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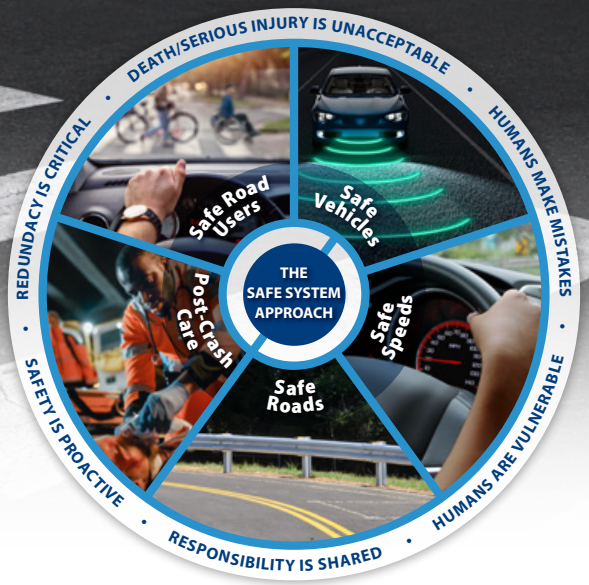

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COVERS and ABOVE—Nations around the world are adopting the Safe System Approach, with the goal of eliminating deaths and serious injuries on roadways. Here in the United States, the Safe System Approach is beginning to be implemented to improve safety for all Americans. The Approach looks at five elements of a safe transportation system: Safe Roads, Safe Speeds, Safe Vehicles, Safe Road Users, and Post-Crash Care.

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A Promising Future

Source: FHWA.

In 2020, the number of people killed on our Nation's roadways was the highest since 2007, and early estimates of fatalities for the first half of 2021 reflect the largest six-month increase in fatalities ever. Similarly, over the past decade, the proportion—and number—of fatalities occurring *outside* a vehicle dramatically increased. Given these increases, countless families and friends have suffered the unimaginable loss of loved ones to traffic-related crashes. These troubling trends have prompted transportation professionals to begin reexamining their approach to safety.

This unacceptable loss of life highlights the limitations of our traditional transportation strategies and emphasizes that our approach to roadway safety must change. At the Federal Highway Administration, we are pivoting to the Safe System Approach—an internationally recognized and successful practice that sets an ethical imperative that no one should die or be seriously injured on roadways. The Safe System Approach centers on humans, regardless of their mode of travel, and requires proactively building redundant layers of protection. The human body is vulnerable; as such, there is only so much kinetic energy transfer it can withstand. Under the Safe System Approach, the transportation network is designed and operated in a way that minimizes serious injuries and fatalities in crashes.

Particularly troubling is the dramatic increase in the number of pedestrians killed by motor vehicles. These fatalities have increased over the last decade by approximately 50 percent. Moreover, research shows that people walking in lower-income areas are more likely to be struck and killed than people walking in higher-income neighborhoods. Similarly, studies have demonstrated that persons with disabilities, racial minorities, gender minorities, children, older adults, and other underserved communities are at a higher risk of dying or being injured in a crash. They also have less access to affordable, quality, and accessible transportation choices. Because of these increased risks, the topics of both equity and pedestrian safety are intertwined in many of the articles within this issue.

The Safe System Approach also stresses that safety is everyone's responsibility (even if the word "safety" isn't in our job title). The Safe System Approach offers a promising future; imagine a world where no one dies from vehicle crashes. Tested and proven strategies in engineering countermeasures hold much promise to save lives and prevent serious injuries. Notably, results from Australia, Sweden, and Norway—early adopters of Safe System approaches—show that fatalities on our roadways *can* be prevented. You can read more about the Safe System Approach in "Making our Roads Safer through a Safe System Approach" (on page 3).

This special issue of *Public Roads* also elaborates on FHWA's efforts to integrate the Safe System Approach into our portfolio to comprehensively address safe roads and safe speeds (see "The Highway Safety Improvement Program: Paving the Road to a Safer Future" on page 8). Our partners at the National Highway Traffic Safety Administration—with whom we work closely to advance the Safe System Approach—detail their work in addressing safe vehicles, road users, and post-crash care (on page 18). We highlight Safe System examples from States and cities as well as international partners (on pages 30 and 36, respectively). Finally, the issue provides insight into "Speed Management Is Key to Road Safety" (on page 24) and the Hot Topic focuses on "Bringing Human Factors Research Into the Next Era" (on page 2).

By embracing the Safe System Approach, we are embracing a safer and brighter future on our roadways.

Cheryl J. Walker
Associate Administrator for Safety
Federal Highway Administration

Bringing Human Factors Research Into the Next Era

by **JESSE EISERT** and **MICHELLE ARNOLD**

Current model of the Highway Driving Simulator.
Source: FHWA.

The Human Factors team is in the process of expanding its research capabilities and tools in an effort to ensure that the Federal Highway Administration (FHWA) remains on the cutting edge of research. This expansion will be achieved via four unique mechanisms: the Highway Driving Simulator (HDS) Virtual System Upgrade, the Virtual Reality (VR) Lab Upgrade, the HDS and CARMA℠ Integration, and the development of Connected Simulation.

The mission of the Human Factors team is to further the understanding of highway user needs so that those needs can be incorporated into roadway design, construction, repair, and improvement. Because the American highway system is constantly evolving, it is imperative that the team's research tools evolve so that the team can accurately study this system.

HDS Virtual System Upgrade

Currently, the Human Factors teams' HDS is running on seven-year-old software and hardware—a lifetime in technology years. One of the most important upgrades being made to the HDS is the installation of 4k projectors. These new projectors and visual system upgrades will help keep the HDS at the front of cutting-edge research by improving its overall immersion, scenario realism, and its accuracy surrounding real-world simulations. These new upgrades will also meet the requirements of modern and developing automated system technologies.

HDS and CARMA Integration

Another upgrade in development is the integration of the HDS into the CARMA platform. By merging the HDS with the capabilities of the CARMA platform, the Human Factors team anticipates new, game-changing potentialities. This incorporation will provide opportunities for the Human Factors team's HDS studies to utilize real-world automated vehicle models, to combine on-road and simulation-based testing of various scenarios, and to study the requirements for new automated systems.

For more information about CARMA, please visit *https://www.fhwa.dot.gov/publications/publicroads/19autumn/hottopic.cfm*.

Aerial view of the VR world from within the VR Lab.
Source: FHWA.

VR Laboratory Upgrade

The first considerable modification in renovating the Human Factors teams' VR Lab is its relocation to a larger area that allows for more space for virtual simulation—physical space is integral to creating authentic, immersive experiences. The Human Factors team is also switching to a next generation VR headset that will allow for eye tracking, increased resolution and frame rate, and mixed reality. And the Human Factors team is working on upgrading some of the lab's peripherals into an omni-directional treadmill and a VR bike to allow for even more flexibility in scenario and research testing.

HDS and VR Lab Connected Simulations

Lastly, the Human Factors team is working toward developing a distributed simulation in which the HDS and VR Lab will be integrated into a shared simulation. Although in its early stages, this intriguing technology will allow for the testing of highly complex scenarios with real participants in a safe setting.

As FHWA moves into the next decade, the Human Factors team is hard at work to ensure it continues to lead the charge when it comes to understanding how users of our roadways interact with one another. These new research tools and capabilities will help further the Human Factors teams' knowledge and understanding.

JESSE EISERT leads various human factors research at FHWA including automation and how it interacts with vulnerable road users. He received his Ph.D. in psychology from George Mason University.

MICHELLE ARNOLD leads a variety of human factors research and manages the FHWA highway driving simulator laboratory contract. She received her Ph.D. in psychology from Western Michigan University.

For more information, see *https://highways.dot.gov/research/laboratories/human-factors-laboratory/human-factors-team-members* or contact Jesse Eisert, 202-493-3284, *Jesse.Eisert@dot.gov* or Michelle Arnold, 202-493-3990, *Michelle.Arnold@dot.gov*.

MAKING OUR ROADS SAFER

through a Safe System Approach

The United States is beginning to adopt a Safe System Approach to address roadway safety challenges.

Source: FHWA.

"FHWA has a vision of working towards zero deaths on our Nation's roads, along with many of our partners and stakeholders. To make this vision a reality, we are revitalizing our safety program with the adoption of the Safe System Approach."

– Cheryl Walker, Associate Administrator for Safety, FHWA.

by **MARK DOCTOR** and **CHIMAI NGO**

Achieving the vision of eliminating deaths and serious injuries from the Nation's roads may seem daunting with traffic fatalities in the United States stubbornly remaining between 32,000 and 39,000 annually for more than a decade. To make meaningful progress, changes are needed in how to think about the traffic safety problem and the approaches to solve the problem. The Safe System Approach is being applied with great success in a growing number of nations and cities around the world and has now taken hold in the United States.

The Safe System Approach has origins in Sweden through its Vision Zero program and with the Sustainable Safety program in the Netherlands. These early adopters experienced impressive decreases in road traffic fatalities—each with at least a 50-percent reduction in fatalities between 1994 and 2015. The concept has spread to other countries in Europe and beyond with notable success in Australia and New Zealand.

> The Safe System Approach requires a culture that places safety first and foremost in road system investment decisions.

In comparison, fatalities in the United States decreased by less than 13 percent during the same 1994–2015 period. International success with the Safe System Approach gives promise that the United States may also be able to achieve similar positive safety outcomes. With growing momentum and initiatives being taken by agencies across the country, the United States has started on the journey toward implementing a Safe System.

The vision of eliminating fatalities and serious injuries on the Nation's roads are shared through such parallel initiatives as Vision Zero, Toward Zero Deaths, and Road to Zero. All three efforts acknowledge the importance of implementing the Safe System Approach in different contexts. With Vision Zero, local communities are applying the Safe System Approach with a focus on safe mobility for all road users, especially those in the underserved communities. The Vision Zero Network is working with communities committed to reaching their Vision Zero goals. Many State agencies have adopted zero-deaths goals in their Strategic Highway Safety Plans (SHSP), using

the Safe System framework from the report *Toward Zero Deaths: A National Strategy on Highway Safety*. The American Association of State Highway and Transportation Officials (AASHTO) has been leading Toward Zero Deaths efforts since 2009. A third effort, the Road to Zero Coalition, under the leadership of the National Safety Council, also identified as a main initiative the need to prioritize safety by adopting a Safe System Approach and to create a positive safety culture.

Safe System Approach Principles and Elements

The Safe System Approach starts with a mindset that it is unacceptable to allow deaths and serious injuries to occur on the roads. It also acknowledges that road users are human beings and that humans will inevitably make mistakes. On the roads, those mistakes may lead to crashes. The goal of "zero" is to eliminate fatal and serious injuries, not to eliminate crashes. This is a very important distinction for understanding how the road safety problem is viewed under the Safe System Approach.

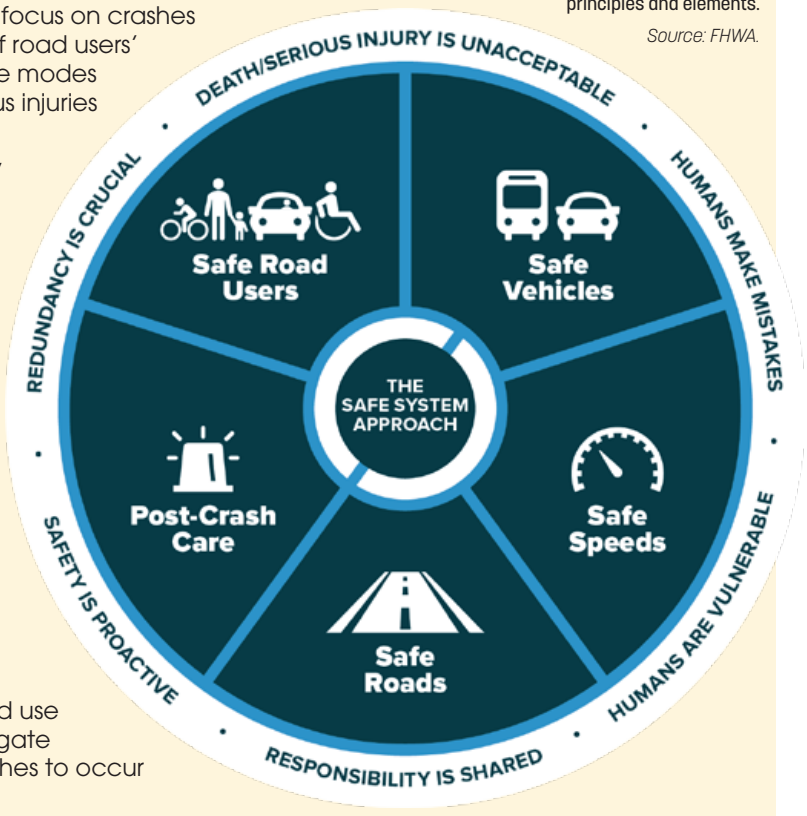
To achieve zero deaths and serious injuries, when crashes do happen, they must be managed so that the kinetic energy exchange on the human body is kept below the tolerable limits for serious harm to occur. This important principle is at the core of applying a Safe System Approach in designing and operating the road system. Human error is to be expected so the road infrastructure and vehicle technology must be designed and operated so that deaths and serious injuries are engineered out. This may be achieved first by reducing the risk of error occurring and secondly by keeping collision forces on the human body within tolerable levels, when crashes do occur, by managing speed and crash angles to reduce injury severity.

The Safe System Approach considers five elements of a safe transportation system—safe road users, safe vehicles, safe speeds, safe roads, and post-crash care—in an integrated and holistic manner. Achieving zero traffic deaths and serious injuries requires strengthening all five elements. A Safe System cannot be achieved without all five elements working in synergy. Within a Safe System Approach, weaknesses in one element may be compensated for with solutions in other areas. A true systems approach involves optimizing across all the elements to create layers of protection against harm on the roads.

- Safe Road Users—The safety of all road users is equitably addressed, including those who walk, bike, drive, ride transit, or travel by other modes.
- Safe Vehicles—Vehicles are designed and regulated to minimize the frequency and severity of collisions using safety measures that incorporate the latest technology.
- Safe Speeds—Humans are less likely 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 transportation infrastructure to accommodate human mistakes and injury tolerances can greatly reduce the severity of crashes that do occur.

Six Foundational Principles for Understanding and Applying the Safe System Approach:

- **Deaths and serious injuries are unacceptable**—While no crashes are desirable, the Safe System Approach emphasizes a focus on crashes that result in death and serious injuries. Regardless of road users' socio-economic backgrounds, their abilities, and the modes they use, no one should experience deaths or serious injuries when using the transportation system.
- **Humans make mistakes**—Road users will inevitably make mistakes, and those mistakes can lead to crashes. The Safe System Approach expects the road system be planned, designed, and operated to be forgiving of inevitable human mistakes, so that serious injury outcomes are unlikely to occur.
- **Humans are vulnerable**—Humans have limited ability to tolerate crash impacts before harm occurs. Although the exchange of kinetic energy in collisions among vehicles, objects, and road users has multiple determinants, applying the Safe System Approach involves managing the kinetic energy of crashes to avoid serious injury outcomes.
- **Responsibility is shared**—All stakeholders (transportation system users and managers, vehicle manufacturers, etc.) must work collaboratively to ensure that crashes don't lead to fatal or serious injuries.
- **Safety is proactive**—Transportation agencies should use proactive and data-driven tools to identify and mitigate latent risks in the system, rather than waiting for crashes to occur and reacting afterwards.
- **Redundancy is crucial**—Reducing the risk of severe crash outcomes requires all parts of the system to be strengthened, so that if one element fails, the others still protect road users.



The Safe System Approach principles and elements.

Source: FHWA.

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—People who are injured in collisions rely on emergency first responders to quickly locate and stabilize their injuries and transport them to medical facilities. Post-crash care also includes forensic analysis at the crash site, traffic incident management, and other activities.

Providing a Safe System for All

Progressing with implementation of a Safe System requires equitable solutions. By examining road safety data with correlations to community sociodemographic characteristics, many agencies have found that higher risks of crash deaths are concentrated in lower-income neighborhoods where exposure to traffic may be higher and past investments in safety programs and infrastructure may be lower. Prioritizing these communities for implementation of the Safe System Approach can offer substantial safety improvements and close the gap between risk in well-invested and underserved neighborhoods.

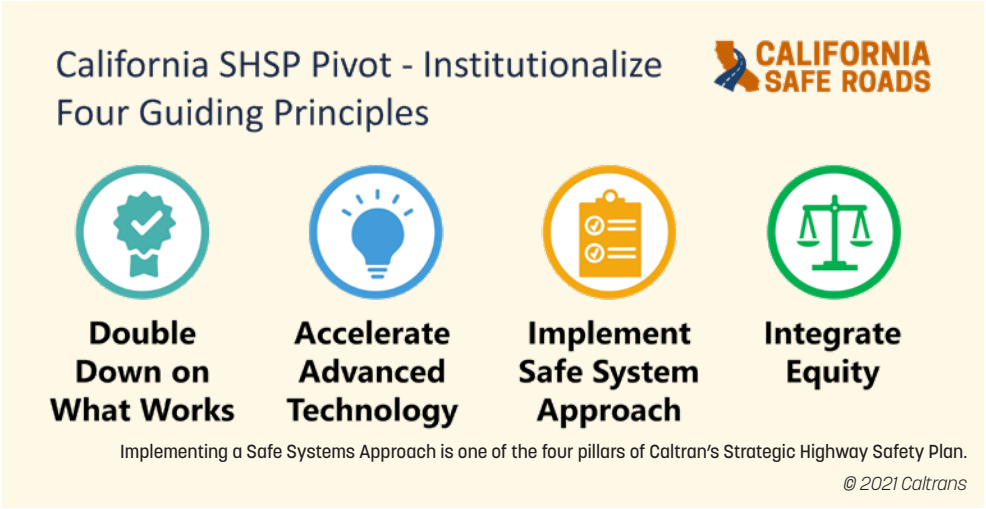
"Centering equity within Vision Zero efforts is vitally important and timely," says Leah Shahum, founder and executive director of the Vision Zero Network. "Communities across the country are struggling with social, racial, and economic inequities, including disparities within the transportation realm. Low-income communities and communities of color often bear a disproportionate burden of traffic-related injuries and fatalities. We cannot reach zero traffic deaths without addressing issues of equity."

Notable Safe System Practices: California, Florida, and Washington

Numerous transportation agencies across the United States have already begun to implement and institutionalize Safe System principles. While these agencies are at different stages of implementation, they all have pivoted to this approach with the goal of making positive and significant differences in safety. Three such States are highlighted here. Other articles in this issue of *Public Roads* will further detail these efforts.

To integrate the Safe System Approach at the program level, the California Department of Transportation (Caltrans) introduced a new safety paradigm in 2020. The agency established the new Division of Safety Programs and incorporated four safety-focused initiatives or pillars into its SHSP. One of the pillars calls for implementation of a Safe System Approach. The institutional commitment to the Safe System Approach has been the foundation for many positive cultural and programmatic changes within the agency, one of which is the establishment of the Pedestrian Systemic Safety Improvement Program that had been started as a pilot in 2016. The program integrates Safe System elements and principles into a systemic approach to further the goal of zero deaths.

"Caltrans has adopted the Safe System Approach and is institutionalizing it department-wide as part of our new approach to safety," says Rachel Carpenter, the chief safety officer for Caltrans. "Our updated Strategic Management Plan reflects our commitment to the Safe System Approach and we are actively working to incorporate Safe System principles and elements across all divisions and the entire project lifecycle."



Implementing a Safe Systems Approach is one of the four pillars of Caltran's Strategic Highway Safety Plan.

© 2021 Caltrans

The Florida Department of Transportation (FDOT) and its safety partners work toward their Vision Zero goal of zero fatalities and serious injuries through the State SHSP, which serves as the overall framework of efforts and activities to improve safety toward that ultimate goal. Florida's 2021–2025 SHSP introduced the Safe System Approach to address safety in an integrated manner with a collective commitment of time, talent, and resources to new priorities, strategies, and enhanced partnerships. Because Florida experienced a 27-percent increase in fatalities at intersections between 2015 and 2019, intersections are identified as an emphasis area within the SHSP. Among the focused strategies identified in the SHSP is the systematic use of Intersection Control Evaluations to implement innovative designs such as roundabouts and reduced left-turn conflict intersections on projects that offer opportunities to make intersection improvements.

Alan El-Urfali, the State traffic services program engineer for FDOT, says, "Including the Safe System for intersections assessment framework into our Intersection Control Evaluation process can help inform designers on better intersection design choices that proactively take steps to reduce fatal and serious crashes at intersections."

The Washington State Department of Transportation (WSDOT) recognized that to achieve its zero-deaths goal, appropriate policies must be in place to implement a Safe System Approach throughout the planning, programming, design, and operations sections of its department. WSDOT leverages its SHSP and Target Zero efforts to align Safe System principles across discipline areas and provide direction throughout capital and operational program elements. WSDOT changed the safety subprogram to emphasize proactive safety projects; 70 percent of its funds are targeted towards the crash prevention category.

"Adopting a Safe System Approach led WSDOT to change its philosophy to focus on fatal and serious rather than all crashes," says John Milton, the State safety engineer at WSDOT. "Our focus also shifted to managing kinetic energy and addressing safe speeds through data-driven and performance-based approaches that incorporate using context-sensitive design."

This philosophical shift has resulted in many positive changes, among which are updated safety policies and associated budget programing, the creation of the Active Transportation division to recognize all transportation modes, updated design and traffic manuals to incorporate context-sensitive design and operations, a draft policy framework for injury minimization through speed management that serves as a model for any jurisdiction in the State, incorporation of safety for all modes in the new Transportation Systems Management and Operations plan currently under development, and incorporation of Level of Traffic Stress metrics for active transportation in its definition of asset conditions to be used in programming preservation funds.

One Death is Too Many: Portland, OR

The city of Portland, OR, committed to Vision Zero when the city council unanimously passed a resolution in June 2015 and adopted a Vision Zero Action Plan in December 2016. Portland's reputation as a walkable, bikeable, and livable city was strong motivation to address a rise in the percentage of pedestrian deaths and steady percentage of bicycle deaths. Data indicated that while pedestrian trips account for about 9 percent of all trips in Portland, pedestrians were nearly one-third of the traffic-related deaths.

Portland's Vision Zero Action Plan also recognizes the need for working toward equitable communities and prioritizing infrastructure investments on the most dangerous streets in traditionally underinvested communities. Using a data-driven approach, Portland was able to identify that although deadly or serious injury crashes can happen anywhere, more of them happen on certain street types. Wide, fast arterials with multiple lanes in each direction had a disproportionate number of traffic deaths. Also, many of the streets went through lower-income neighborhoods where people rely heavily on walking and transit. In Portland, more than half of deadly crashes occurred on just 8 percent of city streets. Improving this identified "high-crash network" is a central element of Portland's Vision Zero strategy.

