

Associating Crash Contributing Factors for Depressed Divided Highways: A Multinomial Logistic Regression Approach

Ghulam H. Bham, PhD
Civil Engineering Department
University of Alaska Anchorage

DOT&PF Quarterly Design Meeting #55
October 25, 2016

Organization

- ▶ Acknowledgment
- ▶ Objectives
- ▶ Data
- ▶ Crash Contributing Factors
- ▶ Methodology
- ▶ Results: MLR, Haz. Loc.
- ▶ Conclusions, Recommendations, Next Steps

Acknowledgments

- ▶ Engineers at AK DOT&PF
- ▶ Research Grants
 - ▶ AK DOT&PF
 - ▶ PacTrans/AUTC

Objectives

For depressed divided highways

- a) Identify *factors* associated with *median* crashes
- b) Identify location of median crashes
- c) Propose locations for median barriers

Focus & Archived Data

- ▶ Divided highways with depressed medians
 - ▶ Glenn Highway
 - ▶ Minnesota Drive
 - ▶ New Seward Highway
 - ▶ Parks Highway
- ▶ Crash data: 2007-2012 (6 years)
- ▶ Analyzed: 2450 crashes
- ▶ Reviewed Police Crash Reports ≈ 1300 crashes
- ▶ Additional crashes observed, 2013-2016

Focus & Archived Data

Highways	Frequency	Percent
Glenn Highway	1688	66.46
Minnesota Drive	270	10.63
New Seward Highway	455	17.91
Parks Highway	127	5.00
Total	2450	100

Categories of Contributing Factors

- ▶ Driver
- ▶ Environment
- ▶ Highway Geometry
- ▶ Vehicle
- ▶ Crash

Each category has several sub-categories

Data Compilation

▶ Driver

- ▶ Age

- ▶ Alcohol

- ▶ Gender

- ▶ Restraint

- ▶ Human Circumstances - Driver behavior

- ▶ Levels - Two to several

Data Compilation

▶ Environment

- ▶ **Surface conditions**

- ▶ **Light conditions**

- ▶ **Weather**

- ▶ **Air Temperature (NOAA & RWIS)**

- ▶ **Surface Temperature (RWIS)**

Data Compilation

- ▶ Highway Geometric/Surface Characteristics
 - ▶ Highway Alignment
 - ▶ Median Slope
 - ▶ Median Width
 - ▶ Rutting

Data Compilation

- ▶ Vehicle
 - ▶ Collision Types
 - ▶ Tires - **not used**
 - ▶ Vehicle Action
 - ▶ Vehicle Type

Data Compilation

- ▶ Crash
 - ▶ Severity
 - ▶ Temporal
 - ▶ Hours
 - ▶ Weekday
 - ▶ Event type - not used - about 40 levels

Organization

- ▶ Acknowledgment
- ▶ Objectives
- ▶ Data
- ▶ Crash Contributing Factors
- ▶ Methodology
 - ▶ Explanation of Variables
 - ▶ Data Compilation/categorization
 - ▶ Multinomial Logistic Regression (MLR)
 - ▶ Multicollinearity (MC)
 - ▶ Goodness of Fit (GOF) Tests
 - ▶ Models developed
- ▶ Results: MLR, HL
- ▶ Conclusions & Recommendations
- ▶ Next Steps

Methodology

- ▶ Commonly used linear regression model

- ▶ $N = B_0 + B_1.X_1 + B_2.X_2 + \dots$

- ▶ $E(Y|x) = B_0 + B_1.X_1 + B_2.X_2 + \dots$

- ▶ Two main types of variables

1. **Independent variables (IV)** or predictor variables e.g. $X_1 \dots X_n$

Coefficients: B_0, B_1

Independent variables are also called explanatory vbls. or covariates

2. **Dependent variables (DV)** or response variables e.g. N

Methodology

- ▶ Commonly used model
 - ▶ $N = B_0 + B_1.X_1 + B_2.X_2 + \dots$
- ▶ Two main types of variables
 - ▶ **Independent variables (IV)** or predictor variables e.g. $X_1 \dots X_n$
 - ▶ Crash contributing factors with two or more levels
 - ▶ Examples: **Gender**: Male/Female, **Alcohol**: Yes/No
 - ▶ Example: **Hours**: 0 - 6 am, 6 - 10 AM, 10 AM - 3 PM, 7 PM - 12 AM, etc.
 - ▶ Example: **Road Surface**: Wet/Water, Dry, Ice, Snow, etc.

Methodology

- ▶ Commonly used model

- ▶ $N = B0 + B1.X1 + B2.X2 +$

- ▶ Two main types of variables

- ▶ **Dependent variables (DV)** with more than two categories

- ▶ Example: Median, Roadway, Roadside

- ▶ Example: Median Rollover, Median Non-Rollover, etc.

Methodology

- ▶ Commonly used regression model is linear regression
 - ▶ $N = B_0 + B_1.X_1 + B_2.X_2 + \dots$
- ▶ In linear regression, the outcome variable is continuous
 - ▶ A value

Objectives

For depressed divided highways

a) Identify *factors associated with median crashes*

- Median Encroachment
- Cross Median

Median Crashes	Frequency
Encroachment	291
Cross Median	68
Total	359

Archived Data Categorization

Crash Location	Freq- uency	Types of Crashes	Freq- uency	Types of Median Crashes	Freq- uency
Median	359	Rollover	522	Encroachment	291
Roadway	1721	Non-Rollover	1114	Cross Median	68
Roadside	460	No-Information	904	Total	359
Total	2540	Total	2540		

Methodology

- ▶ Types of Crashes: Dependent variables (DV) or response variables

- ▶ Two Types of Models Developed

1. Median crash model:

- ▶ Median Encroachment: Rollover (RO) and Non-Rollover (NRO)
- ▶ Cross Median: Rollover (RO) and Non-Rollover (NRO)

Archived Data Categorization

Type of Median Crashes	Frequency	Type of Crashes	Frequency
Encroachment	291	Rollover Non-Rollover (No-Info.)	215 59 (17)
Cross Median	68	Rollover Non-Rollover	34 34
Total	359	Total	342

Methodology

- ▶ Types of Crashes: Dependent variables (DV) or response variables
 - ▶ Two Types of Models Developed

