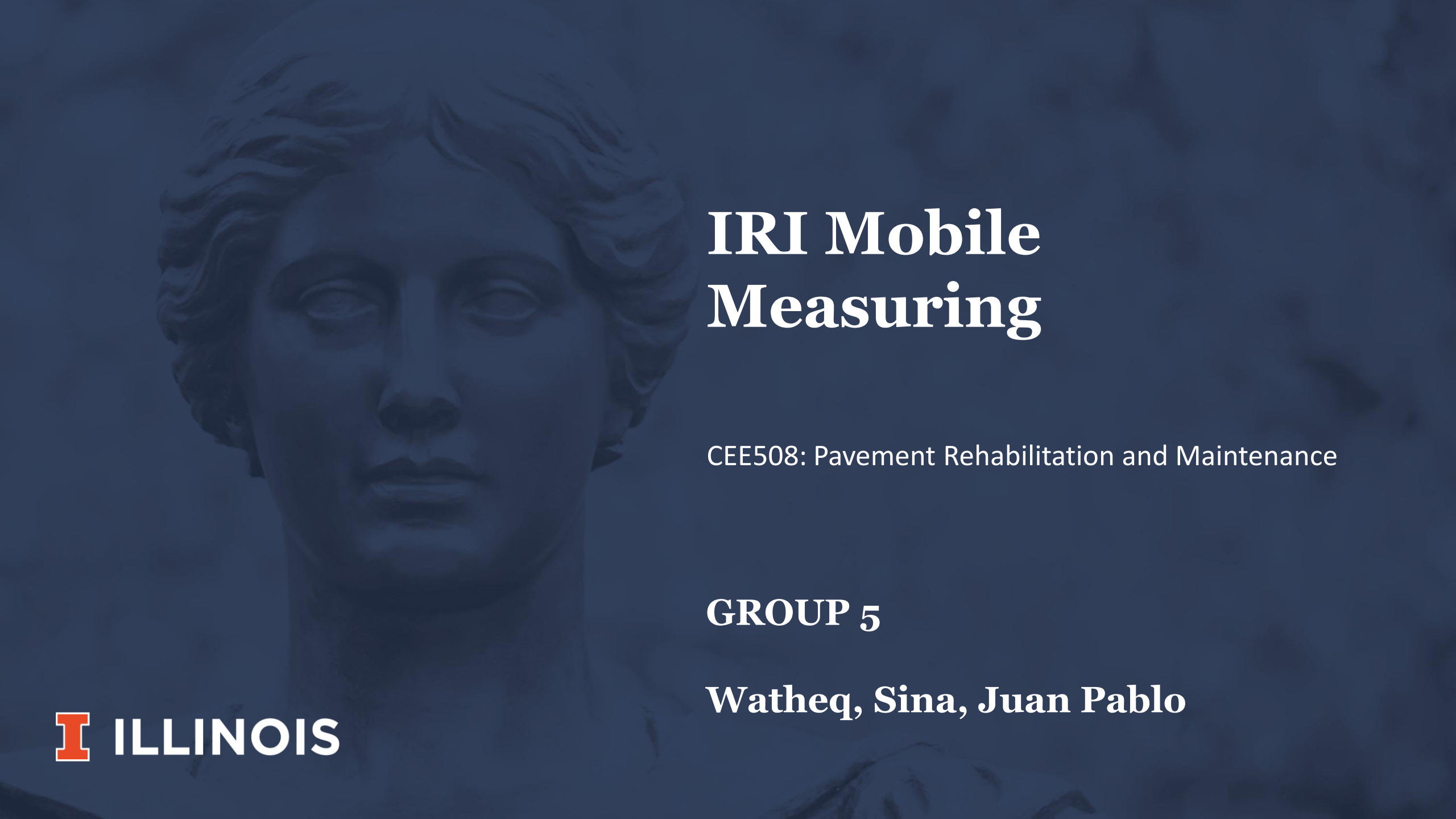


IRI Mobile Measuring

CEE508: Pavement Rehabilitation and Maintenance

GROUP 5

Watheq, Sina, Juan Pablo

ILLINOIS

Introduction

- Roadway network is a very important asset
  - Good management of this asset is crucial
- Pavement roughness measurement is necessary
  - An acceptable reflection of overall pavement condition
  - However, can be costly; especially when frequent
- Different low-cost alternatives are available
  - Including mobile phone apps
- RoadLab Pro software

RoadLab Pro

- A mobile phone app that reports IRI at roughly 100-m intervals
  - Developed by SoftTeco; funded by a World Bank project in 2018
  - Available for both Android and iOS
  - Uses kinematics to estimate IRI
    - Converts accelerometer data into IRI measurements
    - Phone should be mounted as vertically as possible
    - Uses GPS for location
  - Intended to obtain road conditions in developing countries

Software Overview

- Driving with at least 15km/hr
- Gives the option of choosing car's suspension
  - Hard
  - Soft
  - SUV
  - Custom
- Takes almost continuous measurements
  - Reports results every 100m
  - Available in SI units
- Open source app (free)
- Can be linked to online drives (e.g. Dropbox)

RoadLab Pro Manual

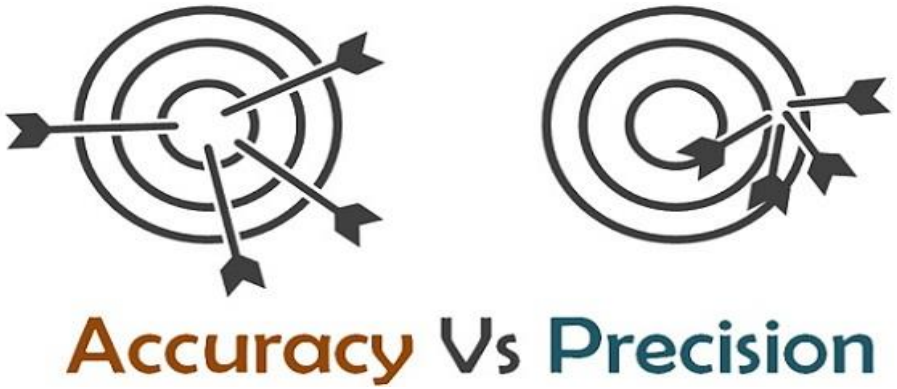
Research Motivation

- ***Cost***
  - Every municipal entity has a fleet of moving cars (almost no additional cost!)
  - Compared to around $120/mile for Data Collection Vans (DCV)
- Practicality
  - Simplicity compared to profilographs, etc.
- Accuracy??
  - Can it be accurate enough for some applications?

