NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: **Diagnostic Assessments and Countermeasure Selection in the Safe System**

November 4, 2025

12:00PM – 1:30 PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

ENGINEERING
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REGISTERED CONTINUING EDUCATION PROGRAM

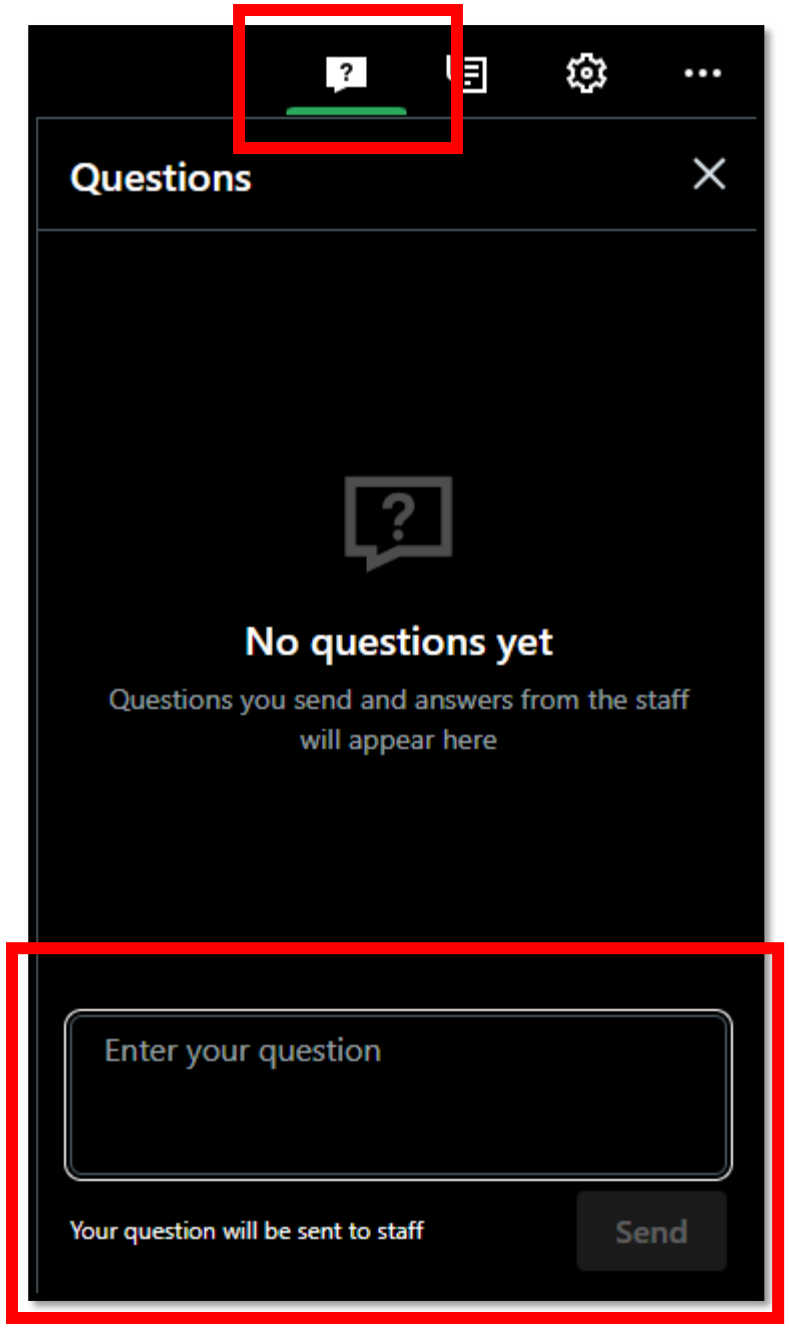
Learning Objectives

At the end of this webinar, you will be able to:

- (1) Describe the differences between human factors and driver behaviors as they relate to crashes
- (2) Assess key human factors issues that contribute to crashes
- (3) Identify and select crash countermeasures matched to underlying contributing factors

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

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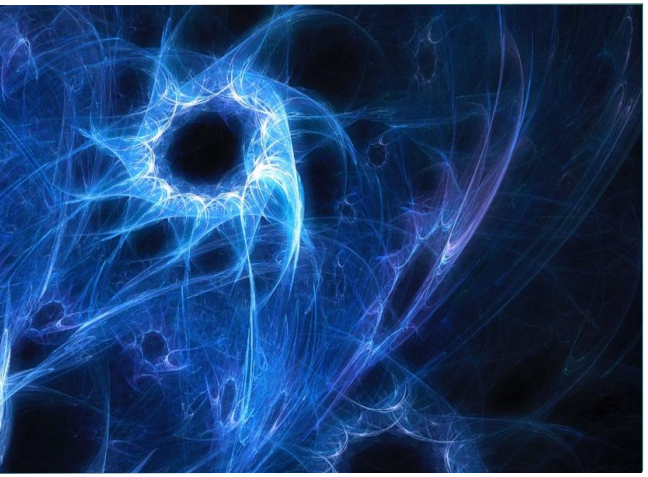


Diagnostic Assessment and Countermeasure Selection in the Safe System (NCHRP Project 22-45)

TRB Webinar, November 4, 2025

Welcome and Webinar Overview

Agenda

- Project Overview
- Benefits to the Traffic Safety Practitioner
- The Role of Human Factors in Diagnostic Assessment
- Modified Haddon Matrix
- Countermeasure Selection
- Key Takeaways

Project Overview: NCHRP 22-45

- Project Objectives
  - Develop new methods and tools for diagnosing contributing factors leading to crashes and selecting appropriate countermeasures.

- Identify Methods and Tools that:
  - Reflect practitioner's needs
  - Provide value to the diagnostic assessment & countermeasure selection process
  - Are viable to develop

- Develop Procedures, Methods, and Tools that are:
  - Empirical (grounded in relevant scientific studies and data),
  - Practical (understandable and usable for day-to-day use by practitioners),
  - Actionable (provide insights implementable by State DOTs).

- Key Deliverable:
  - NCHRP Report 1111, BTSCRP Report 12
  - Diagnostic Assessment and Countermeasure Selection: A Toolbox for Traffic Safety Practitioners | The National Academies Press

Benefits to the Traffic Safety Practitioner

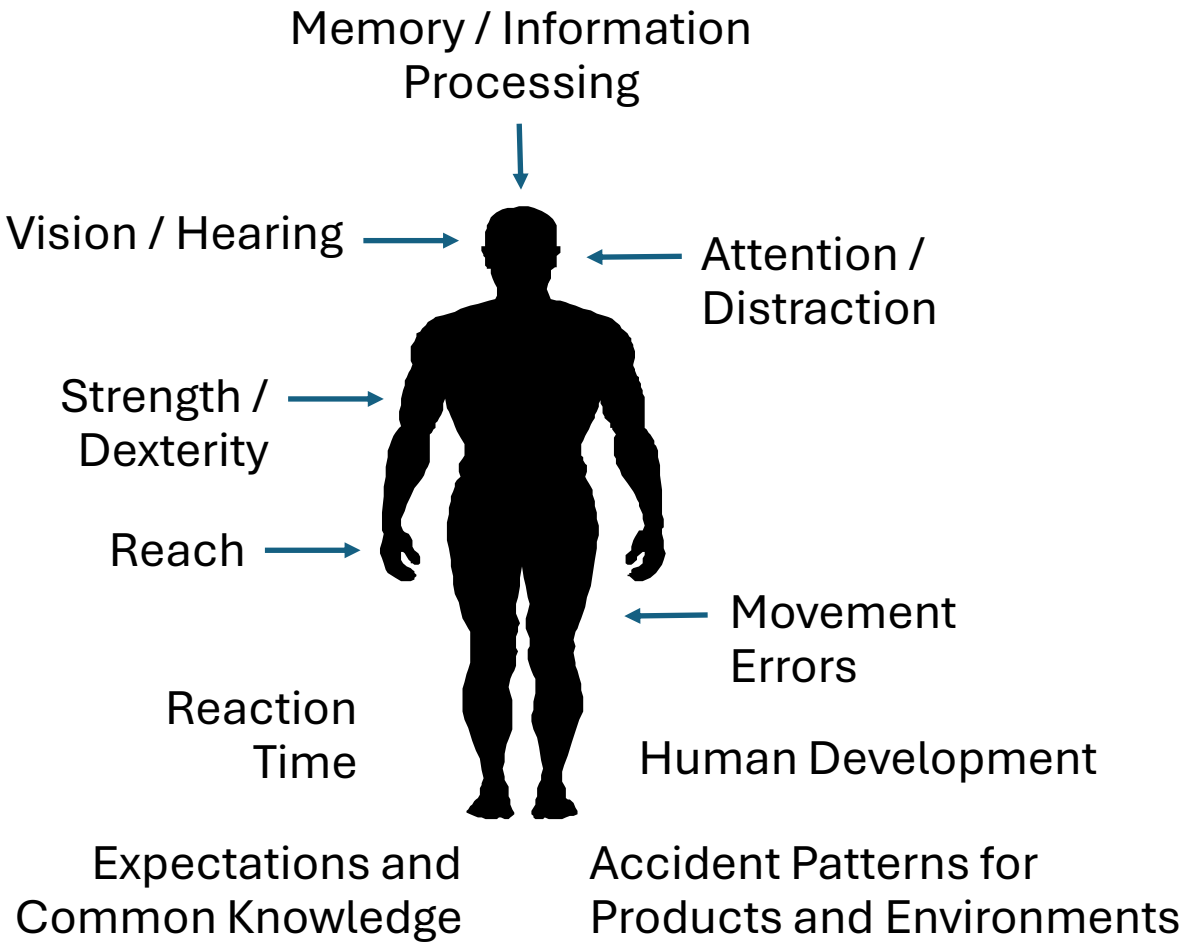
Why this matters

- We plan, design, and operate a system with users
- When we **start with the user**, our tools we will discuss today, will be a powerful way to **prevent and mitigate death and serious injuries** on the roadways
- Late 1990's, practical application, and meaningful changes

The Role of Human Factors in Diagnostic Assessment

What is Human Factors?

Scientific study of how the capabilities and limitations of people shape the ways in which they interact with and use products, equipment, and systems in their environments.



Why is Human Factors Important to Roadway Design and Operations?

