




Practical Safety Solutions for Local and Tribal Roads: A Human Factors Approach

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16. Abstract Human factors principles explain how road users gather information, make sense of that information, make decisions, and execute actions when traveling on the roadways. Understanding these principles can assist in identifying safety issues and		

selecting the most effective countermeasures to address those issues on local and tribal roads. Using plain language, this report provides the practitioner with information on the effects of road users actions on roadway safety and how, when, and where to use this information to improve safety on their roadways. The information provided is not a substitute but a complement to technical information found in other documents. Throughout the report references are provided.

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Glossary

The definitions in this glossary are written in plain language. Further technical information is available in the text, references, and at www.fhwa.dot.gov.

Advisory Speed: a speed below the speed limit that is recommended for a section of highway. The advisory speed is normally determined through an engineering study that considers highway design, operating characteristics, and conditions.

Alignment: The path or direction a roadway takes.

Center line: Pavement marking that marks the separation between opposing streams of traffic.

Changeable Message Sign: An electronic traffic sign used to give road users information.

Clear Zone: An unobstructed roadside area that allows road users to stop safely or regain control of a vehicle that has left the roadway. Clearing obstructions can assist road users in their view of the road ahead and can minimize the consequences of roadway departure. The width of the clear zone should be based on risk (also called exposure). Key factors in assessing risk include traffic volumes, speeds, and slopes.

Crown: The part of the roadway shape in which the center of the road is higher than the outer edges.

Design Consistency: Conformance of a highway's geometric and operational features with driver expectancy.

Design Speed: The speed selected for the roadway during the design process. Designers consider the shape and use of the surrounding land, the expected operating speed and types of vehicles, and the type of roadway needed. They use this information to determine the characteristics of the roadway to be built.

Edge Line: The line that marks the edge of the road.

Gateway: A combination of traffic control treatments that mark the entrance to a town or village.

Guide Signs: Signs that direct road users along streets and highways and inform them of important destinations.

High Friction Surface Treatment (HFST): Pavement treatments that dramatically and immediately reduce crashes, injuries, and fatalities associated with friction demand issues, such as wet pavement, excessive vehicle speed, or roadway geometry/curvature.

Horizontal Pavement Markings: Simple regulatory, advisory, or guidance information that is applied to the roadway as a pavement marking to supplement one or more signs. Sometimes called "horizontal signing."

Operating Speed: When vehicles are in freeflow (undisturbed by traffic control devices or heavy traffic) the operating speed is usually defined as the 85th percentile of the observed vehicles speeds. That is, 85% of vehicles are traveling at this speed or slower, and 15% are traveling faster than this speed. Operating speed is a measure of actual use, and it may not be the same as the design speed.

Perception-Reaction Time: The amount of time a road user needs to perceive and understand information, make a decision, and execute the response.

Posted Speed: The highest lawful speed vehicles can travel.

Regulatory Signs: Signs that inform road users of traffic laws or regulations.

Retroreflective Materials: Sign and marking materials that reflect light straight back to the source. These materials look bright when headlights hit them. Retroreflective materials are conspicuous at night or under low-light conditions.

Road Diet: Reducing the number or width of through travel lanes to provide space for bike lanes, sidewalks, and/or medians.

Roadway Departure: When a single vehicle leaves the road or crosses the center line.

Rumble Strips, Longitudinal: A series of milled or raised elements on or near the center or edge line of a paved roadway. These alert road users (through vibration and sound) that their vehicles have left the travel lane.

Rumble Strips, Transverse: A series of milled or raised strips across the roadway that act as a warning to road users when approaching a curve or intersection.

SafetyEdgeSM: A pavement edge consolidated at approximately 30-degrees while paving to prevent vertical pavement edge drop-off. This allows drivers who drift off the roadway to safely re-enter.

Self-Enforcing Road: Road users make inferences about speed selection and expected maneuvers based on physical characteristics of the roadway. A self-enforcing road has characteristics that lead users to select appropriate speeds.

Shared Use Path: A path separated from a roadway that can be used by cyclists, pedestrians, and other non-motorized users.

Sight Distance: The distance at which a driver can see objects in the roadway before their line of vision is blocked.

Sign Complexity: The amount of information provided and how hard it may be to process it.

Skewed Intersection: Optimally, an intersection should be designed to have roadways cross at a 90-degree angle. In situations where the intersecting angles are 60 degrees or less, the intersections are considered skewed.

Transition Zone: The section of roadway before a motorist enters a community, where drivers need to identify an upcoming change in roadway character and reduce travel speed in preparation for entering the community.

Warning Sign: Gives road users advance indication of a hazard ahead on the roadway.

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Introduction

An understanding of basic human factors principles can be useful when identifying and addressing local and tribal road safety challenges. Human factors principles explain how road users gather information, make sense of that information, make decisions, and execute actions. This understanding can assist in selecting the most effective countermeasures for safety challenges.

This guide assists road practitioners in understanding road user capabilities and limitations. Practitioners can then use that understanding to improve safety. This guide is not a replacement for other design references and standards such as the Manual on Uniform Traffic Control Devices (MUTCD), the Highway Safety Manual, or any other guidance. It is a complement to them – another tool to use in the pursuit of enhanced safety.

The Guide

The purpose of this guide is to provide information on how road user actions affect road safety and how to apply this information. This document defines and describes some useful human factors principles and supplies information about using the principles to improve safety.

This guide offers six basic human factors principles that can be useful to practitioners.

- **Information Overload:** When road users are overwhelmed with information, they make errors. When there is too much information, road users may not have time to locate the most critical information, make sense of it, make decisions, and respond appropriately.
- **Positive Guidance:** Road users need information about the road ahead so they can prepare the correct maneuvers. They need accurate information, placed in the correct location, in a form they can understand easily.
- **User Expectancy:** Road users make assumptions about the road ahead. When these expectancies are violated, users' planned responses will be incorrect, and they may not have time to evaluate the roadway and change their responses quickly enough.

- **Priority of Information Needs:** Information that is necessary for basic vehicle control is more urgent than guidance (for example, choosing the correct lane); guidance is more urgent than wayfinding information. When offering information to road users, consider which level of information they need.
- **Distraction:** When road users' attention is diverted from their primary task, they miss important information about the roadway and other road users.
- **Visual Perception at Night:** Nighttime limits the timing, quality, and location of information road users can acquire and use for safe travel.

These principles can help practitioners identify issues and select potential solutions. The guide then gives eleven common Safety Challenges, as follows:

- **Unsignalized Intersections**
- **Signs**
- **Pavement Markings**
- **Roadway Departure on Straight Sections**
- **Roadway Departure on Curves**
- **Speeding**
- **School Zone and School Crossings**
- **Pedestrian Safety**
- **Bicyclist Safety**
- **Work Zone Safety**
- **Unpaved Roads**

Each safety challenge includes an explanation of how human factors principles relate to that challenge; how they help practitioners to anticipate and mitigate human error; and how to use the principles to select effective, practical solutions. Each topic offers other online and print resources and defines technical terms that are often used when discussing that topic.

The Office of Safety maintains a web site with information that local and tribal practitioners will find useful. This web site covers a variety of topics. <https://safety.fhwa.dot.gov/>

Guide Elements

Human factors principles help us understand and predict road user actions. The most basic principles that help with road safety are those that explain how road users get information, make decisions, and execute actions on the road. Each principle describes the way human capabilities and limitations affect road safety.

The tabs on the side of each page represent the guide element. Each element is examined in the following format:

- Guide Element Title
- **WHY** is this important?
- **WHEN** and **WHERE** is this useful?
- **WHAT** can we do to improve safety?
- An illustration or photo
- Useful Terms for Further Reading
- Cross-references in this book
- Useful Links

HUMAN FACTORS PRINCIPLE / SAFETY CHALLENGE: GUIDE ELEMENT TITLE

Guide Element Title <i>Principle or Challenge</i>
Name and Definition
WHY is this important?
<ul style="list-style-type: none"> • For Human Factors Principles, the importance is described. • For Safety Challenges, the most relevant human factors topics are identified and explained.
WHEN and WHERE is this useful?
<p>This section gives specific information about the most relevant roadway locations or situations. For Safety Challenges, human factors principles are linked to the offered countermeasures.</p>
WHAT can we do to improve safety?
<p>This section gives specific human factors guidance and potential solutions for safety challenges.</p>

Illustration clarifies the issue and/or potential solution.

