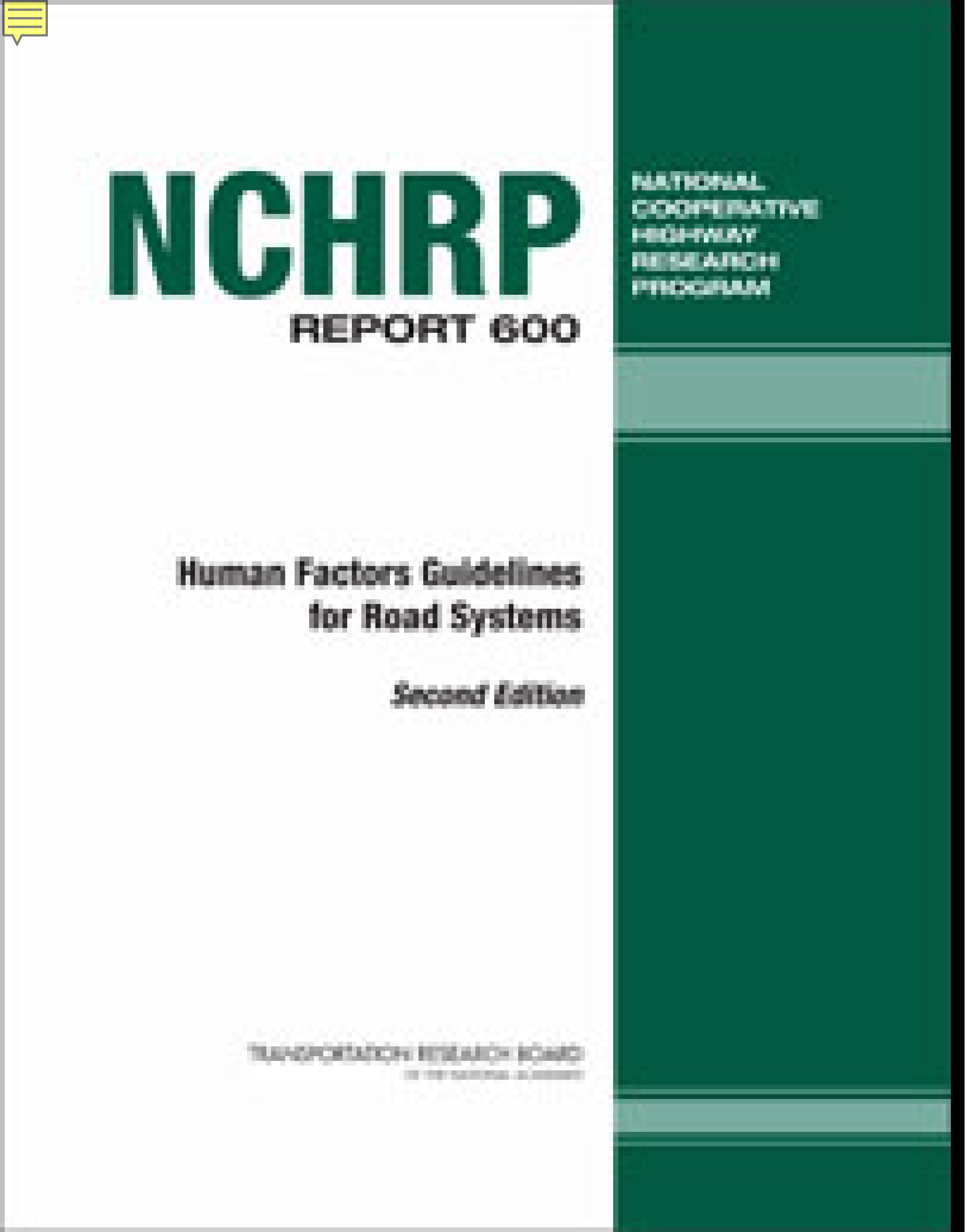


Road Safety Assessment

Incorporating Human Factors

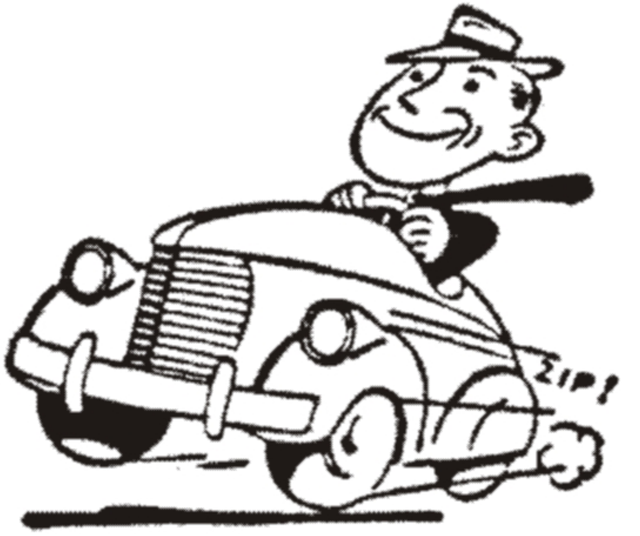
66th Illinois Traffic Engineering Safety Conference

October 18, 2017

Definition of Human Factors

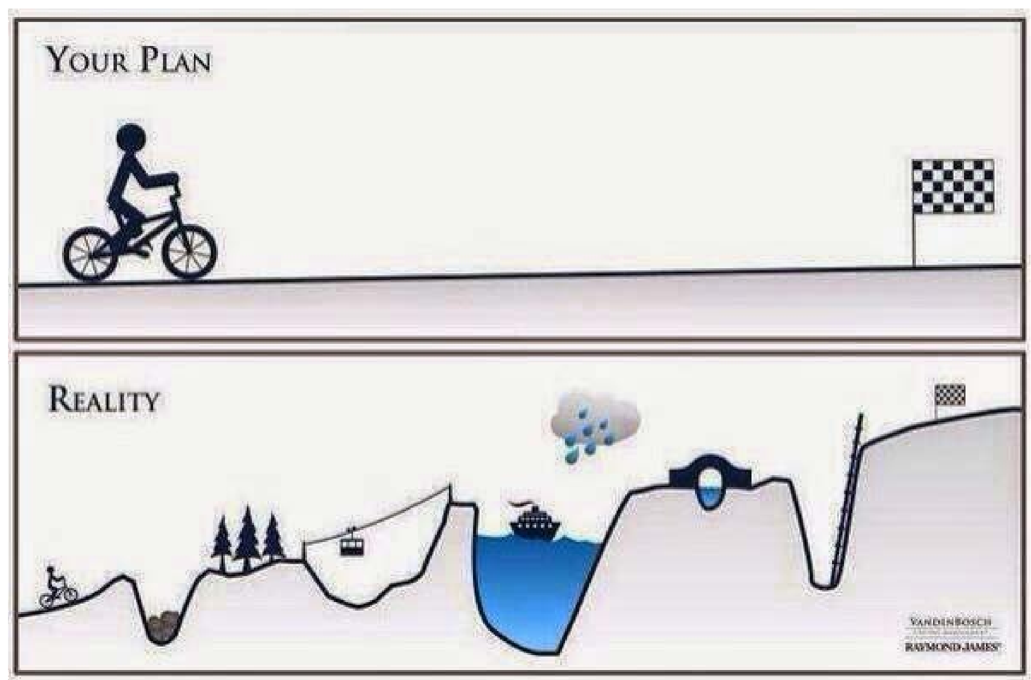
<u>IT'S US</u>

Drivers Ability and Limitations to (1)Detect, (2)Recognize, (3)Decide, (4)Initiate and (5)Maneuver within the Roadway Environment.