A fundamental principle of the Safe System Approach is that people make mistakes. Impairment, speeding, distracted driving, aggressive driving—these are all discouraged behaviors and the Portland Vision Zero Action Plan includes coordinated actions to deter them. But the plan also acknowledges the role that street design plays to encourage and enable safe behaviors. Streets should discourage unsafe driving by design. Safer street designs can

Portland, OR, is known as a walkable and bikeable city, so its Vision Zero Action Plan includes a focus on safety and equity for all road users.

© Portland Bureau of Transportation.

slow down traffic, provide visual cues that make it clear when different user groups share the space, and when needed, provide separation between the user groups when vehicular operating speeds are incompatible for sharing space with other users. Adhering to these design principles keep all people safer—even when they make mistakes.

With Portland's data indicating a disproportionate number of pedestrian deaths, slowing vehicular speeds is a critical part of the city's Vision Zero plan. A person's chances for surviving a crash increase dramatically with lower speeds. A pedestrian struck by a person driving at 40 miles (64 kilometers) per hour is 8 times more likely to die than one struck at 20 miles (32 kilometers) per hour. Managing speed is critical, and Portland has taken action by setting appropriate speed limits, designing streets to support safe speeds, and operating safety camera programs to enforce speed limits.

The Portland Vision Zero Action Plan recognizes that improving safety requires a suite of actions spanning policy, infrastructure, education, and enforcement. This aligns closely with the Safe System principles of shared responsibility and having redundancy in the system.

What's Ahead of Us?

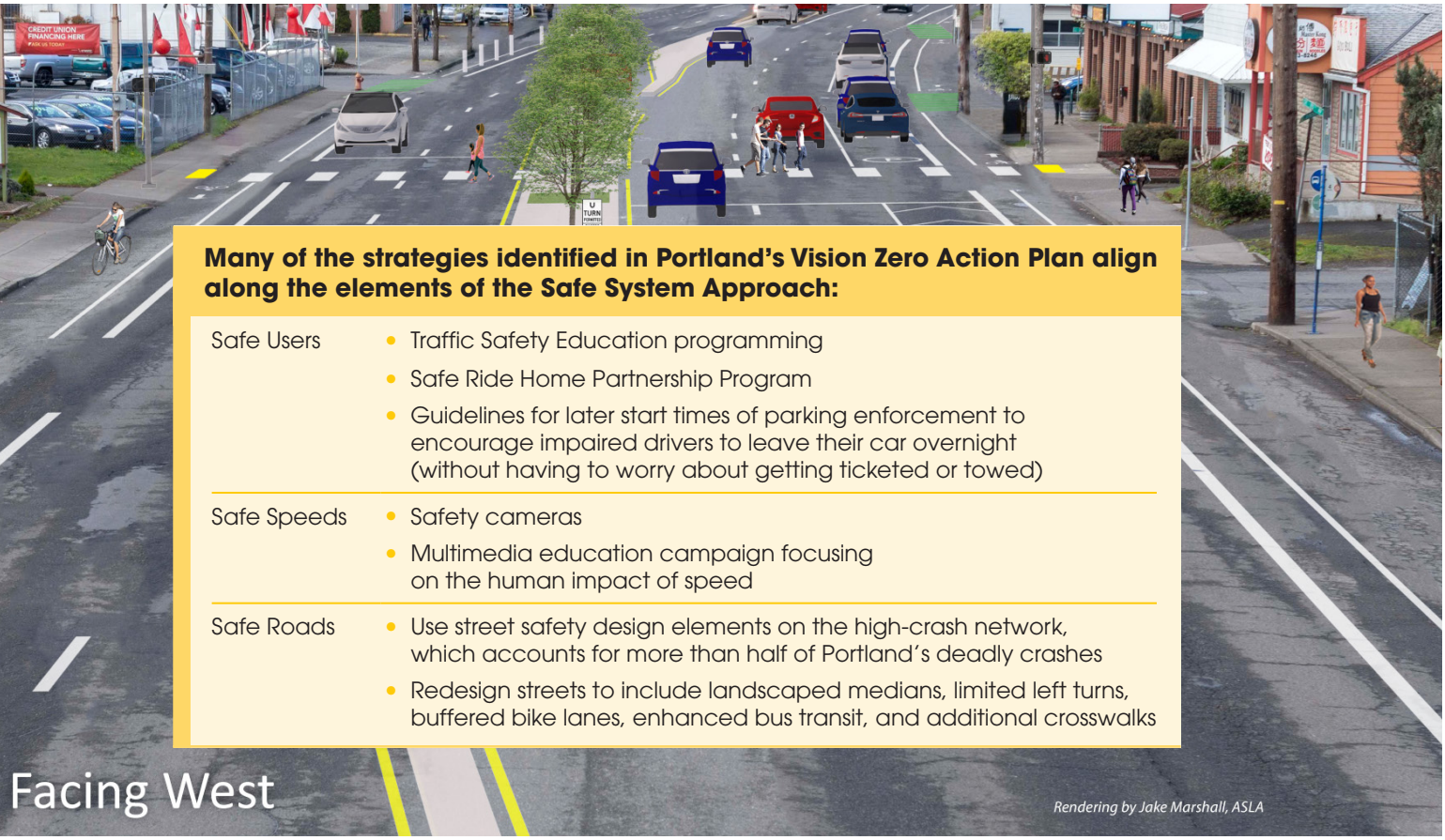
Creating a Safe System is a journey that will take time, commitment, and collaboration across disciplines. The Federal Highway Administration and its stakeholders across the transportation community are acting now to advance the Safe System Approach, making decisions guided by the underlying principles, and promoting implementation across the Nation. FHWA is making strides to advance the Safe System Approach through publications and outreach materials, including an overview flyer and awareness presentation. FHWA has issued several reports, including *Integrating the Safe System Approach with the Highway Safety Improvement Program* (FHWA-SA-20-018) and *Safe System-based Framework and Analytical Methodology for Assessing Intersections* (FHWA-SA-21-008). FHWA has also published a primer on the Safe System Approach for pedestrians and bicyclists. These reports can be found on FHWA's Zero Deaths website at *https://safety.fhwa.dot.gov/zerodeaths*, which provides resources on the Safe System Approach as well as material related to zero-deaths goals and strategies. Additionally, organizations and initiatives, including the Road to Zero Coalition, Toward Zero Deaths, and Vision Zero Network, offer valuable resources and references. The Institute of Transportation Engineers also offers a comprehensive website of technical resources for agencies looking to bring a Safe System Approach to their community.

As the United States advances along the journey to implement a Safe System to eliminate traffic deaths and serious injuries, everyone is a stakeholder with an important role.

MARK DOCTOR is a senior safety and design engineer in the FHWA Resource Center. Mark provides technical services and advances technology deployment in performance-based safety and design areas. He holds an M.S. degree in transportation engineering from the University of Florida.

CHIMAI NGO is a program manager for zero deaths, safety culture, and transportation safety planning initiatives in the FHWA Office of Safety. She holds a master's degree in planning from the University of Virginia.

For more information, visit *https://safety.fhwa.dot.gov/zerodeaths/*, or contact Chimai Ngo at *chimai.ngo@dot.gov* or Mark Doctor at *mark.doctor@dot.gov*.



Many of the strategies identified in Portland's Vision Zero Action Plan align along the elements of the Safe System Approach:

Safe Users	• Traffic Safety Education programming • Safe Ride Home Partnership Program • Guidelines for later start times of parking enforcement to encourage impaired drivers to leave their car overnight (without having to worry about getting ticketed or towed)
Safe Speeds	• Safety cameras • Multimedia education campaign focusing on the human impact of speed
Safe Roads	• Use street safety design elements on the high-crash network, which accounts for more than half of Portland's deadly crashes • Redesign streets to include landscaped medians, limited left turns, buffered bike lanes, enhanced bus transit, and additional crosswalks

THE HIGHWAY SAFETY IMPROVEMENT PROGRAM:

Paving the Road to a Safer Future

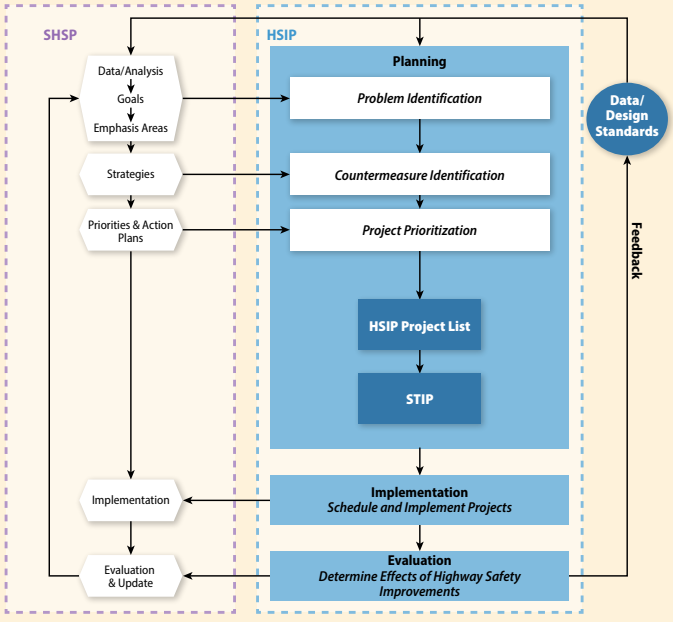
FHWA identifies opportunities to integrate the Safe System Approach with States' existing and future highway safety improvement programs.

This section of highway has multiple roadway departure countermeasures, including rumble strips, guardrails, high friction surface treatment, and horizontal curve signs.

Source: FHWA.

by **DANIELLE BETKEY** and **KAREN SCURRY**

The Highway Safety Improvement Program (HSIP), which sets the funding and policy tone for national safety implementation efforts, is a key place to begin advancing implementation of the Safe System Approach. The HSIP includes the States' Strategic Highway Safety Plan (SHSP) and the program of highway safety improvement projects (or States' HSIPs), as well as foundational elements of the HSIP that influence both program areas. In the informational report *Integrating the Safe System Approach with the Highway Safety Improvement Program* (FHWA-SA-20-018), the Federal Highway Administration identified opportunities and noteworthy practices to align the Safe System principles with the foundational elements of the HSIP, SHSPs, and States' HSIPs.



The SHSP data analysis, goals and emphasis areas feed into HSIP problem identification; the SHSP strategies feed into HSIP countermeasure identification; SHSP priorities and action plans support HSIP project prioritization; implementation of HSIP projects supports SHSP implementation; and HSIP evaluation feeds into the evaluation and update of the State's SHSP.

Source: FHWA.

Overview of the HSIP

The FHWA oversees the HSIP, which is a core Federal-aid highway program, with the purpose to significantly reduce fatalities and serious injuries on all public roads through the implementation of highway safety improvement projects. The HSIP is a federally funded, State-administered program that requires each State to develop and administer a program that best meets its safety needs. The HSIP requires a data-driven, strategic, and performance-based approach to improving highway safety on all public roads.

As part of the HSIP, States are required to develop an SHSP that provides a comprehensive framework for reducing traffic fatalities and serious injuries on all public roads. The SHSP guides investment decisions made in the HSIP toward projects that focus on mitigating the highest priority safety issues in each State. The SHSP is an opportunity for highway safety programs and partners in the State to work together to align goals, leverage resources, and collectively address the State's safety challenges.

According to FHWA's *Highway Safety Improvement Program Manual* (FHWA-SA-09-029), "The SHSP influences decisions made during each step of the State HSIP process." Thus, emphasis areas and strategies identified in the SHSP inform the development and selection of viable safety projects in the State's HSIP process and guide a State's investment decisionmaking. These safety projects include infrastructure countermeasures that further a State's specific goal of reducing fatalities and serious injuries. The results of implementing and evaluating the HSIP in turn inform future SHSP and HSIP planning efforts.

Integrating the Safe System within SHSPs

One of the first opportunities to incorporate the Safe System Approach is within the State SHSP. The SHSP provides a unique opportunity to integrate the Safe System principles and core elements within the current SHSP framework. It also provides an opportunity to reframe the SHSP by refocusing countermeasures and strategies to align with the Safe System Approach. There are several opportunities that a State can take to begin integrating the Safe System Approach, including committing to a goal of zero fatalities, reorganizing the SHSP emphasis areas and strategies, and refocusing the speeding emphasis area.

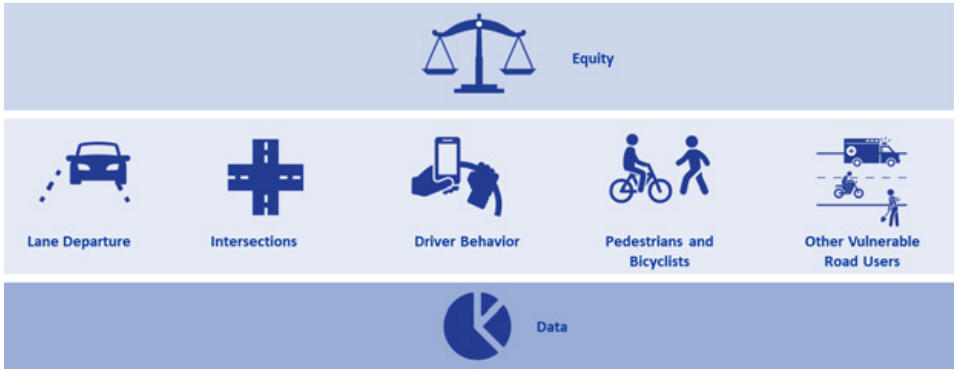
Commit to a Zero Goal

The first step a State can take in updating the SHSP is to adopt a goal of zero fatalities. This supports the Safe System principle that deaths and serious injuries are unacceptable. Adopting a zero-death goal ensures that the SHSP's top priority and focus is on achieving a reduction to zero. Many States have already begun committing to zero-death goals in the SHSP. For example, the *Washington State 2019 Strategic Highway Safety Plan* has a Target Zero goal that represents the vision of zero deaths and serious injuries on Washington roadways by 2030. Maryland is another State that has made a commitment to zero deaths. According to the *2021–2025 Maryland State Strategic Highway Plan*, the State's zero death strategy "incorporates principles from Vision Zero and other proven safety programs to provide a broad systems perspective that considers the interaction of the road user with the road design as a necessary component to achieve zero deaths on our roads."

"In Maryland, we consider even one roadway death to be unacceptable," says Christine Nizer, Administrator at the Maryland Department of Transportation Motor Vehicle Administration. "By focusing on proven strategies to reduce fatalities and serious injuries, our SHSP reinforces what works and provides all our safety partners with a comprehensive framework including behavioral and engineering strategies to reduce and eliminate deaths and serious injuries."

Reorganize SHSP Emphasis Areas and Strategies

Another way the Safe System Approach can be integrated into the SHSP is by organizing the SHSP around the Safe System's six core principles and five elements. For example, a State may choose to fully replace emphasis areas with the five elements, and each of the elements would then incorporate all of the Safe System principles. Or States could revise emphasis areas within the framework of the five elements to become the overarching framework for the SHSP emphasis area strategies.



New Jersey's 2020 SHSP emphasis areas include equity to ensure highway safety investments are inclusive of the interests of traditionally underserved populations and is considered more deliberately.

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Before transitioning to a Safe System Approach in the SHSP, States would benefit from performing a Safe System assessment to determine how well the current SHSP's emphasis area structure aligns with the Safe System elements and principles. By performing this assessment, States will have a better roadmap for pivoting to the Safe System Approach and creating a focus on the core principles and elements within the SHSP. States will also want to engage safety partners and stakeholders early to collaborate and encourage engagement while also shifting to more effective and measurable actions.

Several States have already begun developing SHSPs that reflect a Safe System Approach. Missouri's 2021–2025 SHSP, *Show-Me Zero: Driving Missouri Toward Safer Roads*, aims to address four key behaviors (occupant protection, distracted driving, speed and aggressive driving, and impaired driving) and three roadway user groups (teen drivers, older drivers, and pedestrian and other nonmotorized users). Missouri selected these emphasis areas and user groups to represent "virtually every road user" and to ensure "no group or demographic is unrepresented." Missouri believes that this shift will help address the primary underlying causes of most fatal traffic crashes within the State and help move in a direction to achieve its zero goal.

Another State that has embraced the Safe System Approach is New Jersey, with the update of its 2020 SHSP. The New Jersey SHSP added a fifth "E" to the "4 E's" of highway safety (engineering, enforcement, education, and emergency medical services) to place a new focus on equity for all of its safety investments.

"For the first time, New Jersey Department of Transportation (NJDOT) is recognizing equity as a priority in highway safety as part of our Strategic Highway Safety Plan," says NJDOT Commissioner Diane Gutierrez-Scaccetti. "NJDOT is working diligently to ensure that all strategies and activities emanating from the plan fairly consider the needs of all users and all communities—particularly minority populations, economically depressed communities, and those that are differently abled."

Refocus the Speeding Emphasis Area

The Safe System element for safe speeds represents another opportunity that can be directly addressed in the SHSP. Refocusing the speeding emphasis area on speed management and roadway design shifts the traditional application of education and enforcement strategies to using roadway design to reduce speeding-related crashes. It also addresses the Safe System principles that humans are vulnerable, responsibility is shared, and redundancy is crucial. Addressing designing for safe speeds and speed management in the SHSP can help States make progress toward the zero-fatality goal.

States can take a similar approach to what Minnesota and the city of Sacramento, CA, have done to address speeding. Minnesota addresses speeding as an emphasis area in its 2020–2024 SHSP. In addition to developing strategies that only focus on education and enforcement, Minnesota has also included a strategy to improve road design and speed limit signing by seeking to use appropriate speed limits to account

for roadway design, traffic, land use, and context. Sacramento has also identified roadway design in its 2018 *Vision Zero Sacramento Action Plan* as a primary tool to align enforcement efforts with reducing fatal crashes that occur at high speeds—whether the cause of the crash was speeding or not. The plan makes a clear connection between crash severity and speed, even in cases where the posted speed limit is deemed to be reasonable.

Integrating the Safe System within the HSIP

A roadway safety management process, which is the foundation of the State HSIP, forms a strong basis from which to integrate the Safe System Approach. This includes processes for problem identification, countermeasure identification, project prioritization, and evaluation.

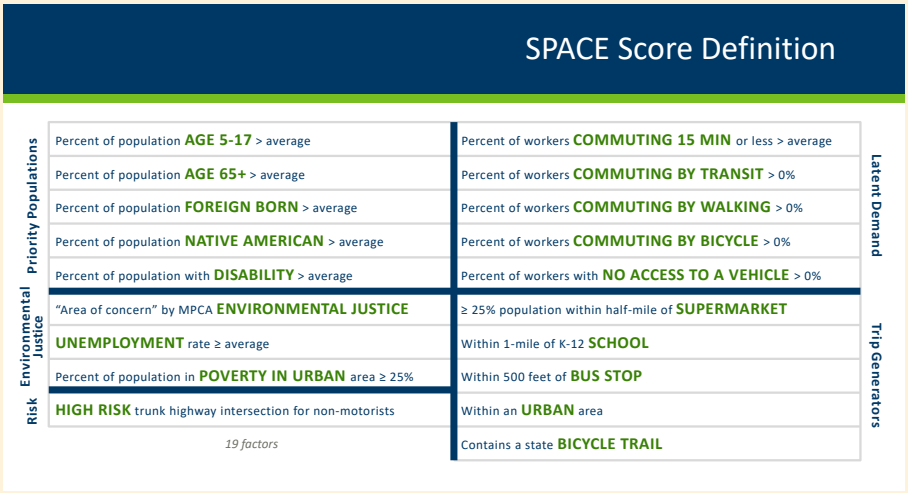
Problem Identification

Safety programs and identified improvement projects are based on a robust, data-driven process that considers both historic crash patterns and a proactive assessment of the crash causation factors that can lead to future crashes. Changing network screening methods to primarily focus on fatal and serious injury crash reduction opportunities can help refocus problem identification on the Safe System principle that deaths and serious injuries are unacceptable.

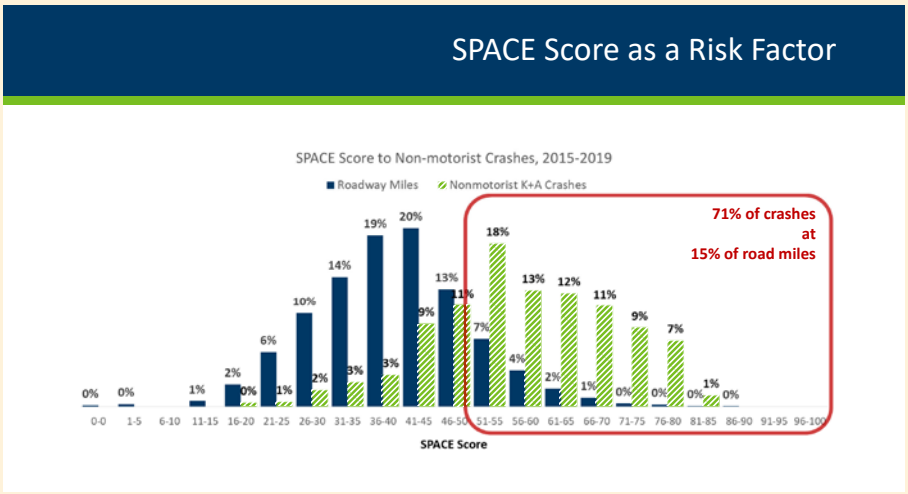
Many agencies also screen their transportation network using a systemic approach to safety. The systemic approach to safety aligns with the Safe System principle that safety is proactive, by identifying locations for potential safety improvement based on the presence of risk factors that are correlated with specific severe crash types. Most States implement systemic safety improvement projects through the HSIP. As described in Virginia's *Highway Safety Improvement Program 2020 Annual Report*, the State "identified $136.7 million in potential funding through [fiscal year] 2025 in order to implement eight systemic countermeasure initiatives" on roadways maintained by the Virginia Department of Transportation. "The systemic countermeasure implementation projects in this initial Systemic Improvement Plan [are] estimated to save 61 lives and 1,174 injuries per year statewide once implemented."

Some agencies are also beginning to consider equity in the problem identification process. Agencies can incorporate socioeconomic data as a potential risk factor in systemic safety analysis. The Minnesota Department of Transportation (MnDOT) created the Suitability of Pedestrian and Cyclist Environment (SPACE) tool, an index of 19 publicly available data measures from the U.S. Census and State agencies that includes measures of demographic populations, environmental justice factors, latent demand, and trip generator factors. Layering the SPACE score with crash data revealed that communities with a SPACE score greater than 50 represent 71 percent of crashes at 15 percent of road miles in the State. This demonstrates that an equity index, like the SPACE score, can be used as an effective predictive risk factor tool for crashes that result in fatalities and serious injuries.