2. Rollover crash model, 1356 crashes:

- | | | |
|------|----------------------|-------------|
| I. | Median Rollover | 249 crashes |
| II. | Roadside Rollover | 215 crashes |
| III. | Roadway Non-Rollover | 892 crashes |

Archived Data Categorization

Crash Location	Frequency	Type of Crash	Frequency	Type of Crash	Frequency
Median	359	Rollover	249	Non-Rollover	93
Roadway	1721	Rollover	58	Non-Rollover	892
Roadside	460	Rollover	215	Non-Rollover	129
Total	2540	Total	515	Total	1114

Type of Crashes	Frequency
Median Rollover	249
Roadway Rollover	215
Roadside Non-Rollover	892
Total	1356

Methodology (MLR)

- ▶ Multinomial logistic regression (MLR) is used to model crash type
 - ▶ Associate variables with crash type
- ▶ MLR used when DV is categorical
 - ▶ Binary or dichotomous
 - ▶ Multinomial or polychotomous

Methodology (MLR)

$$E(Y|x) = B_0 + B_1 \cdot X_1 + B_2 \cdot X_2 + \dots$$

Mathematically

$$\pi(x) = E(Y|X) \dots$$

Specific form of logistic regression, uses the logistic distribution

$$\pi(x) = \frac{e^{\beta_0 + \beta_1 x}}{1 + e^{\beta_0 + \beta_1 x}}$$

Now logit transformation is expressed as

$$\begin{aligned} g(x) &= \ln \left[\frac{\pi(x)}{1 - \pi(x)} \right] \\ &= e^{\beta_0 + \beta_1 x} \end{aligned}$$

Methodology

- ▶ Model development and testing conducted
 - ▶ Variables tested for multicollinearity in data
 - ▶ Statistical hypothesis tested - Likelihood Ratio Test
 - ▶ Model fitness to the data tested - GOF tests
 - ▶ Statistical significance of variables tested - association

Methodology (MC)

- ▶ Multicollinearity (MC)
 - ▶ Independent variables (IV) expressed as linear combination of other IV
- ▶ Severe MC occurs
 - ▶ Standard errors of coefficients tend to be very large
 - ▶ Estimated regression coefficients highly unreliable & results biased

Methodology (MC)

- ▶ Two tests performed to check MC
 - ▶ Variance Inflation Factor (VIF)
 - ▶ Cross Tab Analysis
 - ❖ *Categorical Variables*
 - ❖ Weather and Surface - showed MC, weather not considered

Methodology

- ▶ Model's p-value used for testing statistical hypothesis
- ▶ p-value ≤ 0.05 , model found to be statistically significant
- ▶ The parameters of the model are estimated using the technique of maximum likelihood estimate

Methodology

► Performance measures for association

1. p-value (statistical significance)
 - Three levels: 0.1, 0.05, 0.01
2. β -value (coefficients, B_0 , B_1)
3. $\text{Exp}(\beta)$ (Odds Ratio)

Methodology (β -value)

- ▶ β -value shows effect of independent variables on dependent variable
- ▶ Positive value indicates a positive association
 - ▶ If $B > 0$, more likely to impact dependent variable
 - ▶ If $B < 0$, less likely to impact dependent variable
 - ▶ If $B=0$, equally likely to impact dependent variable

Methodology (Odds ratio)

- ▶ Exponent of β -value is odds ratio for independent variable
 - ▶ $OR = \exp^{\beta}$
 - ▶ $OR > 1$ indicates a positive effect
 - ▶ $OR < 1$ indicates a negative effect
 - ▶ $OR = 1$ indicates no influence

Methodology (Odds ratio)

- Odds ratio compares probabilities of two levels of a dependent variable

$$OR = \frac{p_1/(1 - p_1)}{p_2/(1 - p_2)}$$

p_1 = probability of subject level, group 1

p_2 = probability of reference level, group 2

OR > 1: increased risk of group 1 compared to 2

OR < 1: lower risk of group 1 compared to 2

OR = 1: no difference in risk of group 1 compared to 2

Methodology (GOF)

- ▶ Goodness of Fit Tests (GOF) to evaluate fitness of model
 - ▶ 1. Model fits the data
 - ▶ 2. Predictive power

1. Model Fit: Pearson χ^2 , and Deviance

2. Pred. Power: McFadden and Nagelkerke (Pseudo R-square)

Methodology

- ▶ Multinomial Logistic Regression Model

- 1. Median Crash Model**

- ▶ Dependent Variable with Four categories

- Median Encroachment Rollover
 - Median Encroachment Non-Rollover
 - Cross Median Rollover
 - Cross Median Non-Rollover (Reference Category)

Results (GOF)

Criterion	Value	P _r (Sig)
Likelihood Ratio Test	153.824	<.0001
Pearson	879.173	0.985
Deviance	567.078	1.000
Nagelkerke	.412	-
McFadden	.213	-

Median Crash Model

- ▶ Model compares **Median Rollover, Non-Rollover and Cross Median Rollover** crashes with Cross Median-Non-rollover
- ▶ Cross Median-Non-rollover reference category of dependent variable
- ▶ Results based on p-values
 - ▶ Explained using B coefficients and $\text{Exp}(B)$, Odds Ratio (OR)
- ▶ All standard errors were under 1.5

Results:

Median Encroachment Rollover Crashes

Results (MLR): Median Rollover Crashes

Variable	Categories	Reference	B	p-value	Exp(B)
Median Slope	1:4 - 1:5	1:6	2.058	0.000	7.832
Highway Characteristics	Curve/Level	Straight/ Level	2.748	.030	15.610

Base category: Cross Median Non-Rollover

Results (MLR): Median Rollover Crashes

Variable	Categories	Reference	B	p-value	Exp(B)	1/Exp(B)
Accident Severity	Fatality/ Incapacitating	PDO	-1.586	.038	.205	4.9
Collision Types	Multiple Vehicles	Single Vehicle	-3.938	.000	.019	52.6
Light	Dark-lighted	Daylight	-1.743	.003	.175	5.7

Base category: Cross Median Non-Rollover

Results:

Cross Median Rollover Crashes

Rutting

Categories	Values (Inch)
Lowest	0 - .125
Low (reference category)	>.125 - .362
Medium - Low	>.362 - .599
Medium - High	>.599 - .836
High	>.836 - 1.31

