"Analysis of Factors Affecting the Frequency of Crashes on Interstate Freeways by Vehicle Type and Severity Incorporating Weather Prediction Models"

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AZTrans The Arizona Laboratory for Applied Transportation Research

PSR Pacific Southwest Region UTC University Transportation Center

Introduction

- Focus of study funded by the Arizona Board of Regents (ABOR) Research Innovation Fund (RIF) – Collaborative effort between NAU, UA, and ASU.
- Year 1 of the ABOR RIF project focused primarily on the I-10 as a high freight corridor
- **Year 2 focus was beyond the I-10, and is meant to include the Arizona megaregion including interstates connecting Flagstaff, Phoenix, Tucson, and Yuma**.
- Other funding for this project came from the Pacific Southwest Region 9 UTC

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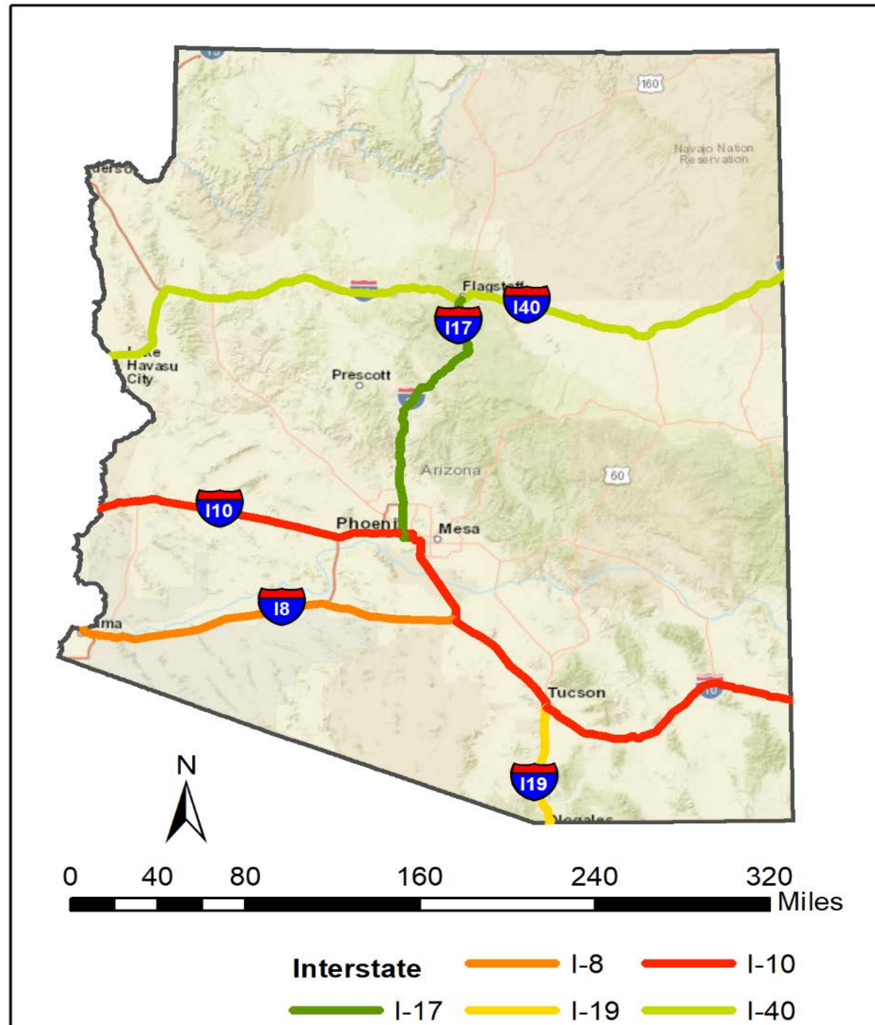
Objective

Primary Goals

- When considering the entire interstate system in AZ, what roadway variables, factors contribute significantly to the frequency of crashes?
- Do these roadway variables affect the frequency of crashes of different vehicle types in similar manner?
- Do these roadway variables affect the frequency of crashes of different severity levels in a similar manner?
- Does incorporating validated weather prediction data provide statistically significant results?

Background – Data Sources

- AZ Crash Reports statewide
  - 2010 to 2016
  - Incidents
- Geometric data package provided by ADOT's Multimodal Planning Division (MPD)
- Datasets to analyze frequency of crashes
- Looked at Interstates 8,10,17,19 and 40.



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Crash Frequency Models

- Negative Binomial Model with Random Effects
- NB is a generalized form of Poisson model:
  - $N_p = EXP(\beta_0 + \beta_1 X_1 + \dots \beta_i X_i)$

Where:
N_p: predicted number of annual crashes
β: vector of estimable parameters
X_i: vector of explanatory (independent) variables

* Random effects allows the intercept term, β_0, to vary across observations in order to account for unobserved geographic and temporal effects.