Useful Terms for Further Reading

Useful Terms gives definitions of jargon and technical terms. Definitions are offered so that users will recognize and understand them in related resources.

Cross-References in this Book

Cross-References gives internal links to related topics. Links are clickable but also are spelled out for the benefit of those using a hard copy.

Useful Links

Useful Links offers external links for further reading.

<http://www.typical.link.com>

Human Factors Principles

Six basic **Human Factors Principles** are described in the following sections:

Information Overload

Positive Guidance

User Expectancy

Priority of Information Needs

Distraction

Visual Perception at Night

Information Overload | Human Factors Principle

Information Overload is a function of the quantity of information offered and the time available for its processing. When the quantity of information is too great for the time allowed, road users can experience **Information Overload** and make errors in comprehension, decision-making, and execution.

WHY is this important?

There is a limit to the amount of information that a person can process in a short time. When a road user tries to take in too much information in too little time, they may miss information, misunderstand it, or they may be confused. They may make incorrect decisions and unsafe maneuvers.

WHEN and WHERE is this useful?

Road users must constantly make decisions as they navigate the roadway. Presenting too much information in the same location can lead to overload resulting in:

- Confusion
- Slowing or stopping in traffic
- Leaving travel lane
- Failure to notice other road users
- Failure to read and understand road signs

WHAT can we do to improve safety?

Recognize that road users must keep most of their attention on the task.

- Signs should be simple so that they are quickly read and understood.
- Space signs apart to give road users time to read and respond while driving. When possible, avoid placing signs in areas with background clutter.
- Minimize demands on attention in places where users must make decisions or where vehicle control is more demanding, like curves or merge points. Try to place wayfinding information on road sections where the driving task may need less attention.



When too much information is presented in too little time, road users may miss important cues in the environment.

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Useful Terms for Further Reading

Information Overload is sometimes discussed as an issue of workload. When a person has to do several things under time pressure, their workload is high, and they may be unable to devote their attention to a single task.

The amount of time a road user needs to perceive and understand information, make a decision, and execute the response is called **perception-reaction time**. Be sure to allow for **perception-reaction time** when placing signs and other information upstream from decision points.

Cross-References in this Book

Distraction, Positive Guidance, Signs, Priority of Information Needs, Roadway Departure, Work Zones

Useful Links

NCHRP Report 600, "Human Factors Guidelines for Road Systems" has more information in Chapter 3, "Finding Information Like a Road User:" http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

The Manual on Uniform Traffic Control Devices (MUTCD) gives specific guidance on **Signs**, their placement, and needed **perception-reaction time** in: https://mutcd.fhwa.dot.gov/hdm/2009/part2/part2_toc.htm

Positive Guidance | Human Factors Principle

Positive Guidance offers information about roadway characteristics to help road users make safe maneuvers.

WHY is this important?

The principle of **Positive Guidance** can help in choosing the right information for road users at the right time. Giving road users accurate information is critical for safety.

WHEN and WHERE is this useful?

When a roadway feature takes drivers by surprise, safety can suffer. Unexpected curves or crests, intersections, lane drops, or other features are often associated with crashes. Offering road users the appropriate roadway information and indicating the safe maneuver speed can help prevent these crashes.

WHAT can we do to improve safety?

Signs, markings, and **advisory speeds** provide a good view of the road ahead to give users the information they need to safely negotiate the road.

Tell road users what to expect. Whenever possible, give road users appropriate information so they can prepare for the correct maneuvers.

- Remove visual obstructions as much as you can.
- Use signs, **pavement markings**, **advisory speed** signs, and **warning signs** to give road users information about the road ahead.
- Provide delineations on guardrails and chevrons at curves when warranted.
- Use countermeasures consistently.



A curve **warning sign** gives road users accurate information about the roadway ahead. ©2018 ODOT.

Useful Terms for Further Reading

When road users can look at the road and know what to expect regarding speed, traffic volume, and the way that vehicles get on and off the road, that is a self-enforcing road. A **self-enforcing road** uses the road itself to encourage road users to naturally adopt proper behavior consistent with road design and function. **Positive Guidance** can target a specific area and give users the information they need to safely negotiate the roadway.

The **clear zone** is an unobstructed roadside area that allows road users to stop safely or regain control of a vehicle that has left the roadway. Clearing obstructions can assist road users in their view of the road ahead and can minimize the consequences of **roadway departure**. The width of the **clear zone** should be based on risk (also called exposure). Key factors in assessing risk include traffic volumes, speeds, and slopes.

Cross-References in this Book

Priority of Information Needs, Work Zones, Roadway Departure on Curves, Speeding

Useful Links

A simple method to evaluate low-volume roads incorporating the principles of driver expectancy and **Positive Guidance**:

<https://rosap.ntl.bts.gov/view/dot/40402>

User Expectancy | Human Factors Principle

User Expectancies are assumptions that road users make about the road ahead based on experience or habit. When expectancies are not met, users are more likely to make errors.

WHY is this important?

User Expectancies affect the way that road users take in information, interpret it, and make decisions. Accurate expectancies are helpful to road users. However, violated expectancies lead to longer reaction times, confusion, and errors.

WHEN and WHERE is this useful?

A road user has expectations about the road ahead based on their experience and what they currently see. Expectancies affect the accuracy and speed of user responses (**perception-reaction time**).

When the user's expectancy is not met, their performance suffers, and they may make unsafe maneuvers that can result in a crash. This tends to be a problem for drivers more than for bicyclists or pedestrians because of the speed of travel but can be an issue for any road user.

Expectancies can be unmet in a number of ways including the following:

- When the road type or features suddenly change (for example, a series of moderate curves that is followed by a very sharp curve).
- Unusual or uncommon features like a left exit, **skewed intersection**, or change in road surface (such as paved road to **Unpaved Road**).
- Unusual environmental features, such as fog or sun glare.
- Features or practices that are new – a change in speed limit, lane shift, new signal, work zone, or recent change can be especially jarring for familiar users who have long-standing expectancies.

WHAT can we do to improve safety?

- Use **warning signs** and **pavement markings** to accurately convey upcoming road features. It is important to give users information about the road ahead.
- Provide backplate for signal heads at strategic locations.
- Use signs and **pavement markings** consistently. Users should be able to rely on information (such as the presence of a **warning sign**) to mean the same thing in different places.



In this work zone, the warning sign shows a lane shift to the left. Road users' expectancies may be violated when the road shifts to the right instead. Source: FHWA

Useful Terms for Further Reading

User expectancies can be leveraged to improve safety when those expectancies give people the correct preparation for the road ahead. A **self-explaining road** conveys proper expectations to road users in terms of the correct speed, amount of traffic, and the ways that vehicles enter and exit the road. Self-explaining roads and **User Expectancy** are strongly related because self-explaining roads use those expectancies to influence behavior.

The amount of time a road user needs to perceive and understand information, make a decision, and execute the response, is called **perception-reaction time**.

Cross-References in this Book

Priority of Information Needs, Positive Guidance, Work Zones, Roadway Departure on Curves, Speeding

Useful Links

A step-by-step guide to analyzing a site for expectancy violations can be found here: <https://rosap.ntl.bts.gov/view/dot/890>

User expectancies and the self-explaining road concept have been investigated the most thoroughly for the potential to decrease **Speeding**. Guidance on self-explaining roads and speed management can be found here:

<https://www.fhwa.dot.gov/publications/research/safety/17098/17098.pdf>

Priority of Information Needs | Human Factors Principle

Road users constantly seek out information. They require different kinds of information for driving and navigation at different times. Considering these needs can help determine which kind of information should be offered and, as a result, where it should be placed. Information that is necessary for basic vehicle control must be prioritized over guidance such as lane choice, and guidance information must take priority over wayfinding.

WHY is this important?

It is important to give road users the type of information they need at the right time for them to safely negotiate the roadway. Road users must control the vehicle with steering, acceleration, and deceleration; they must choose the travel speed and lane; and they must navigate the route to their destination. These fall into three levels of vehicle operation: low-level basic vehicle control (steering), medium-level guidance (curve or intersection ahead), and high-level navigation (wayfinding). These tasks all require different information at different places and times.

WHEN and WHERE is this useful?

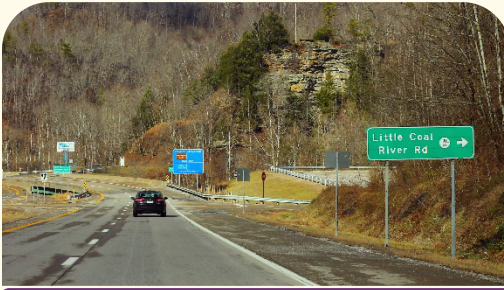
Operators of any vehicle need information for three levels of vehicle operation.

