LIFESAVERS

National Conference on Highway Safety Priorities

THE SAFE SYSTEM APPROACH

Zero is our goal. A Safe System is how we get there.

U.S.Department of Transportation

Federal Highway Administration

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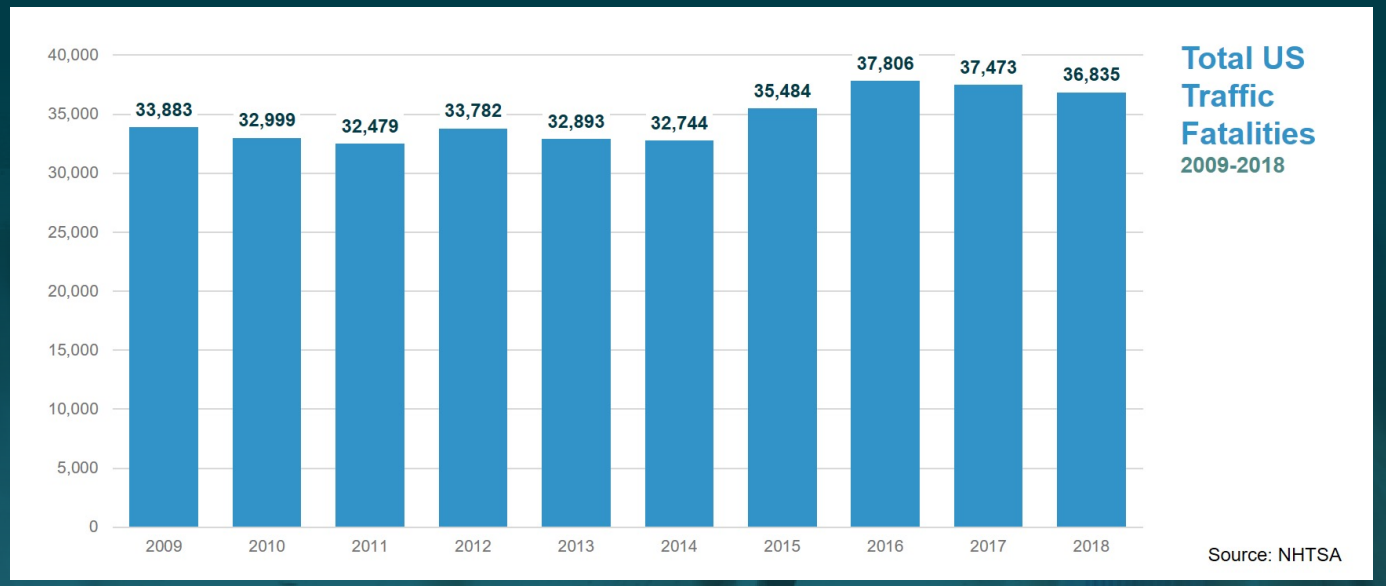
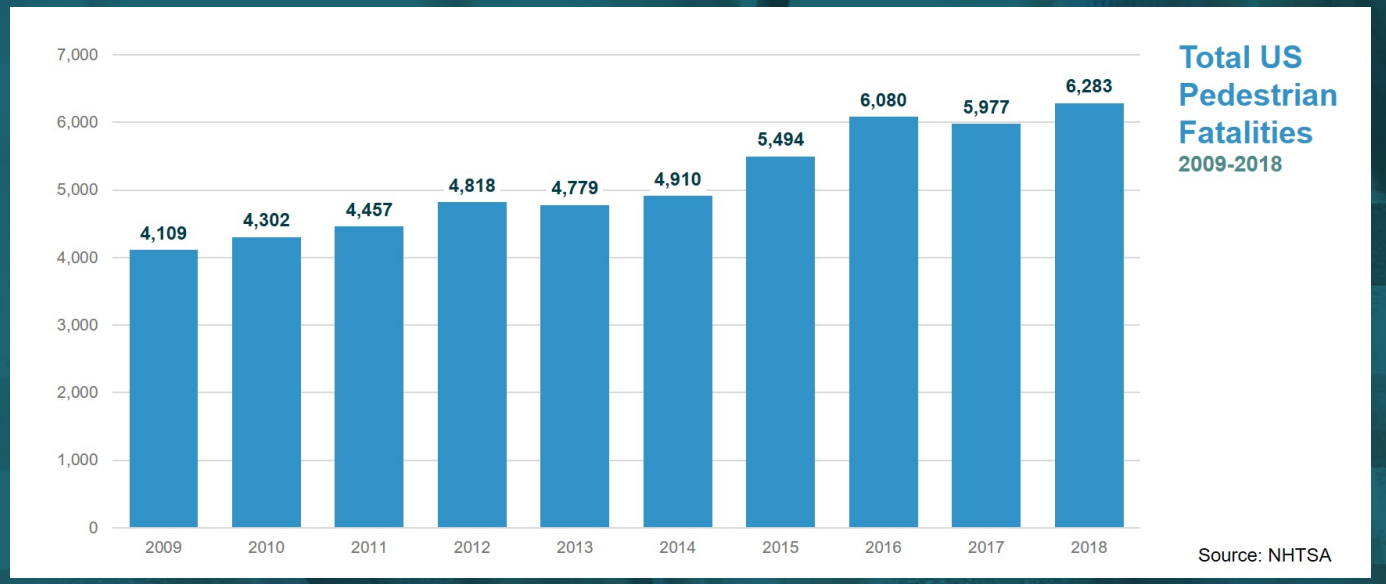
How does the US *reach zero deaths*?



Total US Traffic Fatalities
2009-2018

Source: NHTSA



Total US Pedestrian Fatalities
2009-2018

Source: NHTSA

Source: Fehr & Peers

A NEW DIRECTION

The Safe System approach aims to eliminate fatal and serious injuries for all road users by:

Accommodating human mistakes

Keeping impacts on the human body at tolerable levels

SUCCESSFUL SAFE SYSTEM ADOPTERS

Sweden

Vision Zero

60-70%

Reduction in fatalities
1994-2015

Netherlands

Sustainable Safety

50-60%

Reduction in fatalities
1994-2015

Australia

Safe System

50-60%

Reduction in fatalities
1994-2015

New Zealand

Safer Journeys

50-60%

Reduction in fatalities
1994-2015

Source: World Resources Institute

SAFE SYSTEM IN THE UNITED STATES

VISION ZERO NETWORK

ROAD TO ZERO

TZD Toward Zero Deaths®
National Strategy on Highway Safety

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THE SAFE SYSTEM

APPROACH

Zero is our goal. A Safe System is how we will get there.

Imagine a world where nobody has to die from vehicle crashes. The Safe System approach aims to eliminate fatal & serious injuries for all road users. It does so through a holistic view of the road system that first anticipates human mistakes and second keeps impact energy on the human body at tolerable levels. Safety is an ethical imperative of the designers and owners of the transportation system. Here's what you need to know to bring the Safe System approach to your community.

SAFE SYSTEM PRINCIPLES

Death/Serious Injury is Unacceptable

While no crashes are desirable, the Safe System approach prioritizes crashes that result in death and serious injuries, since no one should experience either when using the transportation system.

Humans Make Mistakes

People will inevitably make mistakes that can lead to crashes, but the transportation system can be designed and operated to accommodate human mistakes and injury tolerances and avoid death and serious injuries.

Humans Are Vulnerable

People have limits for tolerating crash forces before death and serious injury occurs; therefore, it is critical to design and operate a transportation system that is human-centric and accommodates human vulnerabilities.

Responsibility is Shared

All stakeholders (transportation system users and managers, vehicle manufacturers, etc.) must ensure that crashes don't lead to fatal or serious injuries.

Safety is Proactive

Proactive tools should be used to identify and mitigate latent risks in the transportation system, rather than waiting for crashes to occur and reacting afterwards.

Redundancy is Crucial

Reducing risks requires that all parts of the transportation system are strengthened, so that if one part fails, the other parts still protect people.

U.S.Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

SAFE SYSTEM ELEMENTS

Making a commitment to zero deaths means addressing every aspect of crash risks through the five elements of a Safe System, shown below. These layers of protection and shared responsibility promote a holistic approach to safety across the entire transportation system. The key focus of the Safe System approach is to reduce death and serious injuries through design that accommodates human mistakes and injury tolerances.

Safe Road Users

The Safe System approach addresses the safety of all road users, including those who walk, bike, drive, ride transit, and travel by other modes.

Safe Vehicles

Vehicles are designed and regulated to minimize the occurrence and severity of collisions using safety measures that incorporate the latest technology.

Safe Speeds

Humans are unlikely to survive high-speed crashes. Reducing speeds can accommodate human injury tolerances in three ways: reducing impact forces, providing additional time for drivers to stop, and improving visibility.

Safe Roads

Designing to accommodate human mistakes and injury tolerances can greatly reduce the severity of crashes that do occur. Examples include physically separating people traveling at different speeds, providing dedicated times for different users to move through a space, and alerting users to hazards and other road users.

Post-Crash Care

When a person is injured in a collision, they rely on emergency first responders to quickly locate them, stabilize their injury, and transport them to medical facilities. Post-crash care also includes forensic analysis at the crash site, traffic incident management, and other activities.

