Changing the Way we think about Traffic Safety: Current Traffic Safety Research Initiatives

Dr. Mohamed Abdel-Aty, PE

Professor

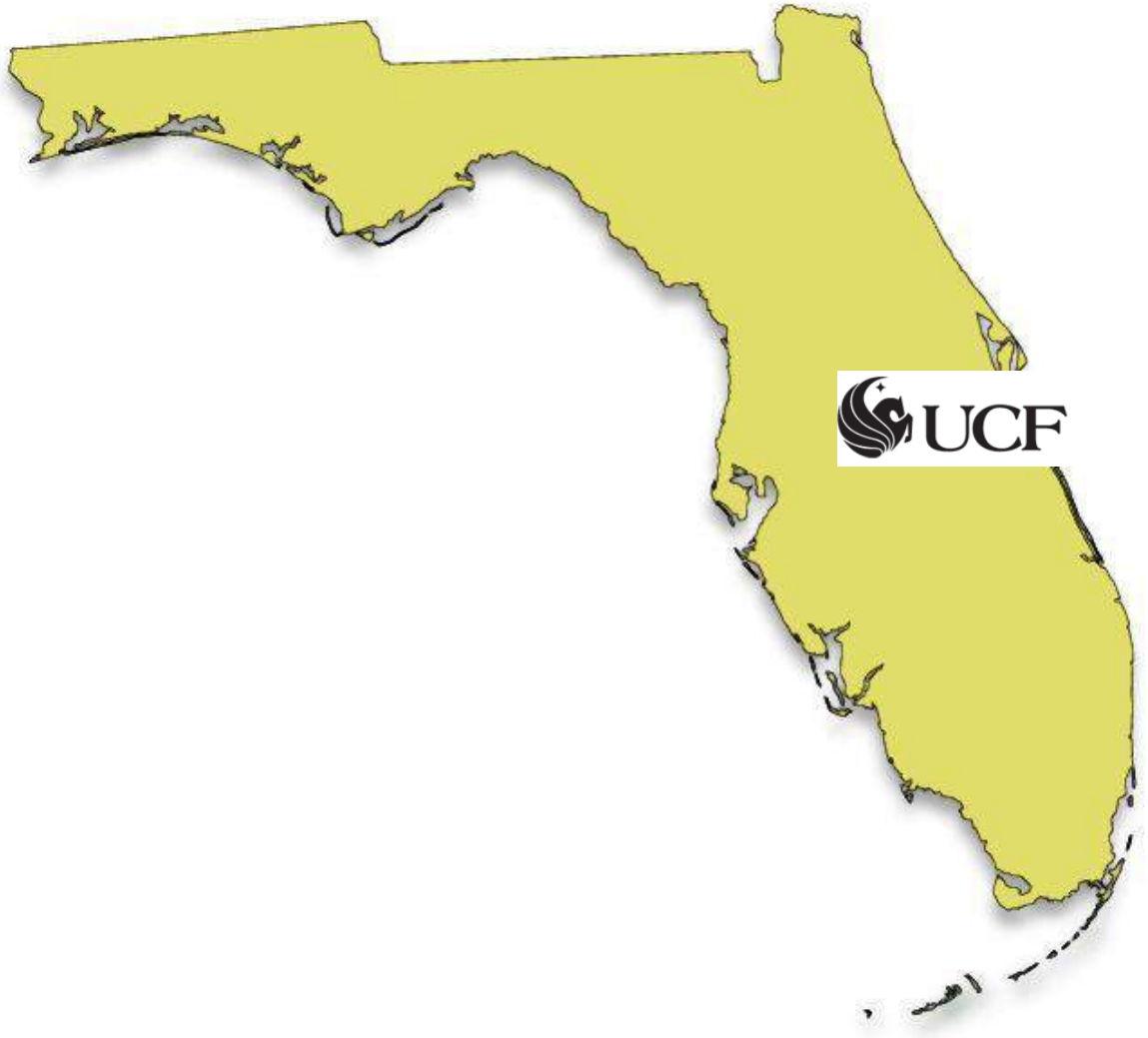
Department of Civil, Env. & Construction Engineering

Deputy Director

Center for Advanced Transportation Systems Simulation

University of Central Florida, USA

Associate Editor, Accident Analysis & Prevention


UCF

Florida
0 20 40 60 80
Miles
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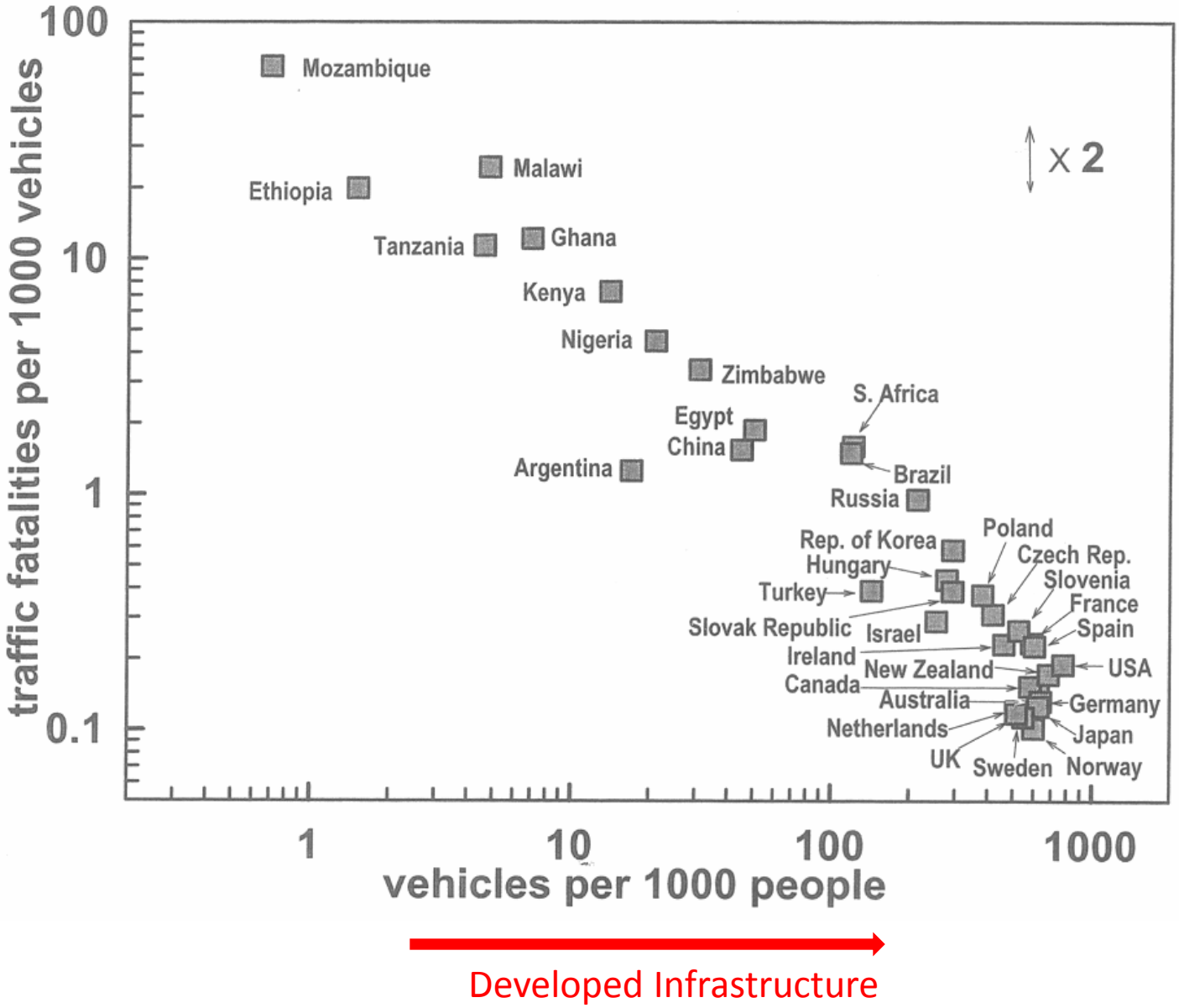
Traffic Safety: A Growing Concern

- The concern about traffic safety has been growing over the years in developed and developing countries alike
- In 2010; ***33,883*** people were killed in traffic crashes in the US. About *2.24 million* people were injured (total 5.5 million crashes cost exceeds $230 Billion)

Fatality rate vs. Motorization (Evans, 2004)



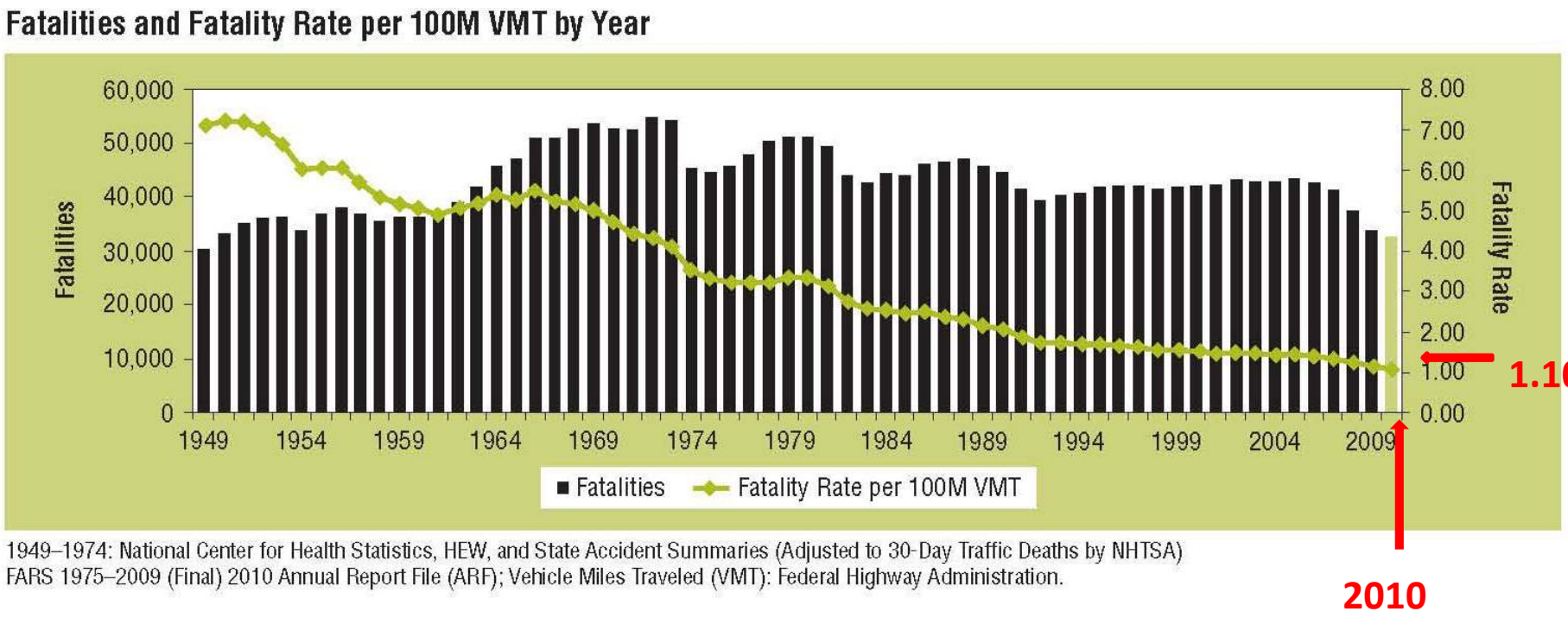
Crash Rates?

- In the US in 2008, Traffic fatalities, 0.78 per 100 Million Vehicle Km Traveled, 12.3 Fatalities per 100,000 Population, 14.5 Fatalities per 100,000 Registered Vehicles, and 17.9 Fatalities per 100,000 Licensed Drivers.
- In Belgium in 2007, 10.2 fatalities per 100,000 of the population (adjusted), -21.8% change from 1997. Front seat belt wearing rate 79%
- In Greece in 2007, 14.1 fatalities per 100,000 of the population (adjusted), -24.9% change from 1997. Front seat belt wearing rate 75%
- In China in 2005, the fatality rate was about 7.6 per 100,000 people
- In Egypt in 2006, Traffic Fatalities were 8.6 per 100,000 of the population, 156.3 Fatalities per 100,000 Registered Vehicles

The American Experience

- Recently there is a notable improvement
- The number of traffic fatalities in 2010 reached its lowest level since 1961.
- There was a 9.7% decline in the number of people killed in motor vehicle crashes in the United States, from 41,259 in 2007 to 37,261 in 2008. This decline of 3,998 fatalities is the largest annual reduction in terms of both number and percentage since 1982.
- Although people may have traveled less in 2008 due to the higher price of gas, the overall injury rate per 100 million VMT declined by 2.4 percent, and the fatality rate also fell to a historic low of 1.27 per 100 Million VMT in 2008.

Fatalities and Fatality Rates per 100 million VMT from 1949 - 2010



1949–1974: National Center for Health Statistics, HEW, and State Accident Summaries (Adjusted to 30-Day Traffic Deaths by NHTSA)
FARS 1975–2009 (Final) 2010 Annual Report File (ARF); Vehicle Miles Traveled (VMT): Federal Highway Administration.

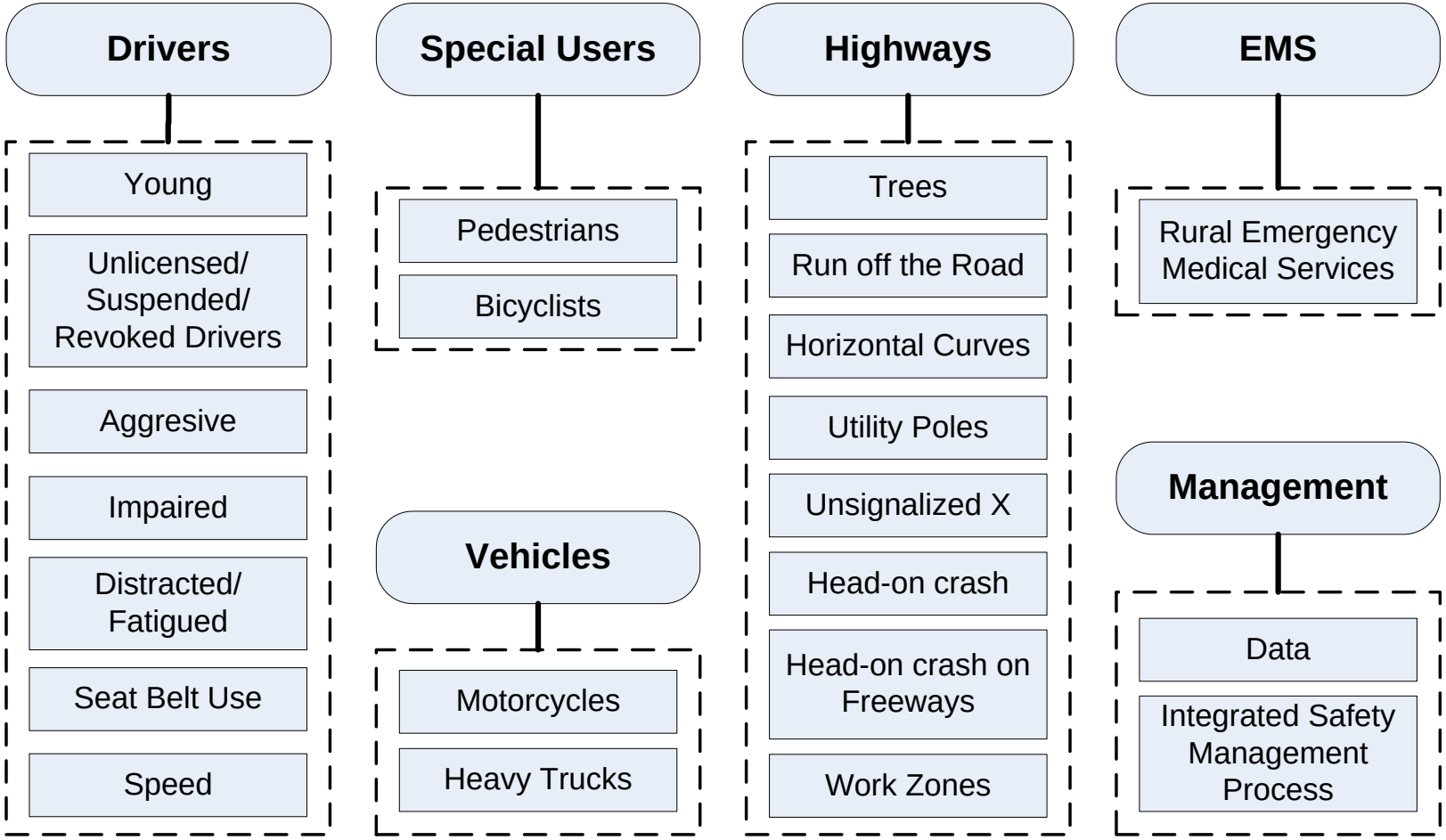
Adapted from FARS, USDOT

In 2011 about 1.05, FL 1.25 Fatality per 100 mil VMT

Strategic Highway Safety Plan

- **NATIONAL GOAL**: AASHTO in 1998, a total reduction of annual highway fatalities by 5,000 to 7,000.
- In 2003, AASHTO, the Governors Highway Safety Association, The American Association of Motor Vehicle Administrators, and the U.S. Department of Transportation set as a goal the reduction of the nation's highway fatality rate by 2008 to not more than one fatality per 100 million vehicle miles traveled (VMT).

To achieve these goals, the updated AASHTO SHSP in 2005 proposed an integrated approach and a series of tools to facilitate for state and local transportation and safety agencies to develop comprehensive highway safety plans. The plan also includes strategies in 22 key emphasis areas that affect highway safety.



Mostly also reflected in States' SHSP

42,000 people were killed in high way crashes in 2003. The following chart shows the number of deaths associated with specific emphasis areas identified in the SHSP.

Contrast to Greece

Emphasis Area	2003 Deaths	Comments
Young drivers	3,571	Ages 16–20
Suspended/revoked licenses	6,973	Involving a driver with invalid licensing
Older drivers	2,716	Ages 65–74
	3,914	Age 74+
Aggressive/speeding drivers	11,990	Speeding/driving too fast for conditions
	3,565	Reckless driving
Impaired drivers	17,013	Alcohol impaired
Drowsy or distracted drivers	3,730	Inattentive
	1,577	Fell asleep
Safety belts	18,019	Driver's and occupants unbuckled
Pedestrians	4,749	
Bicyclists	622	
Vehicle and train crash	324	
Motorcyclists	3,661	
Heavy trucks	4,986	Deaths in vehicles
Safety enhancements in vehicles		Cannot accurately ascertain, although 14 unintentional deaths were associated with carbon monoxide alone in 2002
Run-off-the-road	18,781	Most harmful event involved fixed object or rollover
Intersections	6,903**	
Work zones	1,028	
Survivability of severe crashes	1,850**	Rural: Time from crash to hospital >1 hour
	258**	Urban: Time from crash to hospital >1 hour
TOTAL DEATHS	**42,643***	

Strategic Highway Safety Plan (cont.)

