Utilizing ITS to Reduce Truck Overturn Crashes Due to High Winds at Bordeaux, Wyoming

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Outline

- Background

- Project Location

- Data Sources

- Data Analysis

- High Wind Warning System

Background

- Wyoming noted for frequent severe wind conditions especially at the southeastern part of the state.

- Many wind farms established due to the high wind conditions.

- Wind speeds reach 30 to 40 mph and wind gust speeds of 50 to 60 mph during the winter.

Background

- Wind Direction effect is greatest if it is perpendicular to the road direction.

- High profile vehicles (empty or lightly loaded) are vulnerable to the high wind.

- Previous research have investigated how wind speeds correlated with truck safety.
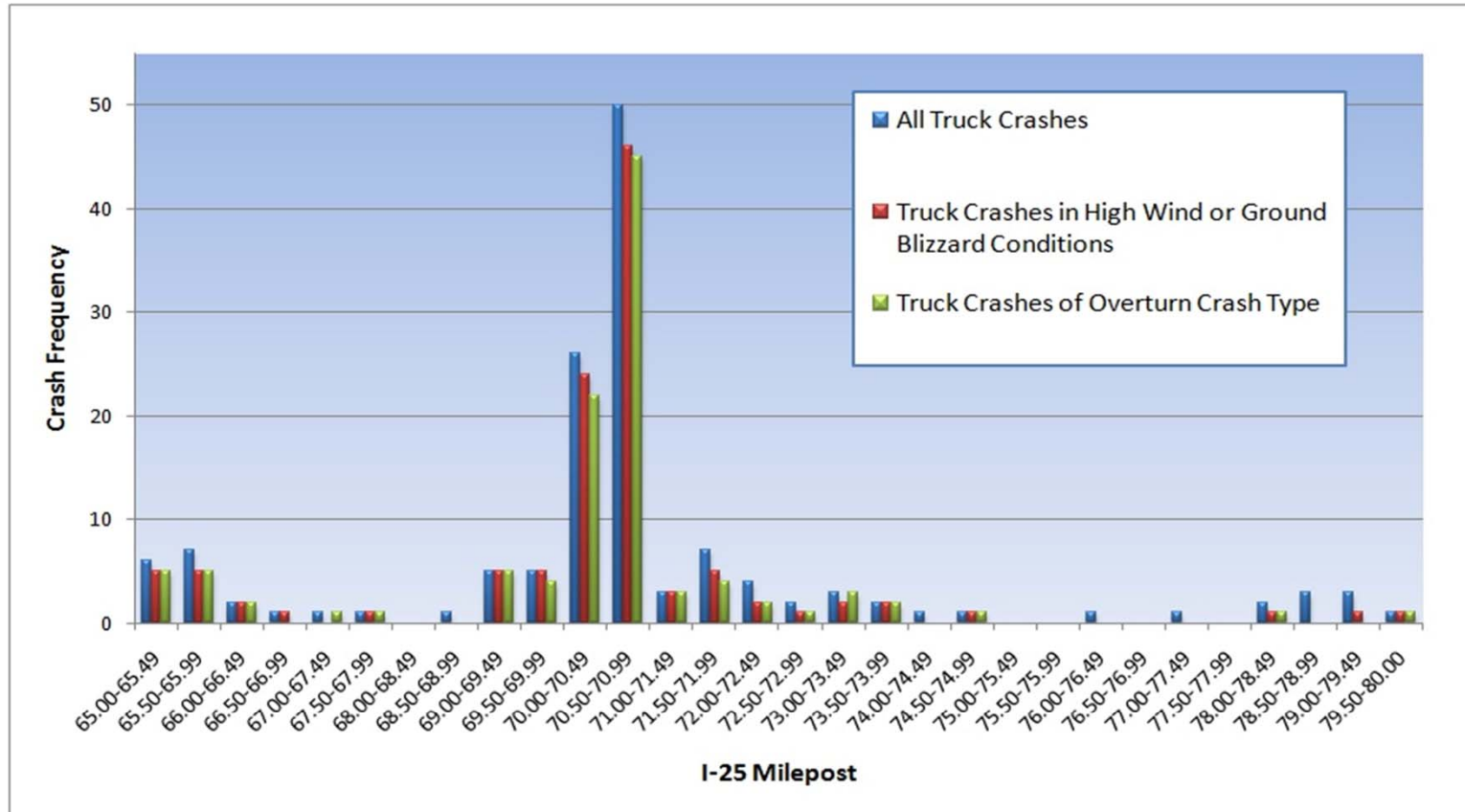
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Research Objectives