THE SAFE SYSTEM APPROACH VS. TRADITIONAL ROAD SAFETY PRACTICES

Traditional	Safe System
Prevent crashes	Prevent deaths and serious injuries
Improve human behavior	Design for human mistakes/limitations
Control speeding	Reduce system kinetic energy
Individuals are responsible	Share responsibility
React based on crash history	Proactively identify and address risks

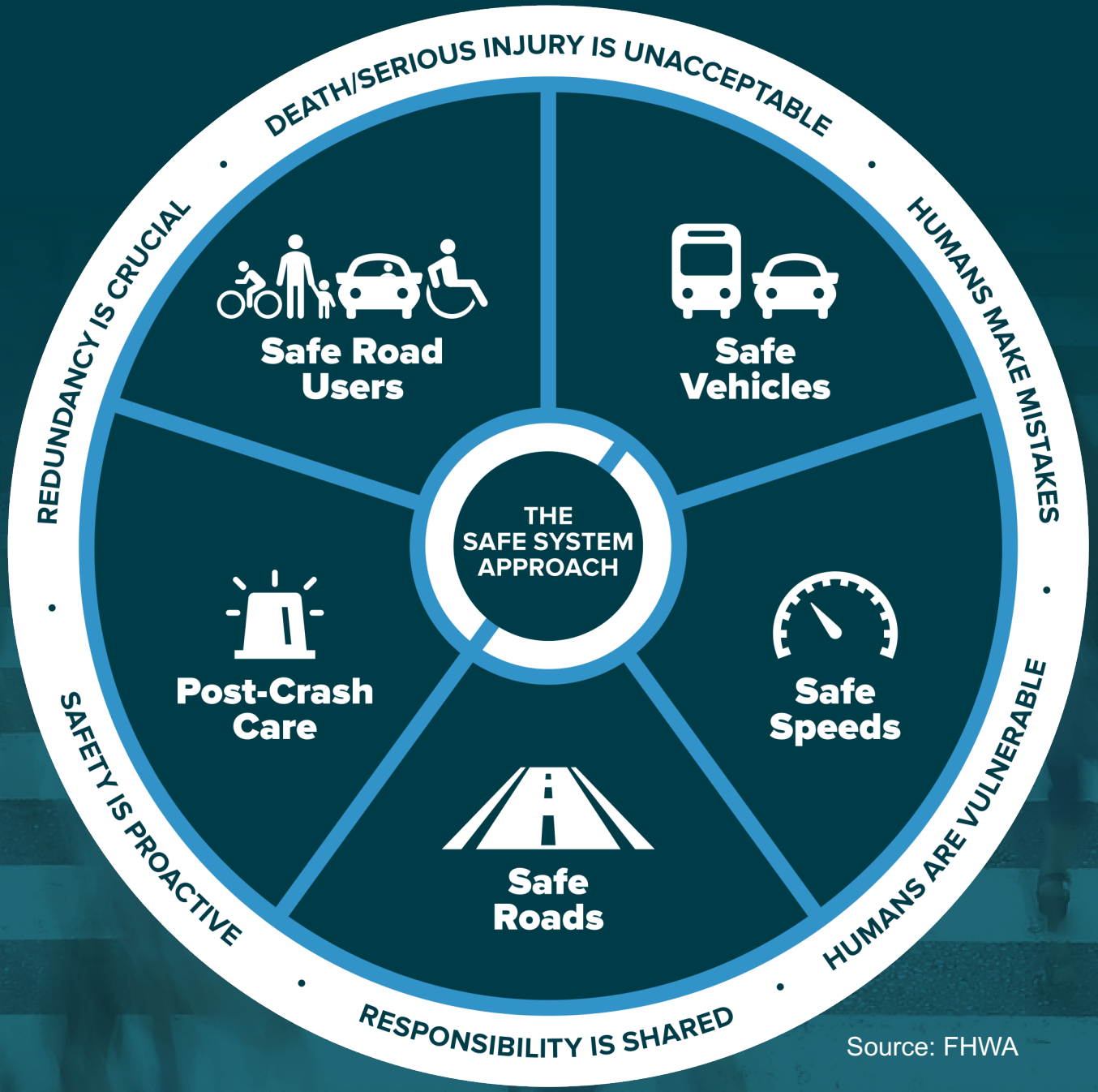
Whereas traditional road safety strives to modify human behavior and prevent all crashes, the Safe System approach also refocuses transportation system design and operation on anticipating human mistakes and lessening impact forces to reduce crash severity and save lives.

WHERE ARE YOU ON THE SAFE SYSTEM JOURNEY?

Implementing the Safe System approach is our shared responsibility, and we all have a role. It requires shifting how we think about transportation safety and how we prioritize our transportation investments. Consider applying a Safe System lens to upcoming projects and plans in your community: put safety at the forefront and design to accommodate human mistakes and injury tolerances. Visit **safety.fhwa.dot.gov/zerodeaths** to learn more.

https://safety.fhwa.dot.gov/zerodeaths/docs/FHWA_SafeSystem_Brochure_V9_508_200717.pdf

THE SAFE SYSTEM APPROACH



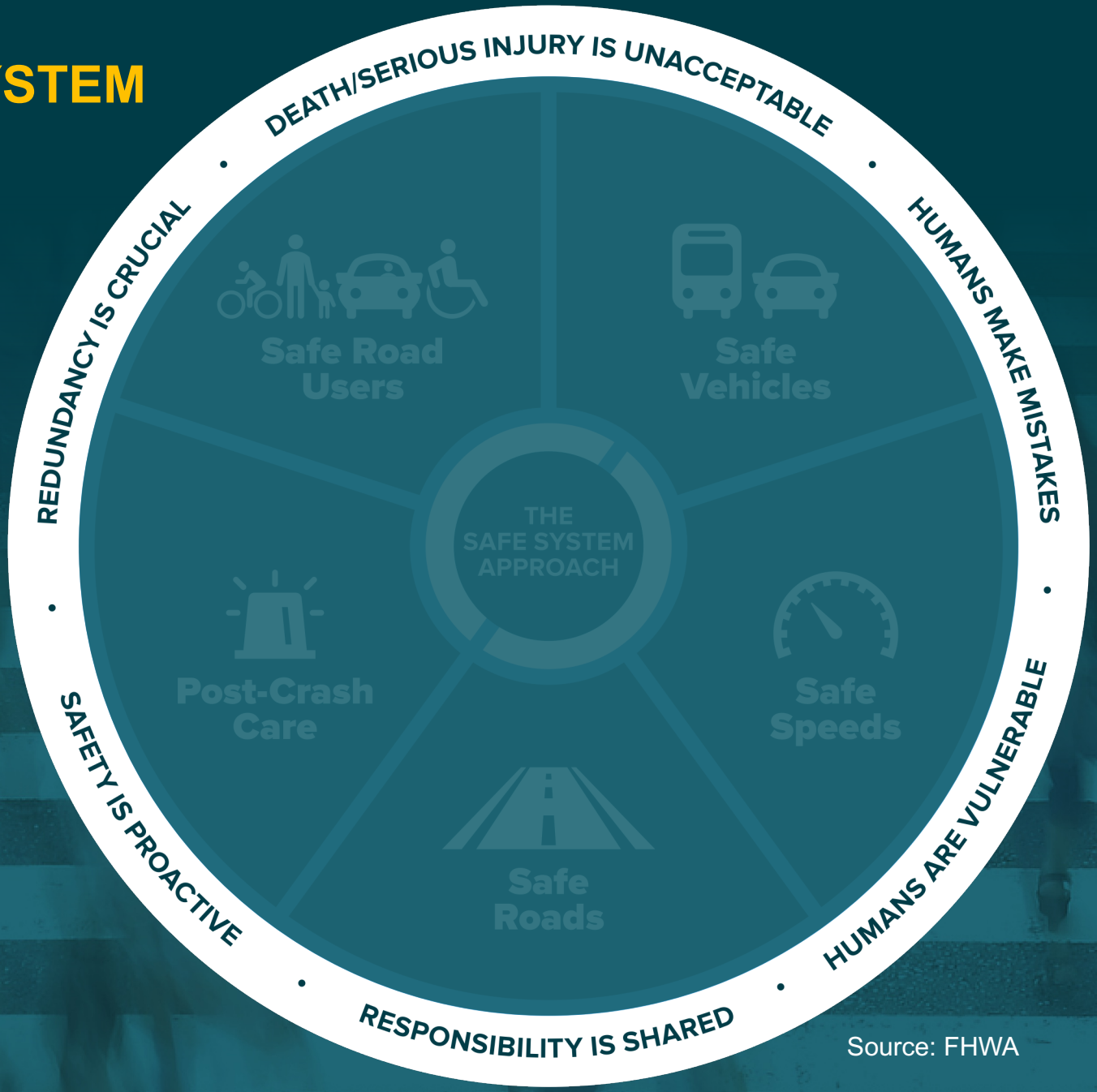
Source: FHWA

THE 6 SAFE SYSTEM PRINCIPLES

Death/serious injury is unacceptable

Humans make mistakes

Humans are vulnerable



Responsibility is shared

Safety is proactive

Redundancy is crucial

Source: FHWA

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Transportation Performance Management

TPM
HOW WE GET THERE

Focusing on Performance for Safe, Reliable Journeys

The Federal Highway Administration defines Transportation Performance Management (TPM) as a strategic app
that uses system information to make investment and policy decisions to achieve national performance goal

Investment Decisions

Using goals, measures, and data to make better informed decisions about how to invest transportation funding.

Aimed at a Better Performing Transportation System

Setting targets, developing plans, reporting results, and being accountable for performance.

