APPLYING HUMAN FACTORS PRINCIPLES TO TRANSPORTATION PROJECTS

VASITE ANNUAL MEETING JUNE 2026

Bryan J. Katz, Ph.D., PE, PTOE, RSP2I
Erin D. Kissner

toXcel
Scientific Excellence to Serve Others

PRESENTERS

Bryan J. Katz (Civil Engineering)
President

Bryan.Katz@toxcel.com

Erin Kissner (Psychology)
Team Leader, Roadway Infrastructure Human Factors

Erin.Kissner@toxcel.com

BACKGROUND

- **What is Human Factors?**

Human Factors is concerned with the application of what we know about people, their abilities, characteristics, and limitations to the design of equipment they use, environments in which they function, and jobs they perform. (Human Factors and Ergonomics Society)

- **Why is human factors important to us?**

We need to design highway systems that meet the needs of road users.

BACKGROUND

- The interdisciplinary study of human factors applies knowledge from the human sciences (such as psychology) to the design of systems, tasks, and environments for effective and safe use
- Drivers make frequent mistakes because of human physical, perceptual, and cognitive limitations

Source: Highway Safety Manual

POLL QUESTION

- Drivers are found to be the critical reason for a crash for what percent of crashes?

Source: NHTSA

BACKGROUND

- Drivers are found to be the critical reason for a crash for what percent of crashes? **94%**

Critical Reason Attributed to:	Estimated Percentage:
Drivers	94%
Vehicles	2%
Environment (Weather, Roadway, Visual Obstructions)	2%
Unknown Critical Reasons	2%
Total	100%

- Crashes are many times caused by a **combination** of factors; these percentages just show the **primary** factor

Source: NHTSA

BACKGROUND

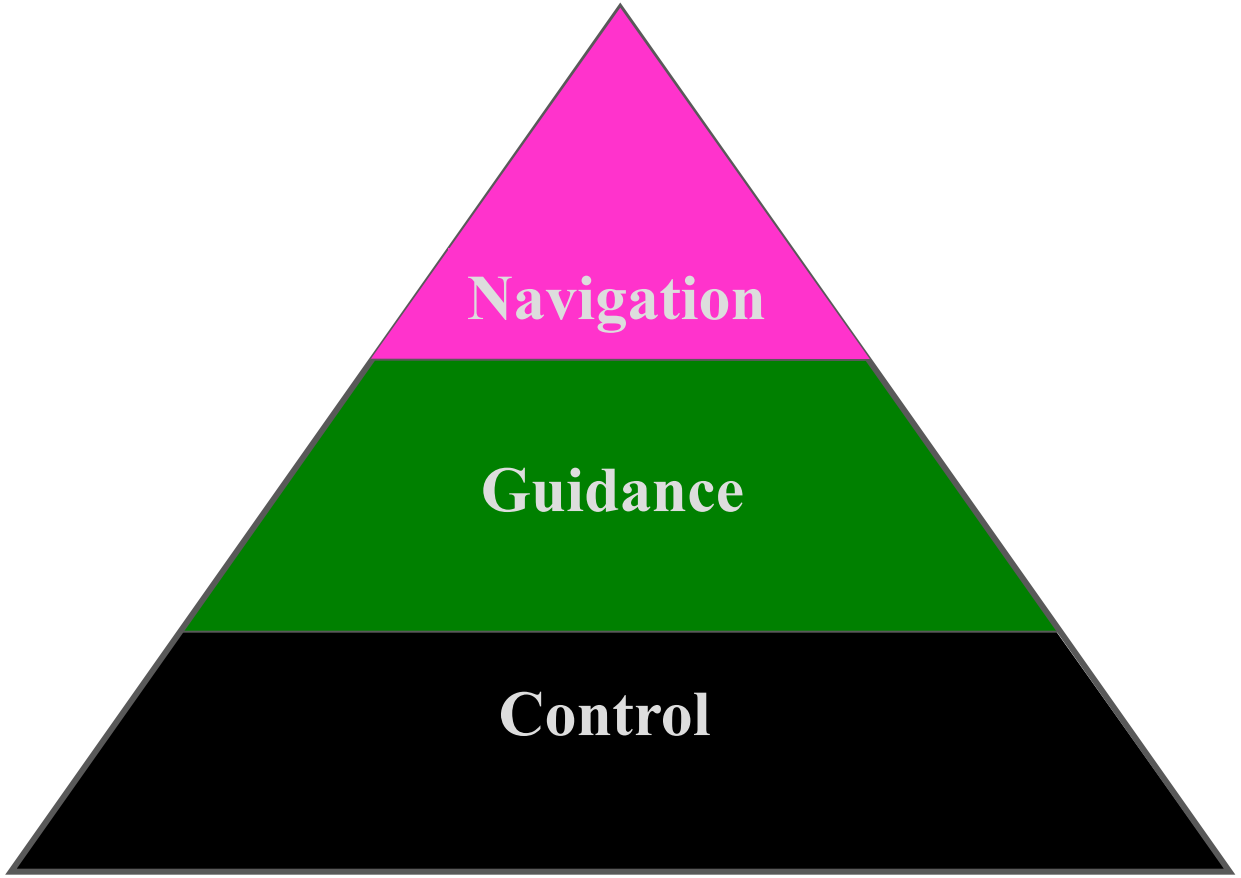
- Driver-Related Critical Reasons:

Critical Reason:	Estimated Percentage:
Recognition Error (Driver inattention, distractions, inadequate Surveillance)	41%
Decision Error (Driving too fast for conditions, too hast for the curve, false assumption of others' actions, illegal maneuver, and misjudgment of gap of others' speed)	33%
Performance Error (Overcompensation, poor directional control)	11%
Non-Performance Error (Sleepy, drowsy driving)	7%
Other	8%
Total	100%