Results (MLR): Cross Median Rollover Crashes

Variable	Categories	Reference	B	p-value	Exp(B)
Roadway Alignment	Curve/Level	Straight/Level	2.982	.026	19.7
Median Slope	1:4 - 1:5	1:6	1.882	.006	6.6
Rutting	0-.125" Lowest	>.125" - .362" Low	2.615	.016	13.7

Base category: Cross Median Non-Rollover

Results (MLR): Cross Median Rollover Crashes

Variable	Categories	Reference	B	p-value	Exp(B)
Light	Dark-lighted	Daylight	1.882	.006	6.6

Base category: Cross Median Non-Rollover

Results (MLR): Cross Median Rollover Crashes

Variable	Categories	Reference	B	p-value	Exp(B)	1/Exp(B)
Collision Types	Multiple Vehicles	Single Vehicle	-2.996	0.000	.050	20.0
Surface	Ice	Other/Missing, Sand/Dirt/ Mud/Gravel, Oil, Water, Wet	-1.645	.097 [^]	.193	5.2
	Dry		-1.986	.053 [^]	.137	7.3

Base category: Cross Median Non-Rollover

Results:

Median Encroachment Non-Rollover Crashes

Results (MLR): Median Non-Rollover Crashes

Variable	Categories	Reference	B	p-value	Exp(B)	1/Exp(B)
Accident Severity	Fatality/ Incapacitating	PDO	-3.670	.003	.025	40.0
Collision Types	Multiple Vehicles	Single Vehicle	-2.958	0.000	.052	19.2
Light	Dark-lighted	Daylight	-1.592	0.013	.203	4.9

Base category: Cross Median Non-Rollover

Results (MLR): Median Non-Rollover Crashes

Variable	Categories	Reference	B	p-value	Exp(B)
Median Slope	1:4 - 1:5	1:6	1.289	0.038	3.629

Base category: Cross Median Non-Rollover

Summary, Odds Ratio: Median Crash Model

Variables	Categories	Rollover (RO)	Non-Rollover	Cross Median - RO
Median Slope	1:4, 1:5	7.83***	3.63**	6.57***
	<u>1:6</u>			
Roadway Alignment	Curve/Level	15.61**	-	19.72**
	<u>Straight/Level</u>			
Rutting	Lowest (0 - .125)	-	-	13.67**
	<u>Low (>.125 - .362)</u>			
<i>Base category: Cross Median Non-Rollover</i>				
<i>Statistically significant at 0.01*** (bold), 0.05** (bold italics) & 0.1* (normal) level</i>				
<i>Only significant variables presented, reference category underlined</i>				

Summary, Odds Ratio: Median Crash Model

Variables	Categories	Rollover (RO)	Non-Rollover	Cross Median - RO
Acc. Severity	Fatality/Incapacitating	.205** (4.9)	.025*** (40)	-
	<u>PDO</u>			
Collision Types	Multiple Vehicles	.019*** (52.6)	.052*** (19.2)	.050*** (20.0)
	<u>Single Vehicles</u>			
Light	Dark-lighted	.175*** (5.7)	.203** (4.9)	6.6***
	<u>Daylight</u>			
Surface	Ice	-	-	.193* (5.2)
	Dry	-	-	.137* (7.3)
	<u>Miscellaneous</u>			
<i>Base category: Cross Median Non-Rollover</i>				
<i>Statistically significant at 0.01*** (bold), 0.05** (bold italics) & 0.1* (normal) level</i>				
<i>Only significant variables presented, reference category underlined</i>				

Methodology

- ▶ Multinomial Logistic Regression Models

2. Rollover Crash Model

- ▶ Dependent Variable with Three categories
 - Median Rollover (combined both encroachment & cross median crashes)
 - Roadside Rollover
 - Roadway Non-Rollover (Reference Category)

Results (GOF)

Criterion	Value	P _r (Sig)
Likelihood Ratio Test	346.560	<.0001
Pearson	2550.641	0.901
Deviance	2031.028	1.000
Nagelkerke	.273	-
McFadden	.145	-

Rollover Crash Model

- ▶ Model compares **Median Rollover** and **Roadside Rollover** crashes with Roadway-Non-rollover
- ▶ Roadway-Non-rollover reference category of the dependent variable
- ▶ Results based on p-values
 - ▶ Explained using B coefficients and $\text{Exp}(B)$, Odds Ratio (OR)
- ▶ All standard errors were under 1.5

Results: Median Rollover Crashes

Results (MLR): Median Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)
Accident Severity	F&I	PDO	1.151	.000	3.163
	B/C		.642	.000	1.901

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
Alcohol	No	Yes	-.639	0.039	.528	.288	.967

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
HOURS	0-6 AM EARLY MORNING	10 AM - 3 PM LATE MORNING/ EARLY AFTERNOON	.527	.057^	1.693	.985	2.912
	15-19 PM AFTERNOON/ EVENING		-.733	.003	.481	.296	.781

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Reference	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
HUMAN CIRCUMSTANCES	DRIVER INEXPERIENCE	UNSAFE SPEED	1.047	.002	2.849	1.460	5.559
	DISTRACTED		-.604	.032	.546	.315	.949

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Refer.	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
Highway Alignment	Curve/ Hillcrest/ Grade	Straight/ Level/ Unknown	.742	.001	2.101	1.331	3.316
	Curve/ Level		.855	.000	2.351	1.454	3.801
	Straight/ Hillcrest/ Grade		.668	.001	1.950	1.308	2.907

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
Rutting	>.836 - 1.31 HIGH	>.125 - .362 Low	.415	.065^	1.515	.974	2.355

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Reference	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
SURFACE	ICE	OTHER/MISSING, SAND/DIRT/ MUD/GRAVEL, OIL, WATER, WET	.532	.054	1.702	.992	2.921

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
VEHICLE ACTION	Vehicle Movements [#] , Avoiding Objects in Road, Slowing, Stopped, Unknown	Straight Ahead	-.726	.005	.484	.290	.808

[#] Vehicle Movements = Backing, Entering/Leaving Lane, U-Turn, Parked, Turning Left/right, starting in traffic

Base Category: Roadway Non-Rollover

Results (MLR): Median Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
VEHICLE TYPE	MOTORCYCLE, PASSENGER CARS, MISC	BUS, SU, SEMI, LIGHT TRUCKS	-.278	.086^	.758	.552	1.040