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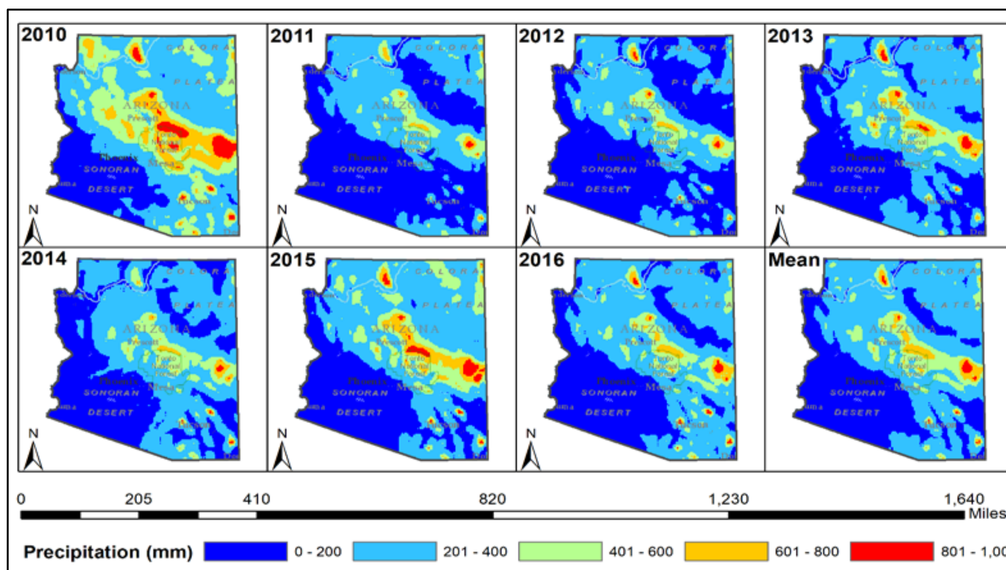
Weather Research and Forecasting Models (WRF)

- The Arizona meteorological Network (AZMET) operates 40 weather stations with 29 active and 11 inactive stations all around Arizona
- Data was validated based on observation data from AZMET by generating annual precipitation data and plotting against the available stations



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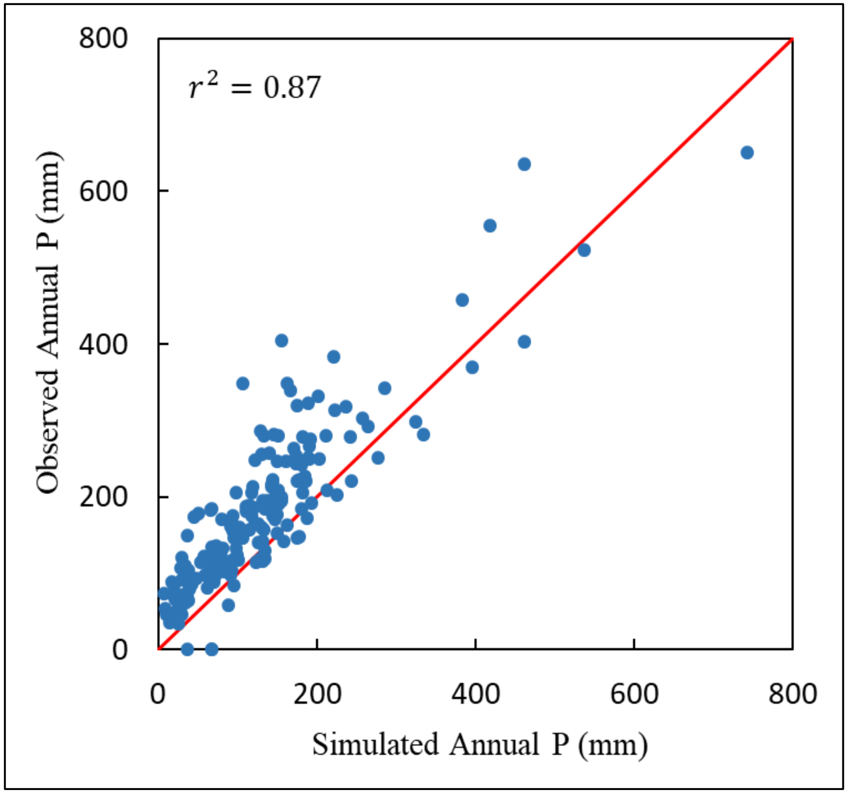
Weather Research and Forecasting Models

- Observed Precipitation (P) from AZMET versus the simulated precipitation (P) obtained from WRF.
- r^2=.87 shows a strong agreement between the simulated and the observed data



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Frequency Model Descriptive Statistics

Parameter	Mean	Std.Dev	Min	Max
Segment Length	3.40	3.06	0.19	21.38
Directional AADT	58,778	64,566	1,324	307,709
Ln(Directional AADT)	10.45	1.01	7.19	12.64
Annual Total Precipitation (inches)	8.40	5.26	0.31	37.40
Concrete Barrier[1]	0.28	0.45	0.00	1.00
Cable Barrier[1]	0.16	0.36	0.00	1.00
No Barrier[1]	0.67	0.47	0.00	1.00
Median Width <39 Feet[1]	0.26	0.44	0.00	1.00
Median Width 40-79 Feet[1]	0.59	0.49	0.00	1.00
Median Width >80 feet[1]	0.15	0.35	0.00	1.00
Right Shoulder (Feet)	10.08	1.48	6.00	22.43
Left Shoulder (Feet)	5.57	2.92	3.00	16.00
2 Lanes[1]	0.67	0.47	0.00	1.00
3 or 4 Lanes[1]	0.25	0.43	0.00	1.00
5 or 6 Lanes[1]	0.10	0.29	0.00	1.00
HOV Lane[1]	0.19	0.39	0.00	1.00
Speed Limit <65 mph[1]	0.12	0.33	0.00	1.00
Speed Limit 65-75 mph[1]	0.21	0.41	0.00	1.00
Speed Limit 75 mph[1]	0.58	0.49	0.00	1.00
Degree of Curvature	0.12	0.54	0.00	4.47
Percent Grade	1.15	1.04	0.00	6.35
Truck Percent	18.88	13.06	2.24	94.00
Phoenix[1]	0.16	0.37	0.00	1.00
Tucson[1]	0.10	0.30	0.00	1.00
Yuma[1]	0.01	0.12	0.00	1.00
Flagstaff[1]	0.03	0.16	0.00	1.00
All Crashes[2]	16.76	24.57	0.00	320.00
No Injury (O)[2]	11.90	17.69	0.00	229.00
Possible Injury (C)[2]	2.10	4.07	0.00	54.00
Non-Incapacitating Injury (B)[2]	2.21	3.27	0.00	39.00
Incapacitating Injury (A)[2]	0.40	0.77	0.00	6.00
Fatal (K)[2]	0.16	0.44	0.00	5.00
No Injury/Possible Injury (O+C)[2]	14.00	21.42	0.00	283.00
Non-Incapacitating/Incapacitating/Fatal (B+A+K)[2]	2.77	3.69	0.00	44.00