- Conduct field studies to provide an overview of the study location and chose the suitable locations for installation of the monitoring equipment.

- Confirm the relation between high wind conditions and high risk of truck crashes.

- Determine appropriate threshold values for the high wind warning system.

- Analyze crash data to create baseline conditions to monitor the future effectiveness of the system.

- Develop final recommendations for the High Wind Warning System.

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Project Location

Milepost 73.03

Milepost 70.62

Milepost 68.45

Image © 2008 DigitalGlobe
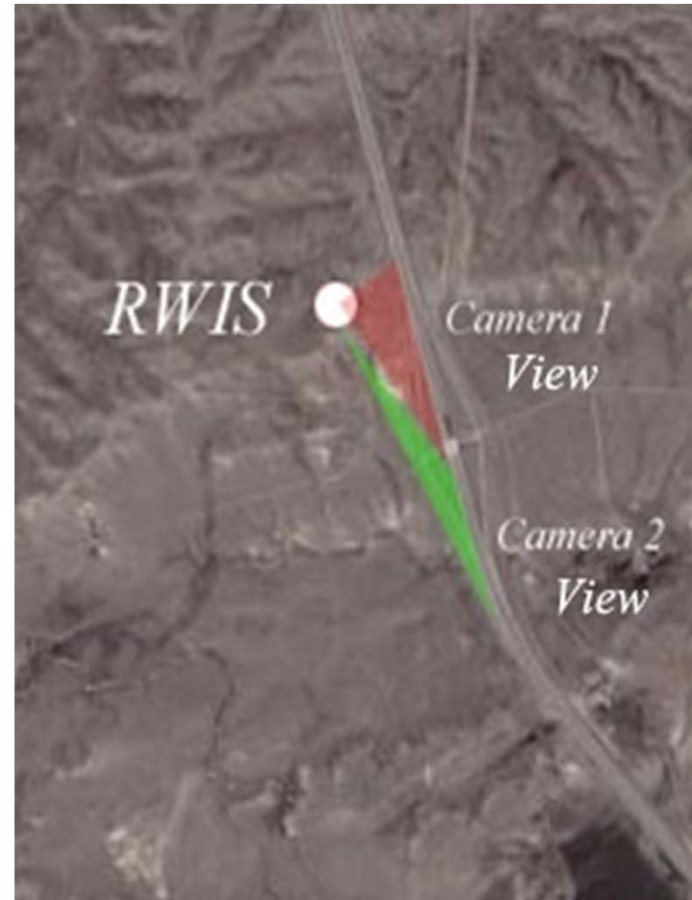© 2008 Tele Atlas

