

Pavement Uniformity Index



A METHOD TO EVALUATE
PERFORMANCE UNIFORMITY FOR
HIGHWAY PAVEMENTS

Iowa DOT Pavements

- 11,092 miles of “Primary” pavements (Interstates, US & Iowa Highways)
 - Backbone of state transportation network (total of 115k miles including streets and county roads)
 - Carries 63% of all vehicle traffic in the state
- Asset value - \$14.2B
- 3,922 management sections
 - Vary 0.1 mile up to 18+ miles
 - Limits based on construction history
- Extensive section data available

Opportunity

Detailed data available

- Data collected every 1/100th mile (52.8 ft)
- 1M+ records each cycle
- 30+ attributes
- Typically aggregated to management section
- Data too dense to be used for most purposes



> PAVEMENT DISTRESS
With the ARAN's pavement imaging subsystem, planar-view digital pavement images are recorded directly to disk for 100% of the driven lane.

> POSITIONING - GPS
Every ARAN is equipped with a GPS and is integrated with other subsystems so that if the receiver cannot lock on enough satellites to determine its position, the ARAN DMI and the ARAN Inertial Reference System will fill in the gaps.

> RIGHT-OF-WAY VIDEO
The ARAN can be outfitted with as many as six HDTV cameras which captures right-of-way images allowing you to virtually view the road from the comfort and safety of your office.

> RUTTING
The Laser Transverse Profiler uses dual scanning lasers to accurately measure the transverse profile of the road with 1280 points over 4 meters.

> GROUND PENETRATING RADAR
An electromagnetic device used to detect changes in road structure, including material thickness, changes in material and changes in material condition.

> ROUGHNESS
The Laser SDP is a longitudinal profile measurement system that provides road profile data capture and real-time roughness index calculation using a combination of high-speed lasers and accelerometers.

> POSITIONING - DMI
The Distance Measuring Instrument measures ARAN chainage and linear distance travelled. Every ARAN is equipped with a GPS and is integrated with other subsystems so that if the receiver cannot lock on enough satellites to determine its position, the ARAN DMI and the ARAN Inertial Reference System will fill in the gaps.

> TEXTURE
Smart Texture utilizes high frequency lasers to measure the mean profile depth of road surface macrotexture.



Project Goals

1. Dig into the detailed pavement measurements
2. Make something useful

I learned from talking to our engineers that it might be useful to gain an understanding of performance variability within management sections

I set out to create a Pavement Uniformity Index

Data

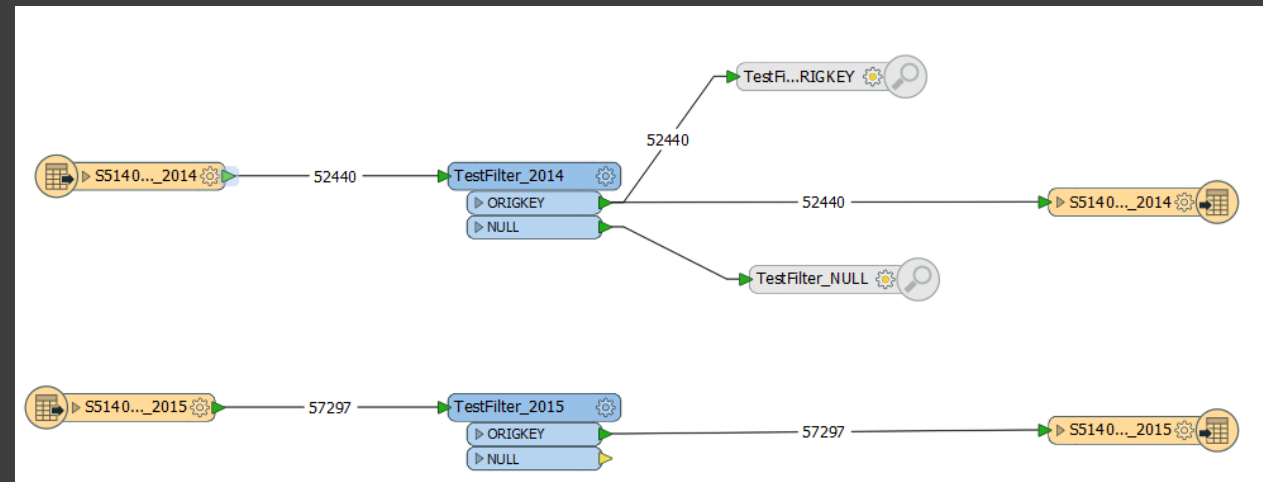
The easy part?