Interactions between drivers and the roadway infrastructure has been a key contributing factor in every large-scale crash investigation

Driver errors play a key role in roadway crashes [1, 2, 3, & 4]

- Deliberate violations and errors, willful inappropriate behaviors
- Unintentional slips, lapses, and mistakes

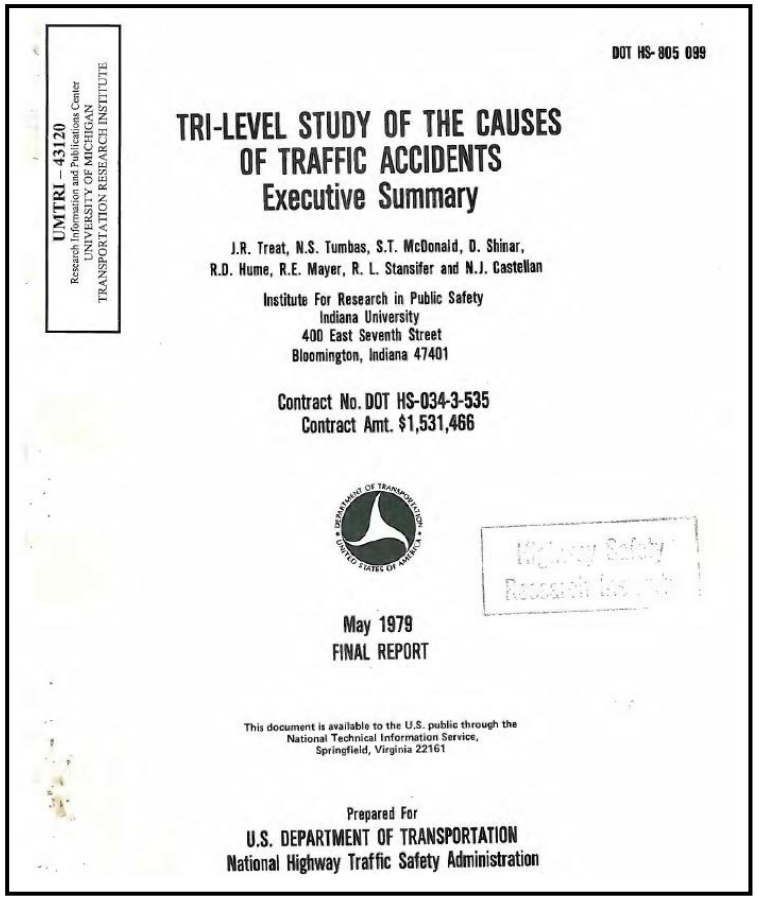
These errors often reflect driving demands that exceed the driver's capabilities

- Confusing, unreadable, or not visible roadway features (signs, signals, markings)
- Too many potential conflicts to monitor

1. Treat, J.R., Tumbas, N.S., McDonald, S.T., Shinar, D., Hume, R.D., Mayer, R.E., Stansifer, R.L., Castellan, N.J. (1979). *Tri-level study of the causes of traffic accidents*. (Report No. DOT HS-805 099).
   Washington, DC: NHTSA. (See Figure 2-2, pg.9)
2. Singh, S. (2015). *Critical reasons for crashes investigated in the national motor vehicle crash causation survey* (Traffic safety facts crash stats. report No. DOT HS 812 506NHTSA.
3. Reason, J. (1995). Understanding adverse events: human factors. *BMJ Quality & Safety*, *4*(2), 80-89.
4. Wierwille, W. W., Hanowski, R. J., Hankey, J. M., Kieliszewski, C. A., Lee, S. E., Medina, A., ... & Dingus, T. A. (2002). *Identification and evaluation of driver errors: Overview and recommendations* (No. FHWA-RD-02-003,).

Large-scale Crash Investigations

- Treat et al., (1979)[1]
  - "View obstruction" was cited as a key environmental factor contributing to crashes.
  - The specific human errors most frequently associated with crashes were:
    - Improper lookout
    - Excessive speed
    - Inattention
    - Evasive action
    - Internal distraction



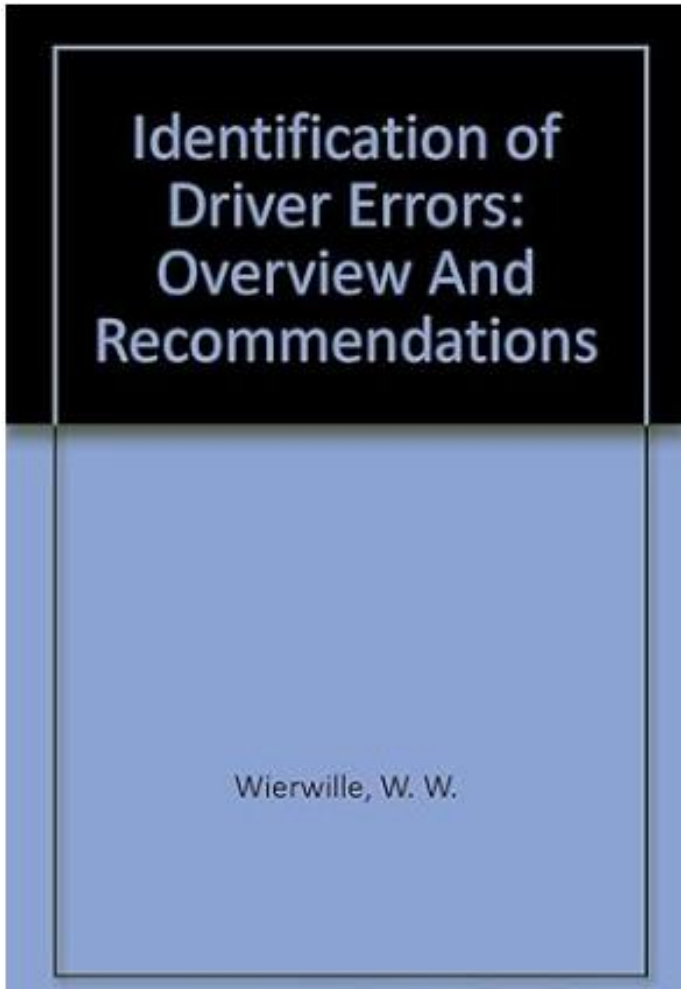
1. Treat, J. R., Tumbas, N. S., McDonald, S. T., Shinar, D., & Hume, R. D. (1979). Tri-level study of the causes of traffic accidents, executive summary (Final report No. DOT HS 034353579TAC [5]). Washington, DC: National Highway Traffic Safety Administration.

Large-scale Crash Investigations

- Wierwille et al. (2002)[1]
  - Driver Errors included:
    (1) recognition errors (e.g., failure to observe, inattention, improper lookout),
    (2) decision errors (e.g., misjudgement, excessive speed, tailgating), and
    (3) performance errors (e.g., panic or inadequate directional control).”

  - Contributing factors most frequently associated with crashes were wilful inappropriate behaviors and violations such as:
    - Impairment due to drugs or alcohol,
    - Aggressive driving,
    - Inattention, and
    - Speeding

  - Crashes are complex and may involve multiple contributing factors



1. Wierwille, W. W., Hanowski, R. J., Hankey, J. M., Kieliszewski, C. A., Lee, S. E., Medina, A., Keisler, A. S., & Dingus, T. A. (2002). Identification and evaluation of driver errors: Overview and recommendations (Report No. FHWA-RD-02-003). Washington, D.C: Federal Highway Administration.

Large-scale Crash Investigations

- Singh (2015)[1]
  - A key focus of the study was to examine what was termed the “critical reason” for the crash; that is, the last event in the crash causal chain.
    - Vehicle (component failure or degradation) - 2%
    - Environment (e.g., slick roads, weather) - 2%
    - Driver – 94%
      - recognition errors (e.g., inattention, distraction, inadequate surveillance) - 41 %,
      - decision errors (e.g., driving too fast for conditions, illegal maneuvers, false assumptions about others’ actions) – 33%
      - performance errors (e.g., overcompensation, poor directional control) – 11%

Critical Reason	Estimated (Based on 94% of the NMVCCS crashes) Number	Percentage* ± 95% conf. limits
Recognition Error	845,000	41% ±2.2%
Decision Error	684,000	33% ±3.7%
Performance Error	210,000	11% ±2.7%
Non-Performance Error (sleep, etc.)	145,000	7% ±1.0%
Other	162,000	8% ±1.9%
Total	2,046,000	100%

1. Singh, S. (2015). *Critical reasons for crashes investigated in the national motor vehicle crash causation survey* (Traffic safety facts crash stats. report No. DOT HS 812 506). National Highway Traffic Safety Administration.

Characteristics of Errors Due Primarily to Human Factors Issues vs. Aberrant Driver Behaviors

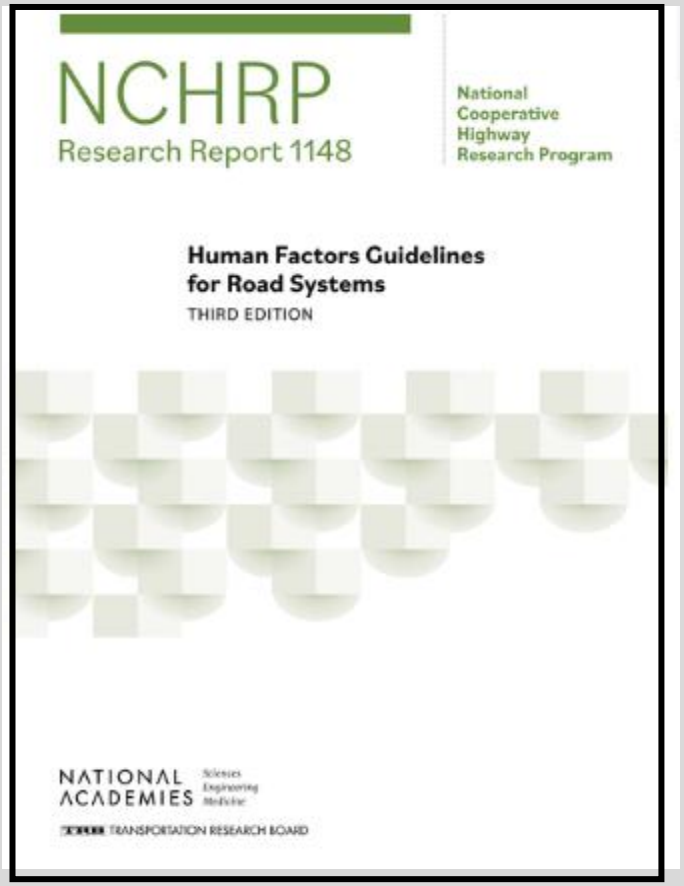
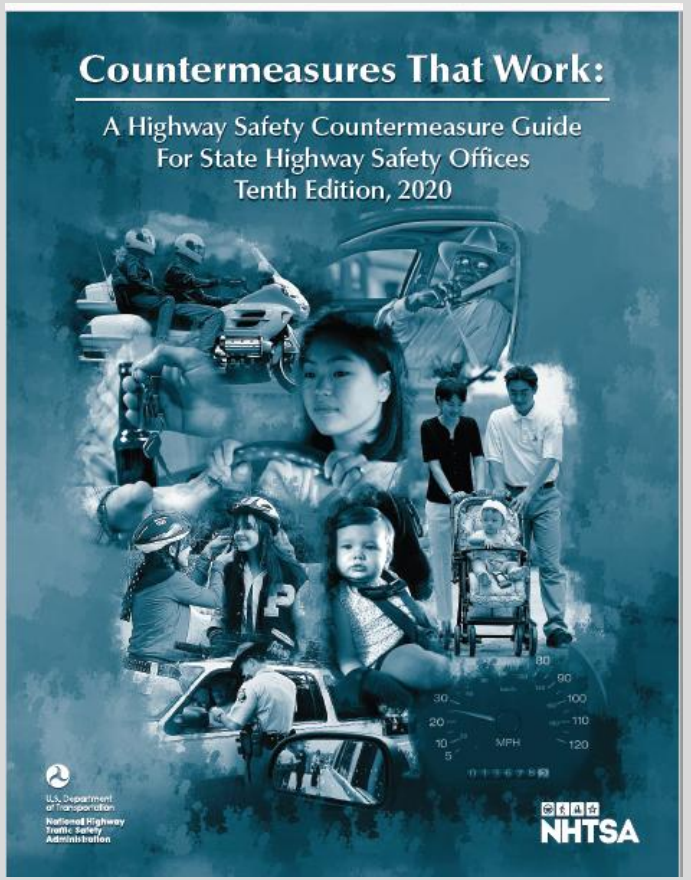
- Human Factors Issues:
  - Driver is alert and attentive
  - Driver follows relevant traffic laws and the typical DMV requirements
  - Often involve interactions between reasonable road user behaviors and environmental/roadway factors
- Aberrant Driver Behaviors:
  - Deliberate violations of law
  - Unsafe driving practices
  - Unreasonable decisions and actions

