

SAFETY PERFORMANCE VS. ASSET PERFORMANCE: AN IOWA DOT CASE STUDY



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Transportation Asset Management
*Making Asset Management Work
in Your Organization*

INTRODUCTION

Problem Statement

- Few studies have explored safety performance and how it is impacted by combined asset performance
- Asset Management & Safety
 - ✓ Resource allocation
 - ✓ Simplify economic process and cost saving
 - ✓ Improve data consistency
 - ✓ Faster response to customer service requests
 - ✓ Reduce duplicated effort



INTRODUCTION

Research Objectives

- To develop a methodology for estimating an index, that represent overall physical asset condition on a roadway segment
- To investigate the effect of asset condition on safety
- To develop a methodology to prioritize asset improvement strategies based on safety



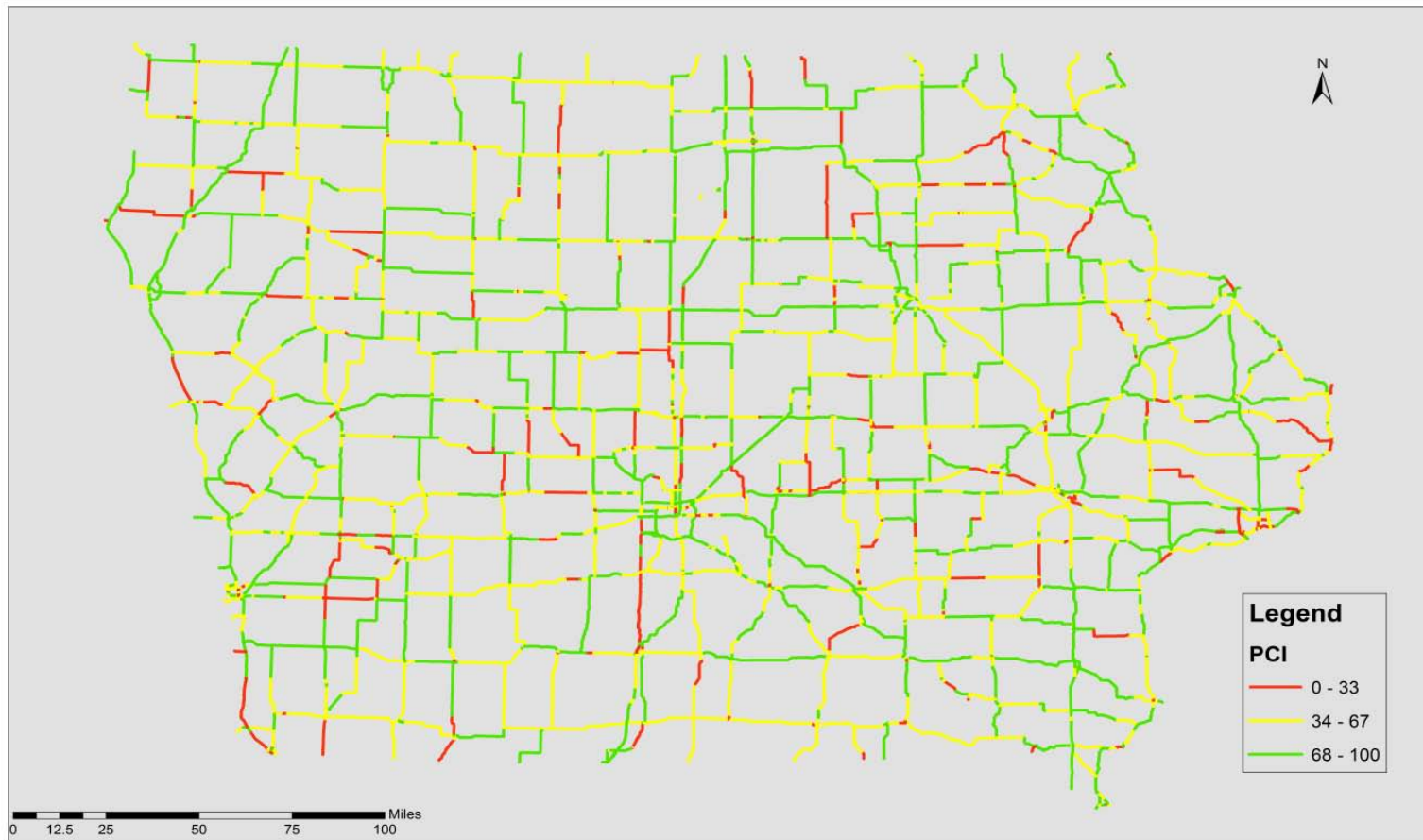
DATA DESCRIPTION

Crash Data

	Mean	Std. Dev.	N
All	1.9946	6.1329	58674
2005	2.2815	6.8918	9833
2006	2.0957	6.2310	9863
2007	2.3312	6.7653	9838
2008	2.3079	6.7242	9400
2009	2.2083	6.3144	9828