Currently AASHTO is developing "**Toward Zero Deaths: a National Strategy on Highway Safety".**

The national strategy will have ***two tiers: Cultural Change and Building the Foundation of Safety.***

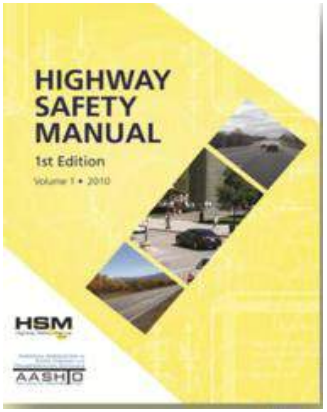
Examples of Implementation guides and tools

- **Highway Safety Manual**, Provide factual information and tools to facilitate roadway design and operational decisions based on explicit consideration on safety consequences.
- **SafetyAnalyst:** A set of software tools used by highway agencies to improve their programming of site-specific highway safety improvements.
- **IHSDM: Interactive Highway Safety Design Model**, A suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on highways.

Highway Safety Manual

- The Transportation Research Board has recently (2010) published the *Highway Safety Manual* to fill the gap between state-of-the-art and state-of-practice.

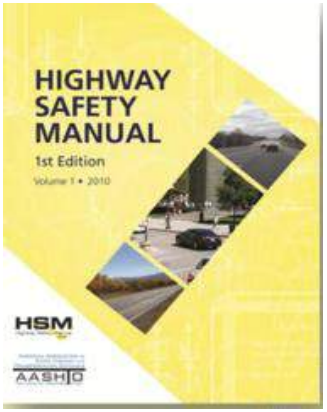
  - Part A: Introduction, Human Factors and Fundamentals
  - Part B: Roadway Safety Management Process
  - Part C: Predictive Method
  - Part D: Crash Modification Factors



Highway Safety Manual

Highway Safety Manual (HSM) Implementation Goals

- Integration of Safety in day to day activities
- HSM becomes a tool routinely used by transportation professionals
- Safety is always another quantified parameter
  - Safety Performance Measurement
    - Safety Performance Functions (SPF)
    - Crash Modification Factors (CMF)



Strategic Highway Research Program

SHRP2: Strategic Highway Research Program 2, Safety, aims to prevent or reduce the severity of highway crashes by understanding driver behavior and performance.

Use Naturalistic driving data from multiple locations in the US.

Understand how the driver interacts with and adapts to the vehicle, traffic environment, roadway characteristics, traffic control devices, and the environment.

Collect pre-crash, crash, and exposure data.

Recent Safety Improvement Programs

- FHWA: Highway Safety Improvement Program
- FHWA: Intersection Safety Program
- FHWA: Local and Rural Road Safety Program
- FHWA: Pedestrian & Bicycle Safety Program
- FHWA: Roadway Departure Safety Program
- FHWA: Speed Management Safety Program
- FHWA: Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures

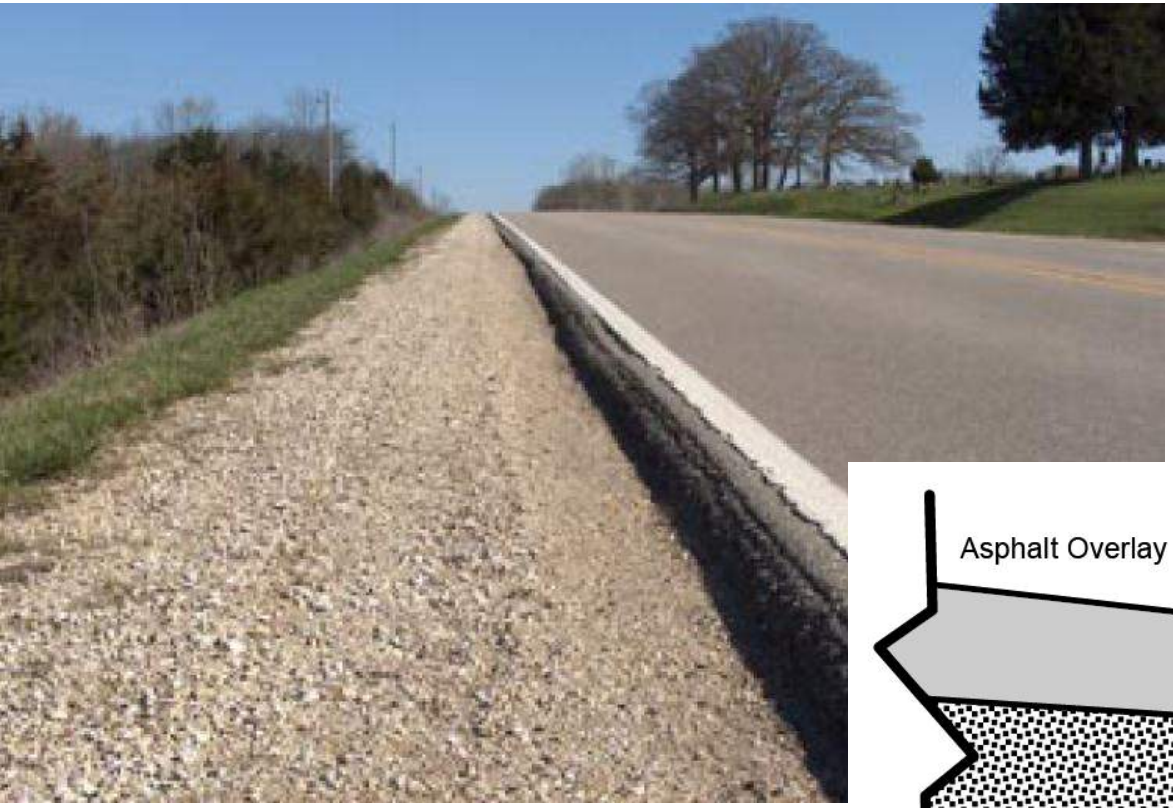
Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
SIGNS											
Implement sign corrections to MUTCD standards	All	Injury	Urban	Local		5	15	10			Meta Analysis
	All	PDO	Urban	Local		5	7	6			Meta Analysis
Install chevron signs on horizontal curves	All	Fatal/ Injury	Rural	2-lane		38	20				
	All	All				15	35				
	All	All	Urban	Arterial (urban)		5	64	49			Simple Before-After
	All	All				15	20				
	All	All				15	35				
	All	All				15	50				
Install curve advance warning signs	All	Fatal/ Injury	Rural	2-lane		38	10				
	All	Injury				5	30	71			Meta Analysis
	All	PDO				5	8	76			Meta Analysis
	All	All				15	30				
	All	Fatal				15	55				
	All	All				15	30				
	All	All				15	23				
	All	Injury				15	20				
	Head-on	All				15	29				
	ROR	All				15	30				
	ROR	All	All	All		1	30				
Install curve advance warning signs (advisory speed)	All	Injury				5	13	9			Meta Analysis
	All	PDO				5	29	23			Meta Analysis
	All	All				15	29				

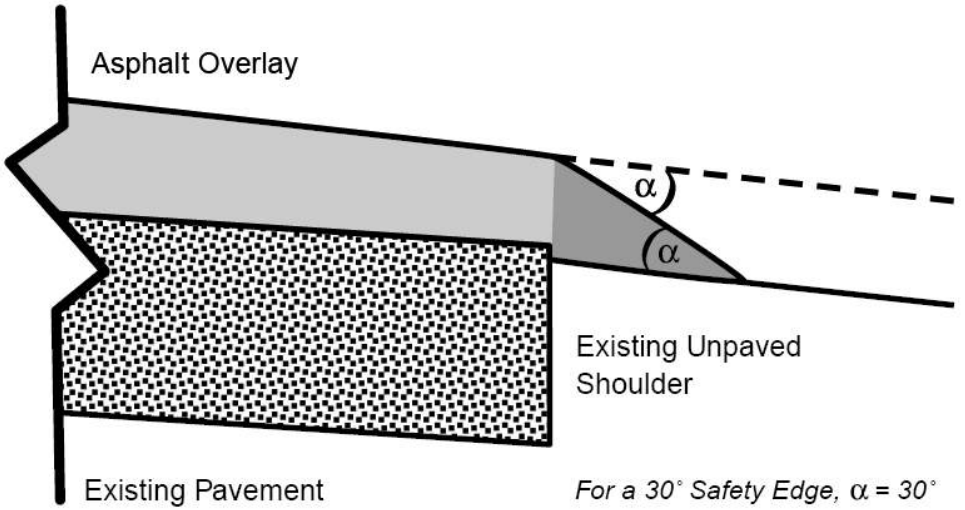
Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Prohibit on-street parking	All	All	Urban	Arterial (64ft)	30,000	5	42	8			Simple Before-After
	All	All				15	22				
	All	All				15	8				
	All	All				15	35				
	All	Injury	Urban	Arterial		5	20	5			Meta Analysis
	All	Injury	Urban	Arterial (64ft)	30,000	5	35	14			Simple Before-After
	All	PDO	Urban	Arterial		5	27	2			Meta Analysis
	All	PDO	Urban	Arterial (64ft)	30,000	5	48	1			Simple Before-After
	Fixed object	All				15	40				
Raise posted speed	All	All	All	All		40	11				Paired comparison
	Fatal/injury	All	All	All		40	7				Paired comparison
Raise posted speed by 5 mph	All	All	All	All		40	8				Simple Before-After
Raise posted speed by 10-15 mph	All	All	All	All		40	15				Simple Before-After
Reduce mean speed by 5% through speed limit change and enforcement	All	Fatal	All	All		5	17	5			Meta analysis
	All	Injury	All	All		5	7	3			Meta analysis
	All	PDO	All	All		5	5	4			Meta analysis
Reduce mean speed by 10% through speed limit change and enforcement	All	Fatal	All	All		5	32	9			Meta analysis
	All	Injury	All	All		5	15	5			Meta analysis
	All	PDO	All	All		5	10	8			Meta analysis
Reduce mean speed by 15% through speed limit change and enforcement	All	Fatal	All	All		5	44	14			Meta analysis
	All	Injury	All	All		5	22	8			Meta analysis
	All	PDO	All	All		5	15	12			Meta analysis

Consideration and Implementation of Proven Safety Countermeasures

- Road Safety Audits (crash reduction up to 60%)
- Rumble Strips and Rumble Stripes (15% of injury crash reduction on rural two-lane roads).
- Median Barriers (Cable systems)
- Roundabouts
- Left and Right-turn lanes at stop controlled Intersections
- Yellow change intervals
- Medians and Pedestrian refuge areas at Urban and Suburban Areas
- Safety Edge (30-35°)

Safety Edge




Asphalt Overlay
α
α
Existing Unpaved Shoulder
Existing Pavement
For a 30˚ Safety Edge, α = 30˚

Recent Safety Improvement Programs

- NHTSA: Countermeasures that Work: Highway Safety *Countermeasure* Guide (4th Ed. 2009).
- NHTSA: *Aggressive* Driving Enforcement: Strategies for Implementing Best Practices
- NHTSA: Identifying Strategies to Reduce the Percentage of *Unrestrained* Young Children
- NHTSA: Increasing *Seat Belt* Use Through State-Level Demonstration Projects
- NHTSA: Development and Testing of Countermeasures for *Fatigue* Related Highway Crashes
- NHTSA: Driver Strategies for Engaging in *Distracting* Tasks Using In-vehicle Technology
- *CMF* Clearinghouse

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http://www.cmfclearinghouse.org/
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CRASH MODIFICATION FACTORS CLEARINGHOUSE

Quick Search

enter search term(s)

- narrow by countermeasure category -
- narrow by crash type -
- narrow by crash severity -
- narrow by roadway type -

Advanced Search

Search CMFs

Need Help?

Find out more about the Star Quality Ratings for CMFs

Read more about the star quality rating applied to CMFs in the Clearinghouse. The star rating is based on a scale (1 to 5), where a 5 indicates the highest or most reliable rating.

A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification

Recently Added CMFs

Improve pavement friction (increase skid

Install median on the minor approach of an

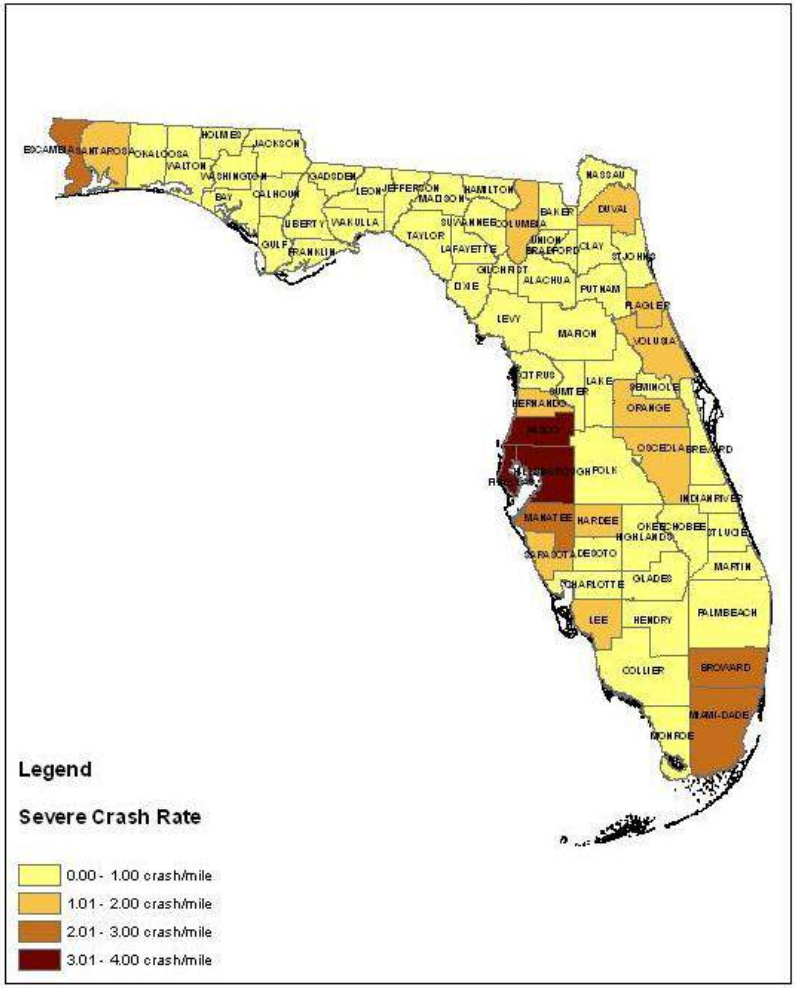
Convert minor-road stop control to all-way

Current Safety Approach

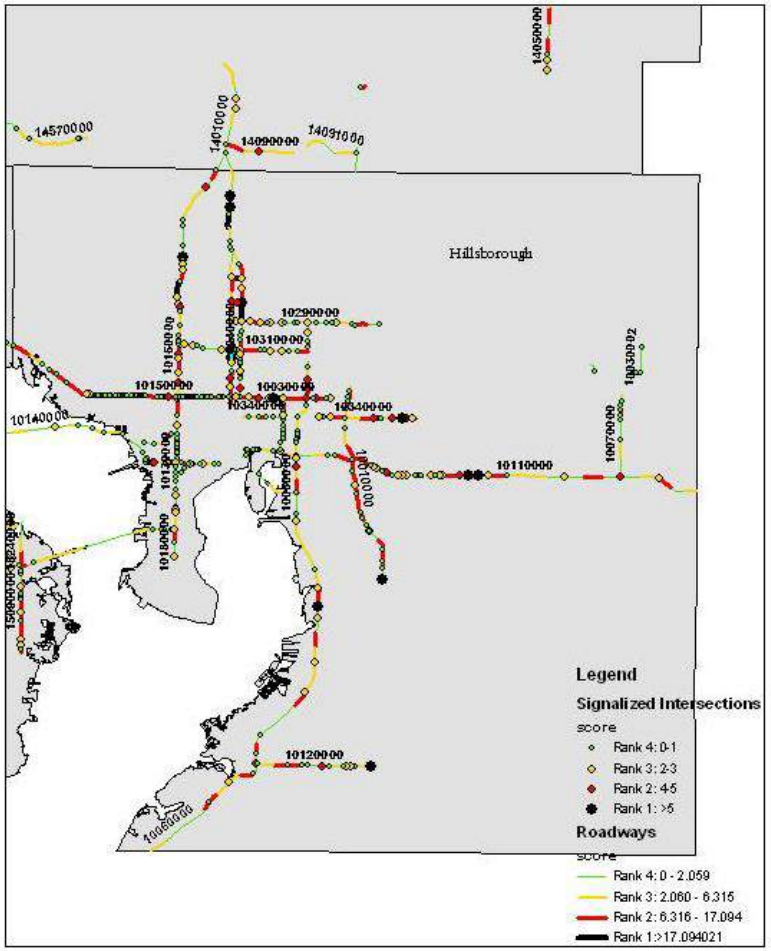
- Mostly Re-active
- Depend on black “hot” spot identification and identifying the factors that contribute to crash occurrence and severity
- Problems already occurring and damage already done
- Important but not enough
- Challenges are increasing and resources are limited

Macro/Micro Level
GIS Analysis

County Severe Crashes Rate per Mile

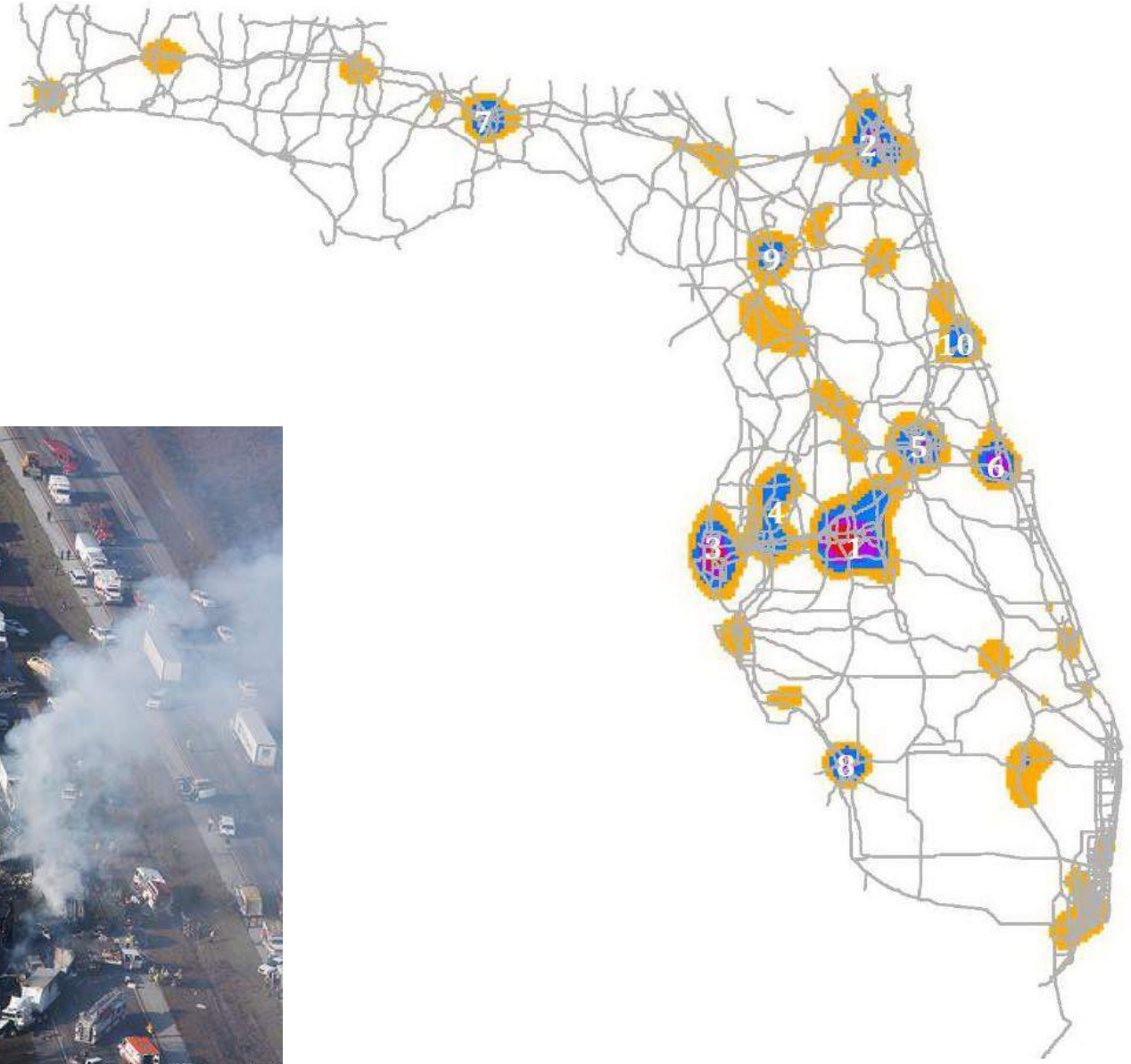


Pasco/Pinellas/Hillsborough Counties Cntd.



