The Value of Safety Analysis

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Outline

- Explicit safety
- Safety in the VE/VA Process
- Tools
- Case Study

Explicit Safety

- Safety as one of the represented disciplines in the Value Engineering/Value Analysis Process
  - What elements of the road present safety concern
    - To what extent?
    - To which road users?
    - Under what conditions?
- Quantify safety in terms of expected frequency and severity of collisions – i.e., the level of safety, whenever possible

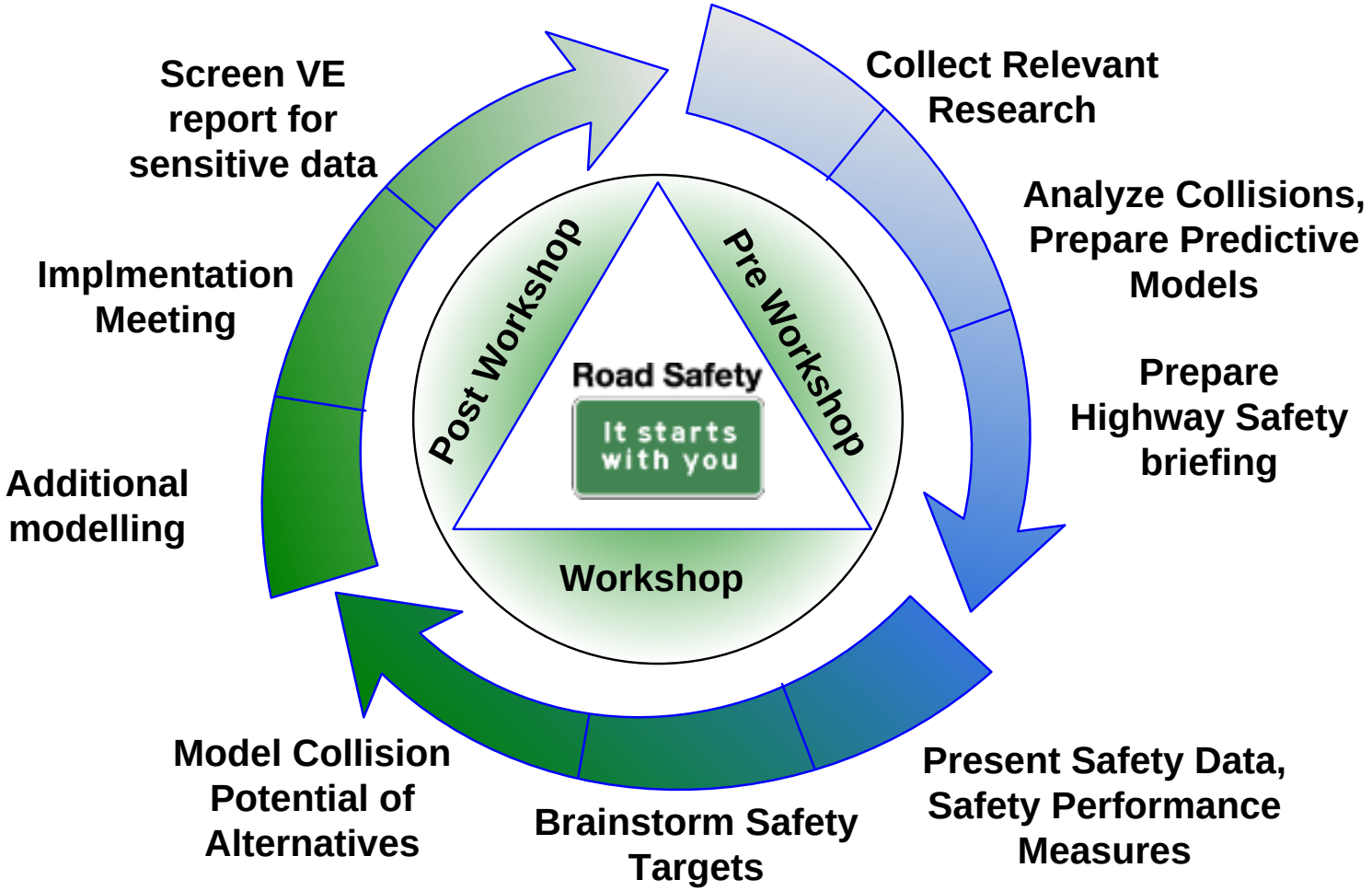
$$E(K_y) = fi * \exp^{\alpha} * \left(\frac{Length_y}{1000}\right)^{\beta 1} * \left(\frac{AADT_y}{1000}\right)^{\beta 2} * \exp\left(\beta 3 * \left(\frac{AADT_y}{1000}\right) + \beta 4 * \left(\frac{AADT_y}{1000}\right)^2\right)$$

