CSVA Conference

Integrating Road Safety Analysis and Value Analysis

Montreal, Quebec

November 26, 2013

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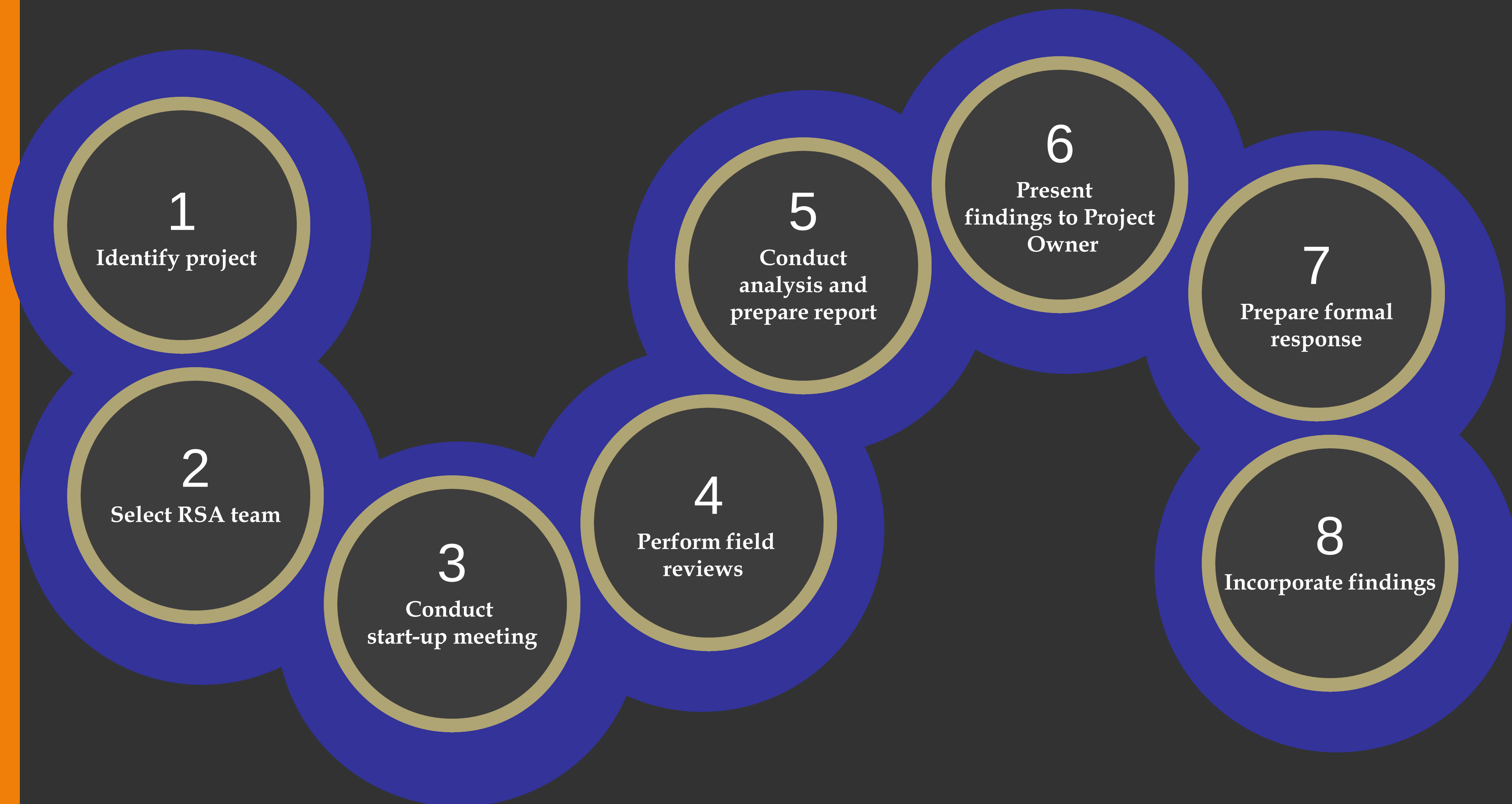
Presentation Key Points

- *Levels of Road Safety Analysis (RdSafAn)– Qualitative, Semi-Quantitative, Quantitative*
- *How to integrate RdSafAn within the Value Methodology?*
- *Participants apply Semi-Quantitative to Sample Project*
- *Sample application of Quantitative RdSafAn within a VA Study*

Background of Caltrans RSA-VA Program

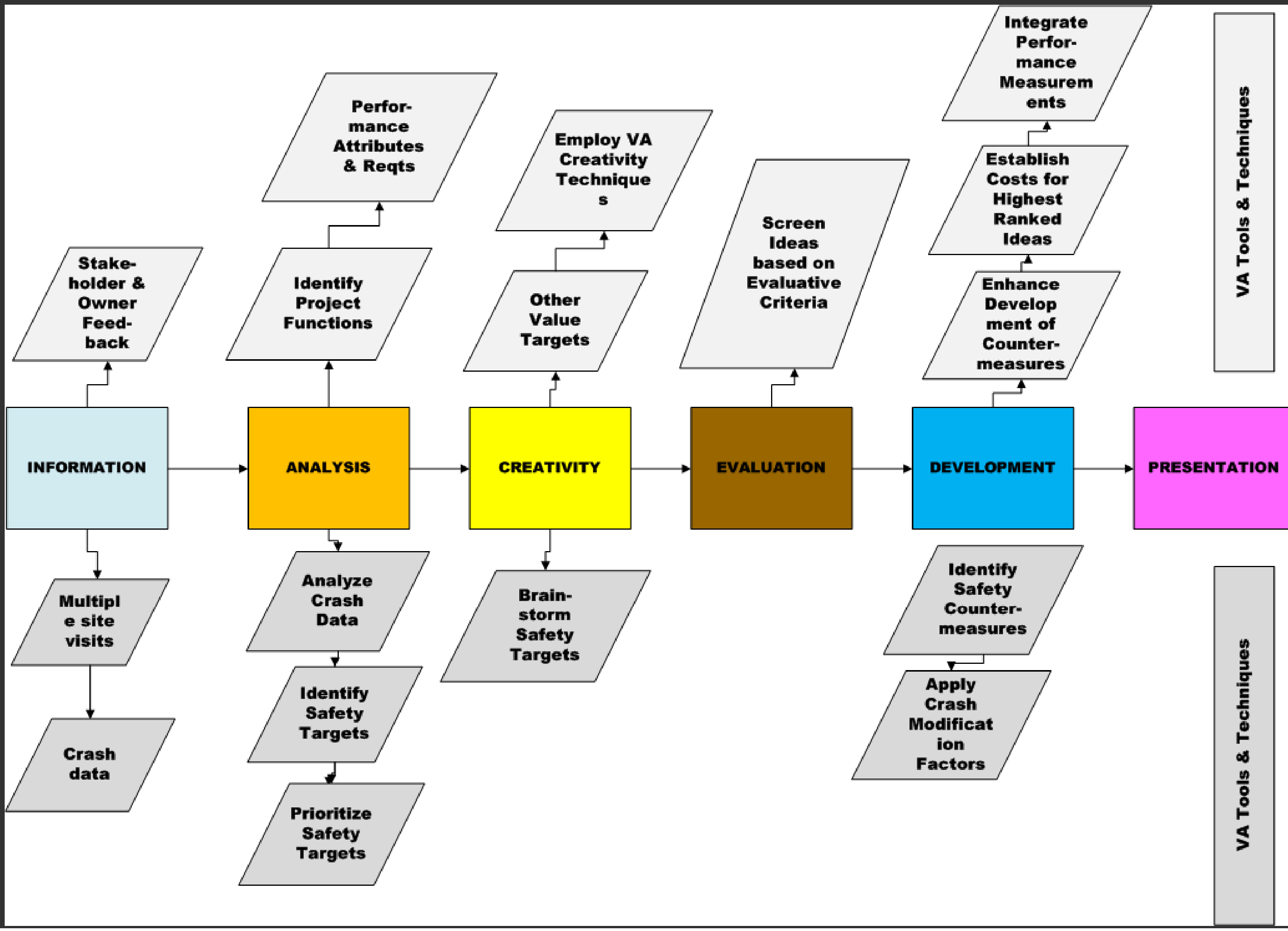
- AASHTO 2009 (FHWA RSA-VA Promotion)
- FHWA/ Caltrans Cooperative Agreement
  - Pilot Programs
    - US-101 Smith River (Qualitative)
    - Yol-16, Capay Valley (Qualitative)
    - Ala-84, Niles Canyon Road (Quantitative)
- MTO Studies (Semi-Quantitative)