Human Factors
Driver Expectations

- Even before Detection we pre-decide how we are going to drive.
- Speed is decided by the perceived risk of the roadway and surroundings.
- Distraction undercuts perception, reaction, and maneuvering.



Human Factors
DETECT

- How we drive, 90% visual, looking for roadway guidance
- How we see
  - Our Peripheral vision is 1/10 of acuity beyond 20 degree sight line. Peripheral vision picks up movement.
  - Turning to look is filled with blind gaps (Saccade masking) Our brains fill the gaps as continuous. The greater the head turn the more chance to jump over seeing an approaching vehicle.
  - Our perception of approaching vehicle's change in size is related to the tangent function (from zero to a vertical asymptote over 90 degrees) not linear.
  - Our night time vison diminishes with age.

Human Factors
RECOGNIZE

- Universal symbols easily recognized
- Design consistency
  - Manual on Uniform Traffic Control Devices (MUTCD)
  - Bureau of Design and Environment Manual
  - Highway Standards for Traffic Control
  - Local Roads and Streets Manual
  - Highway Standards Manual

Human Factors
RECOGNIZE and DECIDE in time

Human Factors
INITIATE the maneuver

NCHRP Report 600
Human Factors
Guidelines for
Road Systems

Table 4-2. Iterative steps used in sampling the road environment for information.

Step	Timing
Eye fixation time	• 0.20 to 0.25 s (Homburger & Kell, 1988) • 0.25 to 0.33 s (Mourant et al., 1969)
Turn head to the left	• 1.31 to 1.52 s (Mourant & Donohue, 1974)
Turn head to the right	• 1.09 to 1.14 s (Mourant & Donohue, 1974)
Car following	• Attention to lead vehicle reduces attention elsewhere by 15% (Mourant et al., 1969)
Sign detection	• Look time: 0.5 s (Zwahlen, 1995; Zwahlen & Schnell, 1998) • Saccade time: 0.03 s (Zwahlen, 1995; Zwahlen & Schnell, 1998) • Time for fixation on sign: 0.3 to 0.8 s (Zwahlen, 1995; Zwahlen & Schnell, 1998)
Sign reading	*Variable message signs* (Staplin et al., 1998) • Minimum exposure time:1 s/short word (four to eight characters) or 2 s/unit of information, whichever is larger • Reading time: 1 to 1.5 s/unit of information in light traffic • Minimum phase or page time: 3 s/page for a three-line message *Video signs* (Smiley et al., 2005) • 20% of glances to video signs exceeded 0.75 s • 38% of glances occurred when headways were less than 1 s • 25% of the glances were at angles greater than 20° • 76% of drivers looked ahead, 7% at signs and signals, 6% at pedestrians • Glances at video signs occurred with longer headways than with static signs
Use of mirrors	• 0.87 s, rear view (Mourant & Rockwell, 1972) • 0.98 s, left side (Mourant & Rockwell, 1972) • 0.78 s, rear view (Mourant & Donohue, 1974) • 0.88 s, left side (Mourant & Donohue, 1974)

Human Factors
MANEUVER

US Customary											
Design Speed of Highway (mph)	Assumed Running Speed (mph)[1]	Length of Taper (ft)	Stop Condition	Speed Reduced to (mph)							
				15	20	25	30	35	40	45	50
			Total Length of Deceleration Lane Including Taper Length (ft)								
30	28	135	250	200	170	140	—	—	—	—	—
35	32	155	280	250	210	185	150	—	—	—	—
40	36	175	320	295	265	235	185	155	—	—	—
45	40	200	385	350	325	295	250	220	—	—	—
50	44	220	435	405	385	355	315	285	225	175	—
55	48	240	480	455	440	410	380	350	285	235	—
60	52	265	530	500	480	460	430	405	350	300	240
65	55	285	570	540	520	500	470	440	390	340	280
70	58	310	615	590	570	550	520	490	440	390	340

Metric										
Design Speed of Highway (km/h)	Assumed Running Speed (km/h)[1]	Length of Taper (m)	Stop Condition	Speed Reduced to (km/h)						
				20	30	40	50	60	70	80
			Total Length of Deceleration Lane Including Taper Length (m)							
50	47	45	80	70	60	45	—	—	—	—
60	55	50	95	90	80	65	55	—	—	—
70	63	60	110	105	95	85	70	55	—	—
80	70	70	130	125	115	100	90	80	55	—
90	77	75	145	140	135	120	110	100	75	60
100	85	85	170	165	155	145	135	120	100	85
110	91	90	180	180	170	160	150	140	120	105

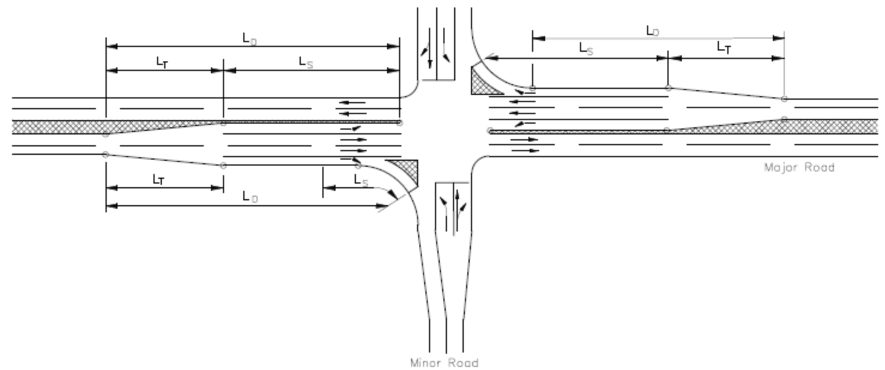
Grade Adjustment Factors[2]			
Downgrade			
6.00% to 5.00%	4.99% to 4.00%	3.99% to 3.01%	3.00% to 0%
1.35	1.28	1.20	1.00
Upgrade			
0% to 3.00%	3.01% to 3.99%	4.00% to 4.99%	5.00% to 6.00%
1.00	0.90	0.85	0.80

(1) *Average running speed assumed for calculations.*

(2) *Ratio from this table multiplied by the length provided above will yield the total deceleration length adjusted for grade. Adjustment factors apply to all design speeds and are added to the tangent or storage length.*

DECELERATION DISTANCES FOR TURNING LANES

Figure 36-3.I



Note: *The schematic of the major road (free flowing) also applies to all legs of a signalized intersection.*

Key: L_T = *Taper length*
L_D = *Deceleration length*
L_S = *Storage length*

See Section 36-3.02(b) for additional guidance.