Source: NHTSA

BACKGROUND

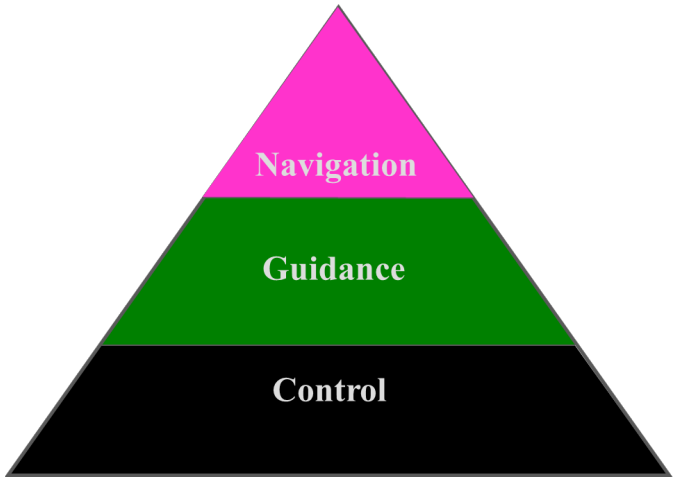
- Driving comprises many subtasks, some of which must be performed simultaneously
- Three primary subtasks:
  - Control
  - Guidance
  - Navigation



Source: Highway Safety Manual

BACKGROUND

- Control – Keeping the vehicle at a desired speed and heading within a lane
- Guidance – Interacting with other vehicles (following, passing, merging, etc.) by maintaining a safe following distance and by following markings, traffic signs, and traffic signals
- Navigation – Following a path from origin to destination by reading guide signs and using landmarks



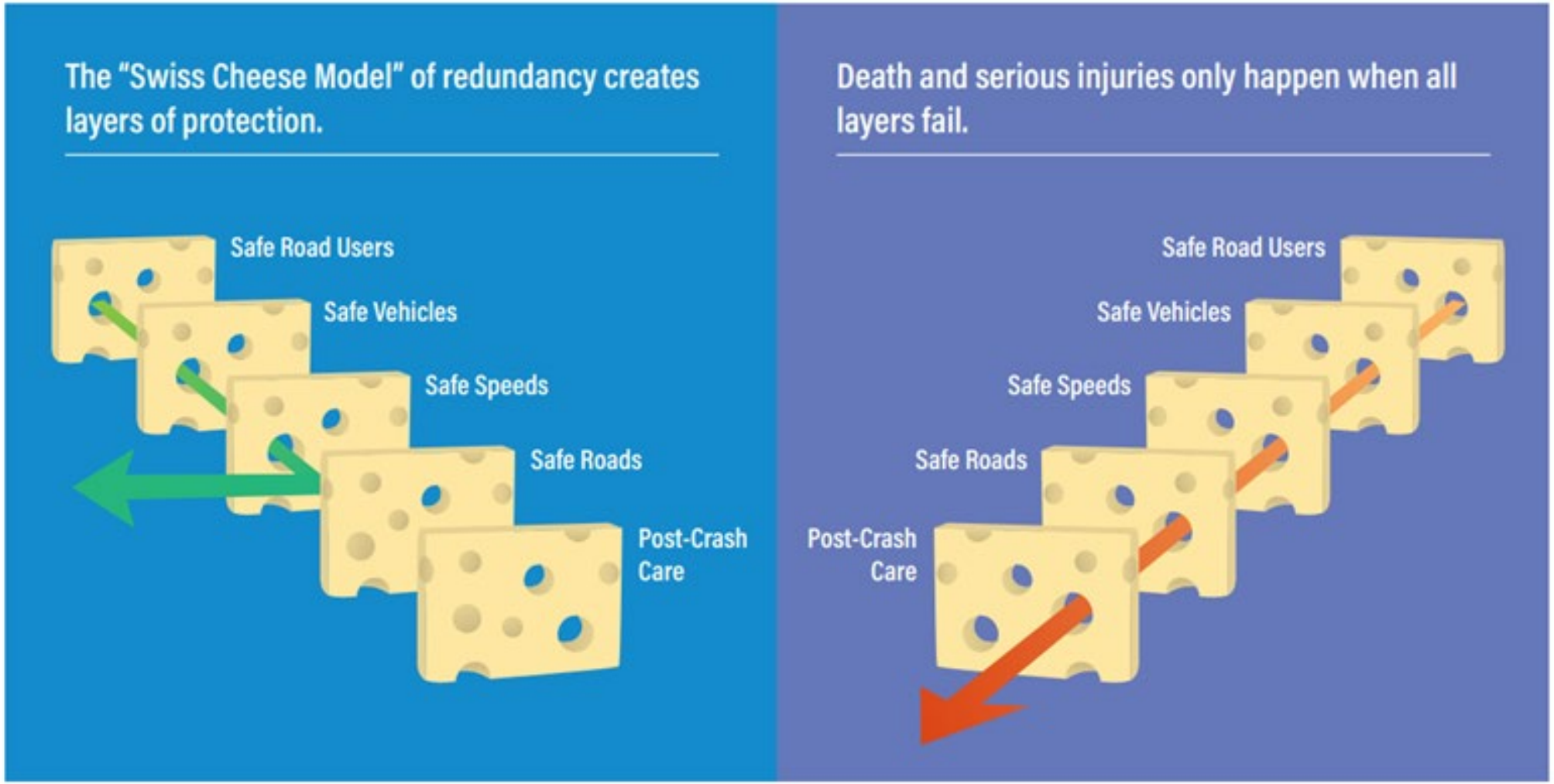
Source: Highway Safety Manual

QUESTION

HOW DO WE AS TRANSPORTATION ENGINEERS AID DRIVERS IN THESE TASKS?