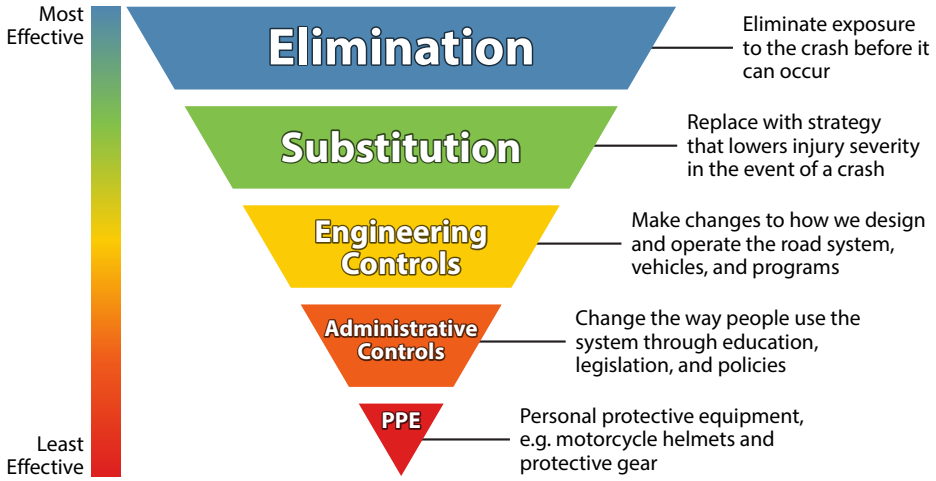
"The SPACE score has helped us prioritize nonmotorized scoping efforts and understand the latent demand in the community," says Sonja Piper, a pedestrian and bicycle safety engineer at MnDOT. "Additionally, the systemic risk attributed to the score has helped us rate HSIP projects. We're looking at ways that SPACE can help prioritize our overall program delivery and have used the concepts of leveraging public data to generate similar analysis for other processes."



The SPACE Score identifies latent demand for nonmotorized infrastructure by combining public data on (1) statewide pedestrian plan priority populations, (2) under-served communities, (3) current commuting patterns, and (4) trip generators. Of the 19 factors, only 1 is based on the existing infrastructure: a proactive risk assessment of MnDOT intersections to identify high risk locations for nonmotorist fatal and serious injury crashes. Note that the SPACE Score primarily identifies social geography and does not necessarily change with an engineering solution: it is one of multiple layers used to identify appropriate solutions.



Similar to the proactive risk assessments in MnDOT safety plans, MnDOT analyzed whether there was over-representation of fatal and serious injury crashes based on the SPACE score. This graphic depicts the distributions of centerline miles on all public roads compared to nonmotorist crashes. Scores of 51 and above, where the site exceeds the thresholds for 10 or more of the SPACE factors, show over-representation. This is striking as the definition for SPACE was derived based on latent demand and priority populations and not necessarily a safety analysis.



The hierarchy of controls illustrates the different approaches to user safety. The strategies that focus on elimination are at the top: these approaches are more effective in reducing fatalities and serious injuries because they eliminate exposure to the crash before it can occur. Substitution follows, where the focus is on strategies that lower the severity of injuries in the event of a crash. Next is engineering controls, where changes are made to the design and operation of the road system, vehicles, and programs. Administrative controls change the way people use the system through education, legislation, and policies. The final and least effective approach is personal protective equipment such as motorcycle helmets and protective gear.

Countermeasure Identification

As part of countermeasure identification, agencies identify proven effective safety countermeasures that address the specific crash patterns and factors present. Changing countermeasure identification to primarily focus on fatal and serious injury crash reduction opportunities can help refocus this evaluation on the Safe System principle that deaths and serious injuries are unacceptable. The Washington State Department of Transportation's SHSP describes a hierarchy of controls to support countermeasure identification. The *Washington State Strategic Highway Safety Plan 2019* states, "Prioritizing efforts in this way creates a system that is generally more effective and protective. While the most effective approaches may in some cases be more difficult or costly to implement initially within existing systems, total lifecycle benefits and avoided tragedies should be greater."

Agencies can consider additional opportunities to incorporate human factor research (such as applying psychological and physiological principles to engineering and design) into the countermeasure identification process. Safety improvement projects should identify opportunities to minimize the potential for road users to make mistakes (such as intersection designs that reduce conflict points) as well as incorporate shared responsibility and design redundancy in the system to prevent crashes. This principle is currently integrated into some road infrastructure safety strategies, such as roadway departure, where the first priority to avoid a roadway departure crash is to keep vehicles on the road (rumble strips, etc.). In the event a vehicle has left the travel lane, the second priority is to provide an opportunity for the vehicle to safely recover and reenter the travel way (clear zone). And last, the goal is to minimize the severity if roadway departure crashes do occur (such as using guardrails).

Each State HSIP should address Safe System elements and principles in a coordinated and systemic manner, and not in silos. This can be accomplished by broadening the focus of engineering countermeasures to include roadway design or control elements that specifically support each Safe System element. This approach provides a buffer or redundancy in the system that can reduce the level of severity when a crash does occur. The countermeasure identification process is also a way to meaningfully engage populations that are traditionally underserved in shared decisionmaking for projects. Improving the safety for all road users is an important consideration for all highway safety improvement projects.

Project Prioritization

Agencies use a variety of methods to prioritize safety projects, including benefit-cost analysis, ranking, and optimization approaches. Changing project prioritization methods to primarily focus on opportunities to reduce fatal and serious injury crashes aligns with the HSIP purpose and the vision of zero serious and fatal crashes. Including only the most serious injury crashes may result in a project prioritization different than when all crashes are factored in the calculation. The FHWA *Selecting Projects and Strategies to Maximize Highway Safety Improvement Program Performance* guide (FHWA-SA-20-001) explored this concept further with two pilot case studies using data from Ohio and Utah. In these case studies, using the benefit-cost ratio only for fatalities and serious injuries resulted in selecting projects expected to prevent more fatal and serious-injury crashes than the current project selection methods used by the two States.

In addition to benefit-cost ratio, States often consider other factors in the project prioritization process. These factors might include project readiness, geographical distribution, or public inputs. Agencies can also consider equity in project prioritization through the HSIP.

The Ohio Department of Transportation (ODOT) made changes to its formal safety application process in the summer of 2021 for the fall round of applications. These changes included modifying the scoring criteria to give higher priority to projects that address crash severity and projects in communities with higher levels of poverty based on census data. Specifically, communities that reach certain thresholds for poverty/economic distress can receive up to 10 points toward their safety application and may be eligible for a reduced local match.

These changes are necessary, notes Michelle May, ODOT's highway safety program manager. "Traffic deaths in Ohio have risen six of the past seven years," she says. "Focusing on severity will help ODOT better address these crashes. In Ohio, fatal and serious injury crashes are overrepresented by 10 percent within census block groups that have a poverty rate at or above 10 percent, when adjusted for population. ODOT wants to help Ohio communities with fewer financial resources struggling to make critical safety investments."

Evaluation

Evaluation is a key component of the HSIP and of the roadway safety management process in general. Evaluation enables agencies to determine the effectiveness of individual projects, countermeasures, and programs, and monitor and track progress toward annual safety performance targets and long-term safety goals. While many

agencies have adopted a goal of zero deaths by 2050, States also set annual safety performance targets that serve as interim performance measures to monitor and track progress toward long-term goals. These interim performance measures enable agencies to take a step back, measure progress, and make course corrections if needed.

Agencies should also consider adopting key performance indicators specific to roadway infrastructure safety. A key performance indicator for road infrastructure should show the safety quality of a road network independent of road user behavior or vehicle technology. Ideally, agencies would estimate the level of safety of existing roads and establish indicators to improve the level of safety over time. However, this may be complicated to estimate, and data may not be readily available. In the interim, agencies may establish other relevant key performance indicators such as the provision of additional infrastructure by length (for example, miles of rumble strips) or installation of additional infrastructure as a percentage of the road network (such as a percentage of areas with pedestrians where sidewalks are provided).

Valuable insights gained in the evaluation process are fed back into the road safety decisionmaking process to enable proactive roadway safety changes. Through continued process and program improvement, agencies will achieve their safety performance goals.

What's Next?

Over the past couple of years, FHWA has been educating safety partners about the Safe System Approach. While there is general support and buy-in from major safety partners, practitioners are also seeking clarity about what the Safe System Approach looks like in practice and how to best integrate this approach into business practices and daily activities.

Establish Safe System Work Group and Conduct Pilot Projects. FHWA encourages agencies to establish a Safe System work group including representatives from various departments (planning, design, civil rights, enforcement, operations, maintenance) to determine the best path forward. FHWA will also be facilitating Safe System pilot projects in which a review team will conduct a road safety assessment of an existing or proposed project through a Safe System lens.

Prioritize Equity. To adequately address equity in transportation safety, agencies should consider incorporating nontraditional data sources in their data-driven safety analysis. There are many free, publicly available, and easily accessible data sources to use to conduct equity analysis and target investment to address disparities in crash fatalities and serious injuries. These data include: (1) public health models in State and local agencies; (2) the Environmental Protection Agency's Environmental Justice Screening and Mapping Tool, available at *https://ejscreen.epa.gov/mapper*; and (3) U.S. Census data. Agencies can then layer these models with crash data, infrastructure data, or transportation safety funding data to determine which communities are experiencing disparities and target HSIP funding in those locations. Engaging with State and local stakeholders such as departments of health will help to better understand what data are available to support safety data analysis.

Conduct Additional Research. Additional research is necessary to fully integrate Safe System principles and elements into existing safety programs and projects. This research includes developing predictive models that focus on fatalities and serious injuries, rather than all crashes. Understanding kinetic energy transfer (crash magnitude) related to different modes, crash types, and roadway conditions could help States identify and prioritize projects. Research should also identify how kinetic energy models can help States identify and prioritize projects, including how the models can be used to complement or supplement crash prediction models.

Moving forward, agencies may also leverage backcasting, which identifies the infrastructure and funding that will be required to achieve zero traffic deaths in a future horizon year, and then set interim funding, policy, and program milestones between the current year and horizon year. This approach will enable States to show the level of investments necessary to reach long-term goals.

Transportation safety professionals play a key role in helping everyone get home safely—every trip, every time. By integrating Safe System principles and elements into existing safety programs and projects, safety professionals can lead by example, developing model practices that can be integrated at all levels of roadway planning and engineering and across all disciplines that have a hand in supporting roadway safety.

This photo shows a guardrail segment with reflectors, which demonstrates redundancy. The reflectors will help keep vehicles on the road, but if needed the guardrail will prevent vehicles from leaving the road.

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THE SAFE SYSTEM PARADIGM:
Reducing Fatalities and Injuries at the Nation's Intersections

A recently completed Federal Highway Administration project proposes a quantitative method to evaluate intersection designs according to Safe System principles.

by **JEFFREY B. SHAW**, **RICHARD J. (R.J.) PORTER**, **MICHAEL R. DUNN**, **JONATHAN SOIKA**, and **IVY B. HUANG**

The Safe System Approach represents a paradigm shift in how road safety is addressed in the United States and aligns with the growing number of Vision Zero goals, efforts, and action plans across the country. While Vision Zero describes the goal and Safe System describes the approach, both accept the premise that crashes will not be completely avoided. However, the Safe System Approach posits that no person should be killed or seriously injured if a crash occurs when using the road system, and that it is a shared responsibility of all parties involved to achieve this outcome. For road design, a Safe System Approach involves managing the circumstances of crashes such that the kinetic energy forces imposed on the human body should not result in death or serious injury. At an intersection, this is accomplished by influencing conflict points, speed, and crash angles, and considering exposure and complexity.

Crashes attributed to intersections contribute significantly to traffic fatality and injury numbers in the United States. In 2019, 10,180 people were killed in intersection and intersection-related crashes, which is roughly one-quarter of all roadway fatalities. Additionally, about half of all injury crashes occur at or near intersections. Intersection projects represent a straightforward opportunity to explore how to apply Safe System principles to the project development planning and design decisions in support of Vision Zero, as well as a performance-based approach to safety.

FHWA sponsored the effort to develop a Safe System for Intersections (SSI) framework and methodology, which represents a first step toward the development of objective and implementable analyses that reflect key Safe System concepts. The Safe System assessment of an intersection can serve as an additional metric to inform alternatives analysis and identify an optimal solution for an intersection. In fact, the SSI method can provide a valuable quantitative safety metric

Crashes at intersections contribute significantly to traffic fatalities and serious injuries in the United States. Applying the Safe System Approach to intersections can improve roadway safety at these critical junctions.

Source: FHWA.

in addition to, or in the absence of, the types of crash-based approaches that are the foundation of the *Highway Safety Manual*.

Bonnie Polin, a State safety engineer from the Massachusetts Department of Transportation (MassDOT), says, "We had an opportunity to test out the SSI approach to evaluate design alternatives for two irregular, nontypical intersections where safety performance function models were not available. The SSI method, along with other approaches such as road safety audits and video analytics using drone technology, can help us gain a more complete safety performance picture to help us identify a preferred alternative that reduces risk and minimizes the potential for harm."

Explanation of the SSI Method

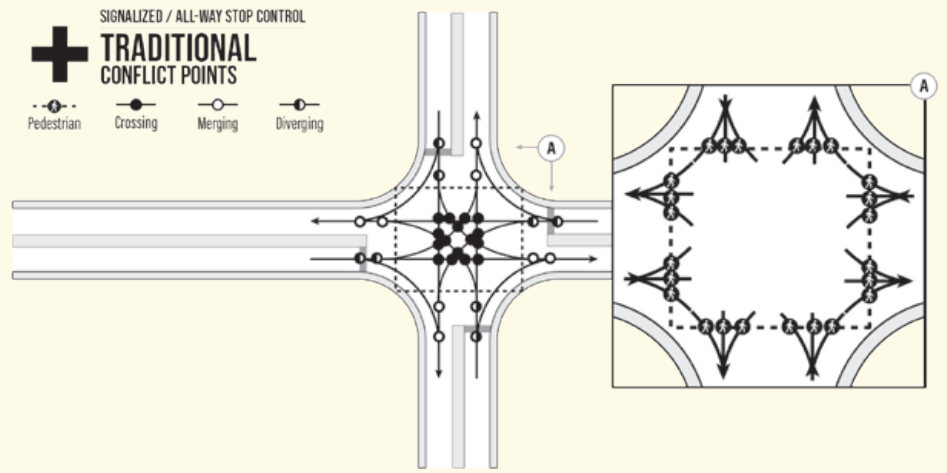
The SSI method uses data that are typically available early in a project development lifecycle, including posted speed limit, average annual daily traffic volumes, and the number of through lanes on the intersecting roads. When available, several optional inputs—such as individual movement speeds, daily nonmotorized volumes, turning movement proportions or volumes, and left-turn traffic signal phasing—can be incorporated to enhance the analysis. The SSI method offers assumptions and default values, but agency-prescribed or project-specific values could also be used.

The overall framework and components of the SSI method are based on conflict point identification and classification, exposure, severity, and complexity. With these inputs, it is possible to quantify the degree to which a given intersection alternative is consistent with Safe System principles, and then contrast different alternatives.

The SSI method begins with the identification and classification of conflict points for each intersection alternative. Since exact lane arrangements may not be known at the project development stage, the SSI method identifies conflict points on a movement basis. A conflict point is any location where road users' paths coincide, categorized as either crossing, merging, diverging, or nonmotorized. This first version of the SSI method assigns both pedestrians and bicyclists to the same path through the intersection, but future enhancements to the method could incorporate additional layers of vehicle-bicycle conflict points depending on the selection of bicycle accommodation through the intersection, such as those described in the FHWA *Bikeway Selection Guide* (FHWA-SA-18-077). The SSI method also does not currently consider rear-end conflicts that result from traffic congestion or deceleration/stopping because of traffic control devices, but does consider rear-end conflicts that result from speed differentials at diverging conflict points where vehicles making different movements have different speeds.

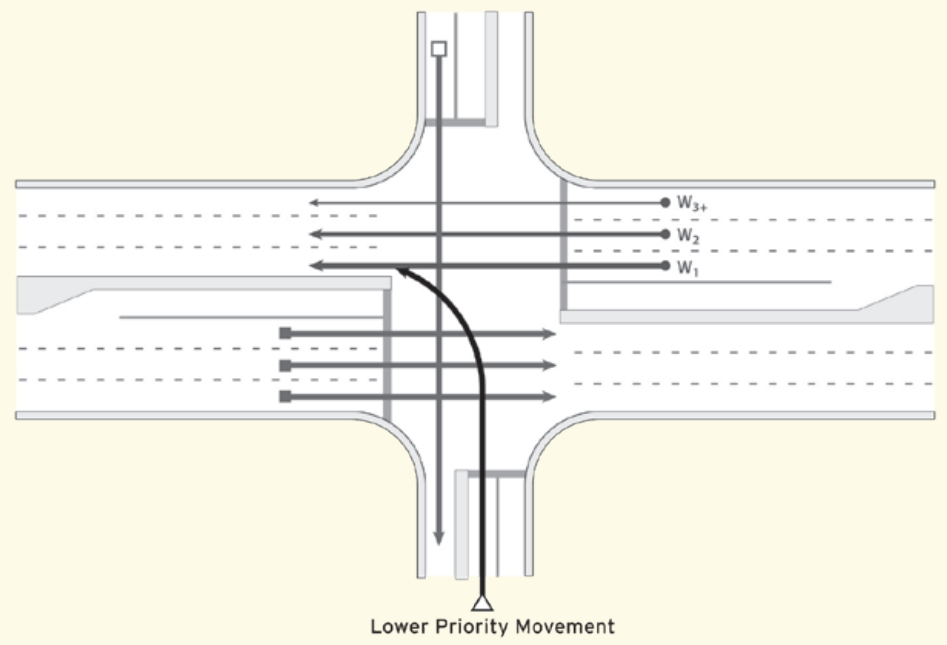
Once the conflict points are identified and classified, the SSI method characterizes exposure, which is the crash likelihood at a given conflict point given the number of vehicles or nonmotorized users that pass through it. To do this, the SSI method employs an exposure index, adapted from past research. The first step involves calculating the product of crossing movements, using vehicle or nonmotorized user daily volumes, through each conflict point. The second step is to sum the results across all conflict points of each type at an intersection to compute total exposure for each conflict point type.

Next, conflict point severity is the estimated probability of at least one fatal or serious injury, or P(FSI), resulting from a crash between conflicting road users making the movements that define the conflict point. The SSI method defines serious injury as an injury with a Maximum Abbreviated Injury Scale score of 3 or above. The SSI method estimates P(FSI) at crossing, merging, and diverging conflict points using an estimated speed for each conflicting movement and an estimated



This diagram illustrates the movement-based conflict points for a traditional four-legged, all-movements intersection.

Source: FHWA.



This diagram indicates some of the conflicting lane considerations for a left-turn movement from a minor road to a major road at a traditional intersection.

Source: FHWA.

angle between conflicting movements. For nonmotorized conflict points, the SSI method only requires the vehicle speed at the conflict point to compute P(FSI). The full report for this project offers additional detailed explanation of the basis and steps for calculating P(FSI).

Finally, the SSI method accounts for movement complexity using adjustment factors that relate to the conflicting traffic scenarios. The conflicting traffic complexity factor is based on the relative complexity due to traffic control (such as permissive versus protected signalized movements), and, for all movements, the number of conflicting lanes and the speed of conflicting traffic. The nonmotorized movement complexity factor addresses complexity specific to nonmotorized movements through the intersection by accounting for indirect and nonintuitive movements at an intersection that may present additional complexity for pedestrians and cyclists. Taken together, the movement complexity factors represent a human factors approach that considers the potential workload imposed on road users as they make specific movements through the intersection.

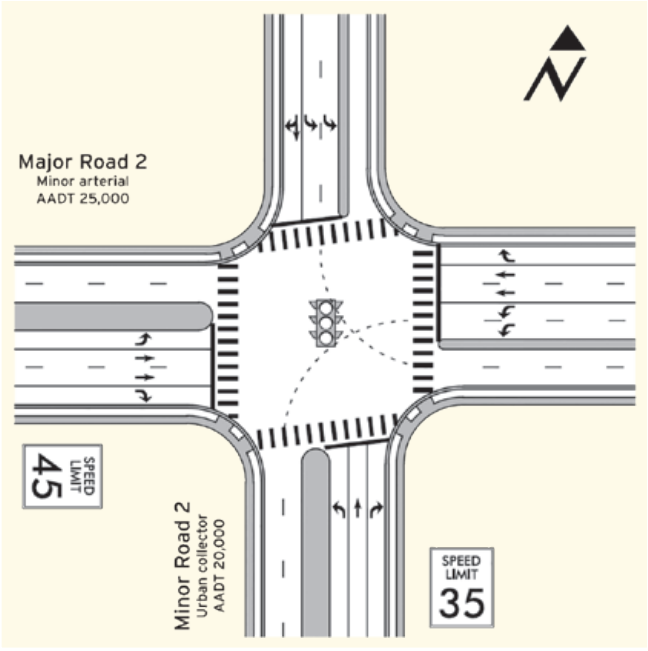
The SSI Score

The first step in determining the SSI score is to compute the sum of the exposure-severity-complexity products for all individual conflict points of a specific type and to apply the appropriate adjustment factors. The second step is to convert that computed value to a score that has a range of 0 to 100, with 100 representing the best score possible, equating to the lowest probability of a fatality or serious injury in the event of a crash. The method produces an SSI score for each conflict point type (such as crossing, merging, diverging, nonmotorized) as well as for the intersection overall. The SSI method also yields relative scores for exposure, severity, and complexity in order to provide additional context to the SSI scores.

Example Application of SSI Method

The example intersection is a signalized suburban intersection of a four-lane major road and a two-lane minor road. Design year traffic volumes are estimated at 25,000 and 20,000 vehicles per day, respectively, on the major and minor roads. The posted speed limits are 45 miles (72 kilometers) per hour on the major road and 35 miles (56 kilometers) per hour on the minor. There are sidewalk facilities along all approaches, and the intersection serves a daily volume of 2,400 nonmotorized road users.

First, a Stage 1 Intersection Control Evaluation (ICE) assessment is completed using the Safety Performance for Intersection Control Evaluation (SPICE) and Capacity Analysis for Planning of Junctions (CAP-X) screening tools (both tools and user guides are available at *https://safety.fhwa.dot.gov/intersection/ice*). ICE is a data-driven, performance-based framework to screen intersection alternatives and identify an optimal solution, and SPICE and CAP-X are screening-level tools used to characterize safety and operational performance. This assessment produces 11 possible alternatives, including ones that the screening tools did not explicitly model. As a means to a quantitative safety metric when crash-based models are not available, this is an area where the SSI method can be immediately helpful. After the SPICE and CAP-X assessments, the SSI method was applied to these 11 different intersection alternatives to produce SSI scores.