TYPICAL AUXILIARY LANES AT AN INTERSECTION

Figure 36-3.H

Human Factors

BDE Manual

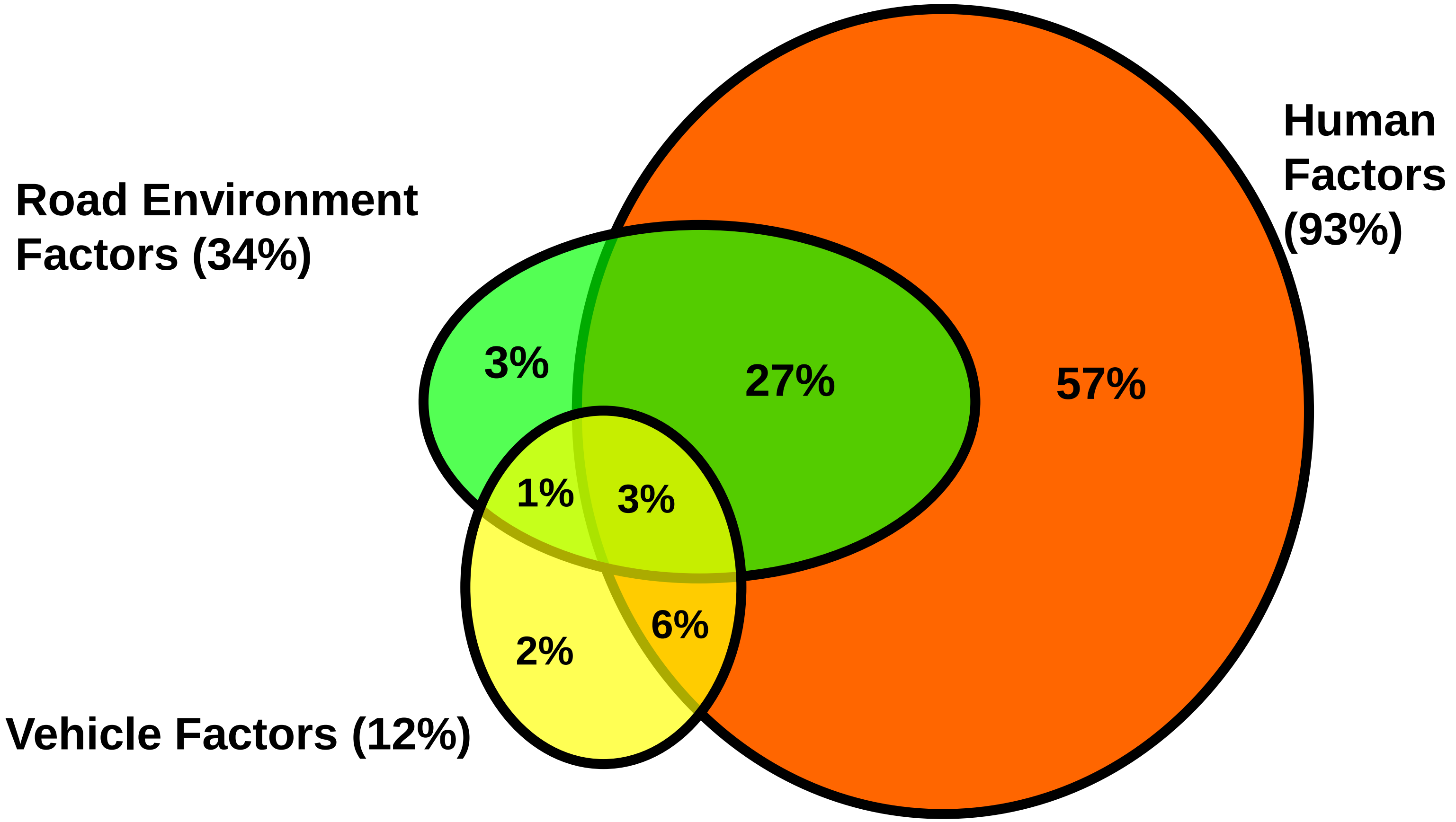
Avoidance MANEUVER

US Customary					
Design Speed (mph)	Decision Sight Distance for Avoidance Maneuver (ft)				
	A	B	C	D	E
30	220	490	450	535	620
35	275	590	525	625	720
40	330	690	600	715	825
45	395	800	675	800	930
50	465	910	750	890	1030
55	535	1030	865	980	1135
60	610	1150	990	1125	1280
65	695	1275	1050	1220	1365
70	780	1410	1105	1275	1445
75	875	1545	1180	1365	1545

Metric					
Design Speed (km/h)	Decision Sight Distance for Avoidance Maneuver (m)				
	A	B	C	D	E
50	70	155	145	170	195
60	95	195	170	205	235
70	115	235	200	235	275
80	140	280	230	270	315
90	170	325	270	315	360
100	200	370	315	355	400
110	235	420	330	380	430
120	265	470	360	415	470

Note:

Avoidance Maneuver A: Stop on rural road.
Avoidance Maneuver B: Stop on urban road.
Avoidance Maneuver C: Speed/path/direction change on rural road.
Avoidance Maneuver D: Speed/path/direction change on suburban road.
Avoidance Maneuver E: Speed/path/direction change on urban road.



TYPICAL REPORTED CRASH CAUSES

There's a LOT Going on Here!

The table below shows the perceptual, cognitive, and psychomotor subtasks associated with the key activities that drivers must perform when making left or right turns across traffic in a four-lane roadway (adapted from Richard, Campbell, and Brown (9)).

Activity	Perceptual Subtasks	Cognitive Subtasks	Psychomotor Subtasks
1. Check for possible conflicts with following vehicle.	Visually assess trajectory of following vehicle.	Determine if distance and speed of vehicle indicate potential conflict.	Head and eye movements to observe rearview mirror.
2. Check for pedestrians/cyclists crossing or about to cross in front.	Look left and right along crosswalk.	Determine if pedestrians/cyclists are present or likely to enter the crosswalk.	Head and eye movements for viewing.
3. Advance into crosswalk.	Visually observe crosswalk.	Determine when vehicle is in appropriate position for turning.	Slowly accelerate and brake.
4. Look for gap in perpendicular traffic.	Visually monitor traffic.	Determine distance and speed of oncoming traffic. Determine if gap is sufficient for turning.	Head and eye movements to monitor oncoming traffic.
5. Check for oncoming vehicles in far lane changing to destination (conflicting) lane.	Monitor oncoming vehicles in far lane.	Determine if vehicle is about to change lanes (e.g., turn signal on, changing trajectory, etc.).	Head and eye movements to monitor oncoming traffic.
6. Check for hazards in turn path.	Visually scan turn path (especially crosswalk) and intended lane.	Determine if any pedestrians/cyclists or other hazards are in the crosswalk or about to enter.	Head and eye movements to view turn path.
7. Accelerate to initiate turn.	View roadway.	Determine that acceleration is sufficient to avoid conflicts with other vehicles	Quickly accelerate. Head and eye movements.
8. Steer into turn.	View turn path.	Determine that vehicle trajectory and lane position are appropriate.	Steering adjustments necessary to stay in lane.

There's a LOT Going on Here!