Base Category: Roadway Non-Rollover

Results: Roadside Rollover Crashes

Results (MLR): Roadside Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
Accident Severity	F&I	PDO	.755	.048	2.128	1.005	4.506
	B/C		.458	.012	1.581	1.106	2.259
Gender	Female	Male	.441	0.011	1.554	1.107	2.180

Roadway Non-Rollover

Results (MLR): Roadside Rollover

Variable	Categories	Reference	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
HUMAN CIRCUMSTANCES	DRIVER INEXPERIENCE	UNSAFE SPEED	.848	.021	2.335	1.134	4.809
	DISTRACTED		-1.075	.002	.341	.172	.679

Base Category: Roadway Non-Rollover

Results (MLR): Roadside Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
Rutting	0 - .125 Lowest	>.125 - .362 Low	.532	.047	1.702	1.007	2.877
	>.599 - .836 Med. High		.442	.070^	1.555	0.964	2.510
	>.836 - 1.31 High		.501	.040	1.650	1.024	2.659

Base Category: Roadway Non-Rollover

Results (MLR): Roadside Rollover

Variable	Categories	Reference	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
SURFACE	DRY	OTHER, MISSING, SAND, DIRT, MUD, GRAVEL, OIL, WATER, WET	-.759	.010	.468	.263	.833

Base Category: Roadway Non-Rollover

Results (MLR): Roadside Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
VEHICLE ACTION	Vehicle Movements [#] , Avoiding Objects in Road, Slowing, Stopped, Unknown	Straight Ahead	-.491	.071 [^]	.612	.359	1.043
	Skidding, Out of Control		.519	.008	1.681	1.144	2.471

[#]Vehicle Movements = Backing, Entering/Leaving Lane, U-Turn, Parked, Turning Left/right, Starting in Traffic

Base Category: Roadway Non-Rollover

Results (MLR): Roadside Rollover

Variable	Categories	Reference Category	B	p-value	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
VEHICLE TYPE	MOTORCYCLE, PASSENGER CARS, MISC	BUS, SU, SEMI, LIGHT TRUCKS	-.352	.041	.703	.502	.986

Base Category: Roadway Non-Rollover

Summary, Odds Ratio: Rollover Crash Model

Variables	Categories	Median	Roadside
Crash Severity	Fatality/Incapacitating	3.16***	2.13**
	Non-incapacitating/Possible injury	1.90***	1.58**
	<u>PDO</u>		
Alcohol	Yes	.528* (1.9)	-
	<u>No</u>		
Gender	Female	-	1.55**
	<u>Male</u>		
Hours	0 – 6 AM – Early Morning	1.69*	2.95***
	6 – 10 AM – Morning	-	1.93***
	3 – 7 PM – Afternoon/Evening	.481*** (2.1)	-
	<u>10 AM – 3 PM</u>		
Base Category: Roadway NRO			
<i>Only significant variables presented, reference category underlined,</i>			
<i>Statistically significant at 0.01*** (bold), 0.05** (bold italics) & 0.1* (normal) level</i>			

Summary, Odds Ratio: Rollover Crash Model

Variables	Categories	Median	Roadside
Human Circumstances	Driver Inexperience	2.85***	2.34**
	Distracted	.546** (1.8)	.341*** (2.9)
	<u>Unsafe Speed</u>		
Alignment	Curve/Hillcrest/Grade	2.10***	1.97***
	Curve/Level	2.35***	2.19***
	Straight/Hillcrest/Grade	1.95***	1.46*
	<u>Straight/Level/Unknown</u>		
Road Surface	Ice	1.70*	-
	<u>Dry</u>	-	.468** (2.1)
	<u>Miscellaneous</u>		
Base Category: Roadway Non-Rollover			
<i>Only significant variables presented, reference category underlined,</i>			
<i>Statistically significant at 0.01*** (bold), 0.05** (bold italics) & 0.1* (normal) level</i>			

Summary, Odds Ratio: Rollover Crash Model

Variables	Categories	Median	Roadside
Rutting	Lowest (0 - .125)	1.52*	1.70**
	Med. High (>.599 - .836)	-	1.56*
	High (>.836 - 1.31)	-	1.65**
	<u>Low (>.125 - .362)</u>		
Vehicle Action	Vehicle Movements, Avoiding Objects Slowing, Stopped	.484*** (2.1)	.612* (1.6)
	Skidding, Out of Control	-	1.68***
	<u>Straight Ahead</u>		
Vehicle Type	Motorcycle, Passenger Cars, Misc.	.758* (1.3)	.703** (1.4)
	<u>Bus, Su, Semi, Light Trucks</u>		
Base Category: Roadway NRO			
<i>Only significant variables presented, reference category underlined,</i>			
<i>Statistically significant at 0.01*** (bold), 0.05** (bold italics) & 0.1* (normal) level</i>			

Objectives

For depressed divided highways

- a) Identify *factors* associated with *median* crashes
- b) Identify location of median crashes**
 - i. Identify hazardous locations
- c) Propose locations for median barriers