Human Factors Issues vs. Aberrant Driver Behaviors: Examples[1]

Human Factors Issues	Aberrant Driver Behavior Issues
• Reaction time • Sight distance • Sign legibility and comprehension • Excessive workload • Mismatches between design and expectations • Target detection/conspicuity • Inconsistent messages to the road user • Failure to accommodate known needs, capabilities, and limitations	• Alcohol- and drug-impaired driving • Intentional/egregious violations of regulatory requirements – e.g., speeding • Inattention to the driving task • Distracted driving • Road rage • Poor driving performance due to physical illness or psychological condition

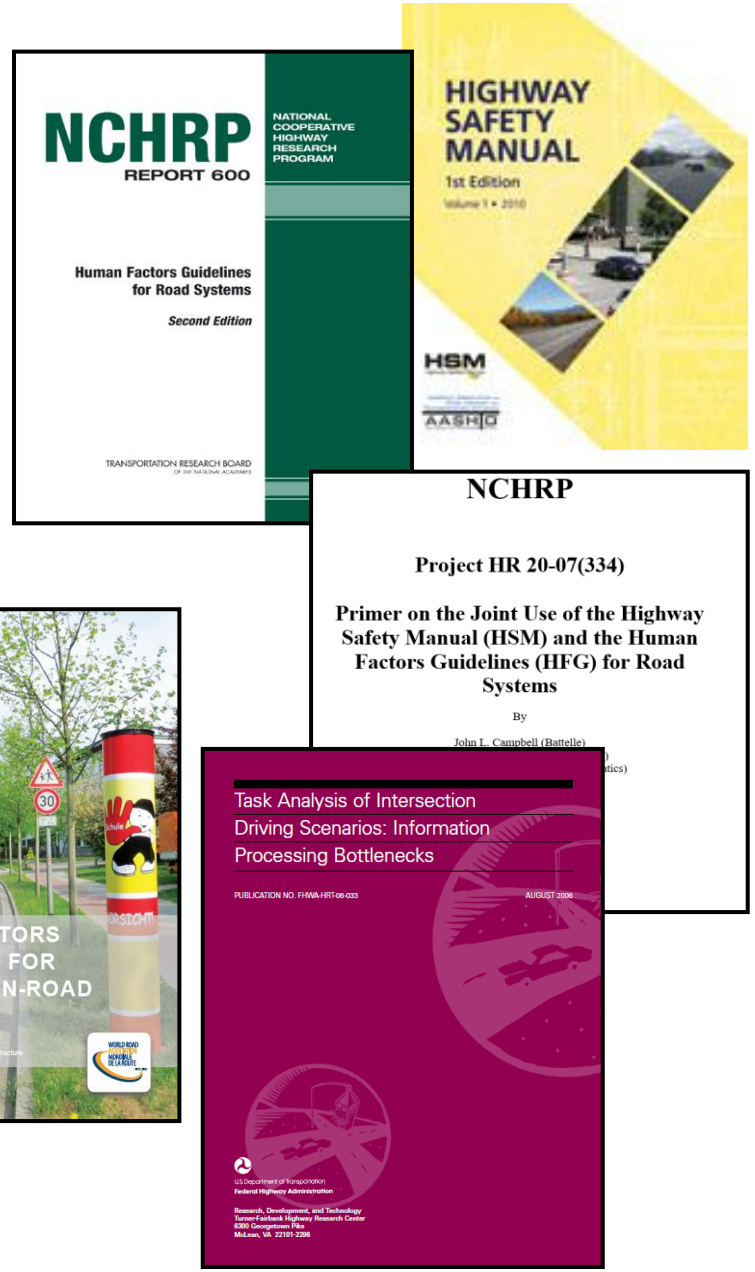
1. Adapted from: PIARC. (2019) *Road Safety Evaluation Based on Human Factors Method*. France: World Road Association (PIARC)

Countermeasures: Human Factors vs. Aberrant Driver Behaviors

Human Factors Issues	Driver Behavior Issues
	

Tools to Aid Diagnostic Assessment

- Design Approaches and Safety Handbooks
  - Positive guidance principles and systemic presentation of information
    - How design elements work together to impact user performance and safety
  - The HSM
- Human Factors Resources
  - The HFG and the HSM/HFG *Primer*
  - *The World Road Association (PIARC) HF Sources - https://www.piarc.org/en/*
- Task Analysis
  - See the HFG: 6-2, 8-2, 12-2, 14-2, and Tutorial 3

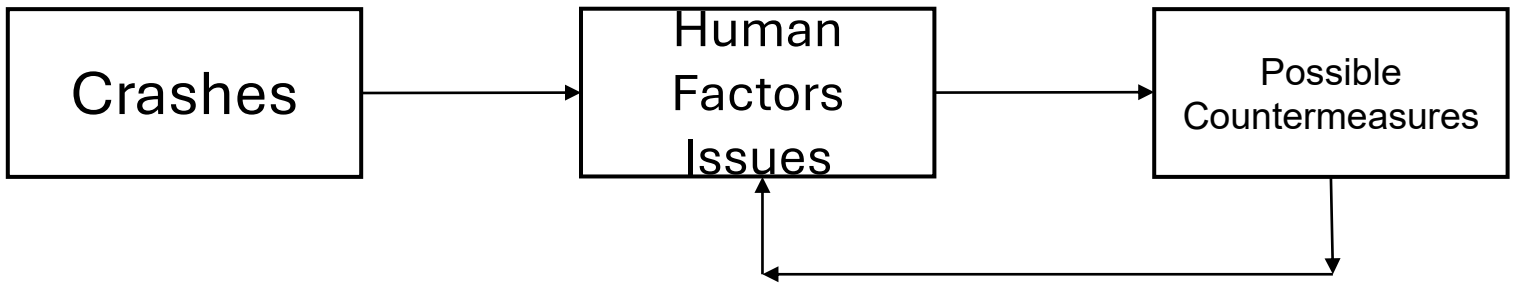


Diagnostic Assessment- Guiding Principles

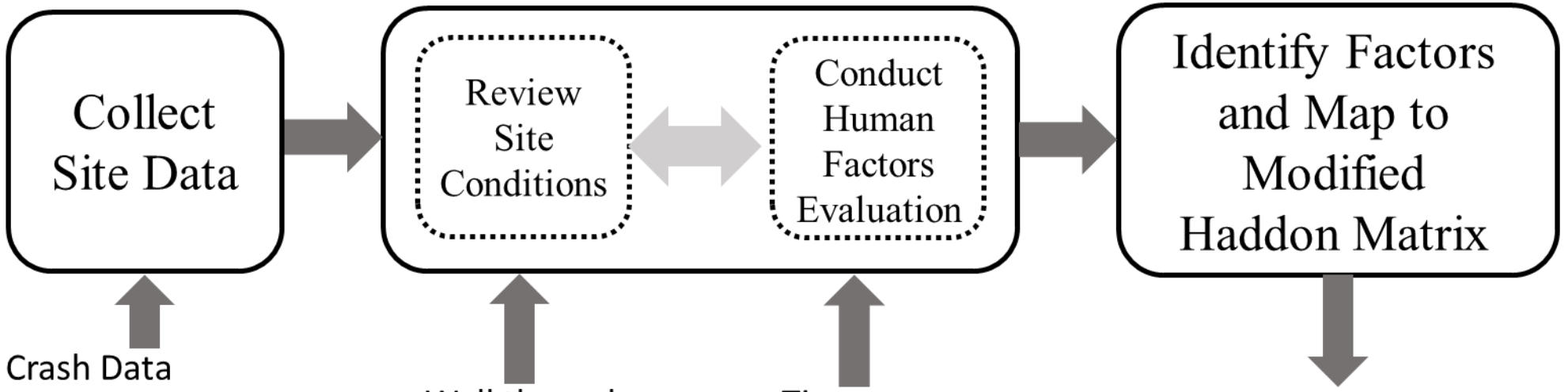
- Consider the full range of contributing factors, including those related to human factors issues
  - Compare task demands to user capabilities and limitations
    - Road users perceive → decide → act
  - Keep in mind differences between human factors and aberrant driving behaviors

- Serve as a virtual user on your roadways
  - What does the facility communicate to the typical road user?

- Avoid simple links between crash types and countermeasure



Crashes→ Contributing Factors



- Crash Data
  - Types
  - Data
  - Patterns
  - Aberrant Driver Behaviors
- Review Locations
- Roadway Conditions
- Volume Data
- Past Studies & Documentation

- Walkthroughs
- Safety Reviews/Audits
- Land Use Considerations
- Prompt Lists

- Time
- Expectations
- Visibility
- Workload

	Factors					
Phases	Human	Vehicle	Physical Environment/ Context	Social Environment	User Mix Considerations	Interactions Between Users
Pre-event (*Before the crash occurs*) **Factors that may increase the likelihood of the crash before the crash event**	• Driver's perceptual, cognitive, and physical abilities • Alcohol and drug impairment • Impairment from fatigue • Distraction • Driver experience • Ability to perceive and react to unexpected events in a driving environment (e.g., understanding the potential for different road users) • Alertness/attentiveness • Familiarity with route • Expectations for the environment/facility	• Maintenance of brakes, tires • Speed of travel • Load characteristics • Size of vehicle • Safety and/or driver assistance features	• Roadway markings • Divided highways • Roadway lighting • Intersections type and angle • Road curvature • Signage • Walking and biking availability, facility type, separation • Roadway shoulders	• Public attitudes on drinking and driving • Impaired driving laws • Graduated licensing laws • Seat belt, helmet, and other Personal Protective Equipment (PPE) laws • Risky behavior prominence • Support for injury prevention efforts • Positive Safety Culture • Equity considerations for lower income (e.g., PPE, Driver Ed., scholarships) • Presence of passengers	• Volume of walking and biking • Type and separation of path/shoulder sidewalk • Route directness • Crossing distance from generators • Reliance on transit, walking, and biking • Lighting Scale • Sense of security of routes • Intersection turning speeds and priorities for operations • Mid-Block Crossing controls • Intersection type • Speed management	• Speed setting consistent with user mix • Ability to maintain consistent operating speeds • Choice-making based on road users' safety and security • Common Behaviors • Education and enforcement • Ability to turn on red, permitted, and protected signals against vulnerable road users
Event (*During the crash*) **Factors that may influence the injury or severity of the crash during the crash event**	• Spread out energy in time and space with seat belt and/or airbag use • Child restraint use • Personal Protective Gear	• Vehicle size • Crashworthiness of vehicle, overall safety rating • Airbags (type and placement) • Padded dashboards, steering wheels, etc.	• Guard rails, median barriers, breakaway devices • Presence of fixed objects near the roadway • Roadside embankments • Other road users	• Seat belts and child restraint, and other PPE laws are followed • Enforcement of occupant restraint laws • Motorcycle and Bicycle helmet laws or use or both are followed and accepted	• Travel speeds • Vehicle size and type • Design exposure that tends to increase speed or threats during crossing or walking on facilities • Separation of users • Proximity of vulnerable road users to vehicles	• Speeds resulting in injury • Angle of crash through design and operation • Vision, speed judgment • Protective equipment and restraint use • Crash-worthy roadside hardware and clear zone
Post-event (*After the crash*) **Factors that may influence the survivability of the crash after the event**	• Crash victim's general health status • Age of victims	• Gas tanks designed to maintain integrity during a crash to minimize fires • Ability to extract injured	• Availability of effective EMS systems • Ability to respond quickly to crash • Distance to quality trauma care • Rehabilitation programs in place	• Public support for an emergency, trauma care, and post-crash rehabilitation • EMS training	• Trauma center availability and proximity • Emergency response	• Redundancy of system • Ability to respond and transport to care