For Connected and Productive Communities

Focusing on the efficient delivery of goods and safe, reliable journeys to work, to school, to shopping, to community activities.

https://www.fhwa.dot.gov/tpm/about/tpm.cfm

0

Death/serious injury is unacceptable

Five Safety Measures

- Number of Fatalities
- Fatality Rate
- Number of Serious Injuries
- Rate of Serious Injuries
- Number of Non-Motorized Fatalities and Serious Injuries

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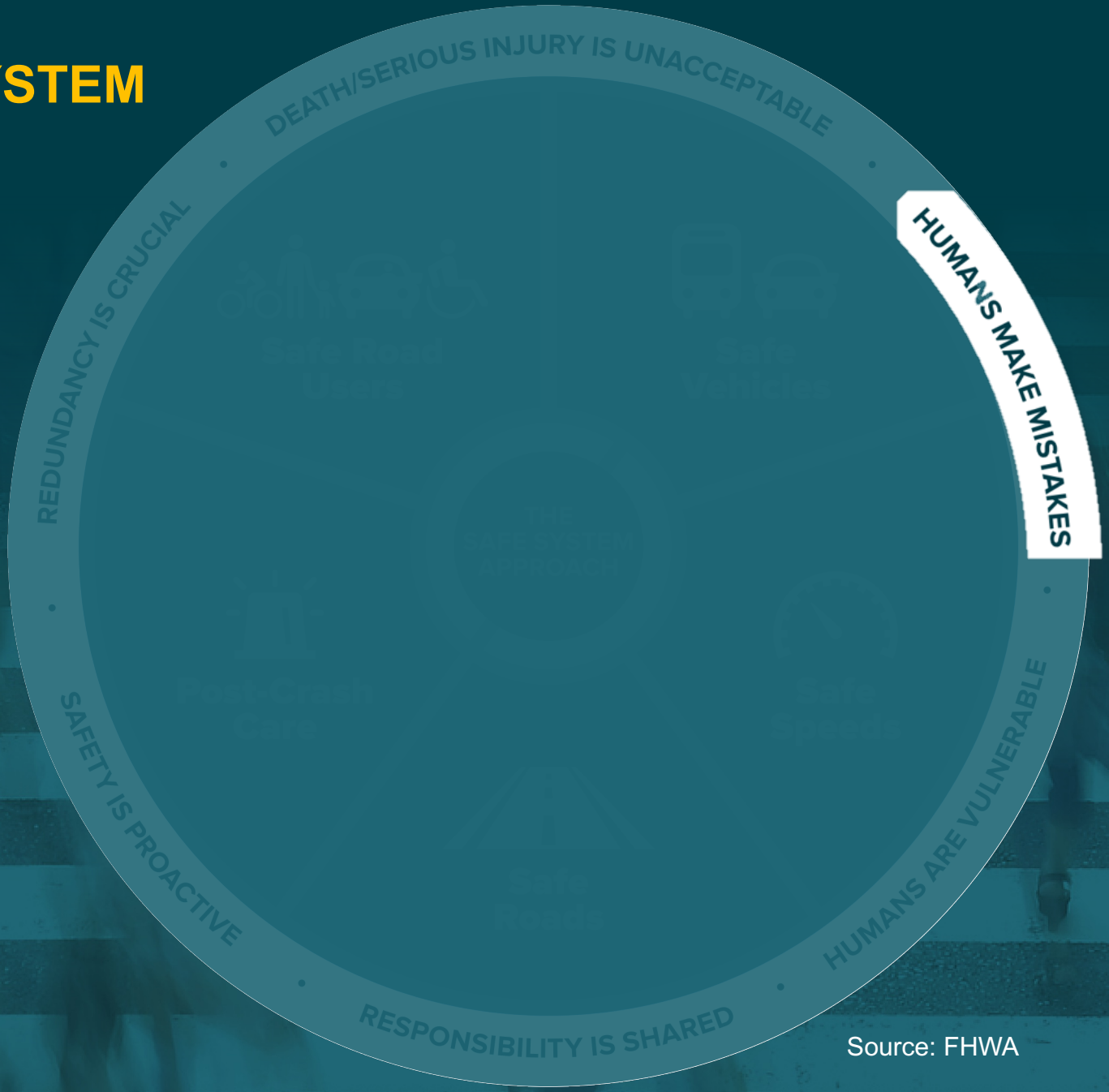

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HUMAN CENTRIC DESIGN

Humans make mistakes

What is Human Factors?

The field of human factors applies what we know about the capabilities and perceptual limitations of people to better design the environments in which they function. It is an interdisciplinary area of research that focuses on a number of real-world applications, including product design, workplace safety, ergonomics, human-machine interfaces, and transportation. The goal is to maximize performance and safety by creating products, equipment, machines, and environments that complement human capabilities.

Source: FHWA

Diverging Diamond Interchange (DDI)

Source: FHWA

Restricted Crossover U-Turn (RCUT)

Source: FHWA

Cooperative Adaptive Cruise Control (CACC)

Source: FHWA

https://highways.dot.gov/research/laboratories/human-factors-laboratory/human-factors-laboratory-overview

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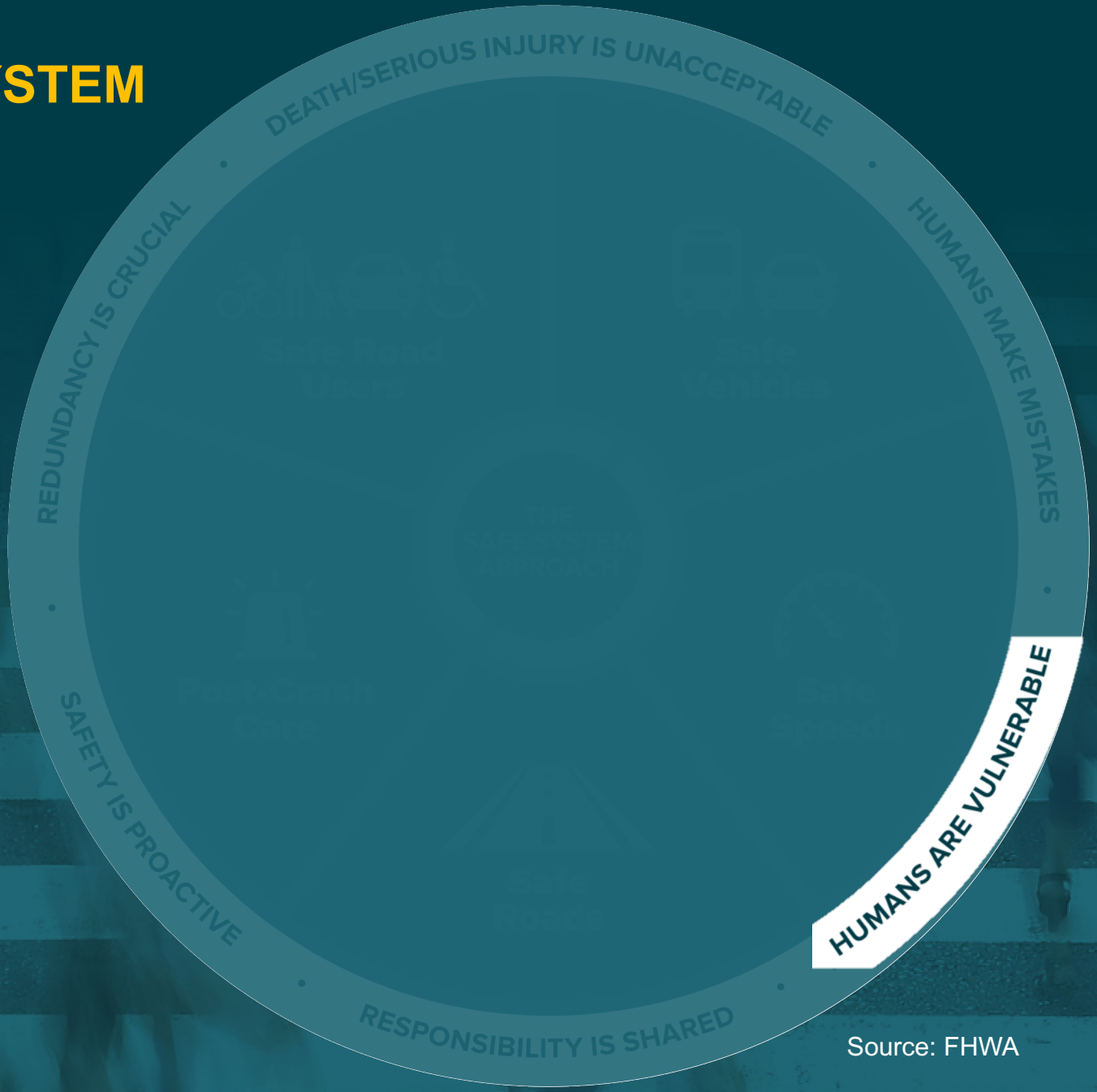