Fog/Smoke Areas

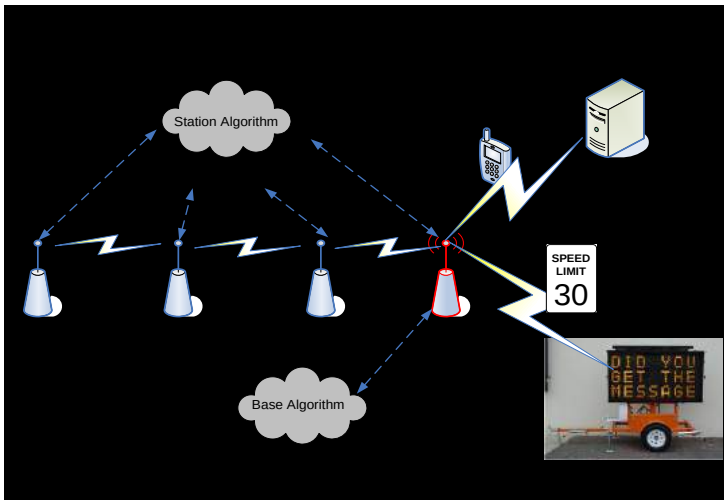
GIS Cluster analysis



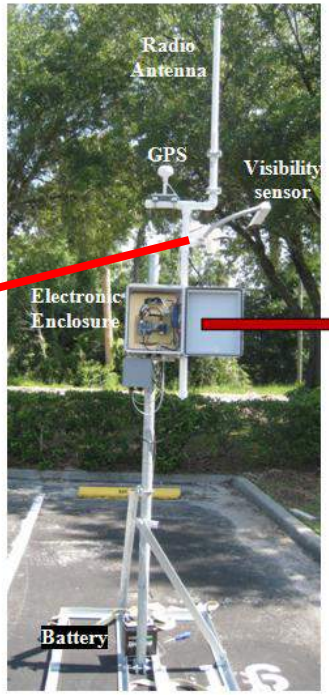
System Components

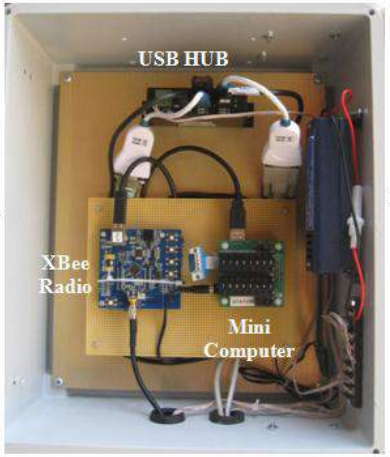
Base

Components of base ele



Station

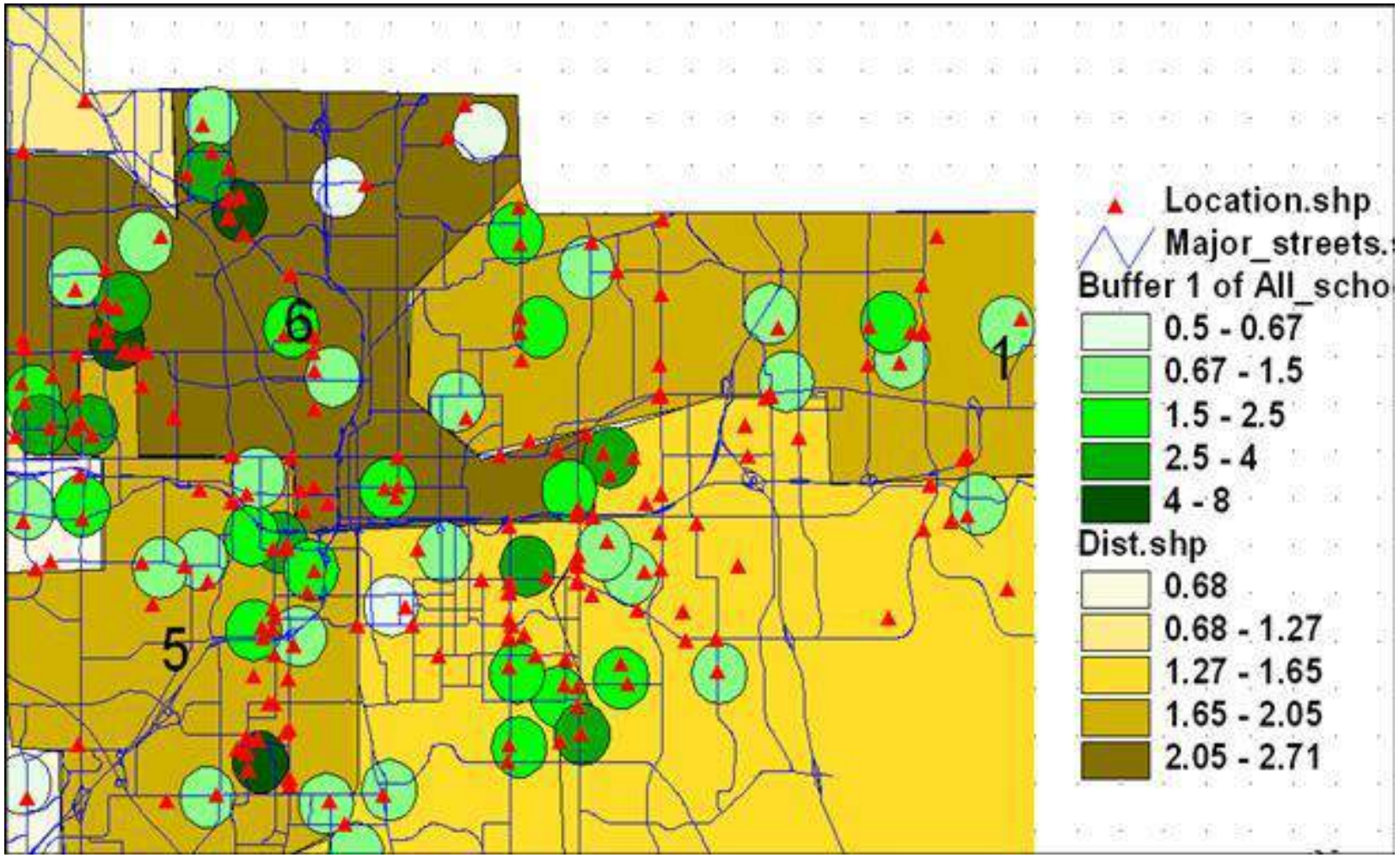




Components of station electronic enclosure

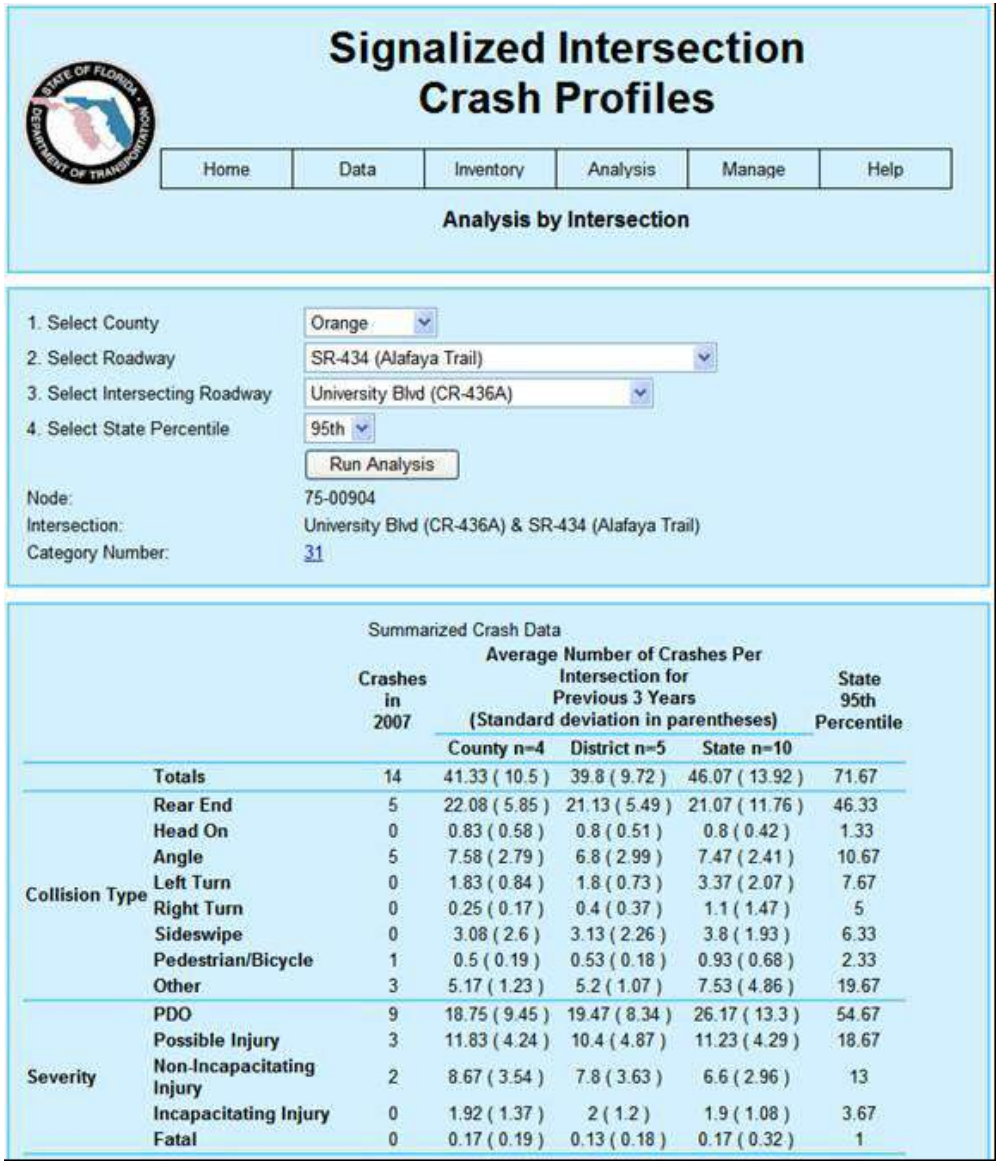
Visibility Sensor

School Zones Safety Analysis



Green circles represent the zones within a half mile of the schools (buffer zones) and darker color in circles represents higher number of crashes per school within the buffer zones. Red triangles denote the crash locations and blue lines denote major streets.

A WEB-BASED Application for Providing Crash Profiles at Intersections



Signalized Intersection Crash Profiles

Home | Data | Inventory | Analysis | Manage | Help

Analysis by Intersection

1. Select County: Orange
2. Select Roadway: SR-434 (Alafaya Trail)
3. Select Intersecting Roadway: University Blvd (CR-436A)
4. Select State Percentile: 95th

Run Analysis

Node: 75-00904
Intersection: University Blvd (CR-436A) & SR-434 (Alafaya Trail)
Category Number: 31

Summarized Crash Data

		Crashes in 2007	Average Number of Crashes Per Intersection for Previous 3 Years (Standard deviation in parentheses)			State 95th Percentile
			County n=4	District n=5	State n=10	
	Totals	14	41.33 (10.5)	39.8 (9.72)	46.07 (13.92)	71.67
Collision Type	Rear End	5	22.08 (5.85)	21.13 (5.49)	21.07 (11.76)	46.33
	Head On	0	0.83 (0.58)	0.8 (0.51)	0.8 (0.42)	1.33
	Angle	5	7.58 (2.79)	6.8 (2.99)	7.47 (2.41)	10.67
	Left Turn	0	1.83 (0.84)	1.8 (0.73)	3.37 (2.07)	7.67
	Right Turn	0	0.25 (0.17)	0.4 (0.37)	1.1 (1.47)	5
	Sideswipe	0	3.08 (2.6)	3.13 (2.26)	3.8 (1.93)	6.33
	Pedestrian/Bicycle	1	0.5 (0.19)	0.53 (0.18)	0.93 (0.68)	2.33
	Other	3	5.17 (1.23)	5.2 (1.07)	7.53 (4.86)	19.67
Severity	PDO	9	18.75 (9.45)	19.47 (8.34)	26.17 (13.3)	54.67
	Possible Injury	3	11.83 (4.24)	10.4 (4.87)	11.23 (4.29)	18.67
	Non-Incapacitating Injury	2	8.67 (3.54)	7.8 (3.63)	6.6 (2.96)	13
	Incapacitating Injury	0	1.92 (1.37)	2 (1.2)	1.9 (1.08)	3.67
	Fatal	0	0.17 (0.19)	0.13 (0.18)	0.17 (0.32)	1

A Manual for Intersection Safety

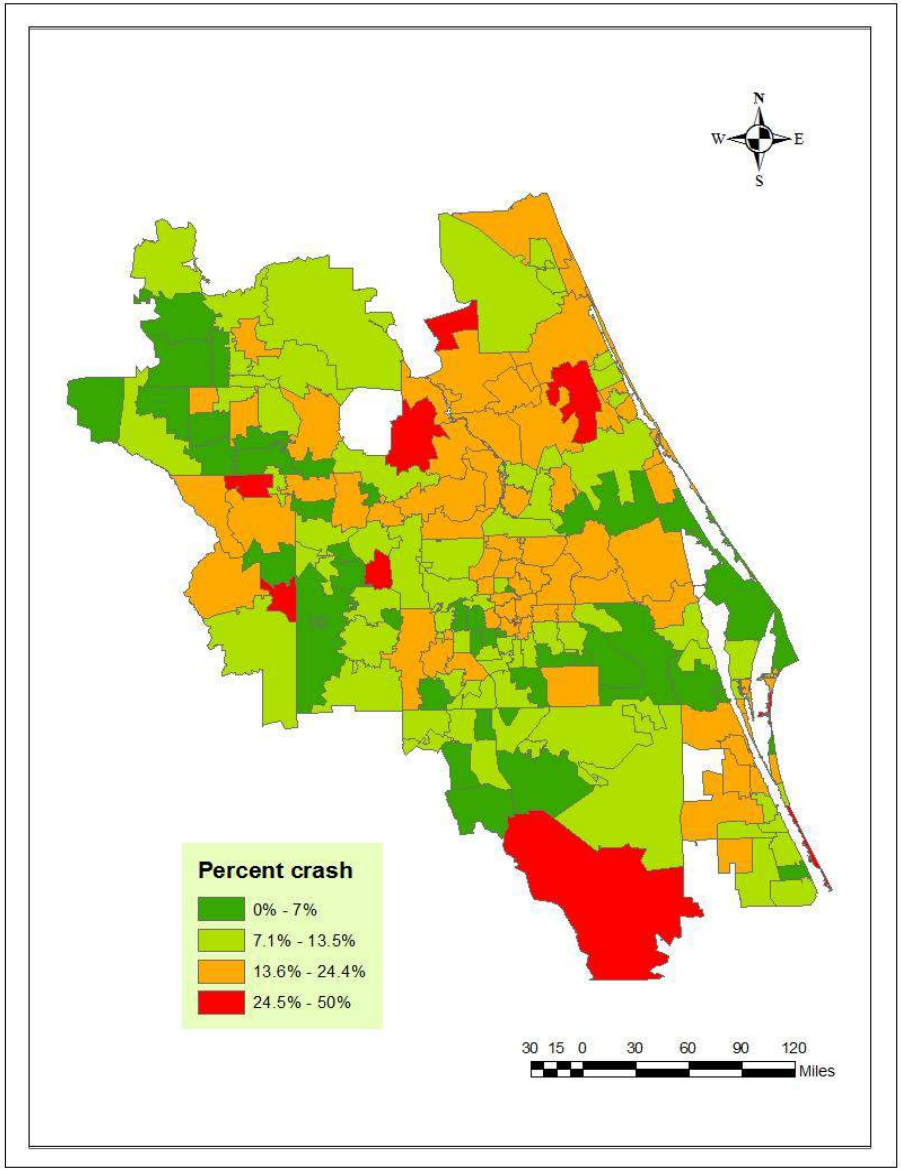
1500 signalized intersections divided into 45 signalized categories.

2500 non signalized intersections divided into 60 categories

Targeted Education & Awareness

Crashes Due to Driving Under the Influence

ZIP areas that were identified to have **high number of crashes due to driving under the influence (DUI) per mile of roadway** are Center Hill (33514), Geneva (32732), Melbourne Beach (32951), Orlando (32832), Seville (32190), Windermere (34786), and Zellwood (32798).



Advances in Traffic Safety

Pro-Active Approaches

- Transportation Safety Planning (TSP)
- Real-Time Crash Prediction
- Microscopic Traffic Simulation in Safety Research
- Intelligent Transportation Systems' Applications

Advances in Traffic Safety

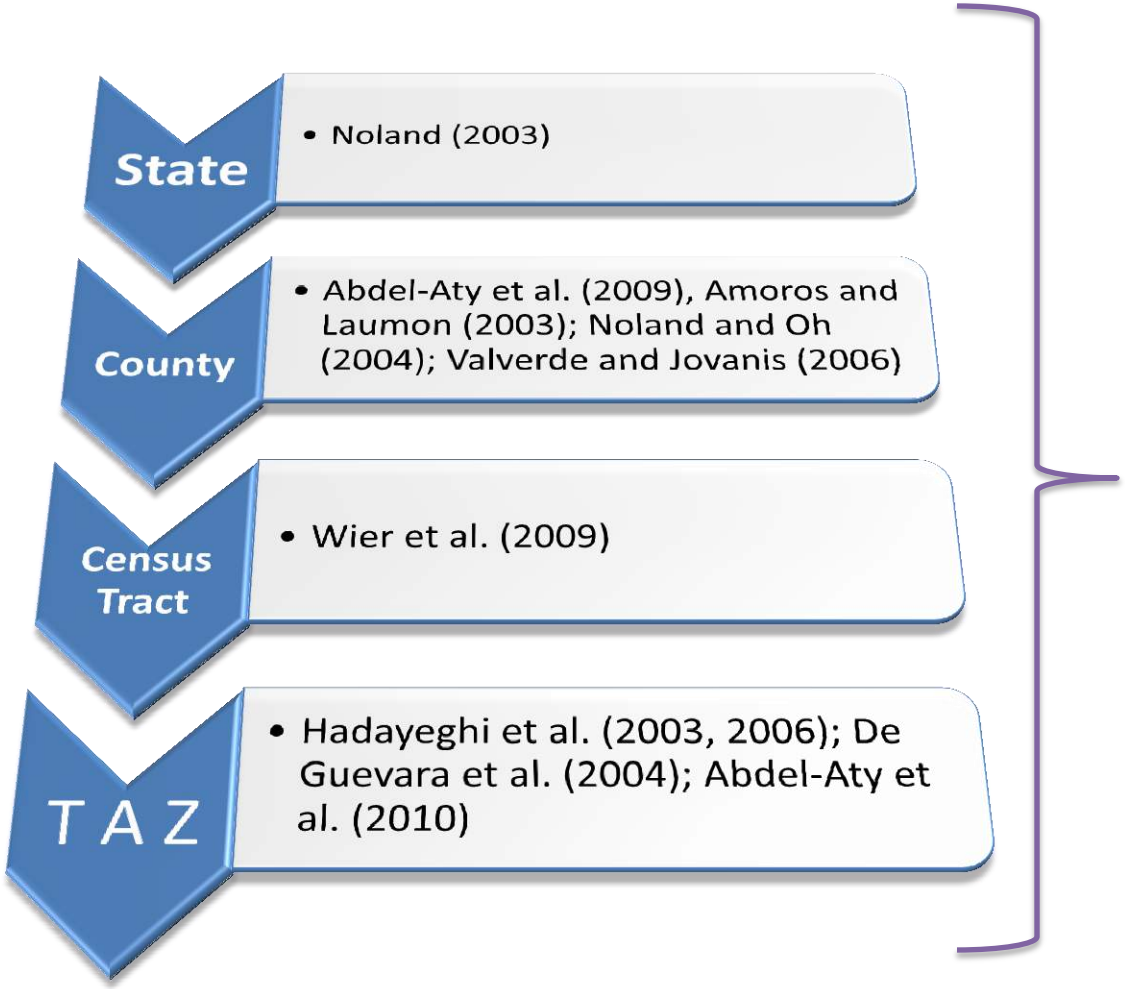
Pro-Active Approaches (cont.)