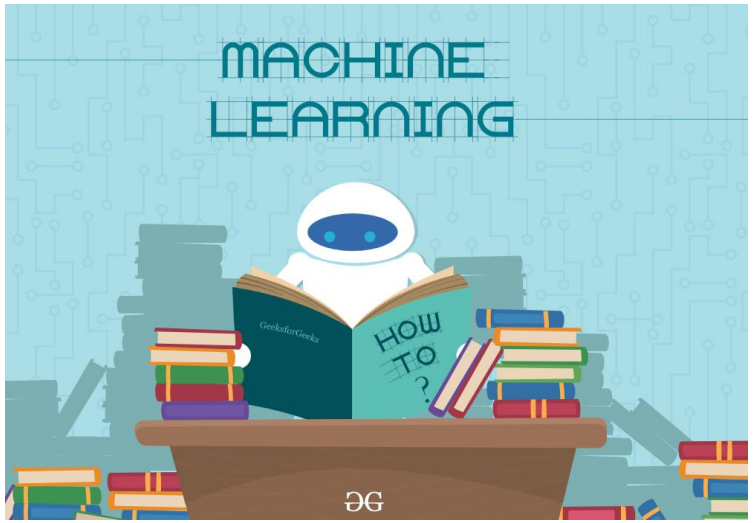
Sina Anesteh

Research Objectives

- Objective A: Assess the accuracy, capabilities of handheld measuring of IRI values



- Objective B: Investigate possible applications of the software based on the its respective performance through machine learning

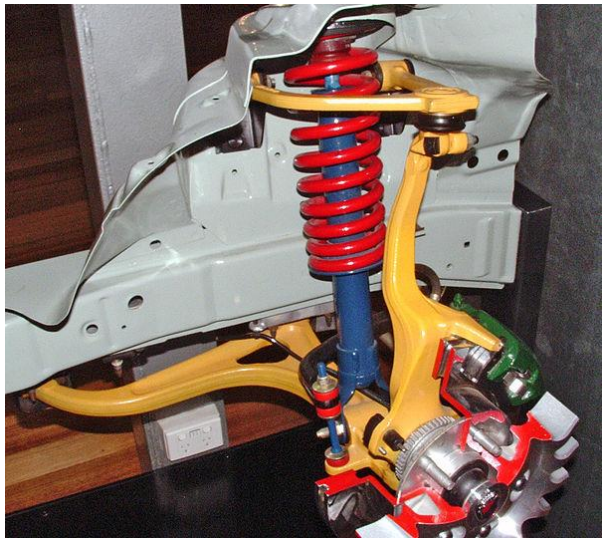


Accuracy analysis

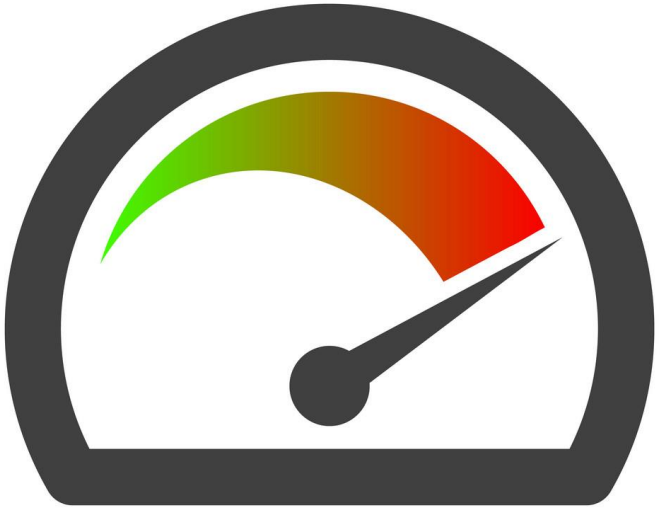
- Step 1: Compare measurements varying internal parameters.
  - How repeatable are the measurements?
- Step 2: Compare with existing measurements
  - Given IRI data for the city of Champaign, how do we compare?

Latitude	Longitude	Street Name	Station	L.IRI	R.IRI
40.10338999	-88.23861073	1st St N NB	0	207	206
40.12000802	-88.23840777	1st St N SB	0	174	228
40.08332992	-88.23908779	1st St S NB	0	131	174
40.09807442	-88.23721922	1st St S SB	0	238	205
40.10931102	-88.23702815	2nd St	0	462	382
40.10367249	-88.23340146	4th St N NB	0	64	79
40.12722847	-88.23423523	4th St N SB	0	123	296
40.0834896	-88.23405613	4th St S	0	89	124
40.12017465	-88.2325954	5th St N	0	287	641
40.10542486	-88.23293155	5th St S	0	383	369
40.11639393	-88.22958696	6th St SB	0	50	152
40.13806403	-88.2584596	Anthony Dr E	0	96	114
40.13622501	-88.23897574	Anthony Dr W	0	111	83
40.1068404	-88.24030524	Armory Ave E	0	103	107
40.10539306	-88.26779825	Armory Ave W	0	97	109
40.14153636	-88.26124683	Baytowne Dr	0	418	386
40.12726927	-88.24547841	Bloomington Rd NB	0	171	175
40.13157015	-88.25789442	Bloomington Rd SB	0	125	155
40.15670174	-88.26292491	Boardwalk Dr EB	0	301	303
40.13859377	-88.23900536	Boardwalk Dr WB	0	141	143
40.12797546	-88.31467402	Bradley Ave EB	0	137	151

1) Variation of Internal Parameters



SUV – Sedan



Speed

Surface Type

Car Type

Sedan A.K.A Black Diamond

SUV A.K.A Blue Sapphire

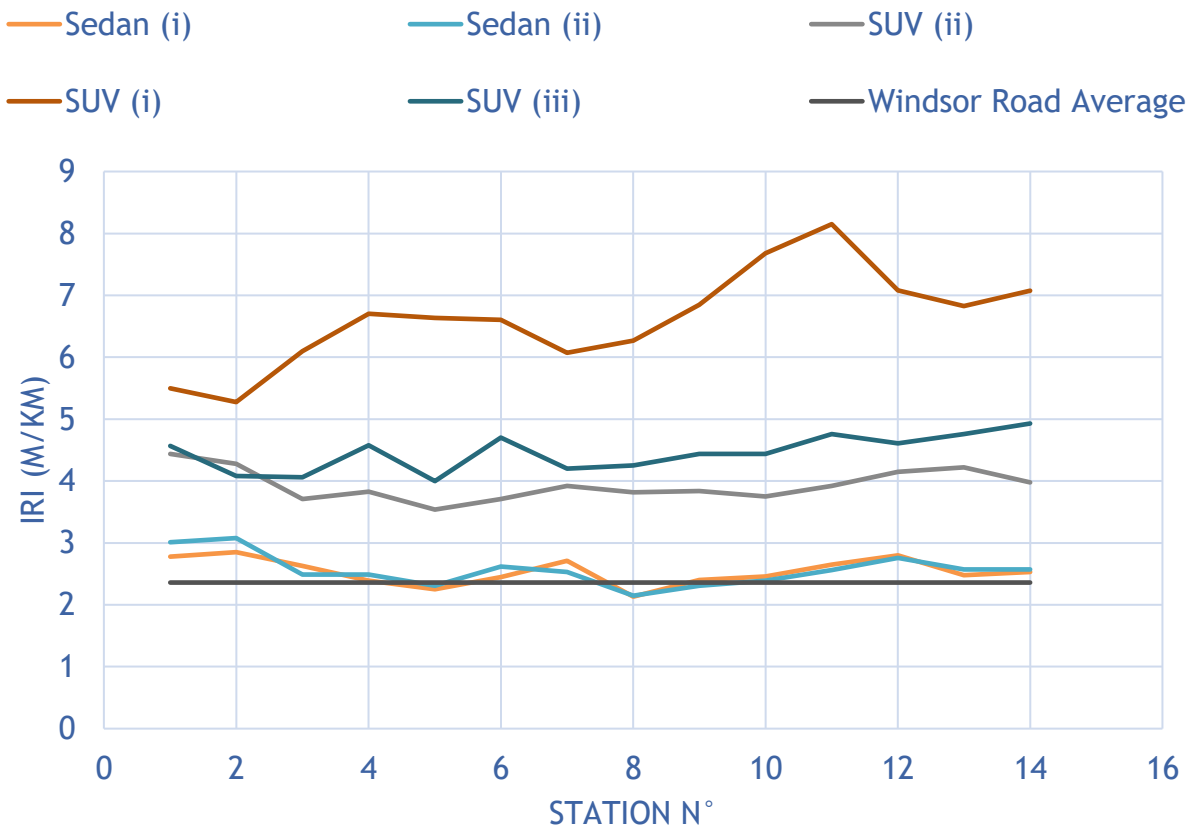
Car Type (ct'd)

Sedan A.K.A Black Diamond

SUV A.K.A Blue Sapphire

Windsor Road

Car Type (Results)



Vehicle Speed

- Choose Interstate Drive at north Champaign, full IRI data and low traffic. PCC.