[1]Binary Indicator Variable (0 or 1)
[2]Annual Crashes Per Segment

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Total Crash Numbers

- Total Crashes 78,675
  - Passenger Vehicle: 65,203
  - Freight Vehicle: 11,675
  - Motorcycle:1,355
  - Bus/RV/Trailer: 442
- Total Crashes 78,675
  - Injury Severity K: 763
  - Injury Severity A: 1,888
  - Injury Severity B: 10,351
  - Injury Severity C: 9,856
  - Injury Severity O: 55,817

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Results Table Output

Freight Vehicle Model	β	Std. Error	P-Value	Std. Dev	Std. Error	P-Value
Intercept	-5.717	0.264	<0.001	0.204	0.014	<0.001
Segment Length	0.087	0.006	<0.001			
Ln(AADT)*	0.564	0.021	<0.001	0.007	0.001	<0.001
Precipitation (inches)	0.027	0.003	<0.001			
Concrete Barrier	-0.518	0.071	<0.001			
No Barrier*	-0.439	0.081	<0.001	0.183	0.017	<0.001
Median Width 40-79 Feet	-0.100	0.047	0.034			
Median Width >80 feet	0.057	0.059	0.340			
Right Shoulder (Feet)*	0.008	0.011	0.496	0.010	0.001	<0.001
Left Shoulder (Feet)	0.013	0.008	0.108			
2 Lanes	-0.363	0.088	<0.001			
3 or 4 Lanes	-0.237	0.072	0.001			
HOV Lane	-0.038	0.084	0.647			
Speed Limit 65-75 mph	0.286	0.058	<0.001			
Speed Limit 75 mph	0.400	0.061	<0.001			
Degree of Curvature*	0.037	0.027	0.165	0.056	0.023	0.017
Percent Grade*	0.005	0.017	0.780	0.113	0.009	<0.001
Truck Percent	0.012	0.002	<0.001			
Phoenix	0.635	0.070	<0.001			
Tucson	-0.239	0.074	<0.001			
Yuma	-0.377	0.185	0.041			
Flagstaff	0.045	0.104	0.661			
Over-Dispersion**	0.376	0.132	<0.001			

* Random Parameter in Model
** Over-dispersion parameter for the negative binomial model framework.

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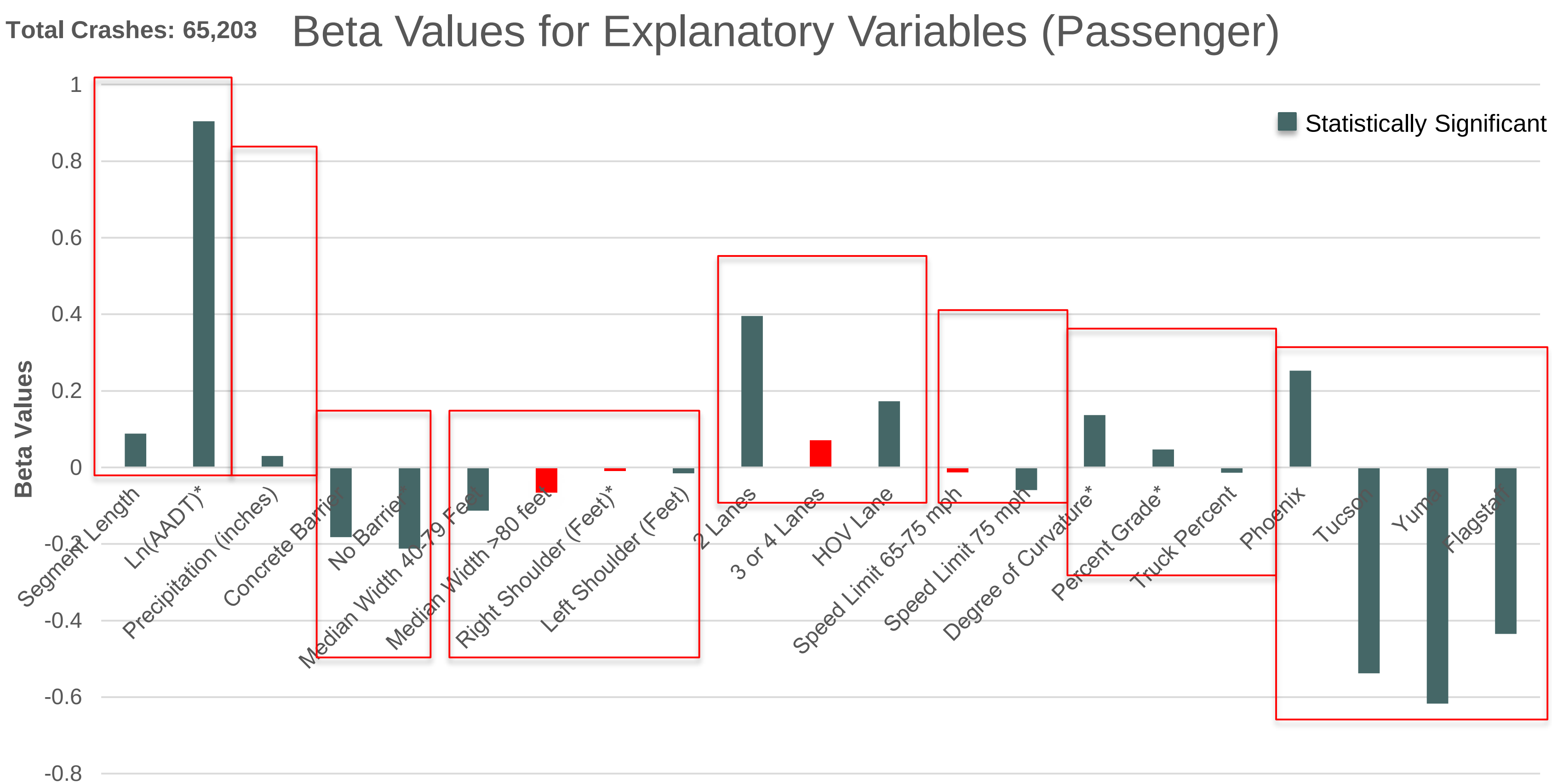
Passenger Vehicle Model Results



