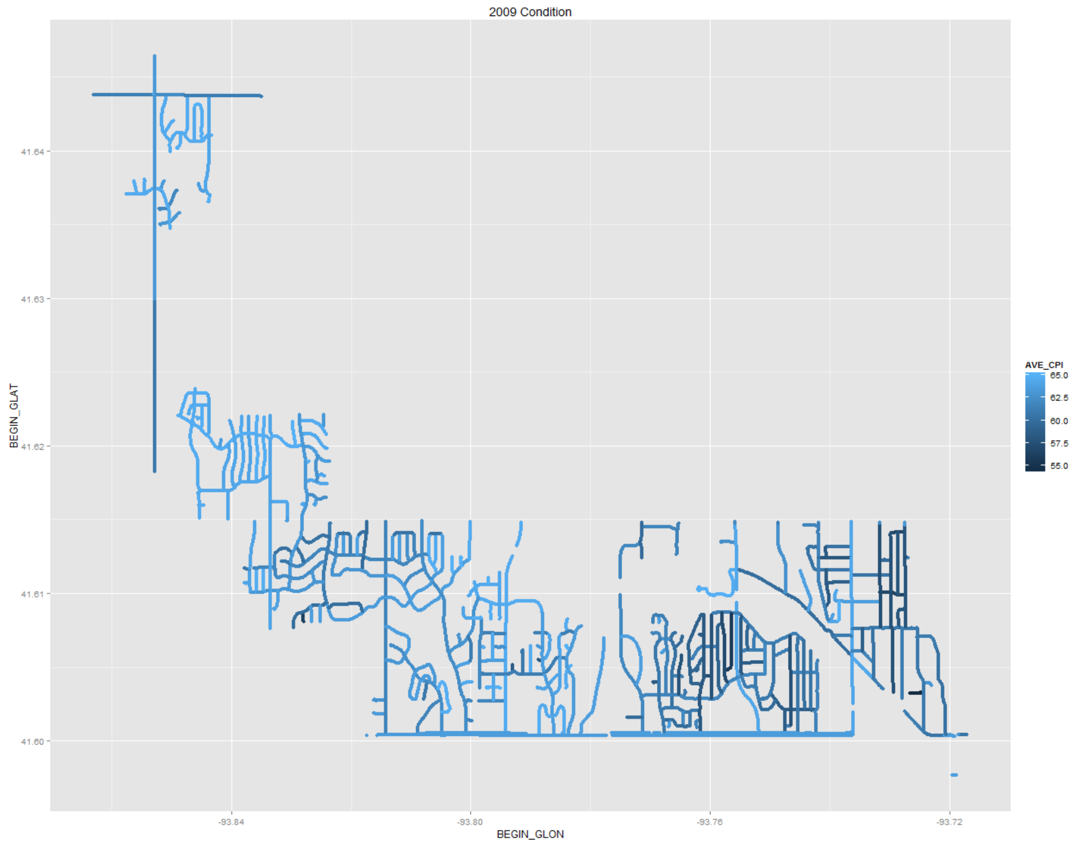

Figure 10: 2009 Condition Index

BENEFITS

This section discusses the various benefits of adopting this project to the local agencies. These benefits obviously will depend on the technical and financial abilities of the local agency involved. Regardless, the approach used in this project can be customized to meet any local agency's needs.

Accurate Representation of Network

Before even going into other more complex benefits of a PMP, just being able to accurately represent the pavement management sections is a huge advantage to the local agencies. It takes a lot of guess work out of pavement maintenance and creates a systematic framework for long term pavement management. On the interim, it provides a measurable technique of presenting the pavement health of the local agencies to the elected officials and other stakeholders.

Short and Long term Planning

Traditionally, the local agencies have been programming streets for various maintenance strategies on a flexible time frame based on year of original construction. Due to the arbitrary improvements within the local agency, combined with long term development plans within individual subdivisions and budget limitations, it has become ineffective to continue to manage a successful maintenance program with such an arbitrary approach. This will allow the local agency to efficiently mobilize and maximize its resources and provide advanced notification to affected areas. Contractual bid prices will likely be lower as a result of consolidation and the reduction of related mobilization costs.

Extended Life span

In the era of budget cuts and limited resources, this approach helps local agencies prioritize their maintenance dollars in order to maintain overall network efficiency that delivers a level of service that maintains a safer, reliable, driving surface.

Cost Savings

The bottom line is to save the local agencies much needed cash that could be re-directed to another area that needs it. In addition the ability to forecast future funding requirements in advance of actual need helps the local agencies spread out their maintenance dollars in the most effective way.

Conclusion and Future Work

Overall, this project attempts to provide a tool that helps local agencies answer the following questions.

- Is the treatment working?
- Where are the bad spots?
- How do they stack by pavement type?
- Can we tell the priority areas?
- Can we tell the well-travelled parts?
- Can we tell the perennial worst case scenarios?
- Which neighborhoods should have the highest number of complaints?
- How can we justify the investments?
- Why is the treatment not working?

As already mentioned, the CPI did not use all the distress variables, hence the need to further explore how to include those variables. The assumption that all the raw data segments are equal does not hold true in reality, hence the need to weight them and in addition to just the mean CPI, there will be need to provide an idea of variance as well to better understand the value.