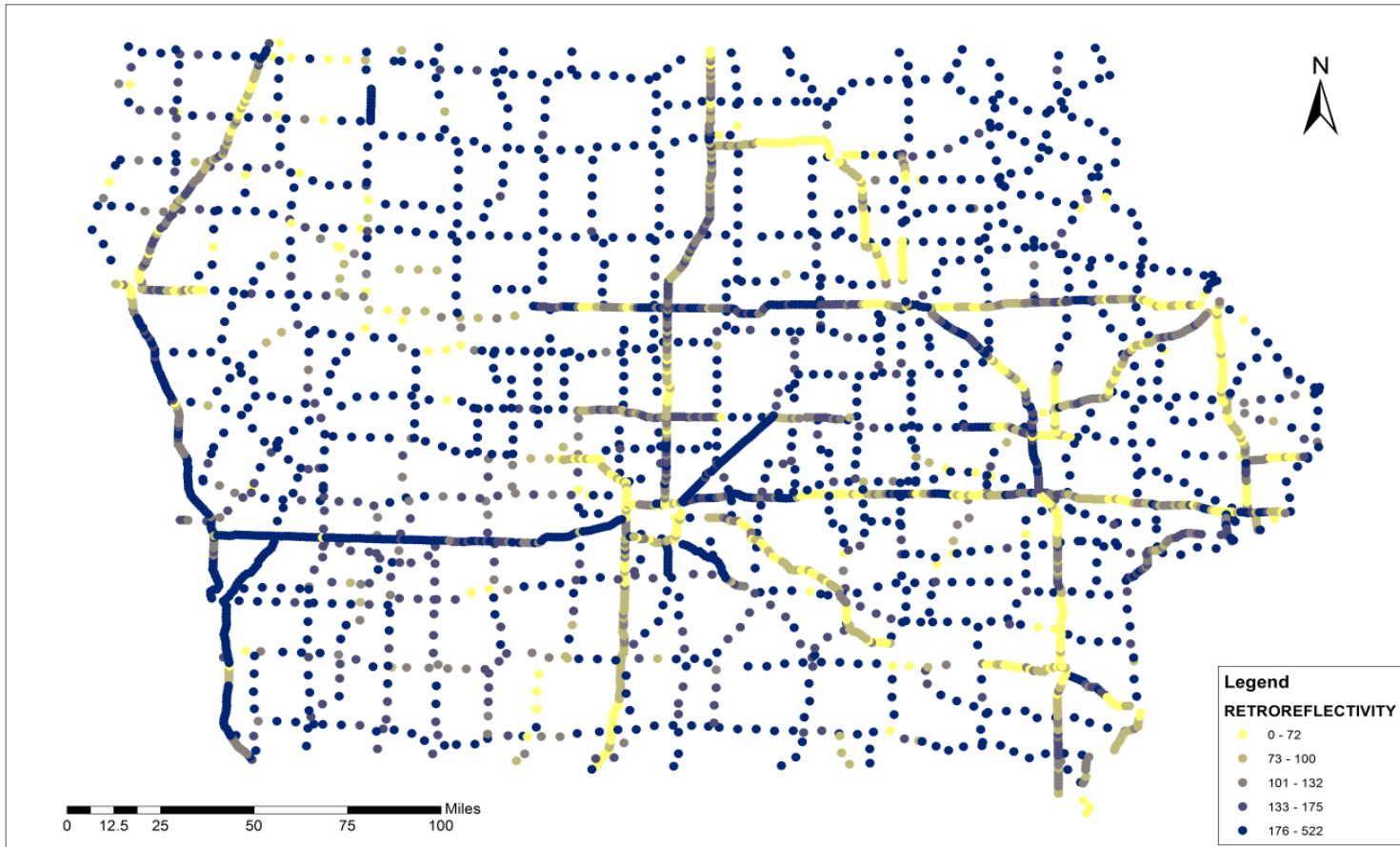
DATA DESCRIPTION

Pavement Condition



DATA DESCRIPTION

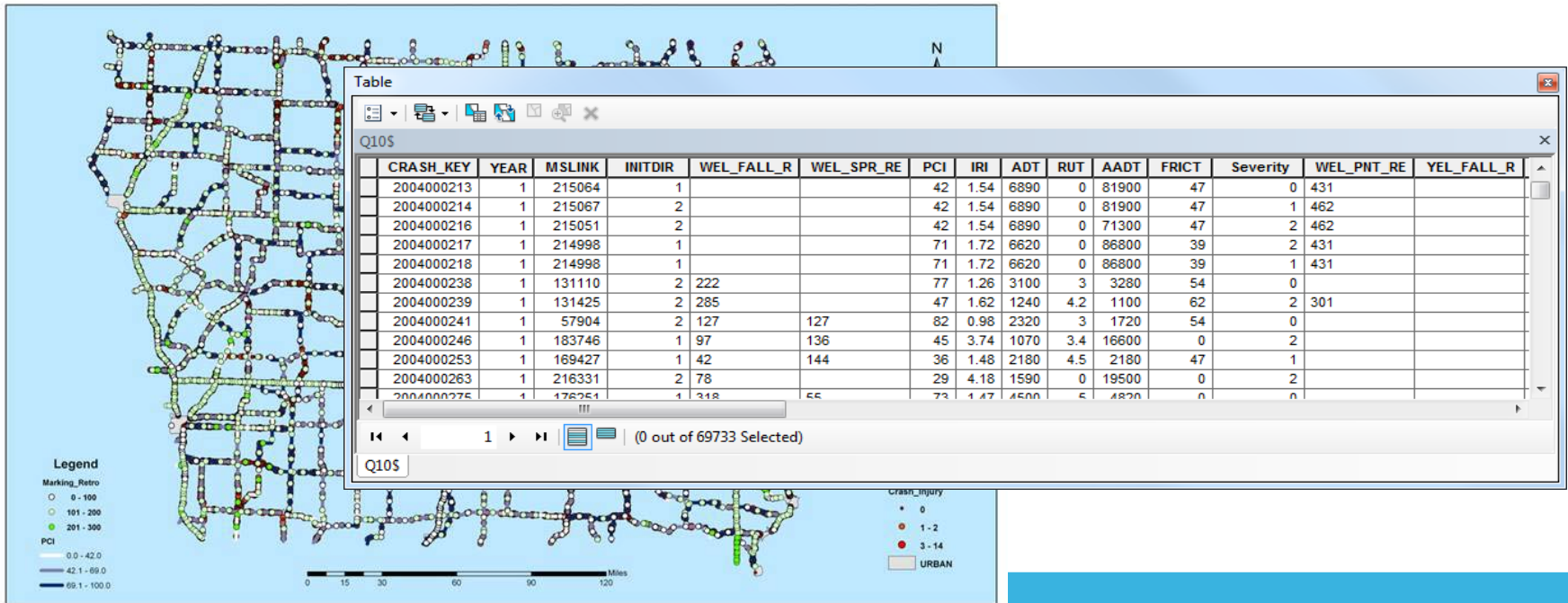
Pavement Marking Retroreflectivity



DATA INTEGRATION

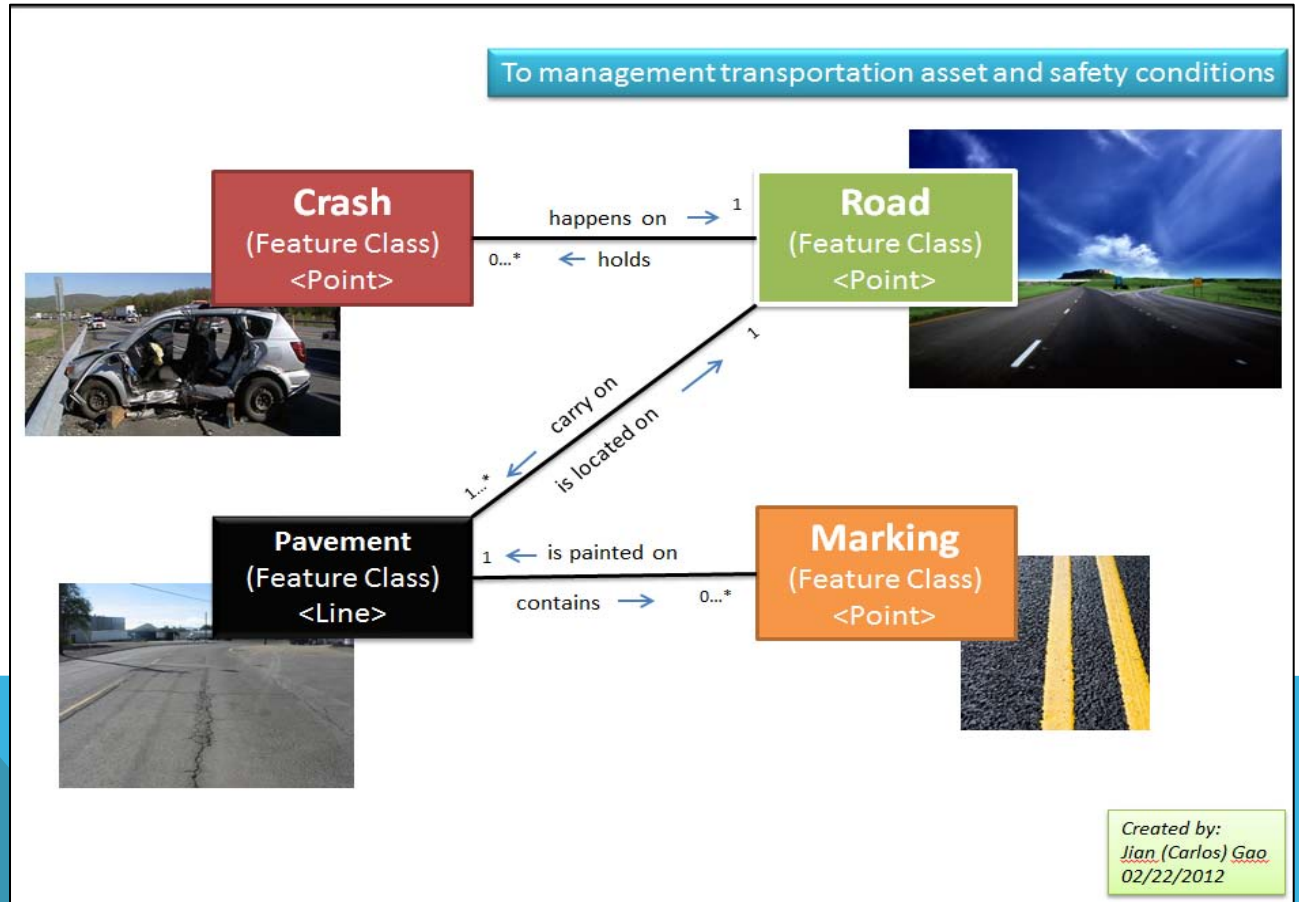
GIS-based Integration

Asset Conditions & Crashes, 2004-2009



DATA INTEGRATION

