Transportation Safety: Integrating quantified safety evaluations in project planning

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October 12, 2017

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Presentation Outline

- **Overview**
- Quantitative Safety Analysis
- Performance-based Analysis

Overview—We hope to share how….

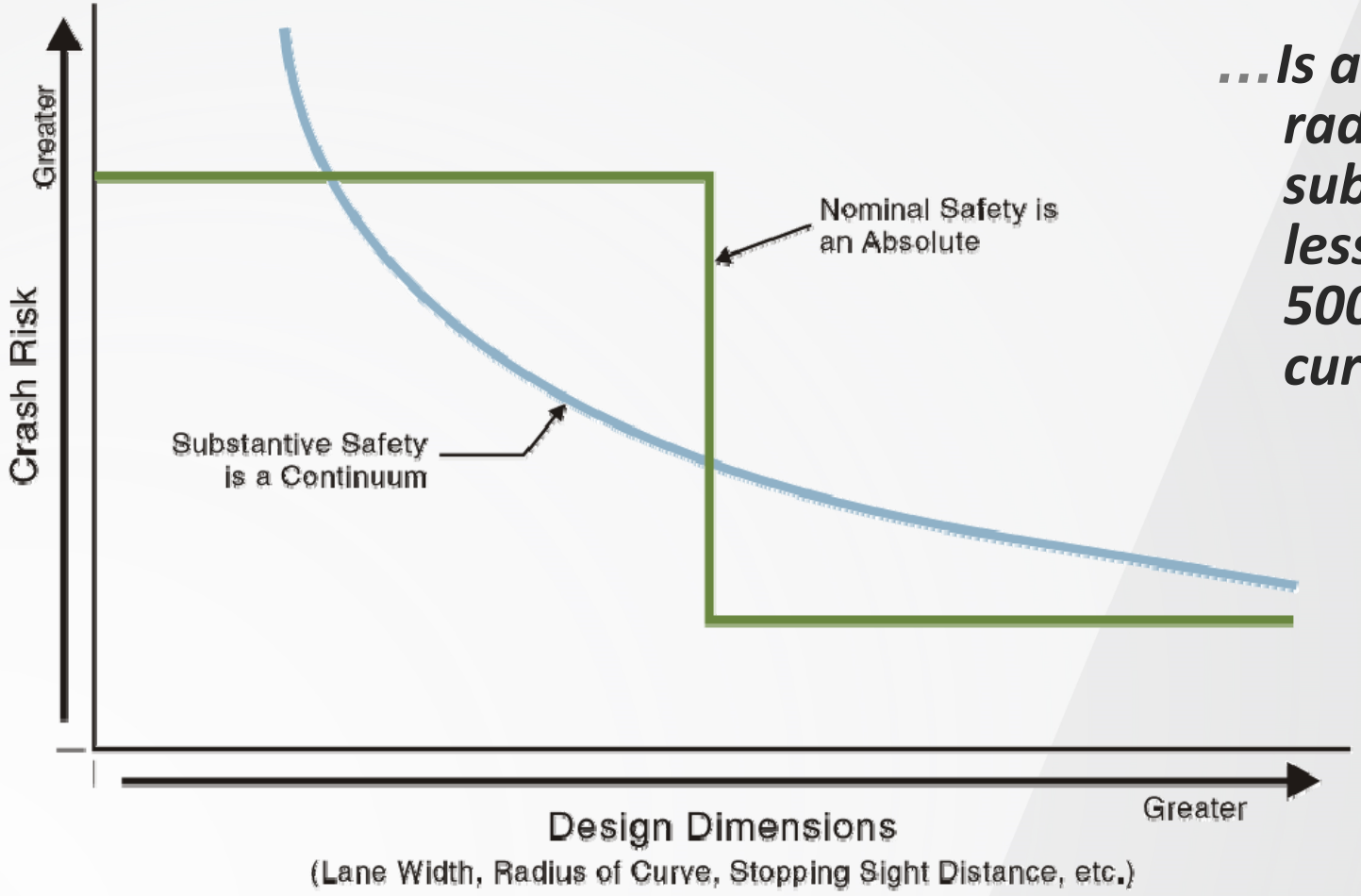
- Performance-based analysis is a means to support project planning and design decisions
- We can make more informed project decisions based on quantitative safety performance
- We are considering factors beyond capacity-based mobility to guide project decisions