Hazardous Locations: A Hybrid Approach

Glenn Highway

- ▶ MP 2.712 - 3.084
- ▶ MP 4.543 - 5.116
- ▶ MP 24.463 - 24.721

Minnesota Drive

- ▶ MP 3.83 - 3.87
- ▶ MP 4.61 - 4.96
- ▶ MP 5.27 - 5.43

Parks Highway

- ▶ MP 0.4373 - 1.557
- ▶ MP 2.3056 - 2.5974

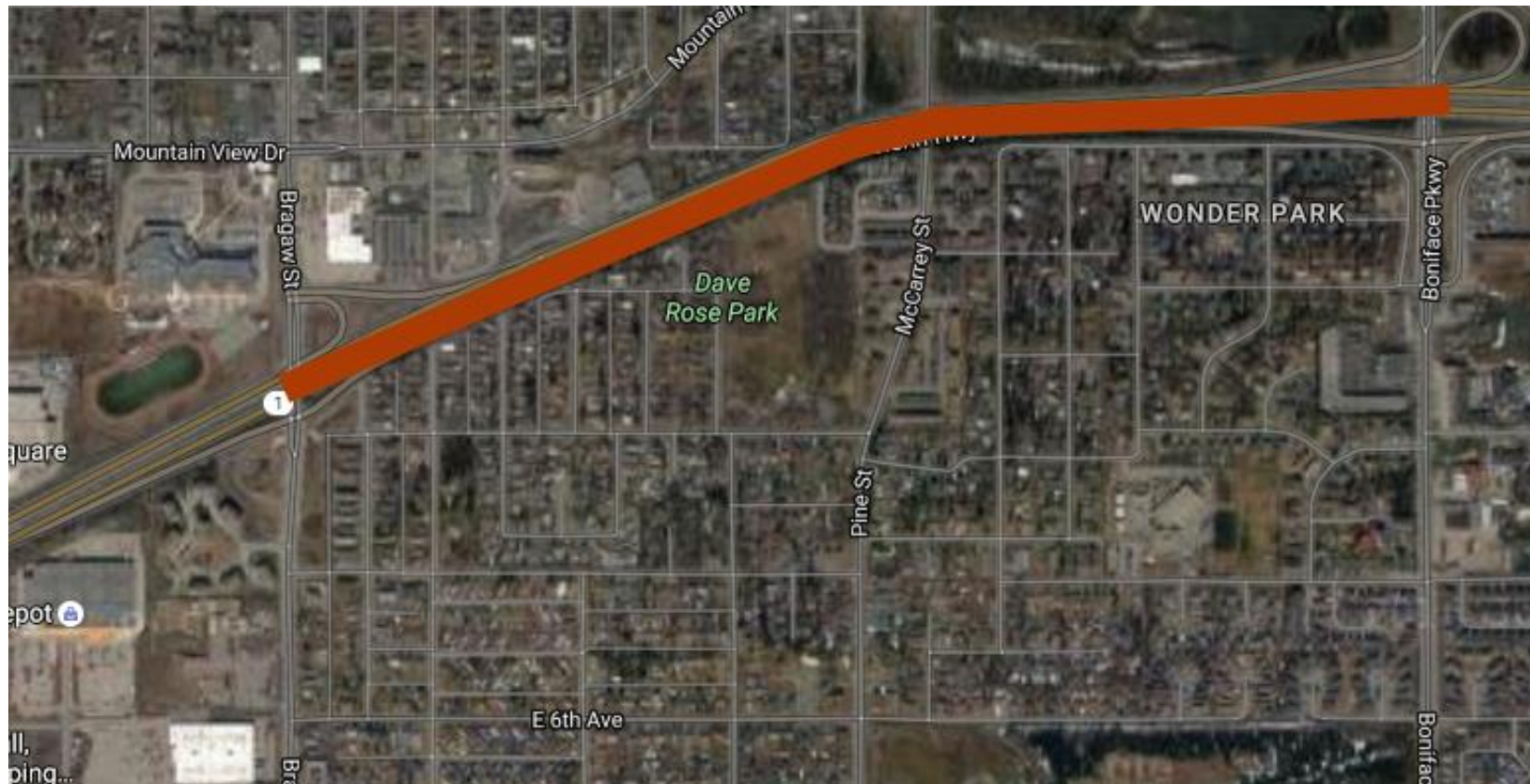
New Seward Highway

- ▶ MP 119.65 - 120.083
- ▶ MP 122.696 - 122.906
- ▶ MP 123.6 - 123.911

Glenn Highway

Most hazardous location: MP 2.71 - 3.08

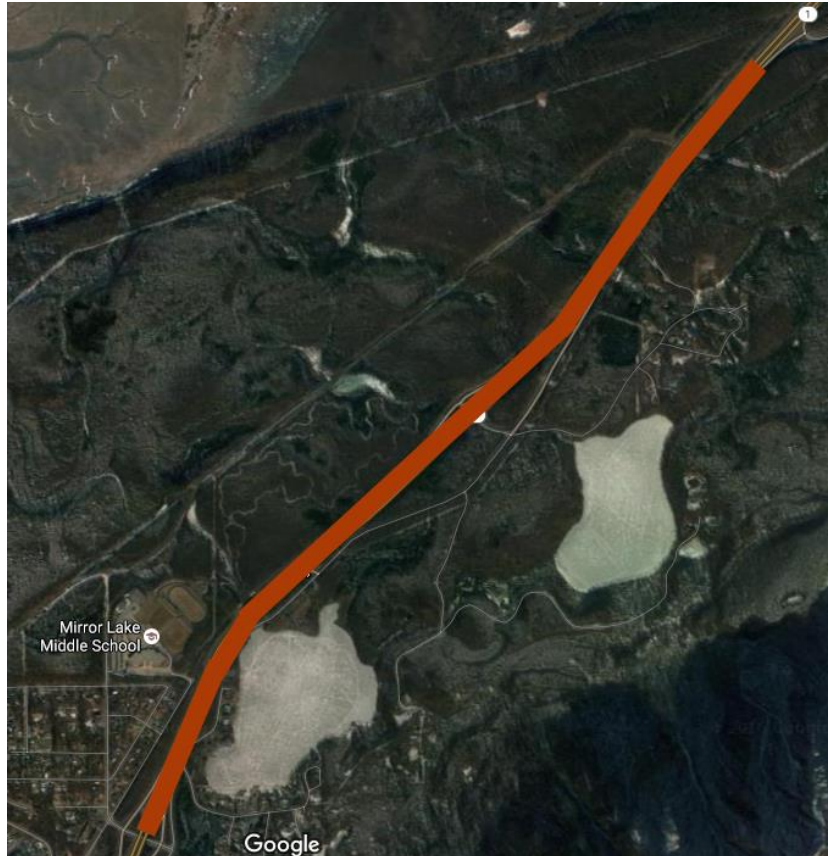
Between Bragaw St. and Boniface Pkwy



Glenn Highway

Second most hazardous location: MP 24.46 - 24.72

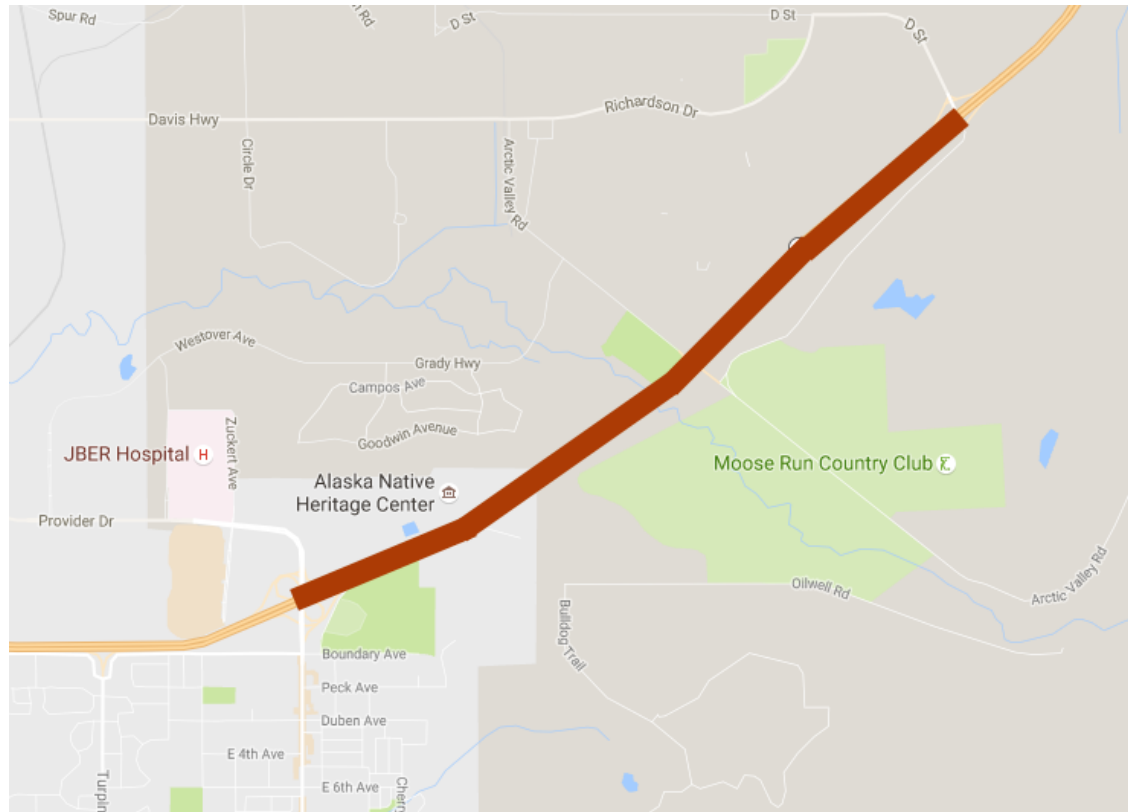
Between SB Mirror Lake exit and Thunderbird Falls