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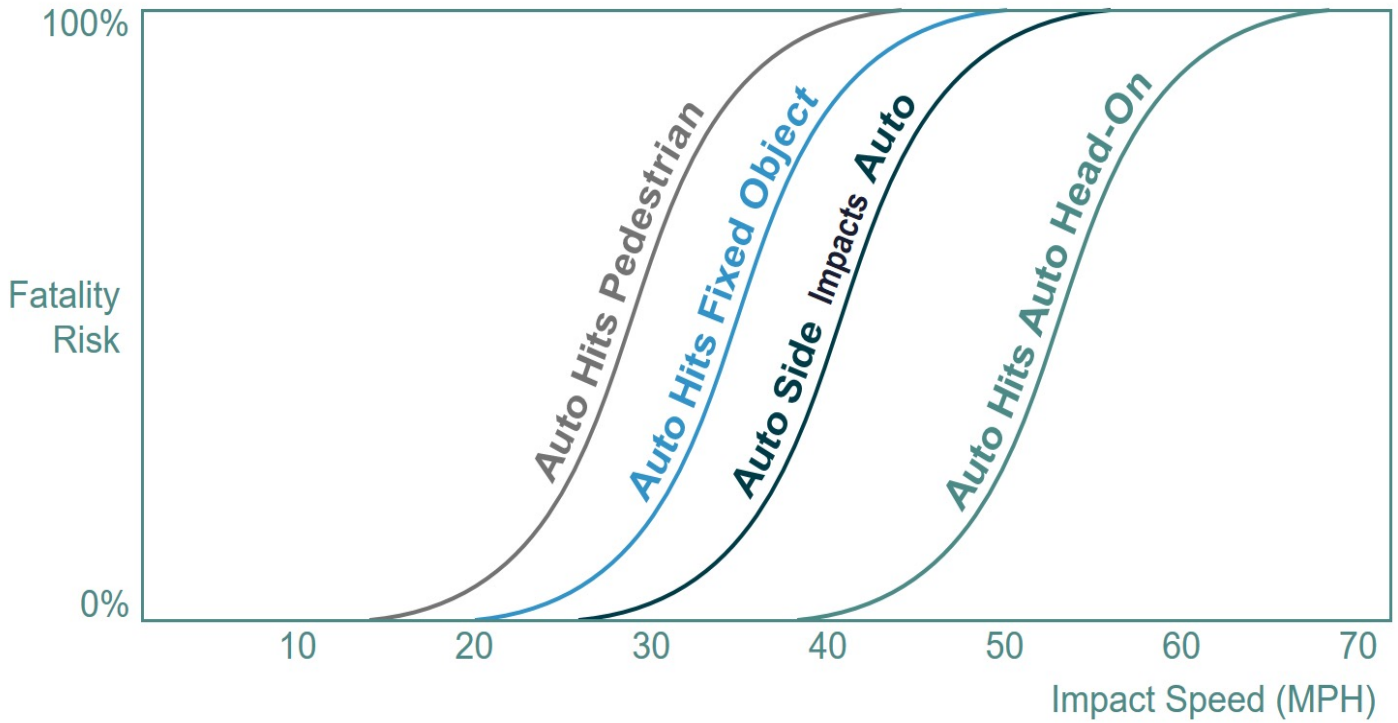
Source: FHWA

HUMANS ARE VULNERABLE

Humans are vulnerable



Designing safer roads is an exercise of managing kinetic energy

$$K = \frac{1}{2}mv^2$$

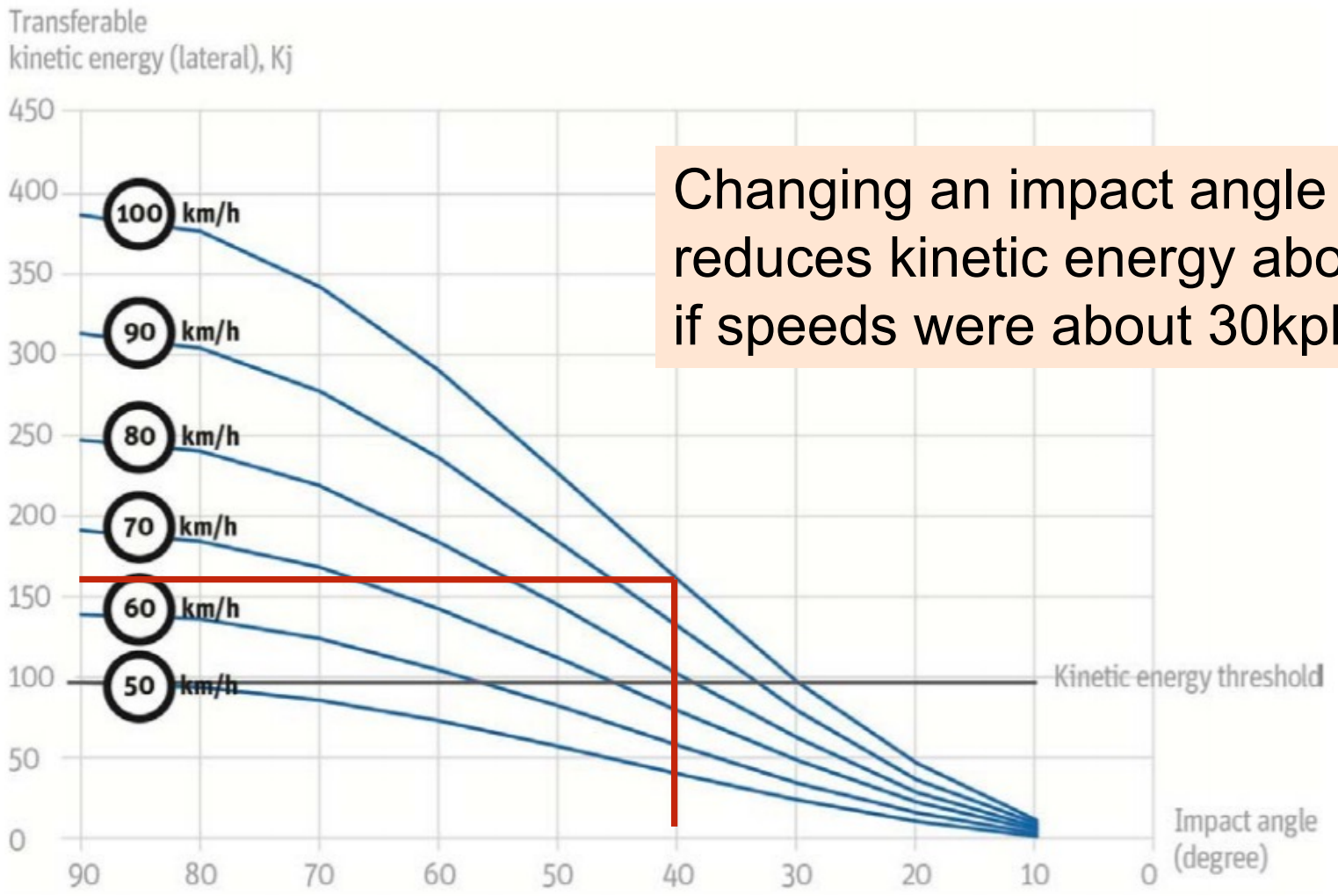
Velocity is a Vector

- Speed
- Direction (angle of impact)

Source: FHWA

Transferable Kinetic Energy (Lateral) vs Impact Angle and Travel Speed

Figure 5.11. **Influenced impact angle on transferable kinetic energy**



Changing an impact angle from 90° to 40° reduces kinetic energy about the same as if speeds were about 30kph (20 mph) less

Source: Zero Road Deaths and Serious Injuries, Leading a Paradigm Shift to a Safe System, ITF, 2016
https://www.itf-oecd.org/sites/default/files/docs/zero-road-deaths.pdf

Image derived from: https://dublinohiousa.gov/roundabouts

Example: Roundabouts vs Signalized Intersections

		
Lower Speeds	✓	
Lower Impact Angles	✓	
Fewer Conflict Points	✓	

Is this why roundabouts are so effective at reducing severe crashes?

YES !!!

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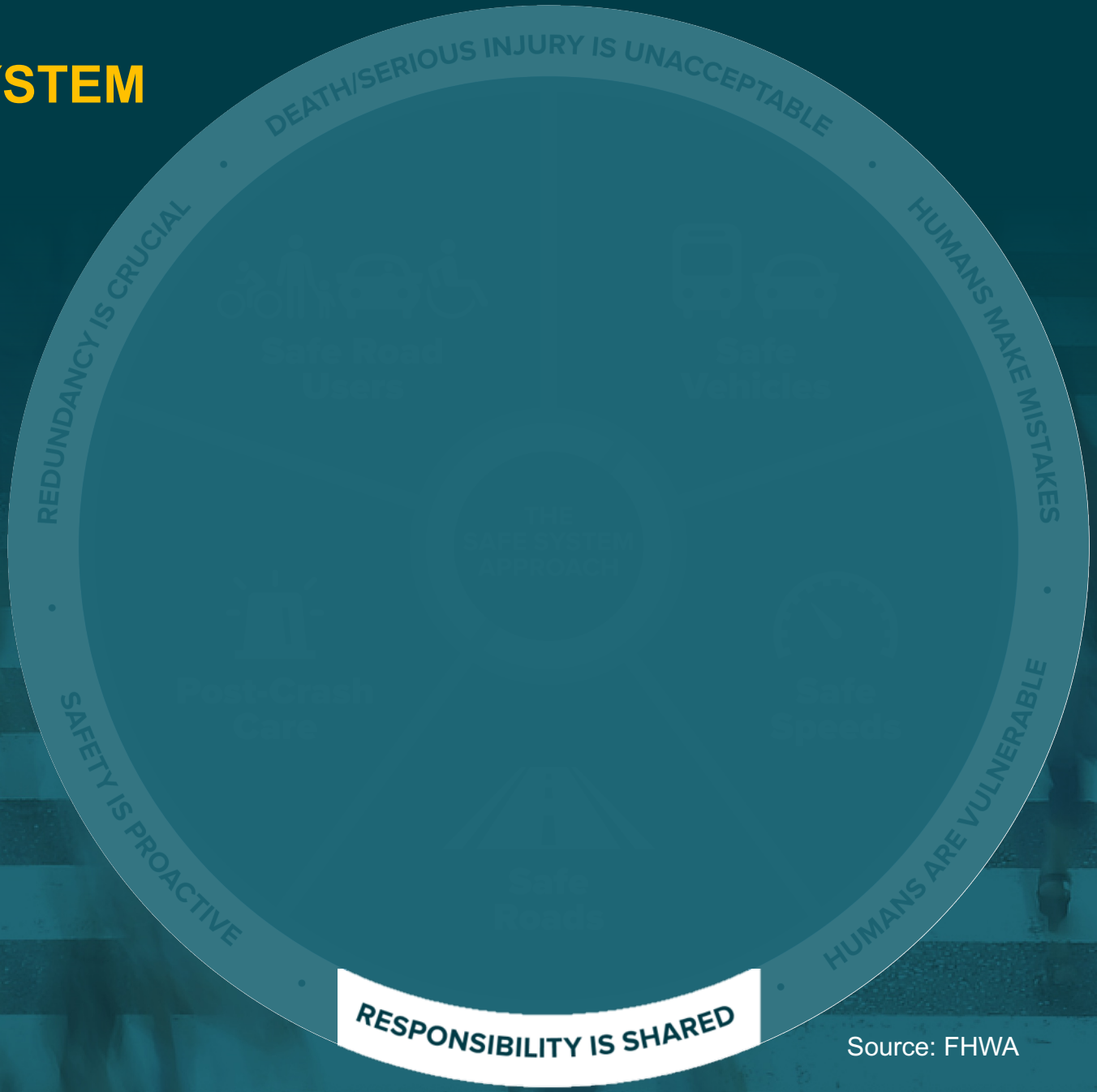