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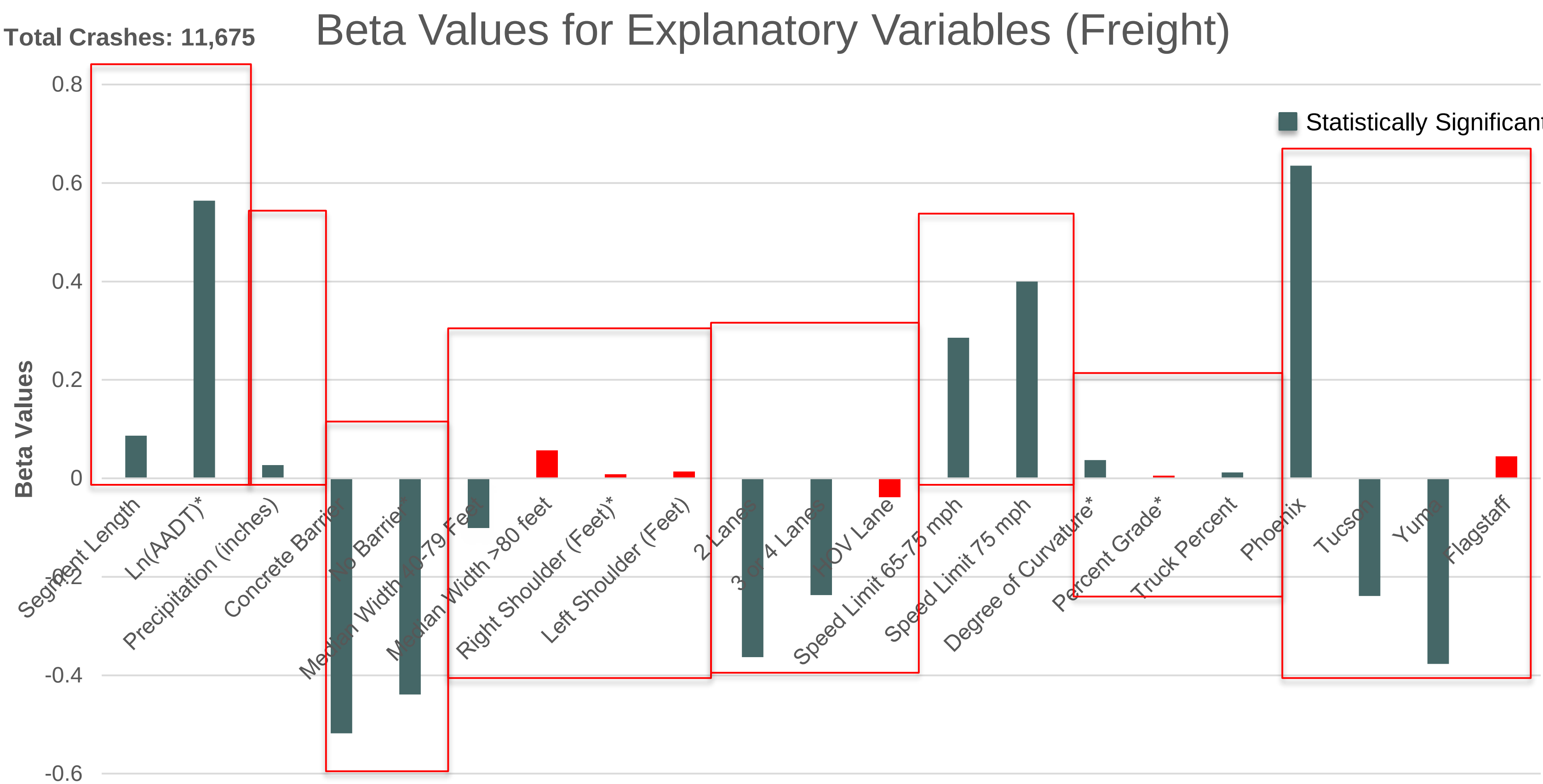
Freight Vehicle Model Results