For low-level basic vehicle control, road users need information about road characteristics that will tell them how to steer and accelerate or brake.

For medium-level driving decisions, drivers need information about traffic and road conditions that will help them choose a lane, maintain following distance, and make other responses that keep them on the correct path.

For high-level navigation, drivers need information that will help them get to their correct destination.

Road users watch for all kinds of information, but when lower-level vehicle control needs are intense, they cannot take in higher-level information. For example, users need information about the road characteristics that is necessary for vehicle control when navigating a sharp curve. At that moment, information about the curve is more important than knowing a lane change might be necessary in the next two miles (a medium-level need); or knowing the name of the next cross street (a high-level navigation need.)



Road users should not be expected to read detailed text on a wayfinding sign while entering a curve. The blue sign should be relocated upstream.

©2017 FormulaNone.

WHAT can we do to improve safety?

- Recognize that information for low-level vehicle control must take priority over higher-level information.
- Recognize that road users have limitations on the amount of information they can take in at one time.
- Give advance warning of hazards with **warning signs** and **advisory speeds**.
- Offer higher-level information (like wayfinding information) at times when lower level tasks are simple. This allows users to take in the wayfinding information before executing a more demanding maneuver.

Useful Terms for Further Reading

The **Priority of Information Needs** is also called the **hierarchy of information** needs.

When we talk about how mentally busy a person is, we call it **workload**. When a road user must do several things in a short time (for example, take in information, make a decision, and execute a maneuver quickly,) their **workload** is high.

When drivers make decisions about their route they are **navigating** or **wayfinding**.

Cross-References in this Book

Information Overload, Positive Guidance, Visual Perception at Night, Signs, Pavement Markings, Maintenance and Work Zones, Roadway Departure on Curves

Useful Links

NCHRP Report 600, "Human Factors Guidelines for Road Systems" has more information in Chapter 3, "Finding Information Like a Road User": http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

The Manual of Uniform Traffic Control Devices (MUTCD) gives specific guidance on **Signs** in Part 2. The information on placement may be especially useful: <https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/part2a.pdf>

Distraction | Human Factors Principle

Distraction is any activity that takes road users' attention away from their primary driving, cycling, or walking task. **Distraction** sources can be inside or outside the vehicle.

WHY is this important?

Road use requires attention. The roadway situation can change rapidly, and failure to pay attention can cause crashes.

WHEN and WHERE is this useful?

Distraction can cause crashes anywhere in the system. Driving, cycling, or walking requires the road user's full attention, whether it takes place at complex curves, intersections, or on straight flat roads.

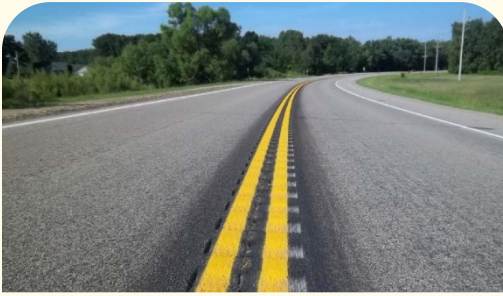
WHAT can we do to improve safety?

Distraction can be addressed through engineering, enforcement and education. Practitioners can apply engineering solutions to minimize the impact of distracted driving.

Install **rumble strips** at **edge lines** and **center lines** to alert road users when they begin to leave the travel lane. The sound and vibration can redirect attention to the driving task.

Help keep vehicles on the road, provide for safe recovery, and minimize the severity of crashes by designing safer slopes/ditches and removing hazardous roadside obstacles.

- Regrade next to the pavement edge to temporarily eliminate edge drop-offs and include the **SafetyEdge** next time pavement is placed to permanently eliminate edge drop-off.
- Widen and pave shoulders.
- Widen two-lane roads and include a narrow "buffer" median between opposing lanes.
- Install median barriers for narrow medians on multi-lane roads.



Center line rumble strips can alert road users when they begin to leave the travel lane. ©MnDOT.

Useful Terms for Further Reading

Longitudinal rumble strips are a series of milled or raised elements on or near the center or **edge line** of a paved roadway. These alert road users (through vibration and sound) that their vehicles have left the travel lane.

Transverse rumble strips are a series of milled or raised strips across the roadway that act as a warning to road users when approaching a curve or intersection.

A **roadway departure** (RwD) crash is a crash which occurs after a vehicle crosses an **edge line** or a **center line**, or otherwise leaves the travel way.

Cross-References in this Book

Positive Guidance, Information Overload, Pavement Markings, Signs, Roadway Departure on Straight Sections, Roadway Departure on Curves

Useful Links

Manual on Uniform Traffic Control Devices (MUTCD) gives specific guidance on **rumble strips**:

<https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/mutcd09r1r2editionhl.pdf>

Find information about advantages and disadvantages of **rumble strips** here: https://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/

The Local Rural Road Owner's Manual on **Roadway Departure** gives a step-by-step guide for non-engineers: https://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/fhwasa1109.pdf

Countermeasures for **Roadway Departure** Crashes:

https://safety.fhwa.dot.gov/roadway_dept/

Visual Perception at Night | Human Factors Principle

Road users get their information differently at night. Visual information is more difficult to acquire while traveling in the dark.

WHY is this important?

Road users depend on vision to acquire information about the road ahead. When traveling in the dark, road users can see only the aspects of the road ahead that are illuminated by headlights, street lights, or other light sources. Information left in darkness is not detected, and road users need more time to detect and understand the illuminated information.

Information conveyed by color may be reduced or lost. Signs and markings that are in poor condition are difficult to see and understand.

WHEN and WHERE is this useful?

Nighttime affects road users' ability to acquire the visual information that they need. Advance warning of hazards and upcoming changes in road characteristics become even more important at night.

WHAT can we do to improve safety?

Retroreflective signs and **pavement markings** are conspicuous at night. When well-maintained, these signs and **pavement markings** can communicate essential information about the road ahead.

- Place signs where headlights will illuminate them. This is especially important on curves.
- Use delineators to highlight the edge of the roadway.
- On unlighted roads, visual information is less easily received by road users. They may need more time and distance to acquire information before maneuvering.
- Consider adding lighting where possible.
- Take older road users into account. Make sure people have enough time to see a sign, understand it, and respond. Accommodating older people can help all road users. Install median barriers for narrow medians on multi-lane roads.



Retroreflective materials are conspicuous at night. ©MDOT

Useful Terms for Further Reading

Sign and marking materials that reflect light straight back to the source are **retroreflective**. These materials look bright when headlights shine on them.

Cross-References in this Book

Positive Guidance, Information Overload, Priority of Information Needs, Signs, Pavement Markings, Roadway Departure on Curves

Useful Links

Learn about maintaining **Signs** here:
https://safety.fhwa.dot.gov/roadway_dept/night_visib/sign_retro_4page.pdf

Learn about maintaining **Pavement Markings** here:
https://safety.fhwa.dot.gov/roadway_dept/night_visib/fhwasa14017/fhwas_a14017.pdf

Find broader resources about older road users here, including the Handbook for Designing Roadways for the Aging Population:
https://safety.fhwa.dot.gov/older_users/

Safety Challenges

Eleven common **Safety Challenges** are covered in the following sections:

Unsignalized Intersections

Signs

Pavement Markings

Roadway Departure on Straight Sections

Roadway Departure on Curves

Speeding

School Zone and School Crossings

Pedestrian Safety

Bicyclist Safety

Work Zone Safety

Unpaved Roads

Unsignalized Intersections | Safety Challenge

An **Unsignalized Intersection** is a location where two or more roads cross that is not controlled by a traffic signal and is not a roundabout. **Unsignalized Intersections** are most commonly controlled with stop signs on the minor approaches. A high proportion of crashes between two or more road users occur at **Unsignalized Intersections**.

WHY are human factors principles important for safety in this topic?

Addressing **User Expectancies** at **Unsignalized Intersections** will enable road users to act appropriately on the approach.

Limitations on **Visual Perception at Night** can keep road users from acquiring the right information in advance of an intersection.

An intersection is a conflict point and requires substantial attention from the road user. If road users are faced with too many information sources, **Information Overload** may prevent them from finding the most necessary information and responding correctly in a timely manner.