North

Locating the Study Area

Data Sources

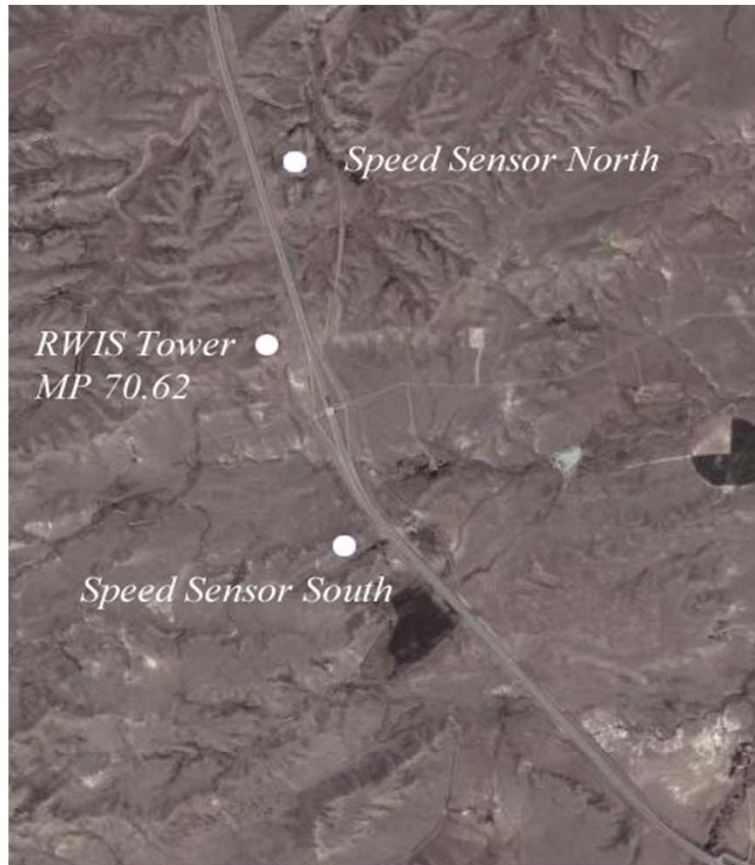- Road Weather Information System (RWIS) Tower with 2 PTZ Cameras