Overview

- **The past….**
  - Focusing on maximizing motor vehicle capacity as the measure of project success.
  - Using dimensional values as the primary determinant of design acceptability
  - Considering design standards as a surrogate for safety
- **The present….**
  - Considering and integrating pedestrians and bicyclists in design configurations
  - Using performance-based analyses to support project decision making
  - Integrating quantitative safety performance in planning, design, and management

The future:
Incrementally integrating technology into infrastructure and vehicles for maximum safety and mobility performance…

Safety is a continuum not an absolute



…Is a 499 foot radius curve substantially less safe than a 500 foot radius curve?

Source: NCHRP Report 480

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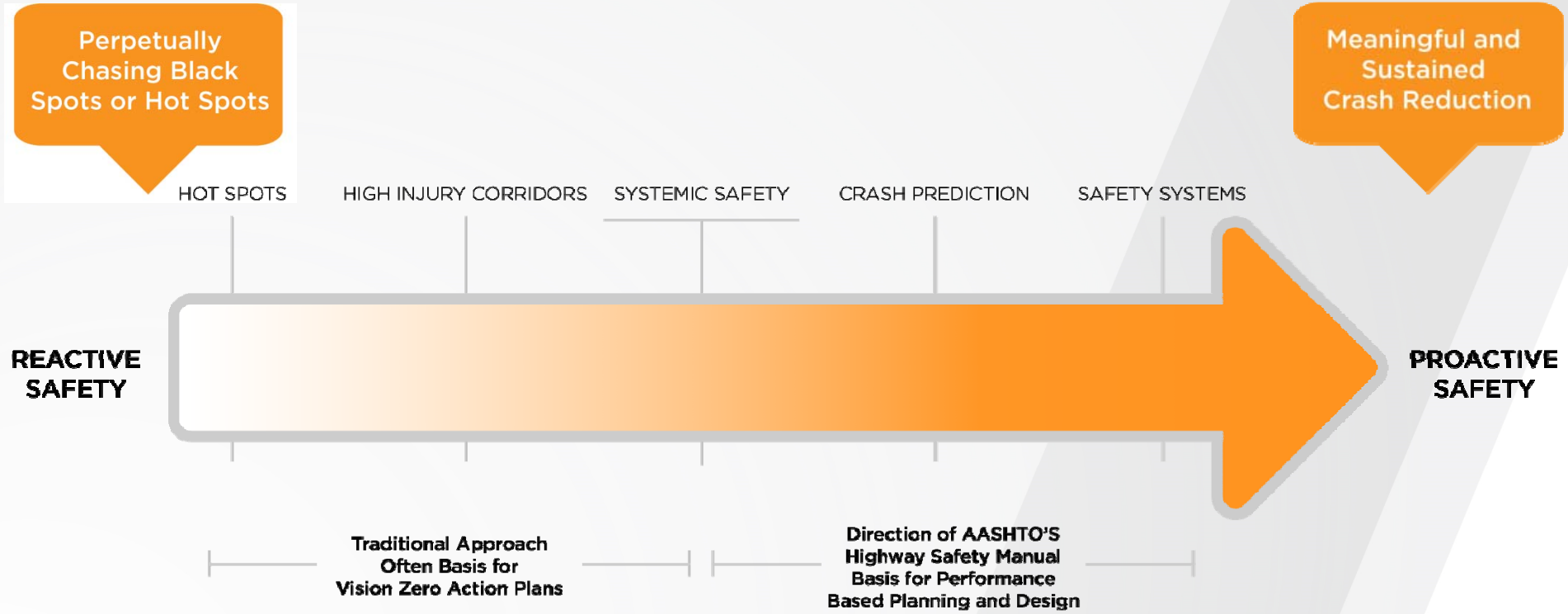
Quantitative Safety Analysis