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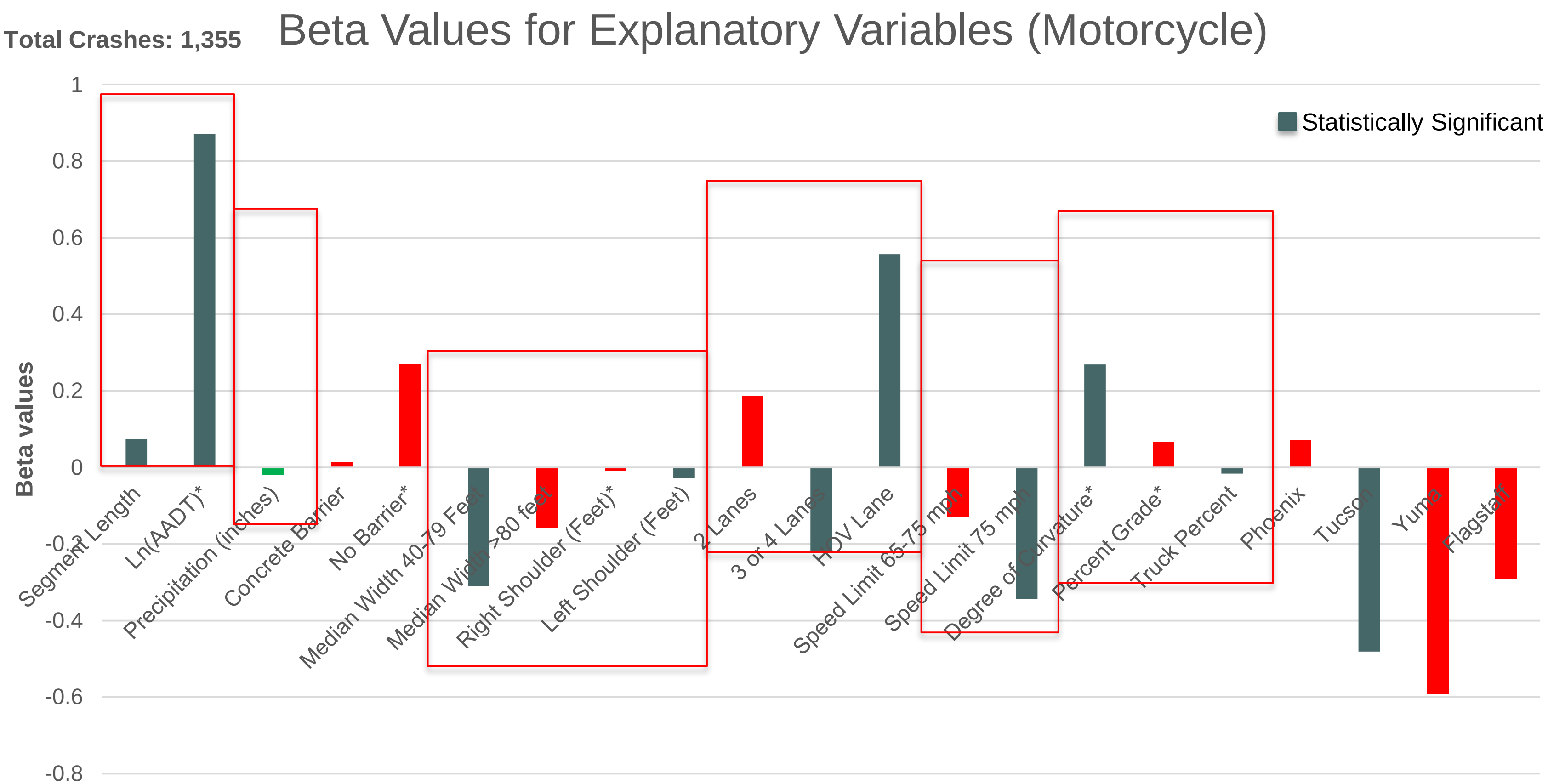
Motorcycle Model Results



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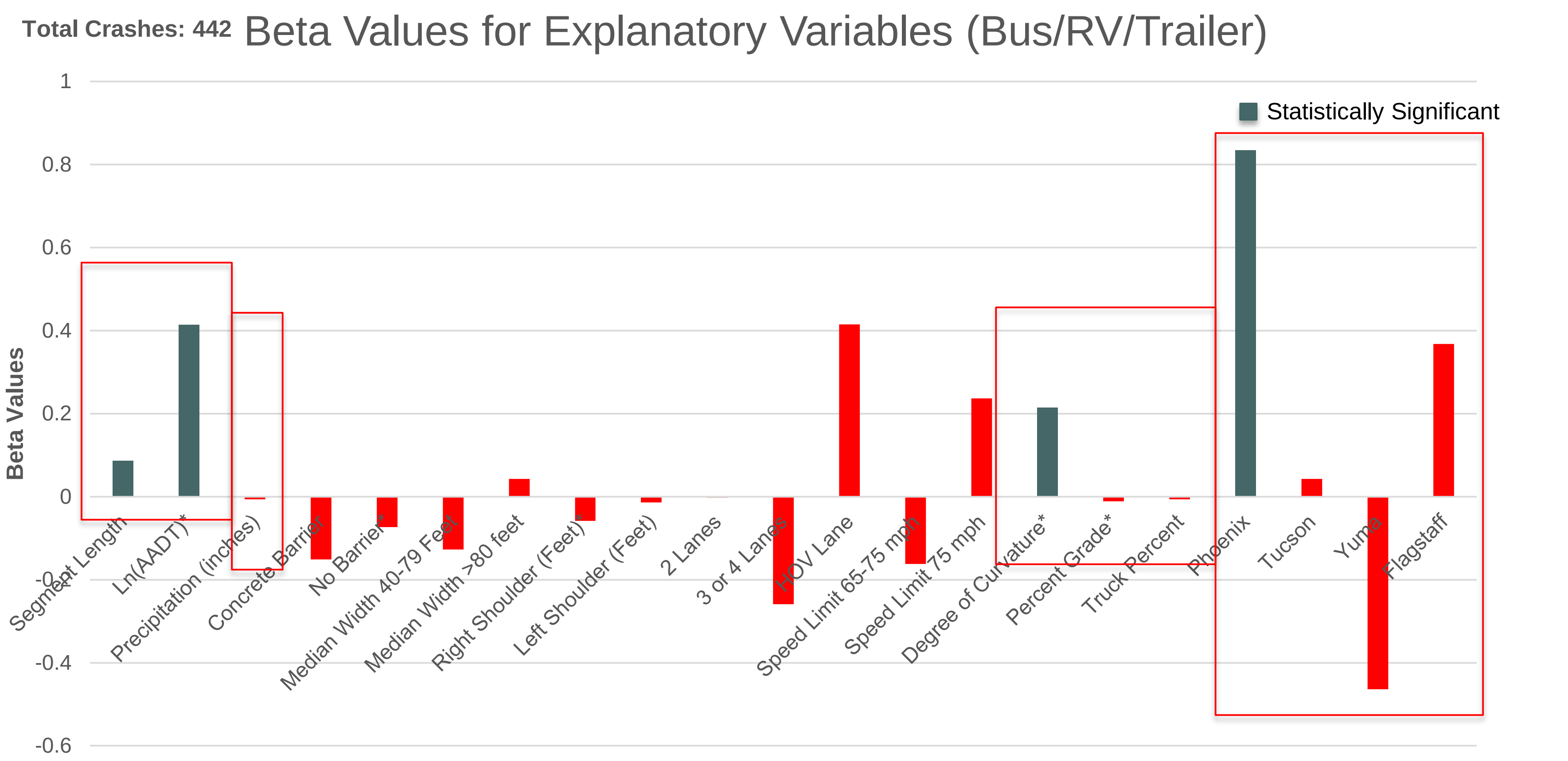
Bus/RV/Trailer Model Results