Explicit Safety

- Why the need to consider safety explicitly?
  - Meeting standards does not necessarily make the road safe
  - Safety evaluation studies provide evidence of safety impacts
  - Road users and their vehicles respond to the combination of geometric design elements
  - Integrating human factors limitations and needs in design and operations will reduce road user errors
  - Corridor alternatives may affect road users beyond the VE study area
- Inclusion of the life-cycle safety costs of alternatives

  ⇒ informed decision-making

Safety in the VE/VA Process



Acknowledgement:
Steve Holmes

Pre-workshop - Preparation is key

- Existing corridor
  - Study collision history
  - Study corridor characteristics
  - Consider opportunities to eliminate or mitigate safety concerns
- Base case scenario
  - What are the key changes or characteristics of new corridor?
  - Review what elements of the road may present a safety concern – consider all road users and different circumstances
  - Were the existing corridor`s concerns eliminated or mitigated?

Pre-workshop - Preparation is key

- Review state-of-art
  - Research information (published and unpublished)
    - TRB and others (Highway Safety Manual; SafetyAnalyst; AASHTO/FHWA Strategic Highway Safety Plans)
    - AMFs (and standard errors)
- Define performance measures (safety and human factors)
  - Frequency and severity of collisions
  - Predictability, workload, information processing

Pre-workshop – Preparation is key

- Tools and Analytical Methods
  - Safety review
  - Safety audit
  - Human Factors analysis
  - Identify innovative and other potential treatments
  - Synthesize safety effects of design and operational elements
  - Select potential safety performance (predictive) models
  - Identify collision costs
  - Develop performance measures
- Safety and human factors report in the pre-workshop binder
- Prepare presentation for workshop

Workshop

- Present the safety and human factors analyses
- Active participation in the VE Process
  - Function Analysis Phase: safety objectives identified as functions (reduce collisions, reduce workload)
  - Creative Phase: generate ideas with increased safety (e.g., roundabout layout to eliminate angle collisions; extend transition road section to meet driver needs)
  - Evaluation and Ranking Ideas; Development and Presentation of Expanded Ideas/Scenarios Phases: use safety and human factors' performance criteria measures, incorporate treatments, AMFs, safety models, and collision costs

Case Study

- Existing two-lane arterial roadway
- Proposed new 8-km alignment
- Significant tourist area during summer and winter seasons
- Serving local and through traffic

Pre-workshop - Safety Analysis -

Existing corridor issues:

- Intersections and multiple driveways on existing 2-lane corridor; they are also inconspicuous and unexpected
- Skewed and offset sideroad intersection approaches
- Bikes and school buses mixed with heavy trucks
- High number of conflicts bet. local and through traffic
- A high potential corridor for safety improvements
- Nine-year collision analysis; and 5-year collision diagram
  - Collision diagram showed site-specific issues
  - About 45% of the collisions happened during wet/snowy/icy conditions; mostly single-vehicle collisions
  - Seventy-five percent of the collisions occurred during the day, most at midday and from 3 to 4 PM

Pre-workshop - Safety Analysis

Base Case Design for new alignment:

- Specific safety improvements but expected increase in collision severity due to speed increase and profile
- Safety and Human Factors issues
  - Inconsistent cross-section and road characteristics along the corridor (divided/undivided, 2-lane/4-lane, interchange/signalized intersections)
  - short transitions between end of controlled access freeway (divided) condition and non-freeway (undivided) conditions

Workshop – Function Analysis System Technique (FAST)

- Initial Basic Function of the project : "Separate Traffic" with the major higher-order function being "Enhance Operations".
- Basic Functions :
  - *enhance operations*
  - improve mobility
  - enhance development
  - increase capacity
  - design flexibility
  - increase safety
- Key secondary functions:
  - *separate traffic*
  - improve driver workload
  - add lanes
  - minimize confusion
  - establish design criteria
  - minimize violation of driver expectation

Workshop – Creativity/Idea Generation Phase

- Identified distinct categories for Idea Development
  - *Transitions*
  - *Cross-section*
  - *Roadside Safety*
  - *Side roads*
  - *Structures*
  - Drainage/Stormwater management
  - Environmental/Noise
- Ninety-four creative ideas

Workshop – Evaluation Phase

- Ninety-four creative ideas – 1st cut evaluation → 50 ideas selected for a more detailed evaluation process
- Category teams assessed and ranked the ideas
- Used performance measures and criteria

Performance Criteria Weighting Matrix

- Road User Safety
- Human Factor
- Traffic Operations
- Level of Service
- Access
- Environment
- Property Impacts
- Construction