Geodatabase Logical Model



ESTIMATION OF ASSET CONDITION INDEX (ACI)

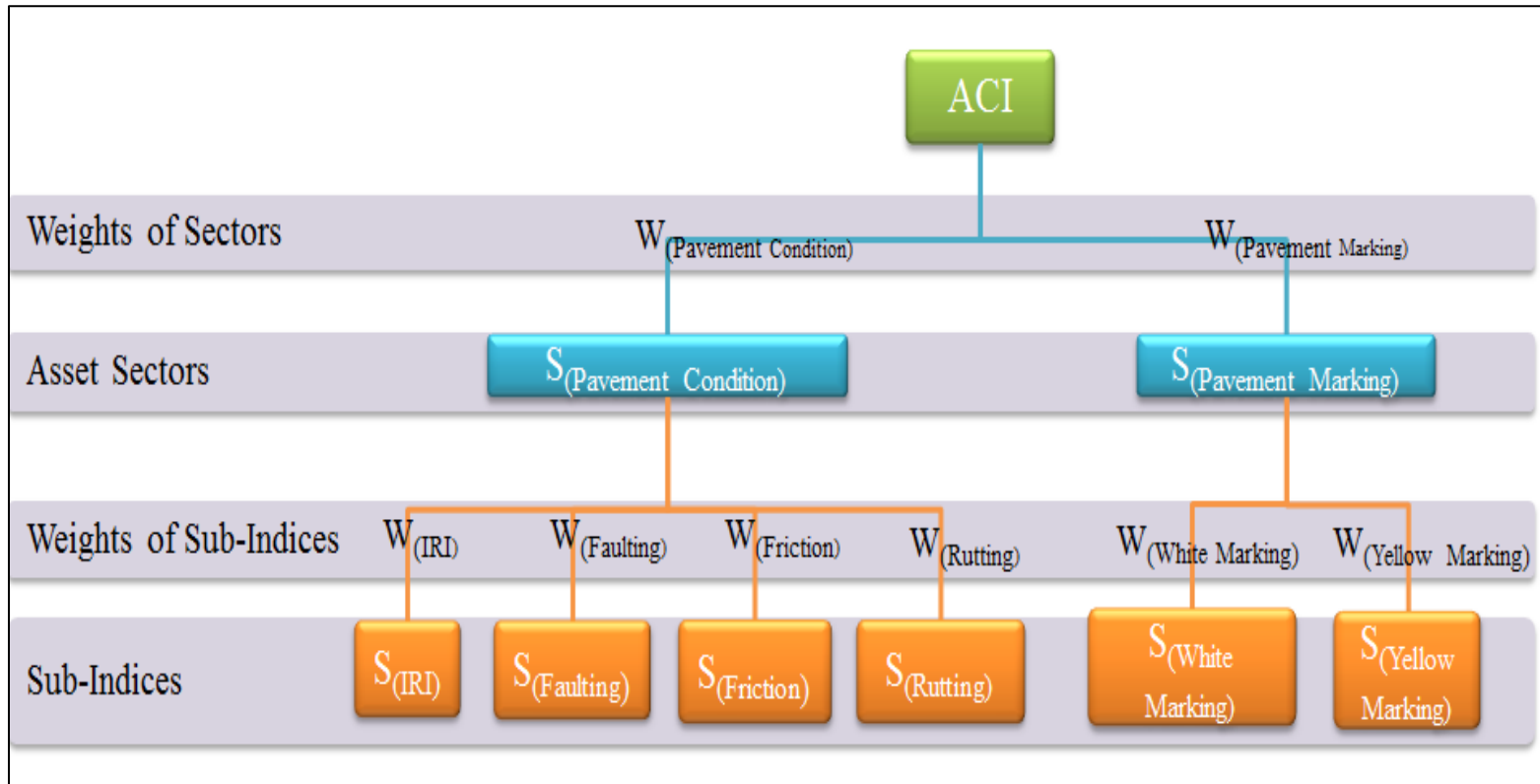
Pavement Condition

- International Roughness Index (IRI)
- Faulting
- Rutting
- Friction

Pavement Marking

- Yellow Pavement Marking Retroreflectivity
- White Pavement Marking Retroreflectivity