FHWA Road Safety Audit Process



Qualitative
Risk Based Safety Analysis

Qualitative *RdSafAn* integrated with Value Analysis



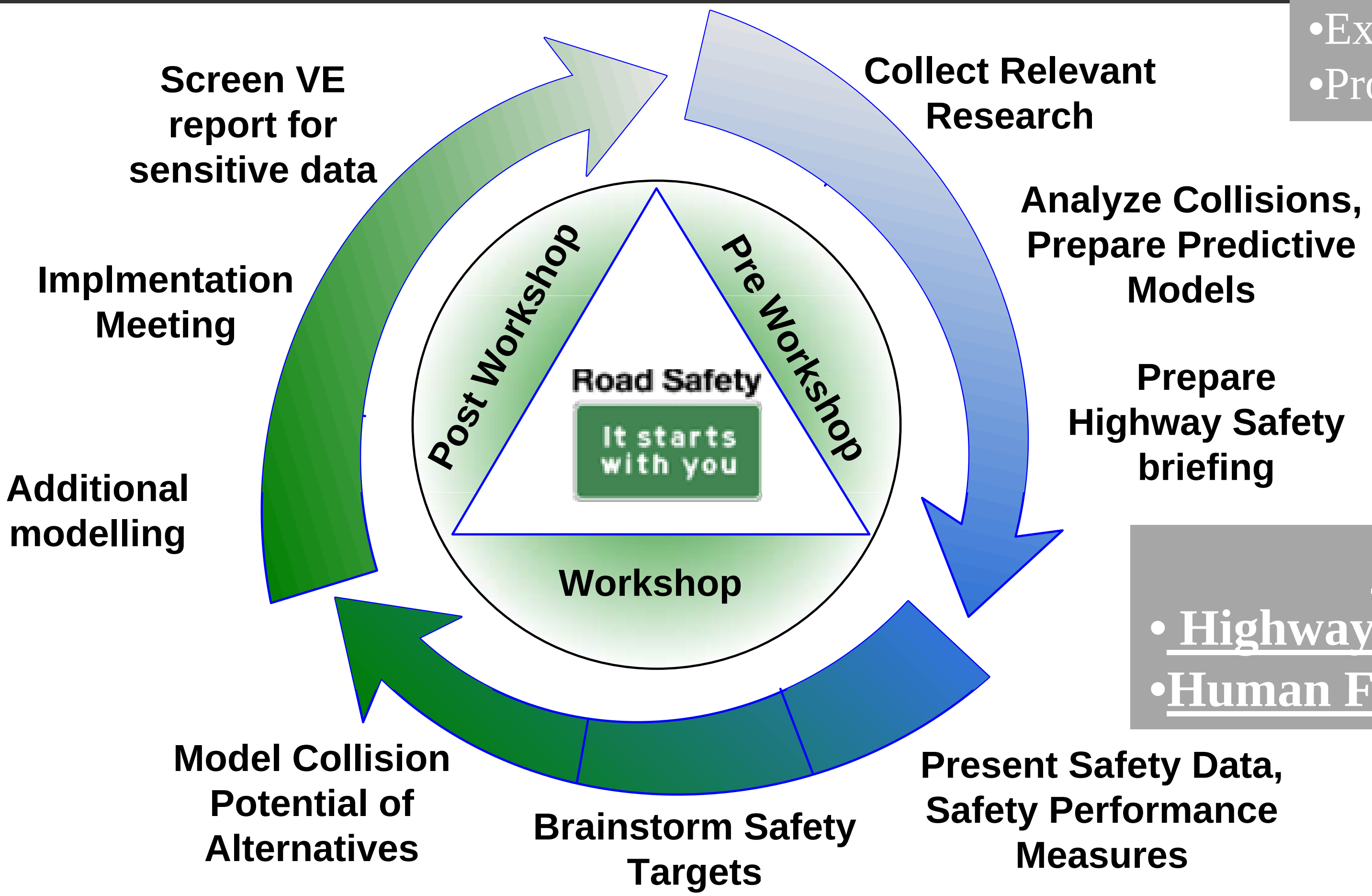
Levels of RdSafAn- Qualitative

Level RdSafAn	Features	Outomes
Qualitative	RSA (field observations) with low level analysis	List of Field Observations (Safety Issues)
	Involves Road Safety Experts	List of Countermeasures that address Safety Issues
	Often (but not always) involves DOT/ Design professionals	Outcomes are largely based on Professional Judgement
	Little to no preworkshop analysis required	Little to no safety analysis of project alternatives
	Supported by the FHWA	Application best on Safety Projects
	Best applied to Safety Projects (improve existing conditions)	Lower Cost
	Little to no project alternative analysis	

Semi- Quantitative
Risk Based Safety Analysis

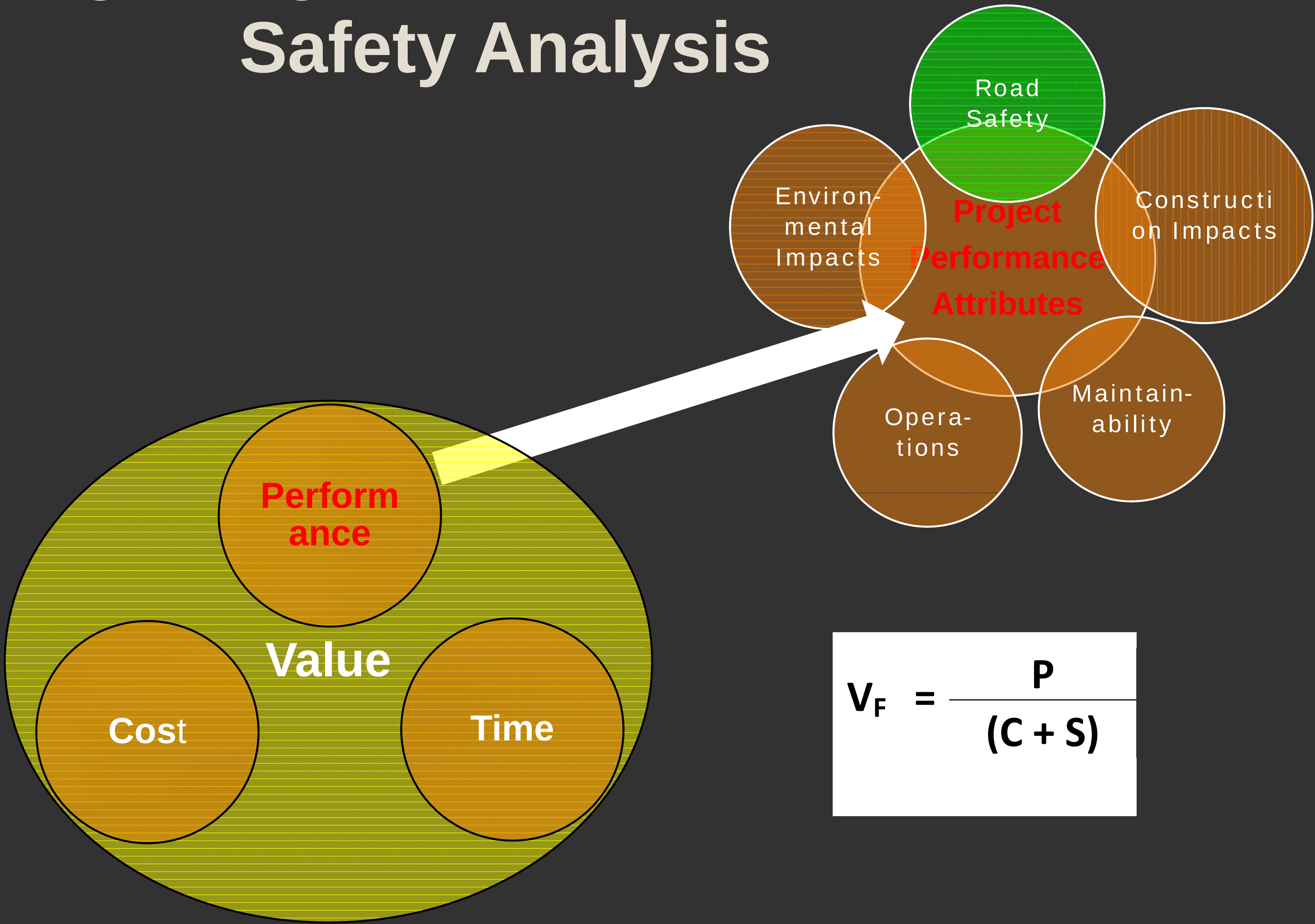
RdSafAn Activities within VM Workshop

Study Focus:
- Existing Conditions
- Proposed Design



SME's:
- Highway Safety Expert/s
- Human Factors Expert/s

Integrating Value Metrics & Road Safety Analysis



$$V_F = \frac{P}{(C + S)}$$

Quantifying Safety using a Risk-Based Approach

- Risk management approach with the identification of risk drivers (i.e. ***collision vectors)***
- Assessment of potential “impact”:
  - 0 to 1 scale reflecting collision severity
- Assessment of “likelihood” of occurrence
  - 0 to 1 scale reflecting likelihood
- Development of a quantitative index:

Risk Index = Impact x Likelihood

Source

Some comments on Risk Index

- Road Safety defined selection of Collision Vectors
  - Elements of facility that contribute to increased collision risk (Safety Drivers)
- Rating is qualitative, based on expert judgement
  - Supported by accepted quantitative & performance-based safety analysis techniques
  - Backed up by seasoned Road Safety Expert
- Relative differences are key
  - Lower values are “more safe”
  - Higher values are “less safe”

Sample Assessment – Baseline Concept

QEW - Highway 403 Preliminary Design Risk Analysis	
	Baseline
	Risk Index
Alternative >>>	Calculated
Risk element	
Speed & Speed Differentials	0.28
Gap search & lane change	0.35
Interchange configuration	0.20
Accommodation of heavy vehicles	0.12
HOV lane entry/exit points	0.20
Lane balance and continuity	0.42
Driver workload	0.16
Average Risk Index	0.25

Collision Vectors Defined:

Collision Vector: Driver workload and operational complexity

The following conditions in the current design contribute to the driver workload and operational complexity:

- Congestion and speed differentials observed at key fwy-fwy merge and diverge points
- Closely spaced interchanges, successive ramps and weaving sections appear to contribute to increased congestion, vehicle conflicts and operational complexity.