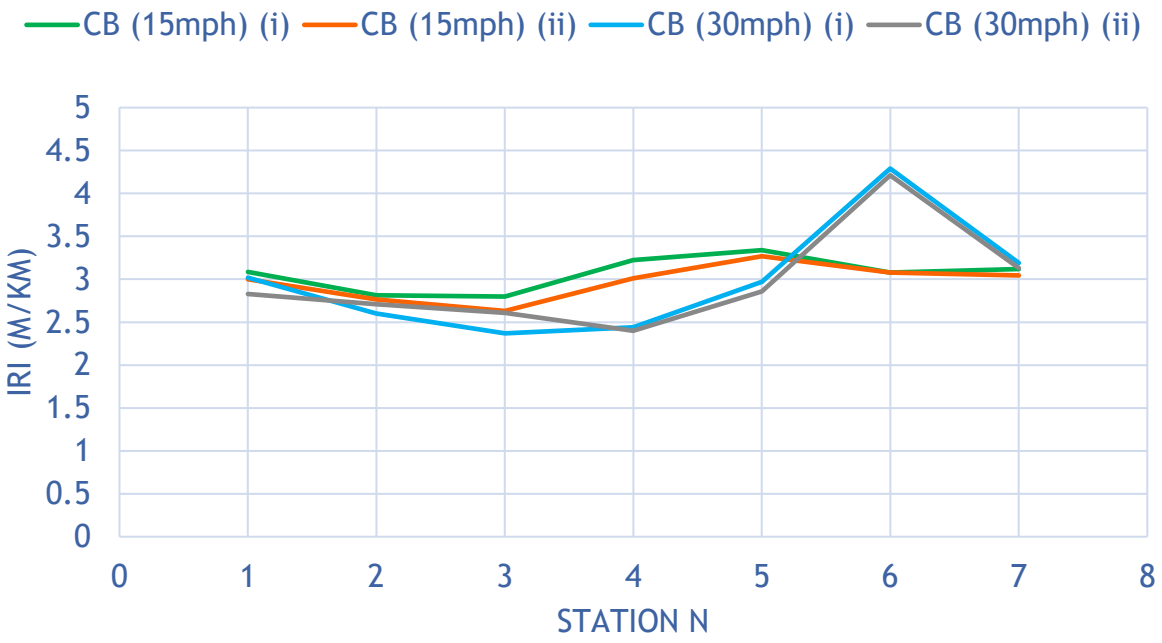
- Choose State St. Relatively low traffic and with IRI data all along. Asphalt surface and fair conditions.

Interstate Drive (PCI:80)

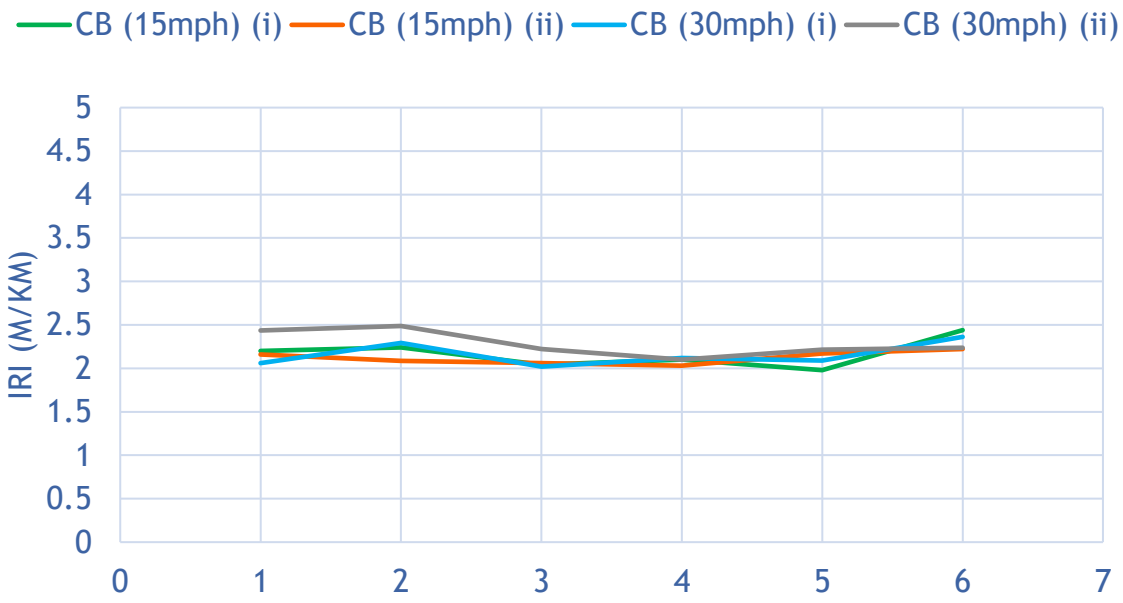
State Street (PCI: 40)

Vehicle Speed

STATE ST. (AC)

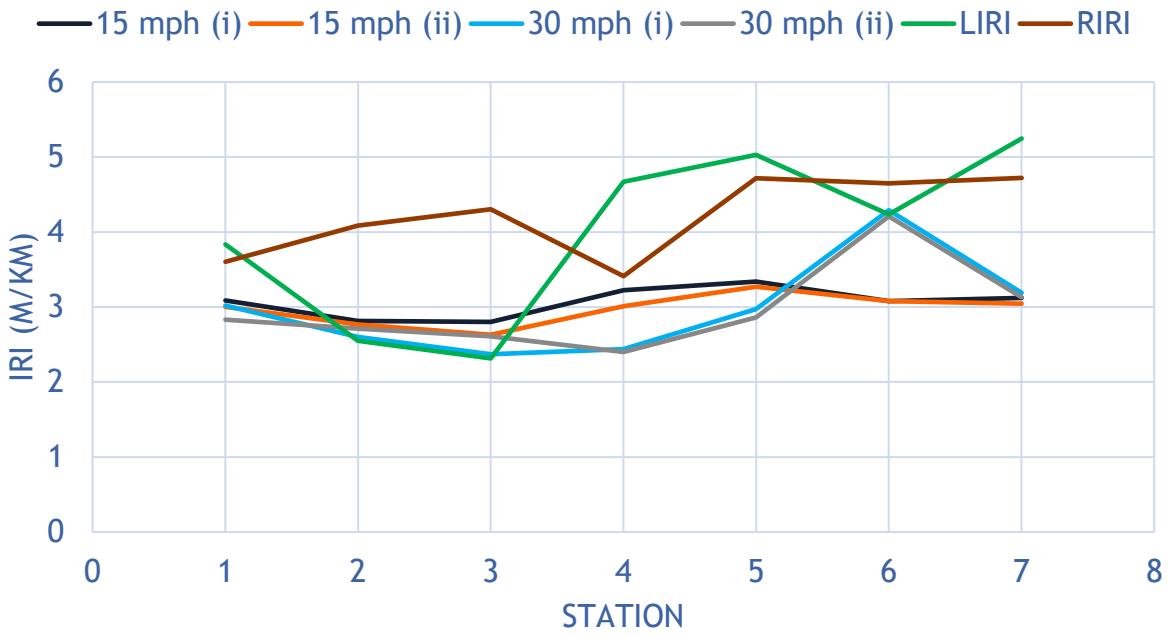


INTERSTATE DRIVE (PCC)