ESTIMATION OF ACI

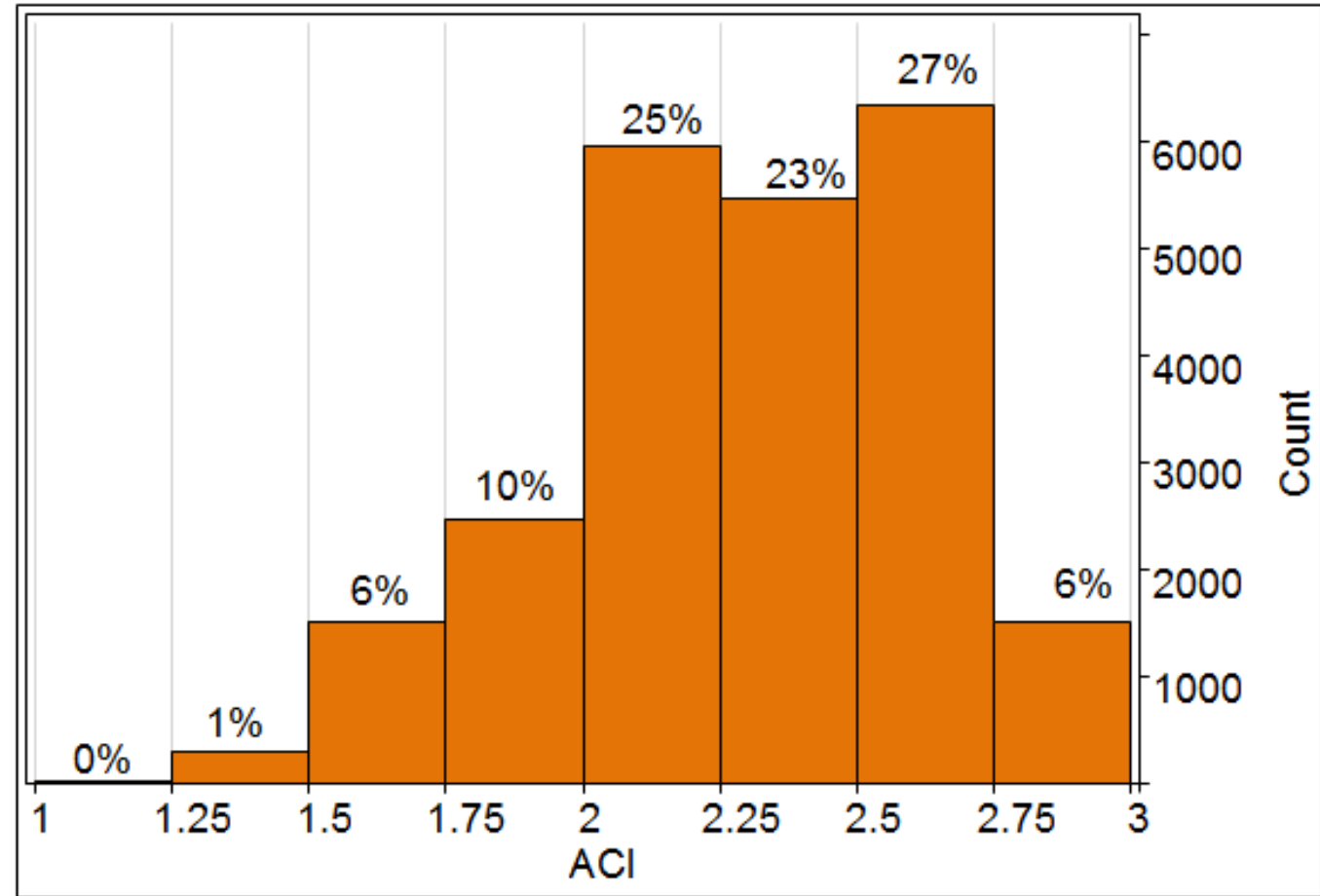


ESTIMATION OF ACI

Asset Condition Catalogs (Sectors)	Asset Condition (Sub-Indices)	Scores		
		3 (Good)	2 (Moderate)	1 (Poor)
Pavement Condition	IRI (in m/km)	<1.5	1.5-2.7	>2.7
	Faulting (in mm)	<2.5	2.5-5	>5
	Friction	>60	60-35	<35
	Rutting (in mm)	<6	6-15	>15
Pavement Marking	White Marking [WEL+WDL] (in mcd/m ² /lux)	>200	200-150	<150
	Yellow Marking [YEL+YCL] (in mcd/m ² /lux)	>200	200-100	<100