- Managed in DOT Oracle database
- Collected since late 1990's

Used FME to obtain data

Section data - Excel

Quality questions



Data

Key Attributes

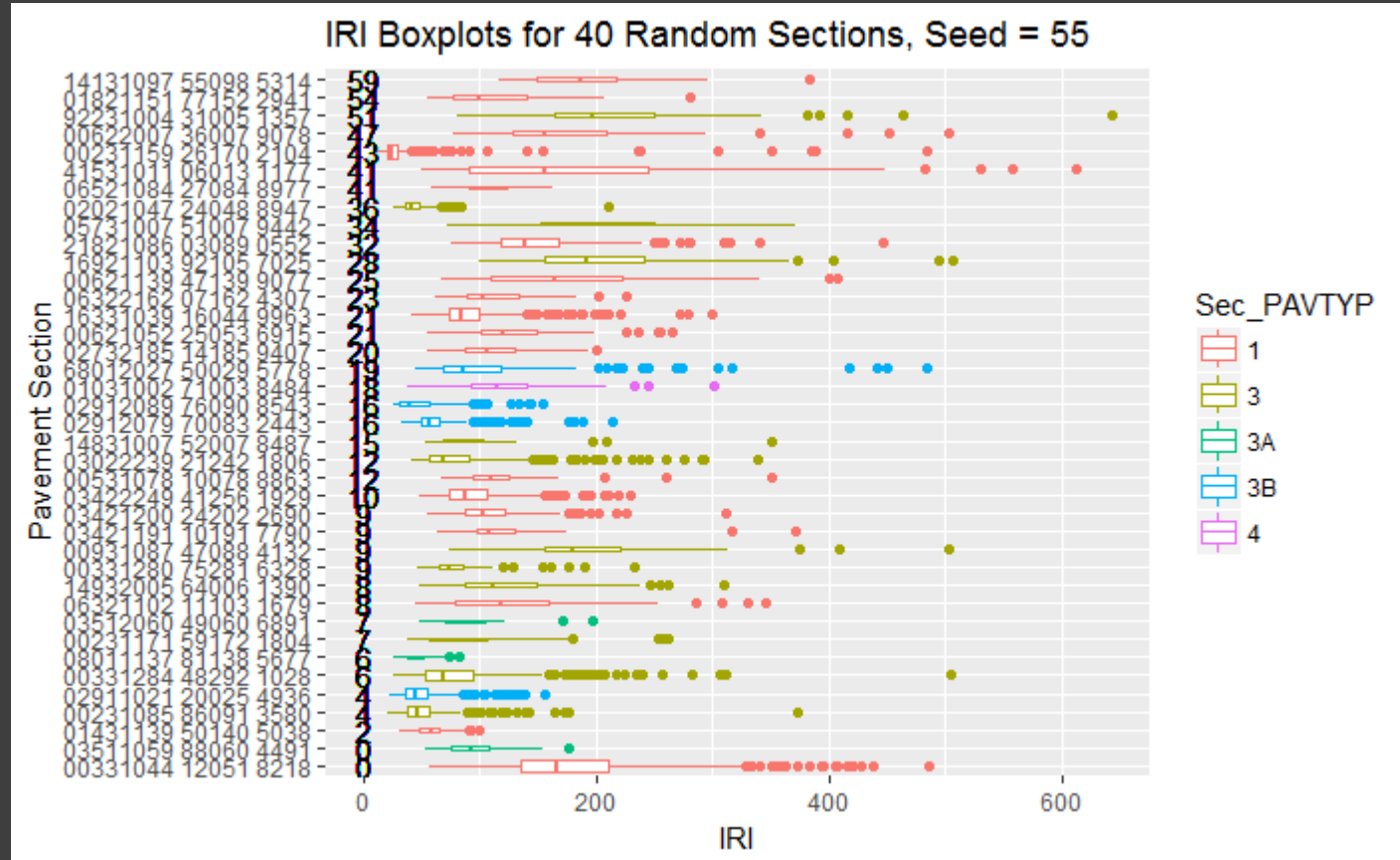
- Ride (IRI)
- Rutting