- Control – Keeping the vehicle at a desired speed and heading within a lane
- Guidance – Interacting with other vehicles (following, passing, merging, etc.) by maintaining a safe following distance and by following markings, traffic signs, and traffic signals
- Navigation – Following a path from origin to destination by reading guide signs and using landmarks

SWISS CHEESE MODEL

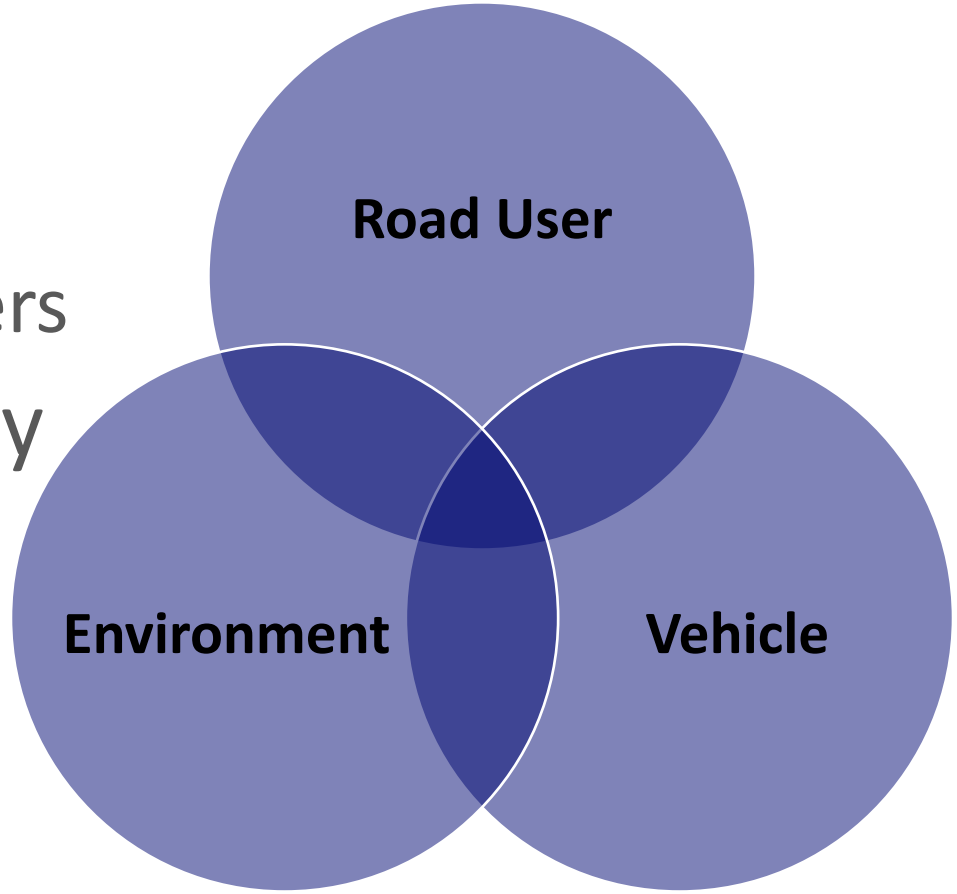


Source: FHWA NHI HFG Course

THREE FACTORS OF DRIVING

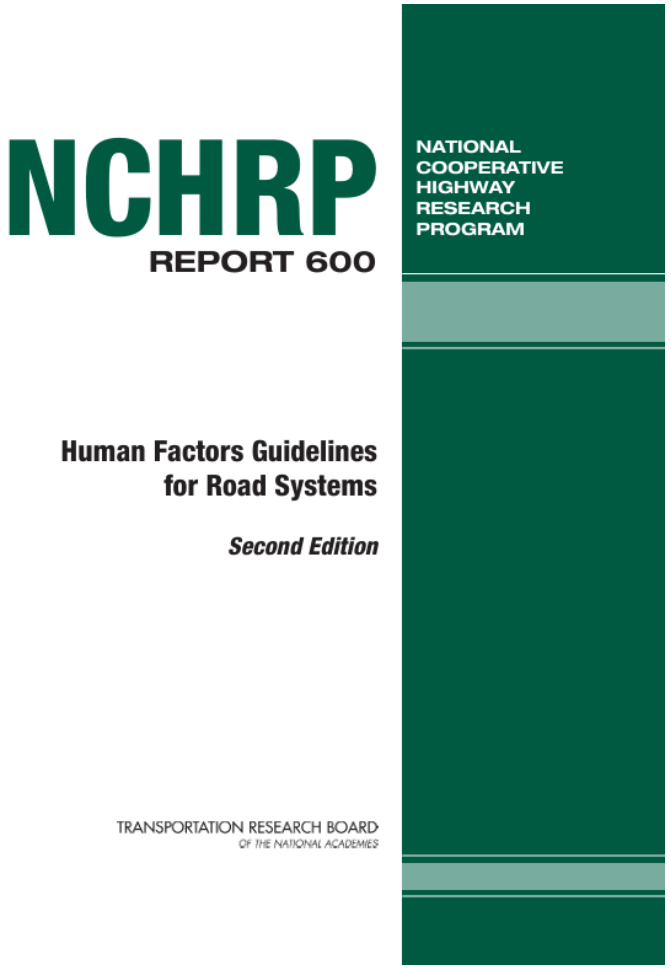
How do we have the right expertise for the job?