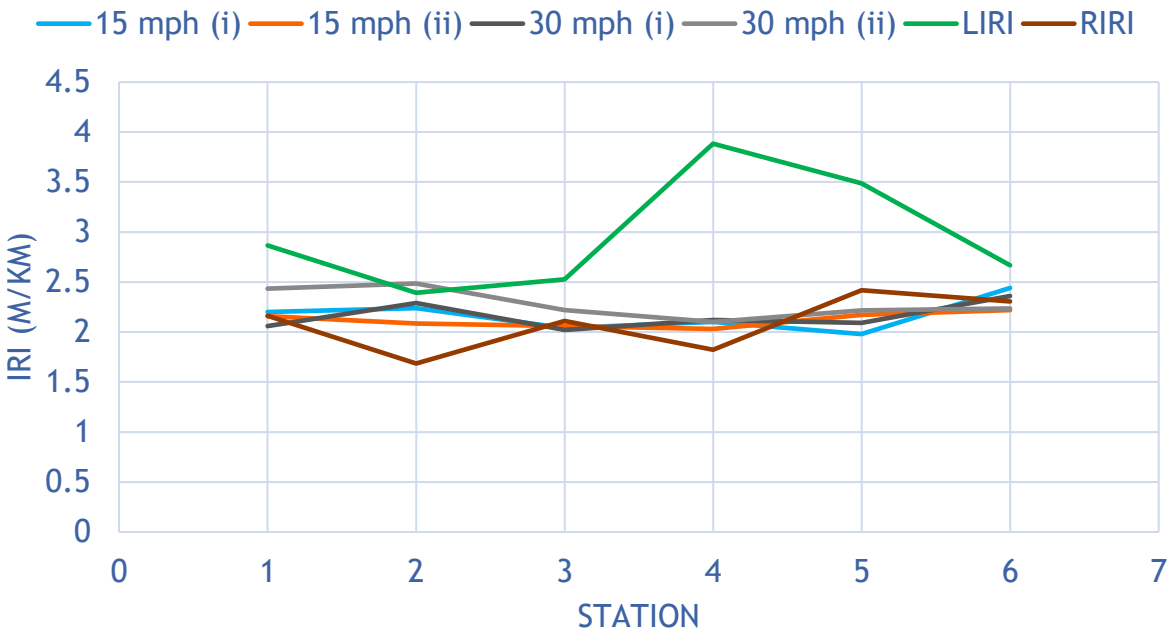


2) Accuracy

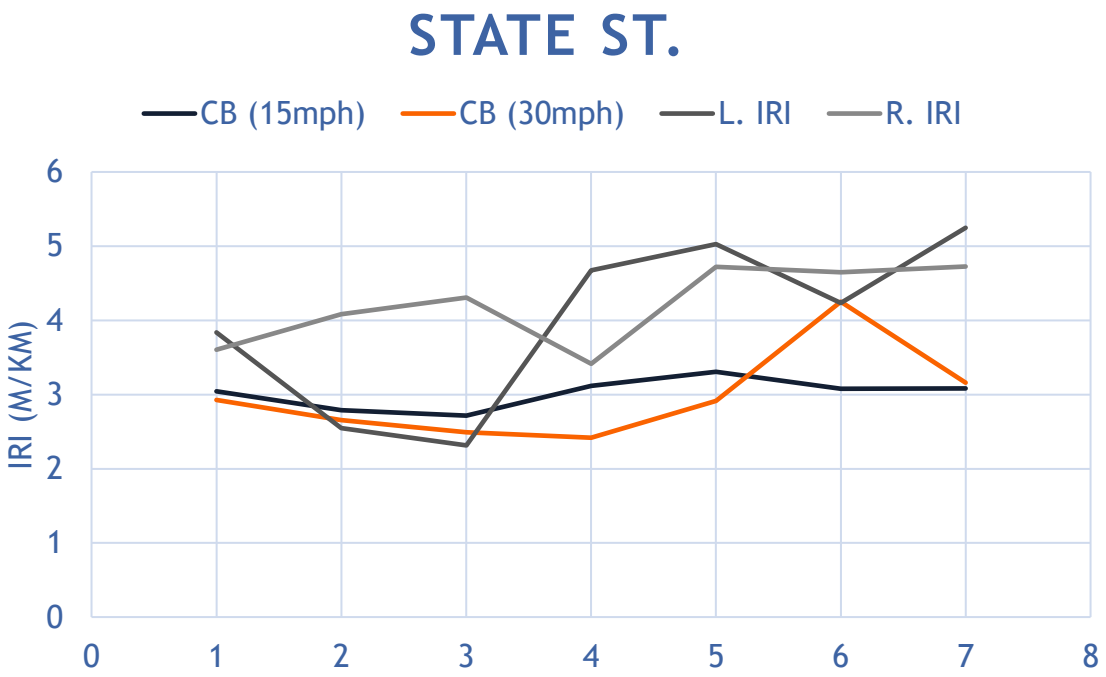
STATE STREET (AC)

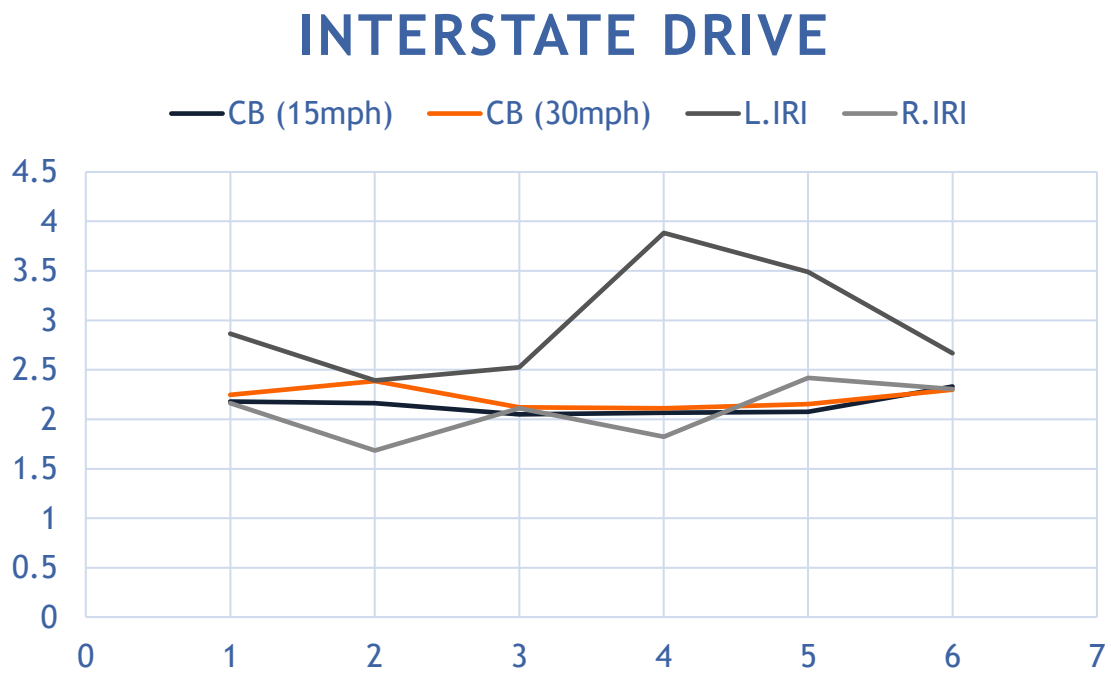


INTERSTATE DR.(PCC)