- Cracking



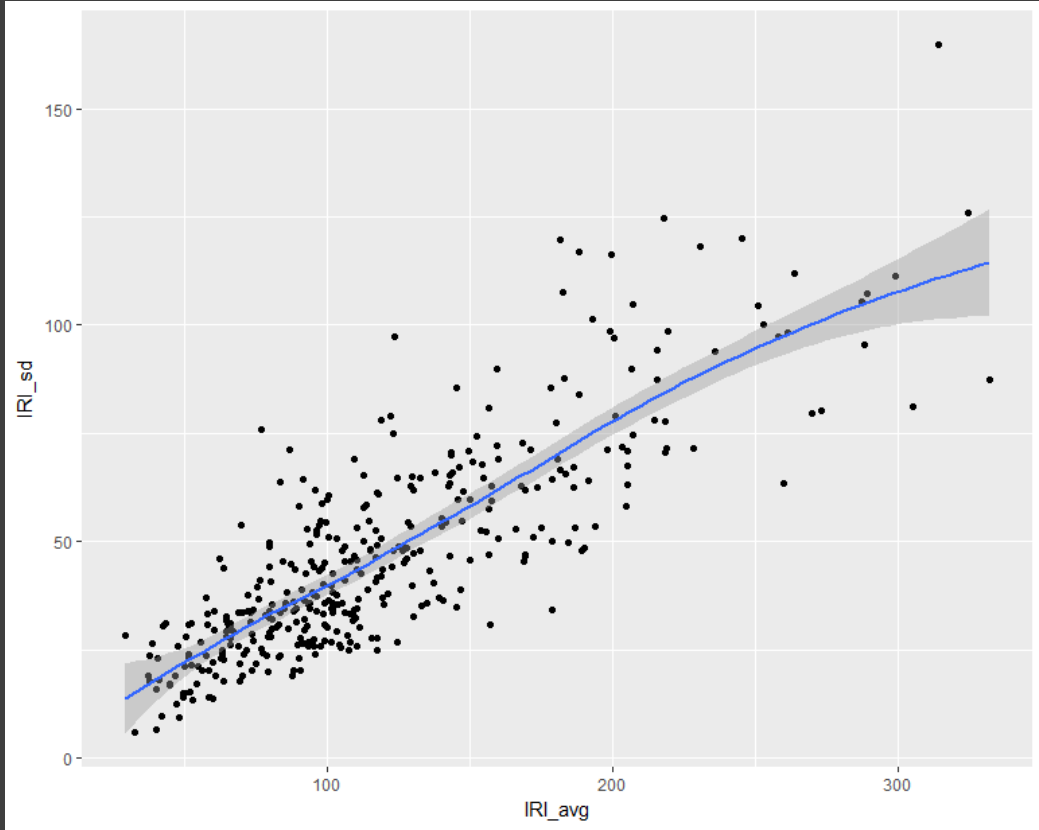
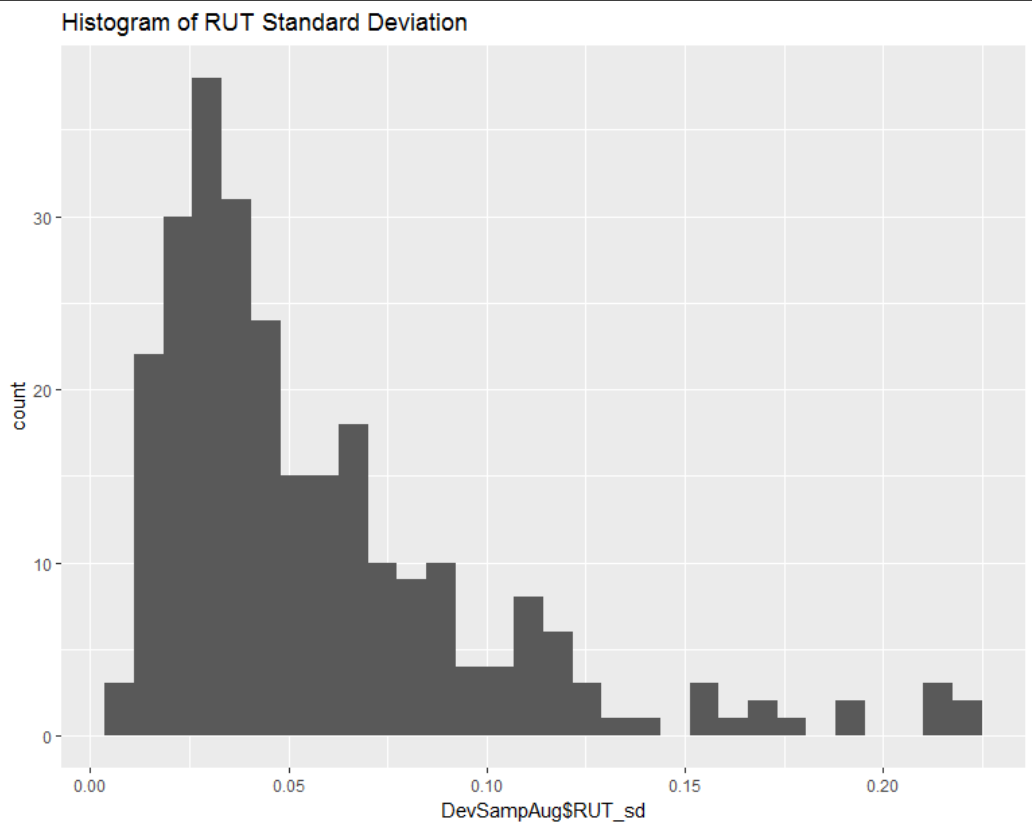
Exploration