Glenn Highway

Third most hazardous location: MP 4.54 - 5.12

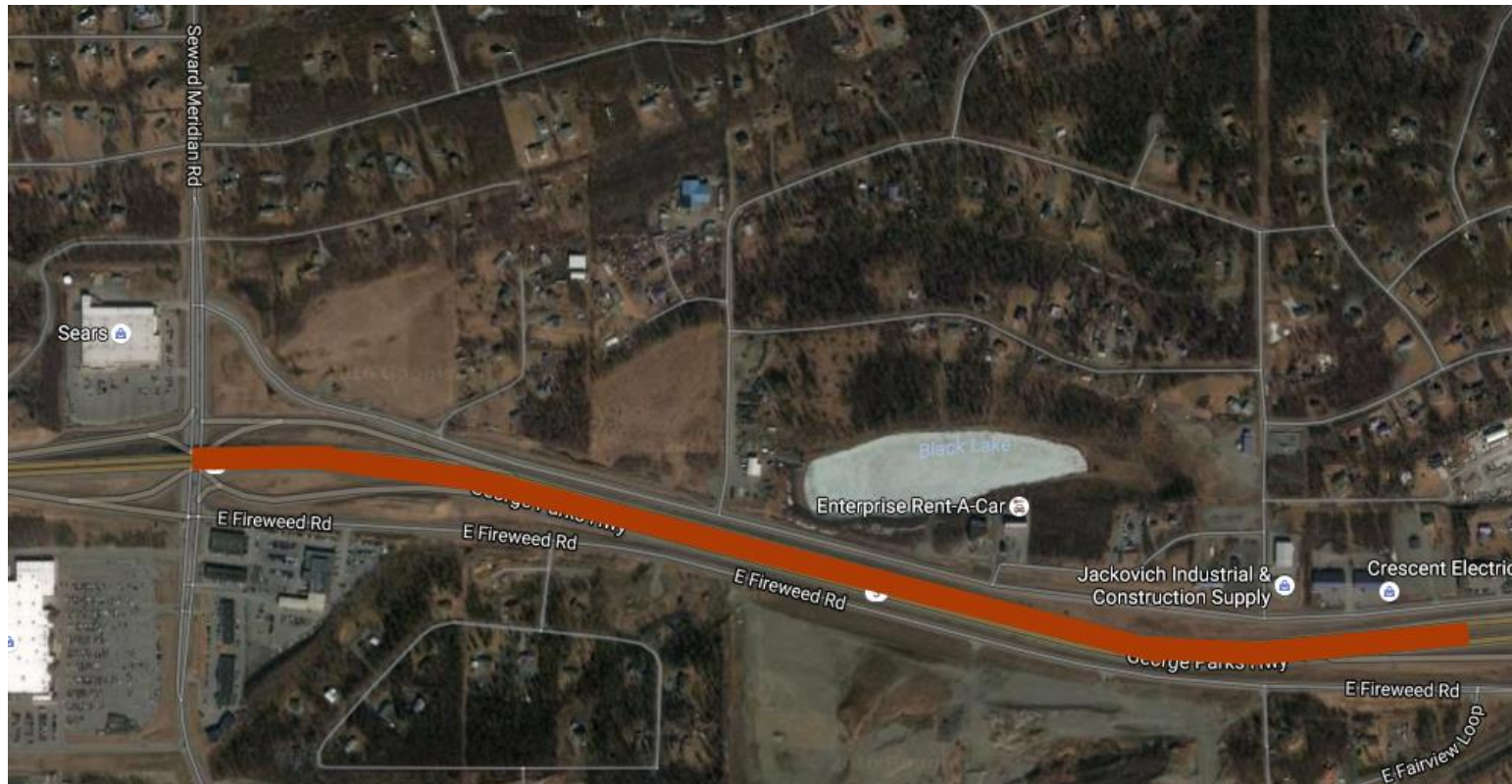
Between Muldoon Rd and JBER exit



Parks Highway

Most hazardous location: MP 37.6 - 37.9

Between Seward Meridian Rd and E Fairview Loop



Parks Highway

Second most hazardous location: MP 35.8-36.8

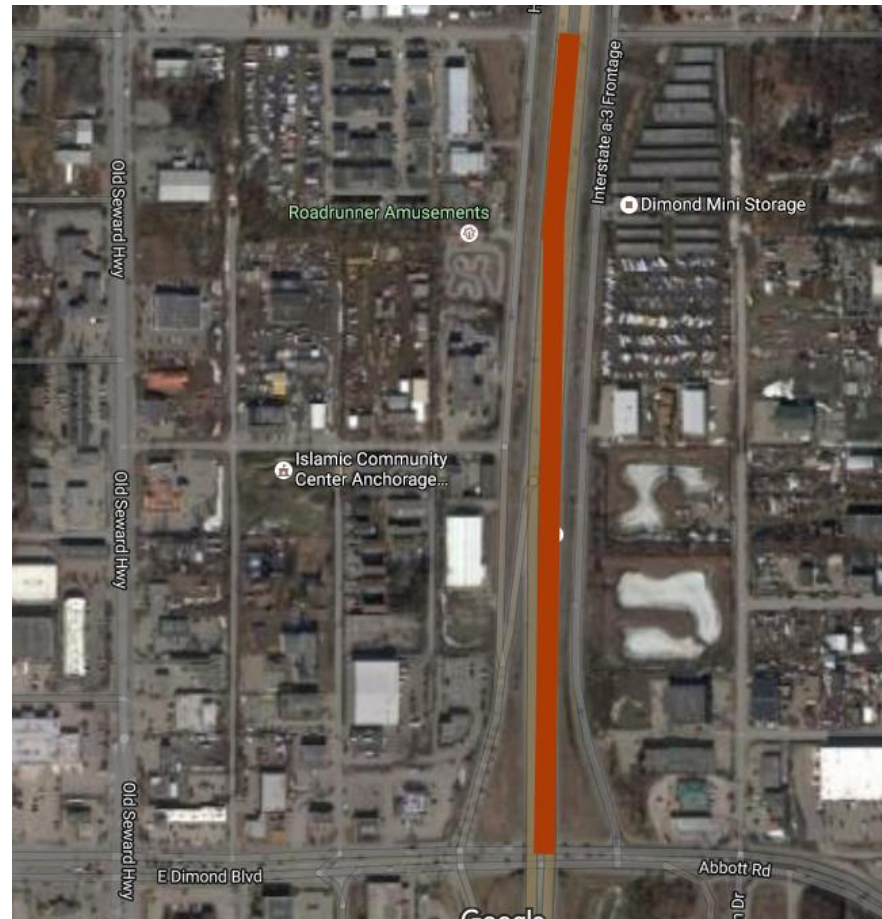
Between Trunk Rd and just before E Fairview Loop