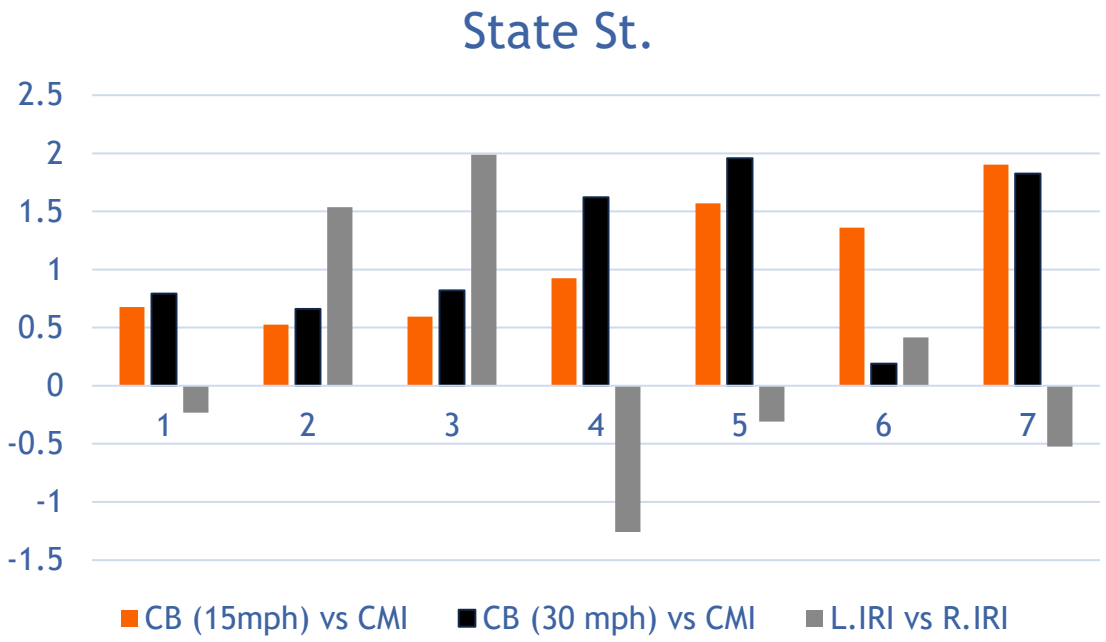


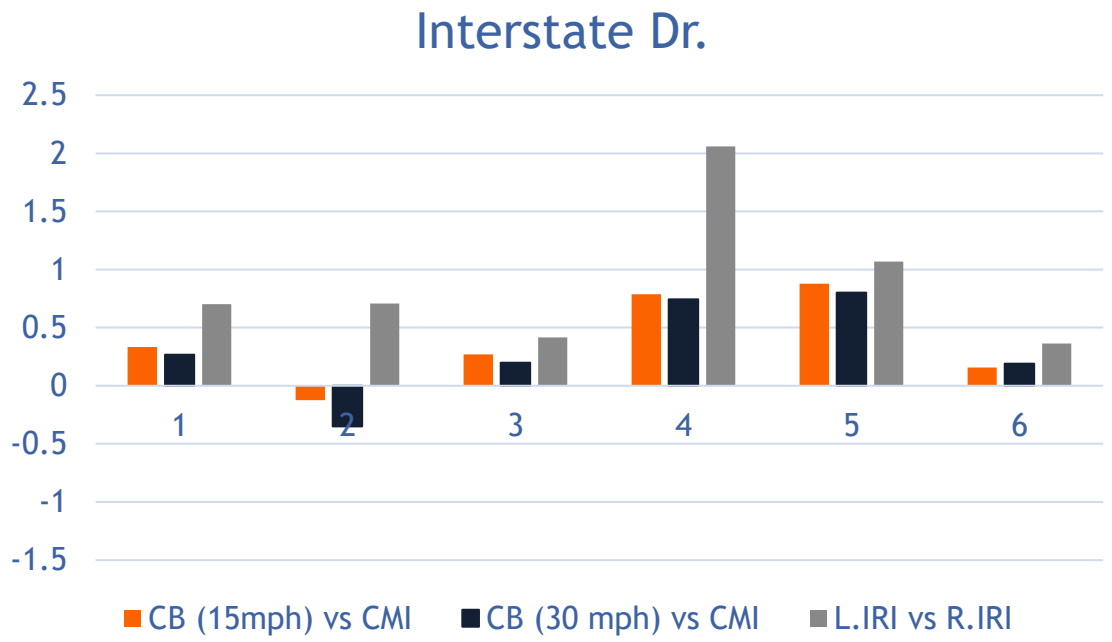
Accuracy (ct'd)





Relative Errors



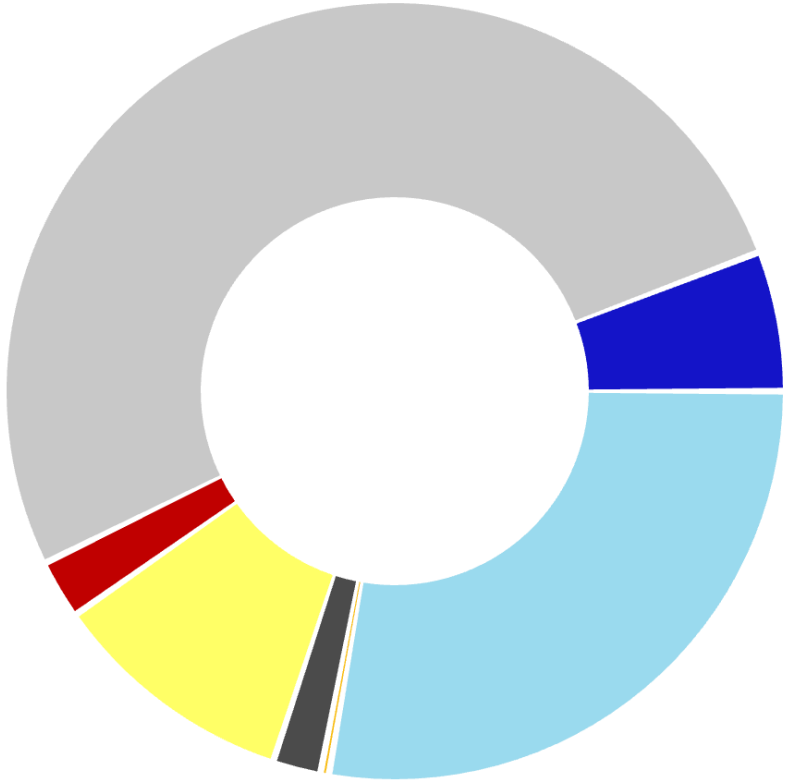


City of Champaign

- Meeting with Champaign Public Works, we discussed:
  - Scheduling
  - Prioritization System
  - Roughness Consideration