Collision Vector Rationale:

- ***Signage at the Ford Drive interchange will require careful consideration for the various movements t***
- ***The QEW eastbound off-ramp to Winston Churchill is located well in advance of the interchange. This may confuse unfamiliar drivers.***
- ***Closely spaced successive diverge points***
- ***Closely spaced successive merge points***

Supporting Data:

Road *Safety* Report (81 pages)

Sample Assessment – Design & VE Concepts

	Baseline	Design Alternative 1	VE Scenario 1	VE Scenario 2
	Risk Index	Risk Index	Risk Index	Risk Index
Alternative >>> Risk element	Calculated	Calculated	Calculated	Calculated
Speed & Speed Differentials	0.28	0.32	0.28	0.26
Gap search & lane change	0.35	0.25	0.30	0.30
Interchange configuration	0.20	0.20	0.27	0.25
Accommodation of heavy vehicles	0.12	0.12	0.12	0.12
HOV lane entry/exit points	0.20	0.20	0.24	0.24
Lane balance and continuity	0.42	0.30	0.36	0.36
Driver workload	0.16	0.25	0.20	0.18
0	0.00	0.00	0.00	0.00
Average Risk Index	0.25	0.23	0.25	0.24
Equivalent Performance Rating (0-10)	5.03	5.16	4.97	5.06

Design Alternative 1 (Section 2-2B)

Collision Vector	Comments
Speed & Speed Differential	The following locations may demonstrate an increased risk of speed differential: Eastbound QEW/403 diverge - similar to base case Eastbound 403/Ford Drive diverge - similar to base case Eastbound QEW on-ramp from Ford Drive - worse than base case Northbound 403 on-ramp from Ford Drive - similar to base case Northbound 403 truck lane - similar to base case Minimun radius curves on QEW/403 connectors (two curves eliminated) - better than base case Westbound QEW access/egress to HOV at Winston Churchill - similar to base case Northbound and southbound 403 at Dundas ramps - similar to base case Northbound and southbound 403 between Dundas and QEW - better than base case Potential for speed differentials on westbound QEW due to weave created between Ford Drive and Winston Churchill - worse than base case Potential for speed differential on eastbound QEW due to weave created between Ford Drive and Winston Churchill - worse than base case
	The QEW west to 403 North and 403 north to QEW west connectors consist of 550 m and 600 m radii. These minimum radius curves are consistent with 110 km/h. Operating speeds through this section will likely be in excess of 110 km/h - Similar to base case
	The elongated configuration of the Ford Drive eastbound off-ramp may promote increased operating speeds on the approach to the ramp terminal - Similar to base case
Gap Search & Lane	

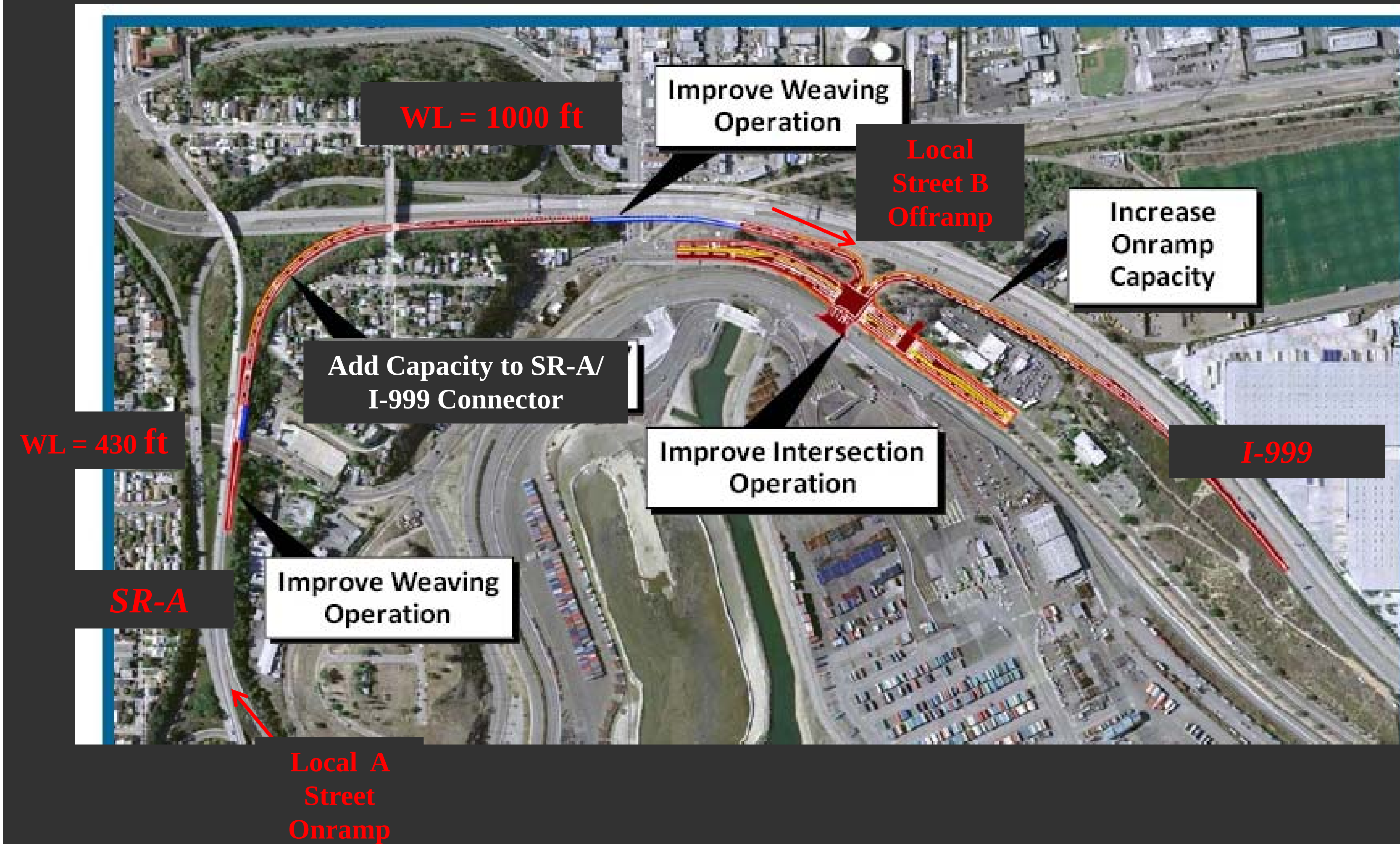
RdSafAn "behind the Scene"