The table below shows the perceptual, cognitive, and psychomotor subtasks associated with the key activities that drivers must perform when making left or right turns across traffic in a four-lane roadway (adapted from Richard, Campbell, and Brown (9)).

Activity	Perceptual Subtasks	Cognitive Subtasks	Psychomotor Subtasks
DETECTION 1A	RECOGNITION 1A	Deter DECISION 1A of vehicle indic	Head and eye movements to observe rearview mirror.
2. Ch cr DETECTION 1B fr	RECOGNITION 1B	Determ DECISION 1B e present valk.	Head and eye movements for viewing.
3. Advance into crosswalk.	RECOGNITION 1	Determ DECISION 1 propriate position	INITIATION 1 MANEUVER 1
4. Lo tra DETECTION 2A	RECOGNITION 2A	Determine distance and speed of oncom DECISION 2A Determine if gap is sufficient for turning.	Head and eye movements to monitor oncoming traffic.
5. Ch in DETECTION 2B destination (connecting) lane.	RECOGNITION 2B	Determ DECISION 2B ange lanes (g trajectory, etc.).	Head and eye movements to monitor oncoming traffic.
6. Ch DETECTION 2C	Visually scan turn path. RECOGNITION 2C	Determ other ha DECISION 2C s or r about to enter.	Head and eye movements to view turn path.
7. Ac INITIATION 2	V ONGOING DETECTION/DECISION to		MANEUVER 2
8. Steer into turn.	ONGOING DETECTION/DECISION/MANEUVER 2		

Human Factors in the RSA Process

Basic RSA Concepts

1. What is a Road Safety Assessment?

2. Where does Human Factors fit into RSA Process?

3. Why should we consider Human Factors in the Countermeasure proposal?

Definition of RSA

A road safety assessment is a formal and independent safety performance review of a road transportation project by an experienced team of safety specialists, addressing the safety of all road users.

An RSA is also…

- A pro-active tool that attempts to minimize collision risks before collisions occur
- A "second look" at a design from a safety perspective
- Comprehensive approach of addressing safety early in the project development stage
- May be required by policy on HSIP Projects >$1 million

RSA Objectives

- Proactively minimize the frequency and severity of collisions
- Explicitly consider the safety of all road users
- Explicitly consider pro-active inclusion of mitigation measures for observed contributing factors
- Explore interactions beyond project limits

RSA Challenge

- Provide the best factual information and insight on factors contributing to crashes from the interaction of road users with the roadway environment and vehicles

- Identify and match selected safety countermeasures with factors contributing to <u>causation</u> of driver error, problems and crashes

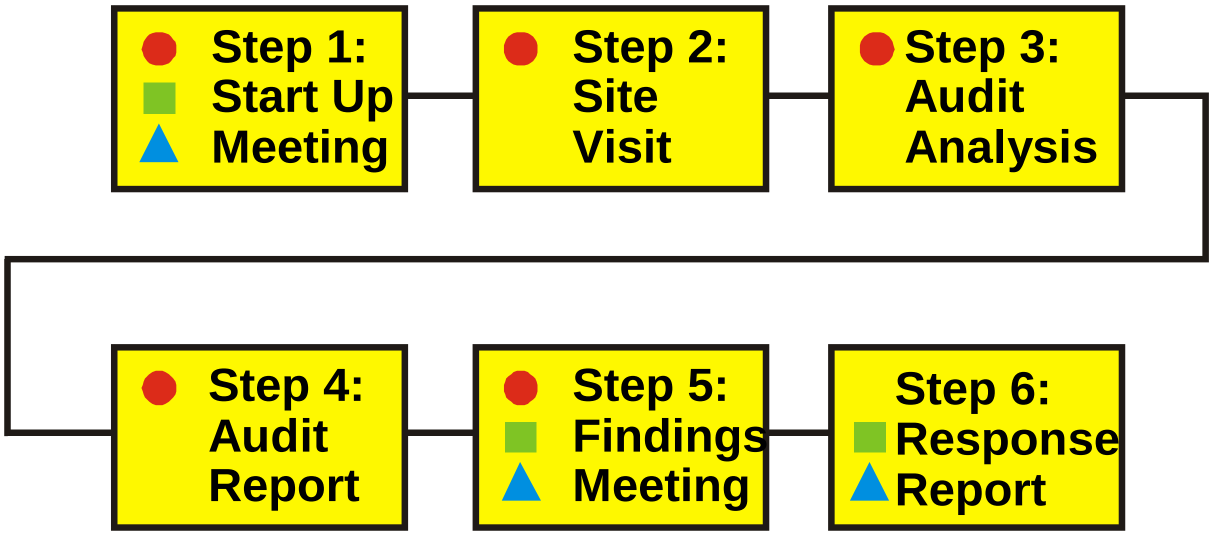
Role of the Road Environment

- Relatively few road/driver-related safety issues are commonly identified in the collision reports
- Road Designs need to ***anticipate*** and ***accommodate*** driver's ability to detect, understand and react to the road environment.
- Easier to design & build safer roads than to modify some entrenched driver behaviors
- Road-related safety issues can be existing, or may be introduced by the proposed work.

Factors that may Contribute to Crashes

Road User	Vehicle	Environment	
• Age • Capabilities • Sensory/Visual • Cognitive • Physical • Experience • Road Familiarity • Training • Attitudes • Learned Behaviors	• Type • Steering capabilities • Braking capabilities • Engine capabilities • Safety features • Height • Headlamps • Distractions • Vehicle direction • Vehicle visibility	• Speed • Traffic Volume • One Way Flow • Two Way Flow • Control Type • Functional Class • Lane Width • Shoulder Width • Roadside Hazards • Pavement and Shoulder type • Roadway Condition • Control Type interactions • Bicyclists • Pedestrians • Distractions	• Enforcement • Grades • Curvature • Signs • Pavement Markings and condition • Weather • Land Use • Urban • Rural • Time of Day • Light Condition • Advertisement Clutter • Scenic/Interests attractions