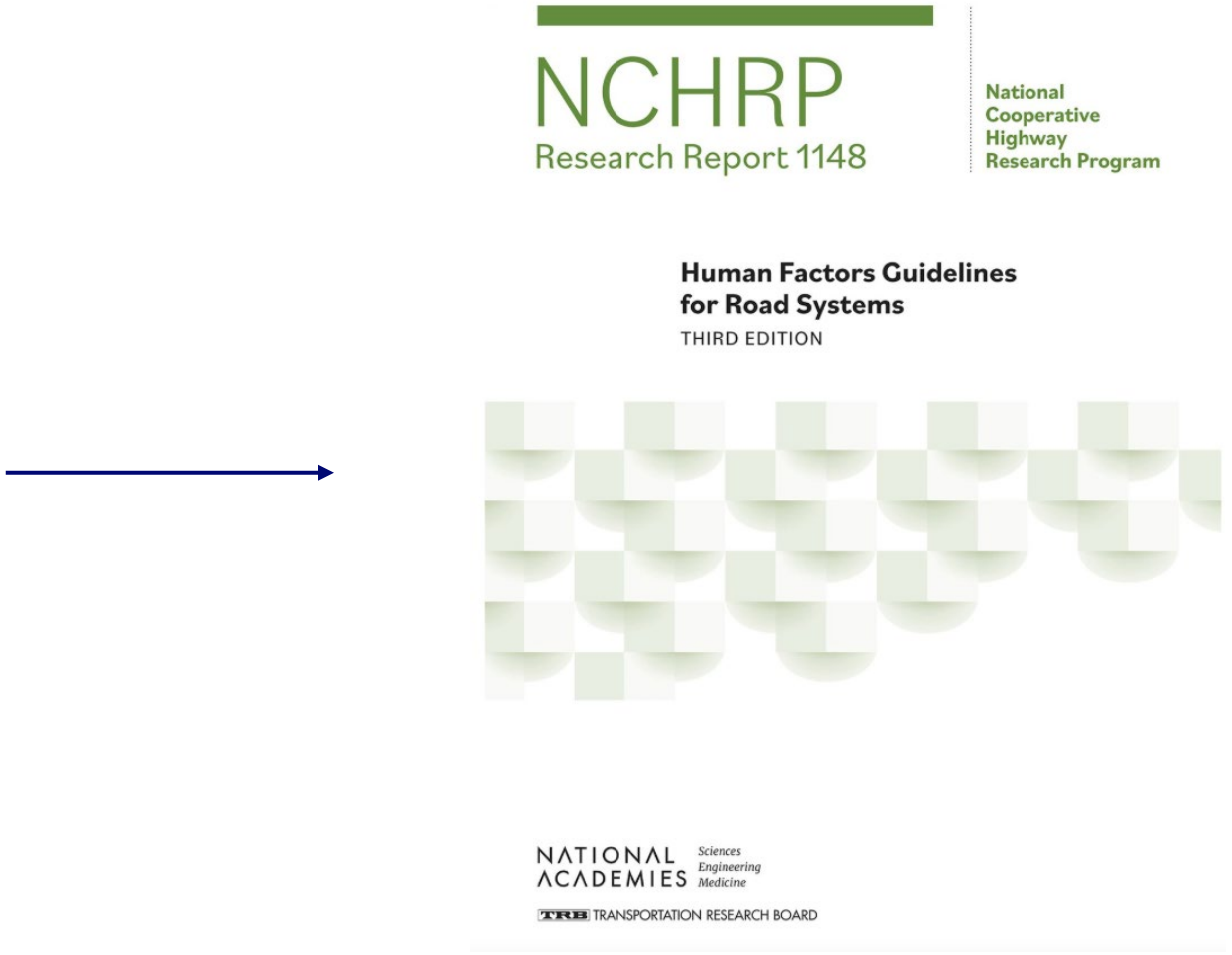
- Vehicle Safety
  - Mechanical and Automotive Engineers
- Environment (Infrastructure) Safety
  - Civil/Transportation Engineers
- Road User Safety
  - Human Factors/Behavioral Safety Specialists



Source: FHWA NHI HFG Course

HUMAN FACTORS GUIDELINES





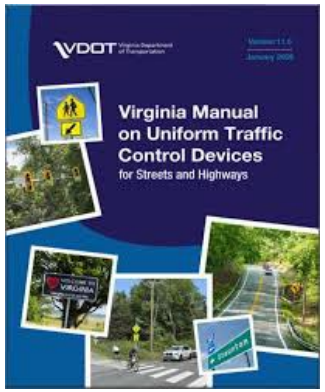
POLL QUESTIONS

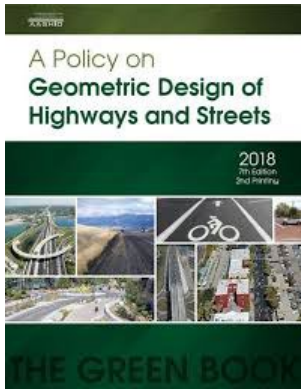
Before we get started…

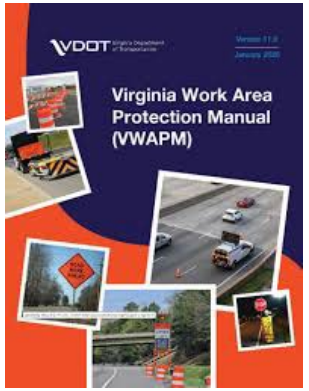
- Have you heard of the NCHRP Human Factors Guidelines document before?
- Have you used the NCHRP Human Factors Guidelines document in your work?
- Is the NCHRP Human Factors Guidelines document something that you use regularly?

GOALS FOR THE HFG

- Focus on road user needs, capabilities, and limitations
- Aid and augment judgment and experience of highway designers and traffic engineers
- Reflect end-user requirements for content, format, and organization (clear, relevant, and easy-to-use)
- Complement existing sources of road design information