TABLE OF CONTENTS

LIST OF TABLES

Example Application
Risk Based Safety Analysis

Sample Project Analysis



Value Solutions to Address SR-A/ I-999 Weaving Condition

Alt 5.1

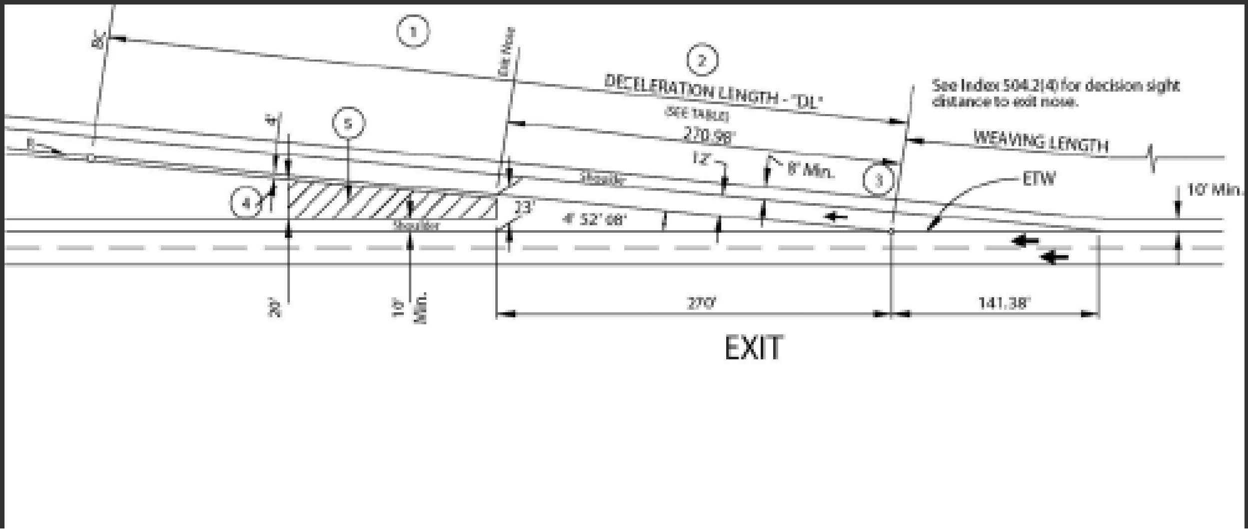
-Move ***SB SR-A/NB I-999 Connector Nose*** Downstream
-Move ***Connector/NB I-999 Nose*** Upstream" to gain 200 ft on each weave movement
- Results in 630 /1200 ft weaving lengths, respectively)

Value Solutions to Address SR-A/ I-99 Weaving Condition

Alt 5.1 (continued)

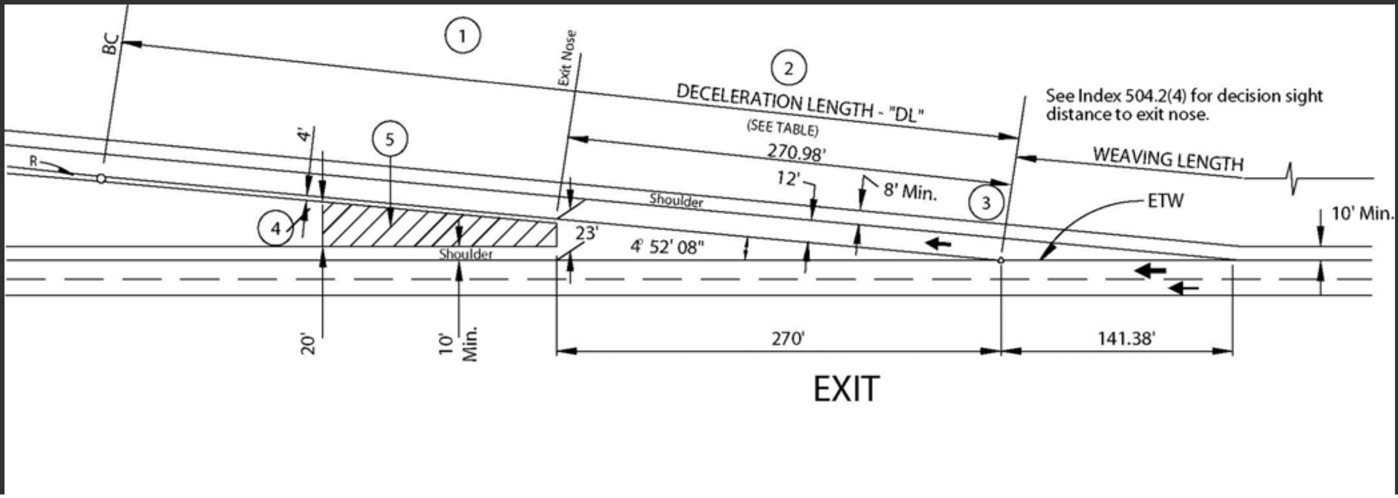
-This alternative was rejected based on the fact that this ramp radius would require the design speed be reduced from 43 mph to 35 mph.

-This speed reduction was due to the alternative's vertical profile (and not on the horizontal curvature)



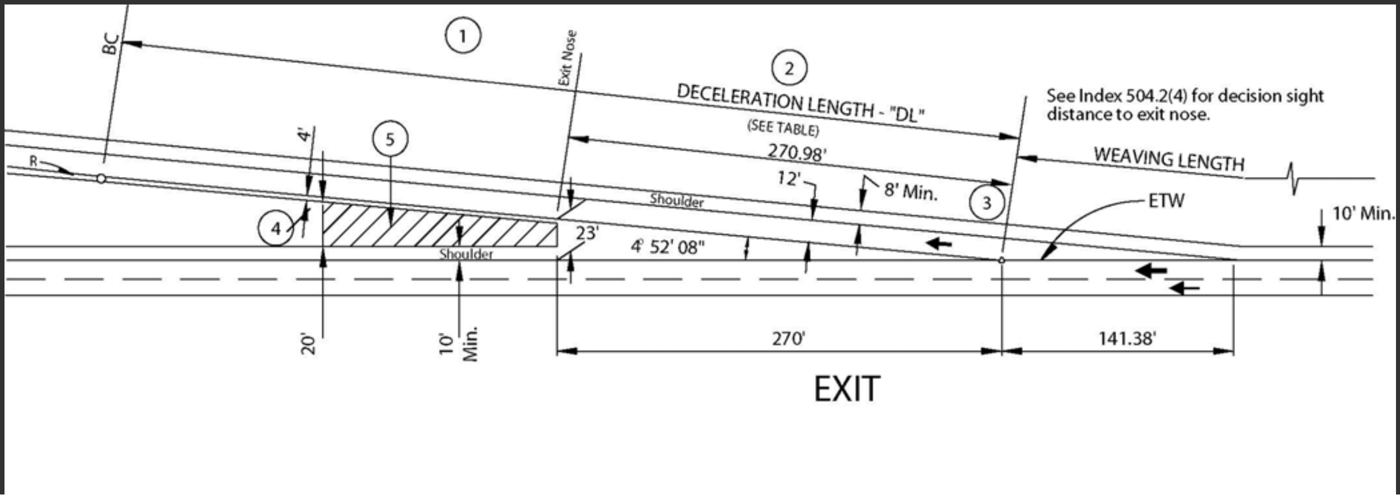
Value Solutions to Address SR-1/ I-999 Weaving Condition

Alt 5.2 "Move only the Southbound SR 1 /Northbound I-99 Connector Nose Downstream" - increased the weaving distance by 300 ft. This alternative was rejected because it creates new mandatory design exceptions for deceleration length (DL). The DL in the Value Alt was 290 ft versus the standard for DL preceding curves is 420. The weaving distance would have increased from 430 ft to 730 ft.



Value Solutions to Address SR-A/ I-999 Weaving Condition

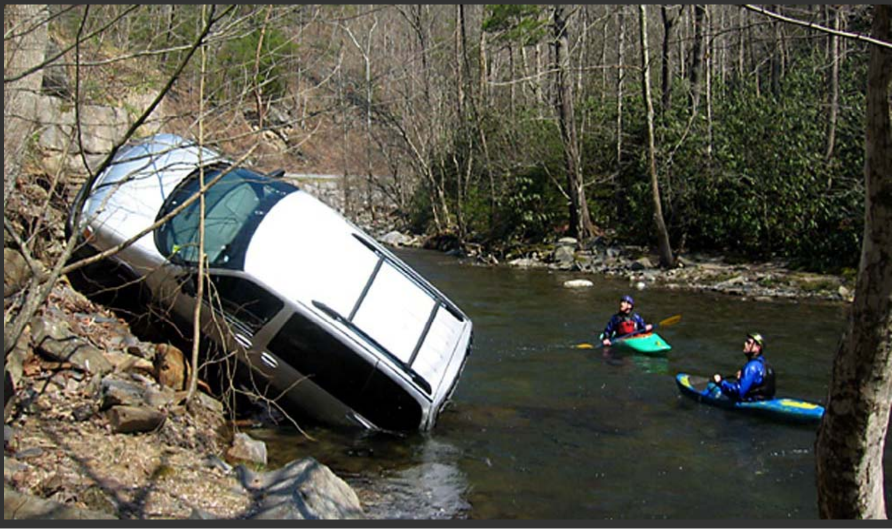
This alternative was rejected because it creates new mandatory design exceptions for deceleration length (DL). The DL in the Value Alt was 320 vs 290 ft. The standard for DL preceding curves is 420. The weaving distance would have increased from 430 ft to 730 ft.



What collision vectors would you use to analyze the Road Safety of the merge / diverge points?