- Two Wavetronix Speed Sensors

ITS Equipment

RWIS TOWER

Propeller Anemonmeter

PTZ Camera 2

PTZ Camera 1

Hygrometers

RWIS Cabinet

DVR Cabinet

RWIS

Camera 1 View

Camera 2 View

ITS Equipment

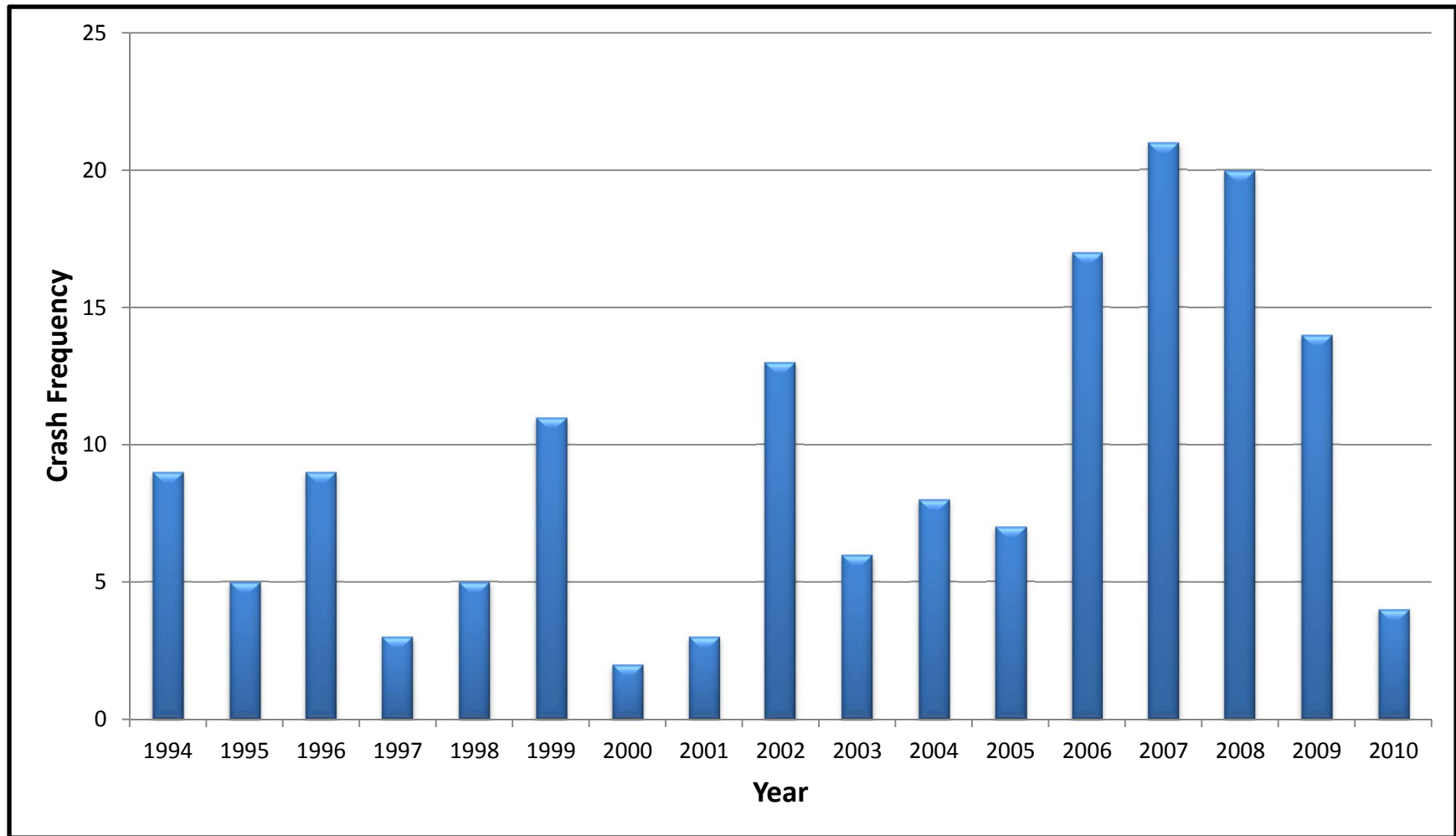**Speed Sensor Cabinet**

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ITS Equipment

HOBO Weather Station

CRASH VIDEO SNAPSHOTS

CRASHES THAT OCCURRED DURING 2008 – 2010 WINTER SEASONS

Index	Crash Key	Milepost	Date	Wind Speed	Wind Gust Speed	Wind Direction
1	200820435	70.50	12/5/2008	53	73	W
2	200820436	70.25	12/5/2008	49	70	SW
3	200820441	70.00	12/17/2008	35	47	W
4	200820901	70.00	12/27/2008	50	66	SW
5	200820908	70.75	12/31/2008	40	62	SW
6	200820909	70.50	12/31/2008	45	67	SW
7	200822845	70.00	12/31/2008	47	71	SW
8	200900353	70.62	1/5/2009	58	76	W
9	200900354	70.60	1/5/2009	53	74	W
10	200901773	70.00	1/21/2009	40	57	SW
11	200902570	70.62	2/6/2009	45	62	SW
12	200902571	70.00	2/6/2009	55	68	SW

CRASHES THAT OCCURRED DURING 2008 – 2010 WINTER SEASONS

Index	Crash Key	Milepost	Date	Wind Speed	Wind Gust Speed	Wind Direction
13	200902572	70.63	2/6/2009	47	72	SW
14	200903550	69.98	3/8/2009	48	68	W
15	200903552	70.50	3/8/2009	45	73	W
16	200904562	69.88	3/8/2009	51	71	W
17	200903566	71.50	3/9/2009	9	11	NE
18	200915686	70.62	10/31/2009	50	63	SW
19	200918191	65.00	12/07/2010	6	11	E
20	200918731	70.25	12/10/2009	35	55	SW
21	200918197	70.50	12/12/2009	51	70	W
22	201000873	70.60	01/12/2010	40	51	SW
23	201000879	70.50	01/18/2010	29	38	SW
24	201002729	69.10	02/03/2010	20	30	SW

Data Analysis

- **Multiple Logistic Regression Model**
  - Response Variable: Overturning Truck Crash, 1 is assigned for overturning and 0 otherwise
  - Predictor Variables: All weather condition parameters

- **Modeling Methodology**
  - 95% confidence intervals
  - All parameters included in initial model
  - Parameters with p-value larger than 0.05 removed from model one at a time starting with largest p-value variable
  - Filtering loop continue until all parameters have p-value < 0.05
  - Hosmer and Lemeshow goodness-of-fit test to determine how well the model fit the data