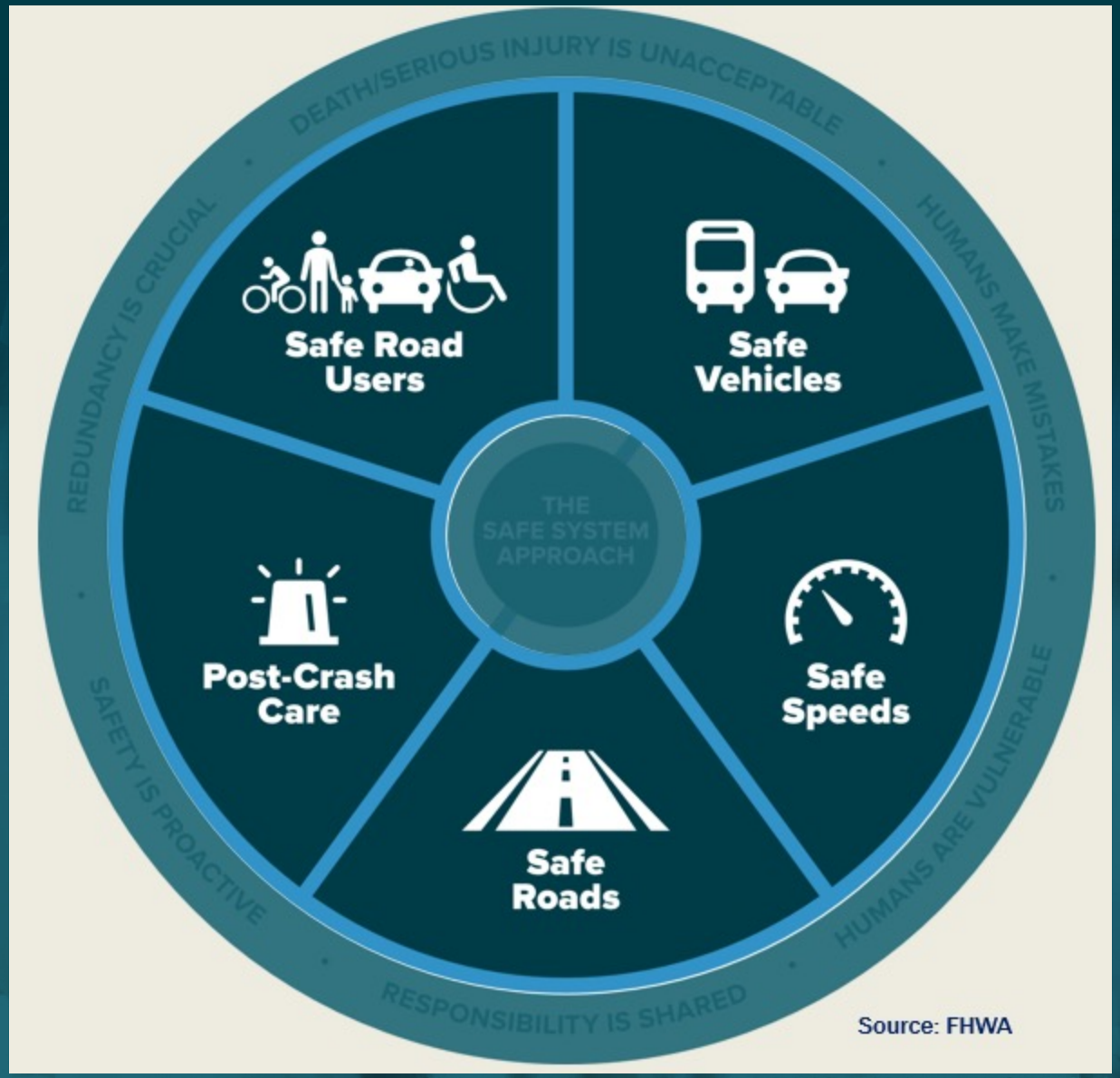
Responsibility is shared

Safety is proactive

Redundancy is crucial

Source: FHWA

Five Safe System Elements



Responsibility is shared

Implementing the Safe System approach is a shared responsibility

It cannot be achieved by engineering alone

Source: FHWA Strategic Highway Safety Plans: A Champion's Guidebook to Saving Lives, Second Edition
https://safety.fhwa.dot.gov/shsp/guidebook/ovrvw.cfm

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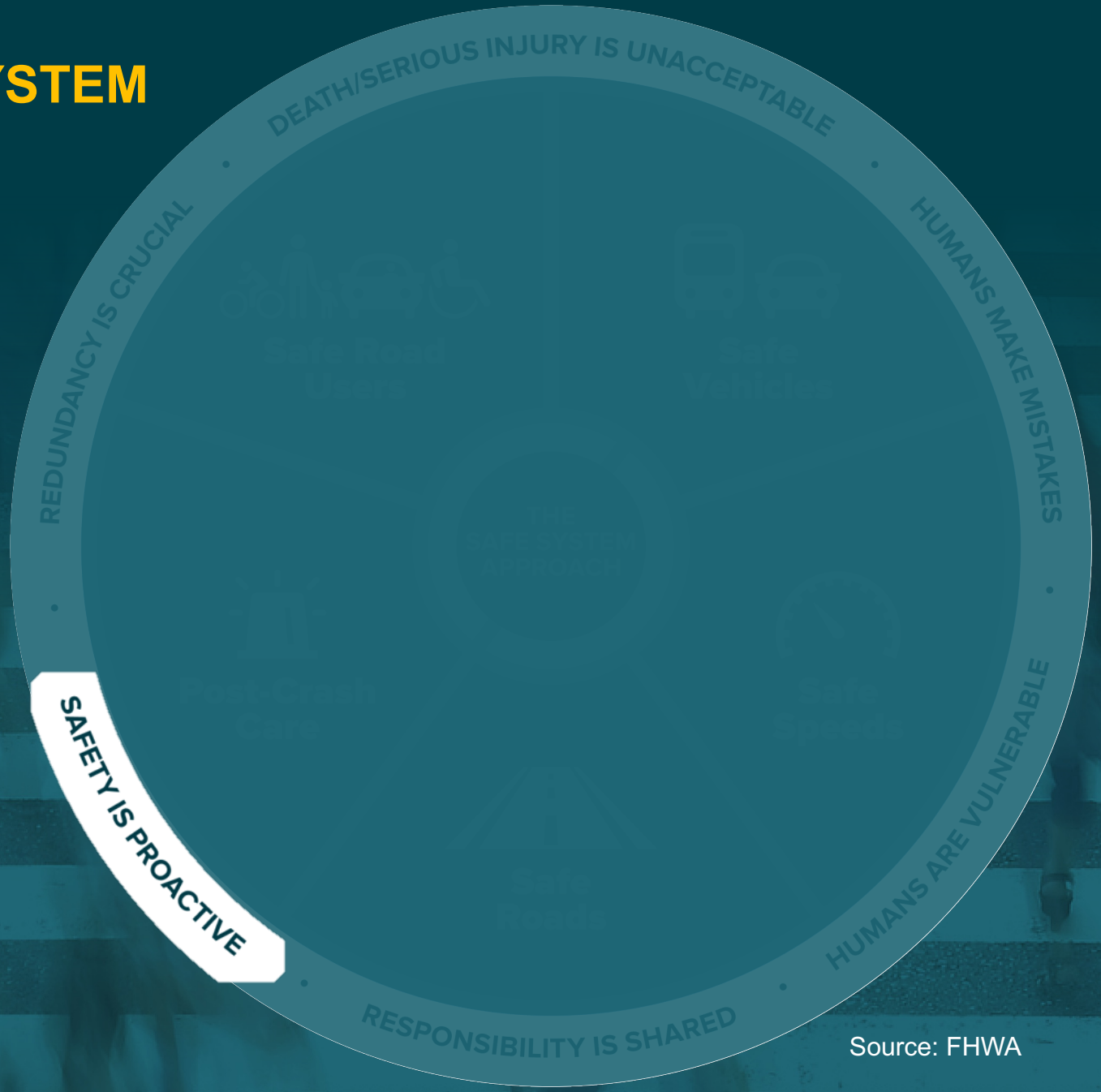