Seward Highway

Most hazardous location: MP 122.69-122.9

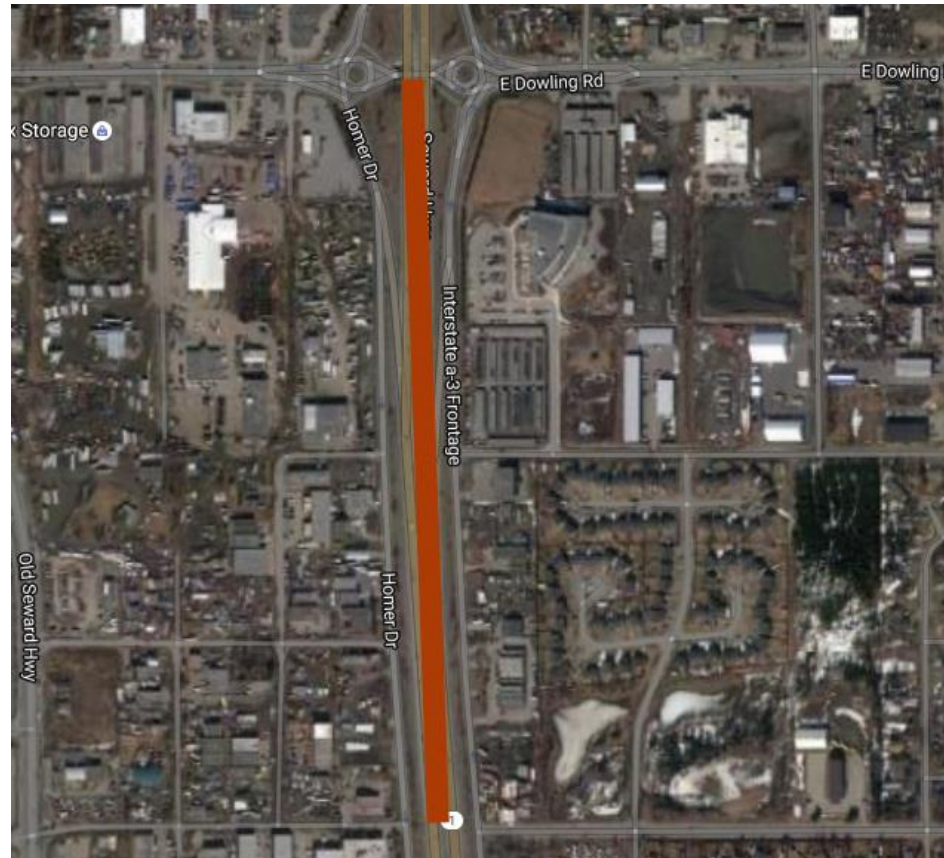
Between Dimond Blvd and E 76th Ave



Seward Highway

Second most hazardous location: MP 123.6-123.9

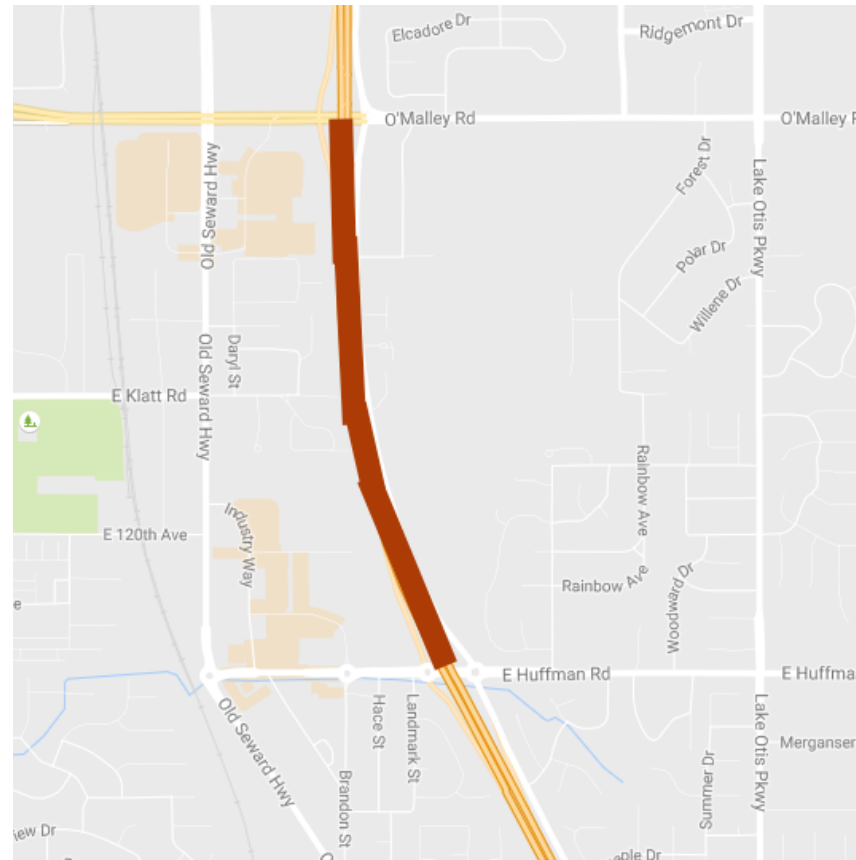
In between E 66th Ave and Dowling Rd



Seward Highway

Third most hazardous location: MP 119.65-120.08

In between Huffman Rd and O'Malley Rd



Conclusions

- ▶ Six years of crash data, 2450 crashes analyzed
- ▶ Median crash and Rollover crash models developed
- ▶ Multinomial logistic regression model used
 - ▶ Crash contributing factors identified
 - ▶ Median, Roadside and Roadway crashes
 - ▶ Rollover and Non-rollover crashes

Significant Variables - Rollover Crashes

► Median

- Accident Severity
- Alignment Curve: level, hillcrest, grade
- Alignment Straight: hillcrest, grade
- Dark Lighted, Early Morning
- Driver inexperience
- Median Slope - 1:4 and 1:5
- Rutting - $>.836 - 1.31$ (maximum)
- Surface: icy conditions

Significant Variables - Rollover Crashes

► Roadside

- Accident Severity
- Females
- Mornings
- Inexperience of drivers
- Median Slope - 1:4 and 1:5
- Alignment Curve: hillcrest, grade, level
- Alignment Straight: hillcrest, grade
- Rutting - all levels
- Skidding, and out-of-control

Significant Variables - Non-Rollover Crashes

- ▶ Roadway
 - ▶ Alcohol
 - ▶ Afternoon and evenings
 - ▶ Distracted drivers
 - ▶ Dry conditions
 - ▶ Avoiding objects on the road
 - ▶ Slowing and stopping

Recommendations

- ▶ Highway sections with rutting especially greater than 0.6 inches
- ▶ Alignment with curves
- ▶ Alignment with grades, hillcrest
- ▶ Median with steep slopes

Recommendations

- ▶ Cross section design - requires evaluation
 - ▶ Median design
- ▶ Crash data collection forms
 - ▶ Event type - snowberm
 - ▶ Rollover
 - ▶ Tires

Next steps

- ▶ Hazardous location on the highways
 - ▶ Most hazardous median locations to be identified
- ▶ Proposed location of barriers
 - ▶ *Economically feasible*
- ▶ *Countermeasures*

Questions

The background features abstract, overlapping green geometric shapes, primarily triangles and polygons, in various shades of green, creating a modern and dynamic visual effect. The shapes are concentrated on the right side of the slide, with some extending towards the left.