Consider pre-, during-, and post-crash factors

Critical Human Factors Contributors to Crashes[1]

Expectations – the facility should be laid out logically, be consistent with expectations, and avoid confusing road users

Visibility – the road design should support perception and extraction of relevant objects in the environment

Workload – navigating the facility should be accomplished within the information processing abilities of a representative road user

Time – the roadway infrastructure should provide enough time for road users to:

- *Perceive relevant information*
- *Decide what to do, &*
- *Act / Respond*

1. PIARC. (2016) *Human Factors Guidelines for a Safer Man-Road Interface*. France: World Road Association (PIARC)

Framework for Applying Human Factors to Roadway Design and Operations[1]

Roadways are a communications device

Errors are more likely when roadway demands exceed road user capabilities

Countermeasures/treatments should be aimed at reducing the demands placed on the road user

Modified Haddon Matrix

Modified Haddon Matrix[1]

FACTORS						
PHASES	Human	Vehicle	Physical Environment/ Context	Social Environment	User Mix Considerations	Interactions Between Users
Pre-event (*Before the crash occurs)*						
Event (*During the crash)*						
Post-event *(After the crash)*						

1. Milton, J. & van Schalkwyk, I. (used by permission, personal communication, January 17, 2022)

Modified Haddon Matrix[1]

Phases	Human	Vehicle	Environment
Before crash			
During crash			
After crash			

Expand into:

- **Physical environment/ context**
- **Social environment**
- **User-mix considerations**
- **Interactions between users**

Reframe for Safe System Approach

1. Milton, J. & van Schalkwyk, I. (used by permission, personal communication, January 17, 2022)

Modified Haddon Matrix

Phases
Before crash
During crash
After crash

Phases
Pre-event *(Before the crash occurs)* Factors that may increase the **likelihood** of the crash and **exposure** before the crash event
Event (*During the crash)* Factors that may influence the **injury severity** of the crash during the crash event
Post-event *(After the crash)* Factors that may influence the **survivability** of the crash after the event

Reframe for Safe System Approach

Modified Haddon Matrix

HUMAN and VEHICLE

Similar to Haddon Matrix but focus is on likelihood and **exposure**

	Human	Vehicle
Pre-event *(Before the crash occurs)* Factors that may increase the **likelihood** of the crash and **exposure** before the crash event	• Aberrant behaviors: impairment, distraction etc. • Expectations for facility from user perspective	• Operating Speed • Vehicle type and mass • Traffic volumes • How well vehicles are maintained
Event (*During the crash)* Factors that may influence the **injury severity** of the crash during the crash event	• Actual use of restraints, helmets	• Vehicle mass & size • Crash compatibility
Post-event *(After the crash)* Factors that may influence the **survivability** of the crash after the event	• Crash victim's general health status • Age of involved drivers and road users	• Ability to extract injured, etc.

Note. Table just shows examples, not intended to be exhaustive

Modified Haddon Matrix

Pre-event - ENVIRONMENT

focus on **likelihood** and **exposure**

Physical environment/ Context	Social environment	User-mix considerations	Interactions between Users
• Infrastructure characteristics with a focus on context, visual environment and cues (signs, markings, geometry, lighting, access management)	• Social norms and values • Socio demographics of the general area and typical users	• Road user types • Type of facilities provided and how they support each of the user types in terms of likelihood and exposure	• Conflict points between users • Speed and conflict compatibility • Behaviors of different users, e.g., desire lines, choices based on personal security

Note. Table just shows examples, not intended to be exhaustive

Modified Haddon Matrix

Event - ENVIRONMENT

focus on **crash severity**

Physical environment/ Context	Social environment	User-mix considerations	Interactions between Users
• Posted speed limits • Roadside safety • Exposure to other road users	• Actual use of restraints, helmets, laws and enforcement	• What would influence the forces (mass, speed) • Design exposure at locations for crossing and shared environments: separation, speed, proximity	• Speed • Angle of crashes (design & operations)

Note. Table just shows examples, not intended to be exhaustive

Modified Haddon Matrix

Post-event - ENVIRONMENT

focus on **survivability**

Physical environment/ Context	Social environment	User-mix considerations	Interactions between Users

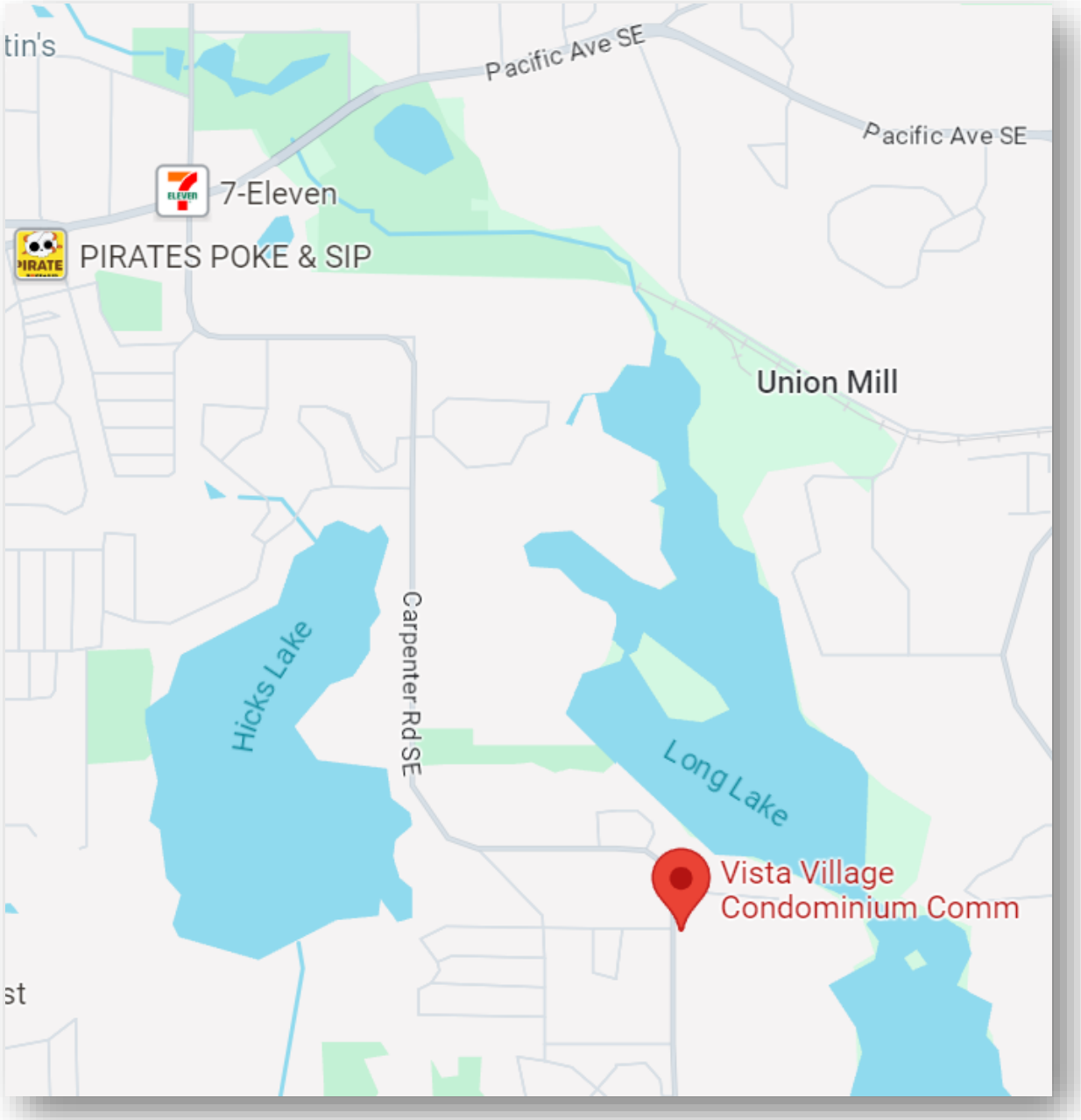
• Availability of effective EMS systems
• Ability to respond quickly to crash
• Distance to trauma center - availability and proximity
• Rehabilitation programs and access to those
	• Public support for
	  ○ EMS
	  ○ Trauma care
	  ○ Post crash rehabilitation
	• EMS training quality
		• Crash worthiness of EMS vehicles	• System redundancy
			• Ability to respond and transport to care given road users present or typical of the facility

Note. Table just shows examples, not intended to be exhaustive

Modified Haddon Matrix

– Real world example

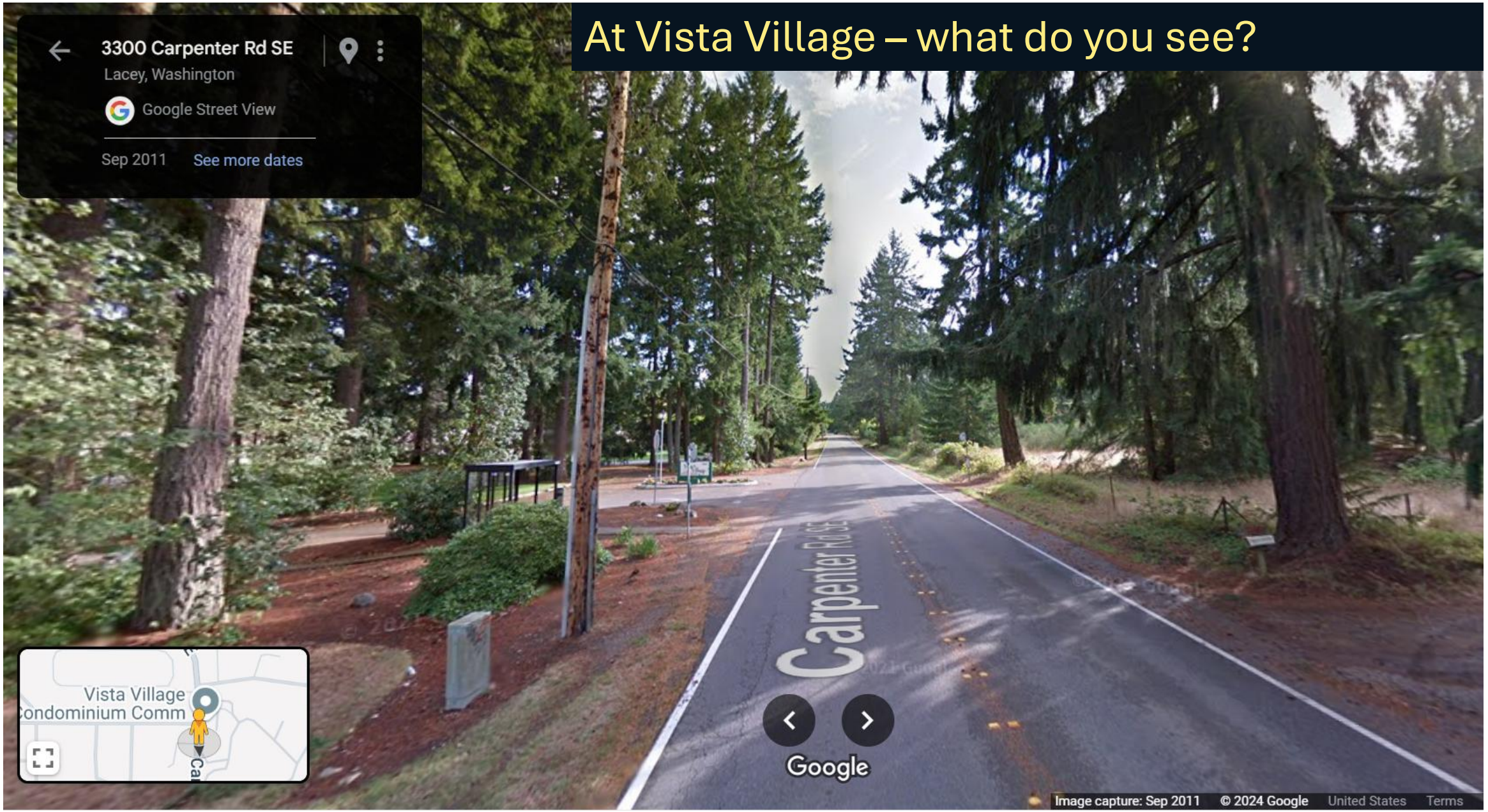
- Pedestrian got struck by a driver on Carpenter Road in Lacey, WA. The narrative states that the pedestrian crossed the roadway near or at the Vista Village Condominium in Lacey, WA. It was just after 5:30pm on December 4th. The driver says they didn't see the man crossing the road.
- The newspaper shares that the man was a 61-year-old executive heading home. He stopped driving because of his eyesight.
- Pin: 3300 Carpenter Rd, Lacey, WA 98503