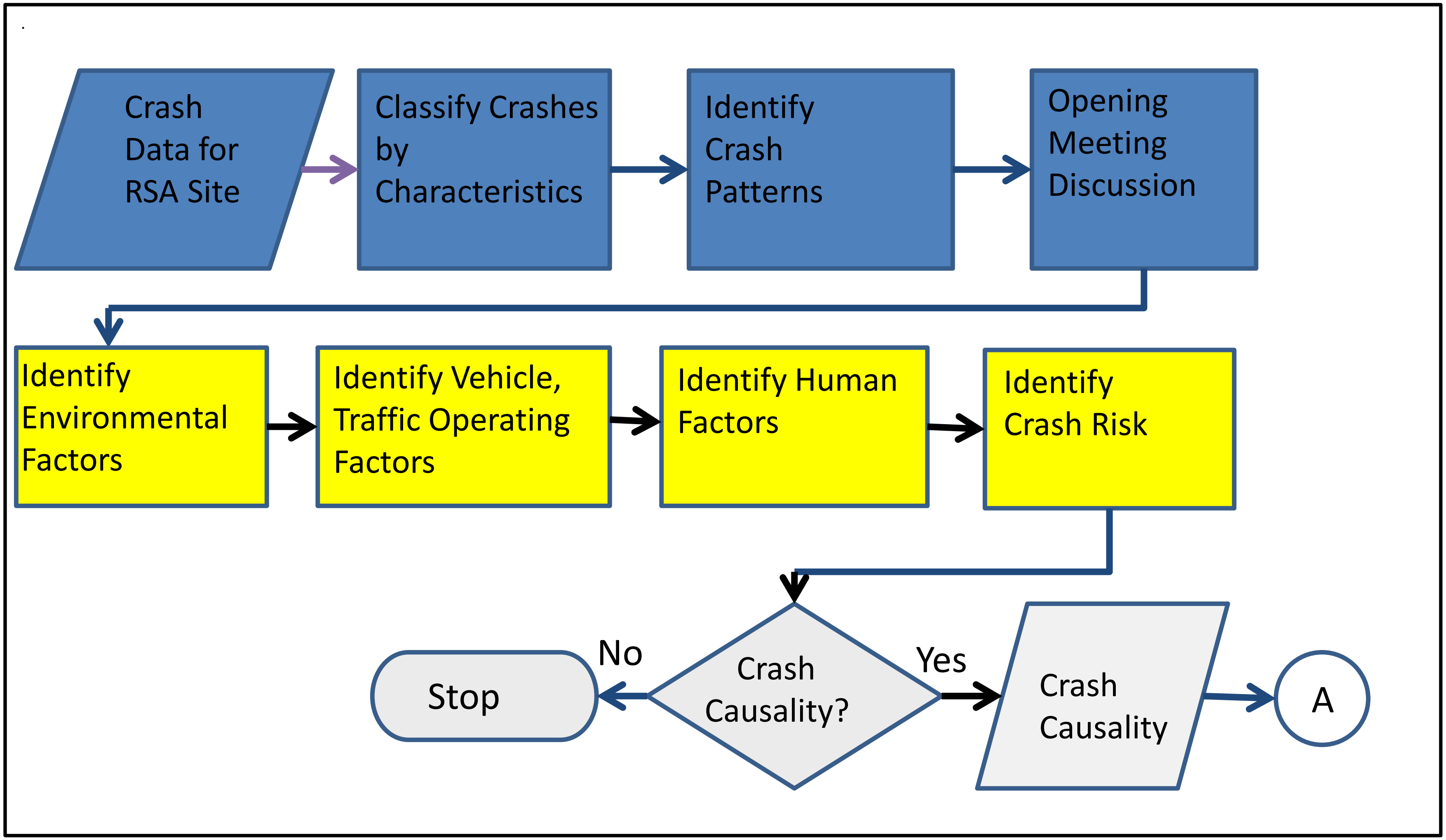
What is the Typical RSA Process?



Responsibilities:
- Audit Team
- Design Team
- Project Owner

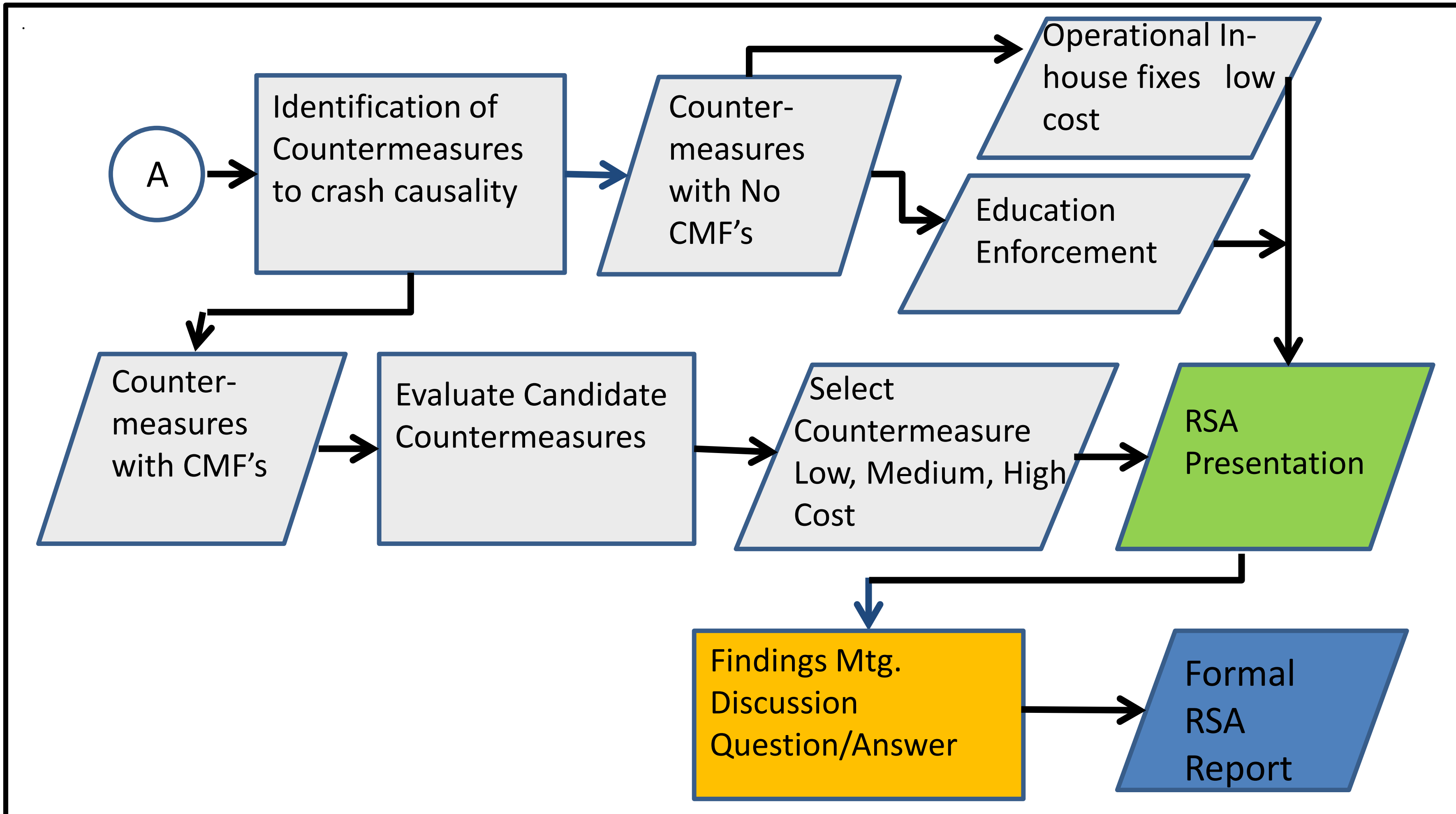
RSA/RSR

(Prior to & Opening Meeting) to (Field Investigation) to RSA Analysis)