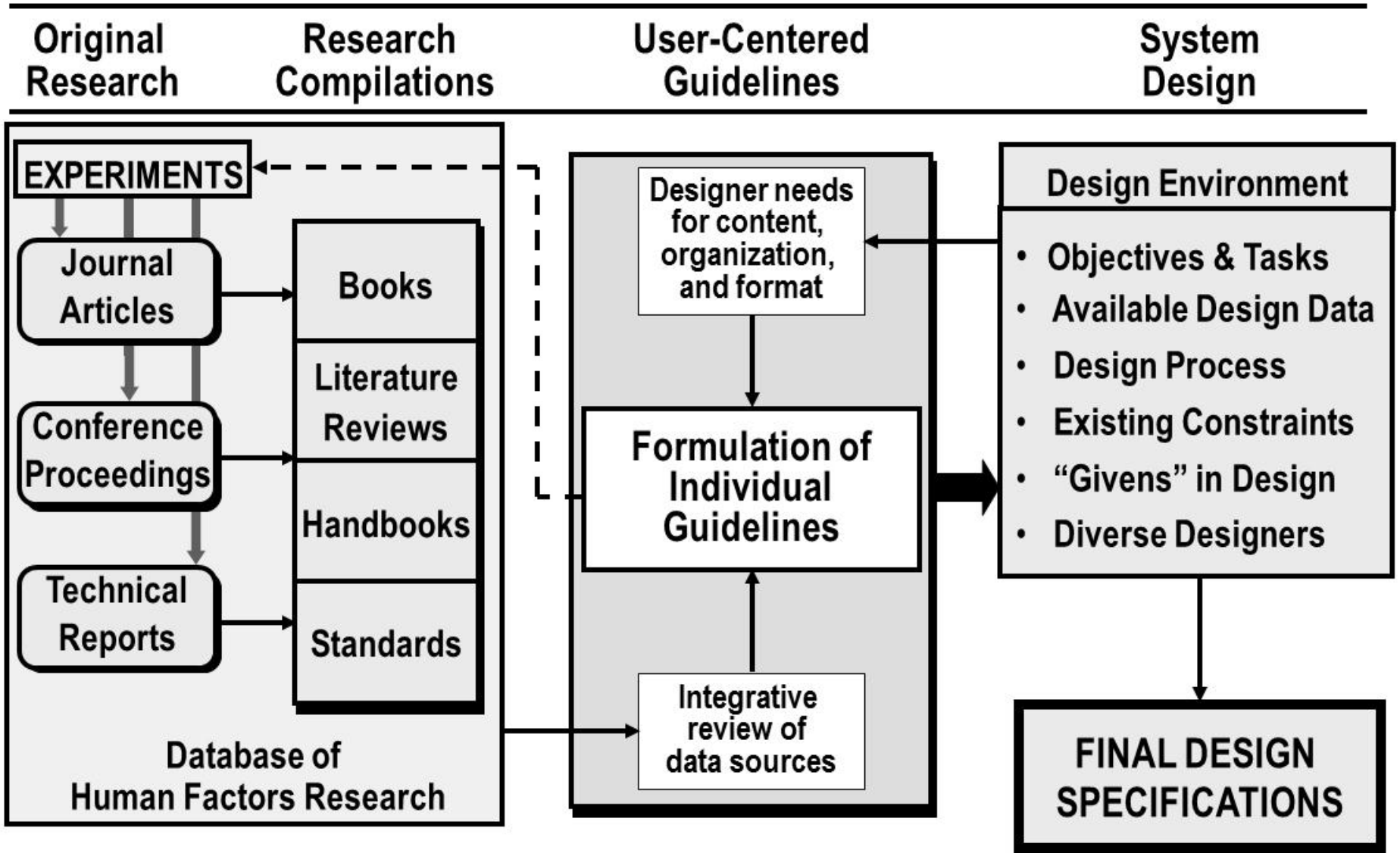




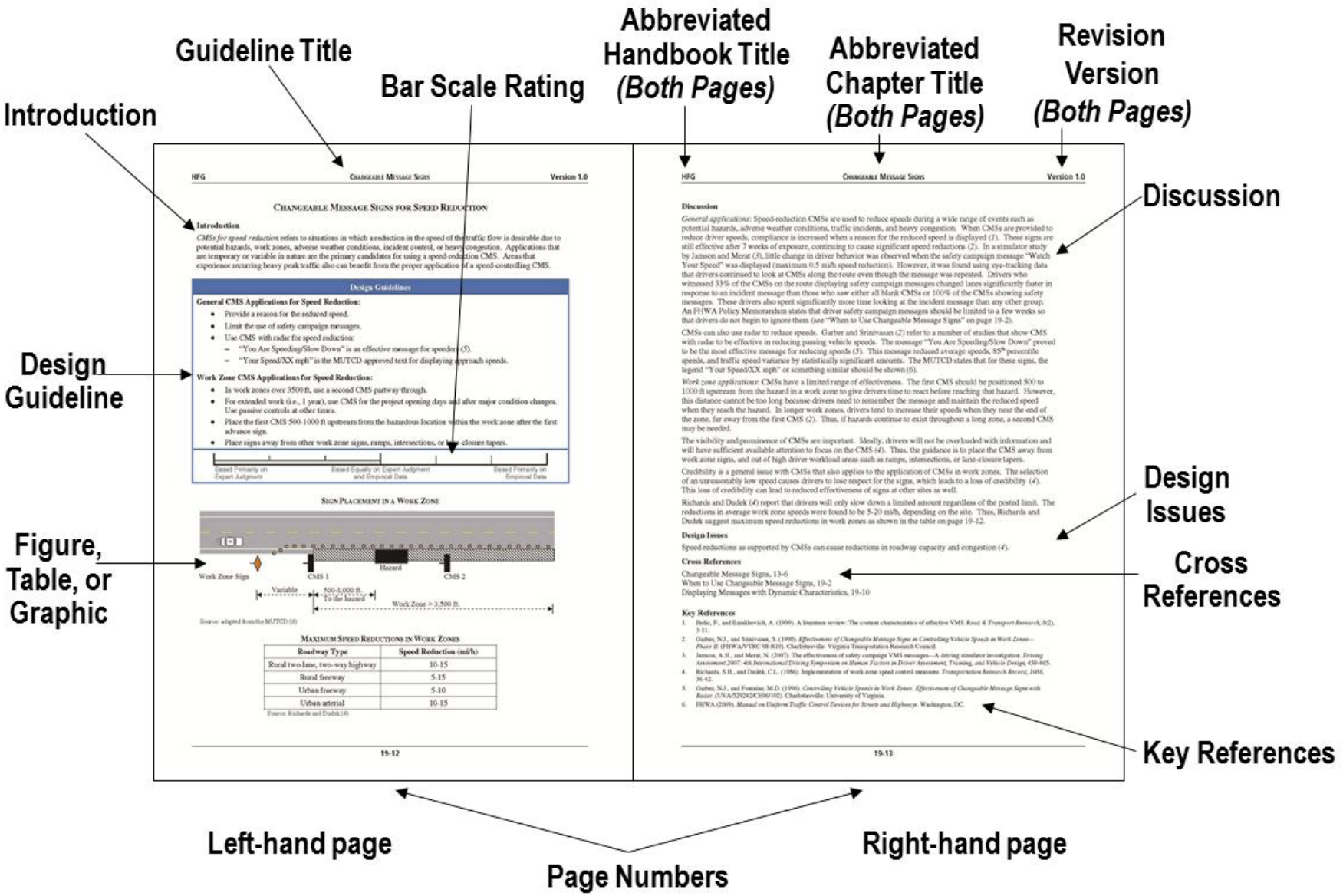
WAYS THE HFG CAN BE USED

- Enhance initial roadway planning and design activities
- Conduct diagnostic assessments of safety concerns & incidents
- Support road safety audits
- Identify and select safety countermeasures
- Educate traffic engineers and designers on user needs, capabilities, and limitations

HOW GUIDELINES ARE DEVELOPED



FORMAT OF THE HFG



WAYS THE HFG CAN BE USED

- Enhance initial roadway planning and design activities
- Conduct diagnostic assessments of safety concerns & incidents
- Support road safety audits
- Identify and select safety countermeasures
- Educate traffic engineers and designers on user needs, capabilities, and limitations

CONTENTS OF THE HFG

- Part I: Introduction
  - Chapter 1 – Why Have Human Factors Guidelines (HFG) for Road Systems?
  - Chapter 2 – How to Use This Document

- Part II: Bringing Road User Capabilities into Roadway Design and Traffic Engineering Practice
  - Chapter 3 – Finding Information Like a Road User
  - Chapter 4 – Integrating Road User, Highway Design, and Traffic Engineering Needs

CONTENTS OF THE HFG

- Part III: Human Factors Guidance for Roadway Geometric Elements
  - Chapter 5 – Sight Distance Guidelines (9 topics)
  - Chapter 6 – Curves (Horizontal Alignment) (6 topics)
  - Chapter 7 – Grades (Vertical Alignment) (3 topics)
  - Chapter 8 – Tangent Sections and Roadside (Cross Section) (2 topics)
  - Chapter 9 – Transition Zones Between Varying Road Designs (1 topic)
  - Chapter 10 – Non-signalized Intersections (5 topics) Part III (Cont.)
  - Chapter 11 – Signalized Intersections (5 topics)
  - Chapter 12 – Roundabouts (6 topics)
  - Chapter 13 – Interchanges (6 topics)

CONTENTS OF THE HFG

- Part IV: Special Design Considerations