Source: Google Earth

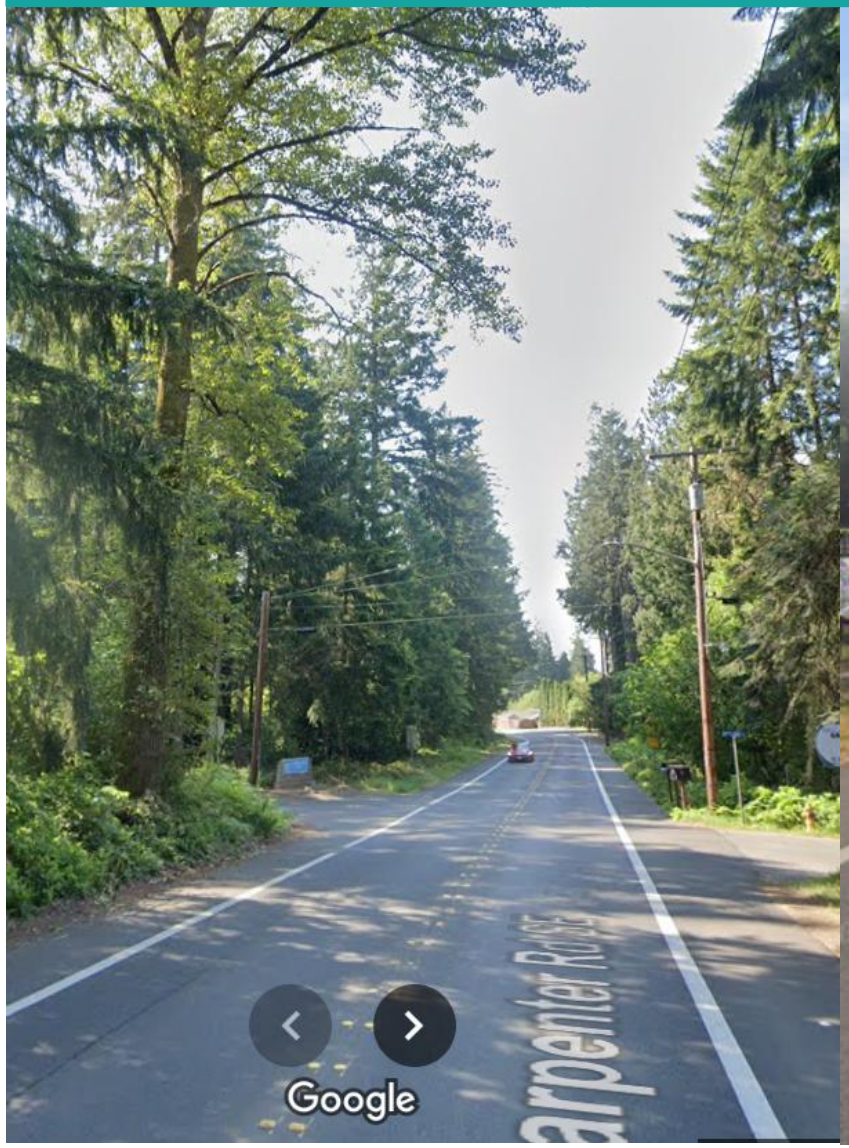
Source: Google Earth

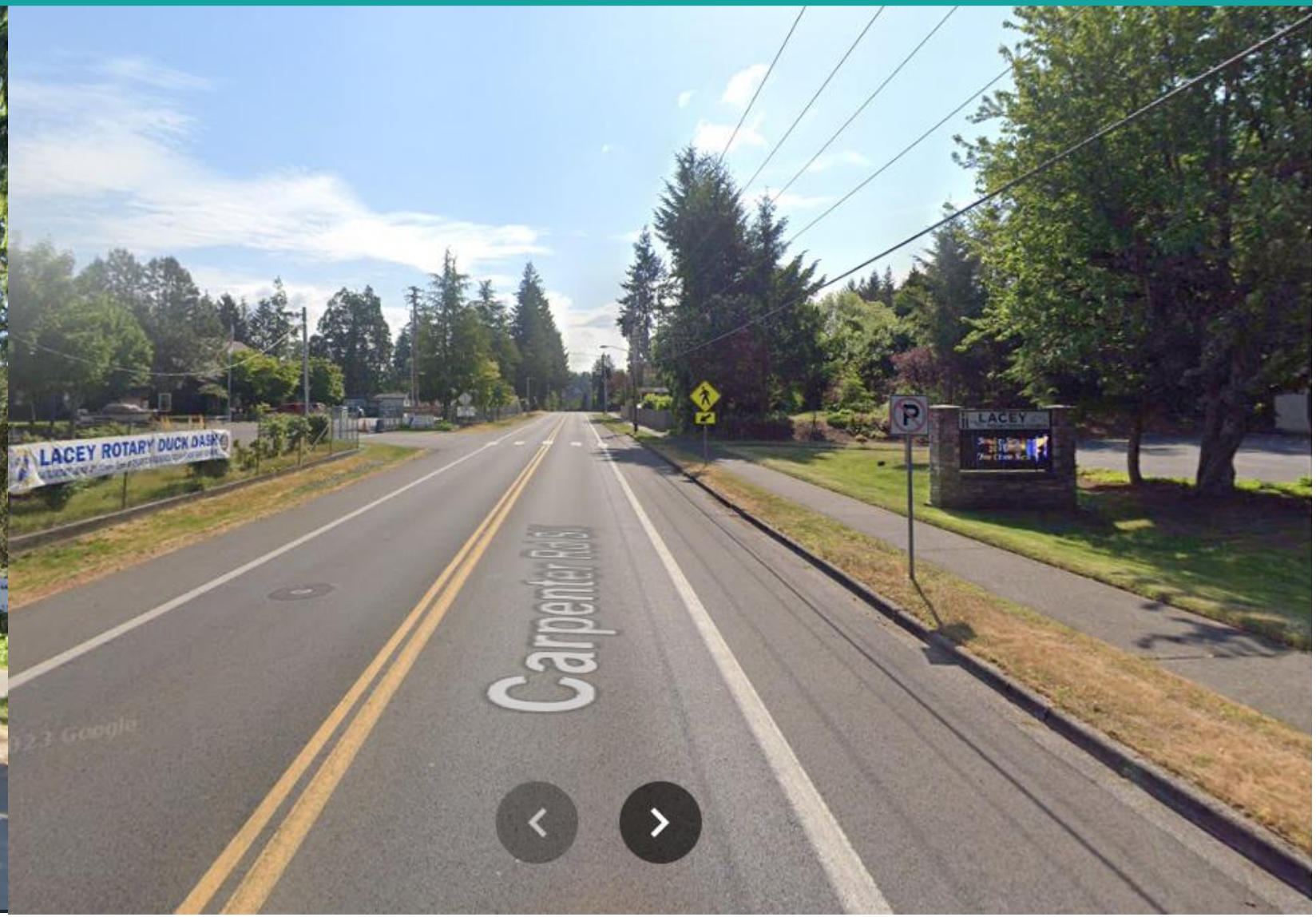
At Vista Village – what do you see?



Source: Google Earth

Upstream – the road the driver was navigating





Roadside? Speed?

Source: Google Earth

Source: Google Earth

Vista Village location on left

Source: Google Earth

Modified Haddon Matrix

Phases	Human	Vehicle	Physical environment/ Context	Social environment	User-mix considerations	Interactions between Users
Pre-event likelihood & exposure						
Event injury severity						
Post-event survivability						

Countermeasure Selection

Decision Trees to Support Countermeasure Selection

- Chapter 10 provides series of decision trees to help select countermeasures to address target crash types and facility types

- Decision trees lead the analyst through series of diagnostic questions to help identify countermeasures that could potentially address crash contributing factors associated with the crash pattern of interest

- Selecting countermeasures for potential implementation, matched to underlying contributing factors to target crash types, are expected to reduce crashes to the greatest extent possible

Decision Trees to Support Countermeasure Selection

- Decision trees are based primarily on diagnostic scenarios incorporated in Safety Analyst
  - Former AASHTOWare product that implemented the six main steps of the roadway safety management process outlined in HSM Part B

- Primary result of reviewing and answering diagnostic questions:
  - List of potential countermeasures for further consideration in economic appraisal and project prioritization processes

Decision Trees to Support Countermeasure Selection

- Decision trees also reflect information from sources such as:
  - PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System
  - BIKESAFE: Bicycle Safety Guide and Countermeasure Selection System
  - usRAP: United States Road Assessment Program
  - Human Factors Guidelines for Road Systems (HFG): 3rd Edition (upcoming)
  - CMF Clearinghouse
  - Field Guide for Selection Countermeasures at Uncontrolled Pedestrian Crossing Locations

Decision Trees to Support Countermeasure Selection

- Decision trees address common crash types and countermeasures included in many State Strategic Highway Safety Plans (SHSP) and for which states use Highway Safety Improvement Program (HSIP) funds:
  - Roadway departure crashes
  - Rear-end crashes
  - Angle crashes
  - Intersection crashes
  - Pedestrian crashes
  - Bicycle crashes

Decision Trees to Support Countermeasure Selection

- Decision trees address crash types along rural and urban segments and intersections, including:
  - Rural two-lane segments
  - Rural multilane undivided segments
  - Rural multilane divided segments