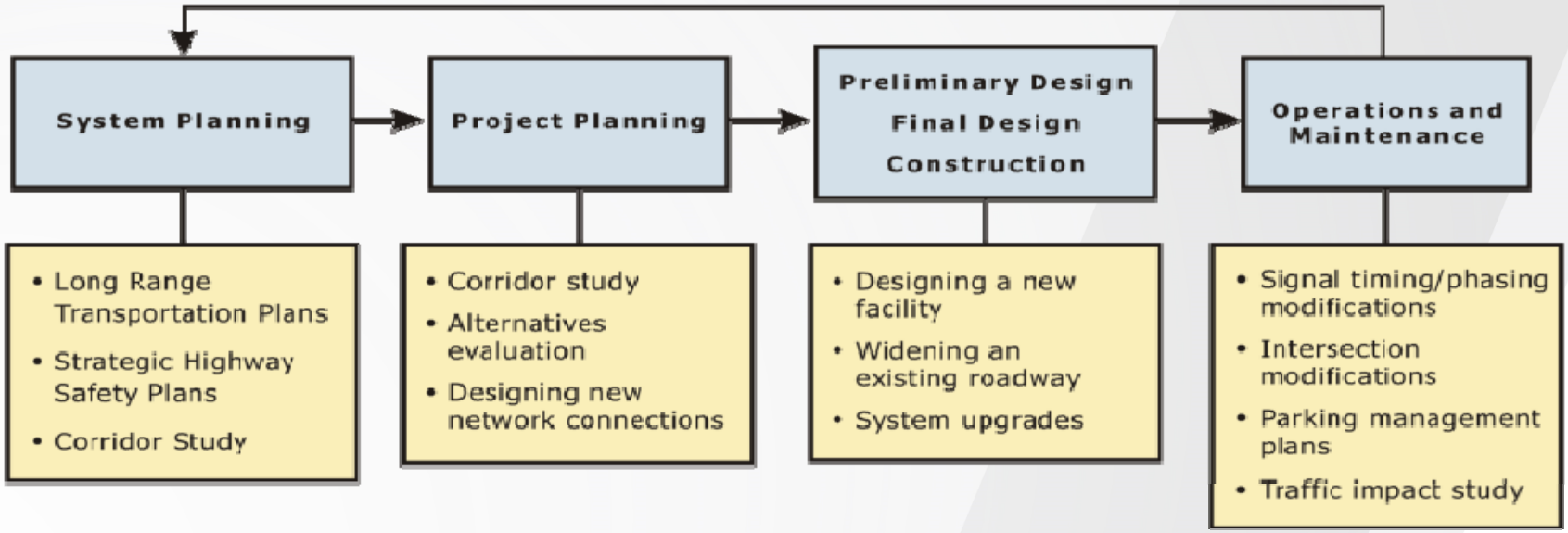


Quantitative Safety Analysis Benefits

- **Measure safety performance objectively (i.e., quantitatively)**
  - Differentiate “safety” from “security”
- **New tools enhance our current practice**
  - Improve reliability
  - Provide new capabilities (e.g., predicting crashes)
  - Quantify safety and compare with other project advantages and disadvantages
- **Incorporate new tools and methods in the near-term and plan for further integrating them in the long-term**
  - No need to do everything at once