Cheat-Cheat: Collision vectors suggested for RdSafAn analysis

- Driver Workload
- Weaving Section Safety Performance
  - Weaving Search and Gap Requirements
  - Speed differential
    - Mainline vs. Ramp/Connector
- Ramp Safety Performance
  - Deceleration distance
  - Sight Distance



Levels of RdSafAn- Semi-Quantitative

Level RdSafAn	Features	Outomes
Semi Quantitative	Requires more analysis, including preworkshop modelling and assessment	Systematic approach to evaluate project alternatives' safety analysis
	Relies on a Risk Based (Risk Index) to compare Project Safety Drivers (Collision Vectors)	Risk based system is focused on safety drivers- i.e. Collision Vectors
	RdSafAnal relies based on both Quantitative and Qualitative measures	Assessment backed by rationales that include quantitative analysis (HSM et.al processes)
	Integrates well with Holistic Project Analysis (Project-wide Evaluative Criteria)	Provides a comprehensive analysis of the project analysis
	Integrates into the Value Engineering (Value Metrics required)	Applies Equally to Safety Projects or Non-Safety Projects
	Can be applied to a variety of projects (safety, expansion)	Moderate Cost
	Can be applied to a variety of projects (safety, expansion)	

Quantitative Road Safety Analysis

STATE ROUTE 84 / NILES CANYON

Case Study Integrated Value Analysis/ Quantitative Road Safety Analysis Study

Study Team

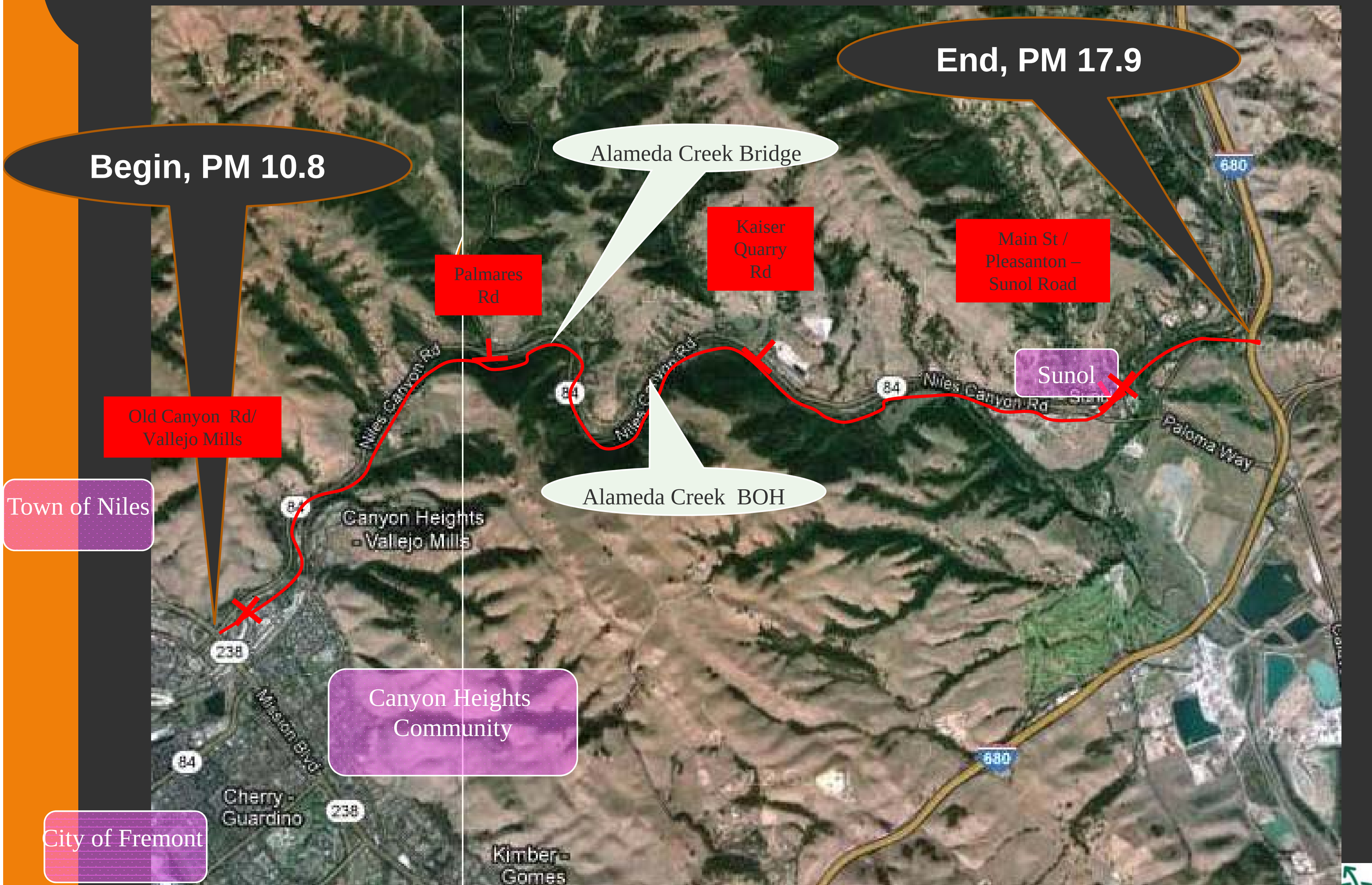
• Jeff Holm	FHWA
• Frank Guros	Caltrans Construction
• Valerie Shearer	Caltrans Env. Planning
• Oliver Iberien	Caltrans Env. Planning
• Keith Suzuki	Caltrans Landscape Arch.
• Mike Thomas	Caltrans HQ Design
• Jana Weldon	Alameda County
• Cris Pena (Part-time)	Alameda County Water District
• Jayson Imai	City of Fremont
• Michael Renk	City of Union City
• Geoff Millen	Delphi MRC
• George Hunter	VMS
• Mark Watson	VMS

delphi MRC A member of MMM GROUP

Caltrans

VMS

State Route 84 / Niles Canyon Study Area



Canyon Features

PROJECT FEATURES:
- Designated Scenic Road
- Natural Resource:
  - Alameda Creek: Water Supply/ Fish Habitat
  - Canyon Habitat
- Community Recreational Use
  - ➢Hiking
  - ➢Bicycling
  - ➢ Weekend Drivebys
  - ➢ "Nature Preserve" in vicinity of urbanized area

PROJECT FEATURES:
- Historic Features:
  - ➢Niles Railroad
  - ➢Niles Aqueduct
  - ➢Vallejo Aqueduct
  - ➢Sunol Water Temple
- Community Resource
  - Town of Niles
  - City of Fremont
  - Canyon Heights
  - Sunol

Original concept work

- Corridor widening & alignment changes
  - $80 million
    - 3 separate projects
  - Rationalized by a safety study conducted in 2000 - head on collisions
  - Opposed by Community

p

Study Approach

Road Safety Audit (RSA) Workshop

- **Field Observations & Collision Data**
- **Identify Safety Issues**
- **Identify Countermeasures**

Value Analysis (VA)/ Quantitative Road Safety Analysis

Workshop

- **Establish Safety Need**
- **Prioritize Safety Issues**
- **Develop Countermeasures**
- **Evaluate Countermeasures**
- **Develop & Evaluate Countermeasure Strategies**