  - Chapter 14 – Speed Perception, Speed Choice, and Speed Control (8 topics)
  - Chapter 15 – Urban Environments (6 topics)
  - Chapter 16 – Complete Streets (3 topics)
  - Chapter 17 – Rural Environments (4 topics)
  - Chapter 18 – Construction and Work Zones (5 topics)
  - Chapter 19 – Rail-Highway Grade Crossings (6 topics)
  - Chapter 20 – Lighting (6 topics)

CONTENTS OF THE HFG

- Part V: Human Factors Guidance for Traffic Engineering Elements
  - Chapter 21 – Signing (5 topics)
  - Chapter 22 – Changeable Message Signs (7 topics)
  - Chapter 23 – Markings (5 topics)
- Part VI: Human Factors Guidance for Vulnerable Road Users
  - Chapter 24 – Pedestrians (9 topics)
  - Chapter 25 – Bicyclists (8 topics)
  - Chapter 26 – Other Road Users (9 topics)

CONTENTS OF THE HFG

- Part VII: Additional Information
  - Chapter 27 – Tutorials
  - Chapter 28 – References
  - Chapter 29 – Glossary
  - Chapter 30 – Index
  - Chapter 31 – Abbreviations
  - Chapter 32 – Equations

DRIVER COMPREHENSION OF SIGNS

There are three stages associated with the comprehension and use of signs:

LEGIBILITY

I see it

RECOGNITION

I know what I'm looking at

INTERPRETATION

I know what it means / what to do

A sign may be visible/legible without being recognized, and recognized without being fully understood

DRIVER COMPREHENSION OF SIGNS

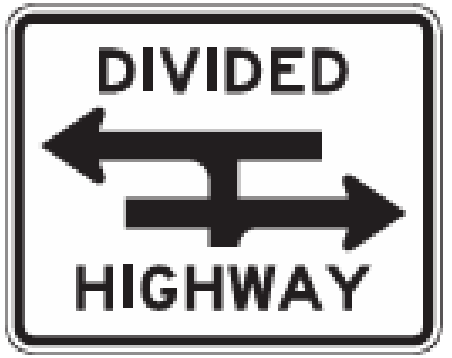
TEXT

- ✓ Complex information
- ✓ Destinations / hazards
- ✓ Unexpected actions

SYMBOL

- ✓ Higher speeds
- ✓ Warning messages
- ✓ Prohibitions

COMBINATION

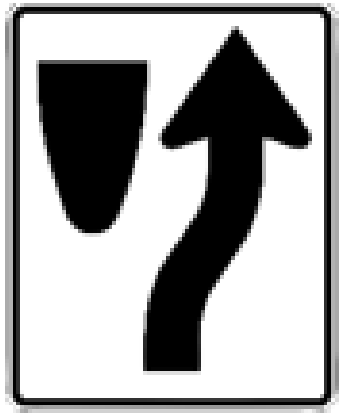


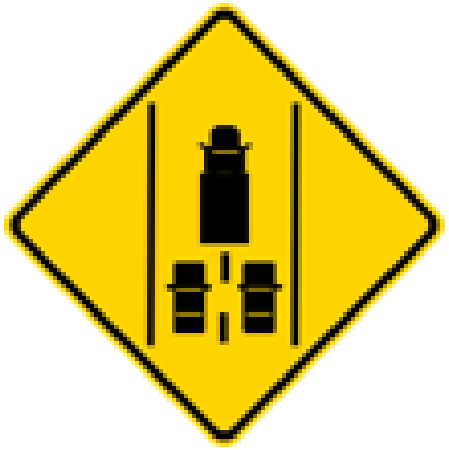
- ✓ Symbols unintuitive
- ✓ Short text (2-3 words)

Match the sign format to the information being communicated to maximize rapid comprehension

WHAT DO THESE SIGNS MEAN?