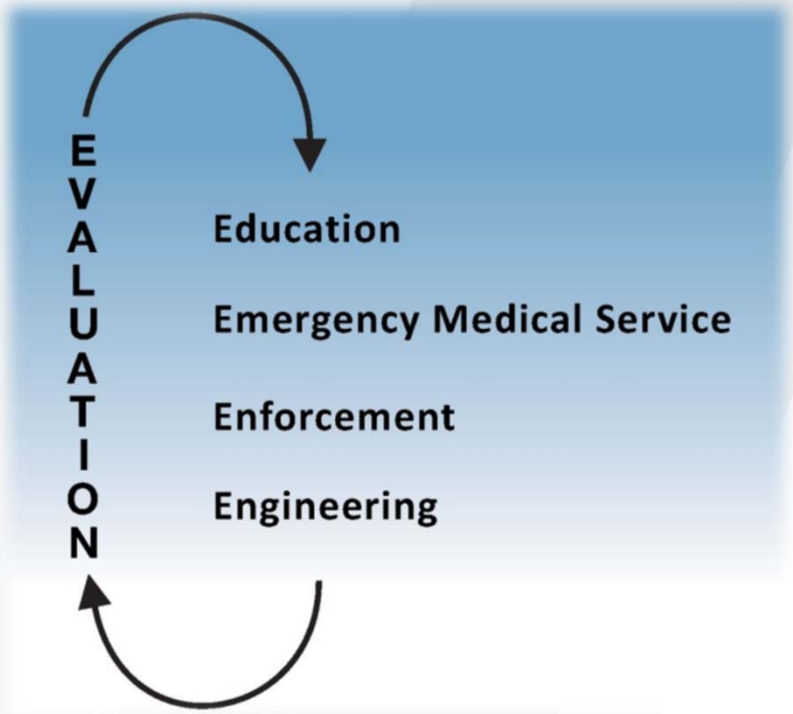
Quantitative Safety Performance begins early, too!

- **Safety integration throughout project development process**
  - Quantify safety performance
  - Comprehensively address safety issues
  - Cost-effectively reduce crashes



Quantitative Safety Analysis

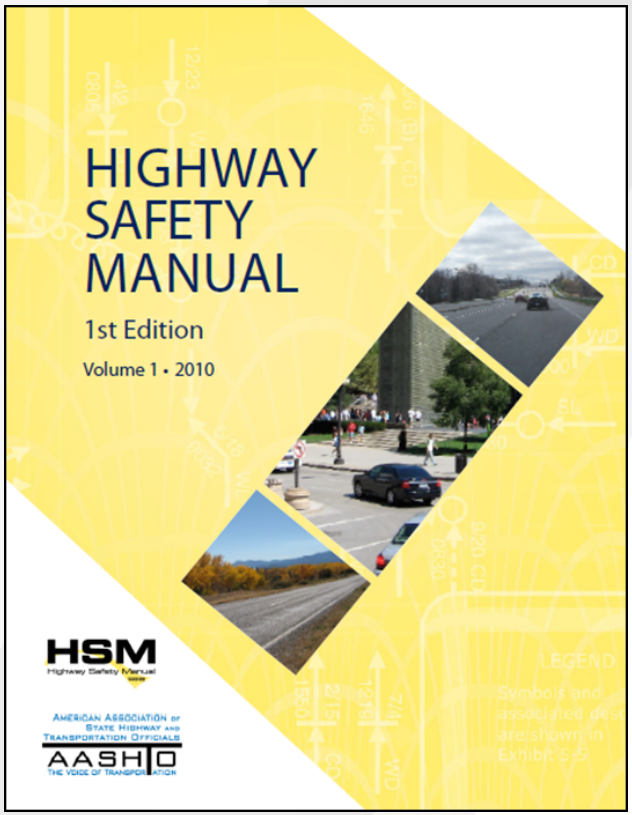
- Apply tools that quantify safety performance (frequency and severity)
- Conduct objective safety analyses
- Focus on mitigations that best address contributing factors
- Spend your money wisely…be prepared for non-engineering solutions