- Using Driving Simulators to Evaluate Safety
- Strategic National Highway Safety Plan
- “Forgiving” Roadway Design.
- Road Safety Audits
- Incorporating Safety in Design

Transportation Safety Planning

- TSP is a proactive approach to the prevention of accidents and unsafe transportation conditions by establishing inherently safe transportation networks.
- Integrate safety considerations into the transportation planning process at all levels. This step should be followed by consideration of safety objectives in the longer range transportation plan (i.e., 20 year plan).
- Lead to further collaboration among transportation planners, traffic engineers, safety stakeholders, and others.

Macroscopic Aggregate Safety Analysis

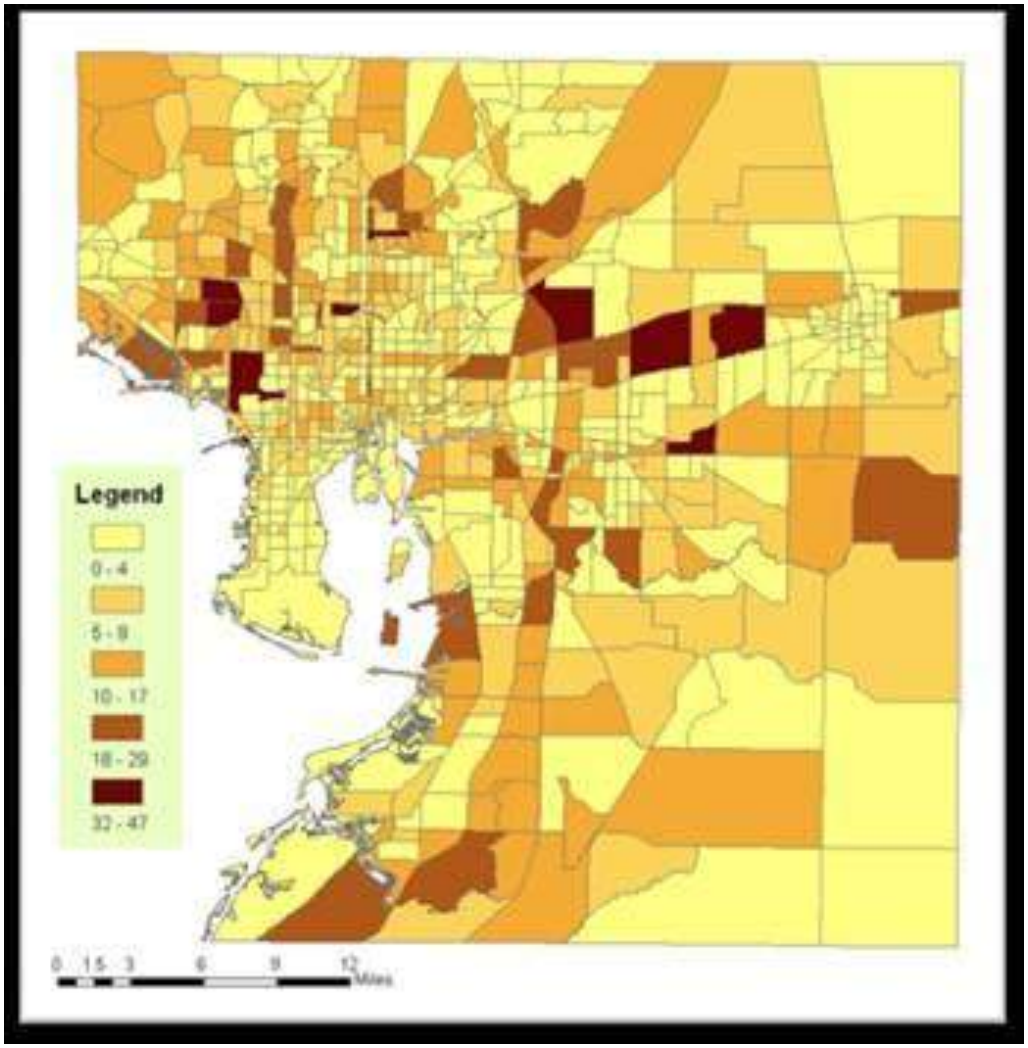


Predictor Categories
Trip Generation
Demographics & Socio-economic
Road Characteristics
Transportation Infrastructure
Weather Conditions
Amount of Travel

Macroscopic Safety Analysis
TAZ level Analysis

- TAZs are defined as part of the Census Transportation Planning Package

- The most important criteria used to define TAZs include spatial contiguity, homogeneity, compactness, etc.

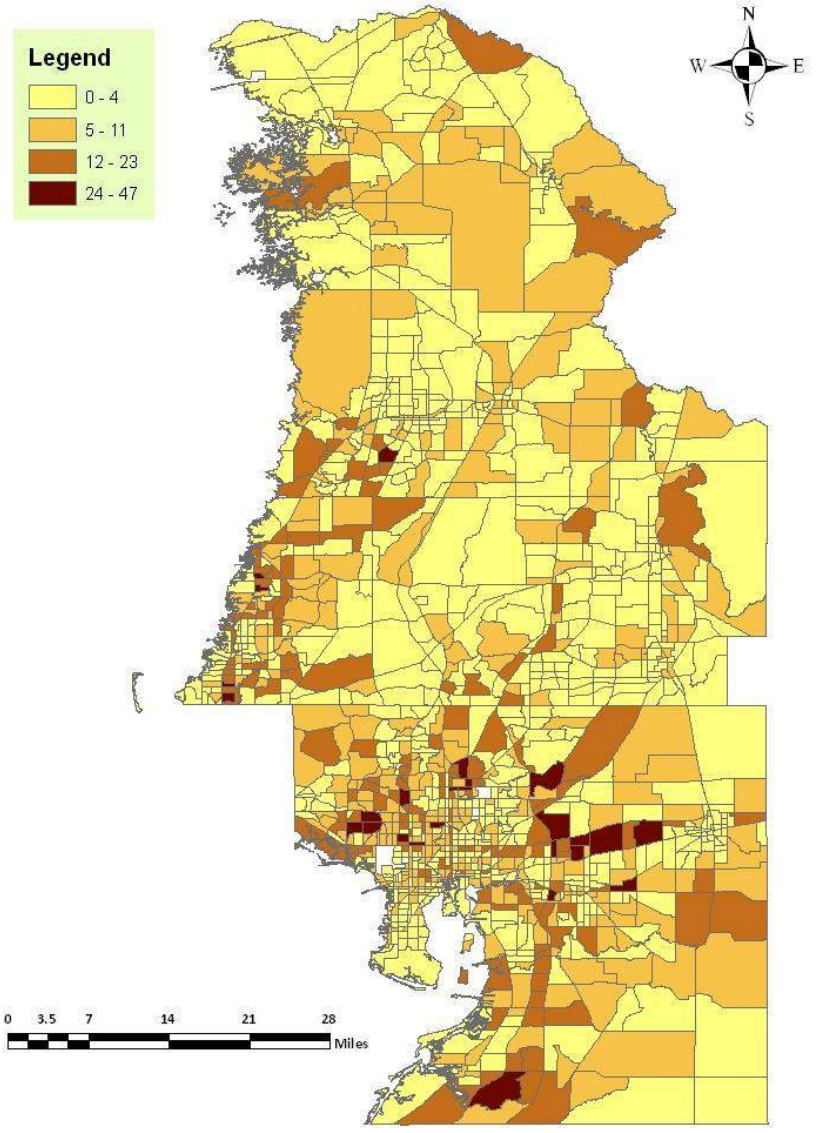


Number of severe (fatal and severe injury) crashes per TAZ in Hillsborough County for 2005 and 2006

Severe Crash Models

Variables- TRIP related only	Severe Crash (Model B)	
	Estimate	S. E.
Intercept	1.1714	0.0462
HBWA	-0.0004	0.0001
HBSHA	0.0001	0
LTRKP	0.0022	0.0002
HTRKP	-0.0011	0.0004
EIA	0.0054	0.0025
α	0.8646	
logL(Intercept model)	7497.97	
logL(Full model)	7603.84	
Deviance Value/DF	1.1366	
Pearson Chi-Square Value/DF	1.0962	

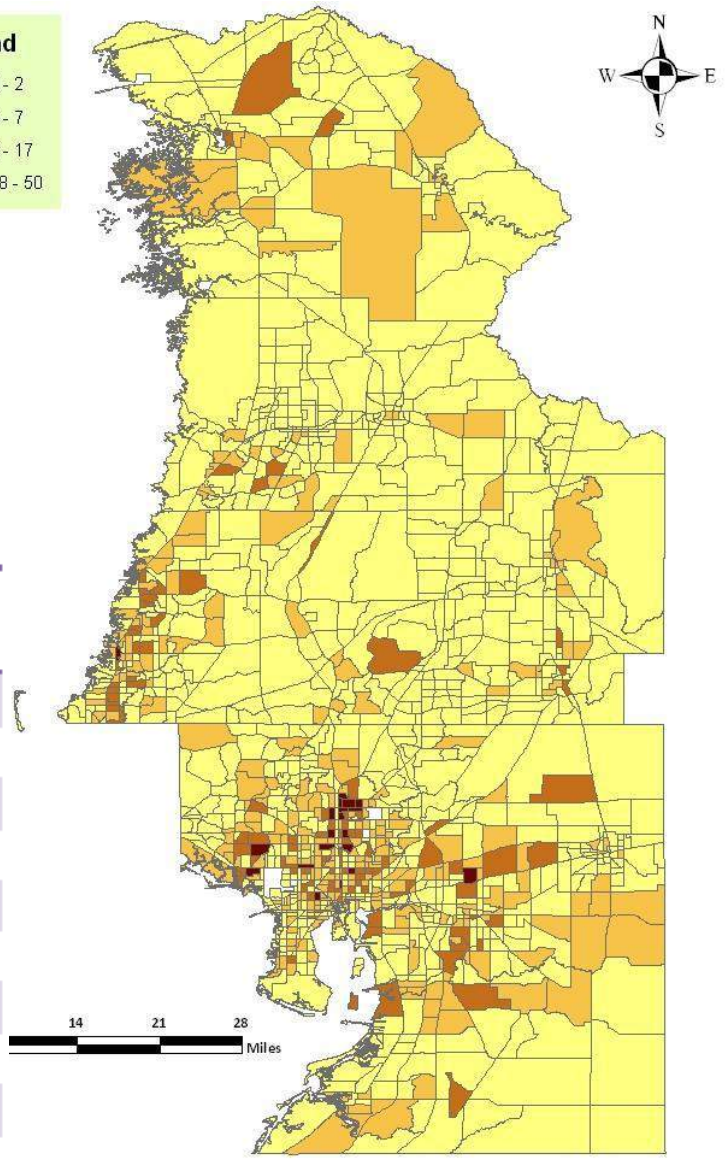
Variables- Total Trip Production & Attraction	Severe Crash (Model B)	
	Estimate	S. E.
Intercept	-0.9455	0.1903
logtp	0.2196	0.0351
logta	0.1135	0.0278
α	0.8577	
logL(Intercept model)	7497.97	
logL(Full model)	7616.1565	
Deviance Value/DF	1.134	
Pearson Chi-Square Value/DF	1.0616	



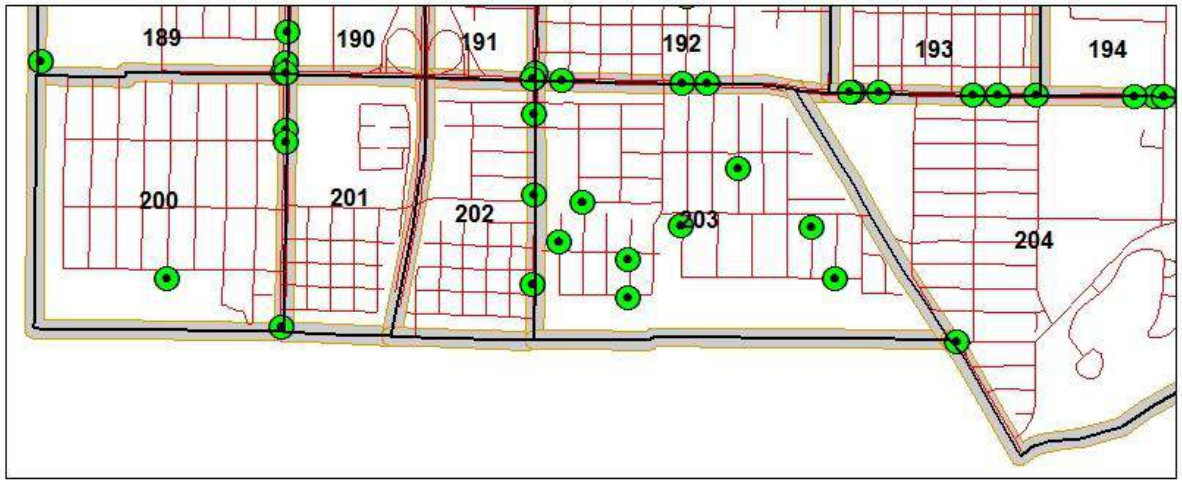
Pedestrian & Bicycle Crash Models

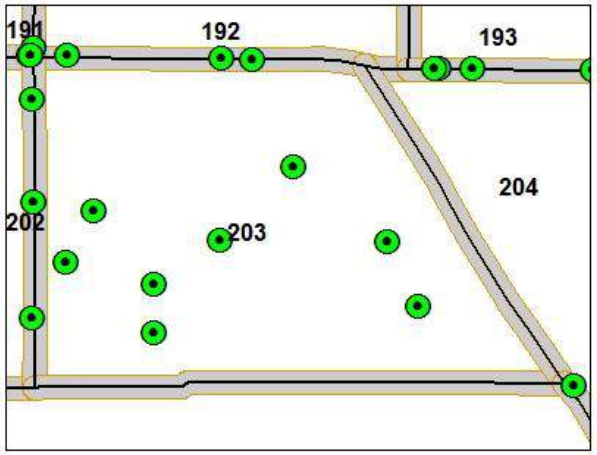
Variables- ROAD related only	Pedestrian and Bicycle related Crash (Model D)	
	Estimate	S. E.
Intercept	0.33	0.0729
seglen35	-0.0598	0.0297
Intersection	0.048	0.0044
α	1.8179	
logL(Intercept model)	1499.53	
logL(Full model)	1567.3662	
Deviance Value/DF	1.0181	
Pearson Chi-Square Value/DF	1.0748	

Variables- ALL	Pedestrian and Bicycle related Crash (Model D)	
	Estimate	S. E.
Intercept	-3.672	0.314
seglen35	-0.1124	0.0257
Intersection	0.0365	0.004
logtp	0.421	0.0522
logta	0.1012	0.0393
α	1.4044	
logL(Intercept model)	1499.53	
logL(Full model)	1673.87	
Deviance Value/DF	1.0309	
Pearson Chi-Square Value/DF	1.0729	



Investigating Crashes at Zone Boundary





Legend

- TAZ boundary
- Pedestrian crash location
- Roadways
- TAZ Buffer - 100ft

Let any TAZ *i* shares its boundary with *1, 2, ..., k* different neighboring zones. Any variable *x* will then be transformed to x_B such that,

$$x_B = \frac{1}{2}\left[x_i + \frac{d_{i1} * x_1 + d_{i2} * x_2 + \ldots\ldots\ldots + d_{ik} * x_k}{d_{i1} + d_{i2} + \ldots\ldots\ldots + d_{ik}}\right]$$

where,

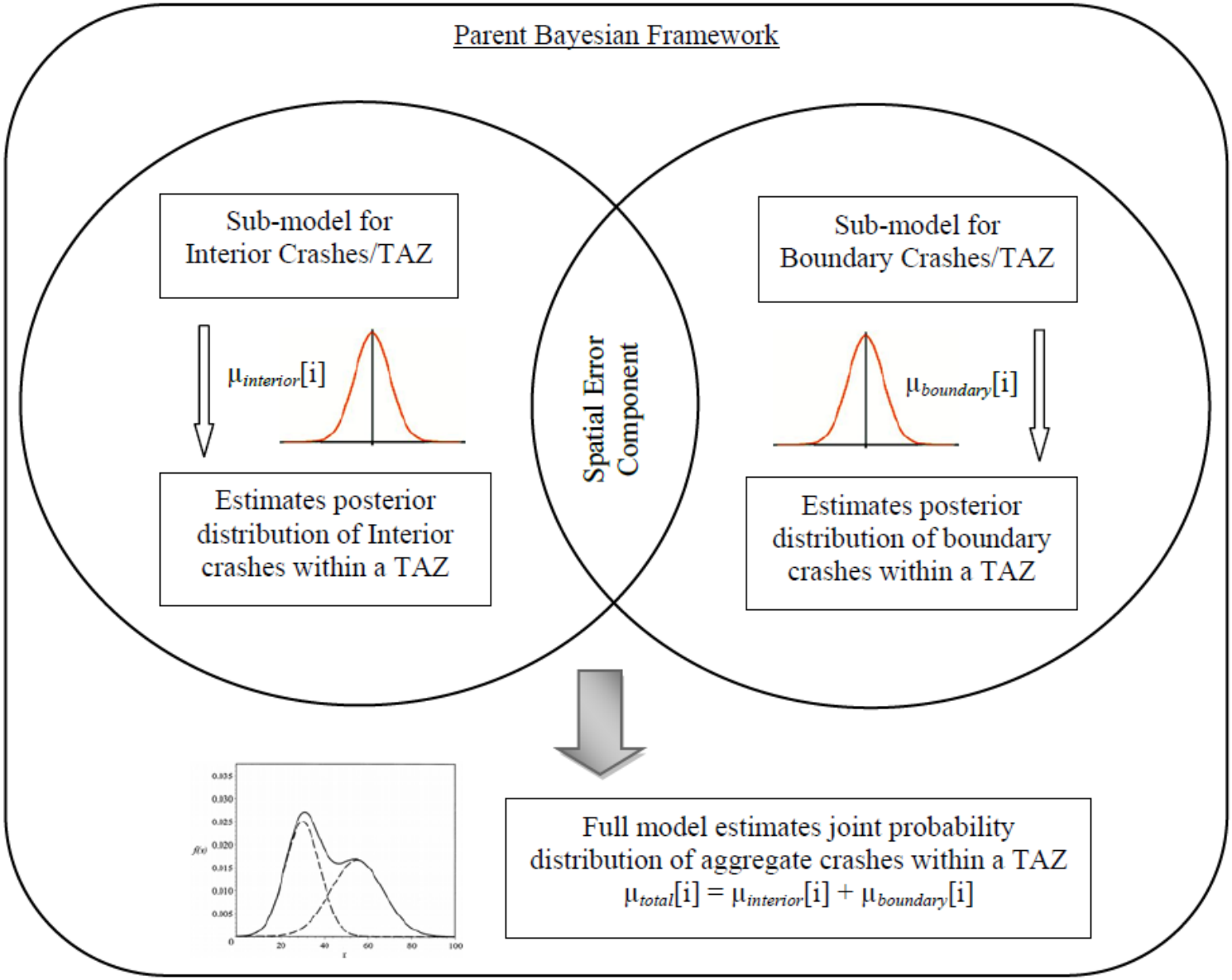
x_i = variable x for i^{th} zone,

d_{i1} = length of the shared boundary between zones i and 1,

$x_1, \ldots\ldots\ldots x_k$ = variable x for the $1, 2, \ldots, k$ neighboring zones,

$d_{i1} + d_{i2} + \ldots\ldots\ldots + d_{ik}$ = perimeter of zone i.