Distraction can affect all aspects of performance including lane-keeping, speed selection, hazard detection, decision-making, and safe maneuver execution.



Road users approaching a **skewed intersection** may have a **User Expectancy** that the angle of the crossing roads will be 90 degrees. As a result, road users may not turn their heads far enough to view cross traffic. The intersection shown had a crash history of side-impact collisions. Installation of stop bars that were parallel to the crossing road communicated to road users the skewed angle of the crossing road and reduced crashes. ©2019 David Orr

WHEN and WHERE is this useful?

Intersections can be reviewed for safety issues, either proactively or in response to crashes. Review existing crash data to find the cause of unsignalized intersection crashes and to select the most effective solutions. Depending on the nature of the crashes, some solutions may attack the problem in a single spot or throughout the network.

WHAT can we do to improve safety?

Strategies to help with user expectancies, **Positive Guidance**, **Visual Perception at Night**, and **Distraction** include the following:

- Maintain **clear zones**.
- Remove objects that may block the view of the intersection (for example, trees, shrubs, parking).
- Add or maintain appropriate **regulatory (stop or yield) signs**, **warning signs**, and **pavement markings**.
- Install signs such as “stop ahead” or “intersection ahead” **warning signs** to notify road users of upcoming intersections.
- Install flashing beacons at intersections that are controlled by stop signs.
- Provide lighting.
- Realign **skewed intersections** to improve road users’ ability to see other traffic or retrofit as a roundabout.

Rumble strips can be used to reduce intersection approach speeds by installing them across the travel lanes approaching the intersection. When installed across the lane rather than along the **edge** or **center lines**, they are called **transverse rumble strips**.

Useful Terms for Further Reading

Rumble strips are a series of milled or raised strips across a road or along its edge. These rough sections of pavement alert road users (through vibration and sound) that their vehicles have left the travel lane.

The **clear zone** is an unobstructed roadside area that allows road users to stop safely or regain control of a vehicle that has left the roadway. Clearing obstructions can assist road users in their view of the road ahead and can minimize the consequences of **Roadway Departure**.

At most intersections, the roads cross at a right angle (90 degrees). At **skewed intersections**, the intersecting angles are 60 degrees or less.

Cross-References in this Book

Positive Guidance, Signs, Pavement Markings, User Expectancy, Visual Perception at Night, Information Overload, Distraction, Speed

Useful Links

For information on identifying intersection safety issues and selecting the proper solution, see Intersection Safety: A Manual for Local Rural Road Owners: https://safety.fhwa.dot.gov/local_rural/training/fhwasa1108/fhwasa1108.pdf.

Unsignalized Intersection Improvement Guide (UIIG) provides a list of strategies that could improve safety at **Unsignalized Intersections**: <https://toolkits.ite.org/uiig/>

The Manual on Uniform Traffic Control Devices (MUTCD) contains information on many solutions that could be implemented at **Unsignalized Intersections**: <https://mutcd.fhwa.dot.gov/>

For additional information on **warning signs**, see <https://safety.fhwa.dot.gov/hsip/hrrr/manual/ch4.cfm>

Signs | Safety Challenge

Signs are placed in key locations to guide and regulate traffic. They provide information about regulations, warnings, and guidance on the roadway using words, symbols, arrows, and color to convey their messages.

WHY are human factors principles important for safety in this topic?

Signs must be deployed correctly in the following ways:

- Avoid **Information Overload** by presenting information at a pace and complexity that road users can understand and apply.
- Correct inaccurate **User Expectancies** by giving road users advance information clearly and consistently.
- Accommodate **Visual Perception at Night** by maintaining visibility and legibility of signs during nighttime conditions.



Maintain signs so they can be seen. ©2020 Toxcel

WHEN and WHERE is this useful?

Place signs where road users need information or guidance. Signs should be placed in locations that give users enough time to read and understand the information and safely react. Place signs where they will be clearly visible.

WHAT can we do to improve safety?

The following strategies will help avoid **Information Overload**:

- Use the fewest signs possible. Too many signs at a single location may confuse or overwhelm road users.
- Keep signs clear and simple. Signs with too many words require longer reading times and may cause confusion.
- Install signs in places where they can easily be seen.

Address **User Expectancies** in the following ways:

- Install signs ahead of key locations so that drivers know what to expect. Reference the MUTCD when choosing and installing a sign.
- Use colors, symbols, and abbreviations that are consistent and conform to the MUTCD. Keeping signs consistent allows road users to recognize them faster.
- Remove signs that no longer apply. If a hazard has been fixed or removed, be sure to remove the **warning sign** as well. This will help maintain sign credibility.

Accommodate concerns about **Visual Perception at Night** with the following:

- Use **retroreflective sign material** that is visible during nighttime conditions.
- Consider installing lighting as needed.

Useful Terms for Further Reading

When road users can rely on signs to be accurate and useful, signs have **credibility**.

The amount of information being provided and how hard it may be to process is known as **sign complexity**.

The amount of time a road user needs to take in information, understand it, make a decision, and execute a maneuver is called **perception-reaction time**.

Cross-References in this Book

Positive Guidance, Information Overload, Unsignalized Intersections, Roadway Departure on Curves, Visual Perception at Night, User Expectancy, Speed

Useful Links

For information on signing, see Chapter 2 of the Manual on Uniform Traffic Control Devices (MUTCD): <https://mutcd.fhwa.dot.gov/>

Best practices associated with **Signs** are included in Chapter 18 of NCHRP Report 600:

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

Additional information on the use of signing as a safety treatment: see Section 4.8 of the Manual for Selecting Safety Improvements on High Risk Rural Roads: <https://safety.fhwa.dot.gov/hsip/hrrr/manual/>

Pavement Markings | Safety Challenge

Pavement Markings provide road users with important information allowing minimal diversion of attention from their travel task. They outline travel lanes, guide road users, and promote safe travel.

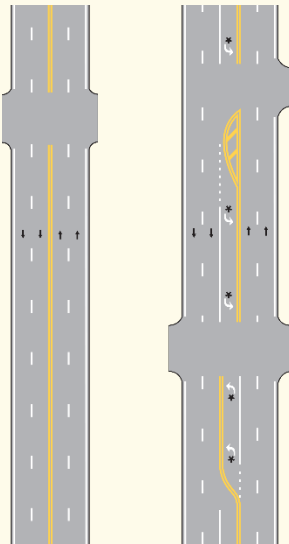
WHY are human factors principles important for safety in this topic?

Applied correctly, **pavement markings** can assist safe travel in the following ways:

- Avoid **Information Overload** by using simple markings that road users can understand and apply.
- Use **Positive Guidance** by giving road users advance information clearly and consistently.
- Accommodate **Visual Perception at Night** by ensuring visibility and legibility of **Pavement Markings**.

WHEN and WHERE is this useful?

System-wide application of appropriate **Pavement Markings** can reduce overall crashes in a jurisdiction more effectively than choosing a small number of spot locations. **Pavement Markings** are considered to be a low-cost method to improve safety.



©2019 MnDOT.

Refer to the MUTCD when applying **Pavement Markings**. Some common markings are shown to the left. Source: FHWA.

WHAT can we do to improve safety?

Avoid **Information Overload** with the following strategies:

- Keep text and symbol markings simple. Complex markings require more time to understand and may confuse drivers.

Conform to the principle of **Positive Guidance** in the following ways:

- Use colors, symbols, and markings that are consistent and conform to the MUTCD. Keeping markings consistent allows road users to recognize them quickly.
- Provide enough time for road users to read and safely react to **Pavement Markings**.

Accommodate concerns about **Visual Perception at Night** with the following:

- **Retroreflective pavement markings** are easily seen at night, especially when well maintained. Use raised pavement markers (RPM) to improve visibility during nighttime conditions and inclement weather.
- Maintain **Pavement Markings** to ensure visibility and legibility.

Useful Terms for Further Reading

The line that divides traffic traveling in opposite directions is called the **center line**.

The line that delineates the edge of the travel way is called the **edge line**.

Sign text that is painted on the road is called **horizontal pavement markings**.

Pavement Marking materials that reflect light back to the source are **retroreflective** and often use glass beads to reflect light.