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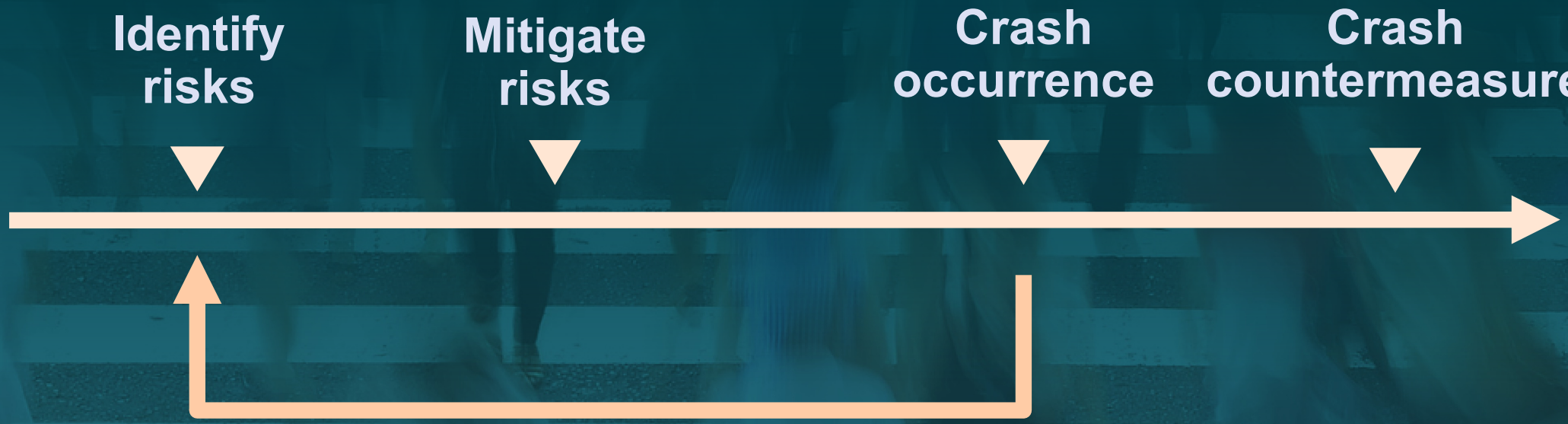
Source: FHWA

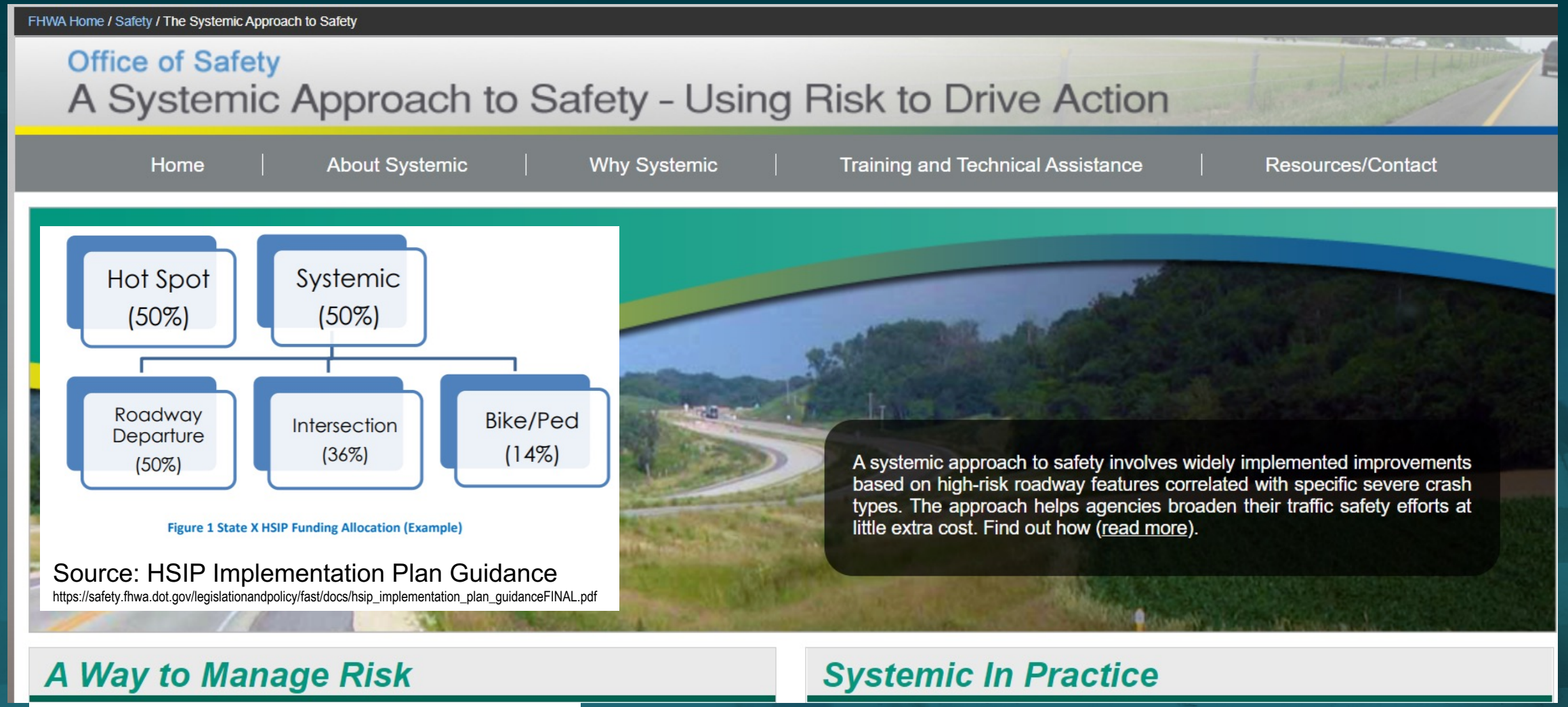
Safety is proactive



Systemic Approach - using data and roadway characteristics to identify patterns of risk and proactively implementing targeted safety measures at locations with those risk characteristics (irrespective of past collision history).

Systemic Approach

Safety is proactive



Source: HSIP Implementation Plan Guidance
https://safety.fhwa.dot.gov/legislationandpolicy/fast/docs/hsip_implementation_plan_guidanceFINAL.pdf

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

Highway Safety Improvement Program (HSIP)

The HSIP is the projects, activities, plans, and reports carried out under 23 U.S.C. 148. FHWA has developed a wide variety of resources to help States **plan** highway safety improvement projects using a performance-driven process; **implement** those projects; **evaluate** the effectiveness of past projects and **report** annually on the status of HSIP implementation efforts.

Resources

PLAN

HSIP planning includes problem identification, countermeasures selection and project prioritization. Click here for more information to support HSIP planning efforts, including systemic safety analysis.

IMPLEMENT

States must schedule and implement the highway safety improvement projects identified under planning. Click here for resources related to HSIP eligibility and HSIP obligations rates.

EVALUATE

States conduct HSIP project and program evaluations. Click here for resources to support HSIP evaluation efforts, including HSIP program assessments.

REPORT

States prepare annual reports on their progress in implementing highway safety improvement projects and the effectiveness of those projects. Click here to view those reports, as well as national summaries and information about the online reporting tool.

https://safety.fhwa.dot.gov/hsip/hsip.cfm

https://safety.fhwa.dot.gov/hsip/docs/fhwasa2018.pdf

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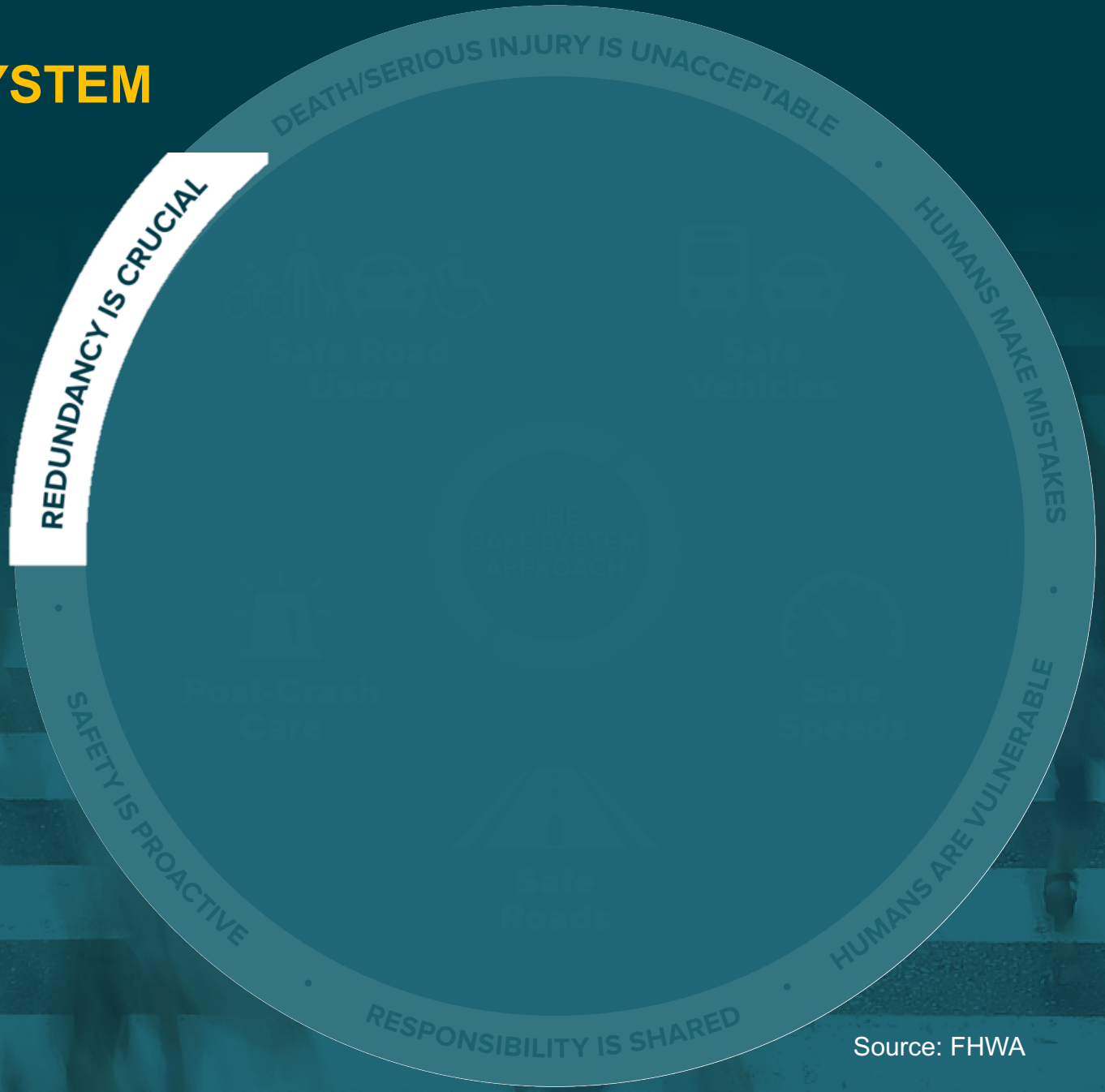