ID	Description	Comments
A	Road User Safety	
B	Human Factors Analysis	
C	Traffic Operations	
D	LOS	
E	Access	
F	Environmental	
G	Property Impacts	
H	Construction	

Criteria Matrix

									Total points	% of Total
A	a1	a2	a2	a1	a1	a1	a3		11.0	26.8%
	B	c1	b1	e1	f1	b1	b2		4.0	9.8%
		C	c1	c1	c1	c2	c2		8.0	19.5%
			D	d1	d1	d2	d2		6.0	14.6%
				E	e1	e2	e2		6.0	14.6%
					F	f2	f2		5.0	12.2%
						G	g1		1.0	2.4%
							H		0.0	
								Total	41.0	100.0%

a	*= A is of greater importance*
a/b	*= A and B are of equal importance*

Comments/Discussion

	Used
A	**25%**
B	**10%**
C	**20%**
D	**15%**
E	**15%**
F	**15%**
G	0%
H	0%
	100%

Workshop – Evaluation (2nd Cut)

- Performance Criteria and Measures for Safety and Human Factors

	A	B
	Expected Frequency of Conflicts	**Expected Severity of Collisions**
0	Significant increase in the frequency of collisions	Significant increase in the severity of collisions
1	No change in safety	No change in safety
2	Significant decrease in the frequency of collisions	Significant decrease in the severity of collisions

	A **Predictability**	B **Driver Workload**	C **Information Processing**
0	Not consistent with driver expectations based on adjacent section	High workload in more than one task (e.g., lane changing plus tight curve following)	Signs inconspicuous, too many signs messages too long, messages or symbols incomprehensible because of unusual geometry or operations that must be conveyed to the driver
1	No Change in human factor	No Change in human factor	No Change in human factor
2	Highly consistent with driver expectations based on adjacent section\or if inconsistent, appropriate gradual transition to new design	Low workload in control, guidance and navigation tasks	Sign information placed where expected and where needed allowing driver to antic ipate demands, spread out so it can be taken in easily, using understandable symbols and messages

Development Phase

- For each of the 14 alternatives
  - Write-up, sketch, calculations, and cost impacts
  - Score against the 6 performance criteria
- Development of four scenarios
  - Combination of alternatives
  - Life-cycle cost calculations
- Comparison with base case design

Safety Estimates – Evaluation and Development Phases

- Safety Performance Functions
  - 2-lane highways
  - 4-lane highways
  - 3-leg signalized intersections (urban, rural)
  - 4-leg signalized intersections (urban, rural)
  - Interchange mainline and ramps
- AMFs or CMFs
  - Roundabout versus signalized intersection
  - Signalized intersection versus interchange
  - Increase of median width

AMFs or CMFs

Safety effects of converting signalized intersections into modern roundabout

Treatment	Setting Intersection type	Traffic Volume	Accident type Severity	AMF	Std. Error
Convert signalized intersection to modern roundabout	Urban One or Two lanes	Unspecified	All types All severities	0.99	0.1
			All types Injury	0.40	0.1
	Suburban Two lanes		All types All severities	0.33	0.05
	All settings One or Two lanes		All types All severities	0.52	0.06
			All types Injury	0.22	0.07

AMFs or CMFs

Safety effects of providing a median on multi-lane roads

Treatment	Setting Road type	Traffic Volume	Accident type Severity	AMF	Std. Error
Provide a median	Urban Arterial Multi-lane	Unspecified	All types Injury	0.78	0.02
			All types Non-injury	1.09	0.02
	Rural Multi-lane		All types Injury	0.88	0.03
			All types Non-injury	0.82	0.03

Post-Workshop

- Review safety considerations and analyses
- Refine models and estimations (if required)
- Prepare presentation including estimates of collision costs for preferred scenarios or alternatives

In Conclusion

- Explicit safety and a safety professional as integral member of the VE Team
- VE /VA Methodology and Process
  - Systematic and focused in identifying value targets and opportunities for improvement
  - Multi-disciplinary creative synergy
- Safety tools and evidence-based knowledge are available and expanding

In Conclusion - Tools

- Road Safety Review and Audit
  - TAC Manuals
  - Highway Safety Manual (Part B)
- Safety Prediction Models
  - *SafetyAnalyst or Canadian agencies: SPFs (OPFs)*
  - *Highway Safety Manual (Parts A and C)*
- Interactive Highway Safety Design Model
- AMFs or CMFs (± standard errors)
  - Highway Safety Manual (Part D)
  - FHWA/ITE Crash Reduction Factors and Function
  - NCHRP/FHWA Evaluation of Low-cost measures
- Research-related web-links and sites

Enhancing the safety of a facility will increase its value

Thank you

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