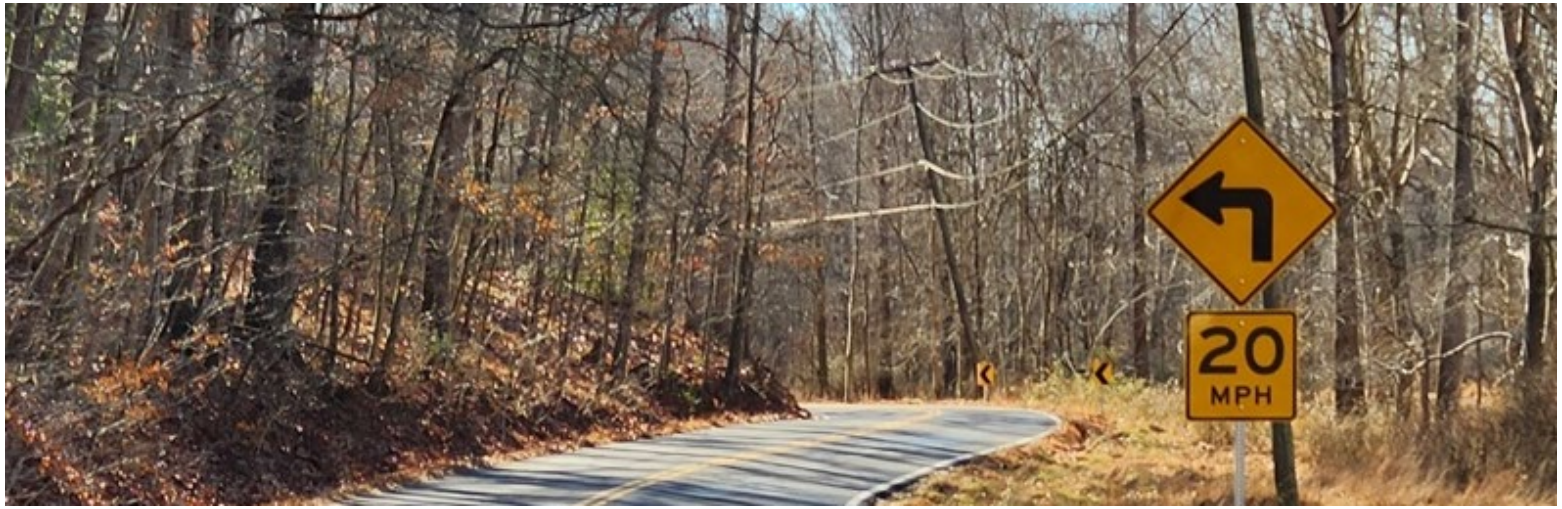
Which of these signs do you think drivers misinterpret?





COUNTERMEASURES FOR REDUCING VEHICLE SPEEDS ENTERING HORIZONTAL CURVES

Inappropriate speed selection before entering a curve is a primary contributor to many curve-related crashes.



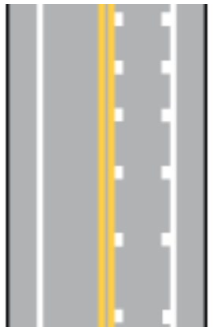
Drivers should have sufficient time to recognize the warning, interpret the message, and reduce speed before entering the curve.