The existing layout (no-build option) of the example intersection is a signalized suburban intersection of a four-lane major road and a two-lane minor road, with the respective speed limits and annual average daily traffic (AADT) indicated.

Source: FHWA.

The SPICE results for the example application contain the predicted number of crashes for the design year for both total crashes (all types and severities) and fatal and injury crashes unless there is not an appropriate safety performance function available, as in the case of the 2x2 roundabout. The results show that all the intersection types for which there are predictive methods available have fewer total and fewer fatal and injury crashes than the signalized traditional intersection that is the no-build condition. Based on these SPICE results, no intersection alternatives are dropped from consideration.

Results from the SPICE tool for the example SSI application.

Intersection Type	Predicted Fatal & Injury Crashes Per Year	Predicted Total Crashes Per Year
Unsignalized RCUT	0.53	1.69
Median U-Turn	1.24	4.08
Jughandle	1.31	3.55
Signalized RCUT	1.38	4.08
Full Displaced Left Turn	1.55	4.22
Signalized Traditional (existing)	1.77	4.80
2x2 Roundabout	No safety performance function	2.29
2x1 Roundabout*	--	--
Quadrant Roadway*	--	--
Partial Displaced Left Turn*	--	--
Bowtie*	--	--

*These intersection types are not included in SPICE, but are included in the SSI library of intersections.

CAP-X primarily assesses intersection types by using critical lane analysis to compute the volume-to-capacity ratio given vehicle volume inputs and intersection lane arrangements. Based on these results, it can be seen that all but the unsignalized restricted crossing U-turn (RCUT) intersections would be operationally similar to or better than the existing signalized traditional intersection. Otherwise, all these alternatives are operationally feasible.

Based on the SSI scores for individual conflict point types, seven alternatives have improved SSI scores for the nonmotorized conflict points compared to the signalized traditional intersection (which is the existing/no-build condition). Eight alternatives have improved crossing conflict SSI scores compared to the no-build alternative: partial multilane (2x1) roundabout, median U-turn, full multilane (2x2) roundabout, signalized RCUT, bowtie, unsignalized RCUT, full displaced left turn, and partial displaced left turn. These designs reroute one or more movements at the intersection, removing crossing conflict points, reducing vehicle speeds and angles at crossing conflict points, or both. Because the SSI method is sensitive to conflict point speed, for alternatives that do not afford nonmotorized users the benefit of either low speed through geometry (such as a roundabout) or separated movements through traffic control phasing (such as the signalized alternatives), the nonmotorized conflict scores can be as low as zero.

With the SPICE, CAP-X, and SSI results available, the alternatives can be compared and contrasted further to make a recommendation on which preferred alternative(s) should be carried forward into the next phase of project development. Alongside the SPICE and CAP-X results, the SSI scores point to the "hybrid" 2x1 roundabout or the 2x2 roundabout as the most appealing alternatives. That roundabouts would compete so well based on Safe System principles supports the international literature and experience on both the Safe System Approach and roundabouts.

The unsignalized RCUT shows promising SPICE results in terms of predicted total crashes and predicted fatal and injury crashes and SSI method scores that are comparable to the existing traditional signalized, except for a particularly poor nonmotorized conflict score of zero that

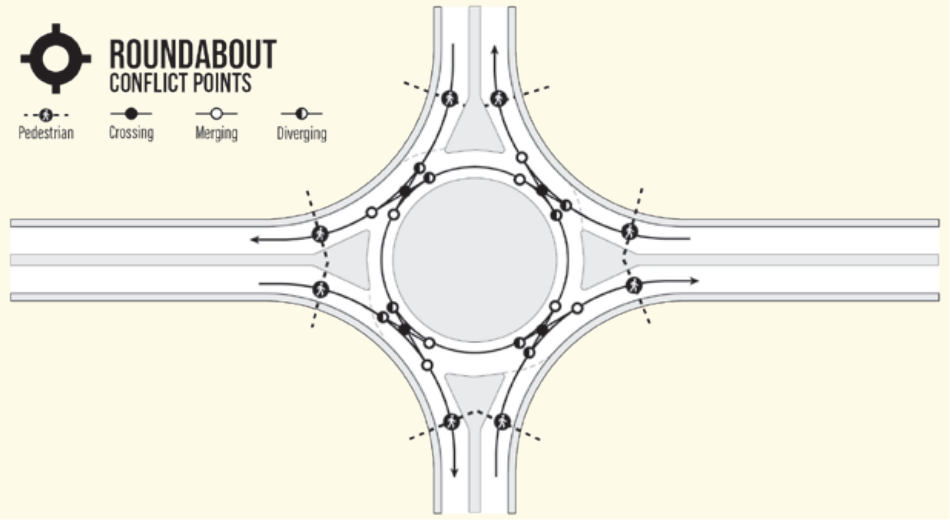
Results from the CAP-X tool for the example SSI application.

Intersection Type	Overall Volume-to-Capacity Ratio
Quadrant Roadway	0.25
Full Displaced Left Turn	0.27
Median U-Turn	0.31
2x2 Roundabout	0.31
Partial Displaced Left Turn	0.32
Bowtie	0.40
Signalized Traditional (existing)	0.44
Signalized RCUT	0.48
2x1 Roundabout	0.53
Unsignalized RCUT	0.85
Jughandle*	--

* The Jughandle intersection is not included in CAP-X, but it has the capacity to handle high intersection volumes.

Results of SSI method calculations for the example SSI application.

Intersection Type	Overall Intersection SSI Score	Nonmotorized Conflict SSI Score	Crossing Conflict SSI Score	Merging Conflict SSI Score	Diverging Conflict SSI Score
2x1 Roundabout	52	8	93	98	100
Median U-Turn	44	10	52	83	88
2x2 Roundabout	42	4	90	98	100
Signalized RCUT	40	5	74	77	86
Bowtie	31	4	23	94	96
Quadrant Roadway	30	6	14	93	94
Jughandle	27	3	18	93	97
Signalized Traditional (existing)	24	2	19	93	100
RCUT	19	0	65	69	86
Full Displaced Left Turn	10	0	32	91	97
Partial Displaced Left Turn	9	0	26	91	97



This diagram illustrates both vehicular and pedestrian movement-based conflict points associated with roundabout intersections based on the SSI method.

Source: FHWA.

brings the overall SSI score down as well. This highlights the importance of giving nonmotorized users greater attention and accommodation at certain alternative intersections that have otherwise been proven to offer significant enhanced safety performance. It is likely that an unsignalized RCUT alternative that reduces speed through nonmotorized conflict points and eliminates indirect or nonintuitive movements could achieve a much better SSI method score and preserve or even enhance the safety performance that has been documented through crash-based studies.

Future SSI Applications

While U.S. intersection planning and design practices have incorporated Safe System principles to some extent over the last several decades, significant opportunities for advancing the Safe System Approach remain. In addition to MassDOT, other State DOTs are also evaluating the SSI method for their intersection projects, including California, Florida, Washington, and Virginia.

Stephen Read, the safety planning program manager for the Virginia DOT, says, "While Virginia is updating [its] Strategic Highway Safety Plan to be more Safe System centric, VDOT's Traffic Engineering Division is conducting a review of the SSI method to determine whether it could be incorporated into a new Intersection Control Evaluation program that is also under development."

Where enough data are available, U.S. experiences with intersection alternatives that simplify road user decisionmaking and manage conflict points, impact angles and speeds have shown safety performance benefits. These safety benefits are typically expressed in the form of crash modification factors (CMFs) derived from retrospective statistical analyses of crash data. The CMFs are usually applicable to the intersection as a whole and reflect overall changes or differences in the number of crashes at the intersection alternative of interest compared to another intersection alternative. In other words, intersection CMFs are often developed with and applicable to an aggregation of crashes resulting from different movements through the intersection, involving different intersection users, and resulting in a range of injury outcomes. For example, intersection CMFs for fatal and injury crashes apply to crashes of all types with injury outcomes ranging from fatal to possible injuries.

As a complement to aggregate crash-based findings such as CMFs, the SSI method provides an approach to characterize intersection alternatives with respect to the Safe System principles of managing impact angles and speeds and simplifying decisionmaking, with the goal of reducing traffic fatalities and serious injuries. The method is applied at the conflict point level and incorporates the characteristics of different movements through the intersection for all road users. The SSI method is sensitive to volumes, vehicle speeds, potential collision angles, and geometry.

The results of applying the SSI method include multiple measures of effectiveness and a set of SSI scores that can serve as additional safety metrics to inform the process of screening intersection alternatives, such as during a Stage 1 Intersection Control Evaluation. Continued advancements in crash reporting, injury surveillance (including linkages between crash reports and hospital records), and more widespread availability of vehicle movement and speed data will enable more empirical connections to be made between SSI scores and fatal and serious injury crash data.

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For more information, visit *https://safety.fhwa.dot.gov/intersection/ssi/fhwasa21008.pdf* for the full FHWA report or contact Jeffrey Shaw at 202-738-7793 or *Jeffrey.Shaw@dot.gov*.

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NHTSA's SAFE SYSTEM APPROACH: Educating and Protecting All Road Users

NHTSA's Safe System efforts focusing on safe road users, safe vehicles, and post-crash care.

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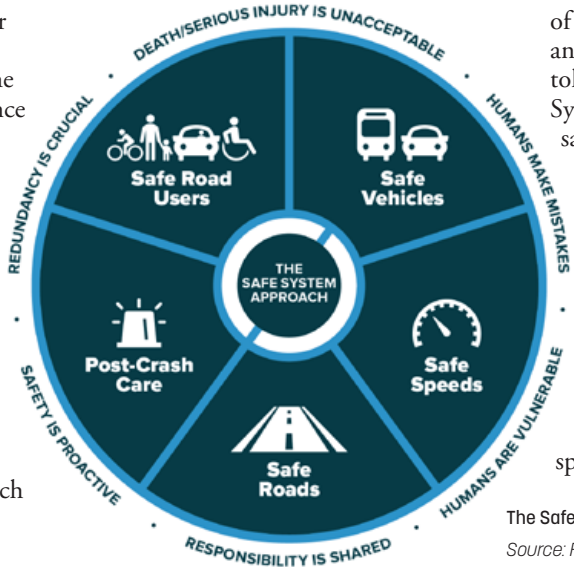
NHTSA supports the Safe System Approach through data-driven measures to make the Nation's transportation network more secure for everyone.

by **ROBERT RITTER**, **DEE WILLIAMS**, and **GAMUNU WIJETUNGE**

More than 50 years ago, the Highway Safety Act of 1970 confirmed the commitment of the U.S. Government to work to protect the traveling public's safety on the road. The legislation established the National Highway Traffic Safety Administration to help reduce the number of deaths, injuries, and economic losses resulting from motor vehicle crashes on the Nation's highways. The agency's efforts since then have saved hundreds of thousands of lives—NHTSA estimates that since 1960, improved vehicle safety technologies alone have saved more than 600,000 people. Unfortunately, the Nation continues to lose too many family members, friends, and neighbors to traffic crashes. In 2020, the United States lost more than 38,000 people to traffic crashes.

"We must address the tragic loss of life we saw on the roads in 2020 by taking a transformational and collaborative approach to safety. Everyone—including those who design, operate, build, and use the road system—shares responsibility for road safety, This is the foundation of the safe system approach, and one that guides our lifesaving work at NHTSA," says Dr. Steven Cliff, NHTSA's deputy administrator.

The Safe System Approach is a data-driven, holistic, and equitable method to roadway safety that fully integrates the needs of all users, anticipates the possibility of errors by drivers and other road users, and manages crash impact forces to levels tolerated by the human body. The Safe System Approach includes five elements: safe road users, safe vehicles, safe speeds, safe roads, and post-crash care. The approach incorporates the 5 Es of traffic safety—equity, engineering, education, enforcement, and emergency medical services (EMS)—but goes beyond the traditional approach to enlist designers, operators, and users of the transportation system to prevent fatal crashes and reduce crash severity. NHTSA's efforts focus on safe road users, safe vehicles, safe speeds, and post-crash care.



The Safe System Approach principles and elements.

Source: FHWA.

NHTSA's Haddon Matrix identifies the factors involved in crashes and provides examples of safety efforts that can influence the outcomes.

Source: NHTSA.

Factor	Pre-Crash	Crash	Post-Crash
Human Factors	• Education & licensing • Driver impairment • Crash avoidance maneuvers (braking, turning, etc.)	• Health at time of crash • Sitting properly in restraint • Impairment	• Response to EMS • Severity of injury • Type of injury
Vehicle/ Equipment Factors	• Crash avoidance equipment & technology (lights, tires, collision avoidance, etc.) • Vehicle design • Vehicle load	• Speed of travel • Functioning of safety equipment (seat belts, air bags, child restraints) • Energy absorption of vehicle	• Ease of extraction from vehicle • Integrity of fuel systems and battery systems
Physical Environment	• Road hazards • Distractions • Weather conditions	• Roadside features • Guardrails • Type and size of object struck	• Distance of EMS clinicians • Notification of EMS clinicians • Accessibility to crash victims
Social/Economic	• Enforcement activities • Insurance incentives • Social norming • Ability to use safety equipment appropriately	• Laws concerning use of safety equipment	• Trauma system equipment, personnel, training • Information sharing

The Safe System Approach broadens NHTSA's scope with the tenets that safety is proactive and responsibility is shared. It challenges everyone involved to not accept fatalities and serious injuries as a consequence of mobility. Instead, the approach is founded in the conviction that no one should be killed or seriously injured while using the roadway system. It recognizes that people make mistakes, and those who oversee, design, and regulate the components of the transportation system have a responsibility to develop a system that accommodates mistakes. In the case where a crash cannot be prevented, the energy that dictates the injury severity, when possible, should be mitigated to improve survivability outcomes. A Safe System provides equitable, timely, and appropriate care.

Historically, NHTSA has always used a data-driven systems approach to crashes, related causal factors, and candidate countermeasures. The agency's foundational work is grounded in the Haddon Matrix, introduced by NHTSA's first Administrator, Dr. William Haddon, in 1969. The Haddon Matrix identifies the factors involved in crashes—from the pre-crash phase, crash phase, and post-crash phase—and how drivers, vehicles, and the environment influence the outcomes of each. The Haddon Matrix embodies the core elements of NHTSA's historic efforts to reduce traffic injuries and fatalities by using data to identify traffic safety issues and employ countermeasures to target those issues.

NHTSA's National Center for Statistics and Analysis (NCSA) supports data-driven decisions through the collection and analysis of data and the dissemination of information to quickly identify potential problems and support data-driven safety decisions. In addition to its own data sources, NCSA uses data from other governmental agencies, as well as crash files from States, to support analytical activities. NCSA also regularly publishes a variety of research notes, crash statistics, traffic safety fact sheets, and reports that provide information on crashes at the national and State levels (for more information, please see *www.nhtsa.gov/data*).

Safe Road Users

The Safe System Approach targets the safety of all road users, including those who walk, bike, drive, ride transit, and travel by other modes. All road users should have the opportunity to travel safely, regardless of how they travel. At the same time, road users have a responsibility to operate, to the best of their ability, within the expectations and boundaries of the transportation system. NHTSA works with stakeholders—road users as well as local, State, and private partners—to help them understand their responsibilities in a Safe System. Everyone shares ownership of the road system and all share responsibility for maintaining a Safe System.

Education and training on safe road behaviors comprise the cornerstones of promoting safe road users. NHTSA works to reinforce positive behaviors (such as reminding motorcyclists to use proper safety gear and vehicle occupants to use proper adult and child restraints) and to deter dangerous behaviors (including impaired, distracted, or drowsy driving).

NHTSA develops research-based programs and safety campaigns that educate road users to drive sober, wear seatbelts, be attentive, and move at safe speeds. For example, NHTSA creates and places social, digital, and traditional media advertisements to encourage all parents and caregivers to use the correct car seat for their child's age and weight.

NHTSA offers resources to educate and train road users on safe behaviors and equipment, including campaigns using the correct child safety seat for a child's age and weight.

Source: NHTSA.

October is National Pedestrian Safety Month, and NHTSA and its partners run awareness campaigns to emphasize that all road users have a role in keeping pedestrians safe.

Source: NHTSA.

NHTSA raises awareness of the dangers to pedestrians by providing safety tips for walkers of all ages, educational material, statistics, resources including information for drivers on avoiding pedestrians, and conducting public campaigns, such as *Everyone is a Pedestrian*. Further, NHTSA has developed resources to help States and local communities identify, address, and improve pedestrian safety, including a data visualization tool, safety tips, and social media graphics and messaging. Additionally, NHTSA places special emphasis on people who walk throughout the month of October which is designated as National Pedestrian Safety Month. Everyone has a role to play and must work together to keep all road users especially our most vulnerable ones safe.

The *Buckle Up. Every Trip. Every Time.* campaign reminds road users that wearing a seat belt is one of the most powerful choices drivers and passengers can make to ensure their safety while in a vehicle. Proper seat belt use means other elements of the Safe System—safe vehicles and post-crash care—can work together to reduce fatalities and serious injuries.

Other examples of NHTSA efforts to educate road users include reminding motorcyclists to make themselves visible, to use motorcycle helmets that are compliant with U.S. Department of Transportation regulations, and to always ride sober. NHTSA helps older road users understand how aging and associated medical conditions can affect driving in addition to adapting a vehicle to meet changing physical needs. On the other end of the age spectrum, NHTSA provides information on States' driver licensing requirements for novice drivers and promotes a three-stage graduated driver licensing system and training for new drivers so that they understand how to safely navigate the built environment with other users.

Source: NHTSA.

Fair and equitable law enforcement is an important component in the Safe System Approach—not only to prevent a crash (supporting voluntary compliance with State laws) and to respond when a crash happens (providing emergency care, ensuring safety of other road users, and expediting scene clearance), but also as part of the shared responsibility to provide feedback to improve the system design and operation based on officers' experience in responding to crashes. Law enforcement officers also serve as educators on the frontline to help remind all road users—drivers, pedestrians, bicyclists, transit riders, and others—to use the transportation system safely.

High visibility enforcement and education campaigns have been successful strategies for many decades at NHTSA, while supporting the Safe System Approach principles that safety is proactive and that responsibility is shared. The "Click It or Ticket" seat belt and

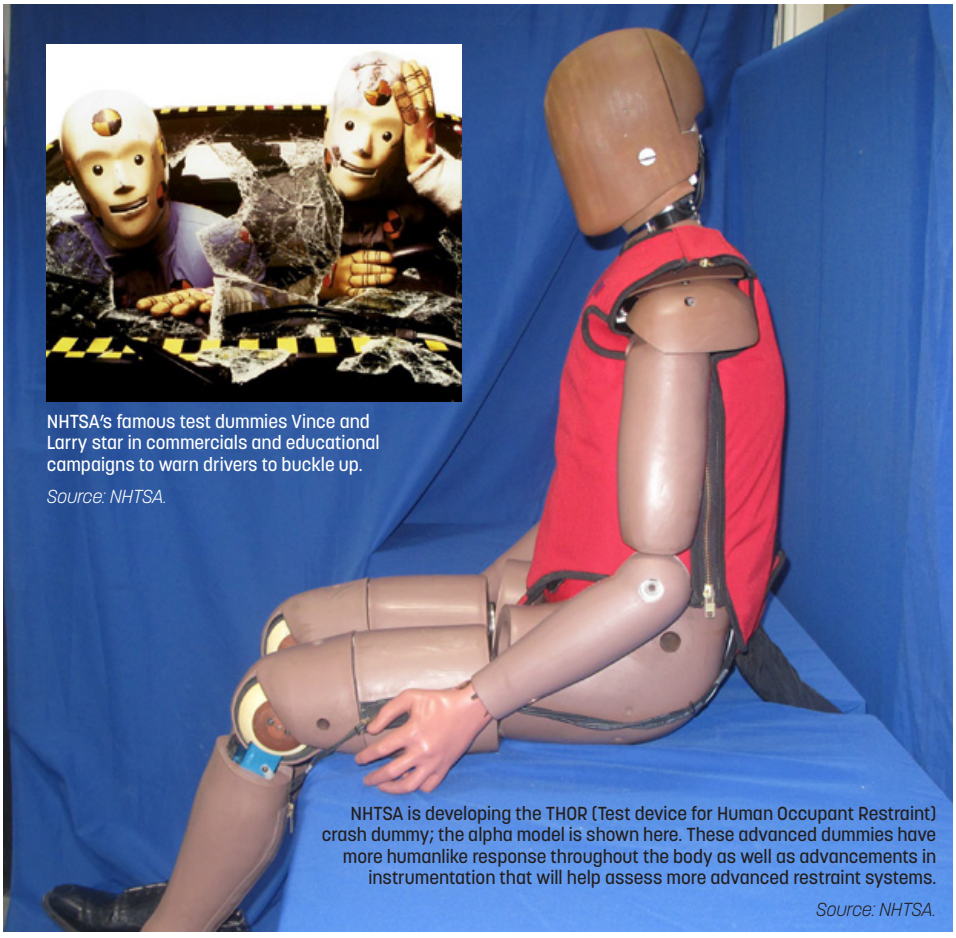
Source: NHTSA.

"Drive Sober or Get Pulled Over" impaired driving campaigns are recognized by most licensed drivers. Currently, NHTSA is working to reduce distracted driving with the "U Drive. U Text. U Pay." campaign. Impaired driving laws and the enforcement and consequences of these laws have worked together to reduce the number of impaired driving fatalities by half since the early 1980s.

To support its education and enforcement efforts, NHTSA has created effective partnerships with community and safety stakeholders to include health professionals, parents, community organizations, law enforcement, members of the justice system, and nonprofit organizations.

Safe Vehicles

The vehicle—be it a car, sport utility vehicle, pickup truck, heavy truck, transit bus, or other type—is an important component of a Safe System. Recent technological advances in the automotive industry provide a variety of tools to enhance roadway safety through this element of the system. Technology provides a key opportunity to address the Safe System tenet that humans make mistakes by supporting drivers where they may err and mitigate some of the outcomes that could result from unsafe behaviors. These systems, when properly used, can substantially reduce crashes. For example, automatic emergency braking system technologies are specifically designed to help drivers avoid, or mitigate the severity of, rear-end crashes. In 2019, almost one-third of all police-reported crashes involved a rear-end collision with another vehicle at the start of the crash. For more information, please see NHTSA's Annual Traffic Safety Facts at *https://cdan.nhtsa.gov/tsftables/tsfar.htm*.



NHTSA's famous test dummies Vince and Larry star in commercials and educational campaigns to warn drivers to buckle up.

Source: NHTSA.

NHTSA is developing the THOR (Test device for Human Occupant Restraint) crash dummy; the alpha model is shown here. These advanced dummies have more humanlike response throughout the body as well as advancements in instrumentation that will help assess more advanced restraint systems.

Source: NHTSA.