Schematic model of the proposed methodology



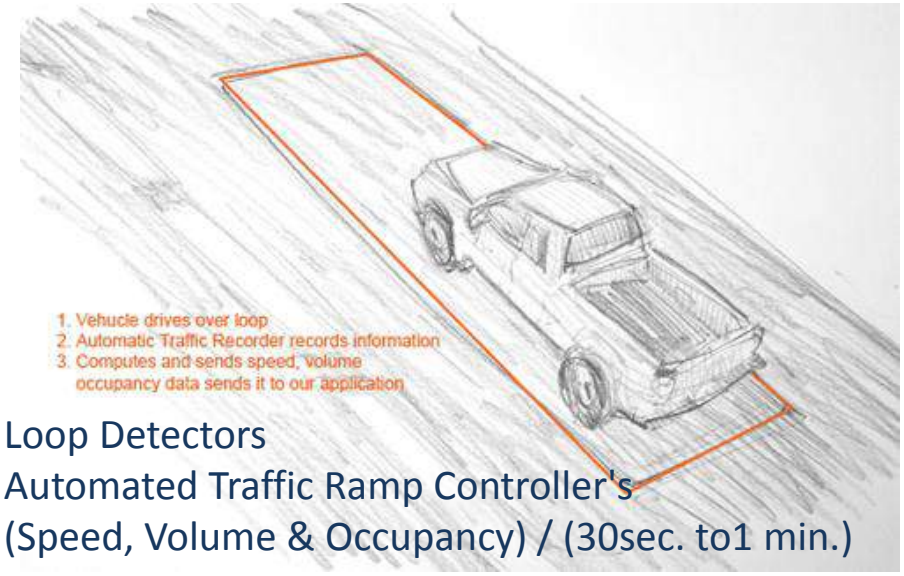
Real-Time Crash Prediction

- Objective of freeway traffic management is to monitor and mitigate ***recurring*** (during peak hours) and ***non-recurring congestion*** (from incidents, weather etc.)

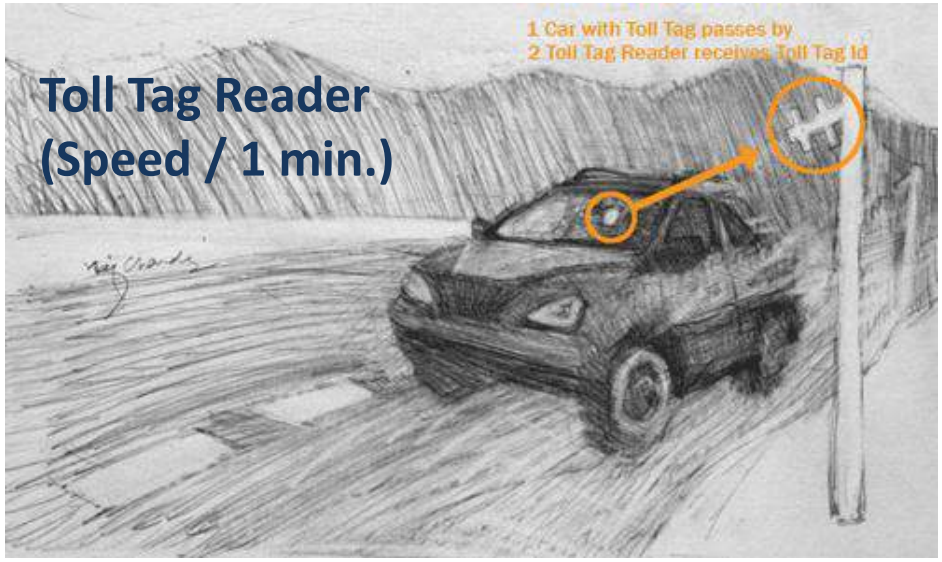
- Traffic management authorities rely on traffic surveillance apparatus (e.g., *loop detectors*, radar detectors, video cameras) to monitor freeway traffic conditions

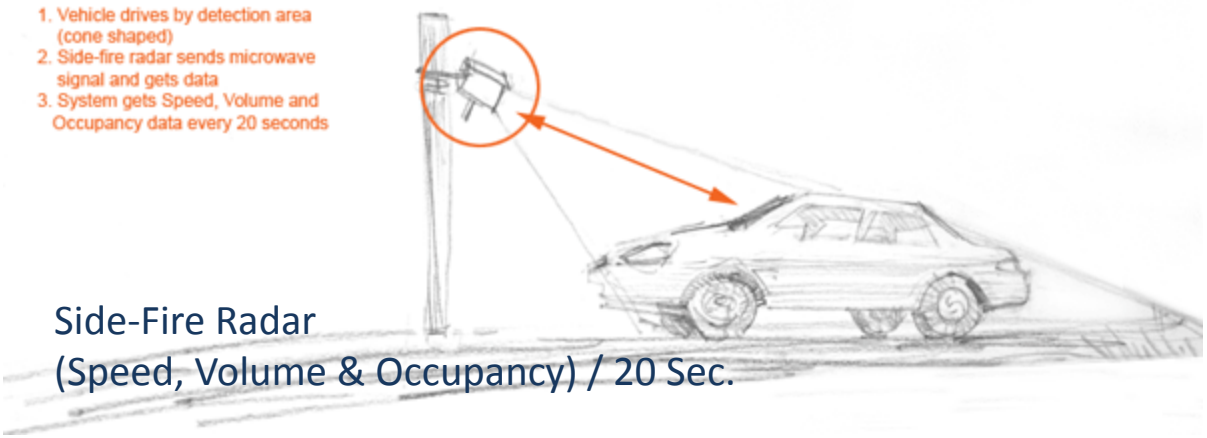
- Loop detectors provide speed, volume, and lane-occupancy for very short durations

How are Traffic Flow Parameters Collected?



Loop Detectors
Automated Traffic Ramp Controller's
(Speed, Volume & Occupancy) / (30sec. to1 min.)

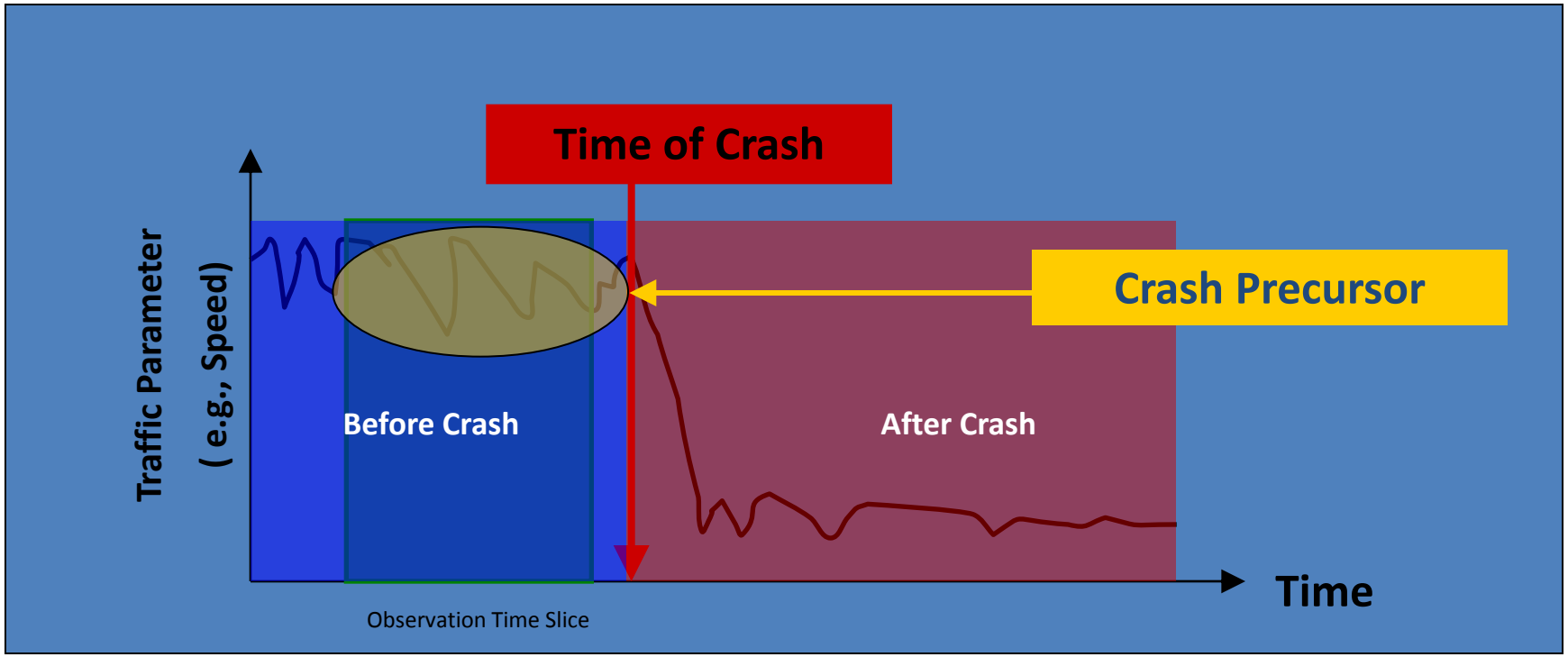




Side-Fire Radar
(Speed, Volume & Occupancy) / 20 Sec.

Which patterns are we looking for?

Traffic flow parameters prior to the time of crash

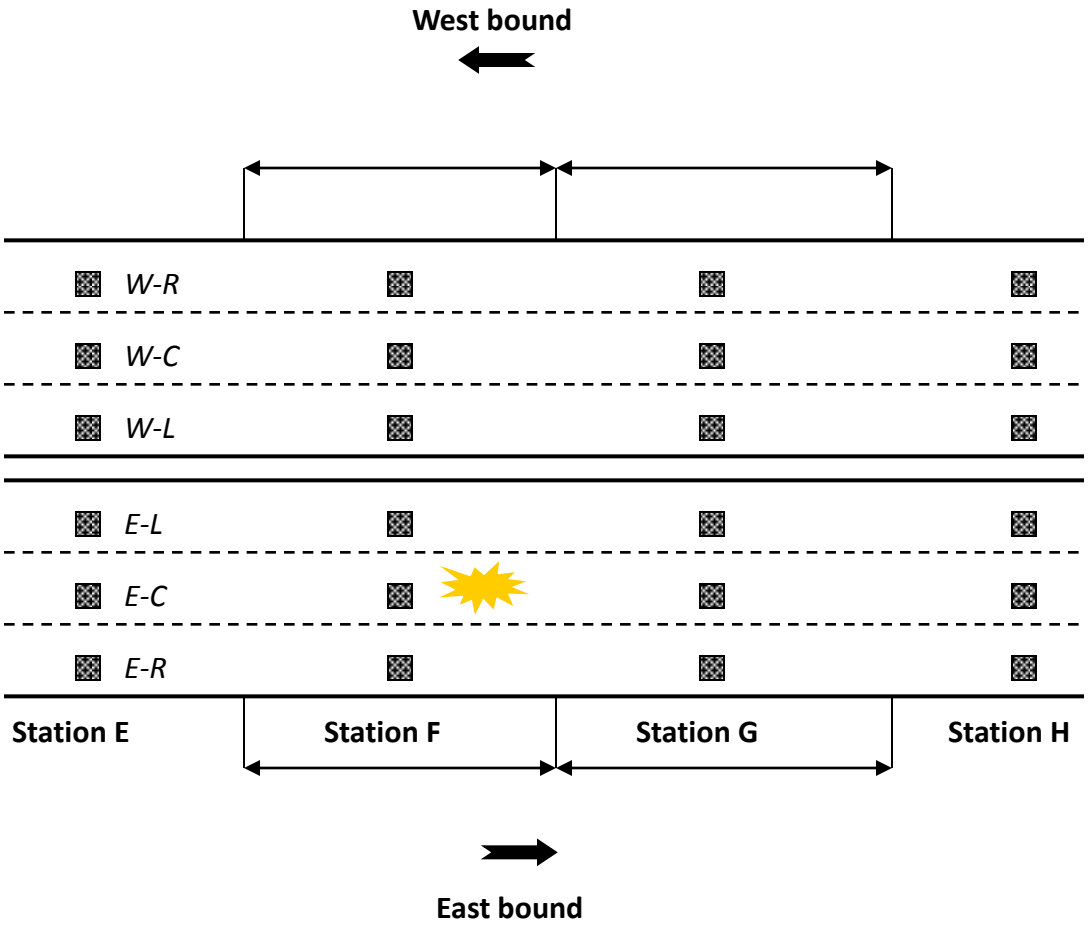


Approach to Proactive Freeway Management

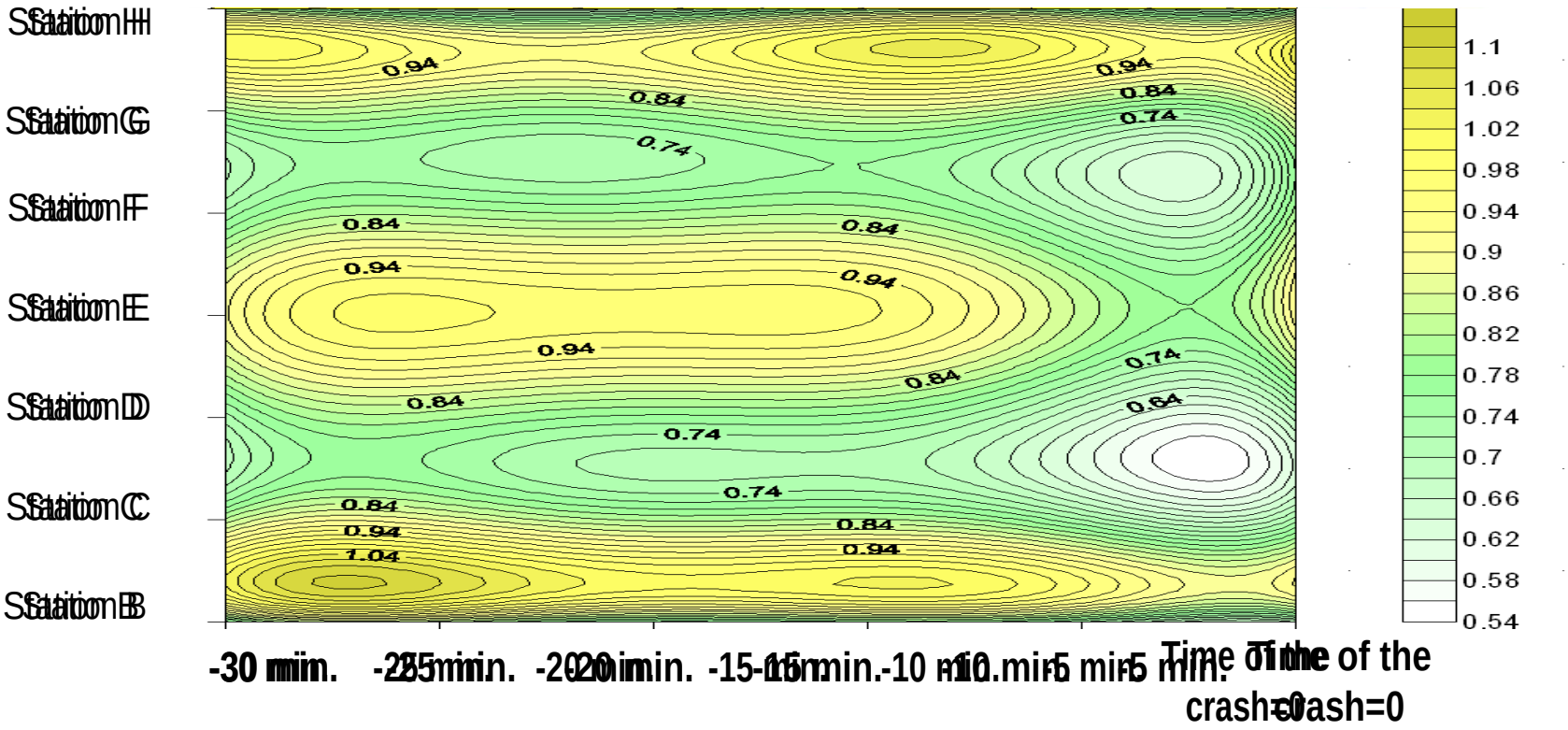
- Analyze historical crashes and traffic surveillance data corresponding to each crash and detect patterns that are often repeated before the crash occurrence
- If these patterns are repeated in the future on a freeway section that section may be identified as a real-time *"black-spot"*
- Real-time proactive measures should be developed to avoid crashes

Microscopic/Disaggregate Safety Analysis

Data Source (Loop detectors)



Real-Time Crash Risk



Hazard Ratio: Contour plots of hazard ratios corresponding to coefficient of variation in speed (42 model outputs)

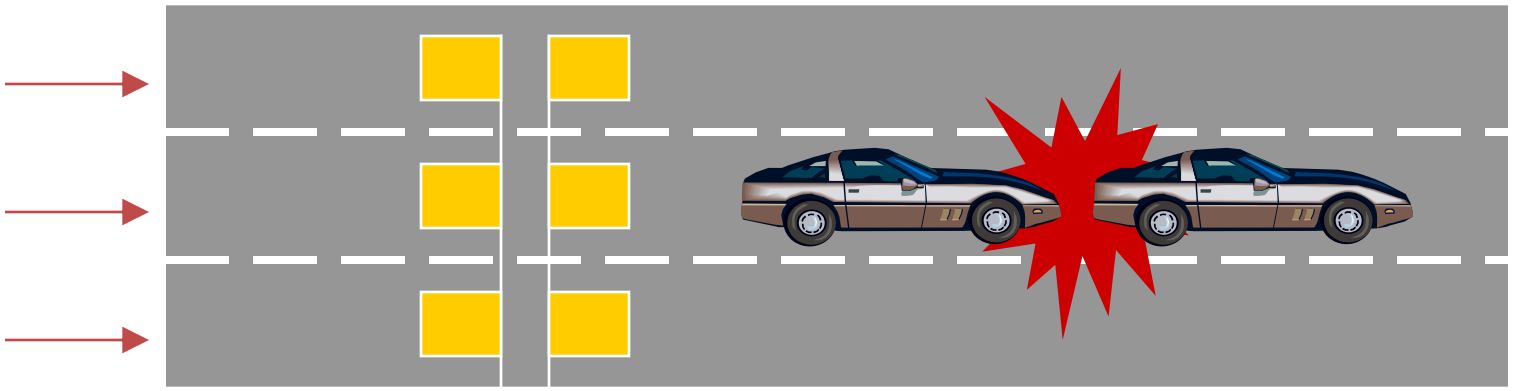
Crash Prediction Model

Crash Precursors

Crash Precursor #1:

Variation in speed upstream of crash location

Upstream of crash location

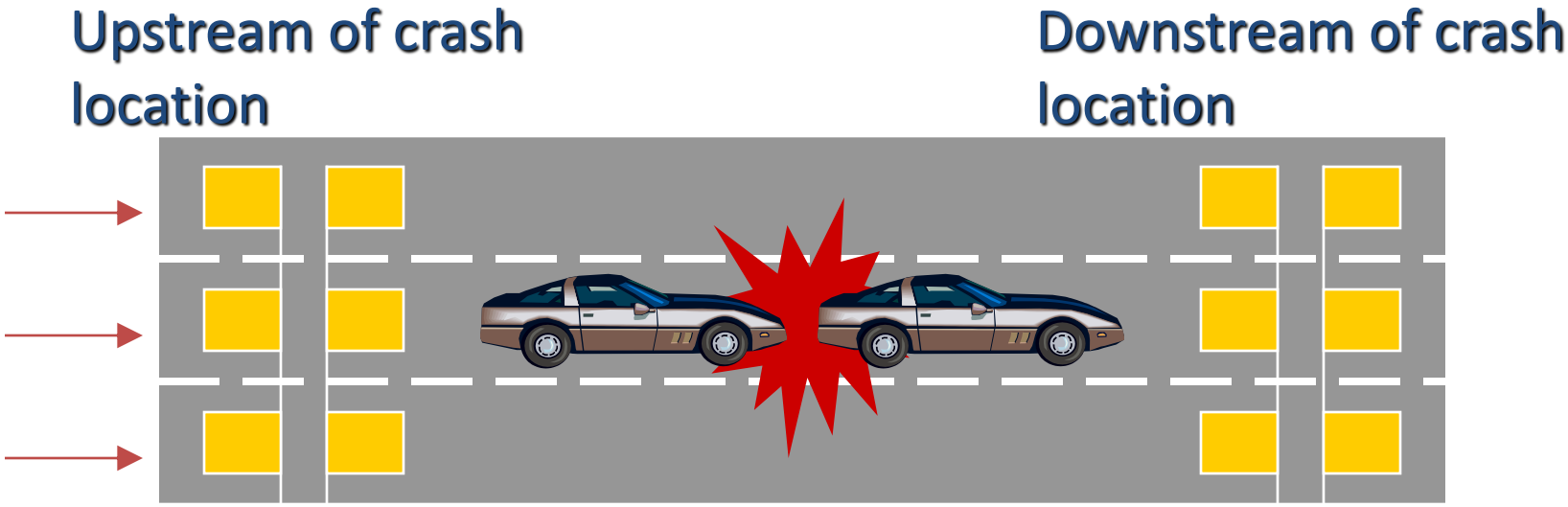


Crash Prediction Model

Crash Precursors

Crash Precursor #2:

Speed upstream of crash location minus speed downstream of crash location



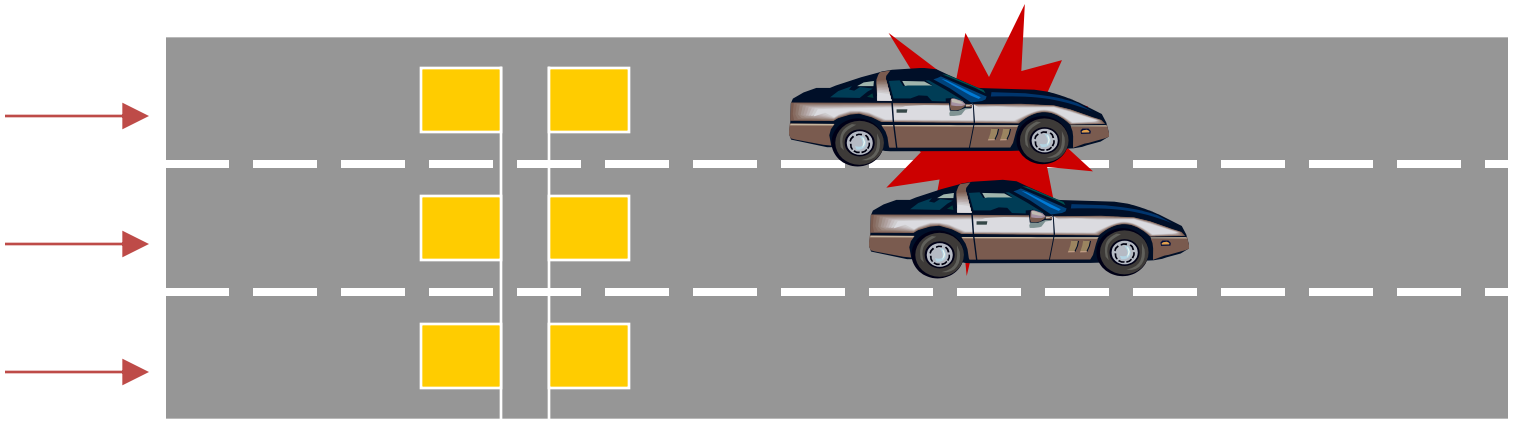
Crash Prediction Model

Crash Precursors

Crash Precursor #3:

Covariance of volume across adjacent lanes upstream of crash location

Upstream of crash location

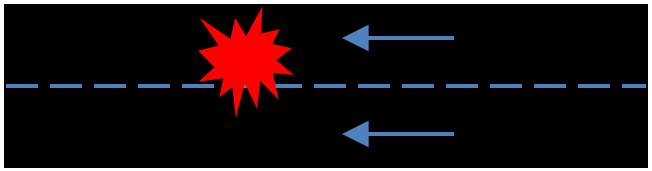


Crash Prediction Model

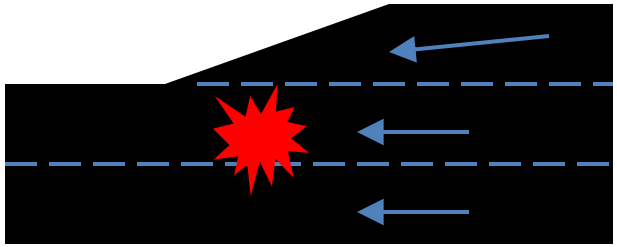
External Control Factor

Road geometry of crash location

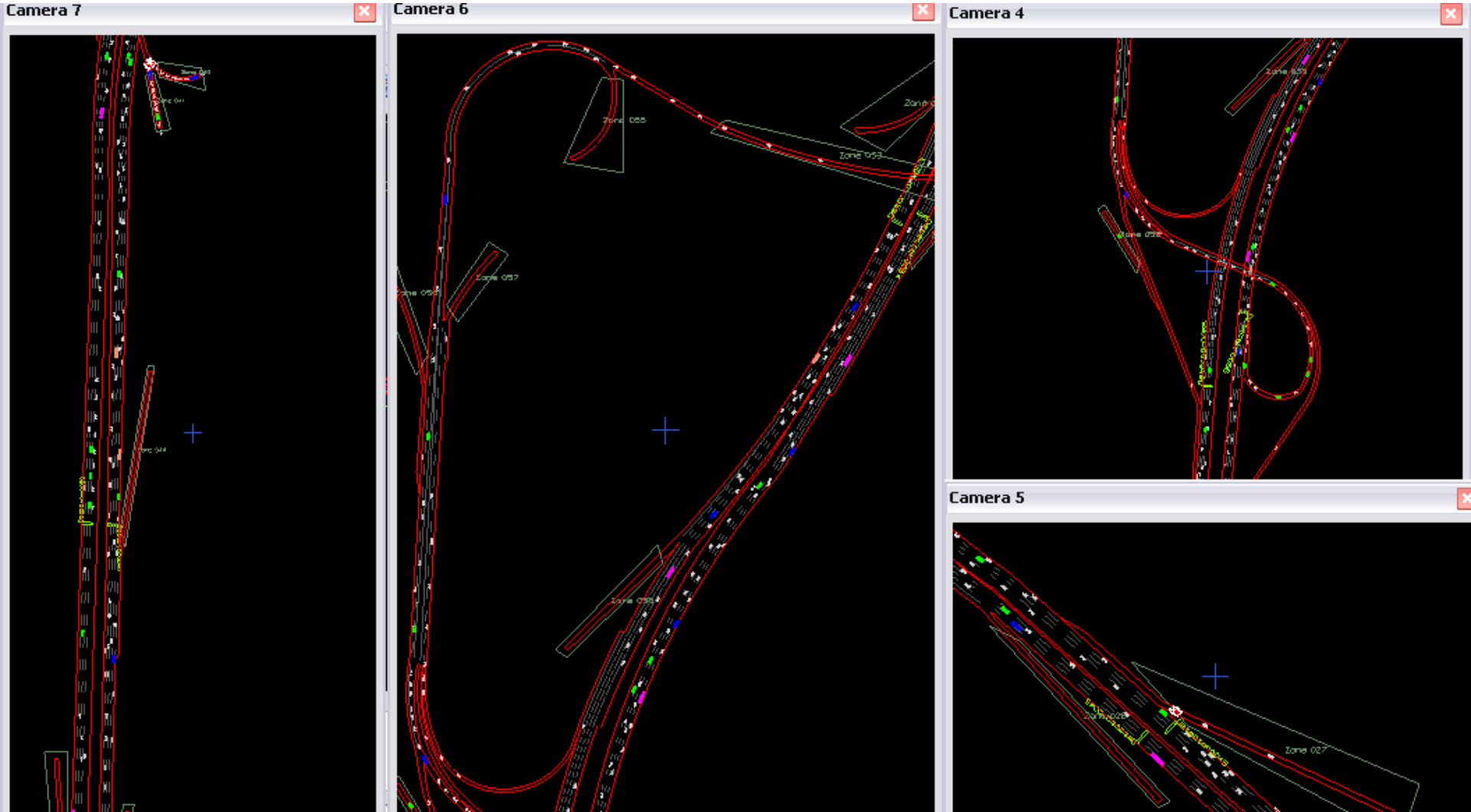
- Straight road sections



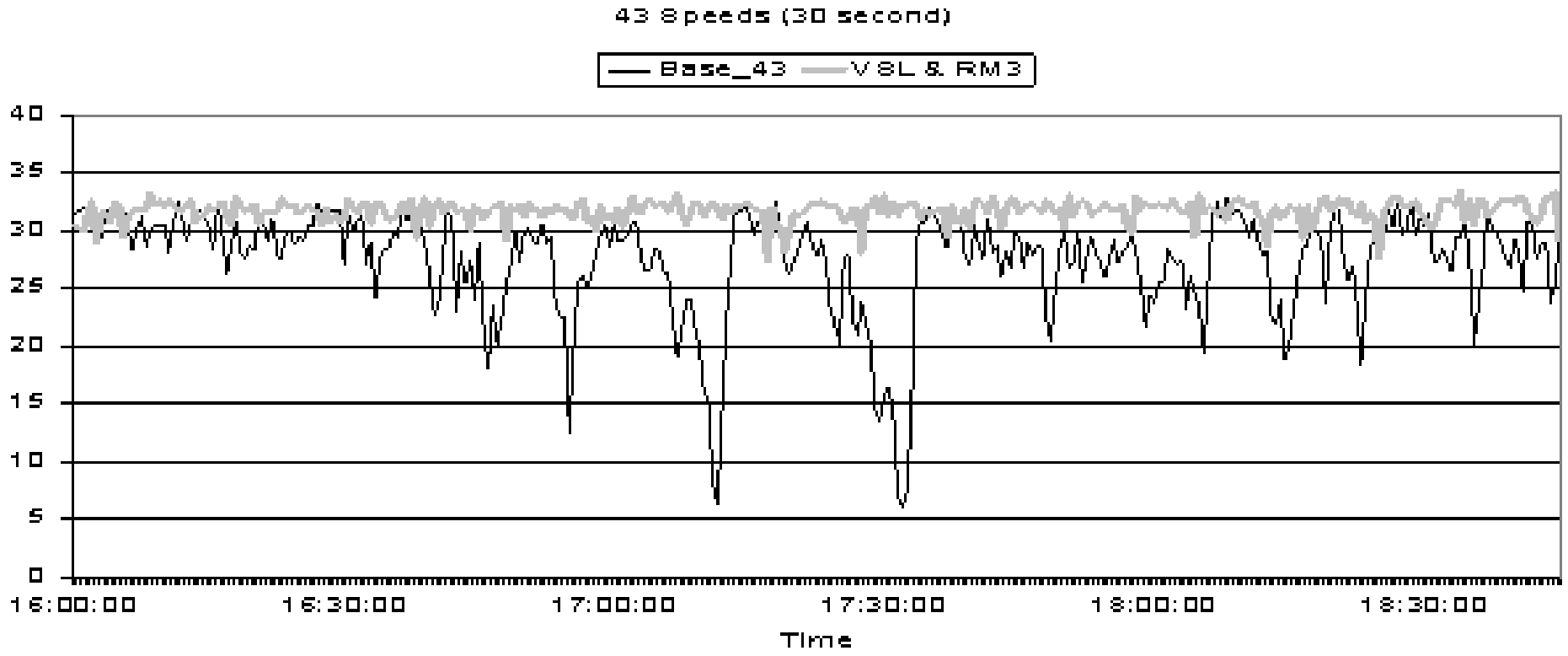
- Merging/diverging road sections



Interstate-4 Freeway, Orlando, FL



Micro-Simulation: Variable Speed Limits



Stabilization in 30-second speed profiles following ITS strategies implementation

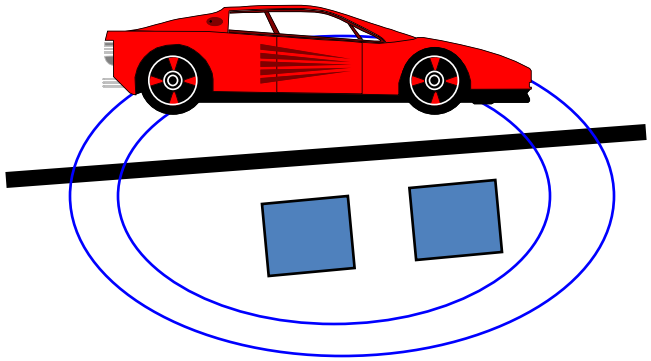
VSL & VMS in Driving Simulator

Warning Message

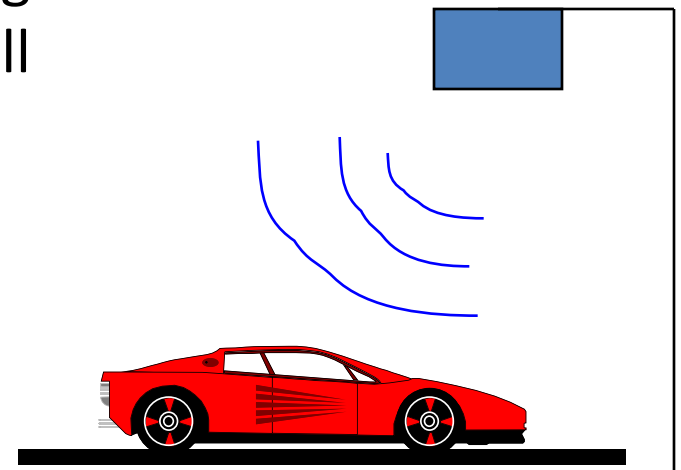
Variable Speed Limit

Proactive Traffic Management

Between 2005-2010 we were pioneers in analyzing real-time data collected from inductive loop detectors and radars in a safety framework, but there are no safety studies that attempted the use of traffic data from one of the most growing surveillance system; the tag readers on toll roads (AVI).



In Ground [Intrusive]



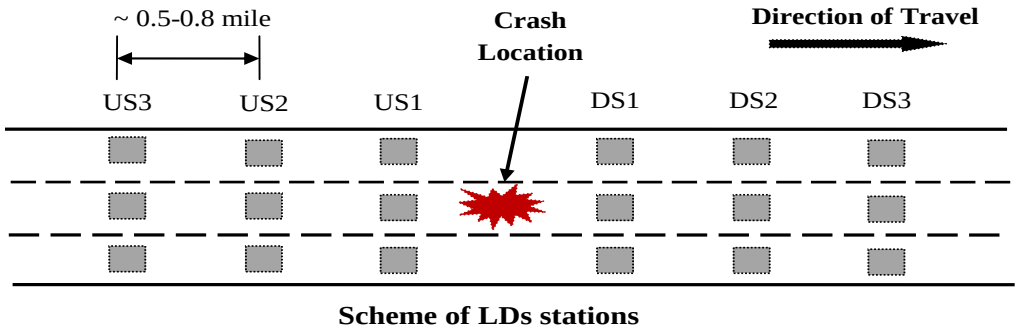
Above Ground [Non-Intrusive]

AUTOMATIC VEHICLE IDENTIFICATION (AVI) SYSTEM

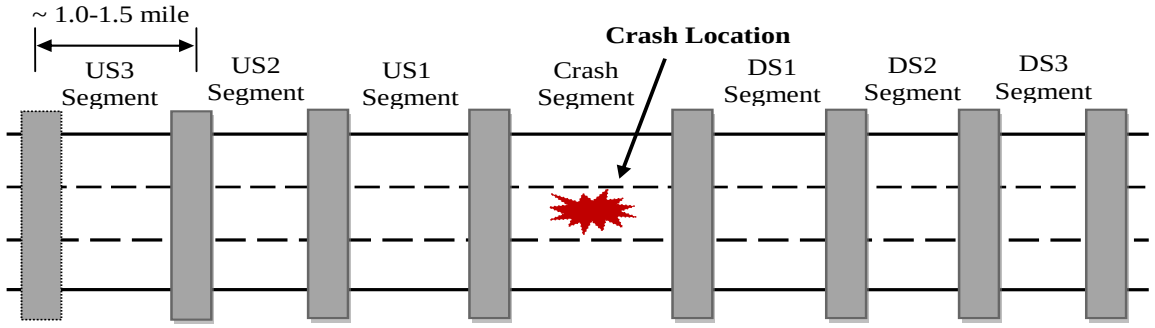
- This system estimates the segment travel time by monitoring the successive passage times of vehicles equipped with electronic tags.
- Data are gathered using AVI tag readers that are installed solely for the purpose of estimating travel times and some for toll collection.

ILDs Speed vs. AVIs Speed

Commonly deployed inductive loop detectors (ILDs) measure time-mean-speed (TMS), whereas AVIs measure space-mean-speed (SMS).