Data Analysis

- Multiple Logistic Regression Model Equation

$$E\{Y_i\} = \frac{exp^{(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k)}}{1 + exp^{(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k)}}$$

Model Output

Predictor Variable	Initial Model		Final Model	
	Estimate	P-value	Estimate	P-value
Intercept(β_0)	-1.7483	0.0782	-1.7522	0.0426
Lighting Condition (β_1)	0.1952	0.8049	-	-
Road Condition (β_2)	-2.6857	0.0061	-2.5628	0.0048
Wind Speed(β_3)	0.1252	0.0801	0.0893	<0.0001
Wind Gust(β_4)	-0.035	0.5257	-	-
Wind Direction Binary(β_5)	0.3387	0.7799	-	-

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Wind Speed and Truck Overturning Relationship
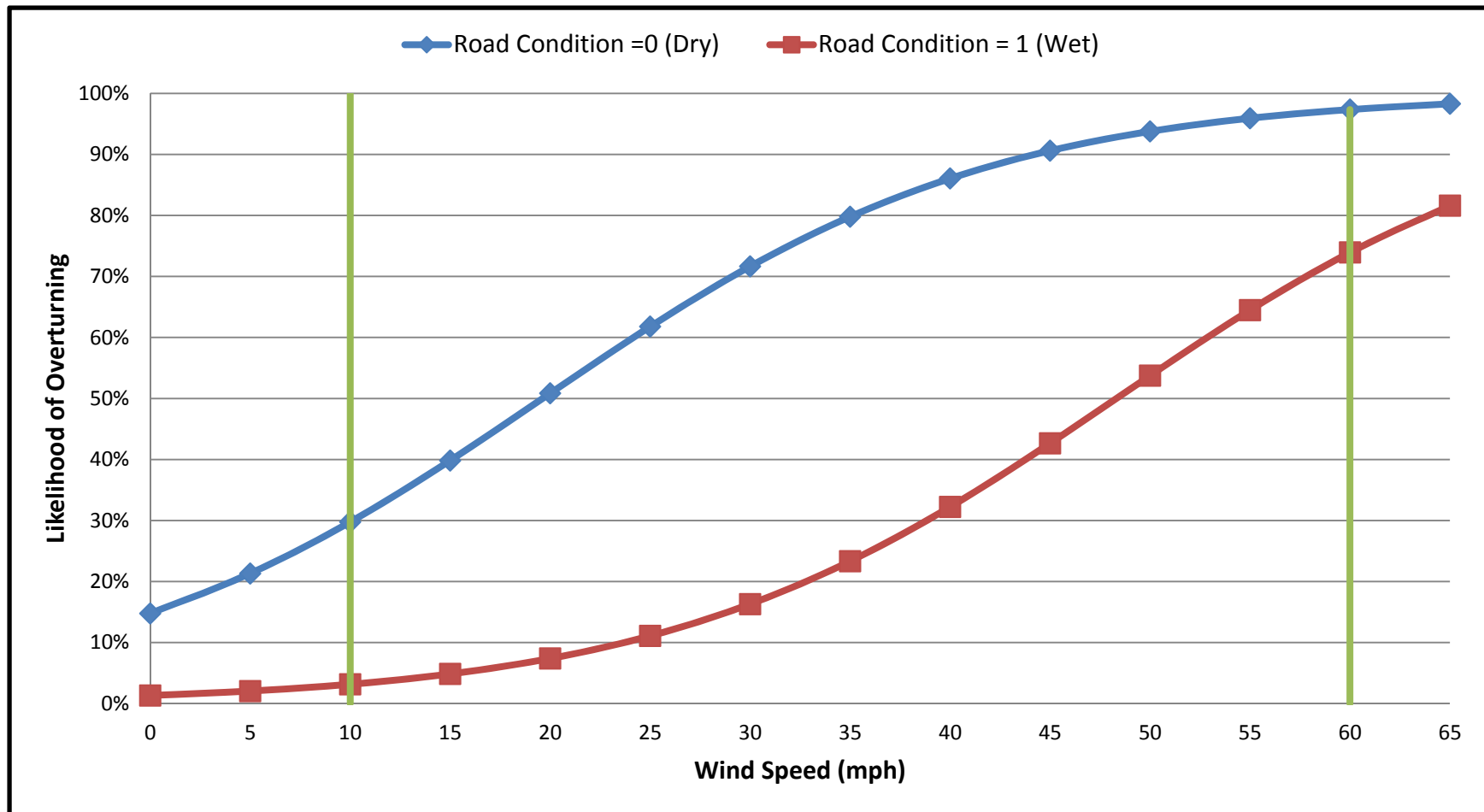
Vehicle Speeds at Different Wind Conditions