Identification of Safety Need drives the process

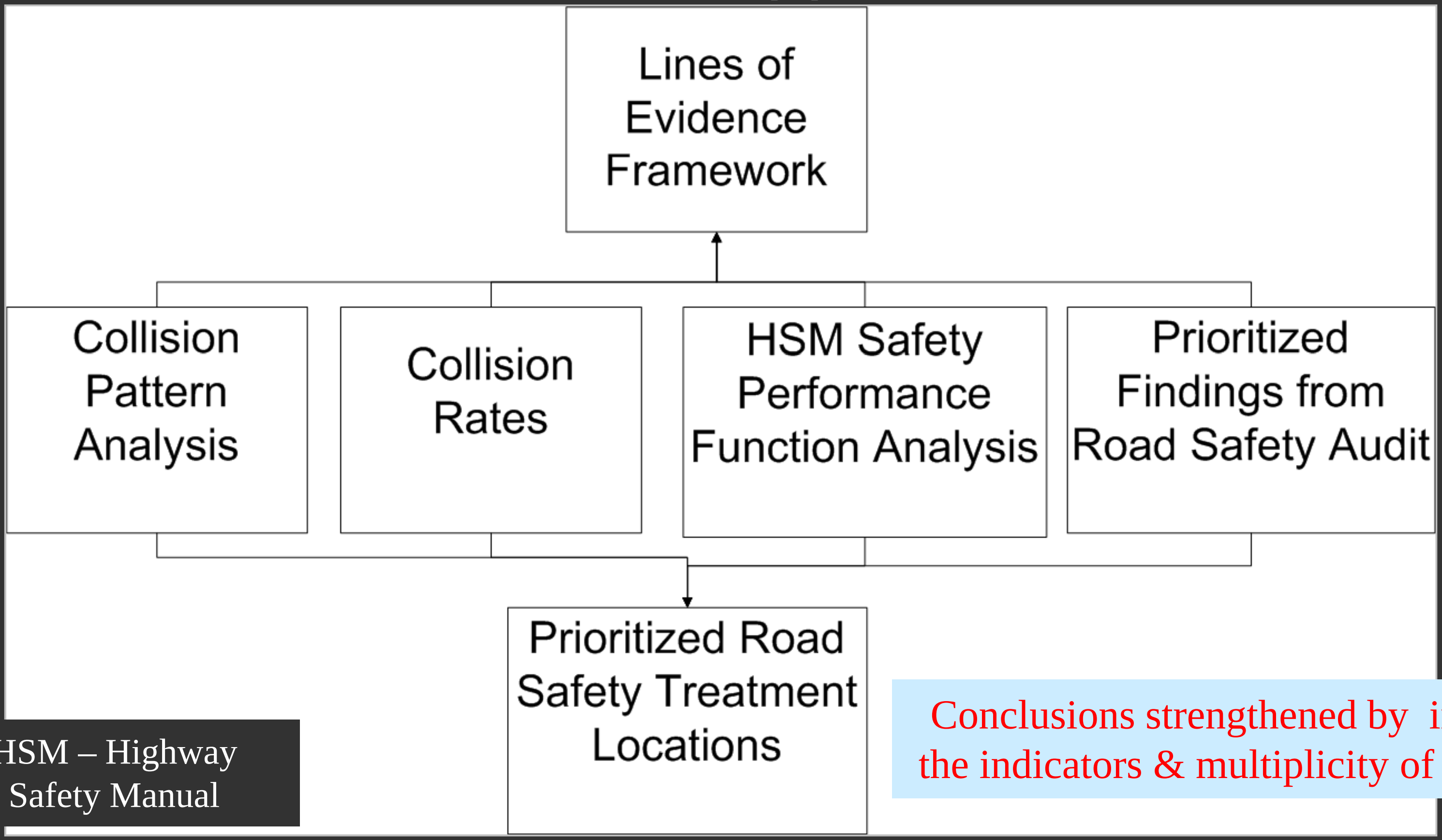
Key Study Focus / Stakeholder Questions

1. Did the centerline rumble strips installed in 2007 address the corridor safety concerns?

2. If safety improvements are needed – can they be minimized to reduce effects to the recreational, cultural, community and natural environment resources of the Canyon?

Identification of Safety Need

- Assessment of the existing road safety performance
- A "lines of evidence" approach.



HSM – Highway Safety Manual

Conclusions strengthened by independence of the indicators & multiplicity of their occurrence

Line 2: Collision Rate Analysis

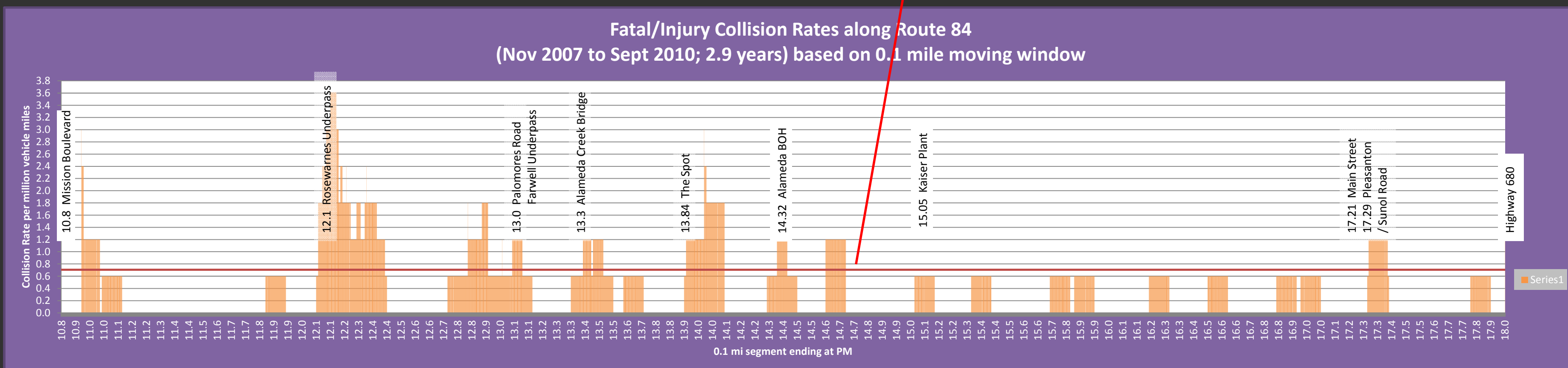
Line 2: Collision Rate Analysis Methodology

- Mainline Collision Rate:
  - Used Nov 2007- Sept 2010 timeframe
  - Normalized data for Fatality, Injury and PDO using a severity-weighted collision rate
  - Sliding window analysis (0.1 mile frame)
  - Compared to State Mainline Average
- Intersection Collision Data
  - Actual collision rates versus statewide average for similar facility

Line 2: Collision Rate (Mainline)

Statewide Average

Mainline Fatality & Injury

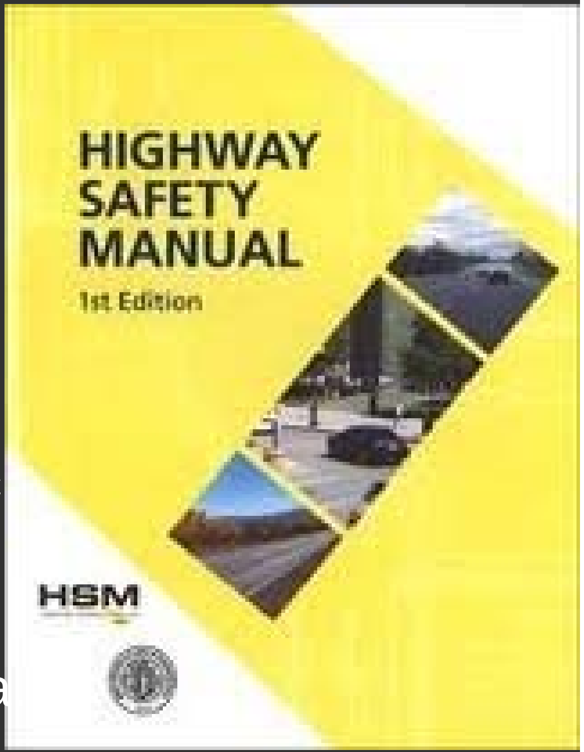


Line 2: Collision Rate (Intersections)

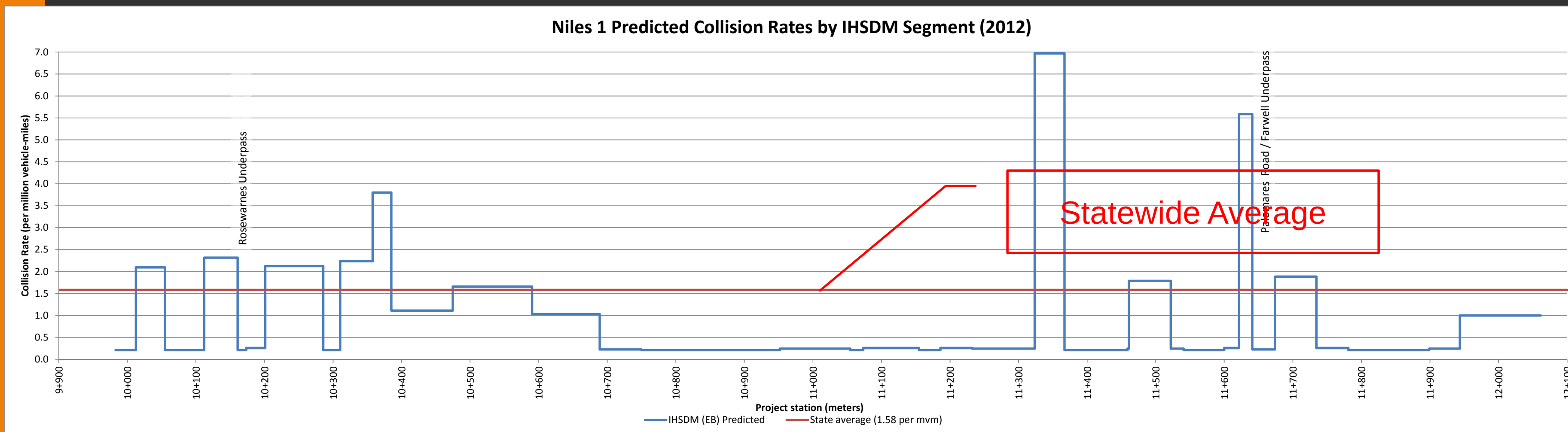
Collisions/Million Vehicles Entering						
Intersection	Actual			State Average		
	Fatal	Fatal & Injury	All Collisions	Fatal	Fatal & Injury	All Collisions
Palomares	0.00	0.07	0.07	0.001	0.06	0.15
Main	0.00	0.00	0.30	0.003	0.08	0.20
Pleasanton	0.00	0.16	0.41	0.01	0.13	0.30