Sampling

- Random sample of 392 management sections and their associated data (105,479 points)
- For some visualizations, sub-samples were generated



Exploration



Exploration

Findings:

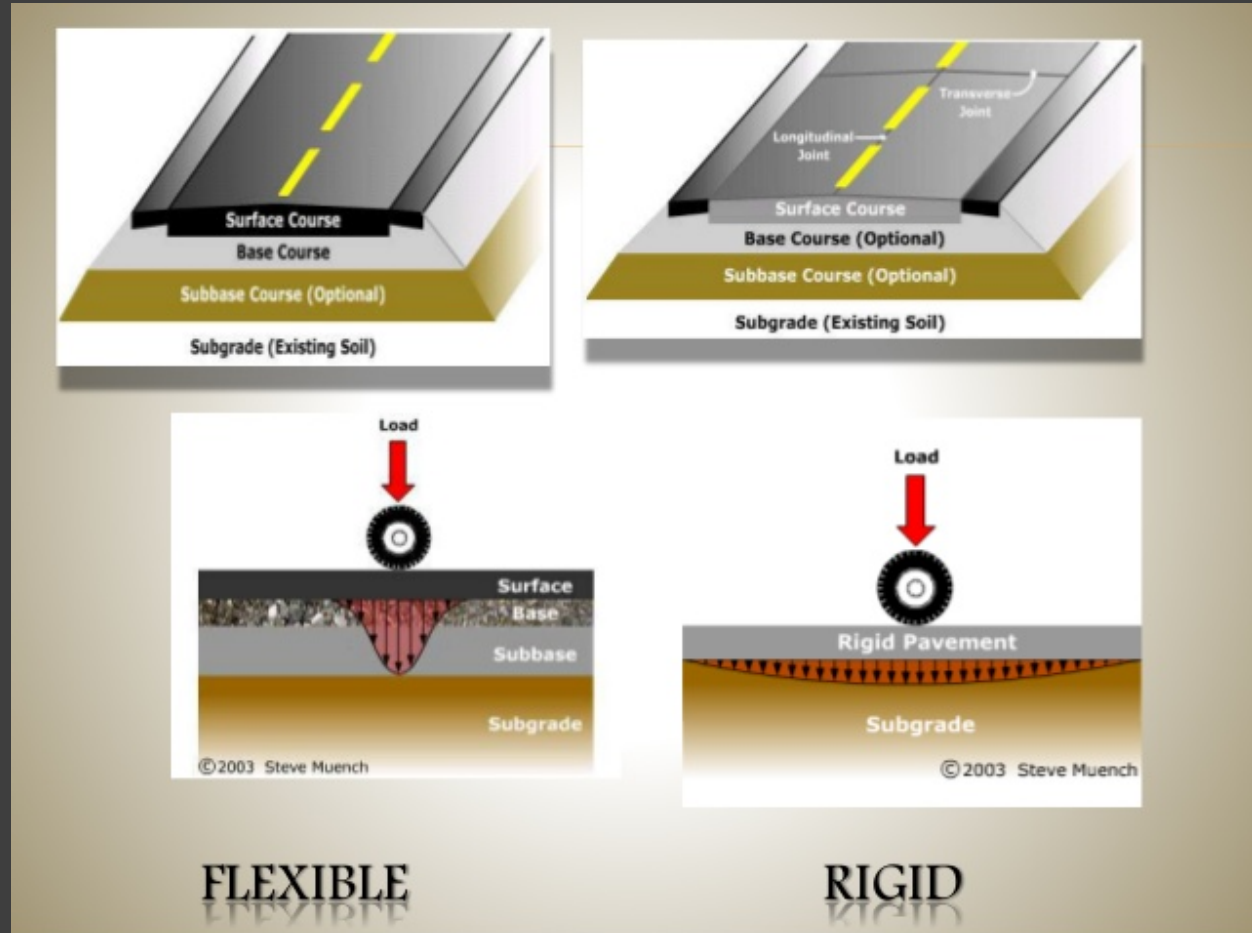
- Remove newer segments (0-2 years)
- Eliminate city segments (1,811 segments, 3,140 miles)
- All distresses have different scales
 - Rutting - 0.1 inch
 - IRI - inches/mi
 - Cracking - mix of length and area
- Some differences by pavement type (rigid, flexible, composite)

Pavement Types

Iowa DOT mix:

- Rigid (Concrete) - 33%
- Flexible (Asphalt) - 16%
- Composite - Asphalt over Concrete - 51%