THANK YOU

Archived Data

Crash Severity	Frequency	Percent
Fatality/Incapacitating Injury	116	4.57
Non-Incapacitating/Possible Injury	738	29.06
Property Damage Only	1686	66.38
Total	2540	100

Methodology (GOF)

- ▶ **Pearson** (χ^2) measures how closely model "fits" observed data
- ▶ High p-value for Pearson statistics is desired

$$\chi^2 = \sum_j \frac{(O_j - E_j)^2}{E_j}$$

where:

O_j is the total observed frequency

E_j is the total expected frequency

Methodology (GOF)

- ▶ **Deviance (G^2)** measures how closely model "fits" the observed data
- ▶ High p-value is desired

$$G^2 = 2 \sum_j O_j \log \left(\frac{O_j}{E_j} \right)$$

where:

O_j is the total observed frequency

E_j is the total expected frequency

Methodology(MC)

- ▶ *VIF* is the factor by which variance is inflated and can be calculated as:

$$\text{▶ } VIF = \frac{1}{1 - R_k^2}$$

- ▶ where R_k^2 is the R^2 -value obtained by regressing the *kth* predictor on the remaining predictors.

Recommendations

- ▶ DOT should evaluate and place a value of the conversion
- ▶ From a depressed median expressway to a barrier or a raised median separated arterial
- ▶ Modification in typical cross-section design
- ▶ Modifications such as the median fore slope, shape and width of the berm, etc.(based on Alaskan conditions)

Mathematical Model

$$\begin{aligned} \text{Median Crash Type}_i = & \beta_0 + \beta_1 \text{Acc. Severity}_{ij} + \beta_2 \text{Collision Type} + \beta_3 \text{Light}_{ij} \\ & + \beta_4 \text{Median Slope}_{ij} + \beta_5 \text{Hwy Characteristics}_{ij} + \beta_6 \text{Rutting} \\ & + \beta_7 \text{Surface}_{ij} \end{aligned}$$

$$\begin{aligned} \text{Highway Crash Type}_i = & \beta_0 + \beta_1 \text{Acc. Severity}_{ij} + \beta_2 \text{Alcohol}_{ij} + \beta_3 \text{Gender}_{ij} + \beta_4 \text{Hours}_{ij} \\ & + \beta_5 \text{Human Characteristics}_{ij} + \beta_6 \text{Hwy Characteristics}_{ij} + \beta_7 \text{Rutting}_{ij} \\ & + \beta_8 \text{Surface}_{ij} + \beta_9 \text{Vehicle Action}_{ij} + \beta_{10} \text{Vehicle Type}_{ij} \end{aligned}$$