| Vehicle Type	Category	Average Vehicle Speed (mph)	Standard Deviation
Cars	Wind Speed <=10mph	76.65	4.86
	Wind Speed >=30mph	77.09	7.03
Trucks	Wind Speed <= 10mph	69.75	8.42
	Wind Speed >=30mph	67.72	8.63

RWIS vs. HOBO
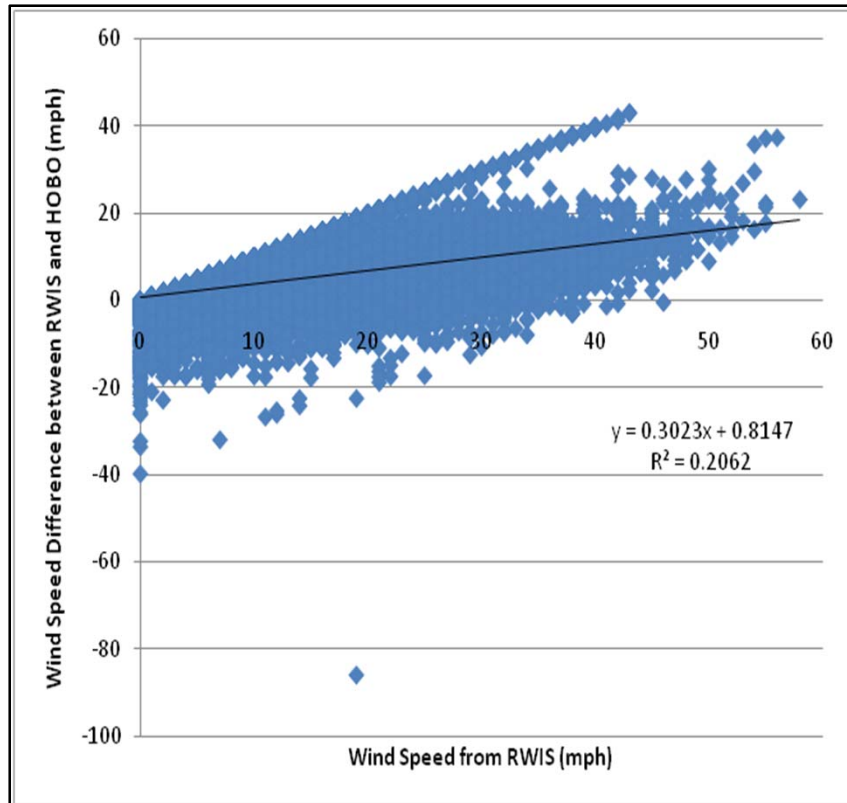
- RWIS located near the top of an adjacent hillside.

- HOBO located 40 feet near the roadside.

- Positive difference indicate RWIS Data > HOBO Data.

- RWIS wind speeds higher than HOBO wind speeds.

- Difference increases as the wind speed increases.