City of Champaign

2017 Percent of Area by Pavement Surface Type



By Surface Type

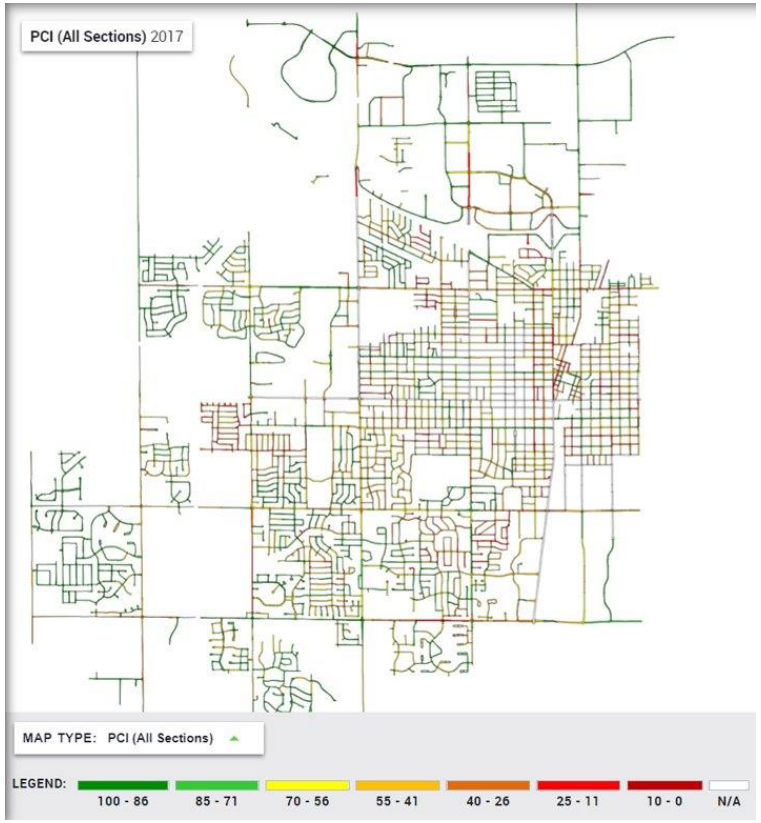
Surface Type	Area, sf	Percentage
HMA - AAC	13,169,250	27.7%
HMA - ABR	167,286	0.4%
HMA - AC	944,778	2.0%
HMA - APC	4,859,874	10.2%
Brick	1,167,220	2.5%
PCC	24,461,553	51.5%
Surface Treatment	2,759,878	5.8%

- AAC: Asphalt over Asphalt Concrete
- ABR: Asphalt over Brick
- AC: Asphalt Concrete
- APC: Asphalt over Portland Cement Concrete

Champaign's Current Methodology

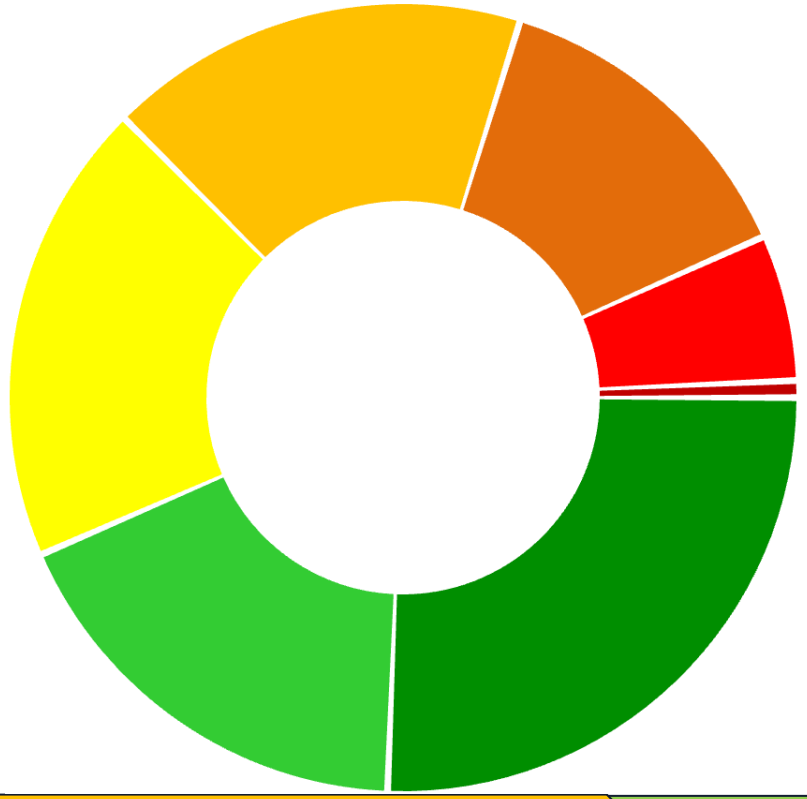
- City of Champaign uses PCI (Pavement Condition Index) to evaluate pavement conditions:
- Using IDEA (Interactive Data Exchange Application) to summarize the collected data

PCI	Grade	Condition
81-100	A	Excellent
61-80	B	Good
41-60	C	Fair
21-40	D	Poor
0-20	F	Failed