Total Crashes: 442



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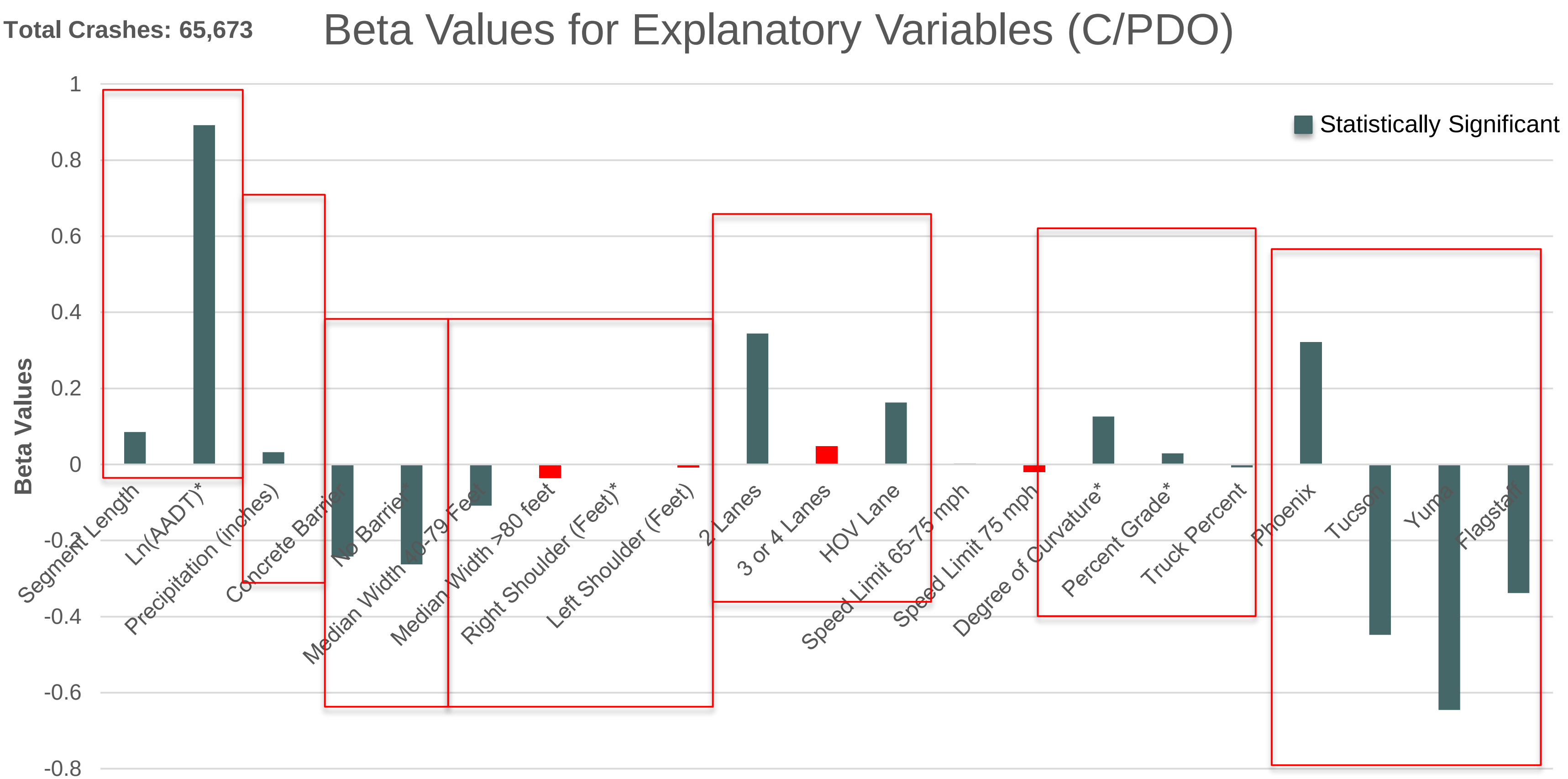
Injury Severity Levels C/PDO Model Results