Trivia Time - Iowa is unusual in having a high percentage of rigid pavements



Cracking

Four major types

- Transverse, Longitudinal, Wheelpath, Fatigue

Four classifications

- Low, Medium, High, Sealed

Variations depending on pavement type

Engineers say: $L \times 2 + A \div \text{total area} = \% \text{ Cracking}$

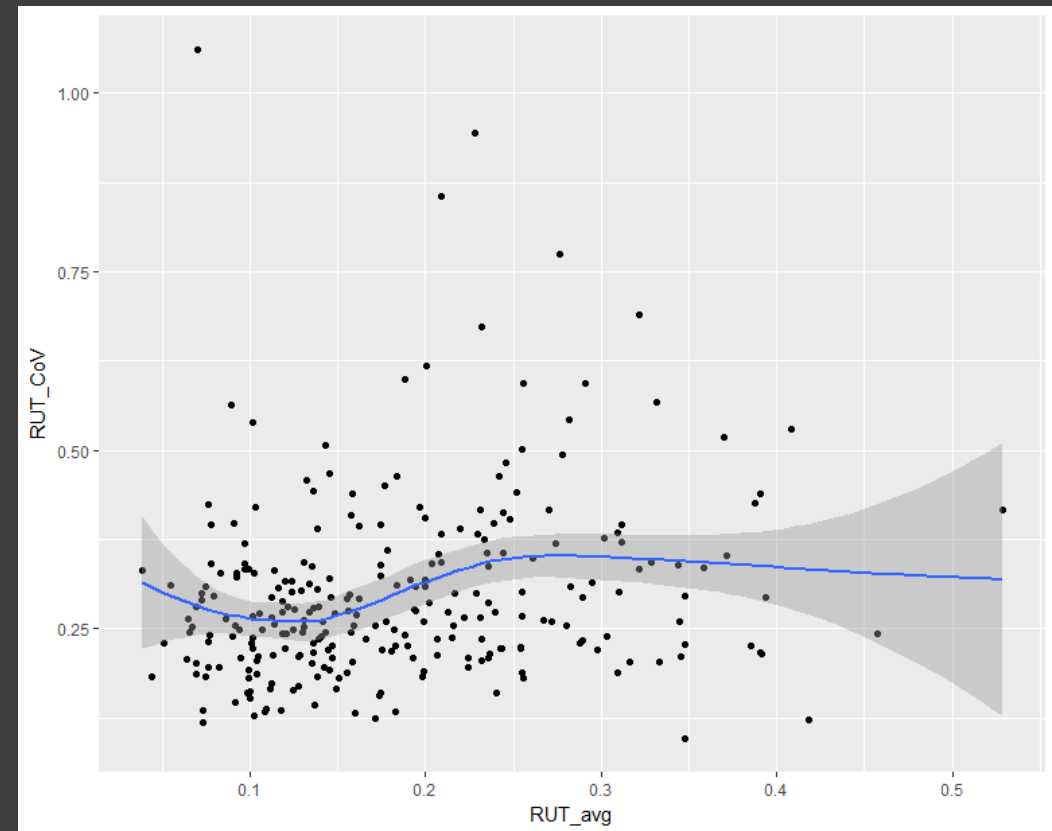
Methods

Use Coefficient of Variation since

- SD often depends on mean value
- Scales all different

Formula: $c_v = \frac{\sigma}{\mu}$

- Calculated for EACH section



Index Calculation Method

Raw Score

$$PUI_{raw} \begin{cases} \frac{(c_v[IRI] + c_v[Crack\%])}{2}, & \text{Pavement Type} = \text{Rigid} \\ \frac{(c_v[IRI] + c_v[Crack\%] + c_v[RUT])}{3}, & \text{Pavement Type} = \text{Flexible} \end{cases}$$

Final Pavement Uniformity Index value (PUI) on 1-10 scale

- Based on deciles of the empirical distribution of PUI_{raw}
- Highest 10% of all values have PUI score of 10