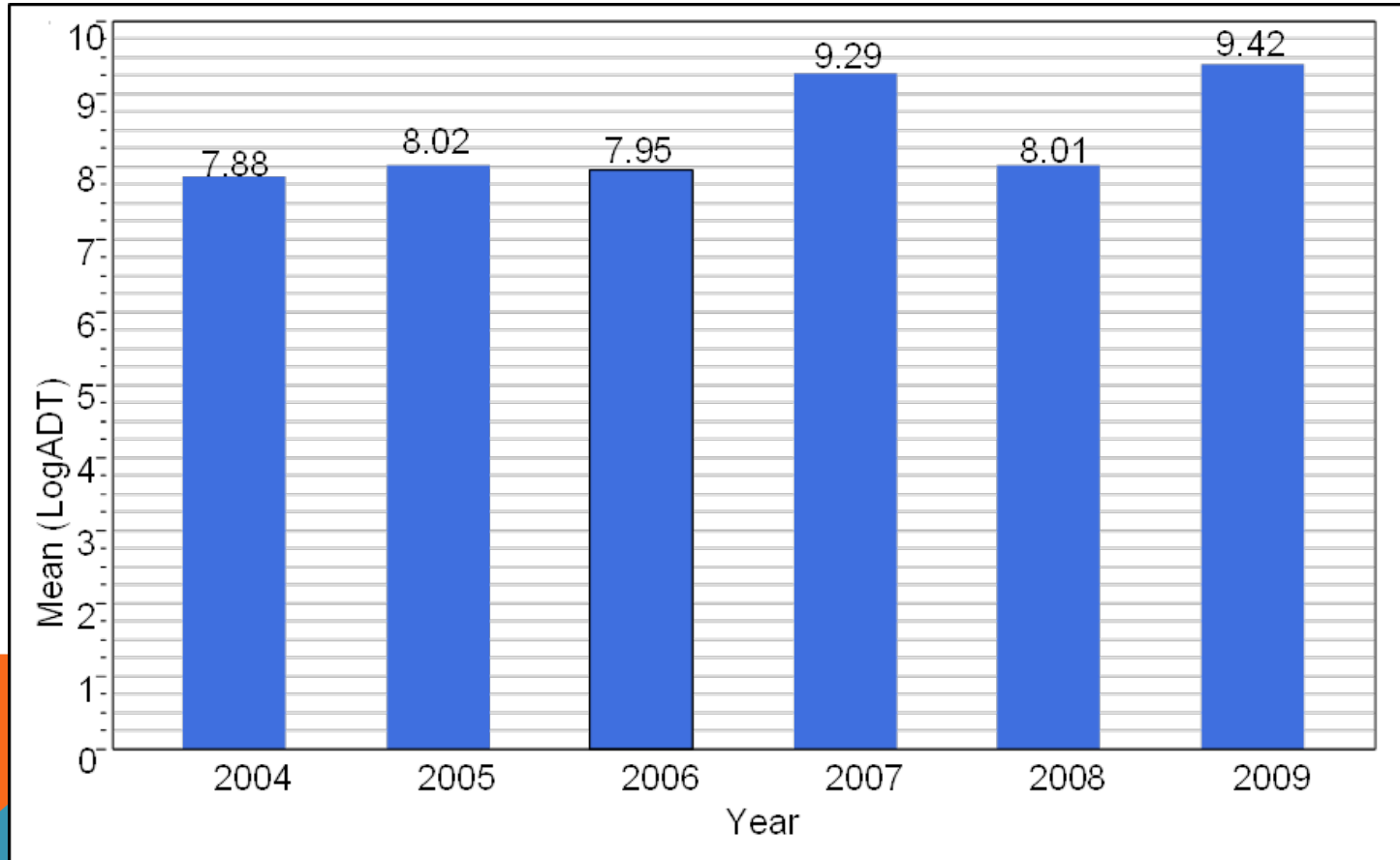
STATISTICAL ANALYSIS

- ACI



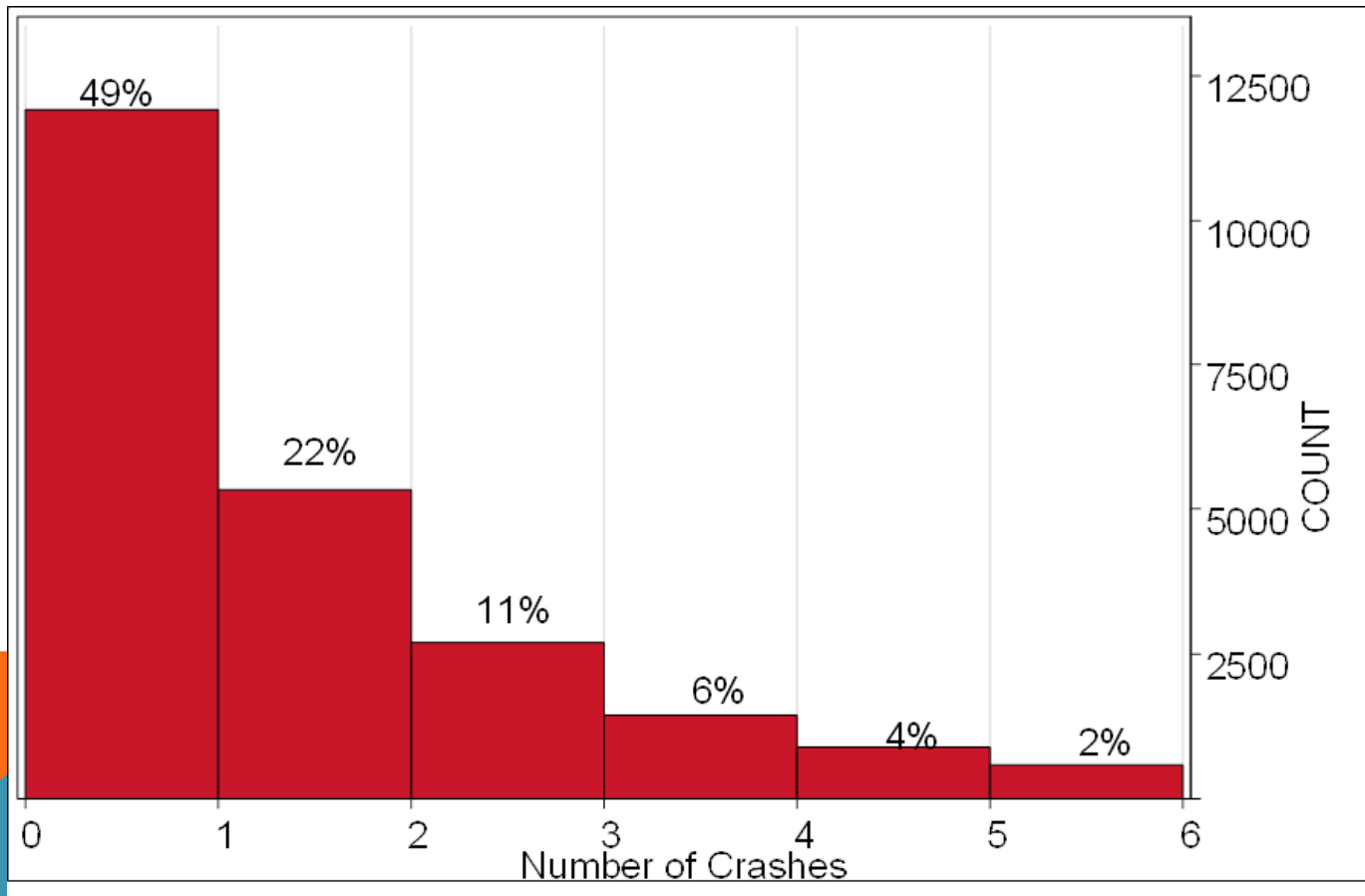
STATISTICAL ANALYSIS

- Log(ADT)