RSA/RSR

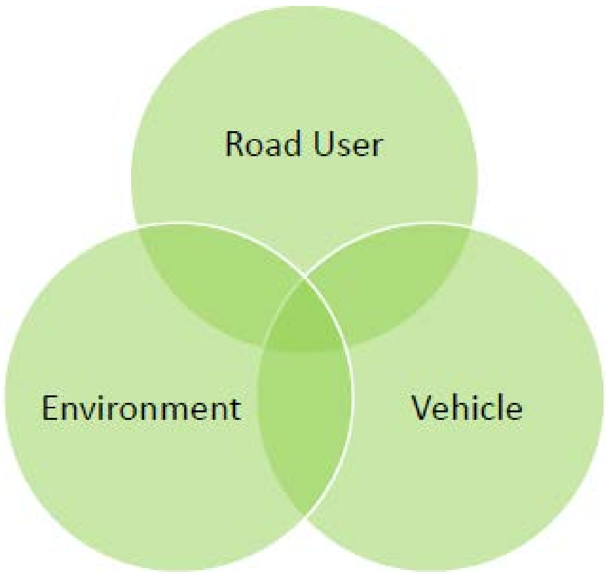
(RSA Analysis) to (RSA Presentation) to (Findings Meeting)



COUNTERMEASURE STAGE

Conducting RSA Field Diagnostic

- Identify driver information needs and/or limitations that could lead to error or problems with the roadway environment and other vehicles
- Describe these issues “Why is it a problem?”
- Describe potential interactions across issues
- Identity key information and design solutions to best address the issues described



Field Investigation, Safety Risk and Diagnostic

Observed Safety Risk			
Roadway Diagnostic	**Human Factors**	**Environmental Factors**	**Vehicle Factors**
Roadway User information needs or limitations			
Why an issue?			
Potential Interactions			

Examples with Human Factors and Causation


PEPSI
PEPSI

Hidden Through Vehicle

Roadway Diagnostic	Human Factors	Environmental Factors	Vehicle Factors
Roadway User information needs or limitations	See and react to approaching vehicles	Minor Stop Control High Speed Intersection	Right turning vehicles block sight triangle
Why an issue?	Inadequate reaction time	Visual Site Distance dynamically reduced	Both through and turning Vehicles can't see each other
Potential Interactions	Angle and R.E. Crashes	High Speed collisions	Presence of large trucks in crashes


Righter
BILL BRADY

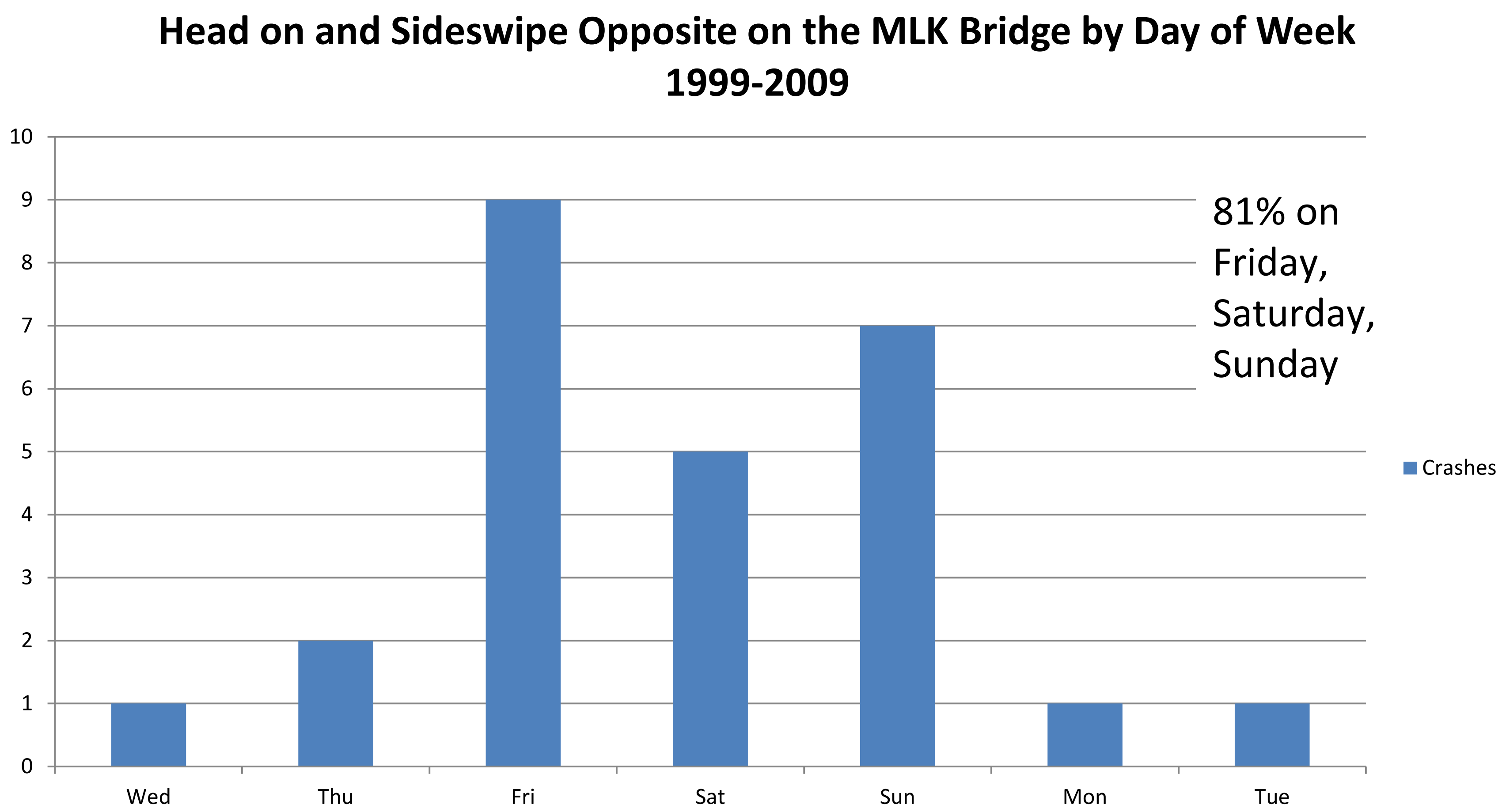
Hidden Mainline Curve

Roadway Diagnostic	Human Factors	Environmental Factors	Vehicle Fa
Roadway User information needs or limitations	Detect, recognize and react to change in alignment	Very sharp curve, little super-elevation	Vehicle performance on curves and braking
Why an issue?	Inadequate reaction time to maneuver	High speed into a low design speed curve	Pick-Ups and SUV’s have high center of gravity
Potential Interactions	Head On and Fixed Object crash	High Speed crashes	Rollover