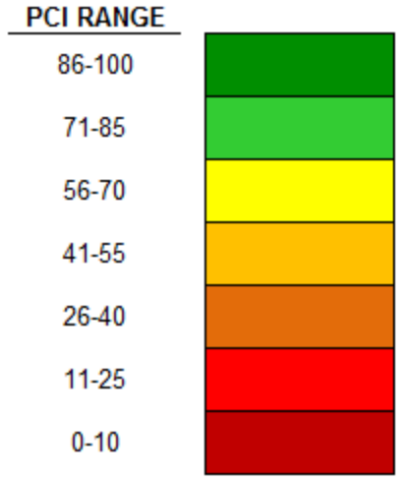
Champaign's Current Methodology

2017 Percent of Area by PCI Range - All City Sections



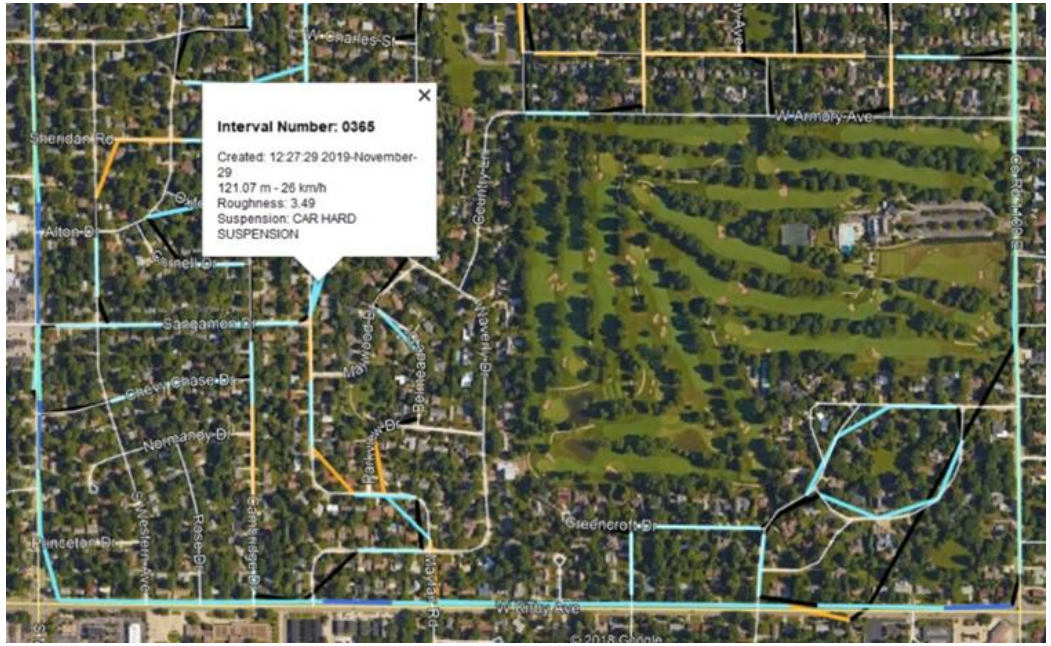
By PCI Range

PCI Range	Area, sf	Percentage
Good	11,851,913	25.6%
Satisfactory	8,259,026	17.9%
Fair	8,799,231	19.0%
Poor	7,995,524	17.3%
Very Poor	6,250,567	13.5%
Serious	2,771,051	6.0%
Failed	320,312	0.7%



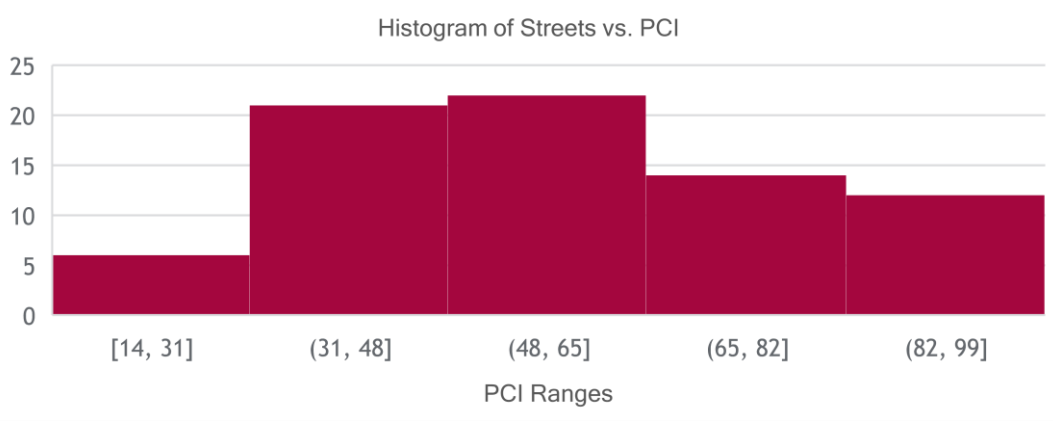
Practical Evaluation (Data Collection)

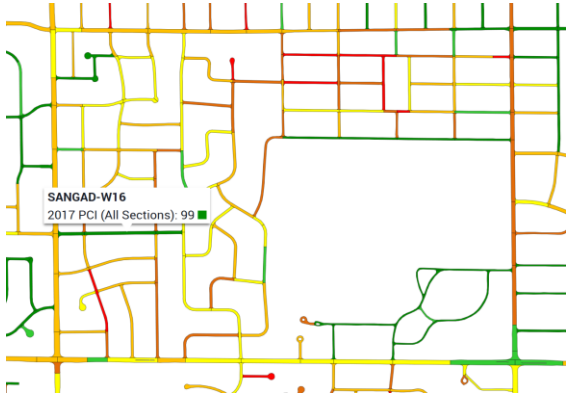
- A section of the pavement network system rich in PCI data was selected:
  - Delimited by Kirby Ave., Mattis Ave, John St. and Prospect Ave
  - Having low traffic
  - Presenting a good wide range of PCI
- To contrast IRI results obtained via the app and current available PCI measurements

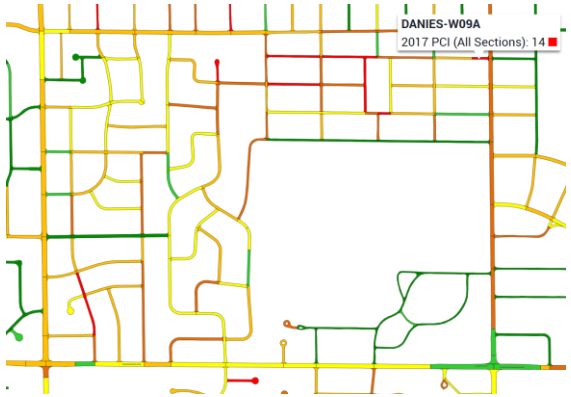


Practical Evaluation (Data Collection)

- PCI range in selected section:
  - Max = 99 (Sangamon Dr.)
  - Min= 14 (Daniel St.)







Practical Evaluation (Model Fitting)

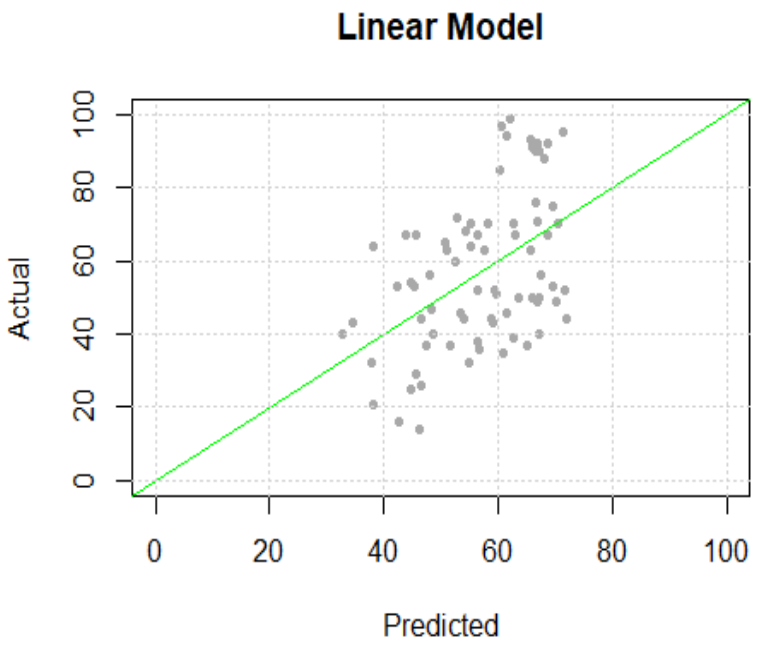
- To evaluate the capabilities of a model that predicts PCI through IRI data, we proposed:
  - Linear Model
  - K Nearest Neighbors Model
  - Random Forest Model
- Random Forest Model fits the best
- In all cases a correct correlation was evidenced, but stronger correlation on very good or very bad values of PCI