Another essential aspect of a safe vehicle is crashworthiness—how well a vehicle protects its occupants in a crash. NHTSA's aim is to make vehicles as safe as possible or their crashworthiness as great as possible by affording injury protection to occupants when a crash occurs. NHTSA also focuses on addressing the safety of those vulnerable road user populations outside or around the vehicle to minimize impact or severity of injury through data collection, research, and leveraging of new technologies. NHTSA efforts on vehicle crashworthiness have focused on new and improved vehicle design; biomechanics and injury causation; field data collection; and analysis of serious injury cases, safety countermeasures, and equipment to enhance occupant safety. Despite modern vehicles being safer than ever, the need remains to improve the understanding of injury causation through the development and upgrade of test procedures for the evaluation of motor vehicle safety, the development of crash test dummies and human body computer models, and appropriate injury metrics.

NHTSA uses a family of crash test dummies to help the agency understand and measure the human body's movement, vehicle performance, and the performance of various safety features during a crash. Measurements from the test dummies predict the risk of injury to each part of the body during air bag deployment and in crashes involving frontal, side, and rear impacts. NHTSA has dummies that differ in size, weight, and movement to account for some of the variations in body types, as well as crash circumstances.

NHTSA's family of dummies ranges from newborns to 10-year-old children to small females and average males. NHTSA is also involved in worldwide development and evaluation of crash test dummies even more advanced than those used today. Design, instrumentation, and testing with these crash test dummies help ensure the safety of vehicle occupants in the unfortunate event that a crash occurs by encouraging safety improvements to vehicles to provide better vehicle crashworthiness through occupant protection—saving lives. Technologies that improve crashworthiness and afford protection to the users include seat belts, advanced air bags, and electronic stability control.

While protecting occupants and vulnerable road users in a crash is important, the most desirable outcome would be to prevent crashes from happening whenever possible:

Active safety systems like automatic emergency braking technology can assist drivers and prevent crashes.

Source: NHTSA.

no crash, no injuries, no fatalities. Advancements in technology have added a new dimension to the vehicle safety space. Active safety systems, which are types of advanced driver assistance systems (ADAS), proactively anticipate and assist drivers who may not respond to immediate and/or imminent dangers around them. These technologies include automatic emergency braking system technologies and electronic stability control—both referred to as active safety systems—to provide momentary intervention during potentially hazardous situations.

There are a variety of other passive ADAS technologies available in the marketplace now. Passive ADAS technologies alert drivers of potential risk situations to give the driver time to respond. Some examples of these systems include forward collision warning, which detects a potential collision with a vehicle ahead and alerts the driver (some systems also provide alerts for pedestrians or other objects); lane departure warning, which monitors a vehicle's position within the driving lane and alerts the driver as the vehicle approaches or crosses lane markers; and blind spot warning, which detects vehicles in the blind spot while driving and notifies the driver to their presence (some systems provide an additional warning if the driver activates the turn signal). Note that these systems only provide a warning to the driver and do not take action to avoid a crash.

The benefits of these various active and passive safety systems are well documented in helping drivers avoid or mitigate crashes, but they can only address a portion of related crash circumstances. It is vital to emphasize that drivers will continue to share driving responsibilities for the foreseeable future and must remain engaged and attentive to the driving task and the road ahead.

Newer vehicle innovations under testing and development, such as Automated Driving Systems that at maturity contemplate replacing human drivers, also follow the Safe System principles and involve all stakeholders early and often, as an opportunity to contribute to the Safe System Approach.

Post-Crash Care

Even with improvements in all components of the Safe System Approach—roads, vehicles, and road users—traffic crashes still happen. A comprehensive and integrated post-crash care system can further reduce fatalities and serious injuries resulting from those crashes. 911 emergency communications centers, first responders and highly trained EMS personnel, emergency departments, and trauma centers are all essential parts of that system.

The actions taken after a crash are vital to reducing death and disability. Improvements to EMS systems, such as automated communication of crash location and severity, may reduce the 40 percent of deaths from traffic crashes that occur after the arrival of EMS at the crash scene. The information collected by 911 telecommunicators and EMS clinicians also serves as a robust resource for examining the factors that influence traffic crashes and patient outcomes.

NHTSA has integrated post-crash considerations in its work since the very beginning. NHTSA's Office of Emergency Medical Services was part of the group of EMS stakeholders that developed standard curricula for EMS clinicians, the National EMS Information System (NEMSIS), and evidence-based guidelines for prehospital care. NHTSA also maintains *EMS.gov* and *911.gov*, which serve to educate and inform the general public, EMS, and 911 stakeholders about critical issues.

Today, NHTSA continues to collaborate with partners to advance post-crash care. A key component of post-crash care is the National EMS Education Standards. The standards support consistency in EMS care across the country. NHTSA also funds the development of several evidence-based guidelines for clinical care,

including guidelines for bleeding control, pain management, and the appropriate triage of trauma victims to ensure that the right patients get to the right hospital at the right time.

The NEMSIS establishes a common data standard used by EMS systems throughout the country. When EMS clinicians respond to a 911 call and treat a patient, they complete an electronic patient care report that uses the NEMSIS standard. This common NEMSIS language enables information to be easily combined for surveillance, analysis, and research. The National EMS Database collects NEMSIS data—via State repositories—in near real time. In 2020, EMS systems in 50 States and territories submitted more than 43 million EMS records. The National EMS Database can provide information on nearly every 911 activation for a medical emergency or injury, making it a powerful tool for studying everything from the COVID-19 pandemic to pedestrian injuries to vehicle crashes.

NHTSA also houses the National 911 Program, which supports the advancement of 911 systems across the country. The program works with stakeholders to ensure a smooth transition to an updated 911 system to leverage new technologies. The program also administers a 911 Grant Program, which has awarded more than $100 million to States and Tribal nations.

In Conclusion

"NHTSA believes in an approach that is people-focused, meaning that infrastructure serves the needs of its users, not the other way around. As we continue to move forward [with] a Safe System Approach, we will not forget the voices of those who use the roads, particularly those in communities of color, underrepresented communities, and people with disabilities. A successful Safe System Approach respects all users," Dr. Cliff says.

All system managers, owners, designers, and users need to be actively involved in advancing and preserving the safety of the system. Everyone plays a role—from community and advocacy organizations to public safety officials and transportation experts, road users, vehicle designers and developers, law enforcement, and first responders. Building a Safe System requires an extraordinary commitment to community engagement. System users need to be involved in decisions before building the road system, in education on how to use it, and in reinforcing public trust that the system will be safe for users when everyone shares responsibility for it. And, most important, when assessing Safe System decisions, NHTSA will integrate the input and needs of all road users—not just drivers and passengers but pedestrians, cyclists, children, older Americans, and people with disabilities—as the Nation moves forward.

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Post-crash care, including the sharing of information like crash location and injury severity with responding emergency personnel, is critical to improving patient outcomes.

Source: NHTSA.

Speed management is a critical element of the Safe System Approach.

© Joshua Fulle / Unsplash.com.

SPEED MANAGEMENT Is Key to Road Safety

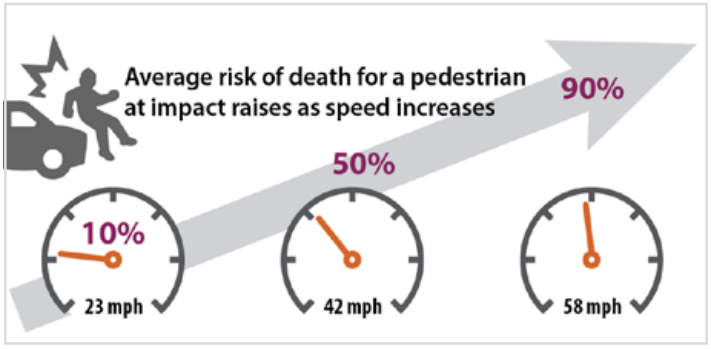
Advancing speed management for safety can reduce speeding-related injuries and fatalities on the Nation's highways and byways.

by **GUAN XU**, **ABDUL ZINEDDIN**, **RANDOLPH ATKINS**, and **SARAH ABEL**

Much progress has been made in transportation safety over the last several decades. Despite the large increase in traffic volume, the fatality rate decreased from 5.5 fatalities per 100 million vehicle miles traveled (VMT) in 1966 to 1.11 fatalities in 2019. Despite this success, reducing traffic speeds and speeding-related crashes and fatalities continue to pose some complex challenges. Early estimates show that fatality rates and speeding-related fatalities increased in 2020 during the COVID-19 public health emergency, compared to 2019, although 2020 was anomalous.

Studies clearly show that higher speeds result in greater impact at the time of a crash, which leads to more severe injuries and fatalities. This is especially concerning for more vulnerable road users, such as motorcyclists, bicyclists, and pedestrians. Per vehicle miles traveled in 2019, motorcyclist fatalities occurred nearly 29 times more frequently than passenger car occupant fatalities, and 33 percent of motorcycle riders involved in fatal crashes in 2019 were speeding. Pedestrians made up 17 percent of traffic fatalities in 2019 with 6,205 fatalities. Bicyclists accounted for approximately 2 percent of fatalities in 2019 with 846 bicyclist fatalities.

Because higher speeds increase fatalities, new approaches in speed management, such as the Safe System Approach, are needed to reduce roadway fatalities and increase the safety of all



The greater the speed of a vehicle at the time of a crash, the higher the risk of death for a pedestrian struck.

Source: Federal Highway Administration. Based on data from the AAA Foundation for Traffic Safety, Impact Speed and a Pedestrian's Risk of Severe Injury or Death, September 2011.

road users. Underscoring the importance of this issue, the National Transportation Safety Board has identified both "implement a comprehensive strategy to eliminate speeding-related crashes" and "protect vulnerable road users through a Safe System Approach" as part of its *2021–2022 Most Wanted List* of transportation safety improvements (found at *www.ntsb.gov/safety/mwl/Pages/default.aspx*).

Speeding as a Safety Problem

The National Highway Traffic Safety Administration defines a crash as speeding-related if any driver involved in the crash is charged with a speeding-related offense or if a police officer indicates racing, driving too fast for conditions, or exceeding the posted speed limit was a contributing factor in a crash. The most recent data from NHTSA's Fatality Analysis Reporting System (FARS) found that, in 2019, there were 9,478 speeding-related fatalities, 26 percent of total traffic fatalities for the year. For speeding-related fatalities where functional class was reported, 86 percent occurred on noninterstate roadways. Drivers in speeding-related fatal crashes were more likely to have previous convictions for speeding and/or alcohol-impaired (BAC .08 g/dL or higher) driving, previous crashes, and license suspensions or revocations compared to nonspeeding drivers in fatal crashes.

Speed feedback signs like this one can encourage drivers to follow posted speed limits and advisory warnings.

© Portland State University.

NHTSA's nationally representative survey of traffic speeds across the United States conducted in 2015 revealed that 70 percent of free-flow vehicles on limited access roads exceeded the posted speed limit, with 59 percent of vehicles on major arterials and 60 percent of vehicles on minor arterials and collector roads also exceeding the posted speed limit. The 85th percentile speeds were significantly higher in 2015 on major arterials and minor arterials and collector roads as compared to the previous national survey in 2009. The full survey is available at *https://rosap.ntl.bts.gov/view/dot/35961*.

The COVID-19 public health emergency made excessive speeding behaviors more evident. Traffic speeds across the country increased during this same period compared to historical levels, especially on urban interstates, with many reports of drivers traveling at extremely high speeds in excess of 100 miles (160 kilometers) per hour. In 2020, while VMT decreased 13.2 percent, the fatality rate increased to 1.37 fatalities per 100 million VMT, up from 1.11 in 2019, with a projected 7.2 percent increase in fatalities and an 11 percent increase in speeding-related fatalities. The evidence indicates that a combination of less congested roads and a higher percentage of riskier drivers contributed to this increase.

Many factors contribute to drivers' choice of speeding, but drivers' beliefs and attitudes play an important role in their driving behavior and the cultural acceptance related to speeding. For instance, NHTSA's naturalistic driving study, "Motivations for Speeding," showed that driver motivations, attitudes, and beliefs are "highly significant predictors" of which drivers speed and how much they speed. Several studies identified speed-contributing attitudes such as being impatient with other drivers, wanting to get where they are going as fast as possible, enjoying driving fast, and believing that driving fast was not dangerous for skilled drivers.

Transportation professionals have realized that creating a positive traffic safety culture is critical to addressing speeding as a safety problem. All five elements of the Safe System Approach can be applied to addressing speeding; however, the safe speeds and safe roads elements are of particular importance when creating a successful speed management program and advancing speed management for safety.

The Importance of Speed Management

When drivers are traveling at higher speeds, they require more time to react once they see changes in the road environment ahead. Once they engage the brakes, the distance required to stop the vehicle is directly related to the speed of the vehicle at the time of braking and the vehicle's weight; higher speeds and heavier vehicles simply take longer to stop, so consequently these factors result in the increased probability of crashes. Speed also impacts the severity of a crash. The force involved in a crash is directly related to the speed at the time of a crash: "The energy release is proportional to the square of the impact speed," according to the Transportation Research Board's *Special Report 254: Managing Speed – Review of Current Practice for Setting and Enforcing Speed Limits*. These factors show how effective speed management using the Safe System Approach, defined as kinetic energy management, can contribute to reducing speeding-related serious injuries and fatalities.

Speed management is an approach that focuses on achieving safe mobility by setting appropriate speed limits, reducing speeding, and reducing and/or mitigating the impact of speeding-related crashes. The goal of the U.S. Department of Transportation speed management program is to improve public

SAFE SYSTEM ELEMENTS

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.

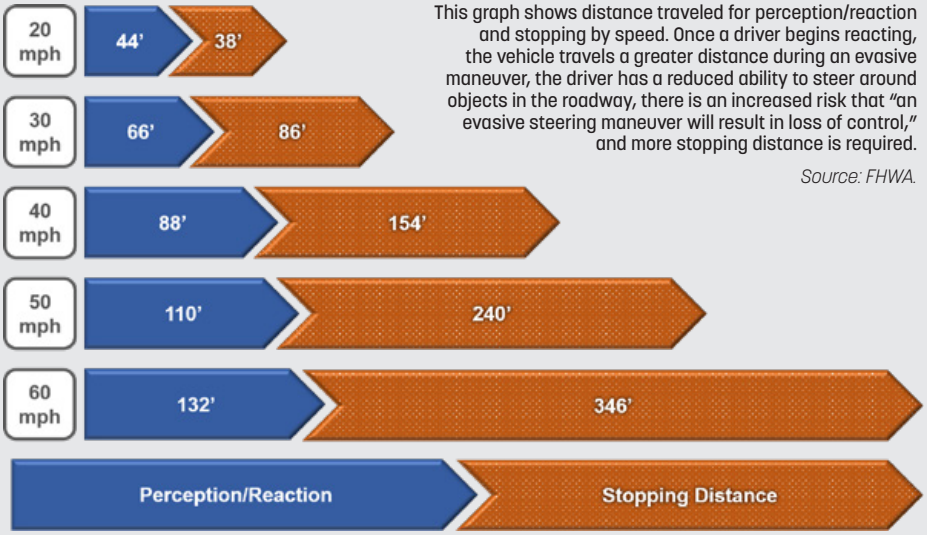
Safe Speeds
Humans are unlikely to survive high-speed crashes. Reducing speeds can accommodate human injury tolerances in three ways: reducing impact forces, providing additional time for drivers to stop, and improving visibility.

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.

Safe speeds is one of the five elements of the Safe System Approach. Applying safe speeds reduces impact forces, increases visibility and decreases stopping distance.

Source: FHWA.



This graph shows distance traveled for perception/reaction and stopping by speed. Once a driver begins reacting, the vehicle travels a greater distance during an evasive maneuver, the driver has a reduced ability to steer around objects in the roadway, there is an increased risk that "an evasive steering maneuver will result in loss of control," and more stopping distance is required.

Source: FHWA.

health and safety by reducing speeding-related fatalities and injuries and achieve improved safety experience for all road users. The following key speed management strategies and activities for achieving the USDOT speed management program goal were identified by the USDOT intermodal Speed Management Team that consists of NHTSA, FHWA, and the Federal Motor Carrier Safety Administration:

- Developing and implementing jurisdiction-wide speed management programs and plans.
- Outlining how to set safe, consistent, and enforceable speed limits based on the presence of all road users and context and not just drivers' operating speeds.
- Applying proven safety countermeasures to help achieve safe speeds for the safety of all roadway users.
- Improving crash data report forms with targeted reporting of speeding-related crashes that provides consistency and focuses on identifying contributing factors.
- Deploying enforcement through transparent high-visibility activities, educational programs, and awareness campaigns rather than a strictly enforcement focus.
- Considering equity in speed management decision making.

The team is currently updating the USDOT *Speed Enforcement Camera Systems Operational Guidelines*. The updated guide is expected to be renamed *Speed Safety Camera Program Planning and Operations Guide* and will emphasize that speed cameras are an effective countermeasure to improve safety by managing traffic speeds.

Noteworthy safety programs recognize safe speeds as a key factor to achieving a goal of zero traffic deaths and serious injuries. All zero-death programs reference the Safe System Approach for achieving safe speeds, and the need to create a positive traffic safety culture and improve driver behavior as a part of effective speed management.

The safe speeds element of the Safe System Approach can be reached through a comprehensive speed management program. There are challenges and opportunities when considering speed management in relation to the Safe System Approach. These include how to define safe speeds consistently across all contexts, how to effectively set safe speed limits that do not rely solely on driver operating speeds, how to achieve a target speed using roadway geometry effectively, and how to incorporate the concepts of kinetic energy forces and speed harmonization in existing speed management guidance. To address the challenges, a joint effort by FHWA and the Institute of Transportation Engineers (ITE) is currently developing additional resources as speed management practices shift toward applying the Safe System Approach.

FHWA: Working Toward Better Understanding and Managing of Speed

Speeding and speed management are cross-cutting and complex challenges involving the interaction of many factors, including effective roadway design, posted speed limits, political climate, road user

The city of Portland, OR, has adopted a new speed limit of 20 miles (32 kilometers) per hour on nearly 70 percent of city streets as part of comprehensive speed management program.

© Hannah Schafer, Portland Bureau of Transportation.

behavior, enforcement strategies, and judicial decisions. Collaboration is the key to combat speeding as a safety problem. National agencies and organizations, such as FHWA, NHTSA, and ITE, provide resources and technical assistance on safety through speed management.

FHWA has been focusing on setting appropriate, consistent, and enforceable speed limits and providing technical assistance to State and local agencies on implementing effective infrastructure and engineering speed management countermeasures to encourage drivers to obey speed limits. Through its Proven Safety Countermeasure Initiatives program, FHWA is promoting, with technical support, the implementation of several proven speed management countermeasures including variable speed limit system, speed safety camera, and setting appropriate speed limits for all road users. Recently, FHWA began a new program to explore concepts and techniques to integrate the Safe System Approach with speed management.

Speed management is receiving increased attention from State and local agencies, especially those that have adopted Vision Zero goals and are beginning to implement the Safe System Approach. Forty-four States have included speeding or speed management in their Strategic Highway Safety Plans. A comprehensive speed management program is crucial to ensure that agencies can work collaboratively to address safe speeds in a holistic approach. Speed management program plans set objectives, identify gaps and needs, lay out strategies and planned activities, and incorporate state-of-practices for successfully implementing speed management programs. FHWA has been providing direct technical assistance and has helped some agencies successfully develop and implement speed management program plans. Some of the recently developed program plans include recommendations and strategies to help advance a positive traffic safety culture and application of the Safe System Approach.

Safe speeds, one of the five elements of the Safe System Approach, are critical for all road users.

© Getty Images.

In recent years, FHWA has endeavored to update existing, and create new, speed management resources for practitioners and provide technical assistance for speed management. This includes the recently published report, *Noteworthy Speed Management Practices* (FHWA-SA-20-047, *https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa20047/fhwasa20047.pdf*), which includes examples of successful implementations of speed management countermeasures by public agencies on:

- Developing and implementing a city-wide Strategic Speed Management Program with comprehensive speed management activities, established key indicators, target achievement metrics, and an integrated effort including enforcement;
- Setting safe, consistent, and enforceable speed limits for all roadway users for rural and urban environments;
- Applying engineering and alternate enforcement countermeasures, such as self-enforcing roadway and speed safety cameras, to achieve the set posted speed limits for the safety of all roadway users;
- Improving crash data forms with targeted reporting of speeding-related crashes that provide consistency and focus on addressing crashes by identifying contributing factors; and
- Implementing enforcement through transparency and using an "educational" initiative rather than a strict enforcement detail.

In addition, FHWA has also increased education and training for more transportation professionals on USLIMITS2, a web-based tool for setting safe speed limits. With the support of the National Cooperative Highway Research Program (NCHRP), FHWA is in the process of developing the next generation of the tool, USLIMITS3, which will incorporate state-of-the-practice research and methods, such as the Safe System Approach, for setting safe speed limits for all road users.

NHTSA Speed Management Activities

The efforts of NHTSA's speed management program focus on the Safe System Approach for enforcement, education, emergency response, vehicle safety, and behavioral research to develop safety countermeasures, as well as providing resources and technical assistance to support practitioners at the State and local levels (*www.nhtsa.gov/risky-driving/speeding#resources*). The agency works closely with law enforcement organizations through its Law Enforcement Liaison Program. It also works with the National Institute on Standards and Technology to establish model specifications for speed measurement devices and maintains a "Conforming Product List" of devices that meet the specifications. Additionally, NHTSA provides training and guidance for using these devices as well as other training for law enforcement personnel, including a High Visibility Enforcement Toolkit.

NHTSA provides training for traffic safety professionals through its speed management course, taught by the Transportation Safety Institute, and issues communications to educate the driving public on speed safety and preventing speeding. The agency also conducts a wide range of innovative research projects to identify safety problems; advance scientific knowledge in this area; and support the development of countermeasures to equitably improve speed management and reduce traffic crashes, injuries, and fatalities, including producing a report on effective countermeasures entitled *Countermeasures That Work*. Additionally, NHTSA supports emergency medical response efforts for crashes and offers a robust vehicle safety program to improve vehicle crashworthiness, occupant protection, and crash avoidance technologies.

"Speeding is one of the top causes for vehicle crashes," says Nanda Srinivasan, NHTSA's associate administrator for Research and Program Development. "Speeding endangers everyone—the driver, occupants, and other road users. There is no excuse to speed—whether you are late, [or] the roads are empty or congested."

ITE's Efforts in Speed Management

ITE continually focuses on advancing speed management for safety, providing updated resources and guidance as speeding-related information rapidly evolves. In 2019, ITE released a resource hub that includes available speed management resources helpful to transportation professionals (*www.ite.org/technical-resources/topics/speed-management-for-safety*).

In partnership with the Vision Zero Network, ITE has conducted several "speed management for safety" workshops to assist agencies with implementing a safe and comprehensive approach to speed

Ossian, IA, received a *Manual on Uniform Devices* experimental waiver for this high-visibility pavement marking to increase compliance with posted speed limit.