Total Crashes: 65,673



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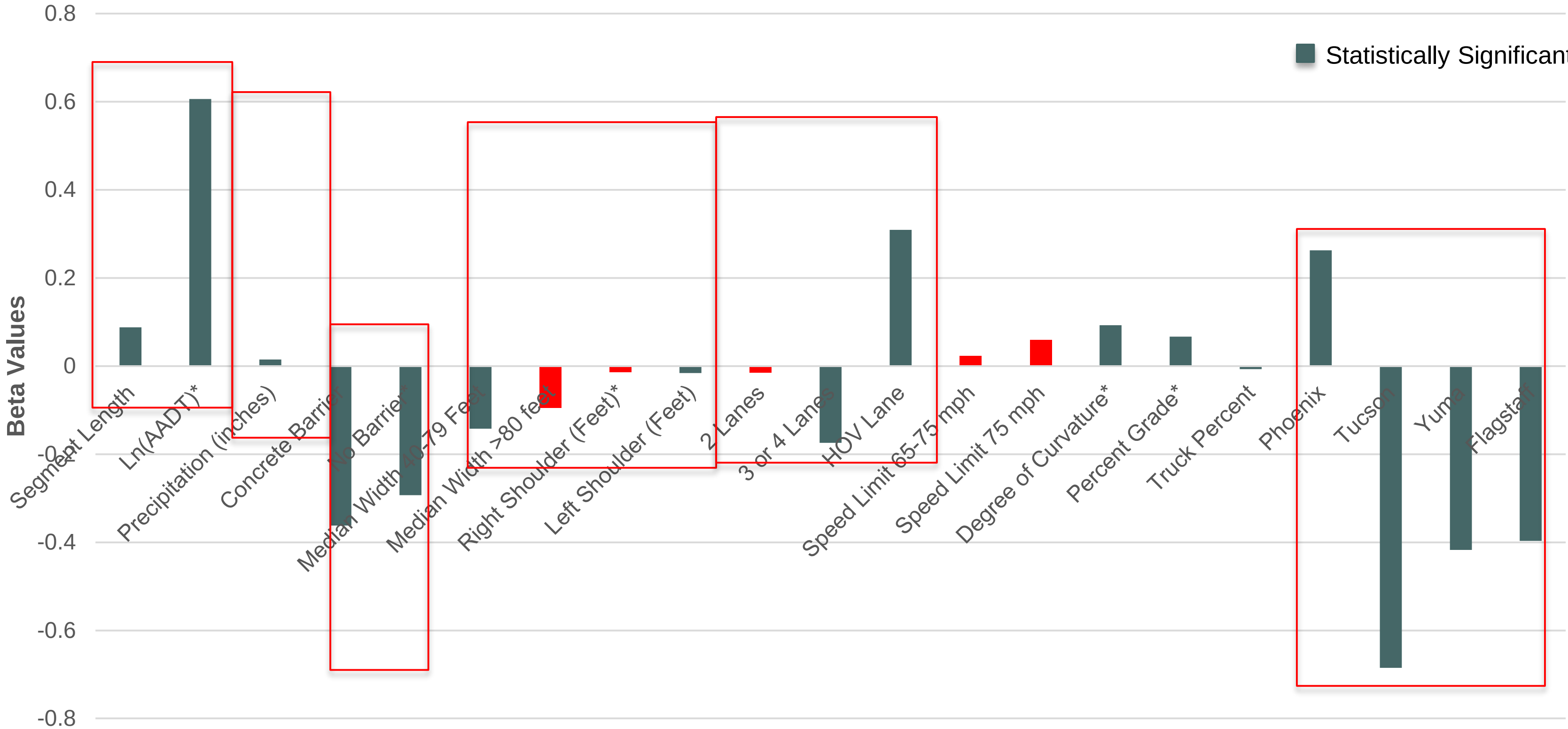
Injury Severity Levels K/A/B Model Results

Total Crashes: 13,002

Beta Values for Explanatory Variables (K/A/B)