  } 34 decision trees

  - Urban two-lane segments
  - Urban multilane undivided segments
  - Urban multilane divided segments

  } 22 decision trees

  - Rural and urban signalized intersections } 16 decision trees
  - Rural and urban unsignalized intersection } 9 decision trees

Rural Segments – Crash Types and Contributing Factors

Crash Type	Type of Segment and Contributing Factor	Figure No.	Page No.
Rural Two-Lane Segments			
Roadway departure crashes (single-vehicle run-off-road)	Driver inattention / impairment	22	90
	Roadside design	23	92
	Speed / curvature / guidance	24	95
	Roadway surface condition / superelevation	25	97
	Roadway surface condition / drainage	26	98
Roadway departure crashes (head-on / sideswipe, opposite direction)	Driver inattention / impairment	27	100
	Roadside design	28	102
	Overtaking	29	103
	Speed / curvature / guidance	30	105
	Roadway surface condition / superelevation	25	97
	Roadway surface condition / drainage	26	98
Rear-end crashes	Driveways / accesses	31	106
	Roadway surface condition / drainage	26	98
Pedestrian crashes	Dart-dash / midblock / along the road	32	108
Bicycle crashes	Bicyclist rode out midblock / motorist turned into path of bicyclist / bicyclist turned into path / overtaking	33	110

Crash Type	Type of Segment and Contributing Factor
Rural Multilane Undivided Segments	
Roadway departure crashes (single-vehicle run-off-road)	Driver inattention / impairment
	Roadside design
	Speed / curvature / guidance
	Roadway surface condition / superelevation
	Roadway surface condition / drainage
Roadway departure crashes (head-on / sideswipe, opposite direction)	Driver inattention / impairment
	Roadside design
	Speed / curvature / guidance
	Roadway surface condition / superelevation
	Roadway surface condition / drainage
Rear-end crash	Driveways / accesses
	Roadway surface condition / drainage
Pedestrian crashes	Dart-dash / midblock / along the road
Bicycle crashes	Bicyclist rode out midblock / motorist turned into path of bicyclist / bicyclist turned into path / overtaking
Rural Multilane Divided Segments	
Roadway departure crashes (single-vehicle run-off-road)	Driver inattention / impairment
	Roadside design
	Speed / curvature / guidance
	Roadway surface condition / superelevation
	Roadway surface condition / drainage
Roadway departure crashes (head-on / sideswipe, opposite direction)	Driver inattention / impairment
	Median design
	Speed / curvature / guidance
Rear-end crash	Driveways / accesses
	Roadway surface condition / drainage
Pedestrian crashes	Dart-dash / midblock / along the road
Bicycle crashes	Bicyclist rode out midblock / motorist turned into path of bicyclist / bicyclist turned into path / overtaking

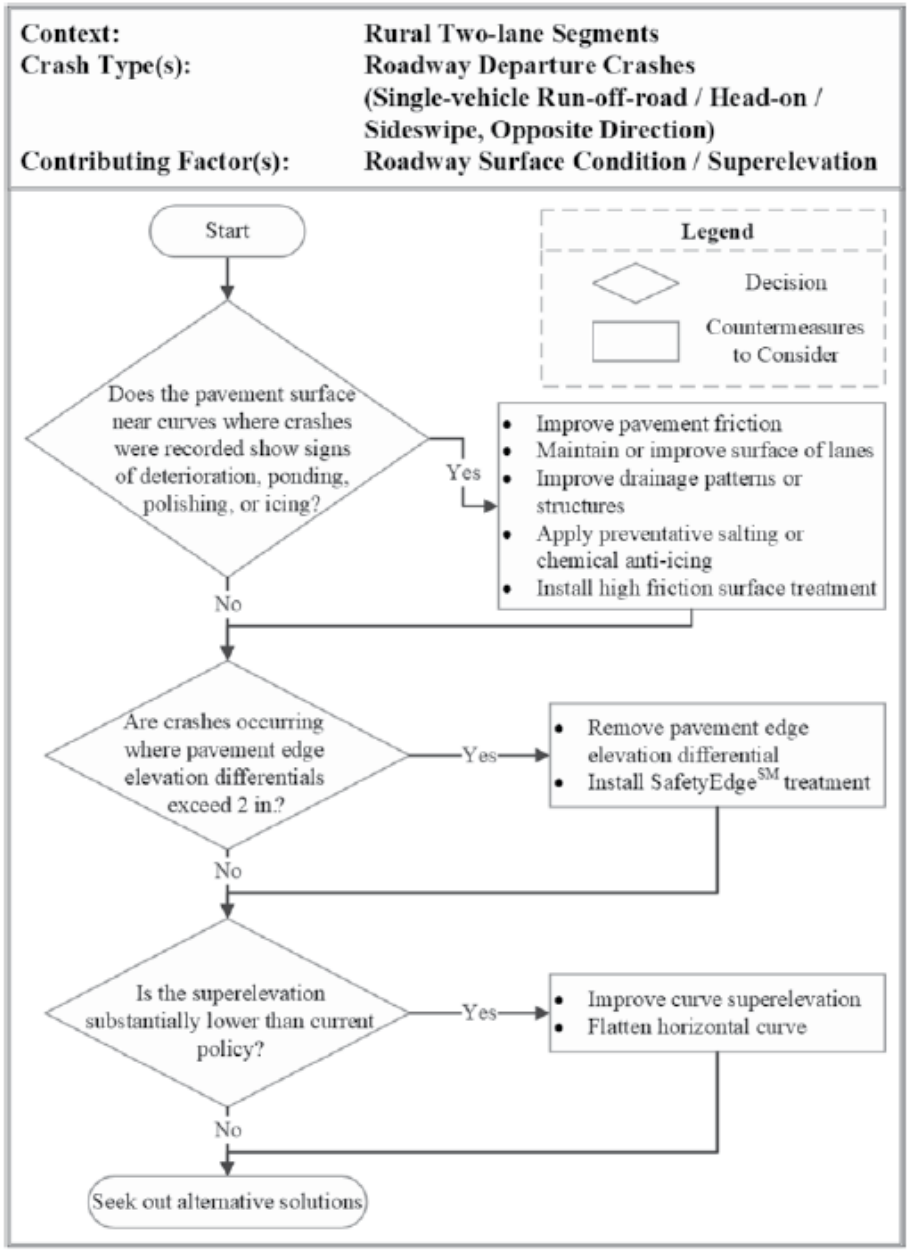


Figure 25. Rural two-lane segments; roadway departure crashes (single-vehicle run-off-road/head-on/sideswipe, opposite direction); roadway surface condition/superelevation.

List of Potential Countermeasures:

- Improve pavement friction
- Maintain or improve surface of lanes
- Improve drainage patterns or structures
- Apply preventative salting or chemical anti-icing
- Install high friction surface treatment
- Remove pavement edge elevation differential
- Install SafetyEdge^{SM} treatment
- Improve curve superelevation
- Flatten horizontal curve

Urban Segments – Crash Types and Contributing Factors

Crash Type	Type of Segment and Contributing Factor	Figure No.	Page No.
Urban Two-Lane Segments			
Roadway departure crashes (single-vehicle run-off-road)	Roadside design	56	151
	Speed / curvature / guidance	57	153
	Roadway surface condition / drainage	58	154
Roadway departure crashes (head-on / sideswipe, opposite direction)	Roadway surface condition / drainage	58	154
	Overtaking	59	156
	Driver inattention / impairment	60	157
Rear-end crashes	Roadway surface condition / drainage	58	154
	Driveways / accesses	61	158
Angle crashes	Driveways / accesses	61	158
Pedestrian crashes	Dart-dash / midblock / along the road	62	160
Bicycle crashes	Bicyclist rode out midblock / motorist turned into path of bicyclist / bicyclist turned into path / overtaking	63	162

Crash Type	Type of Segment and Contributing Factor
Urban Multilane Undivided Segments	
Roadway departure crashes (single-vehicle run-off-road)	Roadside design
	Speed / curvature / guidance
	Roadway surface condition / drainage
Roadway departure crashes (head-on / sideswipe, opposite direction)	Roadway surface condition / drainage
	Driver inattention / impairment
	Speed / curvature / guidance
Sideswipe, same direction crashes	Speed / curvature / guidance
	Driveways / accesses
Rear-end crashes	Driveways / accesses
Angle crashes	Driveways / accesses
Pedestrian crashes	Dart-dash / midblock / along the road
Bicycle crashes	Bicyclist rode out midblock / motorist turned into path of bicyclist / bicyclist turned into path / overtaking
Urban Multilane Divided Segments	
Roadway departure crashes (single-vehicle run-off-road)	Roadway surface condition / drainage
	Speed / curvature / guidance
Sideswipe, same direction crashes	Roadway surface condition / drainage
	Speed / curvature / guidance
	Driveways / accesses
Rear-end crashes	Roadway surface condition / drainage
	Driveways / accesses
Angle crashes	Driveways / accesses
Pedestrian crashes	Dart-dash / midblock / along the road
Bicycle crashes	Bicyclist rode out midblock / motorist turned into path of bicyclist / bicyclist turned into path / overtaking

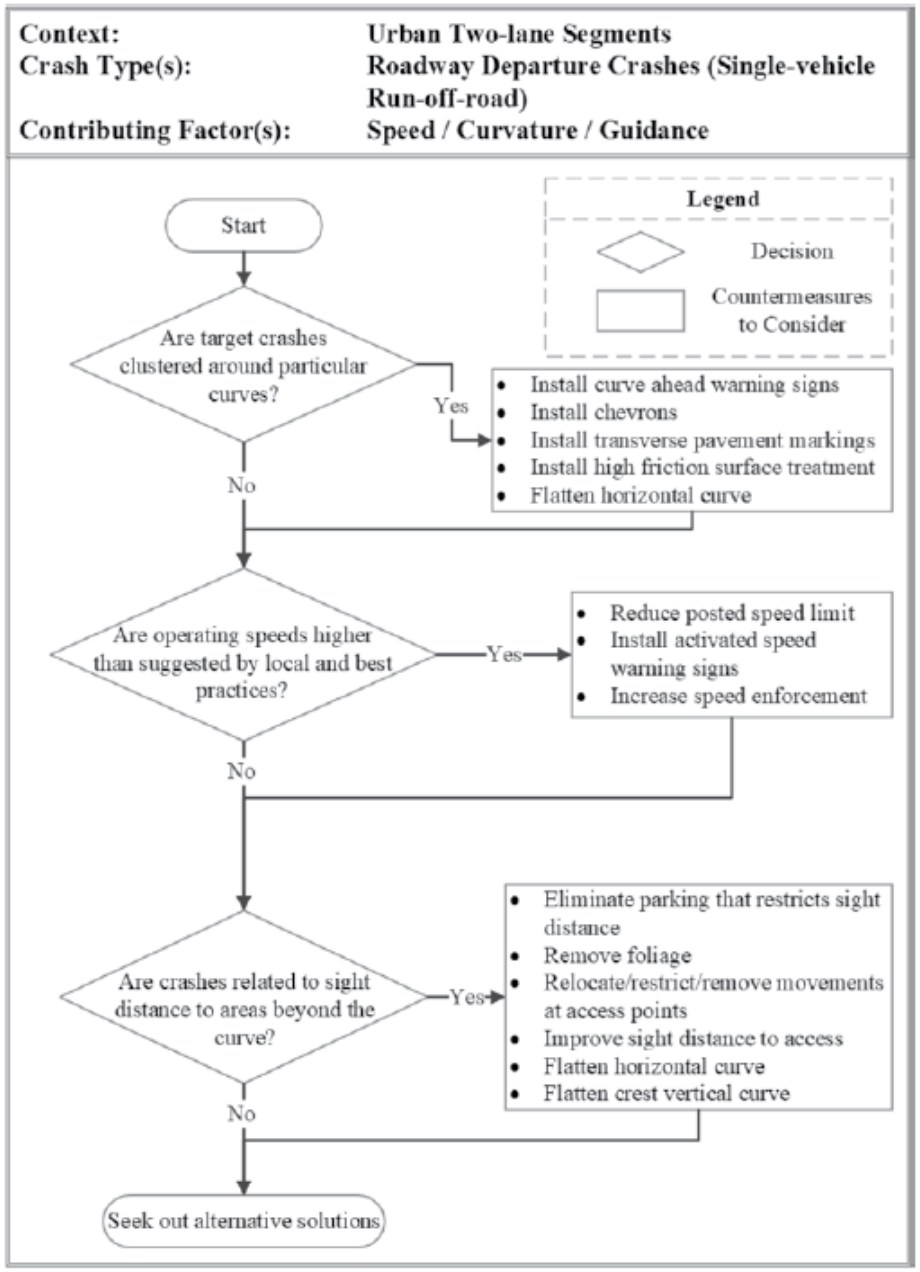


Figure 57. Urban two-lane segments; roadway departure crashes (single-vehicle run-off-road); speed/curvature/guidance.