Cross-References in this Book

Positive Guidance, Information Overload, Unsignalized Intersections, Roadway Departure on Curves, Visual Perception at Night, User Expectancy, Speed

Useful Links

For information on markings, see Chapter 3 of the Manual on Uniform Traffic Control Devices (MUTCD): <https://mutcd.fhwa.dot.gov/>

Best practices associated with **pavement markings** are included in Chapter 20 of NCHRP Report 600:
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

Roadway Departure on Straight Sections | Safety Challenge

A **Roadway Departure** (RwD) crash is a crash which occurs after a vehicle crosses an **edge line** or a **center line**, or otherwise leaves the travel way.

WHY are human factors principles important for safety in this topic?

To effectively prevent RwD crashes and fatalities, FHWA's efforts to reduce RwDs are guided by the Strategic Approach & Plan (see Useful Links) that involves countermeasures that: 1) Keep Vehicles on Roadway, 2) Provide for Safe Recovery, and 3) Reduce Crash Severity.

Vehicle use requires attention. **Distraction** takes the user's attention away from the driving task and can cause crashes. When a single car or truck crashes on a straight section of road (also called a tangent,) it is often because the road user is not paying attention to the driving task. The road user may be distracted, fatigued or impaired.

WHEN and WHERE is this useful?

To prevent single vehicle crashes on straight roads, it is likely that you will need to review and address a section of road rather than a single point.

Review crash reports to determine whether **Roadway Departure** crashes are localized (for example, at a bicycle crossing that violates user expectancies) or scattered through the system (evidence of distracted road users).



SafetyEdgeSM Source: FHWA

WHAT can we do to improve safety?

Provide for safe recovery and reduce crash severity with the following:

- Install **center line** and shoulder **rumble strips** to alert the road user when they begin to leave the lane.
- Eliminate shoulder drop-offs by installing a **SafetyEdge**. Shoulder drop-offs can cause drivers to lose control when they try to re-enter the roadway.
- Widen and/or pave shoulders as appropriate.
- On two-lane roads, include a narrow “buffer” median between opposing lanes.
- Install median barriers for narrow medians on multi-lane roads.
- Install **high friction surface treatments** on problematic curves. The need for pavement friction is higher at curves, and friction degrades with each vehicle that takes the curve.

Useful Terms for Further Reading

The **clear zone** is an unobstructed roadside area that allows road users to stop safely or regain control of a vehicle that has left the roadway. Clearing obstructions can assist road users in their view of the road ahead and can minimize the consequences of **Roadway Departure**.

Cross-References in this Book

Distraction, User Expectancy, Pavement Markings, Signs

Useful Links

The Local Rural Road Owner’s Manual on Roadway Departure gives a step-by-step guide for non-engineers:

https://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/

Countermeasures for **Roadway Departure** Crashes is more technical: https://safety.fhwa.dot.gov/roadway_dept/ and gives information about **SafetyEdge** that may help you fix shoulder drop-offs:

<https://safety.fhwa.dot.gov/safetyEdge/>

The MUTCD gives specific guidance on **rumble strips**:

<https://mutcd.fhwa.dot.gov/hdm/2009/part3/part3j.htm#figure3J01>

More information about **SafetyEdges** and shoulder drop-off can be found in NCHRP Report 600:

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

Roadway Departure on Curves | Safety Challenge

A **Roadway Departure** (RwD) crash occurs after a vehicle crosses an **edge line** or a **center line**, or otherwise leaves the travel way. Vehicles are more likely to leave the travel lane of a roadway where the roadway curves to the right or left.

WHY are human factors principles important for safety in this topic?

When a single car or truck leaves the roadway on a curved section, it is often because the road user has lost control of the vehicle. Appropriate speed selection is needed to safely navigate roadway curves. Road users are more likely to lose control when **User Expectancy** is violated, when there is **Distraction**, or when accurate advance information has not been provided at the right location through proper **Positive Guidance**.

To effectively prevent RwD crashes and fatalities, FHWA's efforts to reduce RwDs are guided by the Strategic Approach & Plan (See Useful Links) that involves countermeasures that: 1) Keep Vehicles on Roadway, 2) Provide for Safe Recovery, and 3) Reduce Crash Severity.

WHEN and WHERE is this useful?

Curves are common locations for RwD crashes. Violations of road users' expectations or a lack of advance information may lead them to select an inappropriate speed on approach and conduct inappropriate maneuvers without adequate time to adjust accordingly. This is more likely at the following locations:

- A curve following a long straight section of roadway,
- A sharp curve after a series of gentle curves,
- Locations where road users cannot see the curve ahead, which may occur at night on unlighted roads or where **sight distance** is limited.



Before- and After- photos show countermeasures designed to help road users detect the upcoming curve. Used with permission. ©Iowa Department of Transportation and ©The Ohio Department of Transportation.

WHAT can we do to improve safety?

Review crash reports to identify contributing factors. Collect additional information through site visits and discussions with law enforcement and the public. When selecting countermeasures, consider the following: **Visual Perception at Night** for nighttime crashes; user expectancies for hot spot curves, and **Positive Guidance** for advance warning needs.

Keep vehicles on the roadway with the following countermeasures:

- Install shoulder and/or **center line rumble strips** to alert the road users to lane departure.
- Guide road users at night by adding and placing signs and delineators where headlights will illuminate them.

Help road users prepare for the correct maneuvers and select the appropriate speed to safely navigate the curve with the following strategies:

- Install chevrons to guide drivers through curves.
- Install reflectors (such as post-mounted delineators or raised pavement markers) before and through curves.
- Install curve **warning signs** and **advisory speed** limit signs before sharp curves, maintaining **consistency** across the system.
- Install **high friction surface treatments** on problematic curves.

Provide for safe recovery and reduce crash severity with the following:

- Eliminate shoulder drop-offs or install a **SafetyEdge**.
- Widen and/or pave shoulders as appropriate.
- On two-lane roads, include a narrow “buffer” median between opposing lanes.
- Install median barriers for narrow medians on multi-lane roads.
- Minimize overturning by designing safer slopes/ditches and removing hazardous roadside obstacles in the **clear zone**.

Useful Terms for Further Reading

The path or direction a roadway takes – curves or straight sections - is known as the **alignment**.

When the road bends to the right or to the left, that’s a **horizontal curve**.

Chevrons are simple arrow signs that indicate the **alignment** of a curve. Chevrons can be seen in the photo on page 30.

Useful Terms for Further Reading (Cont.)

A speed below the speed limit that is recommended for a section of highway is the **advisory speed** and is normally determined through an engineering study.

High friction surface treatments can dramatically and immediately reduce crashes, injuries, and fatalities associated with friction demand issues.

Cross-References in this Book

Pavement Markings, Signs, User Expectancy, Visual Perception at Night, Speed, Distraction

Useful Links

For information on identifying **roadway departure** safety issues and selecting the solutions to address those issues, see Roadway Departure Safety: A Manual for Local Rural Road Owners: https://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/fhwasa1109.pdf

Horizontal Curve Safety (FHWA) lists potential strategies that can be implemented to improve curve safety:

https://safety.fhwa.dot.gov/roadway_dept/horcurves/cmhorcurves/horiz_curve.pdf

Additional information on potential solutions for safety problems on curves can be found in Low-Cost Treatments for Horizontal Curve Safety:

https://safety.fhwa.dot.gov/roadway_dept/horcurves/fhwasa15084/fhwasa15084rev011720_508_FINAL.pdf. Information on advance **warning signs** can be found on Chapter 4, Table 4

For information on **warning signs** that could be placed ahead of curves, see Chapter 2C in the Manual on Uniform Traffic Control Devices (MUTCD): <https://mutcd.fhwa.dot.gov/pdfs/2003/Ch2C.pdf>

For additional information on safety treatments for horizontal curves, see Section 4.1 of the Manual for Selecting Safety Improvements on High Risk Rural Roads: <https://safety.fhwa.dot.gov/hsip/hrrr/manual/>

For additional information on **advisory speeds** on curves, see https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa1122/fhwasa1122.pdf

For additional information on **high friction surface treatments**, see https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/high_friction/

Speeding | Safety Challenge

Speeding is driving above the **posted speed** limit or driving too fast for conditions.

WHY are human factors principles important for safety in this topic?

Human factors principles can offer strategies to help road users choose a safe speed.

Strategies include giving road users information for appropriate speed selection and by increasing their awareness of speed.

WHEN and WHERE is this useful?

Road users tend to speed in areas that lack traffic signals and stop signs, that have lower traffic volumes, and that show only sporadic speed enforcement activity. Some roadways may encourage higher speeds; flat, wide roads can be associated with a **User Expectancy** that speeds should be high. **Speeding** can also be a result of **Distraction**, as road users may not realize that they are traveling too fast.