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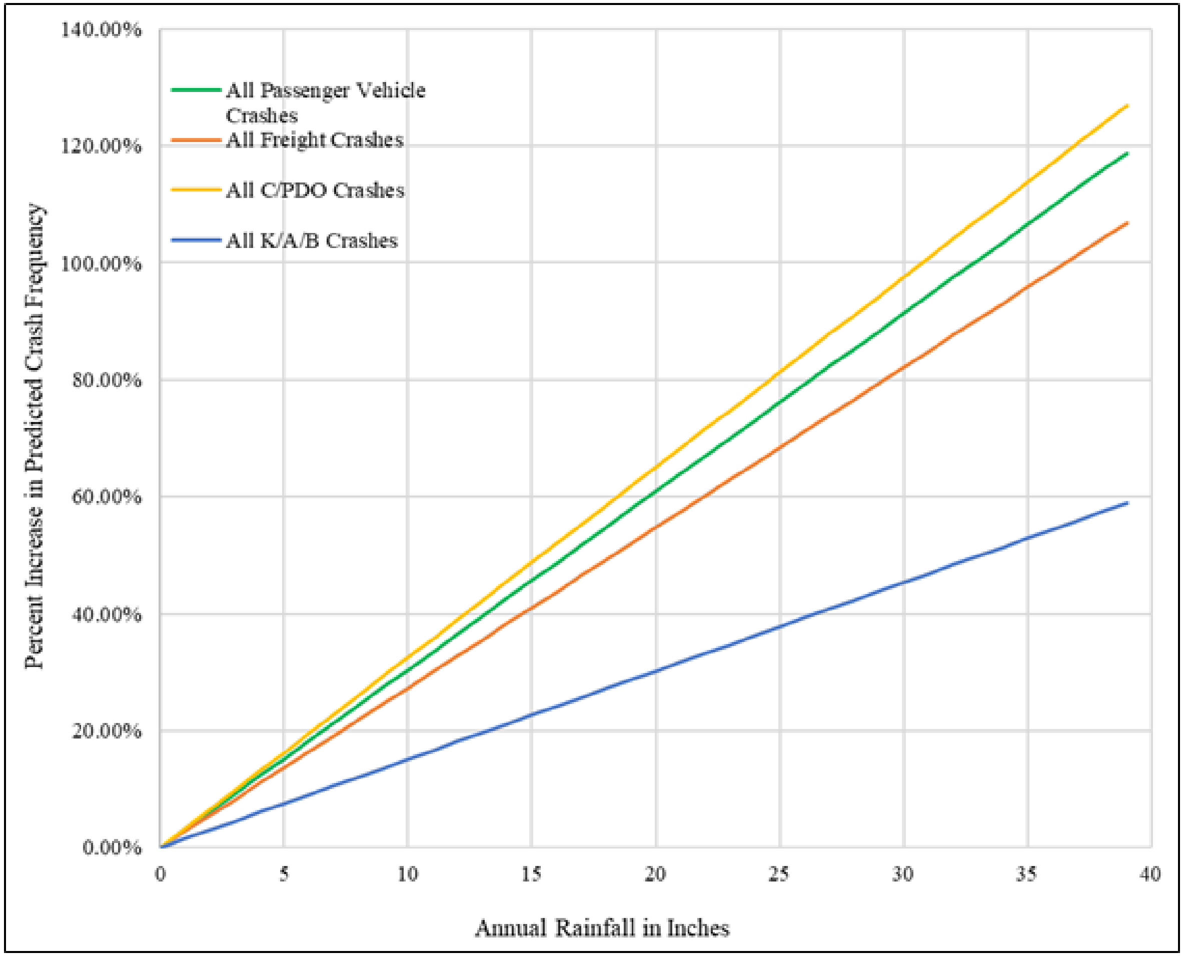
Percent Increase in Predicted Crash Frequency

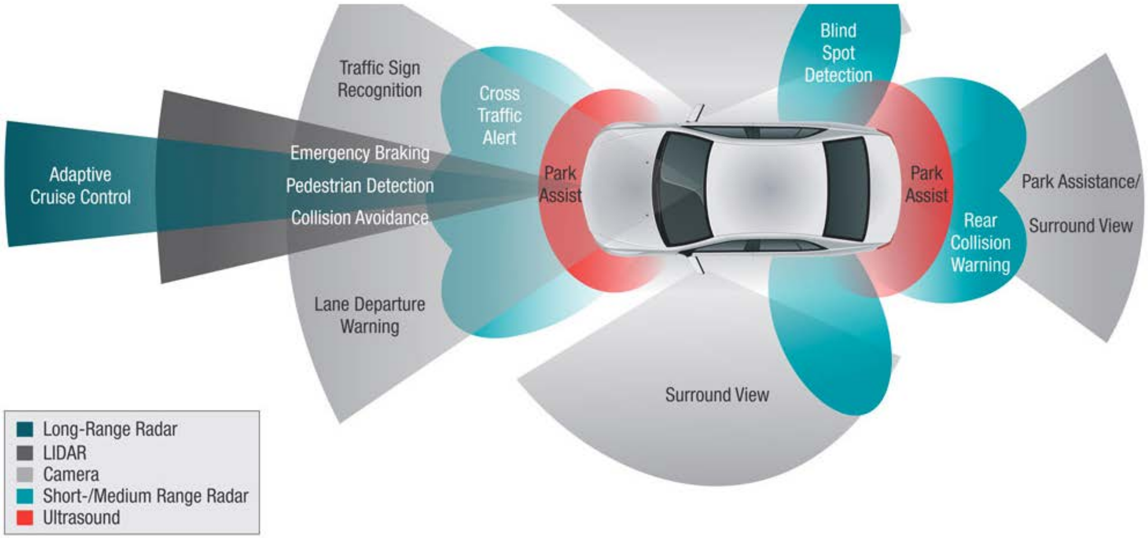


Conclusions

- One of the primary contributions of this paper was using WRF model to obtain accurate, validated precipitation data.
- Precipitation Variable was statistically significant in all models expect the Bus/RV/Trailer and Motorcycle models.
  - In all cases it was statistically significant it was a positive Beta value indicating an increase in the frequency of crashes
- The HOV lane increases the frequency of both frequency-severity models in this paper.
  - This was seen in the passenger vehicle, motorcycle, and severity models.
  - Other lane numbers were not significant in all models (expect 2 lanes for passenger vehicles and C/PDO crashes)
- Agencies should focus one educational campaigns on how to drive in severe weather conditions (not just rain) and HOV usage.
- Agencies should focus on employing new ITS technologies to increase driver awareness and performance.

ITS Countermeasures: Connected Vehicles

- Adaptive Cruise Control
- Collision avoidance technology
- Lane Departure Alerts
- WRF could potentially be used as a source for weather predictions for an in vehicle sensor for vehicle to vehicle communication



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ITS Countermeasure: Active Traffic Management

- Benefits of ATM mainly for congestion caused by crashes.
  - Smoother traffic flow
  - Reduces bottleneck by informing the driver where to merge safely.
  - Can help reduce secondary crashes
  - Can change speed limits for hazardous weather and crashes
  - Shown to decrease crash frequency by 29% in a study in Seattle

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ITS Countermeasure: Dynamic Speed Limits

- Cheaper alternative to ATM
- Can change speed limits based on current road and weather conditions. (rain, dust, snow)

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Thank You. Questions?

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