…We can not "design" our way to target safety performance…

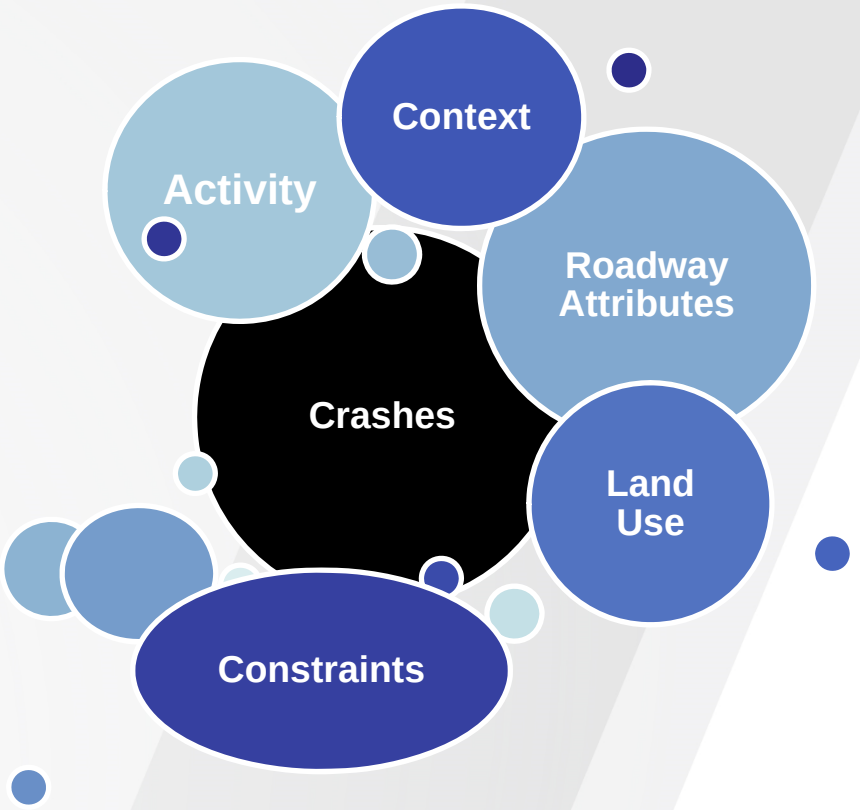
Quantitative Safety Analysis Resources

- **AASHTO's** *Highway Safety Manual, 1st Edition (2010)*
  - 2nd Edition under development
- **FHWA CMF Clearinghouse**
  - Crash Modification Factors
  - Weighted and ranked
- **Agency-specific SPFs**
  - Safety Performance Functions
- **Publically accessible spreadsheets**



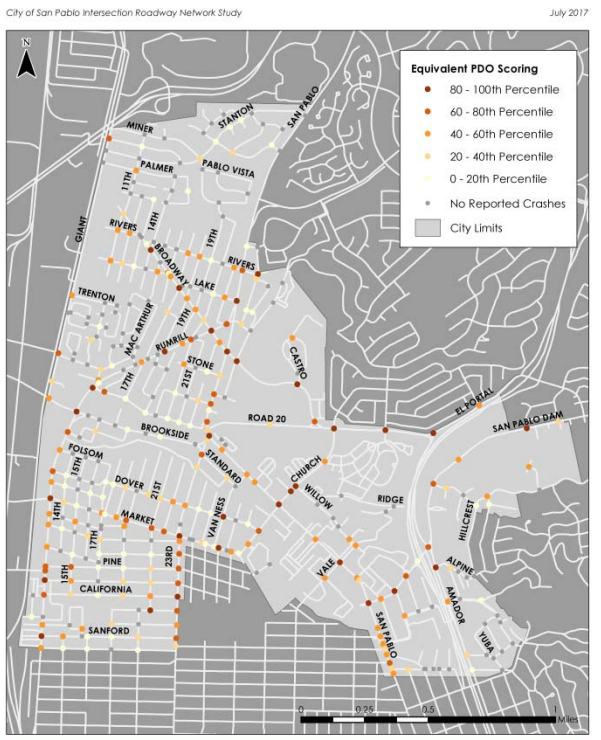
Quantitative Safety Analysis: Network Screening

- **Understand available data**
  - Crash characteristics
  - Roadway attributes
  - Activity (volume)
  - Context and land use
  - Constraints
- **Determine best available safety performance measures**
  - What is the focus of the study?
  - What are our analysis constraints?
  - How will the results be used?