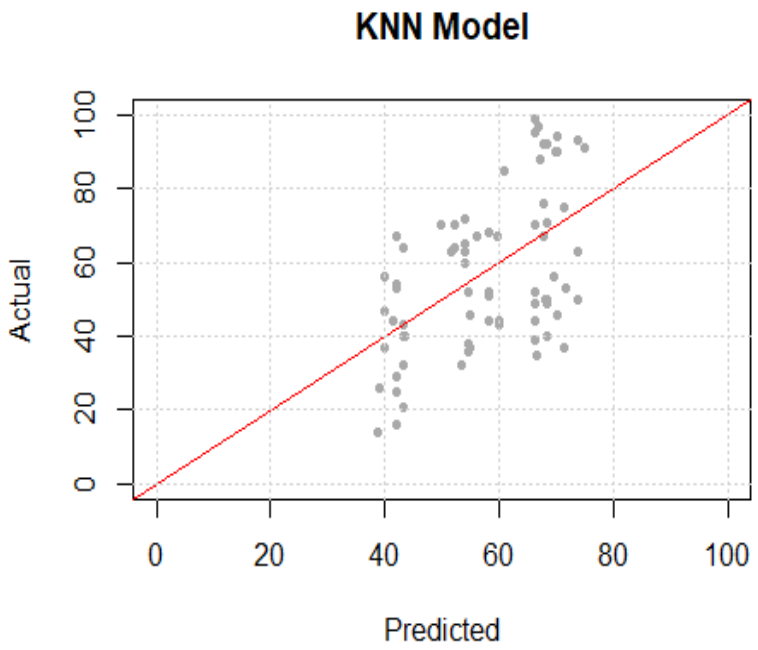
Method	RMSE	R squared	Model Parameters
Linear Regression	18.07	0.236	a = 90.56, m = -10.44
Nearest Neighbor	18.82	0.237	K = 9
Random Forest	13.77	0.575	M_t=19

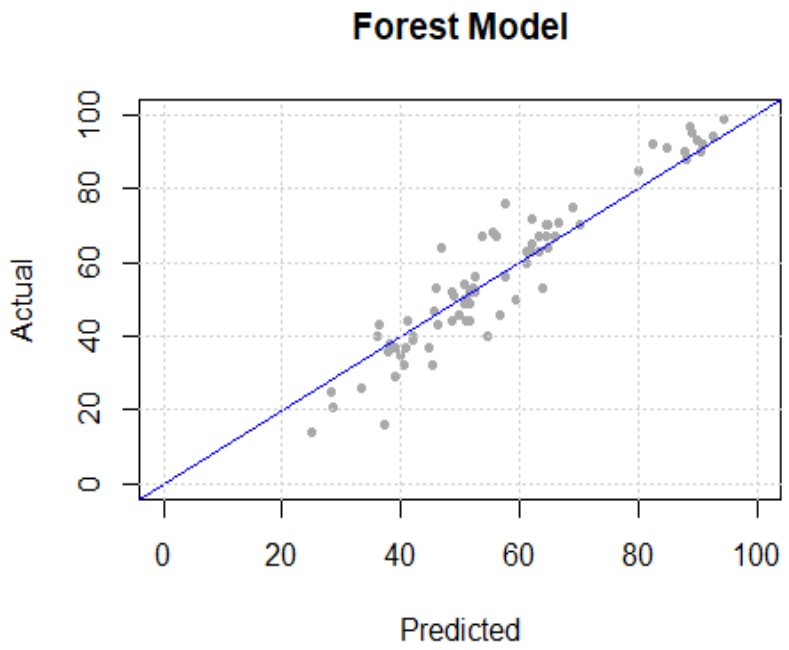
```
fit_knn

## k-Nearest Neighbors
##
## 75 samples
##  1 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 60, 60, 59, 60, 61
## Resampling results across tuning parameters:
##
##   k  RMSE      Rsquared   MAE
##   5  20.63490  0.1610891  17.76946
##   7  19.42948  0.2047556  17.09264
##   9  19.38052  0.1936146  17.05062
##
## RMSE was used to select the optimal model using the smallest value.
## The final value used for the model was k = 9.

fit_knn$results

##   k     RMSE   Rsquared      MAE  RMSESD RsquaredSD    MAESD
## 1 5 20.63490 0.1610891 17.76946 2.19431  0.1222830 2.416988
## 2 7 19.42948 0.2047556 17.09264 1.57143  0.1528751 1.779502
## 3 9 19.38052 0.1936146 17.05062 1.68053  0.1266733 1.707211

plot(fit_knn)
```

```
fit_rf

## Random Forest
##
## 75 samples
##  2 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 59, 60, 61, 60, 60
## Resampling results across tuning parameters:
##
##   mtry  RMSE      Rsquared   MAE
##    2    15.12385  0.6035703  12.84597
##   10    13.11961  0.6075963  10.51618
##   19    12.75191  0.6296628  10.07108
##
## RMSE was used to select the optimal model using the smallest value.
## The final value used for the model was mtry = 19.

fit_rf$results

##   mtry     RMSE   Rsquared      MAE   RMSESD RsquaredSD    MAESD
## 1    2 15.12385 0.6035703 12.84597 2.092102 0.06572844 1.222715
## 2   10 13.11961 0.6075963 10.51618 1.785553 0.04762010 1.180347
## 3   19 12.75191 0.6296628 10.07108 1.644128 0.05001152 1.100144
```

Practical Evaluation (Model Fitting)







Practical Evaluation (Results)

- PCI is more detailed considering the actual distresses evidenced in the pavement.
- Although distresses are captured to an extent by the app IRI measurement, they do not replace the PCI.
- Specific issues may not be detected by a….
  - Ex. Pot Holes if user avoids them
  - In some cases, app failed to detect the road bumps
- Extending the model with other data sources as well as a calibration by measuring some major roads could be the most economical and valuable methodology to enhance Champaign's pavement management system.

Conclusions

- Very disparate measurements between different vehicle categories (Sedan and SUV)
- The final technical paper by WB is not out, we can’t qualify the model used
  - The algorithm may have room for improvement
- Operator dependency
  - Keeping speed, vertical mounting, etc.
- Tire pressure and other variables are not considered
  - e.g. vehicle categorization is very broad
  - Tire pressure may have an effect on the algorithm

Conclusions (ct'd)

- Will require a lot of work and calibrating before being widely used
- Useful for local roads, track everything with same car, prioritize
- Add an overhead camera, might help w/other Machine Learning
- Having more accurate accelerometer data or better resolution could help

cityofnovi.org


thank you
danke
謝謝
ngiyabonga
рахмат
teşekkür ederim
gracias
merci
obrigado
bedankt
dziękuję
go raibh maith agat
sukriya
kop khun krap
terima kasih
mochchakkeram
спасибо
Баярлалаа
mersi
kia ora
barka
welalin
tack
spas
dank je
misaotra
matondo
paldies
grazzi
mahalo
tapadh leat
хвала
asante
manana
obrigada
tenki
murakoze
chokrane
mamnun
дякую
djiere dieuf
tau
faafetai lava
vinaka
спасибі
blagodaram
kiitos
dankie
dhanyavad
nandri
nanni
mauruuru
köszönöm
hvala
gràçie
bayarlalaa
enkosi
dankon
akun
aciu
chnorakaloutioun
gratias ago
gràcies
sulpáy
taiku
arigatô
takk
dakujem
trugarez
sobodi
děkuji
mèsi
didi madloba
sagolun
najis tuke
kam sah hamnida
rahmat
ありがとう
tanemirt
grazie
rahmet
ευχαριστώ
diolch
dhanyavadagalu
shukriya
mercê
мерси
xièxie
감사합니다
তোমাকে ধন্যবাদ

Special Mentions:

Chris Sokolowski (CCPW)

ERI

Arturo (Aptech)

RoadLabPro