List of Potential Countermeasures:

- Install curve ahead warning signs
- Install chevrons
- Install transverse pavement markings
- Install high friction surface treatment
- Flatten horizontal curve
- Reduce posted speed limit
- Install activated speed warning signs
- Increase speed enforcement
- Eliminate parking that restricts sight distance
- Remove foliage
- Relocate/restrict/remove movements at access points
- Improve sight distance to access points
- Flatten crest vertical curve

Rural & Urban Intersections – Crash Types and Contributing Factors

Crash Type	Type of Segment and Contributing Factor	Figure No.	Page No.
Rural and Urban Signalized Intersections			
Angle crashes	Signal visibility	78	187
	Signal timing / capacity	79	189
	Speed	80	190
	Pavement friction	81	191
	Sight distance	82	193
	Driver running red light	83	194
	Driver gap acceptance	84	195
	Driver inattention and/or lack of road messages	85	196
	Driveways / accesses	86	198
Rear-end crashes	Signal visibility	78	187
	Signal timing / capacity	87	200
	Speed	88	202
	Pavement friction	81	191
	Sight distance (for turns)	89	203
	Driver gap acceptance	84	195
	Guidance / road messages	90	204
	Driveways / accesses	86	198
	Unexpected stops on approach	91	205
Pedestrian crashes	Dash-dart / multiple threat / turning vehicle / through vehicle	92	206
Bicycle crashes	Motorist failed to yield / bicyclist failed to yield / turning vehicle	93	209

Crash Type	Type of Segment and Contributing Factor	Figure No.	Page No.
Rural and Urban Unsignalized Intersections			
Angle crashes / rear-end crashes	Stop sign visibility	94	211
	Sight distance	95	213
	Speed	96	215
	Pavement friction	97	216
	Driver gap acceptance	98	218
	Driver inattention and/or lack of road messages	99	220
	Driveways / accesses	100	222
Pedestrian crashes	Dash-dart / multiple threat / turning vehicle / through vehicle	101	224
Bicycle crashes	Motorist failed to yield / bicyclist failed to yield / turning vehicle	102	226

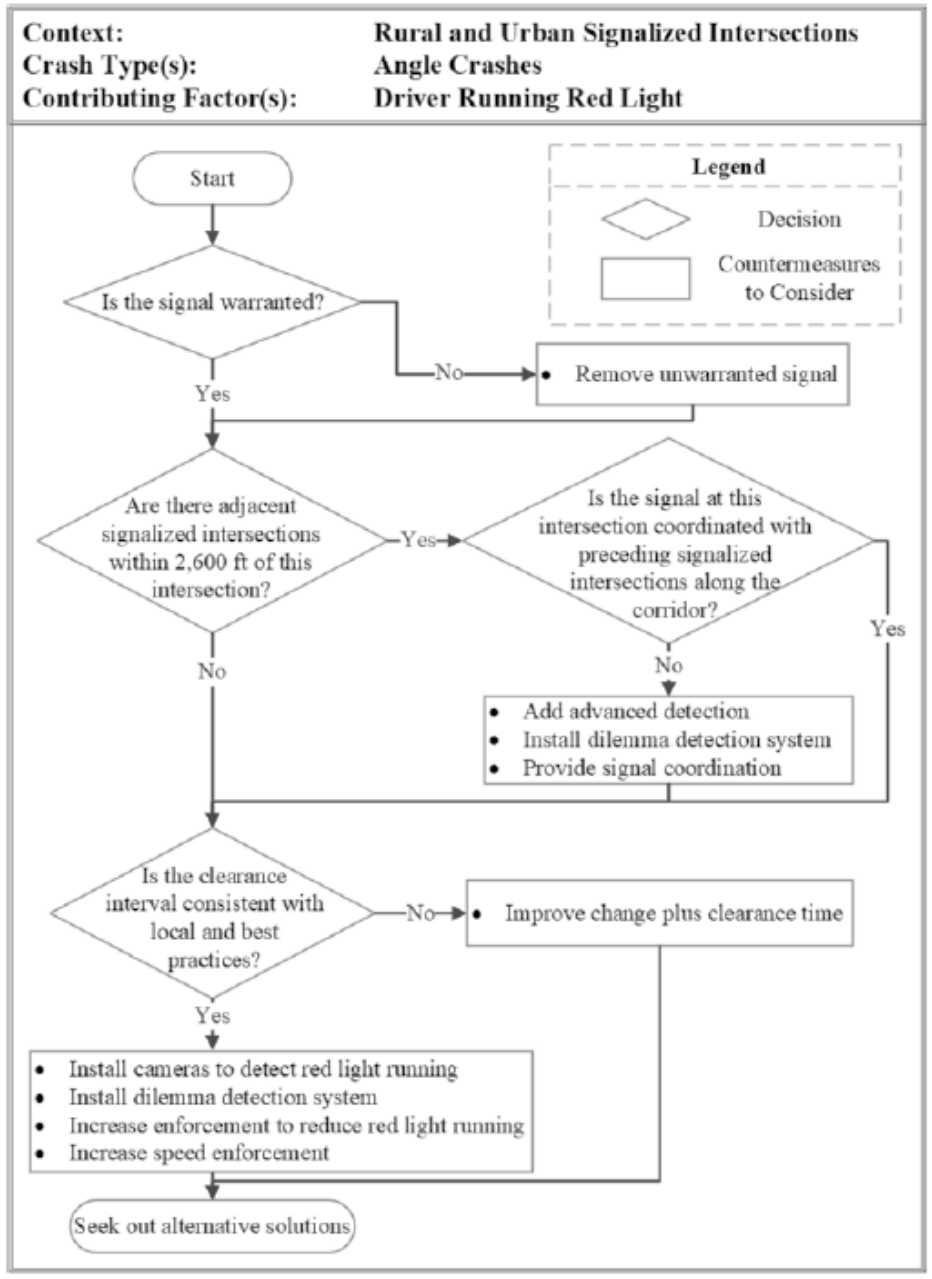


Figure 83. Rural and urban signalized intersections; angle crashes; driver running red light.

List of Potential Countermeasures:

- Remove unwarranted signal
- Add advanced detection
- Install dilemma detection system
- Provide signal coordination
- Improve change plus clearance time
- Install cameras to detect red light running
- Increase enforcement to red light running
- Increase speed enforcement

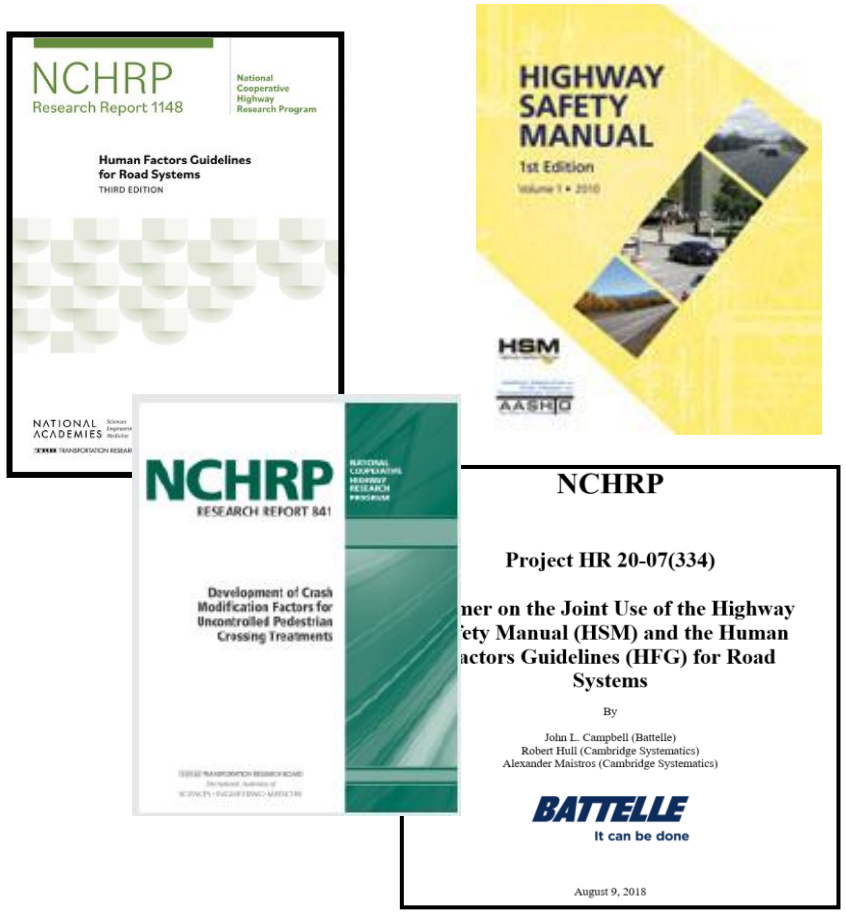
Countermeasure Selection

- List of potential countermeasures is not necessarily exhaustive
- Order of countermeasures presented in decision trees does not signify prioritization for selection or implementation
- Several decision trees have speed related questions
  - Agencies should consider various speed management techniques
  - If agencies cannot reduce speeds, separate road users in space
- Before selecting and implementing countermeasures, consider tradeoffs

Tools to Aid Countermeasure Selection

- CMF Clearinghouse
  - Crash Modification Factors Clearinghouse (cmfclearinghouse.org)
- Design Approaches and Safety Handbooks
  - The HSM
  - Numerous specialized reports [e.g., Zegeer et al. (2017)]
- Human Factors Resources
  - The HFG
  - The HSM/HFG *Primer*

The **Crash Modification Factors Clearinghouse** provides a searchable database of CMFs along with guidance and resources on using CMFs in road safety practice.