Crash reports and police citations can help determine if there is a **Speeding** issue. Physical evidence such as skid marks, sign knockdowns, and guardrail strikes may indicate a **Speeding** problem. Coordinate with local law enforcement whenever possible.

WHAT can we do to improve safety?

Use strategies for **self-enforcing roadways** with signs and **pavement markings** that communicate safe speed selection to road users.

- Install **advisory speed** signs before curves.
- Install a speed activated sign that alerts road users when they are driving too fast.
- Install optical speed bars at spot locations.
- Increase road users' awareness of speed by installing transverse **rumble strips** across the travel lane at decreasing intervals.
- Install speed tables or speed humps.
- Install mini-roundabouts.



*Optical speed bars can increase perceived speed and reduce travel speed.
©Virginia Center for Transportation Innovation and Research.*

Useful Terms for Further Reading

The speed selected for the roadway during the design process is called the **design speed**.

The speed that vehicles travel when they are undisturbed by traffic or traffic control devices is called the **operating speed**.

The highest lawful speed vehicles can travel at is the **posted speed**.

The numerical speed established by state law is called the **statutory speed**.

The use of design features to reduce travel speeds is called **traffic calming**.

Road users make inferences about speed selection and expected maneuvers based on physical characteristics of the roadway. A **self-enforcing road** has characteristics that lead users to select appropriate speeds.

A speed below the speed limit that is recommended for a section of highway is the **advisory speed**. The **advisory speed** is normally determined through an engineering study that considers highway design, operating characteristics and conditions.

The section of roadway before a motorist enters a community, where drivers need to identify an upcoming change in roadway character and reduce travel speed in preparation for entering the community is a **transition zone**.

Cross-References in this Book

Distraction, Signs, Pavement Markings, User Expectancy

Useful Links

For information on how to address speed-related crashes, see Speed Management: A Manual for Local Rural Road Owners:

https://safety.fhwa.dot.gov/local_rural/training/fhwasas010413spmgt/speedmanagementguide.pdf

For information on setting speed limits, see Methods and Practices for Setting Speed Limits: An Informational Report:

https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasas12004/

See Chapter 17 of NCHRP Report 600 for information on **Speeding**:

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

Manual on Uniform Traffic Control Devices (MUTCD) contains information on many solutions that could be implemented to reduce **Speeding**:

https://mutcd.fhwa.dot.gov/html/2009/html_index.htm

For a list of traffic calming strategies, see the FHWA Traffic Calming ePrimer – Toolbox of Individual Traffic Calming Measures:

https://safety.fhwa.dot.gov/speedmgt/ePrimer_modules/module3.cfm#mod31

USLIMITS2 is a tool to aid practitioners in determining appropriate speed limit recommendations: <https://safety.fhwa.dot.gov/uslimits/index.cfm>

Self-enforcing roadways report:

<https://www.fhwa.dot.gov/publications/research/safety/17098/17098.pdf>

For additional information on **transition zones**, see

https://safety.fhwa.dot.gov/speedmgt/ref_mats/rural_transition_speed_zones.cfm

School Zones and School Crossings | Safety Challenge

A **School Zone** is an area on a street near a school or near a crosswalk that leads to a school. A **School Crossing** is a crosswalk that leads to a school.

WHY are human factors principles important for safety in this topic?

Children have difficulty judging speeds and safe gaps in traffic. When crashes occur in a **School Zone**, they are often due to inexperience, **Distraction**, or **Speeding**.

Strategies center on alerting road users and offering them accurate information for safe travel.

WHEN and WHERE is this useful?

User Expectancies can determine whether road users select appropriate speeds and prepare the correct responses in a **School Zone** or at a **School Crossing**. When road users are informed of the presence of children, other pedestrians and bicyclists, they are more likely to respond appropriately.

Road users in motorized vehicles are less likely to expect vulnerable road users on roads that are heavily traveled; have more than two lanes; or are in rural, commercial, or industrial areas. When **sight distance** is limited, the hazard increases.



Consult the MUTCD Chapter 7 for guidance on the placement of **School Zone and School Crossing signs**. ©2013/2019 VHB

WHAT can we do to improve safety?

Alert road users and offer them information so they can prepare appropriate responses. Road users can be prepared for children with use of the following methods:

- Install signs to warn road users that they are approaching a **School Zone or Crossing**.
- Install signs in places where they are easily seen.
- Install crosswalks to guide pedestrians. Use high-visibility markings to ensure that they are seen by other road users.
- Use in-street pedestrian crossing signs to highlight crosswalks near schools.
- Install lighting to improve pedestrian visibility.
- Install flashing LED beacons to warn road users of crossing pedestrians.
- Reduce speeds at **School Zones** to give road users more time to react. Slower speeds also create safer gaps for children to cross the roadway.
- Install flashing **School Zone** signs that clearly display the speed limit to capture the attention of distracted road users.
- Use countermeasures that apply to pedestrians and bicyclists in general.
- Coordinate with law enforcement to enforce safe travel around schools.

Useful Terms for Further Reading

The amount of time a road user needs to perceive and understand information, make a decision, and execute the response is called **perception-reaction time**.

Cross-References in this Book

User Expectancy, Distraction, Speed, Signs, Pavement Markings, Pedestrians, Bicycles

Useful Links

Information on how to manage speed near **School Zones and Crossings** is found in Speed Management: A Manual for Local Rural Road Owners

https://safety.fhwa.dot.gov/local_rural/training/fhwasa010413spmgmt/speedmanagementguide.pdf

NCHRP Report 600 (Chapter 17)

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf Section 15-6 lists methods to reduce driver speeds in **School Zones**

Manual on Uniform Traffic Control Devices (MUTCD)

https://mutcd.fhwa.dot.gov/html/2009/html_index.htm

Pedestrian Safety | Safety Challenge

Pedestrians face daily challenges and safety concerns when using the same roadway as motorized vehicles.

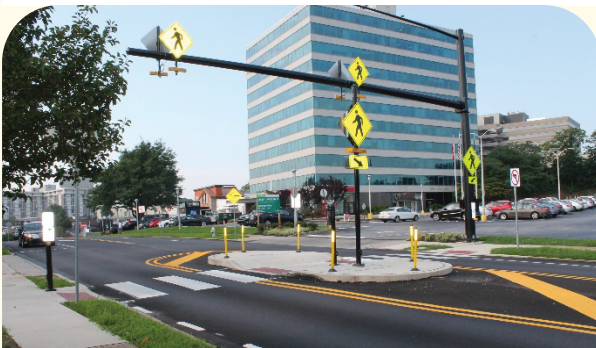
WHY are human factors principles important for safety in this topic?

Pedestrians behave differently from motor vehicles. They move more slowly than motor vehicles, and their speed and behavior is greatly affected by factors like age, physical limitations, and cognitive abilities. Pedestrians react to features that drivers cannot see, such as puddles, and may perform actions that drivers do not expect. Pedestrians are physically vulnerable.

Proper facilities such as crosswalks, pedestrian facilities, sidewalks, or paved shoulders can enhance the safety of pedestrians. Pedestrians may use the roadway with motorized vehicles, resulting in unsafe conditions and drivers do not expect to see pedestrians. Lighting, weather, and clothing choices can affect visibility, especially during bad weather or at night. In many places, motor vehicle drivers do not expect the presence of pedestrians. **Distraction** on the part of any road user can be an underlying cause in crashes.

WHEN and *WHERE* is this useful?

Pedestrian Safety issues can appear anywhere that motor vehicles and pedestrians must interact. An understanding of **User Expectancies**, **Visual Perception at Night**, and **Speeding** can help to identify underlying human factors issues. Review crash reports and citations to identify safety issues involving pedestrians. Depending on the nature of the crashes, the problem may be addressed in a single spot or may involve a larger area such as a corridor.



Shared use path crossing with signs and horizontal pavement markings to alert road users. ©2018 Montgomery County Planning Commission.

WHAT can we do to improve safety?

Know the population and context. Pedestrian crashes next to a school may require different solutions than pedestrian crashes outside a popular bar. Choose solutions accordingly.