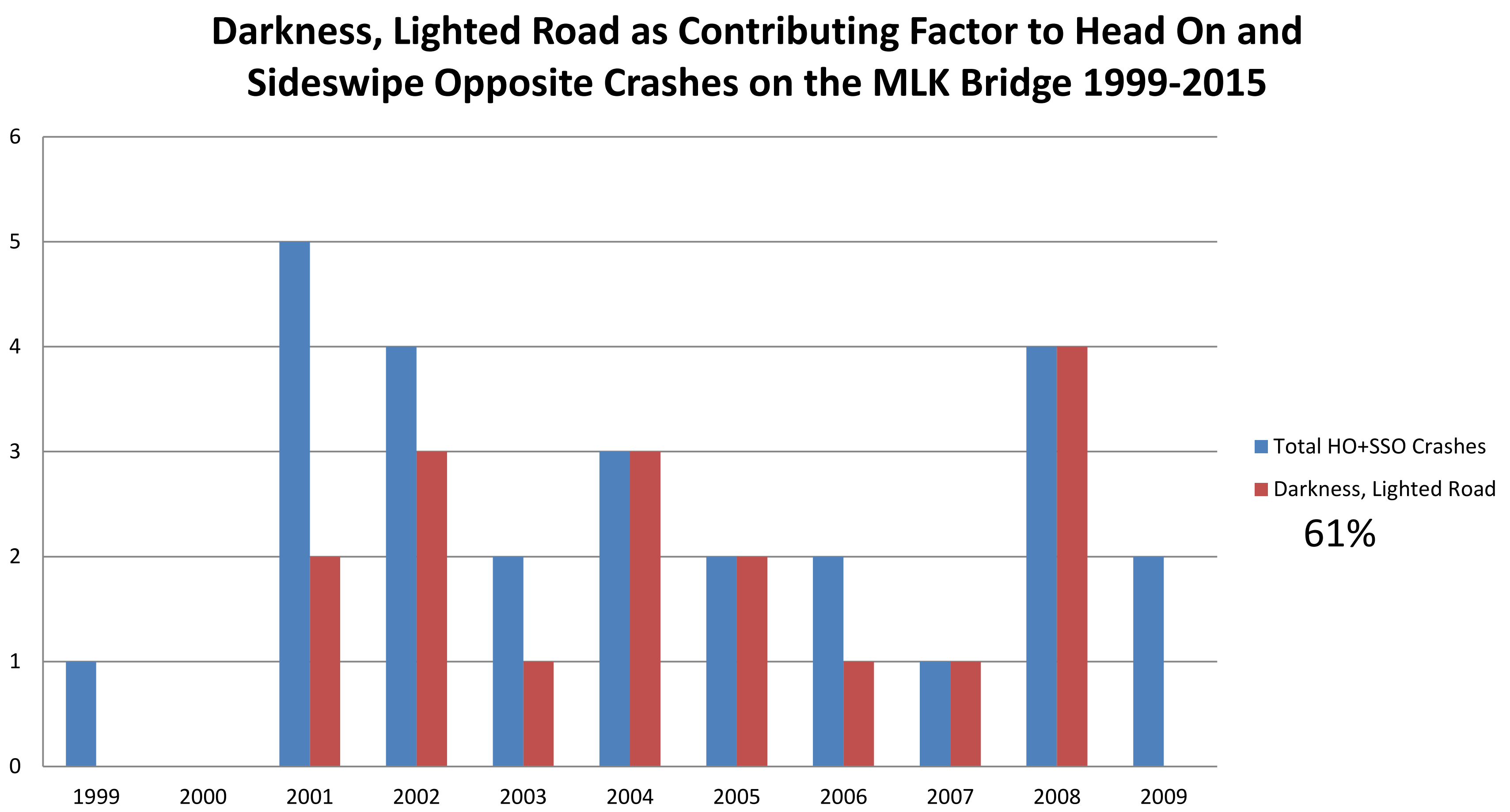

25
MPH


us bank
FedEx
Freight
P15638
FedEx
FedEx

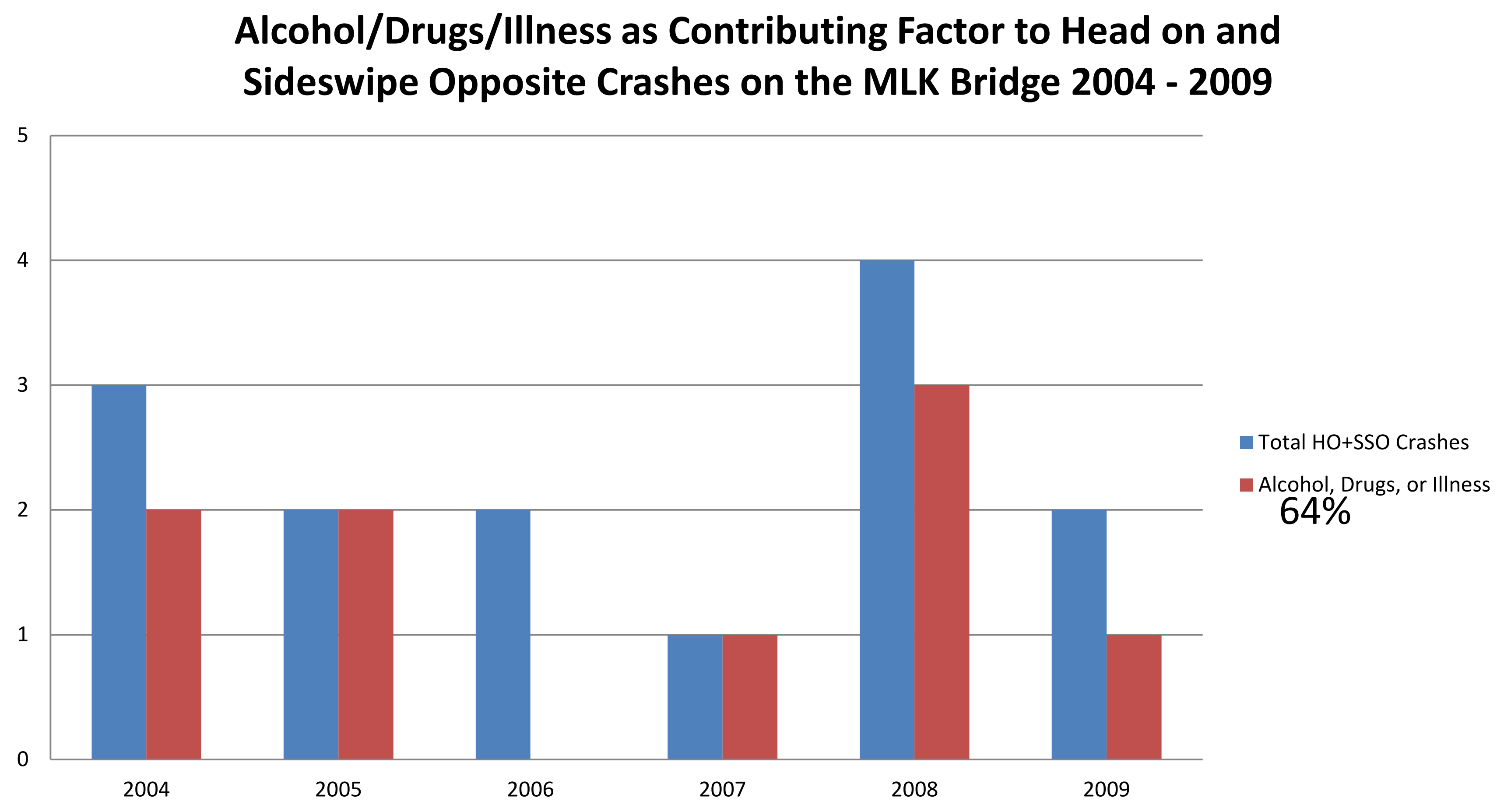
Day of Week Pattern



Contributing Factor -- Darkness



Contributing Factor – Driver Condition



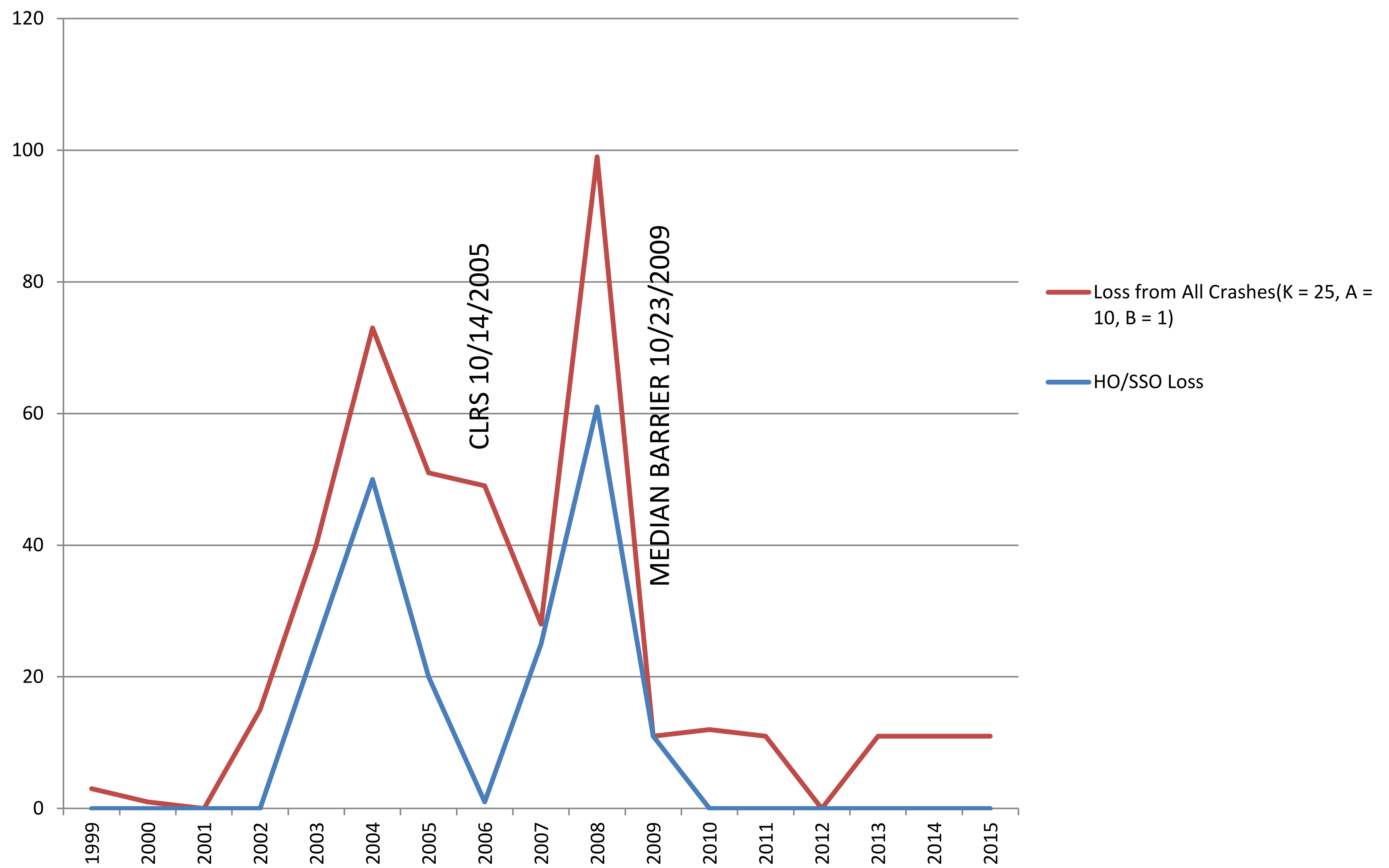
Four 10-Foot Lanes on Through Truss Bridge

Roadway Diagnostic	Human Factors	Environmental Factors	Vehicle Factors
Roadway User information needs or limitations	Interstate expectations. Lane keeping in narrow lane. Reaction to encroachment. Impairment.	Four 10-foot lanes, zero shoulder. Location is a connector/spur from Interstate to Interstate.	Interstate traffic, includes long and large trucks.
Why an issue?	Drivers make errors, require 5 steps time.	No tolerance for error. No room for maneuver.	Passing and side by side operation is inhibited or risky
Potential Interactions	Severe Head-On crashes	Moderate to High Speed crashes	Crashes with large trucks.

Four 10-Foot Lanes on Through Truss Bridge			
Roadway Diagnostic	**Human Factors**	**Environmental Factors**	**Vehicle Factors**
Roadway User information needs or limitations	Interstate expectations. Lanekeeping in narrow lane. Reaction to encroachment	Four 10-foot lanes, zero shoulder. **Centerline rumble stripe.**	Interstate traffic, includes long and large trucks.
Why an issue?	Drivers make errors, require 5 steps time.	No tolerance for error.	Passing and side by side operation is inhibited or risky
Potential Interactions	Severe Head-On crashes	Moderate to High Speed crashes	Crashes with large trucks.


25 25 Martin Luther King Memorial Bridge
Exit Street View
45
© 2017 Google
© 2017 Google
Google earth
Report a problem
Tour Guide
Imagery Date: 9/2014 38°37'50.75" N 90°10'33.24" W elev 14 ft eye alt 8 ft