STATISTICAL ANALYSIS

- Number of Crashes



STATISTICAL ANALYSIS

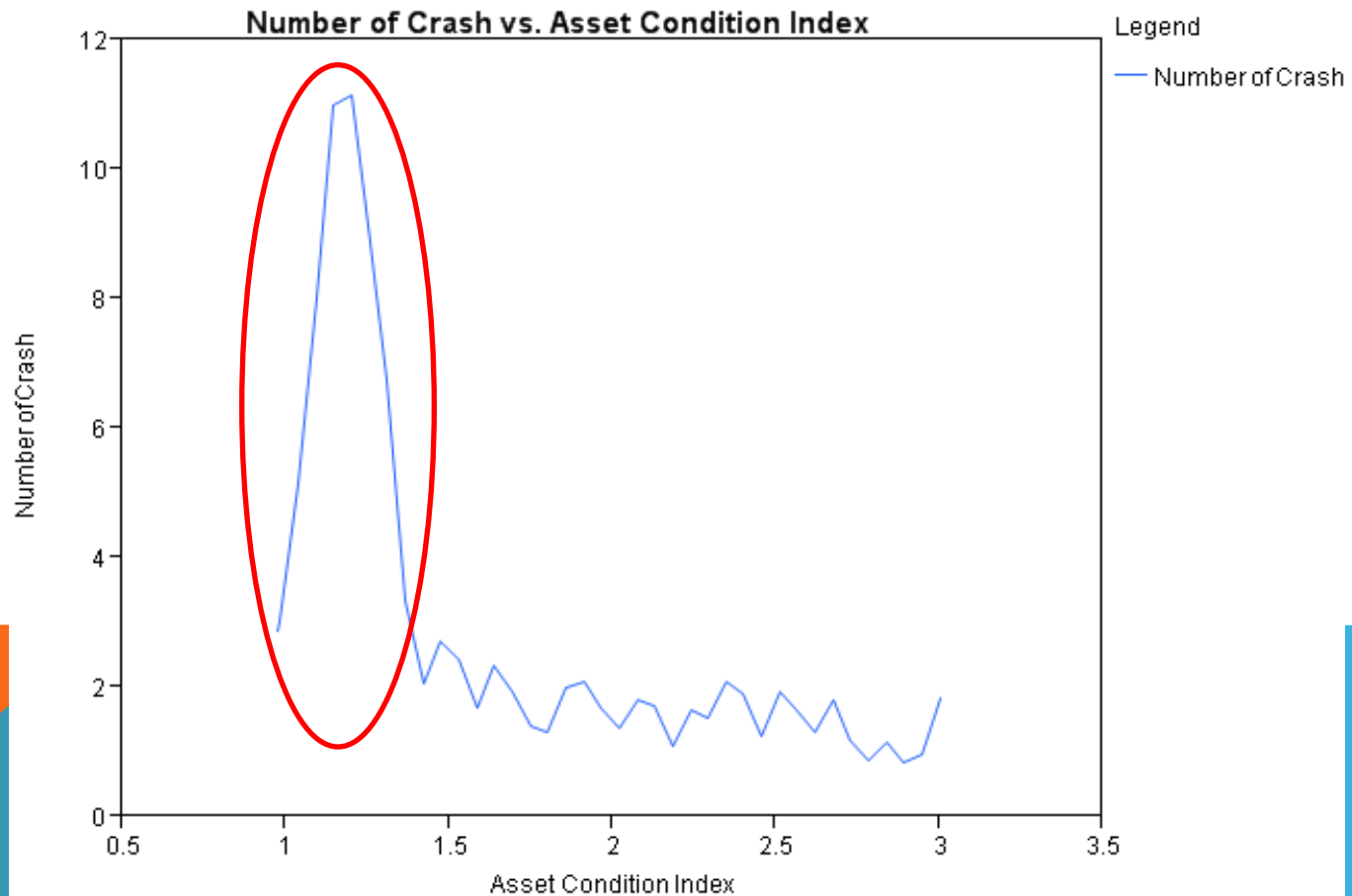
Negative Binomial Model

- Dependent Variable: Number of crashes/ mile
 - Variance(36.9) \neq Mean(2.133)
- Number of crashes/ mile = $\text{EXP}(\text{Constant} + \beta_1 \times \text{ACI} + \beta_2 \times \text{Log ADT})$

Variable	Coefficient	t-test	p-value
Constant	-5.3814	-135.919	0.0000
ACI	-1.2915	-16.716	0.0000
Log ADT	0.7707	226.502	0.0000
N		28,835	
ρ^2		0.2592	
Log likelihood, $L(\beta)$		-45,714.20	
Restricted log likelihood, $L(0)$		-61,707.76	

STATISTICAL ANALYSIS

Negative Binomial Model



STATISTICAL ANALYSIS

- Likelihood Ratio Test
 - $\chi^2=287.59$ ($\chi^2_{0.0001,4}=23.51$)
 - Separate Models

Variables	ACI ≤ 1.5		ACI > 1.5	
	Coefficient	t-test	Coefficient	t-test
Constant	-0.7799	-11.776	-5.761	-79.495
ACI	-1.66786	-20.708	-0.179	-7.905
Log(ADT)	0.3162	42.05	0.784	137.986
ρ^2	0.4998		0.2424	
Number of observations	906		27929	

ECONOMIC ANALYSIS

Treatment Alternatives	Price (per mile)	Relative Improvement of ACI	Service Life (yrs)	Depreciation Rate
<i>Maintenance (Pavement Condition)</i>				
Reconstruction	\$1,000,000.00	2	20	0.075
Major Rehab.	\$500,000.00	1	10	0.15
Minor Rehab.	\$150,000.00	0.5	3	0.5
<i>Replacement (Pavement Marking)</i>				
Regular Paint	\$1,188.00	0.01	0.5	3
Durable Materials	\$11,880.00	0.05	2	0.75
Tapes	\$47,520.00	0.2	5	0.3