© Shauna Hallmark.

management, from helping outline program goals to methods for setting speed limits to effective roadway design to manage speeds. After conducting a workshop in the city of Austin, TX, they went on to adopt a comprehensive speed management program upon the conclusion of the workshop held there in 2019, and FHWA featured the Austin speed management program for its successes in the *Noteworthy Speed Management Practices* (FHWA-SA-20-047) publication the following year. One of Austin's most recent speed management successes took place in June 2020, when the city council unanimously voted to reduce speed limits on residential, urban arterial, and downtown streets.

In 2021, the Vision Zero Network and ITE conduced "speed management for safety" workshops in three California communities to help develop and sustain effective speed management safety programs as the state of California continues to look for ways to further advance safe speeds. Most recently, ITE commented on speed-limit-setting guidance in the proposed amendments to the *Manual on Uniform Traffic Control Devices*, and it is beginning a joint effort with FHWA to explore ways to further advance the Safe System Approach through achieving target speeds.

Speed management countermeasures for residential streets may include speed cushions like these, which calm vehicle traffic but include wheel cutouts that allow fire apparatuses to bypass in case of emergence response.

© Traffic Logix.

"Safe speeds are a key component of the Safe System Approach and critical to achieving Vision Zero," says Jeffrey F. Paniati, P.E., ITE's executive director and CEO. "An effective speed management program can only be created and maintained through strong partnerships among those with responsibility for planning, design, operations, and enforcement on the roadway system."

Looking Ahead

USDOT continues to work diligently to make equitable and effective speed management a priority throughout the country by conducting cutting-edge research and providing crucial resources to support State and local speed management efforts to reduce speeding-related injuries and fatalities. The recent commitment to the Safe System Approach holds great promise and has proven effective internationally as a method for setting safe speed limits and working toward a goal of zero roadway fatalities. Tackling speeding-related safety issues though the incorporation of new concepts, approaches, and technologies with traditional speed management can reduce the country's speeding problem and improve overall traffic safety.

"We are committed to championing the Safe System Approach and working with our partners to achieve safe speeds for all road users," says Michael S. Griffith, the director of FHWA's Office of Safety Technologies.

Undoubtedly, there will be new challenges in the future as practices advance. The Safe System Approach, which considers all road users of the transportation system and new technologies in vehicles and infrastructure, offers opportunity and promise for reducing speeding-related injuries and fatalities. Whatever the challenges that arise related to speeding, USDOT and its partners are prepared to address them through comprehensive speed management as part of the implementation of the Safe System Approach.

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For more resources on speed management, visit ***https://safety.fhwa.dot.gov/speedmgt***.

THE SAFE SYSTEM APPROACH: How States and Cities Are Saving Lives

The Safe System Approach offers useful tactics for saving lives and preventing fatalities on our Nation's roadways.

by **CHIMAI NGO**, **JOHN MILTON**, **LILY REYNOLDS**, **RACHEL CARPENTER**, and **CLAY VEKA**

Over the past decade, many States and local communities have adopted a road safety goal of zero deaths and serious injuries. At the State level, such a goal is reflected in the State's Strategic Highway Safety Plan (SHSP) through various brandings, such as Toward Zero Deaths, Target Zero, and Destination Zero Deaths. At the local level, this goal is known as Vision Zero. The shared belief that deaths and serious injuries are unacceptable is not new. What is new is the paradigm shift in how transportation agencies are approaching safety to achieve the goal of zero deaths.

Progress is not made simply through branding and taglines. While sharing the message of a commitment to zero deaths is important, it is most useful to know what agencies have done differently from traditional practices to achieve meaningful results. What is the foundation for these successes? For many, it is the Safe System Approach.

Countries that have institutionalized the Safe System Approach since the 1990s, like Sweden and the Netherlands, have seen the fruits of their labor. According to a World Resources Institute analysis of 53 countries, those that have adopted the Safe System Approach saw at least a 50-percent reduction in fatality rates between 1994 and 2015. With this encouraging evidence, the U.S. Department of Transportation has taken the leadership role in helping to advance the Safe System Approach in States and local communities. With support from stakeholders across the public and private sector, implementing the Safe System Approach will aid in saving lives and preventing serious injuries.

The following are examples of how two States and two cities committed to the goal of zero deaths by employing the Safe System Approach to address safety for all road users. These States and cities are institutionalizing the approach and

> *"Vision Zero is not a slogan or a tagline. It's a fundamental shift in how we approach traffic safety. It's based on Safe System principles, starting with the ethical imperative that everyone has the right to move safely in their communities. It means using the most effective and equitable solutions to prioritize safe mobility for all."*
>
> – Leah Shahum, Vision Zero Network Founder and Executive Director

U.S. cities and States are adopting the Safe System Approach to address inequities in transportation, protect vulnerable road users, and set safer speed limits.

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using it as a foundation for the policies that affect their operations at both program and project levels.

Safe System: Washington's Actions for All Road Users

Inspired by peer exchanges with Sweden and the Netherlands as well as Australia's integration of Vision Zero and sustainable safety into the Safe System Approach, the Washington State Department of Transportation (WSDOT) developed its first SHSP, Target Zero, in 2000. In doing so, Washington became the first State in the Nation to set the goal of zero traffic fatalities. The multidisciplinary Safe System Approach was a natural next step in WSDOT's progression to performance-based planning, design, and operations (practical solutions) within a multimodal system.

Early on, WSDOT focused on gaining leadership buy-in and support. Significant change initiatives often require leadership from the top to be effective. WSDOT adopted the use of executive orders to drive transformational changes. In 2013, WSDOT developed the Sustainable Highway Safety Program Executive Order. Moving Washington Forward: Practical Solutions followed in 2014 and led to changes in WSDOT engineering practices, providing significant design flexibility and including modal priority and design context in decisionmaking.

The agency also moved boldly to reorganize its structure to better define its hierarchy of responsibilities and activities. Specifically, WSDOT created an Active Transportation Division to position walking, cycling, and other human-scale active modes at the same organizational level as transit, aviation, rail, freight, and central divisions, such as traffic operations, design, and transportation safety and system analysis. The new Multimodal Development and Delivery structure became the home for these divisions, which has resulted in greater collaboration and fostered deeper cross-disciplinary understanding of safety issues, particularly for vulnerable road users. Additionally, WSDOT's Multimodal Technical Forum supports discussions and activities across these divisions.

WSDOT's safety policy initiatives benefit greatly from collaboration with the Washington Traffic Safety Commission (WTSC). This partnership is critical to advancing road safety because WSDOT oversees the infrastructure programing while the Commission is responsible for behavioral programing. The two agencies work together to update the SHSP Target Zero. The 2019 update included a chapter on the principles of the Safe System Approach, and the pedestrian and bicyclist safety chapter emphasized systemic engineering (e.g., narrowing lanes, road diets) and operational approaches (e,g., speed management, enhanced traffic control, and delineation for active transportation) rather than the traditional emphasis on an individual's behavior. While the 2019 SHSP Target Zero included a section on the Safe System Approach, WSDOT and WTSC expect to highlight the principles and elements of the Safe System Approach throughout the plan in the next update. The intent is to clearly outline what the Safe System Approach entails and what is needed from Washington's safety stakeholders, partners, and the public to achieve a Safe System.

WSDOT has now moved to integrating the Safe System Approach in practice by implementing proactive safety strategies. WSDOT has changed the safety program to de-emphasize reactive safety projects—70 percent of its safety program funding is now targeted toward crash prevention. New safety program initiatives address two core components of the Safe System Approach: reduction of crash forces and shared responsibility, which encourages engineers to design for errors. For example, WSDOT aims to reduce the kinetic energy of a crash by installing roadside safety hardware, reduce crash angles by using roundabouts, and support shorter stopping distance by applying high-friction pavements.

Setting appropriate speeds is key to the Safe System Approach, and WSDOT's Active Transportation Division and the WTSC's Cooper Jones Active Transportation Safety Council both provide essential leadership toward that goal. The Active Transportation Division led a multiagency working group that developed an injury minimization policy framework for speed setting based on human injury tolerance rather than the more common speed-setting methods included in the *Manual on Uniform Traffic Control Devices*. The principles from this approach informed a recent update to the agency's *Traffic Manual*, and implementation of this policy will continue in 2022. New funding for speed management in WSDOT's safety program is anticipated.

People walking and bicycling represent a disproportionate share of Washington State's fatalities relative to miles traveled by mode, as WSDOT reports annually in its *Gray Notebook* active transportation safety report. Evaluation of crashes in Washington shows an overrepresentation of fatal and serious crashes involving active transportation within low-income communities and in communities with higher proportions of people with disabilities or who are Black, Indigenous, and people of color. These same locations often suffer from gaps in active transportation facilities. This combination results in people walking and biking, out of necessity, along roadways designed for higher speeds and traffic volumes. Future funding for active transportation projects will be determined based on a systemic analysis of roadway characteristics that prioritizes equity. A recent update to the State's active transportation plan, available at *https://wsdot.wa.gov/construction-planning/statewide-plans/active-transportation-plan*, discusses these issues and provides the underlying methodology for identifying and prioritizing infrastructure gaps on State routes.

Given the importance of equity in safety, WSDOT will be incorporating "equity by design" into its implementation of the Safe System Approach. Program and project choices should result in an equitable system that factors in the context of the road and

Active Transportation Systemic Safety Ranking Matrix

Criterion	Relevant to Gap Location		Score
Safety	Crash history		0 - 5
	Systemic safety issues		5 or 10
	Connectivity (conflict reduction infrastructure)	Destination proximity	0 - 10
		Trail proximity	0 or 10
		Intermodal proximity	0 - 10
Equity	Concentration of low income households		1 - 10
	Concentration of people with disabilities		1 - 10
	Concentration of people of color		1 - 10
Demand	Potential for walking/cycling		0 - 10

Source: 2019 WSDOT.

This "self-explaining" road design for active transportation users separates different road users to avoid conflicts and improve safety.

Source: FHWA.

surrounding land use and demographics. Understanding needs through data analysis and evaluation will result in effective, efficient decisions and will inform modifications that do not have to sacrifice safety for mobility.

WSDOT believes in learning from others through peer exchange, knowledge transfer, research, and innovation. WSDOT wishes to play an active role in implementing the Safe System Approach and looks forward to the future. "WSDOT continues to evolve in how it plans, designs, and operates the transportation system, and advancement toward a Safe System will be key to bringing deaths and serious injuries down. Getting to a high level of implementation of the Safe System will take time, but we are committed," says Barb Chamberlain, director of the WSDOT Active Transportation Division.

Using an Equity-Informed Approach in Philadelphia

Philadelphia is taking an equity-informed Safe System Approach to eliminating traffic-related deaths. The ongoing effort seeks to create safe streets and transportation options for all residents.

Philadelphia has one of the highest rates of traffic-related deaths among major American cities. In 2018, the rate of traffic-related deaths per 100,000 residents was nearly triple that of New York City, about 50 percent greater than Chicago, and almost on par with Los Angeles County, according to the National Highway Traffic Safety Administration. Philadelphians also face high rates of unemployment, poverty, and inequity.

In 2016, the city responded by adopting Vision Zero, an initiative to eliminate traffic-related deaths in Philadelphia by 2030. An action plan released in 2017 laid the groundwork for safe roadway interventions.

"The path to achieving Vision Zero is not accomplished easily and requires a fundamental and widespread commitment to systemic change from how we design our roads, to how we teach our kids to walk to school, to how we design vehicles," said Philadelphia Mayor James F. Kenney in the *Vision Zero Action Plan 2025*. "It will take all of us to reach zero."

The Vision Zero Task Force—a coalition of government officials, partner agencies, and community and advocacy groups—collaborated to introduce new transportation programs and policies that prioritize human life above all else. In these first 3 years, Philadelphia Vision Zero initiatives included 58 miles (93 kilometers) of completed safety projects, the launch of a neighborhood slow zone program, and the passage of legislation enabling an automated speed safety camera pilot on Roosevelt Boulevard, one of the deadliest roads in Philadelphia. Among the safety projects, the city built more than 10 miles (16 kilometers) of protected bike lanes, including a parking protected bike lane on Chestnut Street. Data collected before and after installation of the protected bike lane on Chestnut Street showed a 47-percent reduction in the number of vehicles driving over the speed limit during the morning commute and an 81-percent increase in people biking.

In 2020, Philadelphia renewed its commitment to Vision Zero with the adoption of a 5-year action plan. The Vision Zero Task Force shifted the city's approach to a Safe System framework during a tragic year that saw an 82-percent increase in the number of Philadelphians killed in crashes compared to the previous 5-year average. Philadelphia's Safe System Approach focuses on preventing fatal and serious injury crashes using the pillars of equity, safe speeds, safe streets, safe people, safe vehicles,

and safety data. The plan is available at *https://bit.ly/3qwNVEk*.

By adopting the Safe System Approach, the task force aims to understand the root causes of crash risks across the entire road system and implement proactive safety solutions. One example is a partnership with researchers at the Pedestrian and Bicycle Information Center and the University of North Carolina's Highway Safety Research Center to conduct a systemic analysis of youth pedestrian crashes to determine what types of street characteristics pose a higher crash risk. Using these results, the city can prioritize proactive interventions across the road network.

This plan also elevates the priority of slowing vehicle speeds to match roadway conditions. Automated speed safety cameras installed on Roosevelt Boulevard in 2020 sought to discourage speeding along the entire corridor. Between 2013 and 2017, 14 percent of all fatal crashes in Philadelphia occurred on this road. Cameras at eight locations on Roosevelt Boulevard captured 224,206 violations in the first month of June 2020. The Task Force and partner agencies found the number of violations dramatically decreased in the following months, resulting in a 93-percent reduction in violations by February 2021. Violations issued for vehicles traveling more than 100 miles (160 kilometers) per hour also decreased, from 75 in the first month to 7 in February 2021.This observed reduction in speeding is a significant step in the right direction to reducing risky driving behaviors, which are directly correlated with fatal and serious injury crashes.

In 2020, the Vision Zero Task Force conducted an equity analysis of the city's high-injury network, the 12 percent of Philadelphia roads that account for 80 percent of all traffic deaths and serious injuries. The results showed fatal and serious injury crashes were three times more likely to occur in areas where most residents live on low incomes and 30 percent more likely to occur to people of color. Consequently, the plan made a commitment to focus Vision Zero efforts on low-income and minority neighborhoods.

Philadelphia continues to implement roadway interventions, including a new program known as Neighborhood Slow Zones, which focuses on traffic calming on residential streets and near schools. Construction will start in 2022 on the first two slow zones. The locations were selected through a community-driven process and then filtered through an equity and crash rate scoring system to select the first zones for implementation. Community members will collaborate with city staff to identify traffic safety issues and determine the design of the traffic calming treatments. This program seeks to go beyond single-block solutions and improve safety by addressing entire zones within historically underserved areas.

In 2021 pedestrian median islands were installed in Philadelphia at all intersections on North Broad Street from Poplar Street to Cecil B. Moore Avenue, an intervention that has been shown have a 56-percent reduction in crashes involving pedestrians. North Broad Street is on Philadelphia's High Injury Network; the corridor also connects several business districts and neighborhoods where a majority of residents are Black or African American.

© 2021 City of Philadelphia. Data Sources: Pennsylvania Department of Transportation crash data (2014-2018); U.S. Census Bureau American Community Survey Data (2013-2017). Desktop Reference for Crash Reduction Factors, FHWA-SA-08-011, September 2008, Table 11.

Achieving Pedestrian Safety in California

On average, approximately 3,600 people die on California's road system annually. This represents an average of 10 deaths per day, and 3 of those are the State's most vulnerable road users: people who bike and walk. In the United States, approximately 17 percent of traffic fatalities are pedestrians, but this number is 27 percent in California.

These alarming numbers demanded action, which the California Department of Transportation (Caltrans) undertook beginning in 2020. As Caltrans Director Toks Omishakin said in a press release, "At least two pedestrians or cyclists lose their lives on California's transportation system each day—a number we refuse to accept or normalize. Safety remains our top priority and the department will work diligently until the trend is reversed."

Caltrans' work to accelerate pedestrian safety began with the introduction of a new safety paradigm. In order to establish a high-level, ongoing commitment to safety, Caltrans made a few important organizational changes to the department, including the establishment of a new Chief Safety Officer position as well as the establishment of a new Division of Safety Programs. Caltrans also incorporated four safety-focused pillars into its *2020–2024* SHSP as well as the *2020–2024 Caltrans Strategic Plan*. One of these pillars is to implement the Safe System Approach. The 2021 California State Transportation Agency's *Climate Action Plan for Transportation Infrastructure* details how the State recommends investing billions of discretionary transportation dollars annually to aggressively combat and adapt to climate change while supporting public health, safety, and equity, and explicitly commits to the Safe System Approach.

The institutional commitment to the Safe System Approach enabled Caltrans' Pedestrian Safety Improvement Monitoring Pilot Program, which had been piloted in 2016, to receive further funding and resources. This pilot identified and investigated pedestrian-related high collision concentration locations and was made permanent in July 2020. In addition, in September 2020, Caltrans introduced a new Pedestrian Systemic Safety Improvement Program that addresses serious pedestrian injuries and fatalities before they occur through a combination of crash modeling, statistical analysis, and risk analysis. The program integrates Safe System elements and principles into a systemic approach to emphasize that safety is proactive and to further the goal of zero deaths.

Caltrans' two pedestrian safety improvement programs (Pedestrian Safety Improvement Monitoring Program and Pedestrian Systemic Safety Improvement Program) complement each other. While the Pedestrian Safety Improvement Monitoring Program's approach is reactive in the sense that it focuses on locations that have a history of crashes, the Pedestrian Systemic Safety Improvement Program embodies many principles and elements of the Safe System Approach. The Pedestrian Systemic Safety Improvement Program advances the belief that safety must be proactive—it uses crash data to identify roadways that suffer from recurring safety challenges, but it is also proactive because it provides a mechanism to make improvements at sites that, while they share the same design and operational attributes, have not experienced many, or any, crashes. Both the data-driven and proactive approaches are needed to support pedestrian safety improvements throughout the State highway system.

To develop the Pedestrian Systemic Safety Improvement Program, Caltrans safety staff first gathered and compiled crash data. Then, they teamed up with researchers from the Safe Transportation Research and Education Center at the University of California–Berkeley to develop a pedestrian-specific systemic safety model. The model identifies systemic "hot spots," or locations that are at high risk for future crashes. These hot spot locations are proactively selected not only based on locations where crashes have occurred but also on their specific features, context, and characteristics—providing a comprehensive, systemic view.

Once the team identified the systemic list, they applied a prioritization process to sort the locations for the most pressing intervention need. This prioritization process was based on multiple variables, including collision rate, pedestrian volume exposure, equity as measured by disadvantaged communities, senior and youth population density, and school proximity. This analysis enabled Caltrans to make the most informed decisions about where California should invest its resources to maximize pedestrian safety benefits.

Last, traffic safety investigators implemented pedestrian safety countermeasures at the selected locations. To accomplish this, they relied on the *Pedestrian Safety Countermeasures Toolbox* and a companion training course developed by Caltrans. This toolbox, which includes 47 countermeasures, helps investigators select the most appropriate safety countermeasure for each unique location.

As an outcome, in its first year, the Pedestrian Systemic Safety Improvement Program identified more than 500 locations for investigation and improvements. Caltrans is already implementing pedestrian safety measures at target locations, and the Pedestrian Systemic Safety Improvement Program is currently in its second round. The success of the pedestrian program has laid the foundation for the establishment of additional systemic safety programs based on the Safe System Approach.

The cover of the Caltrans publication *Pedestrian Safety Countermeasures Toolbox*.

Other Caltrans safety efforts include establishing policies and standards on proven safety countermeasures, developing local traffic safety plans for each of the 12 Caltrans districts in California, and implementing the results of a research project titled Developing a Safe System Approach to Setting Speed Limits, which is currently underway. In addition, Caltrans will partner with the California Office of Traffic Safety, which is providing more than $8 million in funding for programs implementing safe and equal access to roads for pedestrians. Finally, the California Transportation Commission recently approved $100 million for projects dedicated to pedestrian-focused infrastructure improvements.

Setting Safe Speed Limits in Portland

Everyone deserves to reach their destinations safely. Safe driving speeds reduce the number and severity of crashes. Slower-moving drivers can stop more quickly to avoid a crash and, when a collision does occur, lower speeds reduce the chance of injury or death.

The city of Portland, OR, is actively managing driving speeds with a four-pronged Safe System Approach: lowering posted speed limits to support safe multimodal travel, redesigning streets, educating drivers, and enforcing speed limits with speed safety cameras. A notable success is Portland's 5-year transition to setting speed limits based on the Safe System Approach.

Oregon sets speed limits on all streets in the State, regardless of street ownership. Speed limits on roads in Oregon have traditionally been established with an engineering approach that relies heavily on street classification and existing driving speeds, especially the 85th percentile speed (the speed at which 85 percent of drivers are traveling at or below during free flow conditions). This approach typically does not adequately consider vulnerable road users, land uses, or existing infrastructure when determining the posted speed limit.

Portland committed to Vision Zero in 2015, and yet struggled to reduce speed limits on its streets, in part because of State control of speed limit setting, including a speed limit request process that did not consider urban context and a lengthy review time. To address those barriers, the Portland Bureau of Transportation (PBOT) has worked with the Oregon Department of Transportation (ODOT) and other jurisdictions to develop, test, and eventually adopt a speed limit setting process statewide that is proximate to the Safe System Approach, which recommends identifying the safest speed for all road users and then building infrastructure to support that speed.

In 2016, PBOT developed an alternative speed-setting methodology that ODOT

agreed to pilot on nonarterial streets in Portland. The alternative methodology identifies appropriate speed limits based primarily on street design and associated crash risk factors for people walking, biking, and driving, such as the presence and quality of bike lanes, sidewalks, and median separators.

The alternative methodology enabled Portland to move quickly in requesting that speed limits be reduced on 46 miles (76 kilometers) of collector streets from 2016 to 2020. The alternative methodology is also simpler, which led to faster ODOT response times (average of 2 months instead of 7 months). However, most of Portland's 30 High Crash Network streets are functionally classified as arterials, and therefore they were not eligible for the alternative speed-setting method, which significantly limited Portland's effort to set safe speed limits on its most deadly streets. Despite this limitation, piloting the alternative methodology built understanding and was an important step in transitioning to the Safe System Approach.

In 2019, ODOT convened a roundtable to address speed setting with participation from cities and counties across Oregon. The event took place as PBOT was advocating for the Safe System Approach to speed setting locally, and national and international guidance was emerging with similar recommendations.

Following the roundtable's recommendations, in 2020, ODOT adopted a new statewide speed setting approach for all street classifications, including arterial streets. The new methodology within city limits primarily relies on context (land use density, nonmotorized activity, and infrastructure), 50th percentile speeds instead of 85th percentile, and setting allowable speed ranges for different land uses and street classifications.