Historic Loss/Year from Crashes on the MLK Bridge from 1999 through 2015 (K = 25, A = 10, B = 1)



Why Do We Need RSA's Incorporating Human Factors?

- Compromises & trade-offs are a normal part of the planning & design decision-making process. Human Factors are the largest part of factors contributing to crashes.
- Safety Assessments using Human Factors are intended to link the target crashes occurring with the specific countermeasures. Without linking a countermeasure to a type of crash, one is guessing and is much more likely to miss how and why the crashes are occurring.
- Ensure that safety is an explicit consideration, and that how we drive does not "fall through the cracks."

Saccadic Masking

- Our vision moves in a series of very fast jumps (saccades).
- Up to 900º/second!
- We only see the scene where we momentarily fixate. The rest is a blur.
- Our brain fills in the gaps, using the part we did see.
- Result – Saccadic masking. We look but do not see!
- London Cyclist. *What an RAF Pilot Can Teach Us About Being Safe on the Road*. 01/11/2012.

Take Aways

- RSAs already include consideration of human factors, and the tools and references here provide more explicit means to include and emphasize human factors.
- Use of human factors analysis can help to identify why and how crashes and crash patterns occur, and lead to effective countermeasures.
- The Human Factors matrix provides a positive guide to assess and diagnose safety issues.
- NCHRP 600
  - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600Second.pdf
- "What an RAF Pilot Can Teach Us About Being Safe on the Road"
  - http://www.londoncyclist.co.uk/raf-pilot-teach-cyclists/
  - https://www.dropbox.com/s/elegi6k9amk8spw/1211%20Road%20Survival%20Guide%20Final.pdf?dl=1

Thank you!
Questions ?

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