ECONOMIC ANALYSIS

- Cost—Unit cost of alternatives
- Benefits– Reduced number of crashes

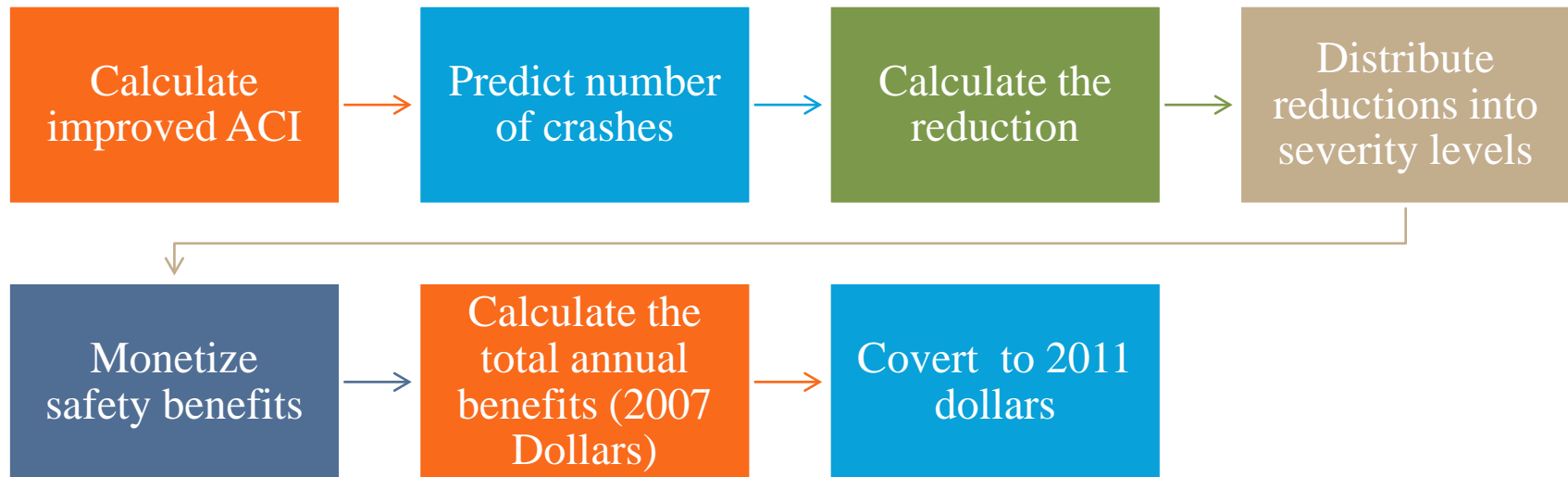
Iowa Crash Costs ('07)	
Collision Type	Crash Cost
Fatal (K)	\$3,500,000
Disabling Injury (A)	\$240,000
Evident Injury (B)	\$48,000
Possible Injury (C)	\$25,000
PDO (O)	\$2,700

Severity	Fatal(K)	Disabling Injury (A)	Evident Injury (B)	Possible Injury (C)	PDO(O)
Percentage	1.20%	3.80%	9.70%	22.60%	62.60%
Counts	876	2712	6968	16238	44909

ECONOMIC ANALYSIS

Analysis

- Part I: Single-year Benefit-Cost Ratio (BCR) analysis



ECONOMIC ANALYSIS

Analysis

Alternatives	Economics	
	NPV	BCR
Reconstruction	\$38,650.53	1.525
Major Rehabilitation	\$50,217.62	1.815
Minor Rehabilitation	\$55,743.38	2.031
Paint Marking	\$482.44	1.195
Durable Marking	\$4,850.66	1.770
Tape	\$4240.80	1.400