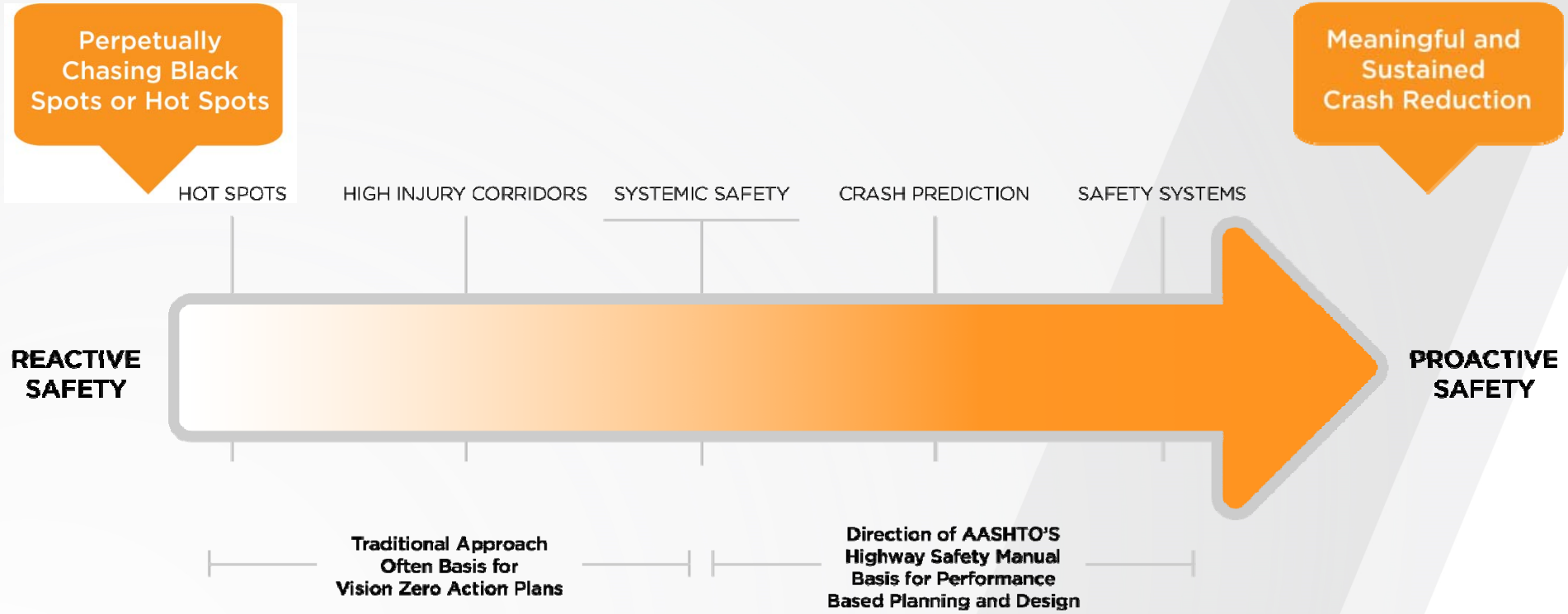


Quantitative Safety Analysis: Network Screening

- **Three ways of thinking about crashes:**
  - **Frequency, Severity, Type**
- **Easy-to-implement *Highway Safety Manual* performance measures:**
  - Crash Rate
  - Equivalent Property Damage Only Score
  - Excess Proportion of Crash Types
- **Improving statistical confidence**
  - Better data
  - Better methods

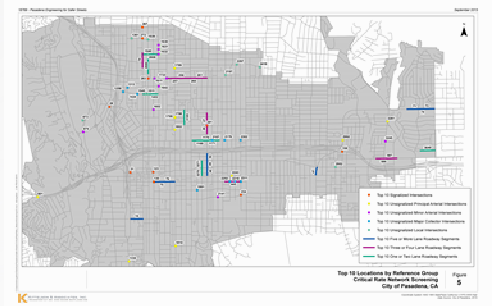


Network Screening Spectrum

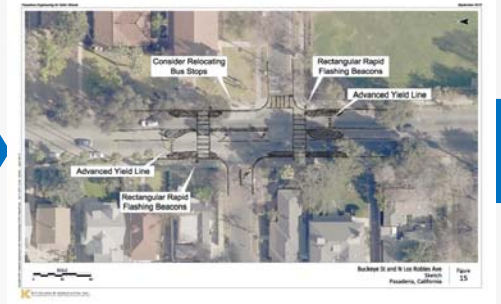


Success Story: Pasadena Safer Streets Projects

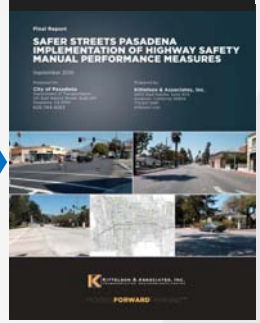
Screen Network



Develop Projects



Findings



Get Funded!