EFFECTIVE COUNTERMEASURES

Horizontal Alignment Signs

Dynamic Curve Warning Systems

Transverse Stripes

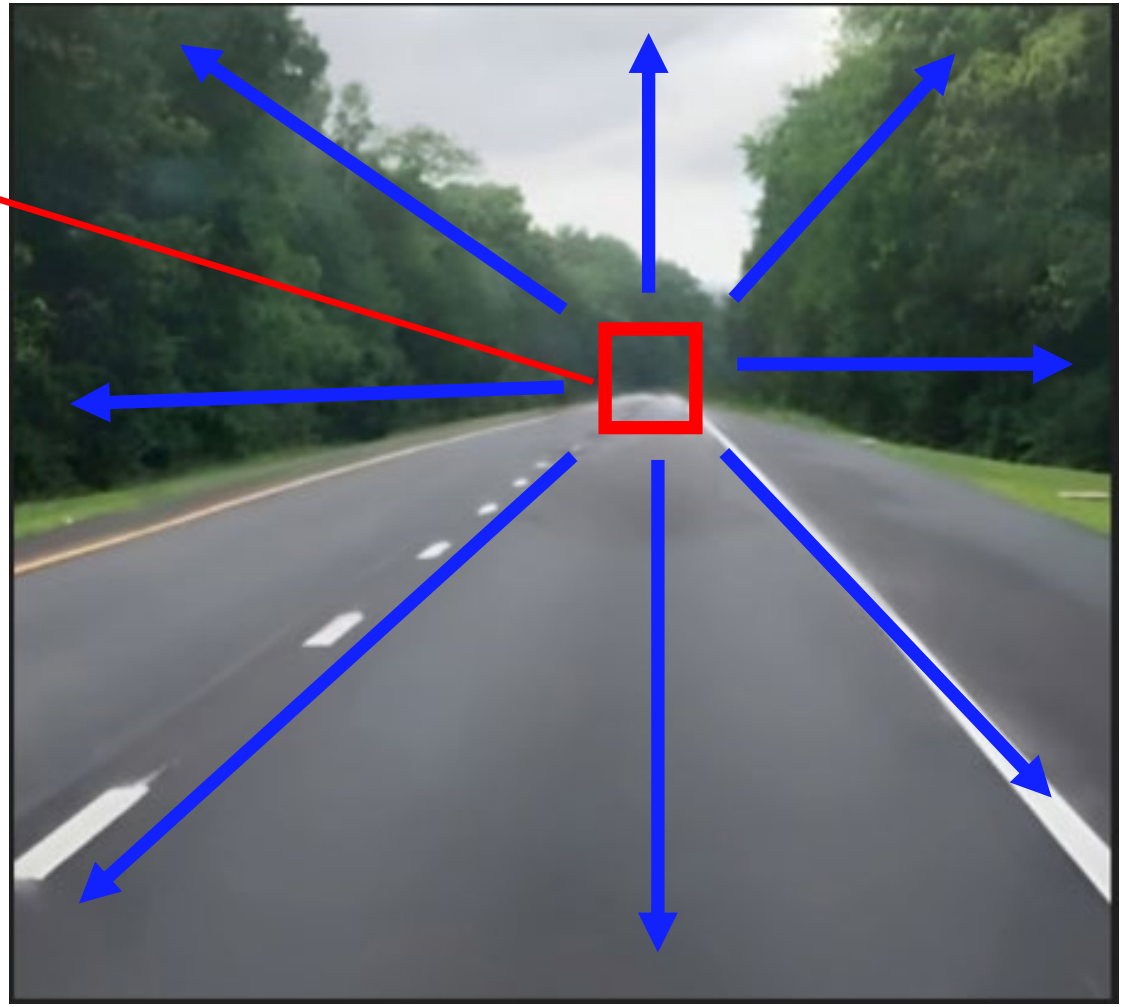


"SLOW" Pavement Marking with Arrow

SPEED PERCEPTION AND DRIVING SPEED

Point of Expansion (appears stationary)

Optic Flow
All other points appear to move away from the point of expansion. Closer objects move across our field of view faster than distant objects.



Speed perception refers to drivers' judgment of how fast they are traveling.

Drivers primarily rely on visual sensation from the roadway environment and objects in their immediate environment.

Underestimating speed = traveling faster than expected
Overestimating speed = traveling slower than expected

SPEED PERCEPTION AND DRIVING SPEED

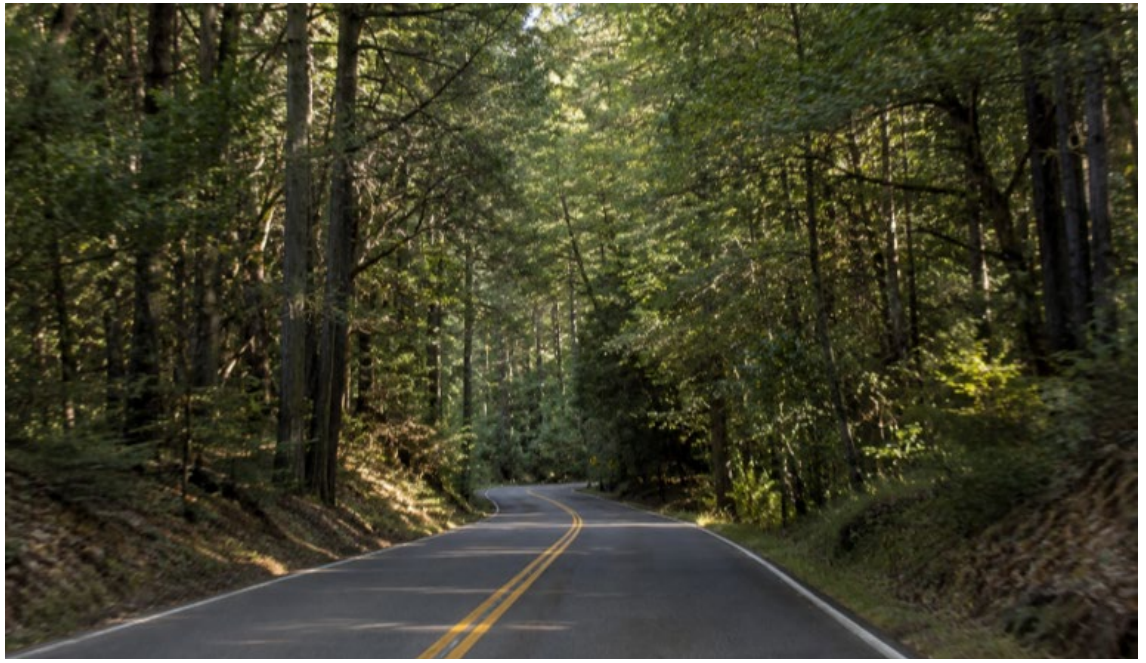
Certain factors may cause drivers to:

UNDERESTIMATE Their Travel Speed

Example: Wide road with open roadside

(few roadside objects, no trees, sparse visual environment)

OVERESTIMATE Their Travel Speed



Example: Narrow road densely lined with trees

(many roadside objects, dense visual environment)

Drivers use roadway cues, not just speed limits, to judge appropriate travel speeds

POLL QUESTION

- Now that you've learned about the HFG, how likely are you to use it as one of your resources?

Source: NHTSA

CLOSING THOUGHTS

- Improving roadway safety requires more than just infrastructure-based solutions
- Human factors is its own profession (think why do engineers take geology):
  - Use documented resources and principles (HFG)
  - Know when to engage a professional
- The NCHRP Human Factors Guide is continually updated to document research-based practices (new version is being developed)

QUESTIONS

Bryan J. Katz (Civil Engineering)
President

Bryan.Katz@toxcel.com

Erin Kissner (Psychology)
Team Leader, Roadway Infrastructure Human Factors

Erin.Kissner@toxcel.com