Scheme of LDs stations

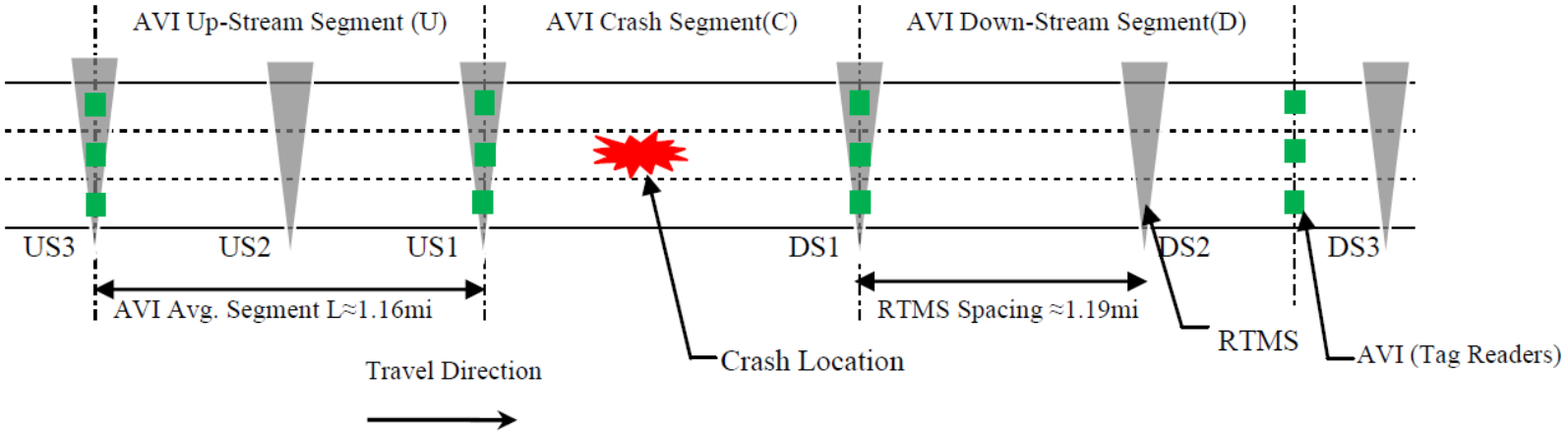


Scheme of AVI stations

ILD vs. AVI

- Our current research implemented for the first time data collected from the AVI in a real-time traffic safety analysis.
- AVI data were found to be promising in providing a measure of crash risk in real-time. The management of expressways can benefit from the collected AVI traffic data not only to ease the congestion and enhance the operation but also by evaluating the increased risk.

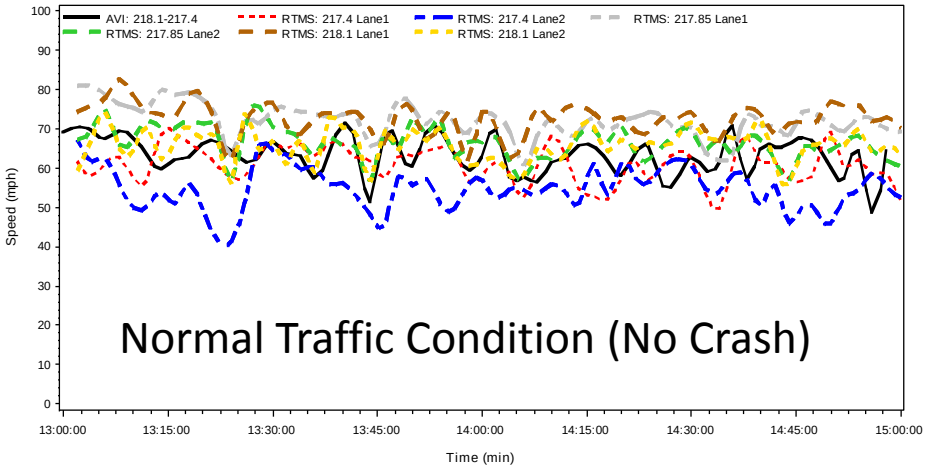
REAL-TIME RISK ASSESSMENT ON FREEWAYS

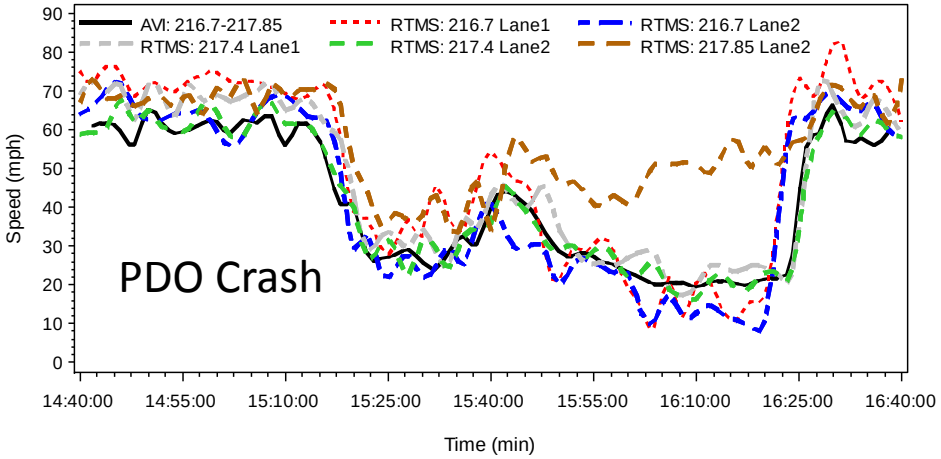


Arrangement of RTMS and AVI Segments

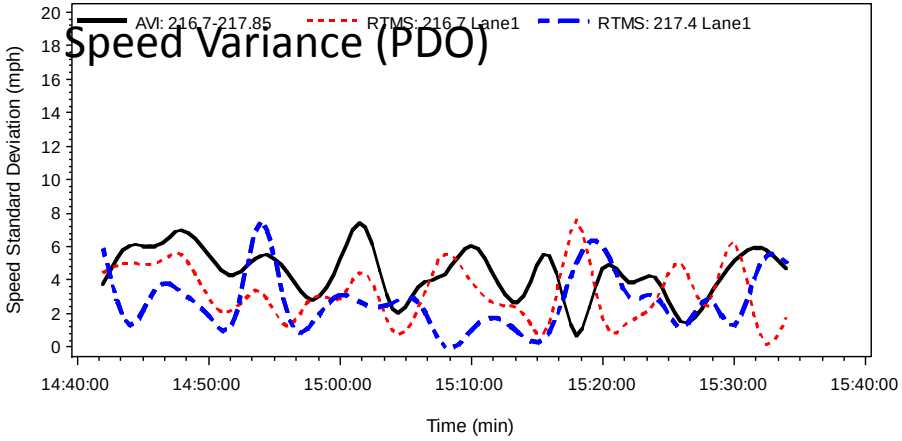
- The 15-mile on I-70 in Colorado is equipped with AVI, RTMS, and Weather Stations.
- There were five sets of data used in this study; roadway geometry data, crash data, and the corresponding AVI, RTMS and weather data.
- Traffic data consists of space mean speed captured by 12 and 15 AVI detectors located on each east and west bounds, respectively along I-70. Volume, occupancy and time mean speed are collected by 15 RTMSs on each direction.
- AVI estimates SMS every 2-minute while RTMS provides traffic flow parameters every 30-second. Weather data were recorded by three automated weather stations along the roadway section for the same time period.

Exploratory Comparison between AVI and RTMS Data

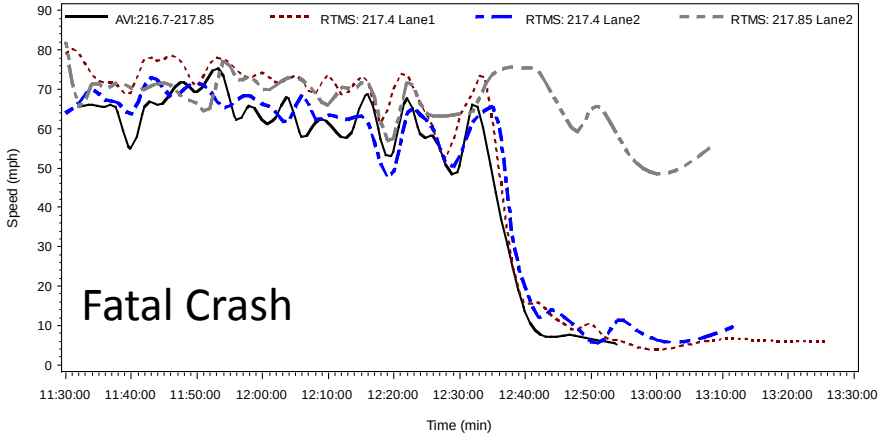




Crash Location: Milepost 217.7



Crash Location: Milepost 217.7

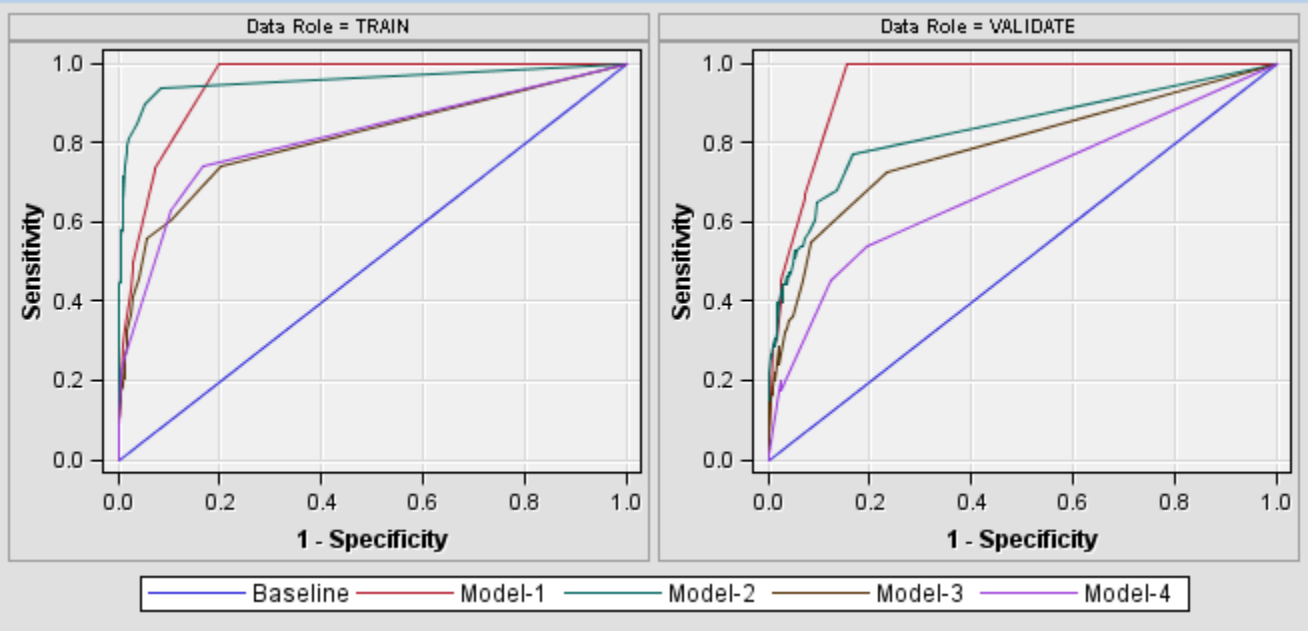


Crash Location: Milepost 217.5

Variable Importance

Model-1 (All Data)		Model-2 (RTMS)		Model-3 (AVI)		Model-4 (Weather)	
Variables	**Var. Import.**	**Variables**	**Var. Import.**	**Variables**	**Var. Import.**	**Variables**	**Var. Import.**
Avg. Occ. Upstream1_Time Slice _2	1.000	Avg. Occ. Upstream 2_Time slice_3	1.000	Log. Coef. of Var. of Speed Crash Segment Time Slice_2	1.000	1-Hour Visibility	1.000
Avg. Occ. Upstream 2_Time slice_3	0.887	Log. Coef. of Var. of Speed Upstream 1_Time Slice_2	0.997	Avg. Speed Downstream Segment Time Slice_2	0.899	10-Minute Precipitation	0.459
Log. Coef. of Var. of Speed Crash Segment Time Slice_2	0.798	Avg. Speed Upstream 2_Time Slice_2	0.804	Avg. Speed Downstream Segment Time Slice_3	0.741	1-Hour Precipitation	0.324
Avg. Speed Downstream Segment Time Slice_2	0.742	S.D. Occ. Upstream 2_Time Slice 2	0.541	Avg. Speed upstream Segment Time Slice_2	0.537		
1-Hour Visibility	0.684	Avg. Speed Downstream 1_Time Slice_2	0.457				
Grade	0.661	Avg. Speed Downstream 2_Time Slice_2	0.391				
S.D. Occ. Upstream 3_Time Slice 2	0.642	Avg. Occ. Upstream1_Time Slice _2	0.374				
No. of Lanes	0.521	Avg. Occ. Upstream2_Time Slice _2	0.348				
Avg. Speed Upstream 1_Time Slice_2	0.519	Log. Coef. of Var. of Volume Downstream 2_Time Slice_2	0.249				
Avg. Speed Downstream Segment, Time Slice_3	0.431						

Models Comparison

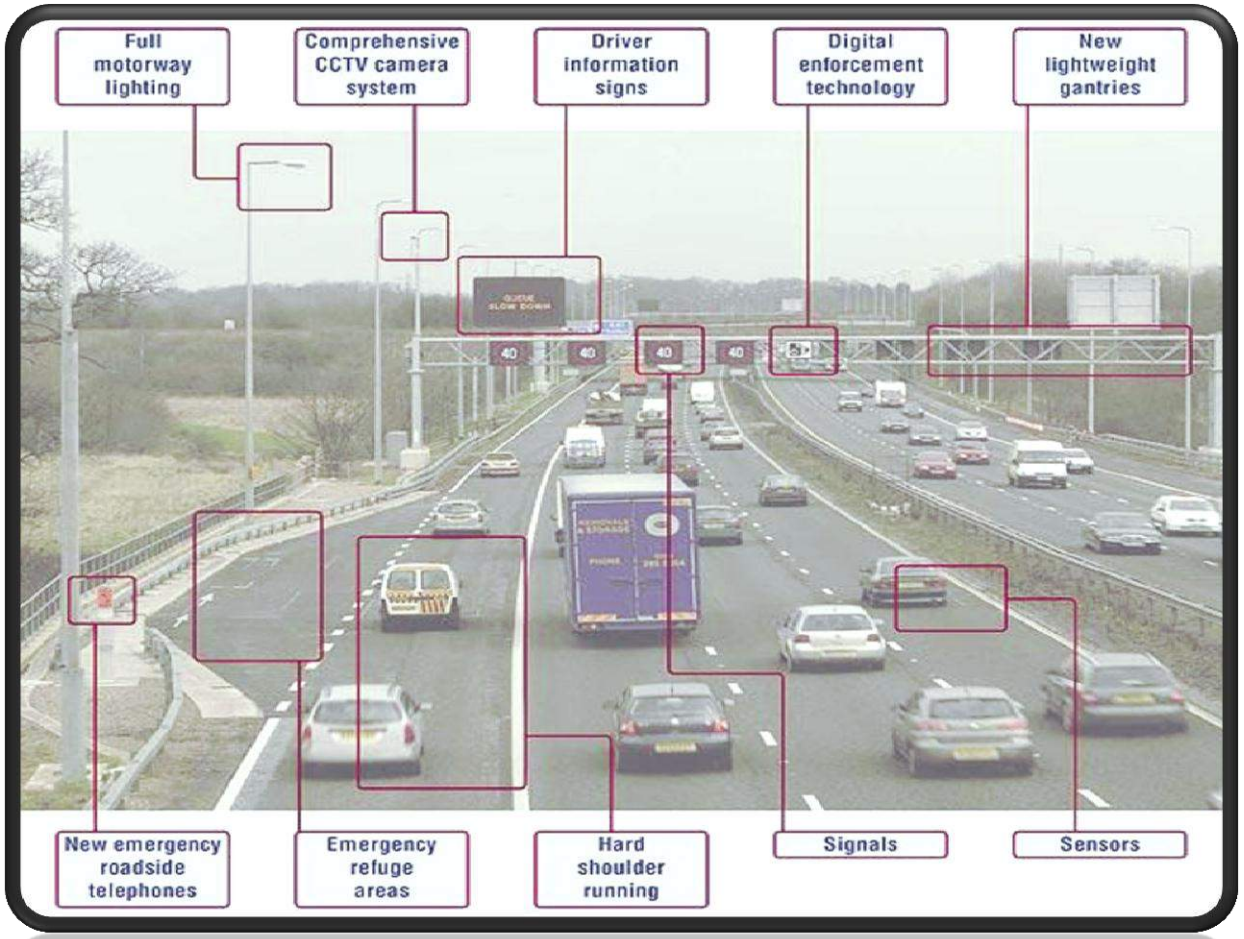


Model	Model Description	Overall Classification Rate	True Positive Rate	False Positive Rate	True Negative Rate	ROC Index
Model-1	All Data	92.157%	88.889%	6.481%	93.519%	0.946
Model-2	RTMS	87.879%	73.333%	7.154%	92.845%	0.762
Model-3	AVI	87.653%	70.192%	6.393%	93.607%	0.721
Model-4	Weather	84.364%	55.714%	5.854%	94.146%	0.675

Components of Active Traffic Management

- Speed Harmonization
- Temporary Shoulder Use
- Queue Warning
- Ramp Metering
- Truck Restrictions
- HOV/HOT Lanes

Need to be more Pro-active by incorporating Real-time accident Prediction



Advanced Safety Performance Functions (SPF)

Advanced Statistical Techniques

- Hierarchical Bayesian Models
- Methods to account for Spatial Effects
- Time Series
- Generalized Estimation Equations (GEE)

Non Conventional Analytical Methods

- Data Mining Techniques
- Neural Networks
- Genetic Programming
- Genetic Algorithms

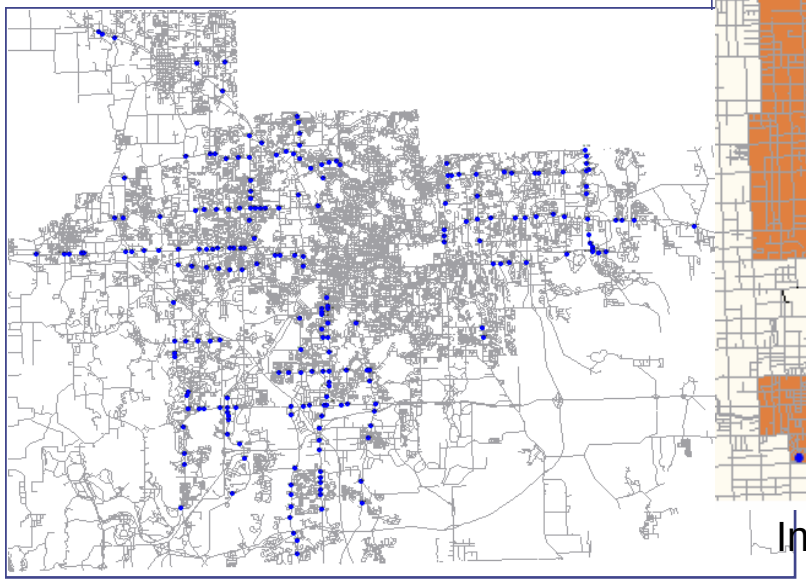
SPFs for Longitudinal Crash Frequencies

- Generalized Estimation Equations (GEE)
  - GEE come from specifying a known function of the marginal expectation of the dependent variable as a linear function of covariates; assuming that the variance is a known function of the mean; in addition, **specifying a "working" correlation matrix for the observations for each location**.