$$

- Integrated HSM performance measures into their crash database and site selection process
- Developed long-term safety evaluation process
- Identified top projects and develop concept designs
- Successful HSIP Cycle 8 grant for 3 intersections
- Additional grants totaling $1.5 million for the City

Presentation Outline

- Overview
- Quantitative Safety Analysis
- **Performance-based Analysis**

Performance-based Analyses

- **Adapting to each project context**
  - Identifying intended project outcomes
  - Establishing whom we are trying to serve
  - Selecting performance measures based on what we are trying to achieve
- **Intersection control evaluations**
  - Consider safety performance, multi-modal needs, service life, and other metrics beyond traffic operations
  - Alternative intersections and interchanges
- **Quantified Safety Performance**
  - Highway Safety Manual (AASHTO 2010)
- **Multimodal Quality of Service**

…Focusing on the "value" of our investments…

Applications of the Predictive Method

- **Safety Management**
  - Network screening to identify high priority sites
- **Corridor and System Planning**
  - Assess and compare safety performance
  - Identify hot spots
  - Identify potential safety improvements and mitigation measures
  - Prioritization criteria
- **Project Scoping and Pre-design**
  - Compare the safety performance of alternatives
  - Evaluate effect of proposed improvements and crash countermeasures
  - Assess the effect of design options (e.g. cross section, horizontal curvature, lighting, etc)
  - Evaluate design exceptions

HSM Predictive Models

Facility	Segment	Intersections							
		3-leg Unsig	3-leg Sig	4-leg Unsig	4-leg Sig	5-leg Sig	All-way Stop	Round about	SPUI Sig
Rural 2-lane Highways	●	●	○	●	●	○	○	○	
Rural Multilane Highways									
4-lane undivided	●	●	○	●	●	○	○	○	
4-lane divided	●	●	○	●	●	○	○	○	
Urban & Suburban Arterials									
2-lane undivided	●	●	●	●	●	○	○	○	
3-lane (TWLTL)	●	●	●	●	●	○	○	○	
4-lane undivided	●	●	●	●	●	○	○	○	
4-lane divided	●	●	●	●	●	○		○	
5-lane (TWLTL)	●	●	●	●	●	○		○	
6-lane divided	○	○	○	○	○	○			
One-way	○	○	○	○	○	○	○		
Freeways & Interchanges									
Basic Segments	●								
Ramps	●								
Speed-change lanes	●								

● Current HSM

○ Potential Addition to next HSM Edition

Integrating Safety with Pavement Preservation

Existing Conditions:

- **AADT:** 1,500 (2011); 1,700 (2030)
- **5-Year Crash Data**
  - **Fatal: 1 Injury: 5 PDO: 14**
- **Level Terrain**
- **12-foot lanes**
- **2 foot paved shoulders**

US 191:, MP 38.0 to MP 45.9

Projects Under Consideration:

- **8-foot shoulders**
- **Reconstructing Flying-Y intersection,**
- **Adding Two Way Left Turn Lane**