Alert road users and give them information with the following strategies:

- Install signs that alert road users to potential pedestrians crossing the roadway.
- Install **Pavement Markings** that highlight pedestrian crossings.
- Install crosswalks and pedestrian crossing signage to notify road users that they must yield or stop for pedestrians.
- Install **transverse rumble strips** across the travel lane to alert road users that they must slow down ahead.
- Accommodate **Visual Perception at Night** by adding lighting when possible.
- Install flashing LED beacons to warn road users about a crossing pedestrian.
- Separate pedestrians from vehicle traffic whenever possible (for example, by installing sidewalks or walkways). Consider a **road diet**, reducing the number of travel lanes to provide space for sidewalks and/or medians.
- Consider installing **shared use paths**.
- Install refuge islands in the middle of roadways to allow pedestrians to safely cross multilane roads.
- Educate all road users on how to safely share roadways.

Useful Terms for Further Reading

Reducing the number of travel lanes to provide space for bicycle lanes, sidewalks, or medians is called a **road diet**.

A path separated from a roadway that can be used by cyclists, pedestrians, and other non-motorized users is called a **shared use path**.

Cross-References in this Book

Pavement Markings, Signs, Visual Perception at Night, Distraction, Positive Guidance

Useful Links

Non-Motorized User Safety: A Manual for Local Rural Road Owners provides a toolbox of resources and information for addressing the safety of non-motorized users: https://safety.fhwa.dot.gov/local_rural/training/fhwasa010413/nonmotorize.pdf. See Appendix A for a list of countermeasures

For information on common crash factors and potential solutions, see Factors Contributing to Pedestrian and Bicycle Crashes on Rural Highways: <https://www.fhwa.dot.gov/publications/research/safety/10052/>

Manual on Uniform Traffic Control Devices (MUTCD)
https://mutcd.fhwa.dot.gov/html/2009/html_index.htm

See Section 2C.50 for information on non-vehicular **warning signs**

See Section 3B.18 for information on crosswalk markings

Learn more about **Pedestrian** and **Bicycle Safety** here:

https://safety.fhwa.dot.gov/ped_bike/ and here:

https://safety.fhwa.dot.gov/ped_bike/step/

Bicyclist Safety | Safety Challenge

Bicyclists face daily challenges and safety concerns when using the same roadway as motorized vehicles. Scooters and other wheeled non-motorized vehicles share many of the same challenges as bicycles.

WHY are human factors principles important for safety in this topic?

Bicyclists often move more slowly than motor vehicles, and their speed and behavior is greatly affected by factors like age and physical abilities. Bicycles are more affected by pavement condition than motor vehicles, and cyclists may react to avoid conditions that drivers cannot see. In many locations, bicyclists are relatively rare, so other road users often do not expect their presence.

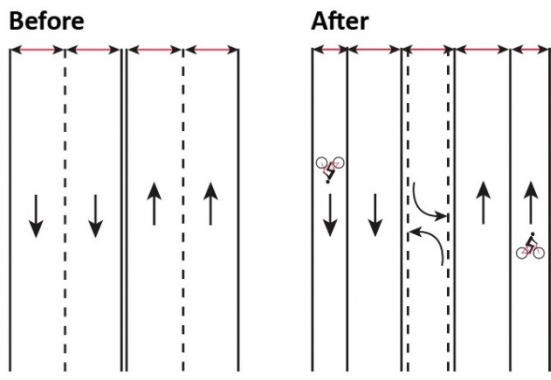
Bicycle facilities (bike lanes, shared paths) can enhance the safety of bicyclists and other road users. Lighting, weather, and clothing choices can affect visibility, especially during bad weather or at night. **Distraction** on the part of any road user can be an underlying cause in crashes. Bicyclists and other non-motorized users are physically vulnerable.

WHEN and WHERE is this useful?

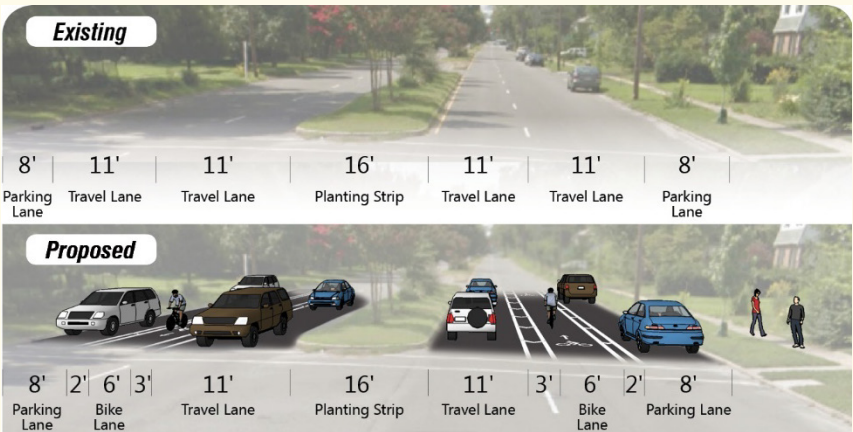
Bicyclist Safety issues can arise in any part of the system where road users include cyclists. Though bicyclists may travel more slowly than many motorized vehicles, it's important to allow enough time for cyclists to take in information, understand it, and respond appropriately. Drivers should be made aware of the presence of bicyclists and the need to share the roadway.

An understanding of **User Expectancies**, **Distraction**, and **Visual Perception at Night** can help to identify underlying issues and choose effective countermeasures.

Review crash reports and citations to identify safety issues involving bicyclists. Depending on the nature of the crashes, the problem may be addressed in a single spot or may involve a larger area. For example, nighttime crashes may suggest the need to accommodate **Visual Perception at Night**. Crashes at a specific crossing may require **Positive Guidance** to help road users prepare the appropriate responses.



Road diet reduces travel lanes to provide space for bicycle lanes and turning lane. ©MoBikeFed



Source: ©2018 VHB

WHAT can we do to improve safety?

Know how road users travel through your network. Incidents next to a school may require different solutions than bicycle incidents in a commuter corridor or recreational area. Choose solutions accordingly.

Strategies to protect bicyclists include alerting distracted road users, accommodating **Visual Perception at Night**, providing users with information that will help them maneuver appropriately, and minimizing the consequences of road user error by physically separating cyclists from motorized traffic.

- Install signs that alert road users to potential cyclists on the roadway.
- Install **pavement marking** symbols that help cyclists on the roadway and alert road users.
- Install **pavement markings** that highlight bicycle crossings.

WHAT can we do to improve safety? (Cont.)

- Install flashing LED beacons to warn road users about a crossing such as trail crossings.
- Accommodate concerns about **Visual Perception at Night** by installing lighting along roadways where applicable.
- Separate vehicle traffic from bicyclists whenever possible: provide bike paths, separated bike lanes on popular biking corridors, **shared use paths**, or bike boulevard/greenways in urban areas.
- Install raised islands in the middle of roadways to allow cyclists to safely cross multilane roads.
- Consider a **road diet**, reducing the number of travel lanes to provide space for bicycle lanes and/or medians.
- Place Signs and other information accordingly, being mindful of the **Priority of Information Needs**.
- Educate all road users on how to safely share roadways.

Useful Terms for Further Reading

Reducing the number of travel lanes to provide space for bicycle lanes, sidewalks, or medians is called a **road diet**.

A path separated from a roadway that can be used by cyclists, pedestrians, and other non-motorized users is called a **shared use path**.

Cross-References in this Book

Pavement Markings, Signs, Visual Perception at Night, Distraction, Positive Guidance, Priority of Information Needs

Useful Links

Non-Motorized User Safety: A Manual for Local Rural Road Owners provides a toolbox of resources and information for addressing the safety of non-motorized users: https://safety.fhwa.dot.gov/local_rural/training/fhwasa010413/nonmotorize.pdf

For information on common crash factors and potential solutions, see Factors Contributing to Pedestrian and Bicycle Crashes on Rural Highways: <http://www.trb.org/Main/Blurbs/163774.aspx>

Learn more about **Pedestrian** and **Bicycle Safety** here: https://safety.fhwa.dot.gov/ped_bike/ and here: https://safety.fhwa.dot.gov/ped_bike/step/

Work Zone Safety | Safety Challenge

A **Work Zone** is an area of roadway that is undergoing construction, maintenance, or utility work. They are typically marked by signs, barriers, **Pavement Markings**, and work vehicles. Workers may or may not be present.

WHY are human factors principles important for safety in this topic?

When crashes occur in a maintenance or work zone, they can be a result of **Distraction** or **Speeding**. Work zones also present unexpected conditions, such as reduced **sight distance**, changes to signs and markings, and shifts in the travel way. Road users can become confused by **Information Overload**.

WHEN and WHERE is this useful?