Responsibility is shared

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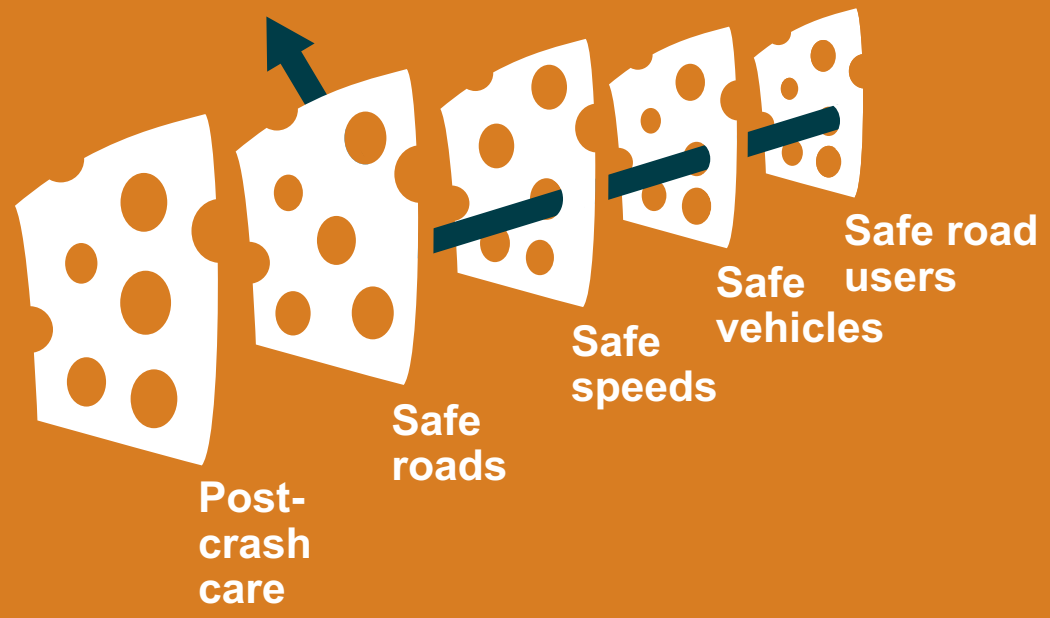
Source: FHWA

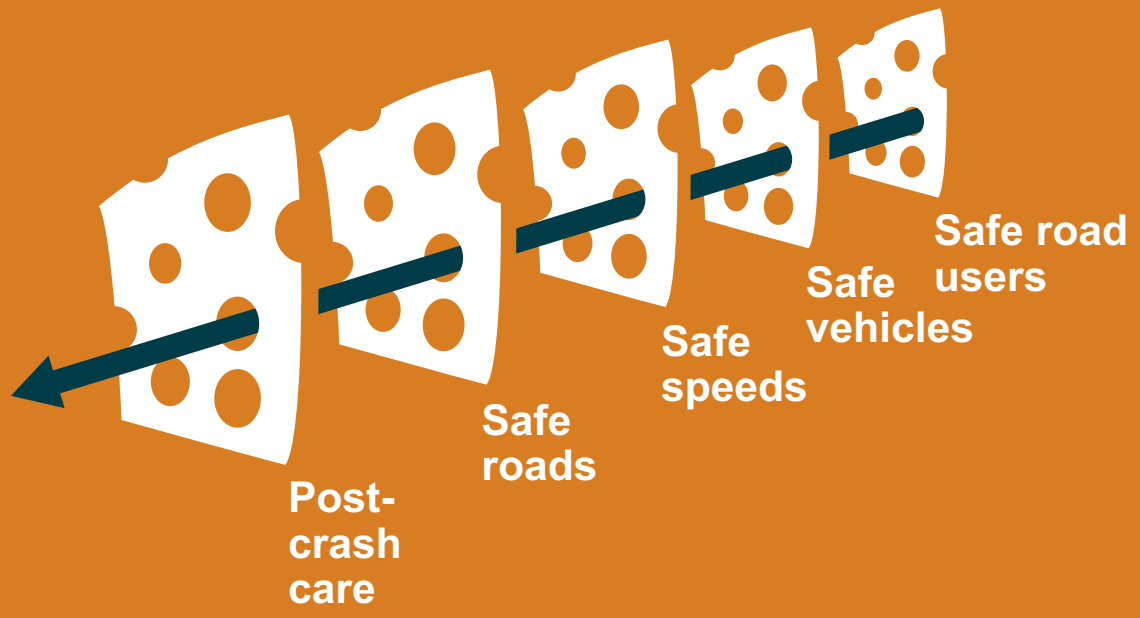
SAFE SYSTEM ELEMENTS CREATE REDUNDANCY

Redundancy is crucial

The “Swiss Cheese Model” of redundancy creates layers of protection



Death and serious injuries only happen when all layers fail



Source: FHWA

SAFE ROADS

Safe Roads

1st
AVOID
CRASH

2nd
MANAGE
CRASH
ENERGY

Avoiding crashes involves reducing the opportunity for error:

Separating users in space

Separating users in time

Increasing attentiveness and awareness

Managing crash kinetic energy involves:

Source: Fehr & Peers

Manage speed

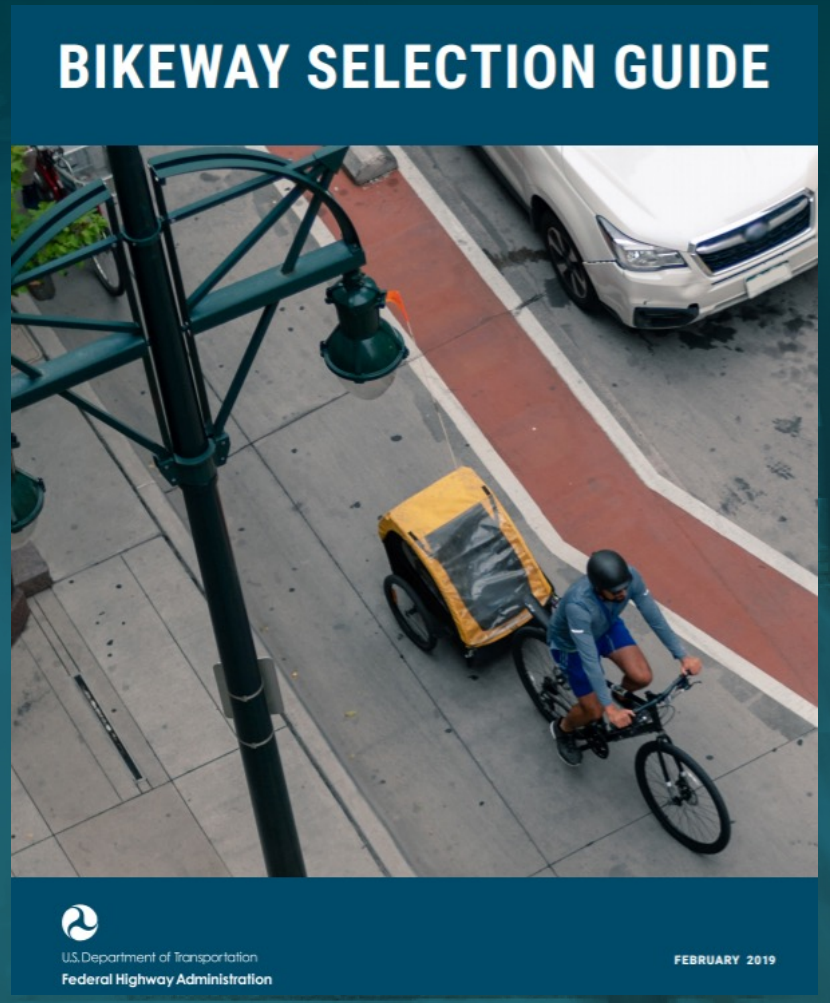
Source: City of Carmel, IN

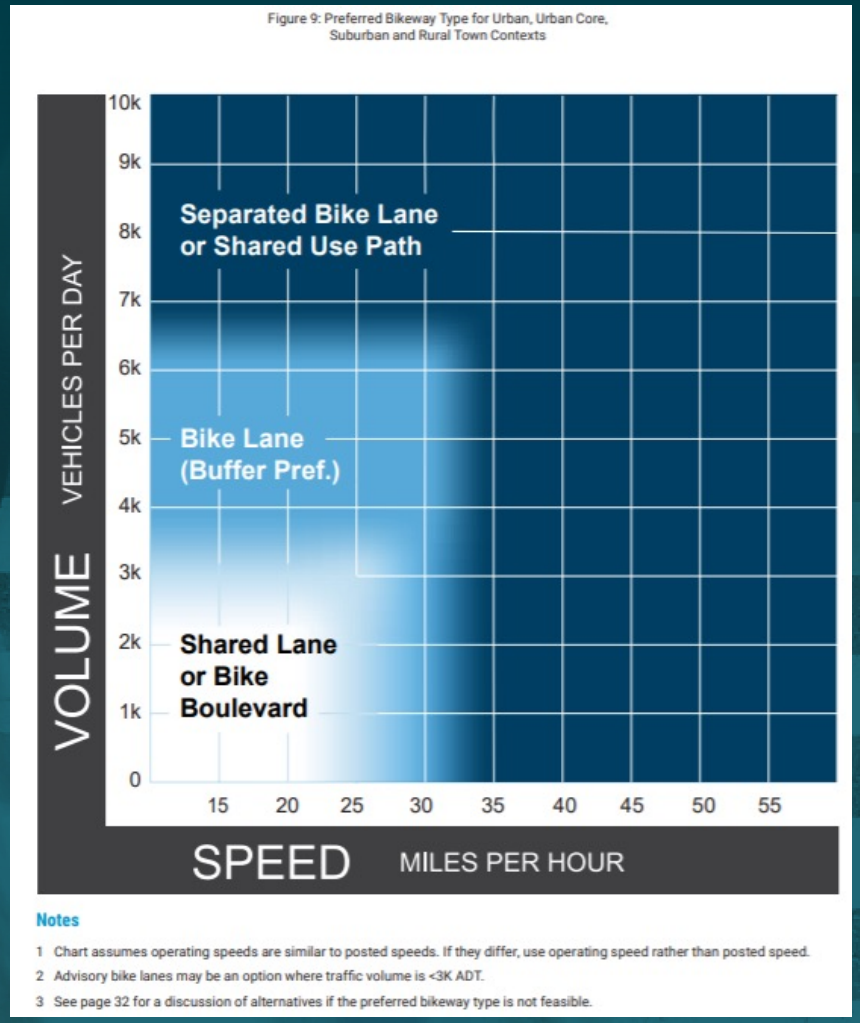
Manage impact angles

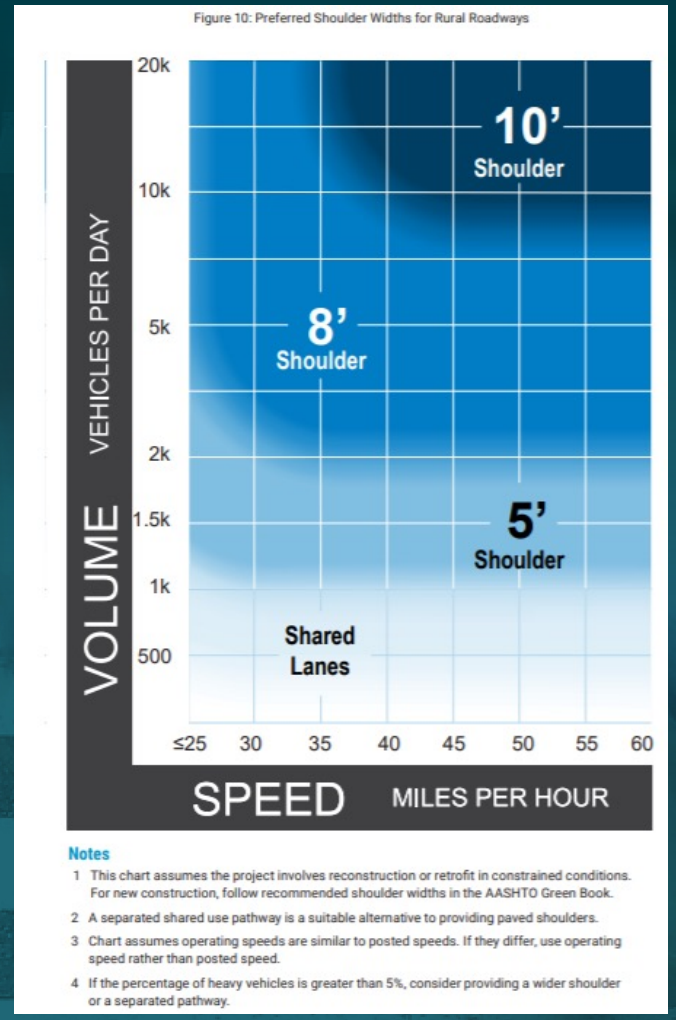
Source: Fehr & Peers

Manage impact energy distribution

Separating Users in Space







https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf

Separating Users in Time

https://safety.fhwa.dot.gov/provencountermeasures/lead_ped_int/

Proven Safety Countermeasures

Safe Roads

ROADWAY DEPARTURE


1. EnhancedDelineation and Friction for Horizontal Curves


2. Longitudinal Rumble Strips and Stripes


3. SafetyEdge$_{sm}$


4. Roadside Design Improvements at Curves


5. Median Barriers

INTERSECTIONS


6. Backplates with Retroreflective Borders


7. Corridor Access Management


8. Left-and Right-Turn Lanes at Two-Way Stop-Controlled Intersections


9. Reduced Left-Turn Conflict Intersections


10. Roundabouts


11. Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections


12. Yellow Change Intervals

PEDESTRIANS/BICYCLES


13. Leading Pedestrian Intervals


14. Medians and Pedestrian Crossing Islands in Urban and Suburban Areas


15. Pedestrian Hybrid Beacons


16. Road Diets/Reconfigurations


17. Walkways

CROSSCUTTING


18. Local Road Safety Plans


19. Road Safety Audits

20. Uslimits2

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

https://safety.fhwa.dot.gov/provencountermeasures/fhwasa18068/FHWA-SA-18-068.pdf

SAFE SYSTEM APPROACH TO INTERSECTION PLANNING & DESIGN

First step towards the development of objective analysis approaches that capture key Safe System concepts and are implementable by intersection planners and designers in the U.S.

Assessment of Exposure-Severity-Complexity

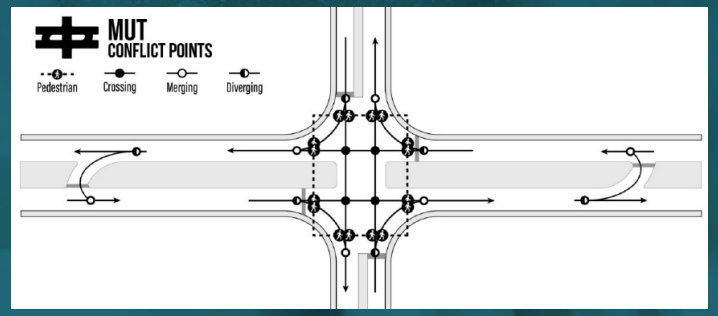
$$E_t = \sum_{i=1}^{n_t} [I_{i,t} * \mathrm{P(FSI)}_{i,t} * L_{1,i,t} * L_{2,i,t}]$$

Equation 7. Sum of exposure-severity-complexity products for all conflict points of type t.

$$SSI_t = 100 \times \exp\left(-\frac{1}{c} \times E_t\right)$$

Equation 8. SSI score for all conflict points of type t.

Conflict point severity serves as an estimate of the probability of fatality or serious injury (P(FSI))



Movement complexity considers Human Factors

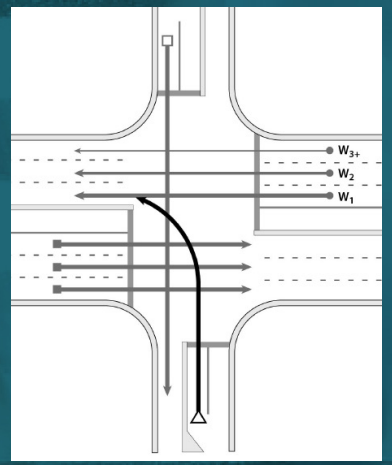


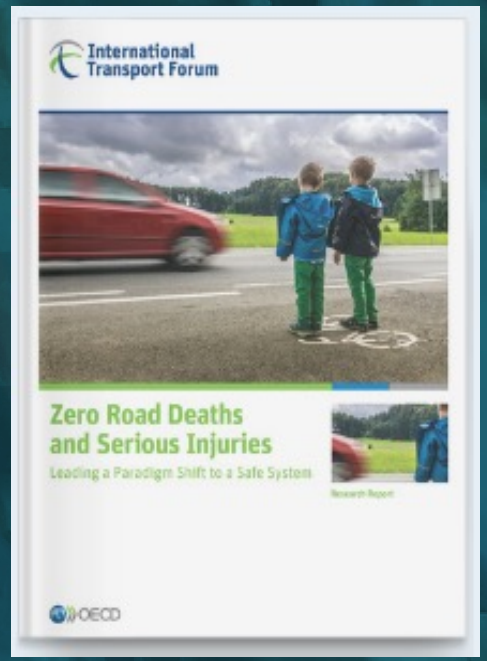
Table 19. SSI score results for Scenario 1.

Intersection Type	Intersection SSI Score	Conflict Type SSI Scores			
		Pedestrian	Crossing	Merging	Diverging
2x1 Roundabout	79	40	95	100	100
2x2 Roundabout	74	32	93	100	100
MUT	23	2	20	91	100
Signalized RCUT	15	0	69	86	100
Jughandle	7	0	4	97	100
Quadrant Roadway	6	0	1	98	100
Bowtie	5	0	2	96	100
Signalized Traditional	4	0	1	97	100
Unsignalized RCUT	4	0	59	68	100
FDLT	1	0	4	96	100
PDLT	1	0	1	94	100

Source: FHWA

Safe System Approach – What's Next?

"There is no single pathway for the adoption, establishment and implementation of a Safe System. Moving to a Safe System is a learning-by-doing process best described as a journey which presents opportunities, hazards and challenges along the way. The experiences of the pioneering countries show that each follows its own journey, shaped by the cultural, temporal, and local context, but guided by the underlying principles."



Source: Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System; OECD (2016)

http://www.oecd.org/publications/zero-road-deaths-and-serious-injuries-9789282108055-en.htm

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