Portland is taking two next steps to advance the Safe System Approach to speed limit setting. First, PBOT is developing comprehensive guidance for speed limit setting for Portland that will identify safe speed limits based on context and human vulnerability. Second, PBOT is working with ODOT to shape guidelines for new statewide legislation that gives Portland and other eligible cities authority to set speed limits as long as State guidelines are followed.

"The 5-year process that Portland has undertaken to transition from a traditional approach to speed limit setting to the Safe System Approach can help provide guidance to other jurisdictions," says PBOT City Traffic Engineer Wendy Cawley. "Setting a vision, collaborating with partners, taking incremental steps, and centering a methodology on the protection of human life are core elements in the process."

Providing Valuable Insight

The Safe System Approach offers the necessary strategies for saving lives and helping to eliminate deaths and serious injuries on the Nation's roadways. Tribal, local, regional, State, and Federal organizations have begun to integrate the approach in their safety programs and projects, and soon will expand the approach beyond the safety disciplines. Examples of successful programs from these organizations can provide valuable insights for others who are planning to advance the approach.

	10 MPH	≤15 MPH	≤20 MPH	≤25 MPH	≤30 MPH	≤35 MPH	≤40 MPH	≤45 MPH	≤50 MPH
PED	Shared Roadway			5′ Sidewalk 100% One Side	Sidewalk Both Sides; Curb or Swale; 8′ Separation	>8′ Separation Both Sides NCHRP 562 Crossings: 20/Hr.	>12′ Separation Both Sides	Impermeable Separation Barrier	
BIKE	Shared Roadway			≤ 5′ Bike Lane	6′ – 7′ Bike Lane	Minimum 2′ Separation from Autos	Permeable Barrier	Impermeable Separation Barrier	
AUTO	Gravel Roadway	≤ 9′ Travel Lanes	10′ Travel Lanes, Bike/Walk Streets	10′ Travel Lanes		≤ 11′ Travel Lanes Angle Crash Mitigations	Permeable Center Barrier; Roadside Object Setback or Shielding		Impermeable Center Barrier

The alternative speed setting methodology that ODOT and PBOT piloted relies primarily on street design and crash risk factors for people walking, biking, and driving, compared to the traditional methodology that set speed limits based largely on the speeds people drive during free-flow conditions.

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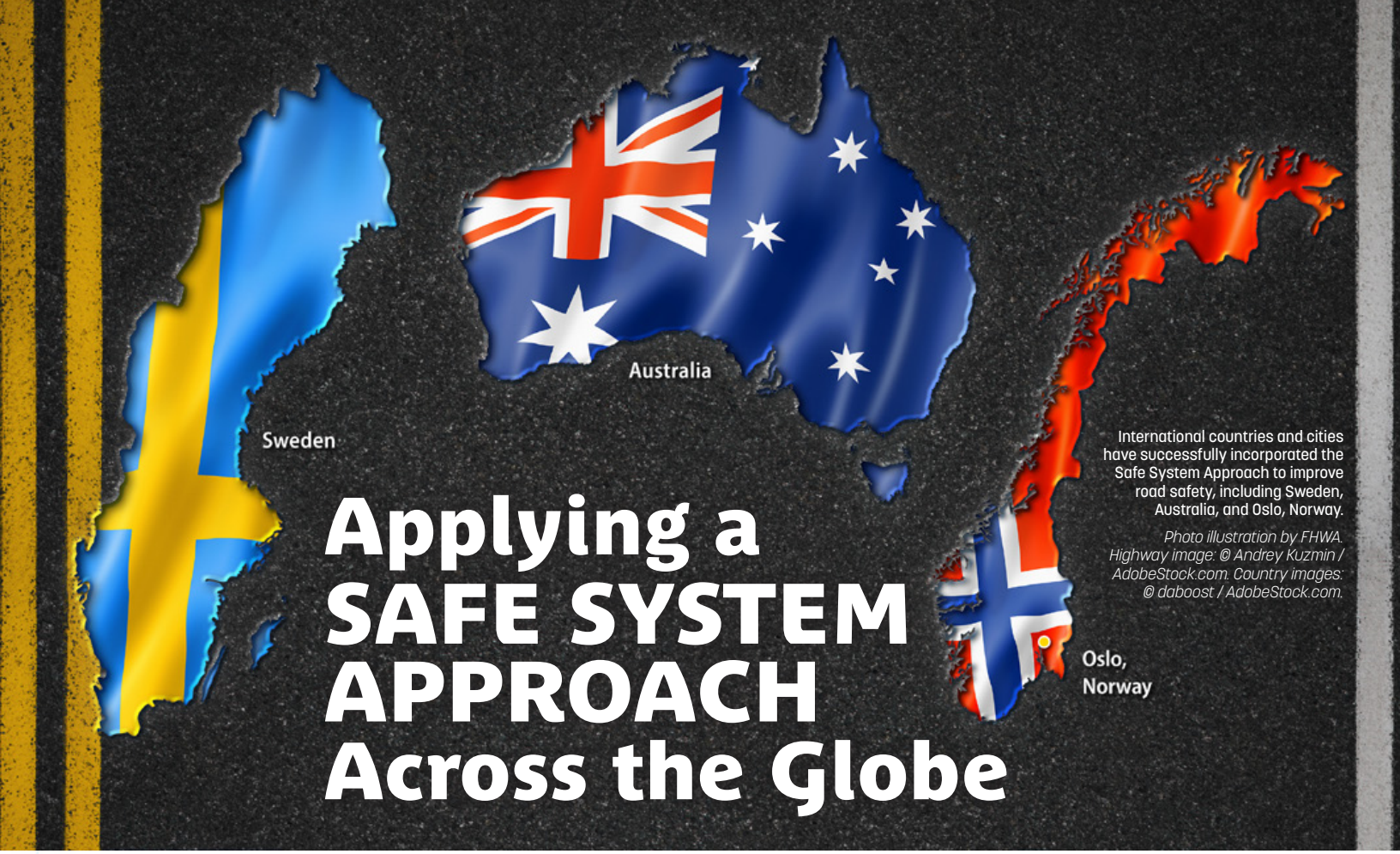

International countries and cities have successfully incorporated the Safe System Approach to improve road safety, including Sweden, Australia, and Oslo, Norway.

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Applying a SAFE SYSTEM APPROACH Across the Globe

Studying three examples in Sweden, Australia, and Norway can help other countries, including the United States, pave their way to zero deaths on highways.

by **MATTS-ÅKE BELIN**, **ANDERS HARTMANN**, **MARI SVOLSBRU**, **BLAIR TURNER**, and **MICHAEL S. GRIFFITH**

The United States can benefit from examining how other countries and international cities have incorporated the Safe System Approach to improve road safety. The following are success stories, insights, and lessons learned from two countries—Sweden and Australia—and one city—Oslo, Norway—in advancing the Safe System Approach.

Vision Zero in Sweden: A Road Safety Policy Innovation

In 1997, the Swedish Parliament adopted Vision Zero. Since then, its success has spread internationally. Vision Zero has not only attracted interest in the transportation sector but in other sectors of Swedish society such as fire safety, patient safety, occupational accidents, and suicide prevention. Although many associate the Swedish version of Vision Zero with a strong ethical imperative and the long-term goal to eliminate fatalities and serious injuries, the strategy is much broader than that.

Vision Zero is a public policy that offers a new perspective on road safety problems and their causes, appropriate overall solutions that need to be implemented, and a new division of responsibilities in order to create a safe system. In short, the Swedish Vision Zero is both a new long-term goal and a new overall strategy that has forced Sweden to substantially transform its daily road safety business through the implementation of the Safe System Approach.

Control for Harmful Energy

According to Vision Zero, the principal reason that people die or are seriously injured on the roads is that the kinetic energy to which people are exposed to in a crash exceeds the energy that the human body can withstand. The Vision Zero strategy rests on the research that well-known American road safety expert William Haddon conducted in the 1960s. Knowledge about energy forces and tolerance has largely served as a basis for the development of the passive safety characteristics of vehicles and for the development of different protection systems such as child safety seats, helmets, and seat belts.

The adoption of Vision Zero as a public policy has increased scientific knowledge about kinetic energy, which has provided an important foundation to develop a sub-component in the transportation system—namely the vehicle. Based on this design parameter, many transportation professionals suggest that the risk for different crash types should set the maximum speed limit. For example, in a situation in which risks exist for crashes with cars and vulnerable, unprotected road users such as pedestrians and bicyclists, the speed limit should not be higher than 20 miles (approximately 30 kilometers) per hour, and for risks of head-on collisions (such as cars to cars), at a speed not higher than 50 miles (approximately 80 kilometers) per hour.

From Policy to Implementation

To paraphrase a quote from social scientist Kurt Lewin, "There is nothing more practical than a good [policy] theory." The "policy" of Vision Zero must be translated into concrete actions. However, to go from policy intentions to sound policy outcomes in a complex world is difficult. Fortunately, Sweden put theory to action and based daily road safety work on Vision Zero. The nation

adopted Vision Zero as a national policy focus throughout its entire transportation system. Vision Zero has influenced vehicle safety, road environment in cities, highways, and road user behavior. Vision Zero has also changed the way that Sweden organizes and governs transportation projects in both rural and urban settings.

Urban Environment

In urban areas in Sweden, transportation safety is largely concerned with conflicts between protected and unprotected road users in which the most important determining factor is the unprotected road users' tolerance level against impact forces. Although the knowledge is still not definitive, when new published research emerges, Sweden plans to adjust its recommended speed limits. So far, 20 miles (approximately 30 kilometers) per hour for unprotected road users seems to be an appropriate tolerance level. If the road owners plan for conflicts between protected and unprotected road users, they need to strive for energy levels less than 20 miles (approximately 30 kilometers) per hour. This tolerance level could become an international standard.

There are two main types of interventions within urban areas: physical separation and speed controlling. Physical separation through sidewalks, bridges, tunnels, bicycle lanes, and special areas only for pedestrians and cyclists eliminates conflicts between unprotected road users and vehicles. This type of intervention is appropriate when the motorized traffic demands high mobility. In areas where pedestrian and cyclist mobility constitute a priority and in areas with mixed traffic, the interventions need to control the speeds below 20 miles (approximately 30 kilometers) per hour. Several traffic-calming interventions such as speed bumps and roundabouts have proved effective. Promising vehicle technologies include intelligent speed adaption systems and automatic pedestrian detection and braking systems.

Rural Area: The 2+1 Roads

Sweden contains a large rural road network. Parts of the road network with high-traffic volume have been rebuilt over the years to become modern motorways. Because of the nation's small population, Sweden built roads 43 feet (approximately 13 meters) wide, a type of "cheap" motorway, during the 1970s and 1980s. These roads were straight with high visibility, and the risk for crashes calculated per mile driven was low. The roads were also built with grade-separated intersections. Although deemed not justifiable to convert to motorways, these rural roads accommodated heavy traffic volume with a speed limit of 70 miles (approximately 110 kilometers) per hour. Even though the risk of crashes was small on these kinds of roads, those that did happen were typically severe. The traditional approach to this problem meant dissemination of information to the public about the risks, enhancing driver education, and to some extent increasing police enforcement—the perception being that a change in motorist behavior was the solution. But these strategies didn't work.

When Sweden adopted Vision Zero, these rural parts of the road network came under scrutiny. A small proportion of the Swedish road network represented a large percentage of the number of fatalities and serious injuries, so action needed to be taken. Upgrading roads to motorways would address the problem of head-on collisions but would be expensive. At that time—the late 1990s—in Sweden, it was estimated that building a motorway would cost approximately 1 billion Swedish krona (approximately U.S. $116 million) per saved life.

This is an example of a 2+1 road in Sweden.

© Lars Ekman.

Another alternative was to lower the speeds. Just as unprotected road users have a certain tolerance against external violence, so does a belted passenger in a modern car—about 50 miles (approximately 80 kilometers) per hour. However, it would likely be impractical to get Swedish road users to comply with that speed limit on high standard roads, and these roads are important from a mobility perspective.

Consequently, Sweden came up with a new solution, an innovation called "2 + 1 roads." Basically, a 2 + 1 road is a three-lane road that consists of two lanes in one direction and one lane in the other, alternating every few kilometers to enable passing. This plan, especially in the beginning stages of implementation, proved to be a cost-effective solution to a major road safety problem, estimated to cost 30 million Swedish krona (about U.S. $3.5 million) per saved life. After some initial resistance, especially among the road builders, the country carried out a 2 + 1 road program. Today, Sweden contains about 2,000 miles (more than 3,000 kilometers) of these roads, and the number of fatalities decreased by 79 percent on approximately 1120 miles (or 1,800 kilometers) of these 2 + 1 roads built that were evaluated with data from 1998 to 2007. The 2 + 1 road illustrates a successful application of a Vision Zero approach.

Promising vehicle technologies include automatic pedestrian detection and braking systems.

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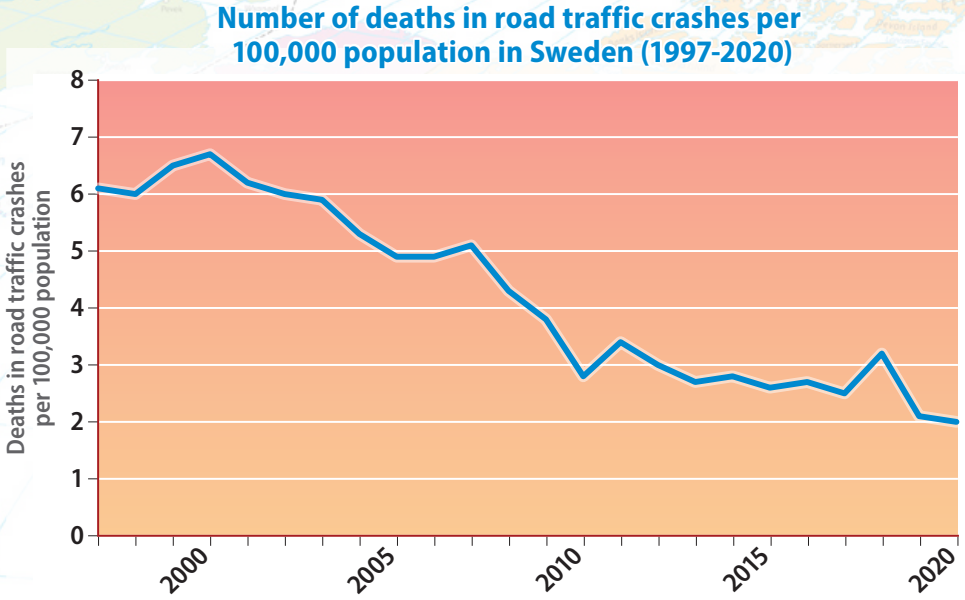

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From Implementation to Result

The number of road fatalities per million inhabitants has declined overall in Sweden over the past two decades. In 1999, the Swedish government launched an 11-point program for Vision Zero, and further implemented several interventions including traffic calming in urban areas, 2 + 1 roads, a new speed limit system, and traffic safety camera programs. In 2009, Sweden initiated a large organizational reform work in the transportation sector, guided by at least three important principles: an integrated transportation system, strict government mandate, and privatization of certain functions such as maintenance and infrastructure construction. In 2009, Sweden formed the Swedish Transport Agency (STA), which regulates and carries out inspection activities of all transport modes. The STA oversees plans for the whole transportation system and established the building and maintaining of road and railway infrastructure beginning in 2010.

Because road safety showed continuous improvement in Sweden through Vision Zero efforts, safety was no longer on the reform agenda. However, since 2010, the data showed that the downward trend in road safety was plateauing, so the Swedish government decided to draft a new policy document, renewing its commitment to Vision Zero. In 2016, Sweden announced its decision to relaunch Vision Zero as an intensified initiative. Based on this policy document, the government also commissioned the Swedish Transport Administration to lead the road safety effort. Sweden is back on track again: the number of fatalities per 100,000 inhabitants decreased from 6.7 road fatalities in the year 2000 to 1.8 fatalities in 2020, a 73-percent reduction.

"Vision Zero is important milestone in road safety because it emphasizes system safety and the need for many stakeholders to work together to deliver a safe system for all users," says Swedish infrastructure minister Tomas Eneroth.

The Safe System Approach in Australia

Australia has achieved success in reducing road deaths since a peak in the early 1970s. Road deaths decreased from around 3,800 per year (about 30 deaths per 100,000 population) in 1970 to around 2,000 deaths in the early 1990s (about 11 deaths per 100,000). However, despite these safety gains, the improvements plateaued throughout the 1990s. To renew efforts and achieve even greater road safety outcomes, Australia adopted the Safe System Approach as the guiding principle for road safety. This approach was based on the Swedish Vision Zero and Dutch Sustainable Safety strategies.

In 2003, Eric Howard, then the head of road safety for the Australian state of Victoria, was invited to Sweden to learn about the implementation of the Vision Zero approach. Upon his return, he says, "I presented to the Vicroads management team. The presentation was very warmly received and Vicroads decided to adopt Safe System thinking." Other road agencies also became interested in this approach around this time.

The Australian road and transport ministers adopted the Safe System Approach in 2004 and embedded it at the federal level as part of the 2005/2006 *National Road Safety Action Plan* produced by the Australian Transport Council in 2005.

Early Implementation Period

The early discussion by road agencies focused on ways to provide environments where the human tolerance to impact forces is not exceeded when road users make errors. Management of vehicle speeds and provision of forgiving roads and roadsides seemed to be the best way forward. However, early guidance on appropriate speed limits for different road environments

This is an example of traffic calming feature in an urban area in Sweden.

© Lars Ekman.

based on Safe System principles and survivability were met with political opposition.

Several states experienced early successes to scale up investment in safe road infrastructure through the provision of forgiving roads and roadsides (such as roadside barrier protection systems). This period in the early to mid-2000s also saw the adoption of some new approaches to help meet Safe System objectives, including a focus on fatal as well as serious injury outcomes, the importance of road safety metrics, attempts to identify infrastructure requirements to achieve Safe System outcomes, and evolving assessment approaches that quantified fatal and serious injury risk.

However, 5 years after the formal adoption of the Safe System Approach in Australia, researchers noted a lack of tangible commitment to actions required for Safe System implementation. The country needed a revised approach to road infrastructure that embedded Safe System principles, funding for infrastructure, a requirement for motorists to drive at safer speeds, vehicle improvements, and the necessity for the community to accept a "no harm" road system.

A full decade after the adoption of the Safe System Approach, the vision for the Safe System strategy was clearer, but the steps required to reach these objectives were less understood. For example, there was no clear, practical guidance on embedding Safe System principles into the provision of new infrastructure or the upgrading of existing infrastructure. In the first years of Australia's Safe System Approach, a lot of time was spent trying to define what was meant by a "Safe System," and many debates occurred about the theoretical interpretation (for example, the role of road user responsibility).

Implementation of Safe System Approach Activity

More recently, around 2015, Australia entered a new era of Safe System Approach implementation. Although not consistent in all locations, realization grew about how to bring about substantive change—which builds on early successes but appears to have accelerated Safe System implementation for several reasons.

The critical importance of speed management is becoming more apparent to road managers and the public—that without effective management of speed and energy there will be no significant reduction in deaths and serious injury. A number of locations now have speed limits of 20 miles (approximately 30 kilometers) per hour to protect vulnerable roads users, while speed limits are increasingly being reduced on low-quality, high-risk rural roads, from the default 60 miles (approximately100 kilometers) per hour to 50 miles (approximately 80 kilometers) or even less. Political understanding is growing on the safety and wider community benefits of this approach, and also on the level of public acceptance of these lower speeds. However, the understanding and response on this issue are not universal, and more political support is needed from the policymakers.

As for road infrastructure, the emergence of tools to help assess Safe System impacts from projects as part of design has been

Cable barrier used along a roadside in Gunnison County, Colorado.

Source: FHWA.

This high-speed roundabout in Victoria, Australia, uses a raised platform to manage speed.

© Blair Turner.

beneficial, including the Safe System Assessment Framework (SSAF), and the Extended Kinetic Energy Management Model for Intersections framework (X-KEMM-X). SSAF provides information about whether road design options are aligned with Safe System outcomes, guidance on ways to improve the design, and impact of this improvement on death and serious injury. This tool is now compulsory for certain projects in several Australian states.

X-KEMM-X calculates the chance of death and serious injury at each conflict point at an intersection based on different design options. Changes in this risk can be determined based on changes in design. Both X-KEMM-X and SSAF provide clear information to designers on the safety implications from their decisions, and led to changes in policies, including the use of alternative intersection designs such as raised platforms.

Also, innovation provided new solutions to fill some of the gaps in Australia's toolbox of road safety interventions. These new tools are providing better ways to manage speed and energy at critical locations, including through the use of raised pedestrian crossings, platforms at intersections, and vehicle-activated speed limit signs at high-speed intersections.

Australia has now set a national target with the objective of reaching zero deaths and serious injuries by 2050. This is significant because it paves the way for long-term, sustainable road safety improvements that are more likely to meet this ambitious target. Shorter-term (10-year) strategies work towards this ultimate Safe System objective, and the new draft road safety strategy currently sets a target of a 50-percent reduction in deaths per capita by 2030.

The new strategy emphasizes the use of outcome measures and safety performance targets. These items are also important because they allow close monitoring of new road safety interventions, the impacts they have on targeted behaviors, and the ultimate change in fatal and serious injury crashes that occurs from these interventions.

"You cannot underestimate the focus a transparent and measurable target brings to determining the allocation of resources and urgency in implementation," says Gabby O'Neill, the head of the Office of Road Safety with the Australian Department of Infrastructure, Transport, Regional Development and Communications. "Within the new National Road Safety Strategy 2021–2030 we're setting outcome measures to support a staged approach to achieving Vision Zero by 2050."

The Future for Australia

There are still issues to resolve to assist in the longer-term implementation of the Safe System Approach in Australia. The concerns include the need to increase awareness among the public and policymakers that there is still a significant road safety problem to address; that deaths and serious injuries are not a necessary by-product of transport, and are not acceptable; that there are effective interventions to reduce severe crashes; and that Australia can eventually eliminate fatalities and harm from their roads.

Oslo, Norway: Safe System Successes

In 2019, the Norwegian capital of Oslo became an instant benchmark for road safety, when, after 50 years of steadily decreasing traffic fatalities, no vulnerable road users—defined for Norwegian statistics as pedestrians, cyclists, and motorcyclists—lost their lives in the city for an entire year.

While Oslo has experienced several traffic fatalities since 2019, particularly during the COVID-19 pandemic, it is still relevant to take a deeper look at the city's efforts to advance urban road safety, considering the Safe System Approach methodology.

Norway implemented Vision Zero nationwide in 2002, 5 years after Sweden. In 2020, currently the latest year with official figures, Norway recorded the world's safest roads in terms of road deaths per vehicle kilometers traveled for the fifth year in a row. National regulations on vehicle safety, speed limits, and highway design provide a foundation for Oslo's efforts.