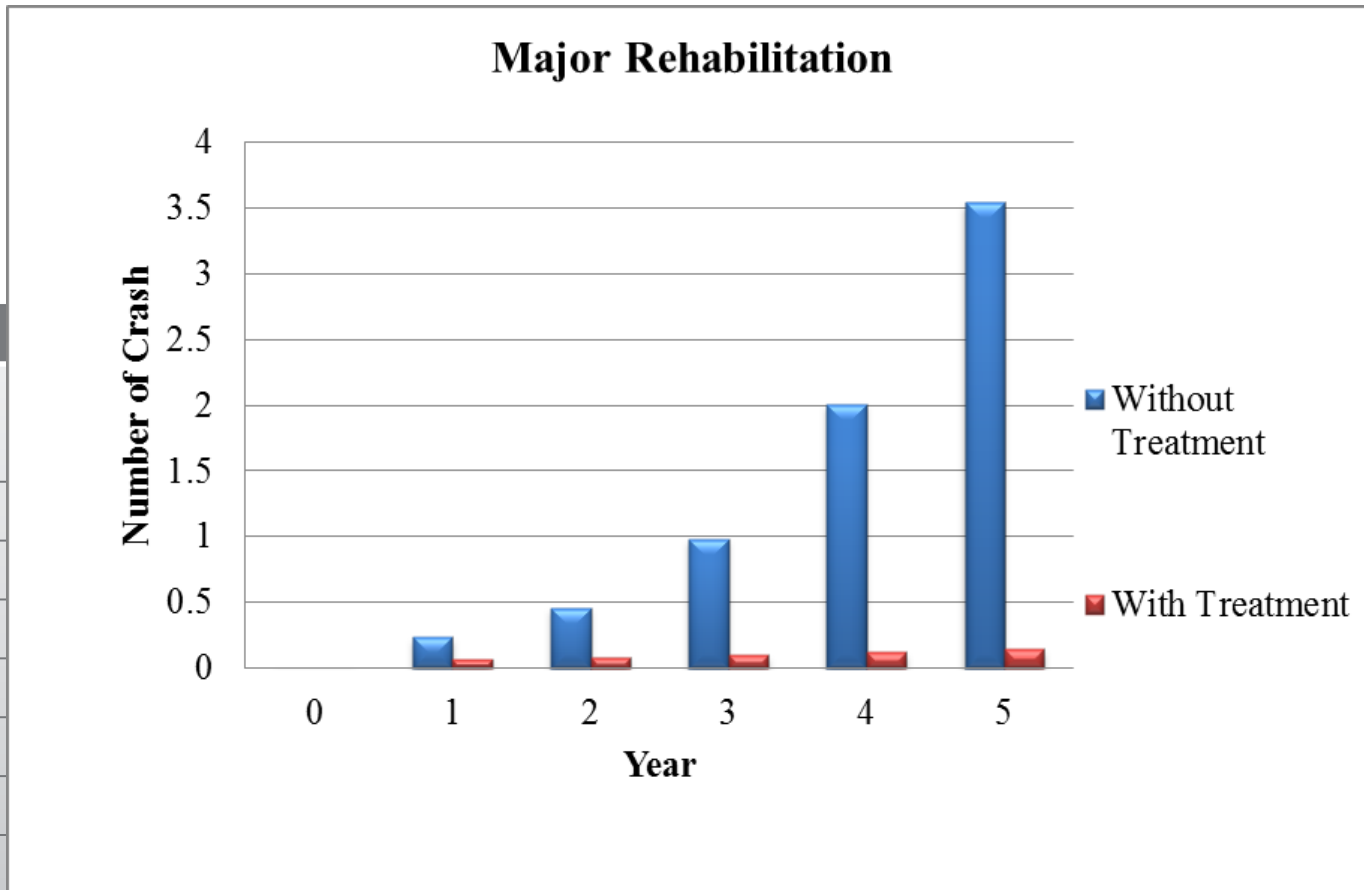
ECONOMIC ANALYSIS

Analysis

- Part II: Five-year Net Present Value (NPV) analysis
 - ACI Ranges:
 - a) $ACI \leq 1.5$;
 - b) $1.5 < ACI \leq 2.00$;
 - c) $2.0 < ACI \leq 2.25$;
 - d) $2.25 < ACI \leq 2.50$;
 - e) $2.5 < ACI \leq 2.75$;
 - f) $2.75 < ACI \leq 3.00$.
 - Equivalent Uniform Annual Cost

ECONOMIC ANALYSIS

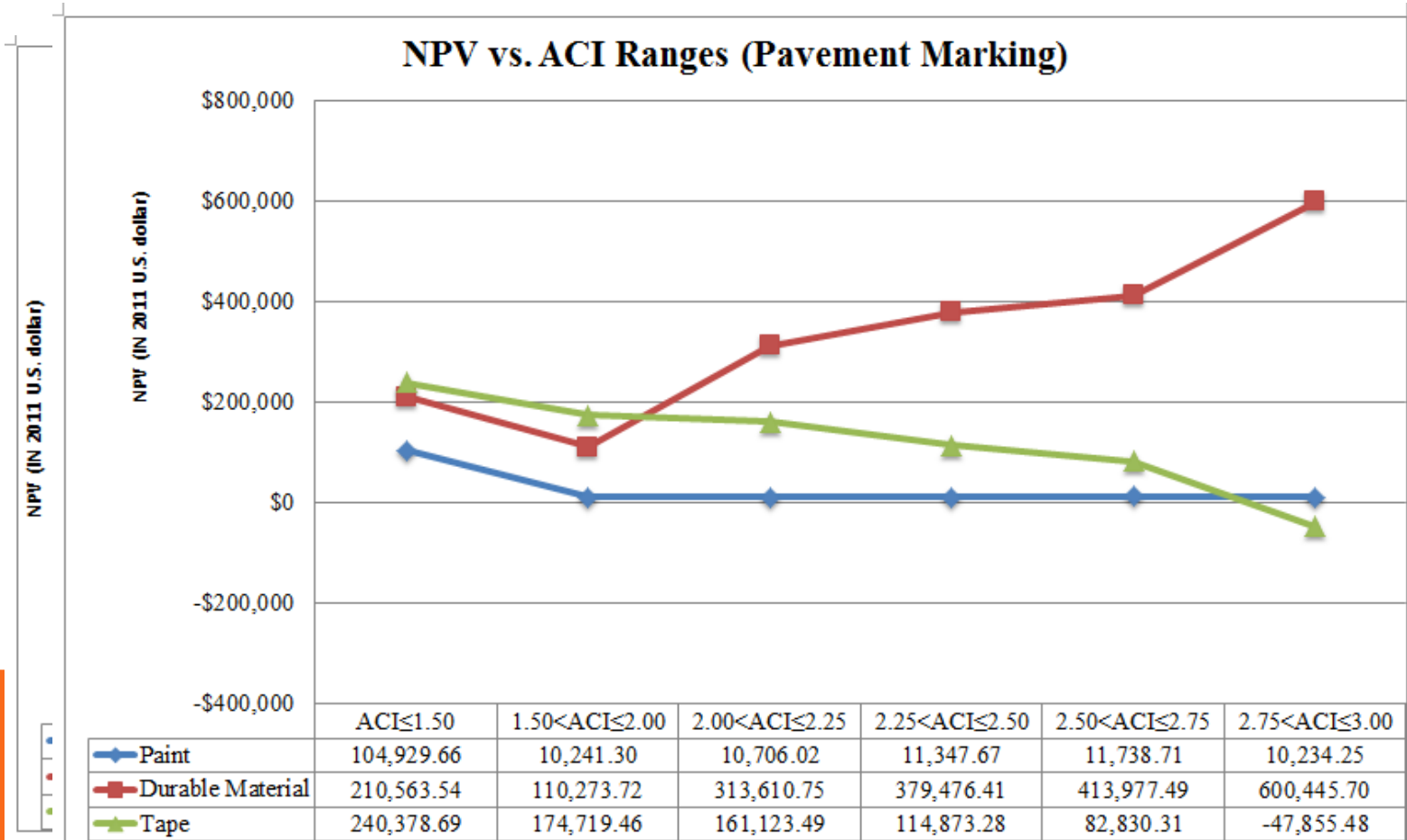
Analysis




year
0
1
2
3
4
5

PV
61,645.47
47,432.17
31,428.91
3,125.45
6,285.54
54,835.84
3,740.28

ECONOMIC ANALYSIS



LIMITATIONS

- Data Integration
 - ✓ Tolerance of spatial joining was 10m
 - Estimation of ACI
 - ✓ Scoring thresholds from expert panel
 - Statistical Analysis
 - ✓ Crashes were related only with asset condition
 - Economic Analysis
 - ✓ Discount rate = 4%
 - ✓ Straight-line depreciation
 - ✓ 5 years study period
- 

RECOMMENDATIONS

- Creating a comprehensive geodatabase for all public roads in Iowa
- Analysis of future data
- Replication of this study in other states
- Consideration of additional asset performance measures
 - ✓ sign inventory
 - ✓ lighting inventory
 - ✓ rumble strips inventory
 - ✓ guardrail condition



QUESTIONS & COMMENTS
THANK YOU !