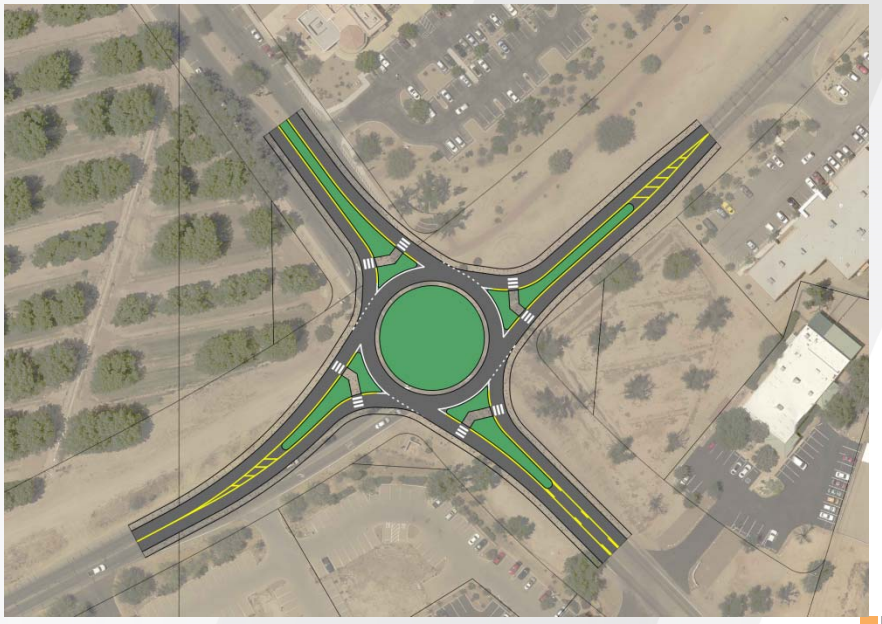
HSM Predictive Method Analysis Results

	Expected Crash Frequency (crashes per year)			Estimated 20-year Total Crashes	Estimated 20-year Total Crash Reduction
	FI	PDO	Total		
Existing Roadway					
2010	1.6	3.2	4.8	**106.0**	
2030	1.9	3.9	5.8		
Remove Flying-Y intersection at Pearce Rd					
2010	1.6	3.2	4.8	**105.0**	**1.0**
2030	1.9	3.8	5.7		
Add TWLTL north of SR 181					
2010	1.6	3.2	4.8	**105.0**	**1.0**
2030	1.9	3.8	5.7		
Widen shoulders to 8 feet with rumble strips					
2010	1.3	2.6	3.9	**85.0**	**21.0**
2030	1.4	3.2	4.6		

Expected Safety Benefit

	Fatal	Injury A	Injury B	Injury C	PDO	Total
Crash Costs (ADOT)	$5,800,000	$400,000	$80,000	$42,000	$4,000	
Project: Widen Shoulders to 8 feet with rumble strips						
Expected Crash Reduction (average over 20 Years)	0.9	0.9	0.9	3.5	12.4	18.6
Benefit over service life (20 years)	$ 5,137,143	$354,286	$ 70,857	$148,800	$ 49,600	$5,760,686

Intersection Control Evaluation



Project Performance Measures

Performance Measure	Traffic Signal	Roundabout	All-Way Stop Control
Weekday Vehicle Delay (hours/year)	52,850	55,150	250,000
Predicted Crash Frequency			
Fatal & Injury	23.2	10.5	10.5
Total	68.5	50.7	50.7

Calculate Net Present Value of Costs

Cost Categories	Net Present Value of Costs		
	Traffic Signal	Roundabout	All-Way Stop Control
Planning & Construction Costs	$ 956,142	$ 646,354	$ -
Annual Operations and Maintenance Costs	$ 138,349	$ 59,292	$ 44,469
Auto Passenger Delay	$ 13,744,297	$ 14,342,231	$ 65,155,904
Truck Delay	$ 556,454	$ 580,662	$ 2,637,912
Safety	$ 25,265,135	$ 18,640,006	$ 18,640,006
Greenhouse Gases	--	--	--
Criteria Pollutants	--	--	--
Total cost	**$40,660,377**	**$34,268,545**	**$86,478,291**

Benefit-Cost Analysis

Benefit Categories	Net Present Value of Benefits Relative to Base Case		
	Traffic Signal	Roundabout	All-Way Stop Control
Auto Passenger Delay	$ 51,411,607	$ 50,813,673	
Truck Delay	$ 2,081,458	$ 2,057,250	
Safety	$ (6,625,129)	$ -	
Greenhouse Gases			
Criteria Pollutants			
Net Present Value of Benefits	$ 46,867,936	$ 52,870,923	
Net Present Value of Costs	$ 1,050,022	$ 661,177	
Present Value of Net Benefits	$ 45,817,915	$ 52,209,746	
Benefit-Cost Ratio	**44.64**	**79.96**	

Thank You!