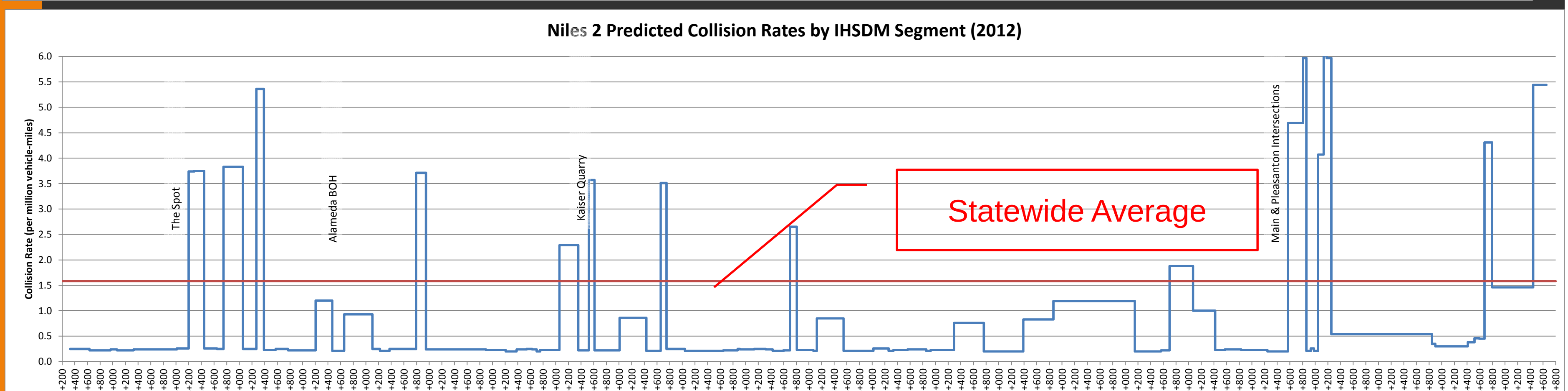
Line 3 – HSM Performance Functional Analysis

- Interactive Highway Safety Design Model (IHSDM).
  - Safety Performance Functions (SPF) are statistical based models used to predict average crash frequency for a specific roadway type.
  - Estimates the expected frequency crashes on a highway based on its geometric design and traffic characteristics.
  - Uses a weighted averaging of the algorithm estimate with project-specific collision history data



Line 3 – HSM Safety Performance Functional- Findings





Predictive model based on existing roadway geometry and cross-section and national collision data

Safety Need
Summary Lines of Evidence

Location	Lines of Evidence			
	Prioritized RSA Findings	Collision Pattern	Collision Rates	Safety Performance Function
Specific Locations				
Mission Boulevard		X		
Rosewarnes Underpass & Approaches (includes passing zone to east)	X	X	X	X
Station 11+350 (approx. mile post 12.8)				X
Palomares Intersection/Farwell Underpass	X	X	X	X
Alameda Creek Bridge	X	X		X
Low-Speed Curve Near "The Spot"	X	X	X	X
Alameda BOH	X		X	
Station 7+800 (approx. mile post 14.6)				X
Kaiser Quarry Intersection	X			X
Station 11+800 (approx. mile post 15.3)				X
Station 13+800 (approx. mile post 15.7)				X
Sunol Interchange on/off ramps				X
Main Street and Pleasanton/Sunol Intersections -queues that extend to Silver Spring UP	X	X	X	X
Corridor Wide Issues				
Roadside Barrier Inconsistencies	X			
Clear Zone Provisions	X	X		
Accommodating Bicycles	X	X		
Shoulder discontinuities	X			
Vegetation limits sightlines	X			

Safety Need
Priorities-Spot Locations*

- Rosewarnes Underpass (including passing zone)
- Low-speed curve between bridges
- Palomares intersection/Farwell underpass & approaches (includes the vicinity of the church parking lot)
- Main Street & Pleasanton Sunol intersections
- Alameda Creek Bridge

*As indicated and supported on all **Lines of Evidence**

Safety Need
Corridor-Wide Issues

- **Accommodation of Bicycles**
  - 2% of collision
  - High Severity
  - Growing Usage
- **Roadside Design Issues**
  - Roadside Hazards
  - Barrier Deficiencies
  - 57% of collisions
- **Shoulder Discontinuities**
  - Vehicle Roadside Departure
  - Disabled Vehicles, Bicycles and Police Enforcement
- **Vegetation**
  - Obstruction signing
  - Restricting lateral sight lines

Safety Improvement Countermeasures

- 51 Countermeasures identified during RSA and VA brainstorming exercises

- 31 Countermeasures Conceptually Developed:
  - (16) – Short-term implementation
  - (12) – Medium-term implementation
  - (3) – Long-term implementation after monitoring

Short Term Countermeasures Development

Install reflective material on underpass abutments

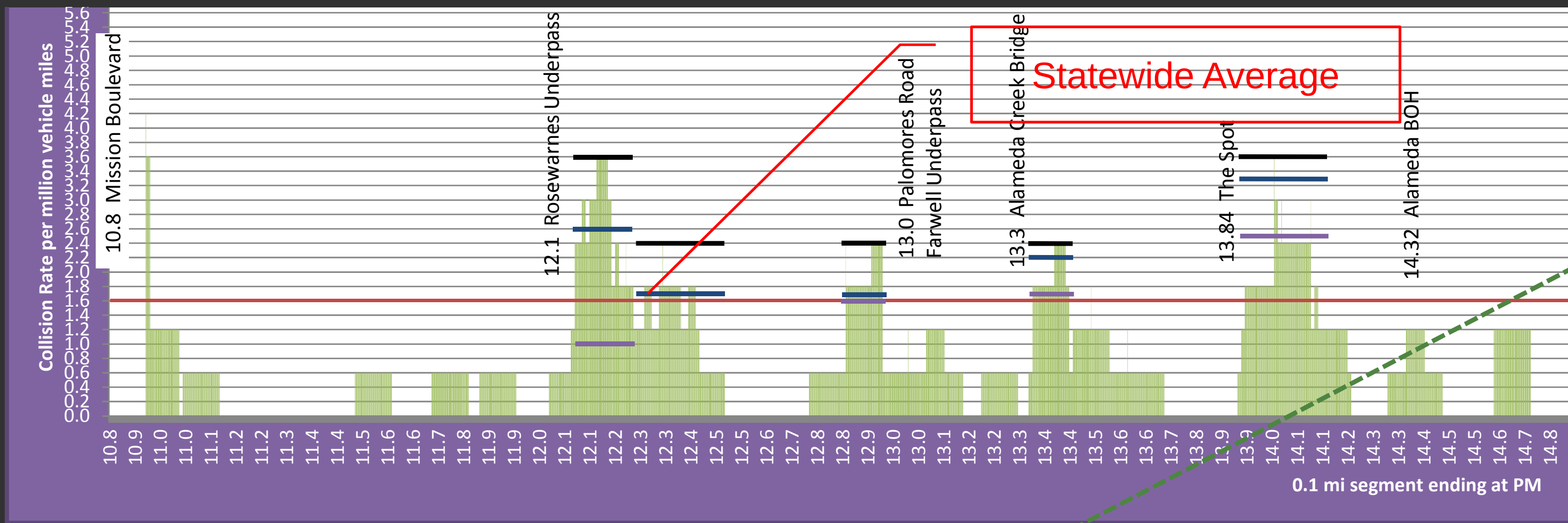
Install reflective material on curbs & rock walls adjacent to roadway

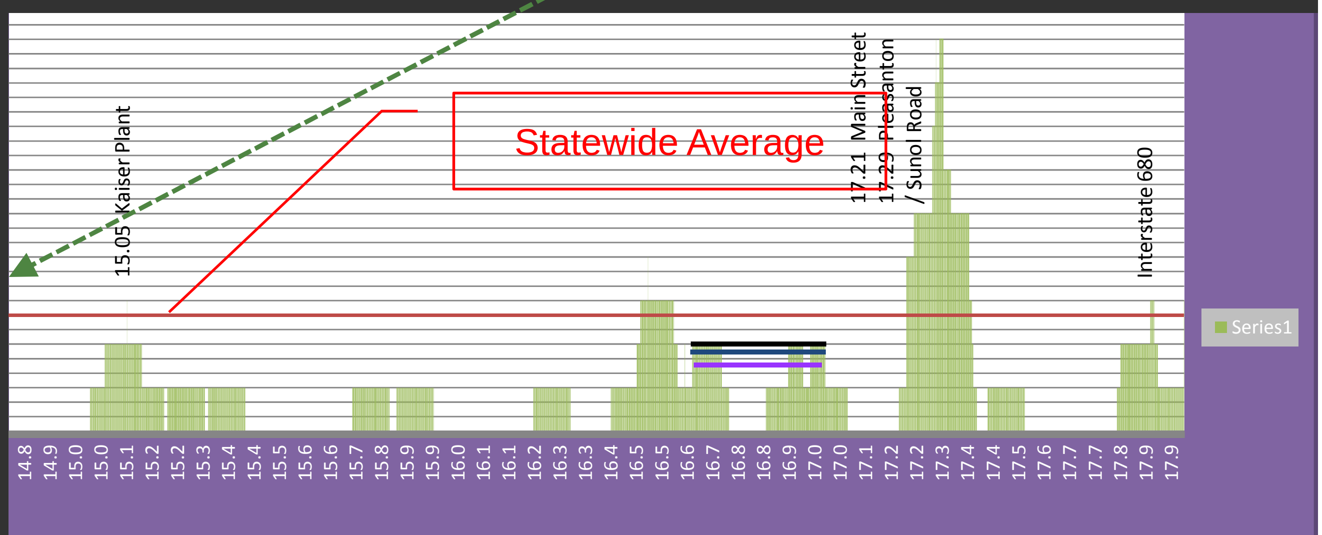
Install speed feedback sign & transverse pavement markings (optical bars) at low speed curves.