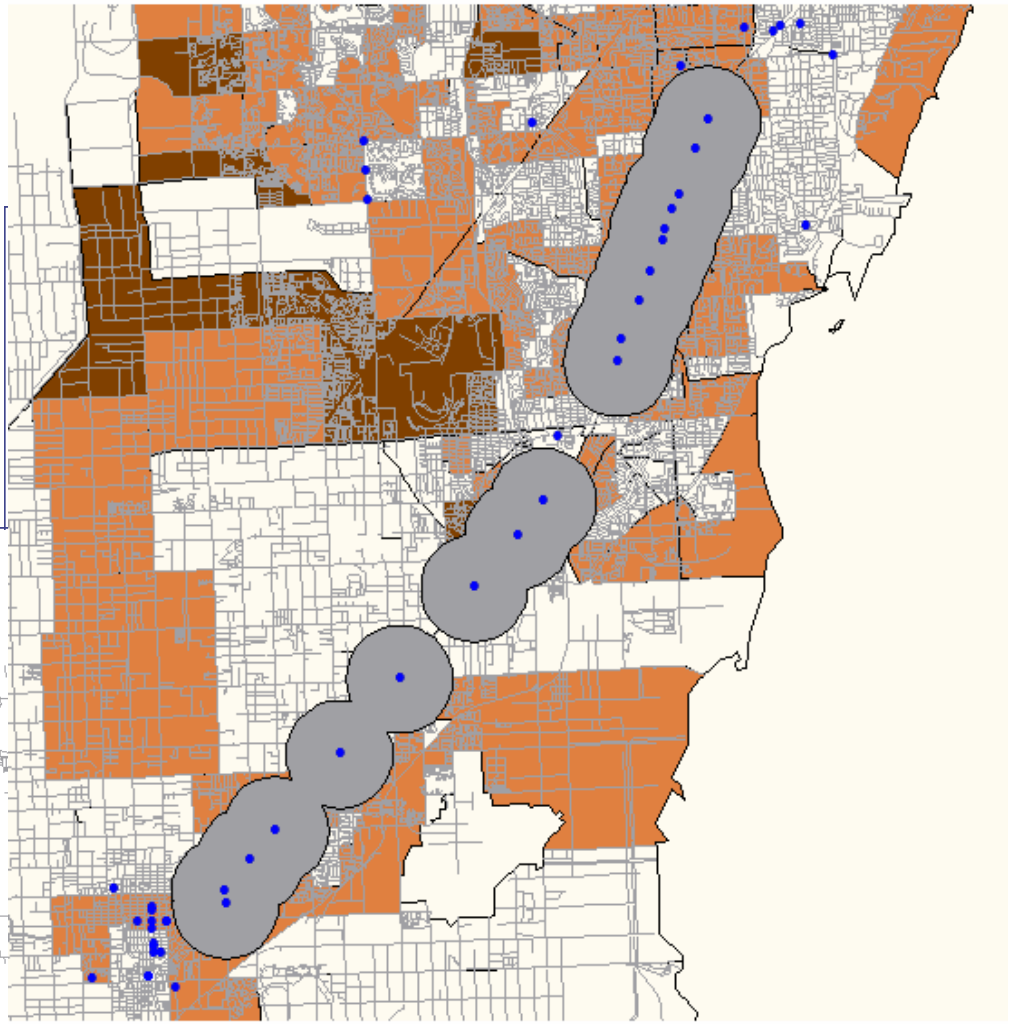
- GEEs with Negative Binomial link function were used to model spatial and temporal correlation for 3-year longitudinal crash data.

Spatial Safety Analysis: Corridor Identification & Cluster Analysis

- A total number of 476 signalized intersections along 41 arterials are selected from 3 counties in Fl.



Orange County



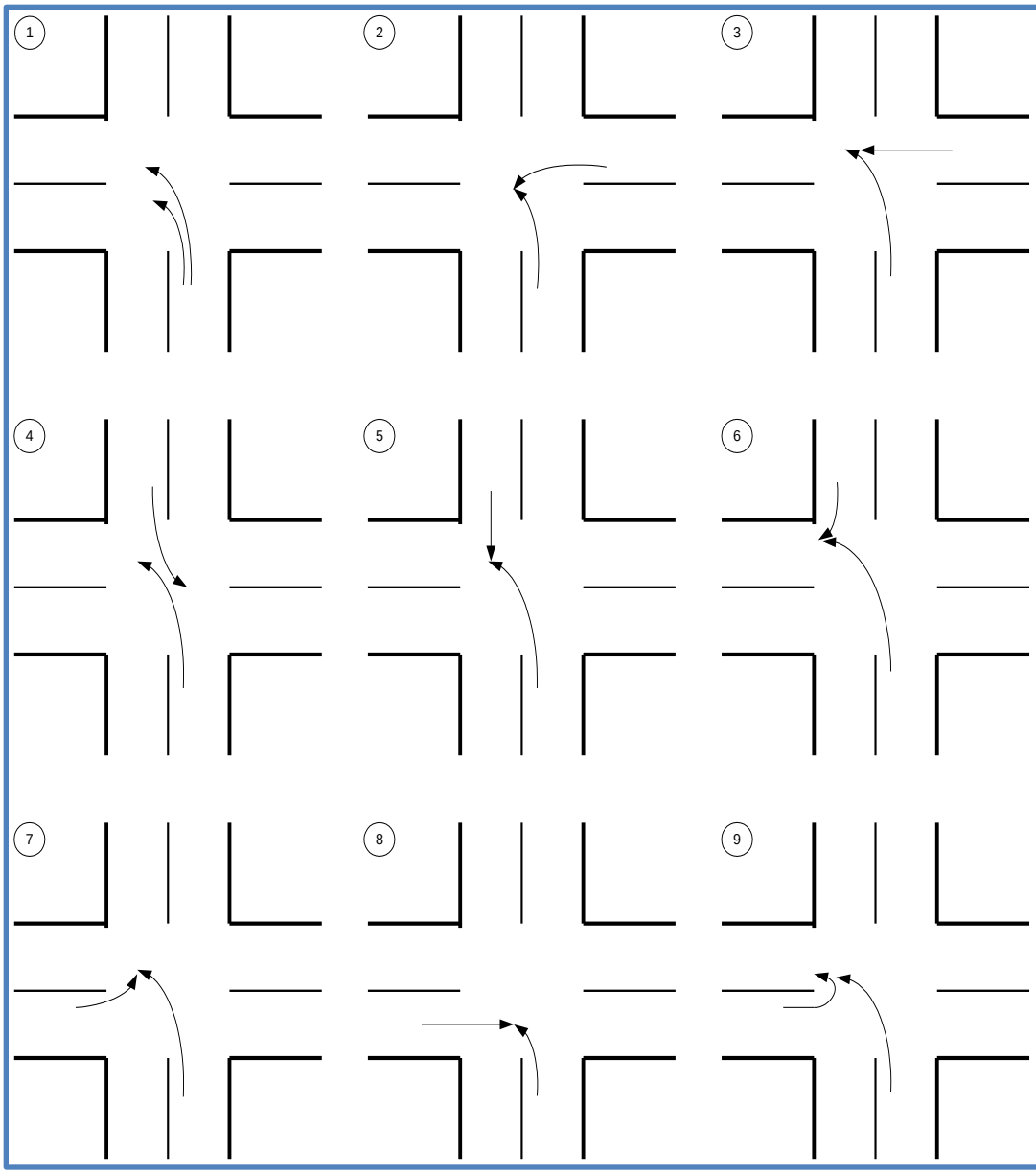
Intersection Cluster Analysis, US 1, Miami-Dade

Safety Analysis by Conflicting Patterns

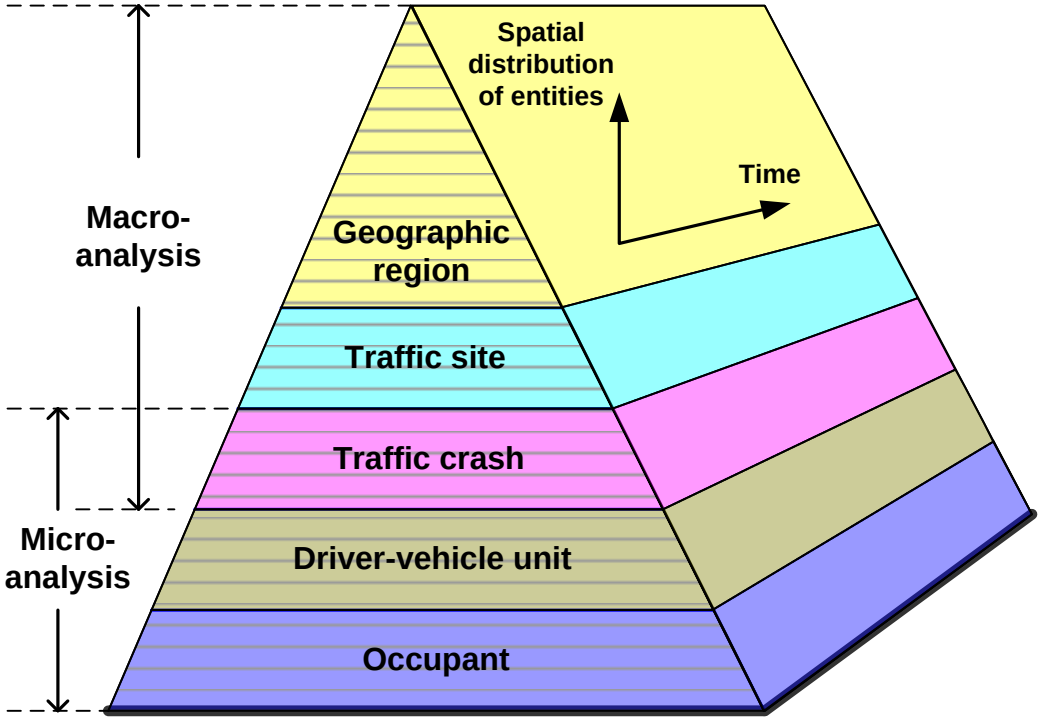
Major Conflicting Patterns

e.g., for Left-turn crashes

Modeling Crash Frequency At the Approach Level: GEE with Negative Binomial to account for "site correlation".



A conceptual model Multi-level and SpatioTemporal data structure



Level 1: Geographic region

Level 2: Traffic site

Level 3: Traffic crash

Level 4: Driver-Vehicle Unit

Level 5: Occupant

Spatial level: Geographic region & Traffic site

Time level: for Panel data

5×ST hierarchy

Huang H and Abdel-Aty M. (2010) Multilevel Data in Traffic Safety: a Five-level Hierarchical Spatiotemporal Model, *Accident Analysis & Prevention*, Elsevier, Volume 42, Issue 6, pp. 1556-1565.

Traditional Approach

Generalized Linear Model

$$Y \mid \boldsymbol{\theta} \sim Dist(\boldsymbol{\theta})$$

$$with \quad \boldsymbol{\theta} = f(\mathbf{X}, \boldsymbol{\beta}, \boldsymbol{\varepsilon})$$

Y: Dependent variable(s) of interest, e.g. crash frequency or severity

$Dist(\boldsymbol{\theta})$: Adapted distribution for $Y \mid \boldsymbol{\theta}$ and its parameter(s)

$\mathbf{X}$: Covariates representing various exposure/risk factors to crash occurrence

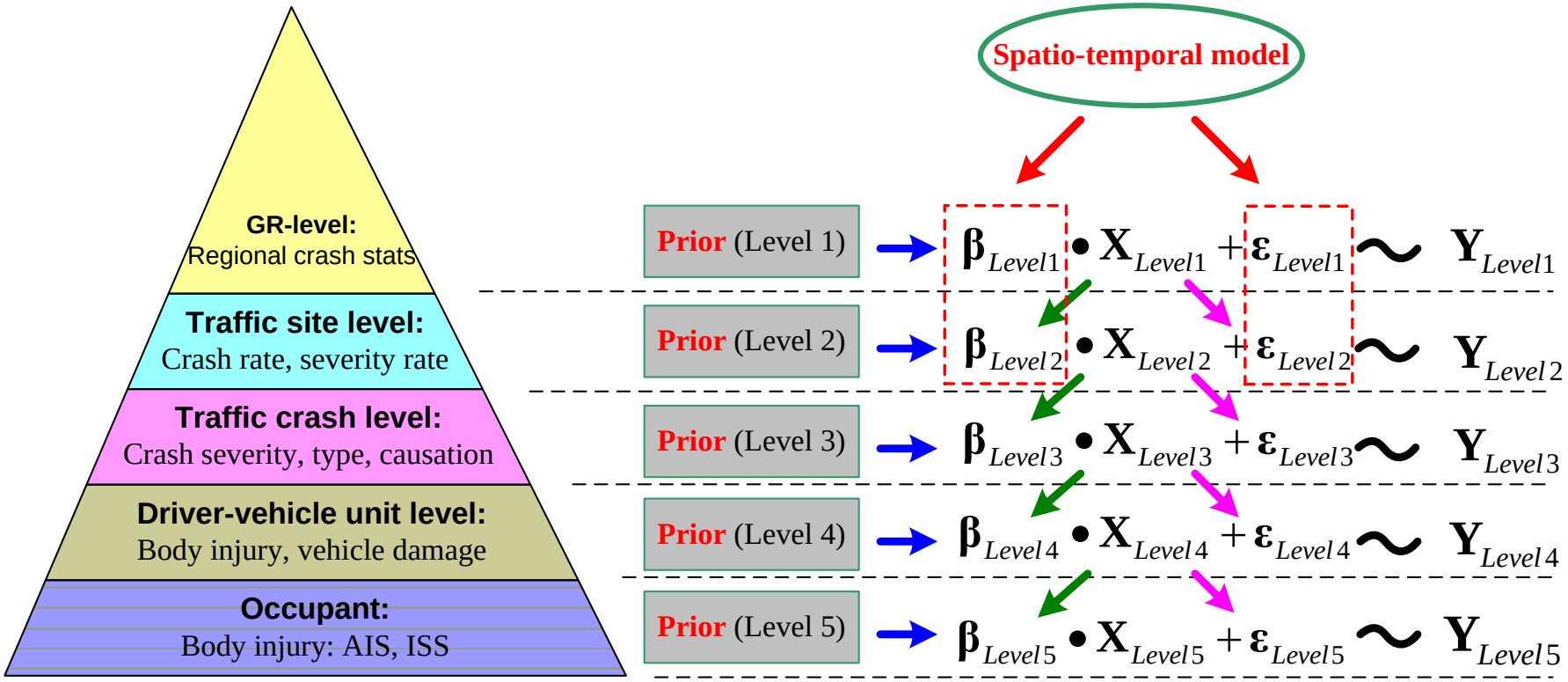
$\boldsymbol{\beta}$: Coefficients, i.e. factor effects of $\mathbf{X}$ on Y

$f(\cdot)$: Link function relating $\mathbf{X}$ and Y

$\boldsymbol{\varepsilon}$: Disturbance/error terms in the model

- GLMs limitation: each observation in the estimation procedure corresponds to an individual situation. Hence, the residuals from the model exhibit independence.
- However, the “independence” assumption may often not hold true since multilevel data structures exist extensively because of the traffic data collection and clustering process.

Solution: Bayesian Hierarchical Modeling



- To examine the effects of various risk factors at different levels
- Cross-group heterogeneity
- Spatial autocorrelation, Time-series correlation

What is the merit ?

Multilevel Model

Simultaneously incorporate risk factors in both individual-level and group-level models with consideration for cross-group variations.

Bayesian Prior

Engineering experiences or justified previous findings can be used as prior knowledge of the posterior model. It is good for small sample size.

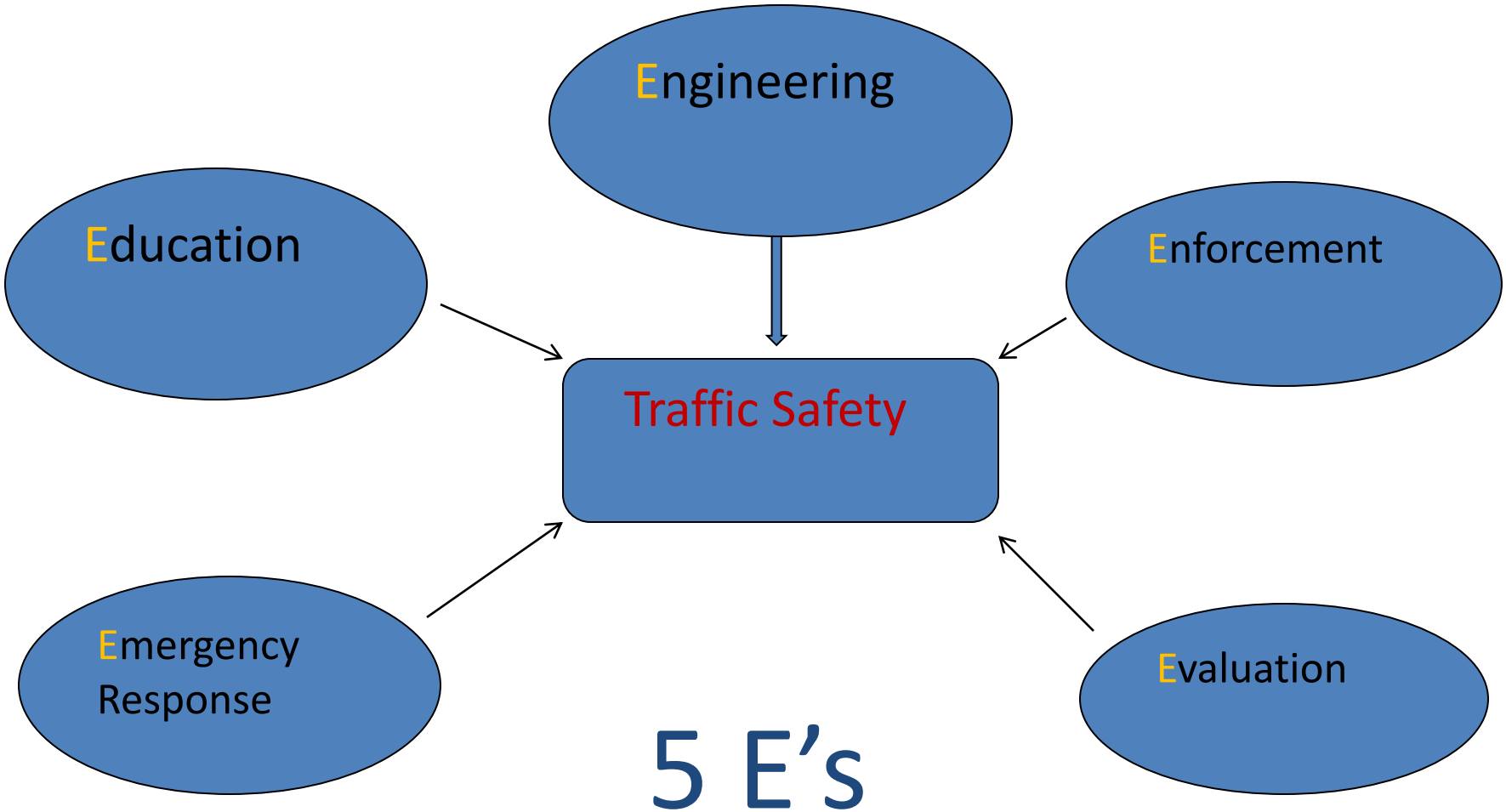
Bayesian Prediction

Hierarchical modeling is a preferred partial pooling of data. By latent variable approach, Bayesian inference provides automatic prediction for missing data and for new units in new groups.

Recommendations

- More Proactive approaches are needed in traffic safety
- Improve Safety Databases.
- Incorporate Safety at the Planning Level
- National and regional Goals and Strategic Safety Plan
- Integrated 5E approach

Overall Safety Strategy



5 E's

Recommendations (cont.)

- Benefit from the wealth of Safety Research from around the world while tailoring it to the specific country (Greece).
- A number of recent studies, including those by the presenter, have shown the usefulness of accounting for specific safety data structure by using Bayesian hierarchical models.
- The proposed 5×ST-level hierarchy represents a conceptual framework with all up-to-date understandings on safety data structure.

Dr. Mohamed Abdel-Aty, P.E.
Professor
Department of Civil, Environmental & Construction Engineering
University of Central Florida
Ph. +1-407-823-5657
Email: *M.Aty@ucf.edu*

Associate Editor
Accident Analysis & Prevention