Key Takeaways

Key Takeaways

- Errors that lead to crashes are more likely to occur when the demands of the roadway exceed capabilities of the road user
- Countermeasures should be aimed at reducing the demands placed on the road user
- Selecting countermeasures, matched to underlying contributing factors to target crash types, are expected to reduce crashes to the greatest extent possible
- A user-centric approach do crash diagnostics using human factors and the Modified Haddon Matrix provide science-based methods for effective treatments and pre-design of new projects.

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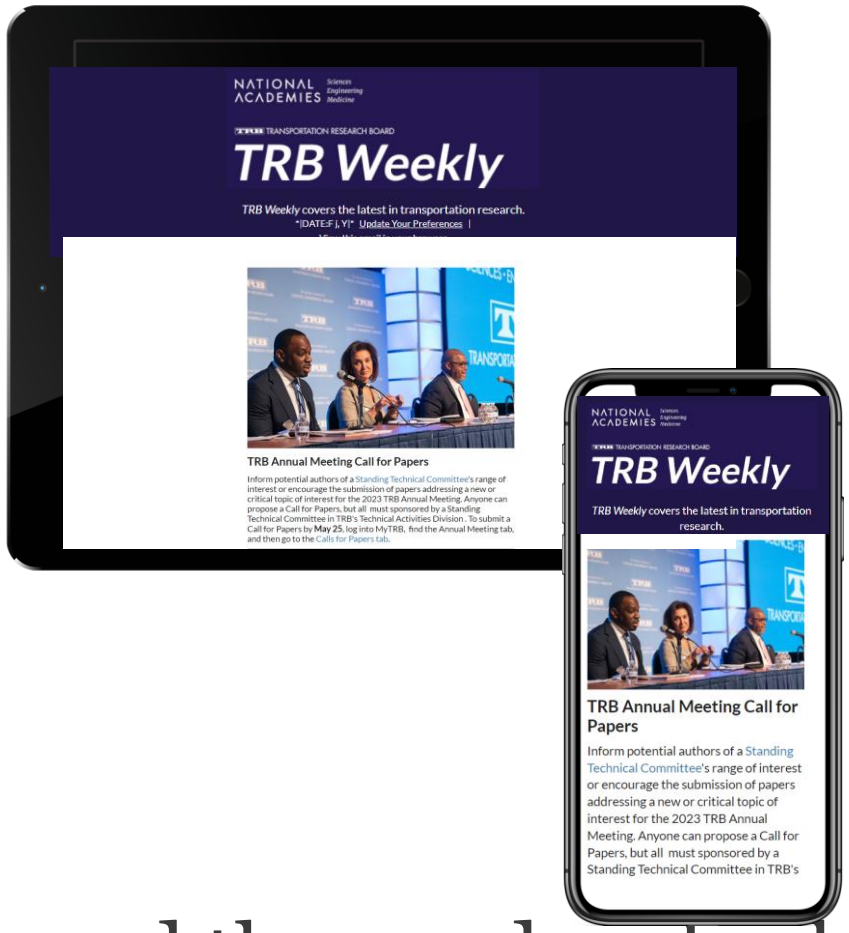

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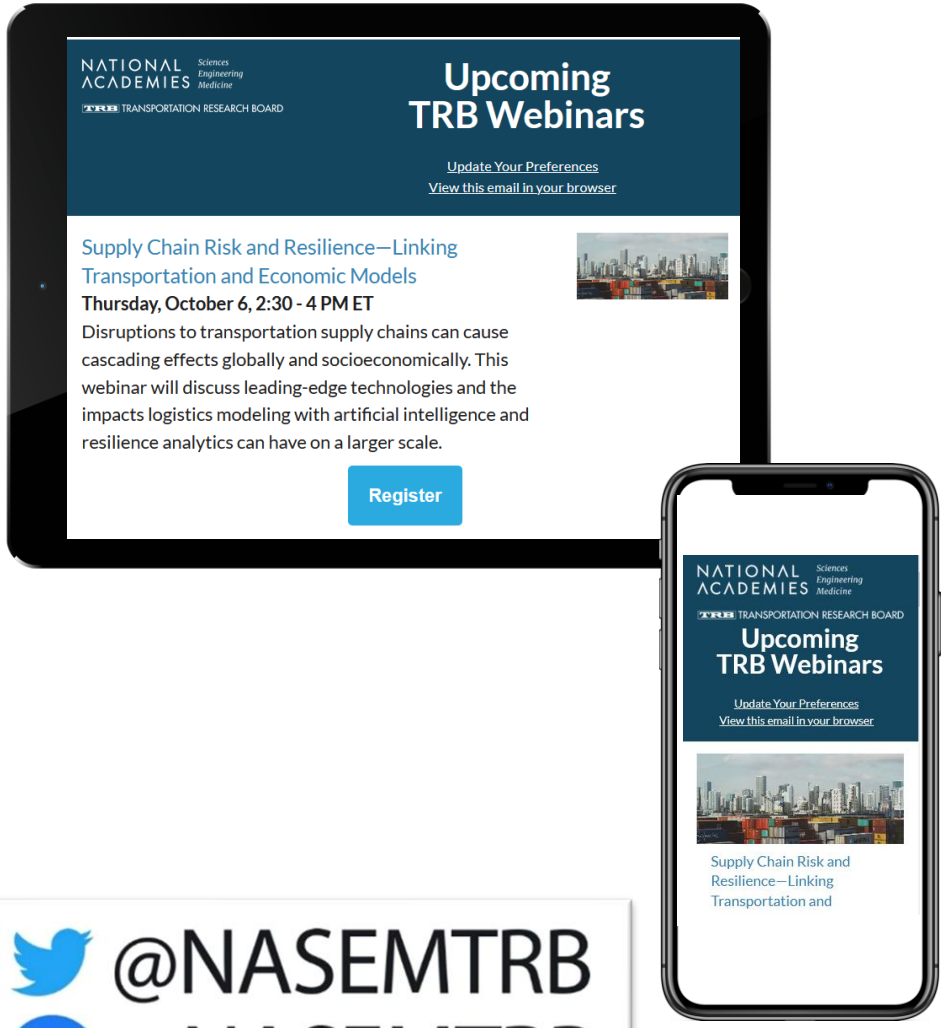

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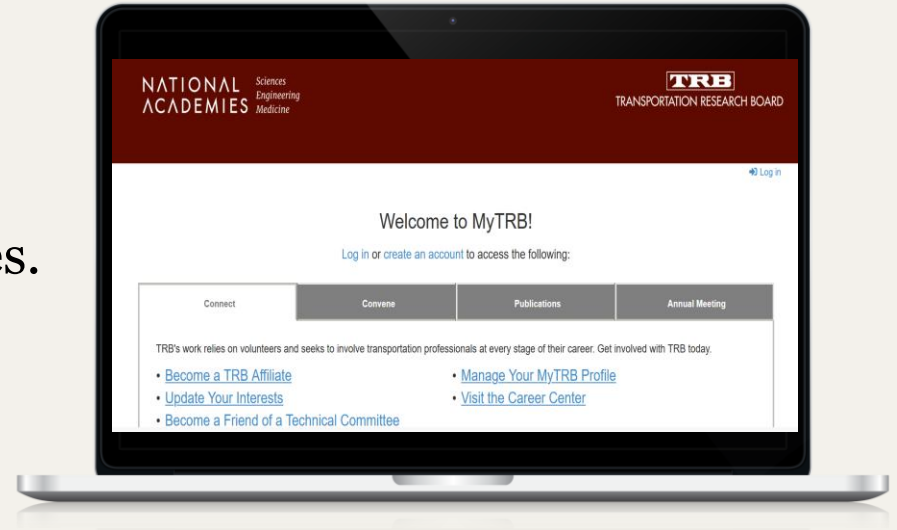

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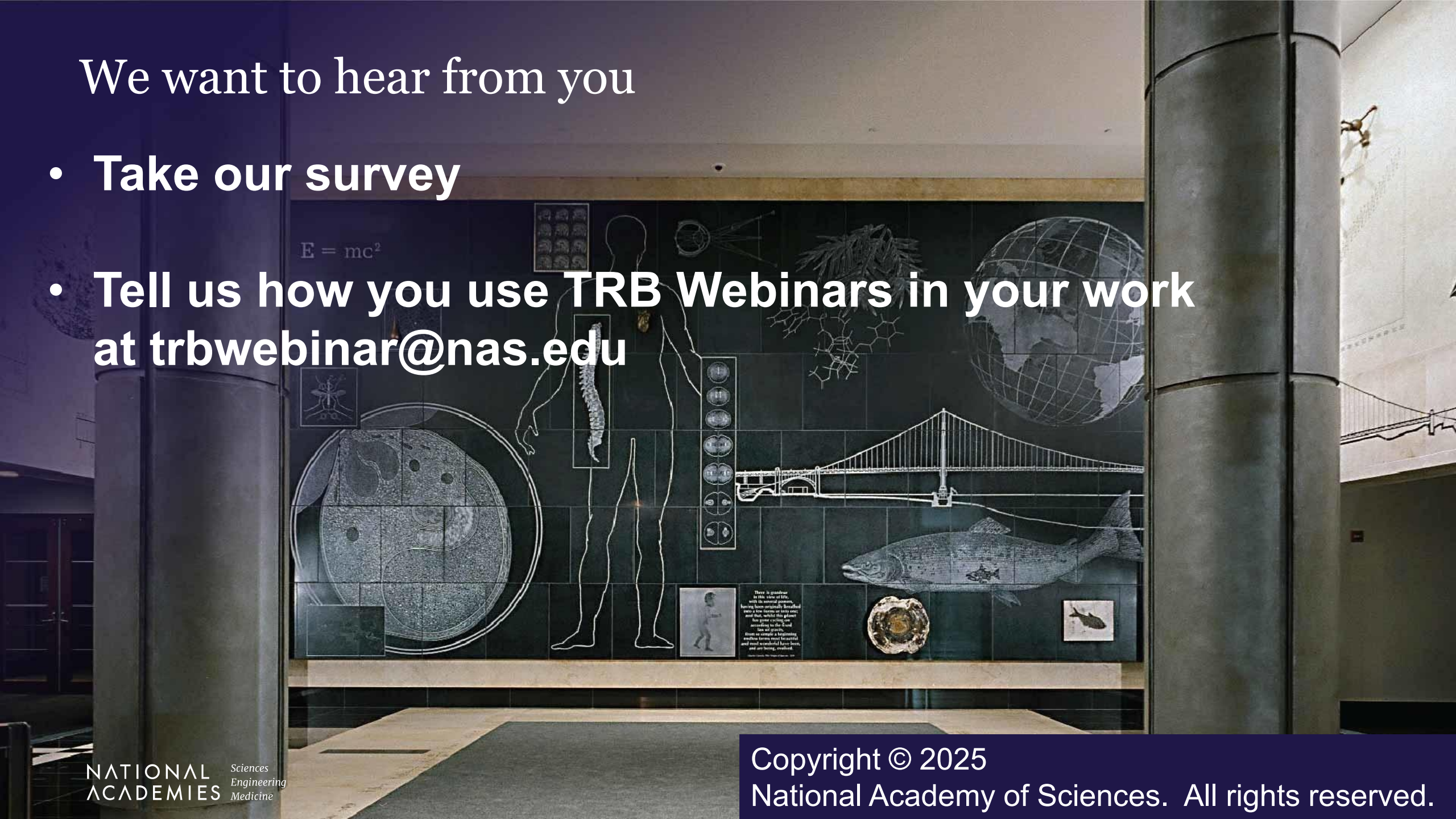

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