Truck Weight Analysis Result
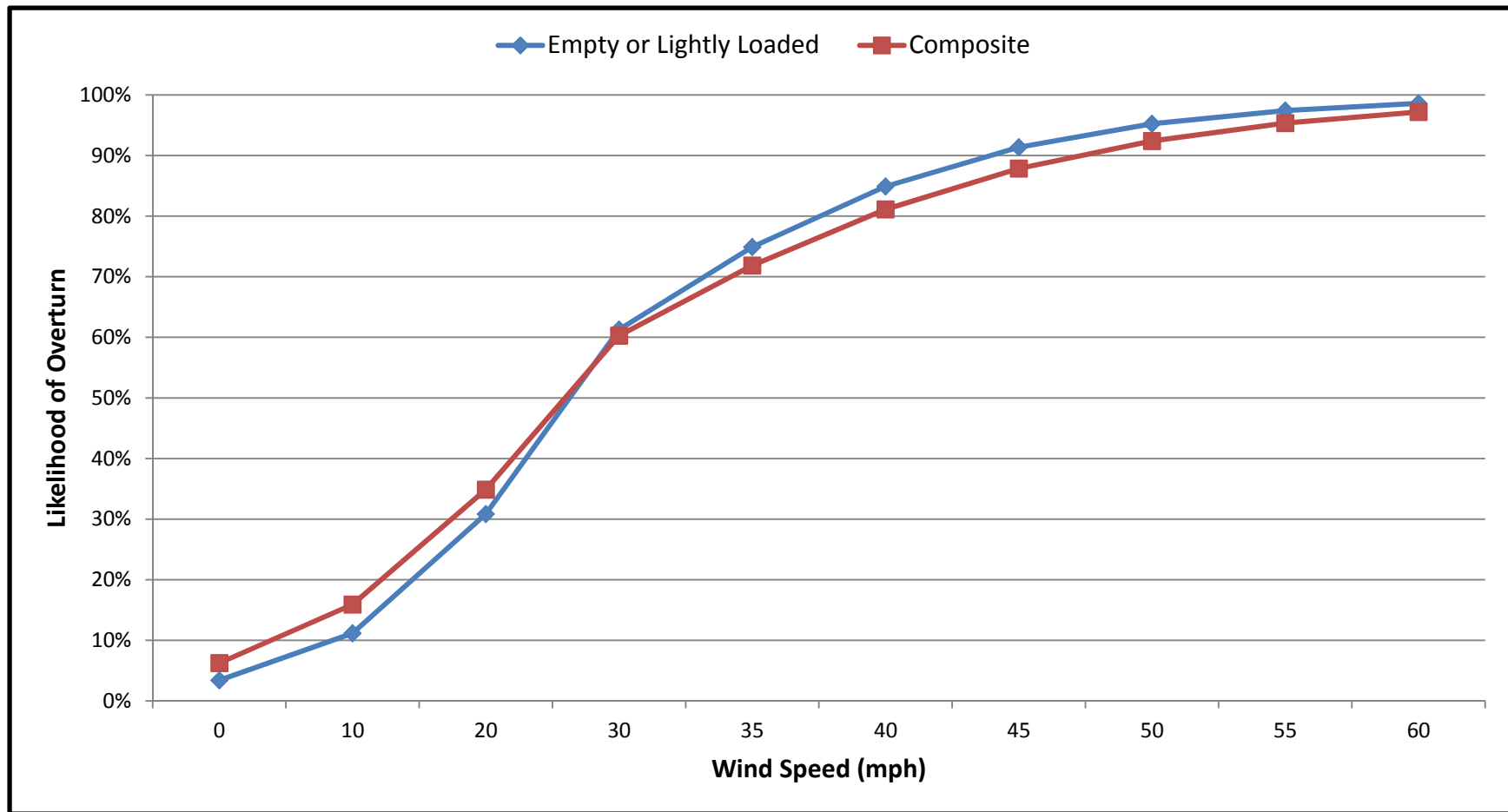
Crash Frequency vs. Wind Speed
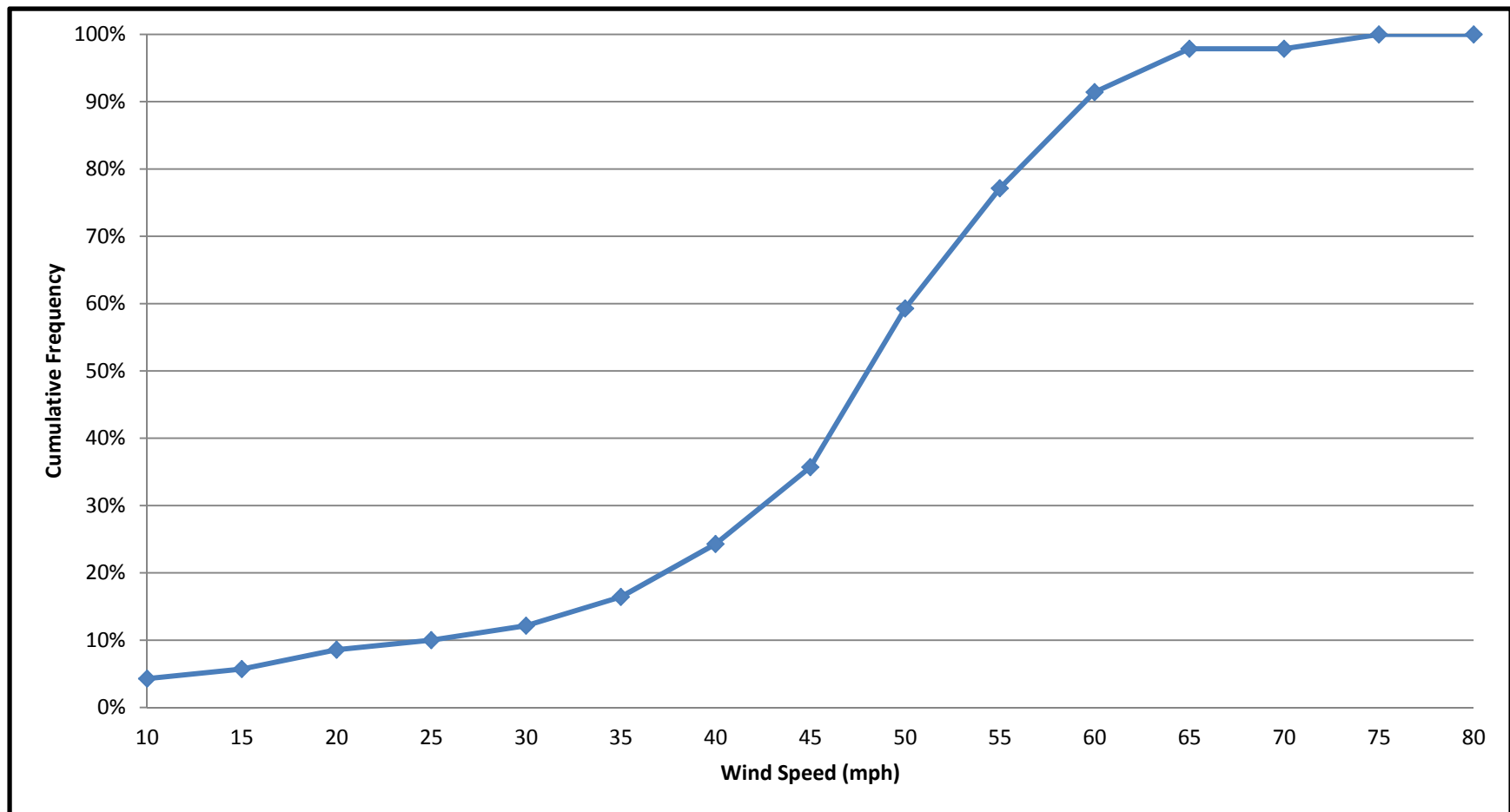
Operational Levels

- Level 1: 30mph wind speed threshold was recommended for advisory warning messages on the DMS's.

- Level 2: 40 mph wind speed threshold was determined for road closure to all high-profile, light-weight vehicles.

- Level 3: 45mph wind speed threshold was determined for road closure to all trucks.

High Wind Warning System

- ❖ DMS signs (2 were installed adjacent to the corridor)
- ❖ CB Wizard
- ❖ Highway Advisory Radio (HAR)
- ❖ 511 Phone Service
- ❖ Website
- ❖ Weigh-In-Motion (WIM)
- ❖ Over Height Vehicle Detector (OHVD)

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QUESTIONS?