In the presence of a work zone, measures must be taken to provide for safe and efficient travel. The type of safety measures used depends on the type and duration of the work being done on a roadway.

WHAT can we do to improve safety?

Provide the correct level of information according to the **Priority of Information Needs** and avoid **Information Overload** with the following strategies:

- Ensure that the work zone is set up according to guidelines in the Manual on Uniform Traffic Control Devices (MUTCD). This includes temporary maintenance projects. Make sure that workers follow guidelines about the advance placement of **warning signs**, cones, delineation, and barriers.
- Use appropriate signs and **Pavement Markings** to provide clear guidance on how to get through the work zone.
- When using electronic message signs, keep messages clear and simple.
- Install signs in places where they can easily be seen and read.
- Offer information regarding speed selection and upcoming features. Set appropriate work zone speed limits to maintain safe traffic flow. Limits that are 10 mph below the usual limit are most likely to reduce speeds and gain compliance.
- Accommodate **Visual Perception at Night** by using signs and traffic control devices that are visible during nighttime conditions and install appropriate work zone lighting to minimize glare to motorists.



Work zones can be complex and confusing for road users.
©2007 Minnesota DOT.

Useful Terms for Further Reading

The control of road users through construction, utility, and maintenance operations is called **temporary traffic control**.

The portion of the roadway closed to road users where the work takes place is called the **work space**.

An electronic traffic sign used to give road users information is called a **changeable message sign**.

Cross-References in this Book

Information Overload, User Expectancy, Distraction, Positive Guidance, Signs, Speed, Visual Perception at Night

Useful Links

See Chapter 13 of NCHRP Report 600 for information on work zones:
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

For information on the parts of a temporary traffic control zone and traffic control devices, see the Maintenance **Work Zone Safety**: Pocket Guide of MUTCD Guidance on Temporary Traffic Control:

https://www.workzonesafety.org/training-resources/fhwa_wz_grant/atssa_maintenance_wz_safety/

Unpaved Roads | Safety Challenge

Unpaved Roads have gravel, dirt, or sand surfaces. These facilities usually carry low volumes of traffic and typically lack **Pavement Markings** and shoulders.

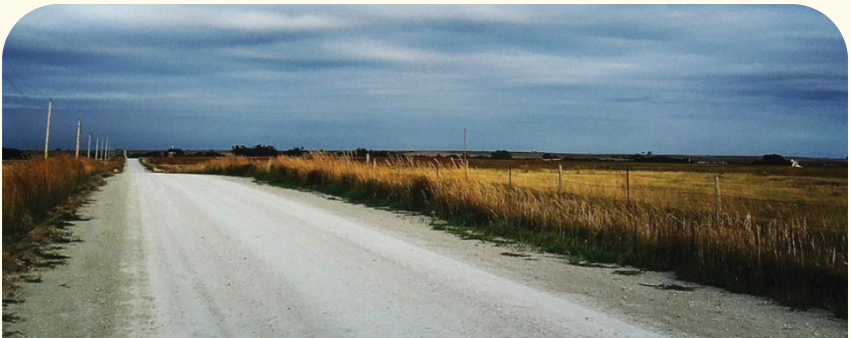
WHY are human factors principles important for safety in this topic?

When a crash occurs on an **Unpaved Road**, it is often due to the road surface, visibility or **sight distance** issues, **Distraction**, inexperience, or a lack of information in the form of signage and **Pavement Markings**. Speed can be a factor. The lack of roadway safety features, such as shoulders and **Pavement Markings**, mean that less information is conveyed to the road user.

Consider these human factors principles when choosing strategies to improve safety: **Positive Guidance** to improve the information offered to road users, accommodating **Visual Perception at Night**, providing for safe recovery, and reducing crash severity.

WHEN and *WHERE* is this useful?

Examine crash reports to find the cause of crashes on **Unpaved Roads** and to select the most effective solution. For example, crashes at uncontrolled intersections may require clearing vegetation to improve **sight distance**, particularly on low volume roads where **User Expectancy** leads road users to expect limited crossing traffic.



Unpaved Roads usually lack safety features such as **Pavement Markings**. ©2019 Erica Dryden

WHAT can we do to improve safety?

Use **Positive Guidance** by offering advance information.

- Install delineators to highlight the **alignment** of the road
- Install advance **warning signs** near narrow segments of road and before curves.
- Clear vegetation within the right of way to improve visibility and **sight distance**. Maintaining the **clear zone** can reduce the incidence and severity of crashes.
- Accommodate **Visual Perception at Night** by placing **retroreflective signs** and delineators where they will be struck by headlights.
- Maintain the road surface to prevent erosion, washouts, and visibility issues caused by too much dust.
- Construct proper drainage along the roadway.
- Harden unpaved surfaces by using dust control additives.
- Provide high quality gravel for the road surface and maintain the **crown**.
- Consider adding lighting if possible, especially at intersections.
- Reduce crash severity by designing safer slopes/ditches and removing hazardous roadside obstacles.

Useful Terms for Further Reading

The **clear zone** is an unobstructed roadside area that allows road users to stop safely or regain control of a vehicle that has left the roadway. Clearing obstructions can assist road users in their view of the road ahead and can minimize the consequences of **Roadway Departure**.

The cross-section roadway shape in which the center of the road is higher than the outer edges is called the **crown**.

A reflective device located on the side of a roadway to indicate **alignment** is called a **delineator**.

Cross-References in this Book

Signs, Visual Perception at Night, Positive Guidance, User Expectancy

Useful Links

Information on safety concerns and solutions along ***Unpaved Roads*** can be found in the Local and Rural Road Safety Briefing Sheets – Unpaved Roads: Safety Needs and Treatments:

https://safety.fhwa.dot.gov/local_rural/training/fhwasa14094/unpaved.pdf



Information on ***Unpaved Roads*** maintenance and proper materials can be found in the Gravel Roads Construction and Maintenance Guide:

<https://www.fhwa.dot.gov/construction/pubs/ots15002.pdf>

For additional information on the maintenance of gravel roads, see Section 4.5 of the Manual for Selecting Safety Improvements on High Risk Rural Roads: <https://safety.fhwa.dot.gov/hsip/hrrr/manual/>

Cross-Reference Table

Human Factors Principles are interrelated with each other and with the Safety Challenges. This Cross-Reference Table shows the most closely-related topics. As you use this resource, you will discover that accessing multiple sections will help your understanding and applications. Use this table and the cross-linked topics to find related Human Factors Principles and Safety Challenges.

 Human Factors Principle Cross Reference  Safety Challenge Cross Reference	<i>INFORMATION OVERLOAD</i>	<i>POSITIVE GUIDANCE</i>	<i>USER EXPECTANCY</i>	<i>PRIORITY OF INFORMATION NEEDS</i>	<i>DISTRACTION</i>	<i>VISUAL PERCEPTION AT NIGHT</i>
<i>INFORMATION OVERLOAD</i>		■		■	■	■
<i>POSITIVE GUIDANCE</i>	■		■	■	■	■
<i>USER EXPECTANCY</i>		■		■		
<i>PRIORITY OF INFORMATION NEEDS</i>	■	■	■		■	■
<i>DISTRACTION</i>	■	■		■		
<i>VISUAL PERCEPTION AT NIGHT</i>	■	■		■		■
UNSIGNALIZED INTERSECTIONS	●	●	●		●	●
SIGNS	●	●	●	●		●
PAVEMENT MARKINGS	●	●	●			●
ROADWAY DEPARTURE ON STRAIGHT SECTIONS			●		●	
ROADWAY DEPARTURE ON CURVES	●	●	●	●	●	●
SPEEDING			●		●	
SCHOOL ZONES & CROSSINGS			●		●	
PEDESTRIAN SAFETY			●		●	●
BICYCLIST SAFETY		●	●	●	●	●
WORK ZONE SAFETY	●	●	●	●	●	●
UNPAVED ROADS		●	●			●

UNSIGNALIZED INTERSECTIONS	SIGNS	PAVEMENT MARKINGS	ROADWAY DEPARTURE ON STRAIGHT SECTIONS	ROADWAY DEPARTURE ON CURVES	SPEEDING	SCHOOL ZONES & CROSSINGS	PEDESTRIAN SAFETY	BICYCLIST SAFETY	WORK ZONE SAFETY	UNPAVED ROADS
●	●				●					
●	●	●		●				●	●	●
●	●	●	●	●	●	●	●	●	●	●
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