Short Term Countermeasures

- Install active warning system to alert motorists to bikes on roadway
- Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage
- Install friction treatment to pavements at low-speed curves and in icy areas
- Modify flashing beacon at Palomares Road to indicate intersection further to the east
- Install mirrors at Palomares Road to view westbound traffic
- Install ITS elements at Palomares Road to signal drivers of approaching vehicles
- Lighting of key areas (Rosewarnes Undercrossing, Palomares Intersection/ Farwell UP)
- Eliminate passing zone adjacent to low-speed curves
- Address guard rail and k-rail end treatments/Upgrade roadside protection appurtenances
- Relocate select fixed objects immediately adjacent to roadway
- Install steel mesh netting on slopes in rockfall areas
- Install reflective material on underpass abutments
- Install reflective material on curbs and rock walls adjacent to roadway
- Install dynamic active warning device for queuing conditions
- Install speed feedback sign and optical bars at low-speed curves
- Narrow lane widths to 11 feet and reapportion to shoulder
- Reduce sign clutter at Old Canyon Road and Palomares Road

Safety Benefit





LEGEND

Existing Condition

Short Term Reduction

Medium Term Reduction

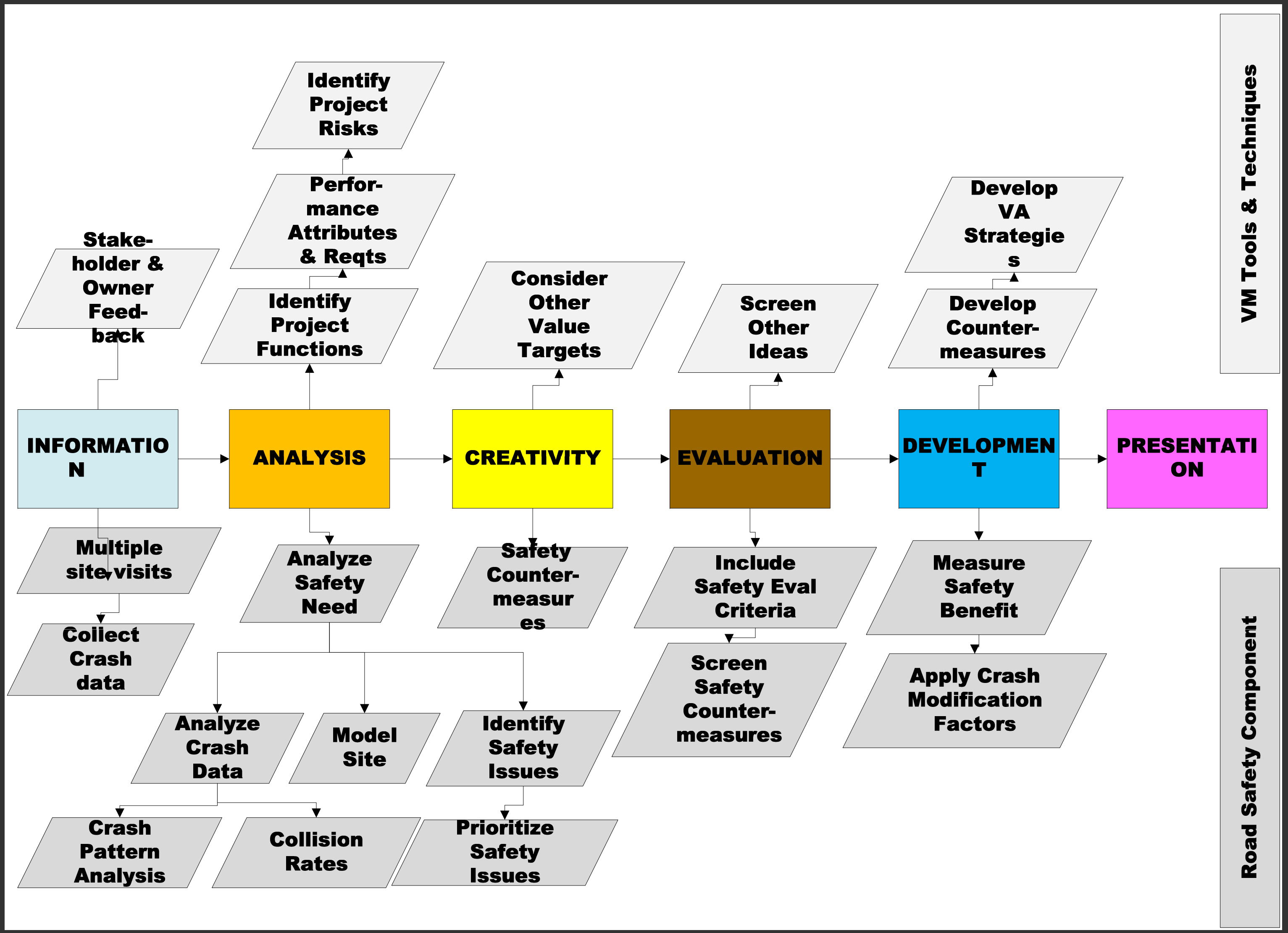
Countermeasures' Safety Benefit

Location	Mileage	Collision Rate Reduction (ACC/MVM)	
		Short-Term	Medium-Term
Rosewarnes UP & Approaches	0.055	27%	62%
Between Rosewarnes UP & Palomares Road	0.300	20%	5%
Palomares Rd / Farwell UP & Approaches	0.132	28%	24%
Between Farwell UP & Alameda Creek Br.	0.273	9%	-
Alameda Creek Bridge	0.300	-	24%
Alameda Creek Bridge to Alameda Creek Bridge BOH	0.956	8%	23%
East of Alameda Creek Bridge (0.2 miles)	0.209	9%	-
Alameda Creek Bridge BOH	0.193		20%
Between Silver Springs UP & Pleasanton-Sunol Intersection	0.318	10%	25%
Aggregating the impact at the Spot Locations	**2.74**	**12%**	**22%**

Corridor collision reduction (applied to 7.1 mile corridor): 10%

Collision rate reduction measurements based an accidents per million-vehicle miles

Quantitative Safety Analysis Activities Integrated Value Management Road



Levels of RdSafAn- Quantitative

Level RdSafAn	Features	Outomes
Quantitative	*Requires a robust amount of preworkshop modelling and assessment*	*Project Alternatives can be assessed explicitly for Road Safety Analysis*
	Relies on Quantitative RdSafAn Models and Analysis	*Outcomes are stated in terms of project specific collision statistics*
		Conclusions are founded on multiple lines of evidence
		A robust RdSafAnal analysis of proposed deviations from Highway Standards
		Less reliant on Expert Judgement
		Supports B/C of Project Alternatives
		Best applied to Safety Projects
		Higher Cost

Summary

Quiz Time

- What should one remember when combining VM and RdSafAn?

RdSafAn/ VM Study Benefits

- Organized Approach
- Better Layering of RdSafAn into Project Decision Making
  - RdSafAnal Evaluative Criterion
  - Inform others of important Road Safety issues/ impacts
  - Allows for holistic project evaluation that includes RdSaf
- VM Job Plan Contributions：
  - ***Function Analysis***
    - Identify and classify Road Safety Function
    - Facilitates identification of other ideas (non-safety functions)
  - ***Safety Countermeasure Idea Generation***
    - Enhanced by VM creativity methodologies and techniques
  - ***Evaluation of Safety Countermeasure Ideas***
    - VM evaluative criteria and techniques
  - **Development of Safety Countermeasures**
    - Enhanced countermeasures development
    - Organization of the countermeasures into project strategies.

Contact Information

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