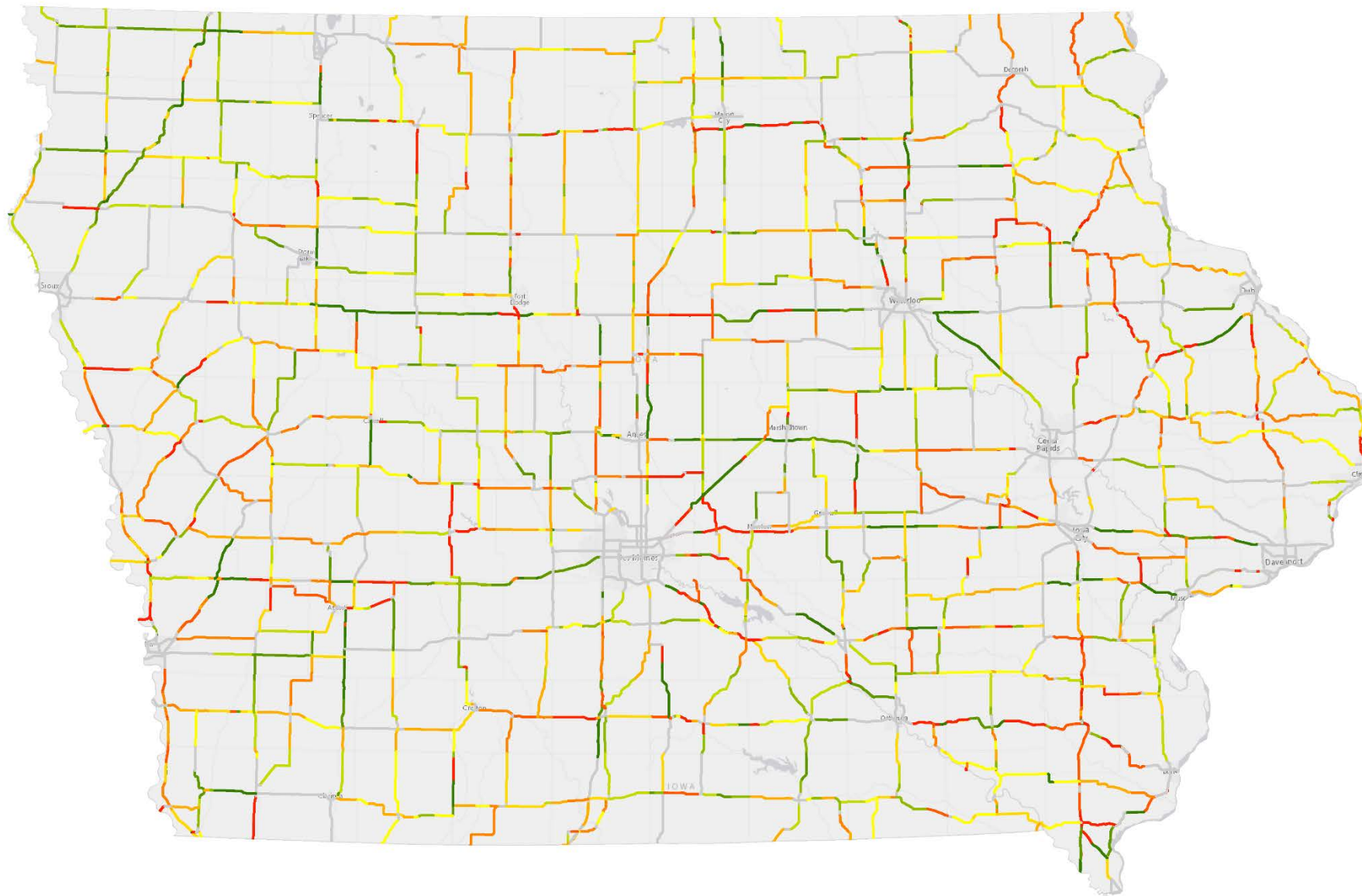
Results

Risk Matrix

- High Risk (red shading): 1,383 mi
- Medium Risk (yellow): 3,046 mi
- Low Risk (green): 3,522 mi

Provides information regarding level of investigation needed to design a treatment

		Uniformity Index									
		1	2	3	4	5	6	7	8	9	10
Condition Index	100	114	84	17	39	39	45	66	125	96	53
	90	334	251	123	120	146	197	244	297	305	248
	80	286	162	89	118	150	199	171	173	154	248
	70	62	29	145	188	209	190	208	78	45	124
	60	2.1	56	207	252	176	115	61	20	49	101
	50		83	119	118	111	61	34	17	25	27
	40		43	32	57	26	55	23	9.4	25	4.4
	30		16	8.2		5.2	3.8	11		24	
	20								1.4		
	10					1.7					



Results

1. Aid in researching needs for a given segment
2. Use to help evaluate pavement deterioration models
3. Easily implemented in SQL - will be in “production” in near future

Future Work

1. Distribution of cracking percent by pavement type
2. Spatial component
3. Temporal component