Vision Zero and the Safe System Approach aim to address the public health issue of death and serious injuries from road traffic. Even though fatalities and harm have been reduced on a national scale, the challenge remains for urban areas to address safety for vulnerable road users. In 2019, 85 percent of serious injuries in Oslo occurred in vulnerable road users.

The focus on road safety alone can lead to a false conflict between safety and increased walking and cycling. Limited road capacity combined with urban growth makes walking, cycling, and transit a necessity. Safer conditions for vulnerable road users should lead to more people walking and cycling and fewer people killed or injured. In 2013, while preparing a new ambitious cycling strategy, a city survey revealed that prospective cyclists cared most about feeling safe while cycling. To make more people get on their bikes, the city not only had to make its streets safer, but those streets had to feel safe, too. The survey, and the resulting cycling strategy enacted in 2015, can be seen as a watershed moment in how the city works on road safety.

Oslo has always received broad political support for road safety, particularly when it comes to implementing sidewalks and safe walking routes to schools. In addition, politicians provide a generous budget for street improvements, bike lanes, and public transit funded by the city's many toll roads.

The idea that pedestrians and cyclists need to feel safe, on their own terms, should be considered as a natural extension of the

Safe System Approach. This perspective is needed because work on road safety sometimes seems to exclude pedestrians' and cyclists' needs. Cities contain hostile environments where pedestrians and cyclists are inconvenienced in the name of their own safety—for instance, where a dangerous crosswalk has been removed in the name of safety, under the false assumption that users will accept a longer, safer detour. A lack of user perspectives in planning can cause unintended use and increased risk. A part of Oslo's success resulted from meticulously weeding out these situations through countless reconstructions of crosswalks, sidewalks, and intersections.

To reach its goals, Oslo has embraced its activists. The city offers a strategy to build its bike network piece by piece, seeking to make cyclists and road safety activists hungry for more improvements. The city has responded to the demand for road safety measures by identifying opportunities for fast and cheap improvements. For example, in providing space for bike lanes by removing parking. The measure can be reversible, but experience demonstrates that opposition to removing parking spaces wanes when the new bike paths are put into place and being used. Simple and cheap measures improve safety on a short-term basis and can pave the way for bigger road reconstructions where necessary in future. Seeing every improvement as a taste for what is to come, rather than an end result, also gives the city flexibility to improve on projects when it sees how users and neighbors react to changes. This strategy helps lower tensions in projects where public discourse can reach heated levels.

View of the street Åkebergveien in Oslo, Norway. Parking was removed to make room for a temporary bike lane going uphill before the street was rebuilt.

© City of Oslo.

Traffic safety improvements are standard practice in every road project in Oslo. However, traffic changes over time in pace with urban development and therefore the city's work with traffic calming is continuous. The city works to eliminate specific dangers, for example by regularly revising speed limits all over the city in recent years and implementing traffic-calming measures such as speed bumps or hourglass chicanes where necessary. In 2020, Oslo studied data on bicycle-related crashes in all the city's intersections, looking for particular patterns of crashes that could indicate the most important measures to work with in future. Narrowing intersections is among the continuous traffic calming measures the city works with. Reducing crossing distances for pedestrians as much as possible and allowing maximum 26 feet crossing distance reduces their exposure to traffic. Traffic islands often let the pedestrian focus on traffic from one direction at a time and make the crosswalk recognizable at a distance for drivers.

One of the most important measures for cyclists is the separation between them and vehicular traffic. This is achieved by elevating bike lanes, by placing medians between the bike and motor lanes, and leading bike lanes out of conflict points, such as bus stops. Parking and loading docks are placed next to the motor lane with a median with a minimum of 2.6 feet safety distance to allow opening of car doors and to allow pedestrians to orient themselves

Shown here is an example of a counterflow bike lane in a one-way street in Oslo. Motorized traffic volumes are typically low in one-way streets, reducing the number of interactions that may end in crashes.

© Geir Anders Rybakken Ørslien, City of Oslo.

before crossing the bike path. Conflicts between pedestrians and cyclists are addressed with crosswalks on the bike path and avoiding elements blocking the line of sight. Reducing the number of places where cyclists are led into mixed traffic on busy roads increase safety and reduce the level of stress on both parties.

To increase the advantage of cycling over driving, all new one-way streets in Oslo have to allow counterflow cycling. This allows cyclists a wider range of route options than motorists. The city has worked to implement this in hundreds of city blocks in existing one-way streets over the past decade. Motorized traffic volumes are typically low in one-way streets, reducing the number of interactions that may end in crashes.

However, one of the recent challenges to traffic safety work is the new policy around the General Data Protection Regulation. This legislation has resulted in anonymization of data on crashes to the point that most planners in Norway lack access to information on where different road users came from and where they are at the time of a crash. This poses the challenge of responding appropriately with road safety improvements following a crash and runs the risk of not adequately identifying or addressing the problem with road design. Planners respond to the best of their ability and to feedback from the public on places or situations where they feel unsafe. In the future, professionals hope to again gain access to more of the registered data that can help target road safety improvements based on crashes on the roads.

The most successful recipe in Oslo's experience has been the broad general public support for traffic safety measures and the political support for reducing parking or number of lanes for motorized traffic to give space for sidewalks and bike lanes. The result shows a steady increase in cycling and the same low level of crashes. In 2019, Oslo reported zero pedestrian or cyclist fatalities and only one driver fatality, and the programs and measures the city have adopted relate to this success.

This narrowing of an intersection forces a speed reduction for motorized traffic that are about to turn. This improves a driver's and cyclist's ability to notice one another and interact in a safe manner. Narrowing intersections also reduce crossing distances for pedestrians and the amount of time they are exposed to motorized traffic.

© City of Oslo.

Building on Safe System Examples for the Future

The United States can learn much from how international partners have implemented the Safe System Approach in their countries and cities. Early adopters in Australia, Sweden, and the city of Oslo have gained recent international recognition for their history and lessons learned implementing a Safe System Approach. Applying Safe System experiences from Australia, Sweden, and Oslo can help to scale up the U.S. approach to zero deaths and fewer injuries along the Nation's roads.

Lessons learned from implementation of the Safe System Approach in countries and cities around the world—like Oslo, Norway, shown here—can help the United States with its own adoption of the principles.

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Metallic roadway litter can cause flat tires for maintenance vehicles.

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Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from U.S. Department of Transportation sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Public Information and Information Exchange

ADOT Innovation Provides Maintenance Savings

The Arizona Department of Transportation (ADOT) fosters an environment of continuous improvement and waste reduction. One idea has created savings in trips to equipment shops and the cost of tire repairs: the pokey picker upper. It is a magnet attached to the front of an ADOT maintenance truck. This device hovers just above the ground, collecting metal pieces and shards along the highway shoulders.

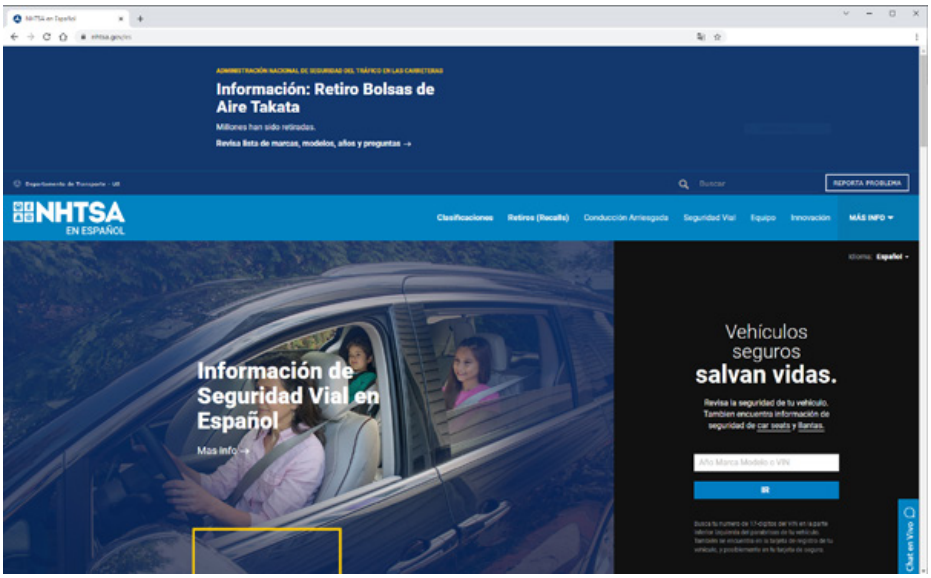
During regular litter removal, ADOT found that their vehicles were getting a high number of flat tires. To reduce the waste and cost associated with flat tires, Timothy Mitchell, a highway operations supervisor at ADOT, brainstormed the idea to use a magnet to grab metal before it could puncture any tires. He affixed a 3-foot bar to the front of a maintenance truck and hung a magnetic bar from it. The device is also interchangeable, so it is easily moved to either the passenger or driver side of the vehicle, depending on where it is needed.

ADOT's pokey picker upper helps protect maintenance vehicles from flat tires caused by metallic roadway litter, saving the agency time and money.

© Arizona Department of Transportation.

Crews began using the new tool in August 2020 to great effect. Since then, ADOT's welder has improved upon the prototype. While the maintenance crew is still compiling data on the number of hours and costs saved by avoiding flat tires, they have noted that trips to the shop have dropped considerably. Previously, crews were trekking to the shop two to four times a week for repairs, and now it's only about two to three times a month—a substantial improvement.

NHTSA Launches Spanish-Language Website



Source: NHTSA.

In September 2021, the National Highway Traffic Safety Administration unveiled a new Spanish-language website, NHTSA en Español (*NHTSA.gov/es*), to provide safety information to more than 62 million Spanish speakers living in the United States. NHTSA's first priority is safety; a large portion of the agency's work includes education and raising awareness of critical safety issues to reduce the number of injuries and deaths on American roadways.

NHTSA en Español is designed for the general Spanish-speaking public, providing information to make informed decisions about road safety. The website replicates all the English-language website's consumer-facing topics, including recalls, vehicle safety ratings, impaired driving prevention, seat belt safety, child passenger safety, technology, and tires and other equipment.

The Spanish-language website also makes NHTSA's multilingual Vehicle Safety Hotline number more prominent and incorporates the agency's existing live chat function, also now available in Spanish.

Additionally, NHTSA will increase its outreach to Spanish-speaking media to help highlight behavioral and vehicle safety programs. After Mexico, the United States is the second largest Spanish-speaking country in the world. According to the U.S. Census Bureau, the Hispanic population in the United States, which includes people of every race, was 62.1 million in 2020, a 23-percent increase since 2010.

NHTSA has long-standing practice of providing translations of its safety campaigns to stakeholders and safety partners through its *TrafficSafetyMarketing.gov* website and will continue this practice by providing customizable templates and media material.

U.S. DEPARTMENT OF TRANSPORTATION
BUILD AMERICA BUREAU

USDOT Celebrates the Build America Bureau's 5th Anniversary

In September 2020, Deputy Transportation Secretary Polly Trottenberg and former Transportation Secretary Anthony Foxx celebrated the U.S. Department of Transportation's Build America Bureau (the Bureau), marking 5 years of offering innovative finance programs and technical assistance to State and local partners across the country.

The anniversary event was highlighted by two major announcements—the Bureau's selection of five recipients for the new Regional Infrastructure Accelerators (RIA)Demonstration Program, and its first-ever INFRA Extra project designations.

Since its creation, the Bureau has closed more than 50 loans totaling over $20 billion to projects in eight States and is accelerating the number of loans being awarded. In fiscal year 2021, the Bureau set records with both the number of loans and the dollar value, closing just under $10 billion in loans.

The Bureau leverages the full resources of all the modes within USDOT and continues to promote a culture of innovation and customer service. The Bureau also serves as a single entity in charge of USDOT credit, large scale and intermodal project development, and provides a single point of contact for working with USDOT on infrastructure finance and development.

The virtual event is available to watch at *http://www.youtube.com/watch?v=g6hOTL2WkY8*.

Virtual Public Involvement Conversations Video Series

The tools and practices associated with public involvement have expanded and shifted over the past decade due to changes in communications, technologies, and lifestyles. To help practitioners navigate this changing environment, the Federal Highway Administration developed video case studies to highlight how transportation agencies are using virtual public involvement (VPI) tools and techniques.

The VPI Conversations Video Series (available at *www.fhwa.dot.gov/planning/public_involvement/vpi/case_studies*) features short conversations with professionals involved in virtual public involvement efforts at State and local transportation agencies. The conversations cover such topics as institutionalizing VPI, virtual open houses, bilingual resources, engaging with diverse communities, and strategies for planning, project development, and environmental review. FHWA's VPI website (*www.fhwa.dot.gov/planning/public_involvement/vpi*) also includes a variety of resources to assist State DOTs and metropolitan planning organizations with implementing the VPI initiative. These resources include fact sheets, peer exchanges, and the video case studies.

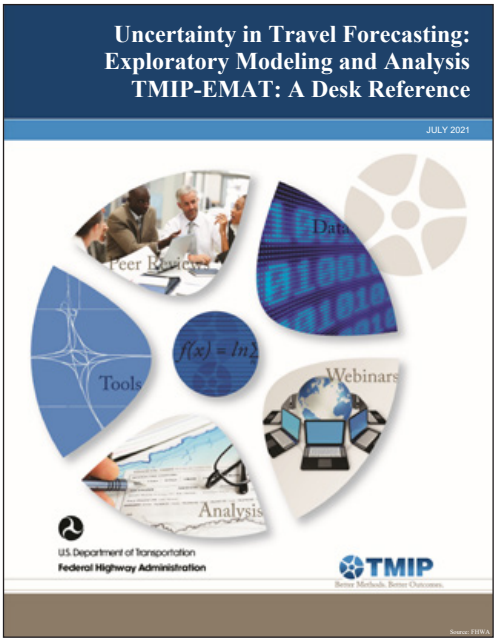
VPI Conversations

Source: FHWA.

Technical News

Accounting for Uncertainty in Travel Forecasting

Traditionally, travel forecasting models have been used to provide single-point predictions—that is, a single future scenario is developed, and the model is applied to that scenario. However, this approach ignores the deep uncertainty inherent in forecasting. This uncertainty comes from other uncertainties, including how systems work, how inputs to a system will change in the future, and which features of a system to focus on. Furthermore, emerging connected and autonomous vehicle technology, new mobility services, and changing travel patterns will potentially have significant unpredictable impacts on future surface transportation operations and travel demand. To help address these uncertainties, the Federal Highway Administration published *Uncertainty in Travel Forecasting: Exploratory Modeling and Analysis – TMIP-EMAT: A Desk Reference* (FHWA-HEP-21-032) in July 2021. This report demonstrates and motivates the use of travel forecasting models in an exploratory manner that accounts for the inherent uncertainties of the future.



Source: FHWA.

This improved approach to travel forecasting is supported by a new planning and modeling tool: the Travel Model Improvement Program Exploratory Modeling and Analysis Tool (TMIP-EMAT). The TMIP-EMAT was developed to facilitate the use of exploratory techniques with travel forecasting models and is one outcome of FHWA's Exploratory Modeling and Simulation Study. This tool is available at *https://tmip-emat.github.io/index.html*.

The full report is available at *www.fhwa.dot.gov/planning/tmip/publications/other_reports/uncertainty_travel_forecasting/index.cfm*.

FHWA Releases Air Quality and Noise Analysis Tools

In 2021, the Federal Highway Administration developed the Database for Air Quality and Noise Analysis (DANA) tool. The DANA tool combines traffic data from existing data sources into a single database and processes the combined data into properly formatted inputs to the Environmental Protection Agency's Motor Vehicle Emission Simulator model and FHWA's Traffic Noise Model Aide (TNMAide). TNMAide—for use in the FHWA's Traffic Noise Model (TNM)—is a spreadsheet tool that aids in the determination of the worst noise hour of the day, as required by 23 CFR 772. TNMAide is also a method to estimate noise impacts by using hour by hour data.

DANA provides real-world measurements of traffic conditions for use in environmental analyses, replacing inputs from transportation models that only generate base-year traffic data. DANA helps ensure that environmental analyses use a consistent set of traffic data and processing methods across the entire country. FHWA provides the DANA tool as a resource to stakeholders. Use of the tool is voluntary and its use may not satisfy all regulatory requirements.

The DANA tool, along with user guides and video training resources, is available on FHWA's Air Quality website at *http://www.fhwa.dot.gov/environment/air_quality/methodologies/dana/index.cfm*. TNMAide is available on FHWA's Noise Website at: *https://www.fhwa.dot.gov/environment/noise/traffic_noise_model/*. For more information, contact *DANAhelp@dot.gov* or David Kall at *David.Kall@dot.gov*.

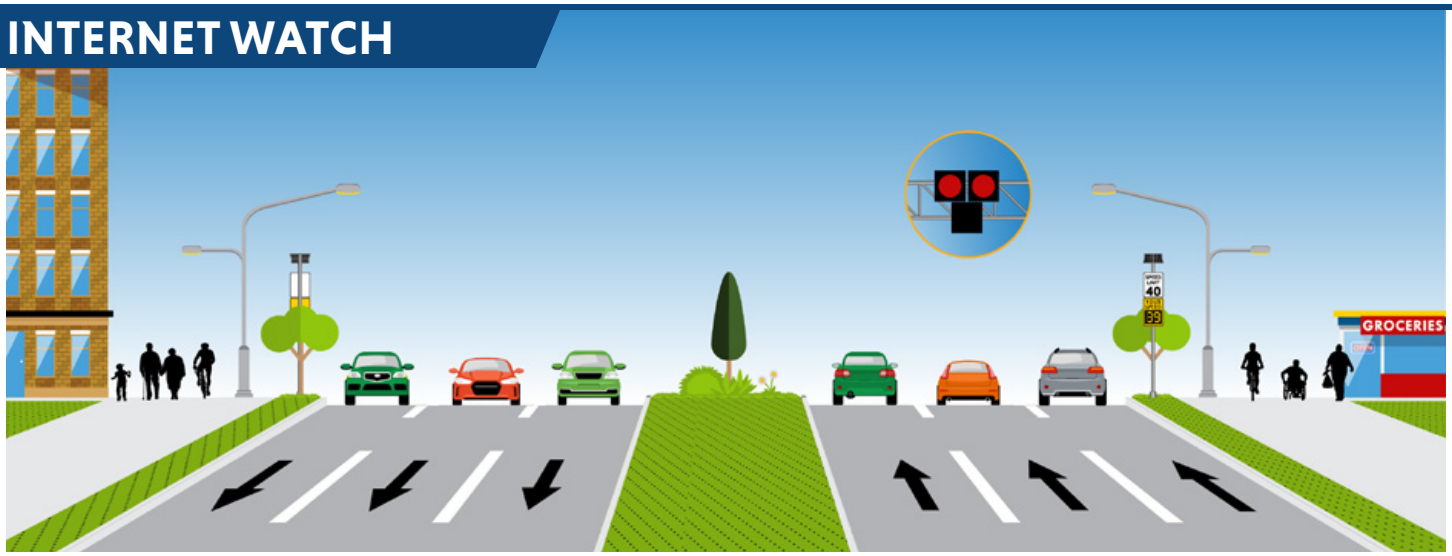
Policy and Legislations

USDOT Announces First Ever INFRA Extra Project Designations

The U.S. Department of Transportation recently designated 44 infrastructure projects around the country as Infrastructure for Rebuilding America (INFRA) Extra—a designation that makes project sponsors eligible to apply for credit assistance for up to 49 percent of project costs. These projects made it to the final round for INFRA funding under the competitive grant program but were not awarded grants due to overwhelming demand and limited funds. Like the projects that received INFRA grants, the projects receiving the INFRA Extra designation will help rebuild the Nation's infrastructure and create jobs.

The INFRA Extra initiative provides certain INFRA applicants the opportunity to apply for the Transportation Infrastructure Finance and Innovation Act (TIFIA) program, which provides Federal credit assistance for up to 49 percent of eligible project costs if the project advanced for funding but was not awarded INFRA grant due to resource constraints. This will potentially provide project sponsors with more funding than they would qualify for under a traditional TIFIA loan—which normally funds up to 33 percent of a project's cost, subject to satisfaction of underwriting requirements.

This year, USDOT received a total of 157 eligible INFRA applications from 42 States, as well as Guam. And this year's applicants collectively requested approximately $6.8 billion in grant funds—nearly seven times more than the $1 billion available for the program. The full list of INFRA Extra designated projects is available at *www.transportation.gov/briefing-room/us-department-transportation-announces-first-ever-infra-extra-project-designations*.



An image from the Complete Streets website showing potential cross section improvements on a suburban arterial.

Source: FHWA.

by **ANTHONY BOUTROS, JEFFREY SHAW,** and **PHILLIP BOBITZ**

Complete Streets Website

The majority of States and hundreds of local jurisdictions across the country have adopted Complete Streets policies that strive to build streets that are safe, and feel safe, for all users. The Federal Highway Administration is focused on supporting transportation agencies to accelerate the implementation of a safe, connected, and equitable transportation network for travelers of all ages and abilities—particularly those from underserved communities facing historic disinvestment. Building Complete Streets combines innovations from multiple transportation disciplines to achieve safe, connected, and equitable street networks. The Complete Streets website serves as a portal to FHWA's extensive resources and trainings, and also includes links to resources from other organizations to assist in planning, designing, and operating streets for the safety of all users. The site emphasizes resources for transforming project development through a Complete Streets implementation strategy for arterials and provides methods and measures of success for evaluating the outputs and outcomes of Complete Streets.

For more information, contact Anthony Boutros at *anthony.boutros@dot.gov*.

Focused Approach to Safety

Since 2004, the FHWA Office of Safety has used the Focused Approach to Safety (FAS) to identify areas of opportunity and to offer priority assistance to Focus States with the goal of reducing fatalities and serious injuries on the Nation's highways. Periodically, the FAS is adjusted and updated based on current data and program evaluations. In October 2021, the FAS was updated again using the National Highway Traffic Safety Administration Fatality Analysis Reporting System, FHWA highway statistics, and U.S. Census data for a 6-year period covering 2014–2019. The update process confirmed the focus areas of roadway departure, intersections, pedestrians, and bicyclists, and rigorous data analysis and screening identified new Focus States. For more information, visit *https://safety.fhwa.dot.gov/fas/*, or contact Jeffrey Shaw at *jeffrey.shaw@dot.gov* or 202-738-7793.

Proven Safety Countermeasures Initiative Update

The FHWA Office of Safety recently introduced nine new countermeasures to the Proven Safety Countermeasures initiative (PSCi). These additions enhance the already diverse set of safety strategies for State, local, regional, and Tribal transportation professionals to consider implementing as part of their efforts to improve safety for all users on the Nation's roadways. In addition to the 9 new countermeasures and crosscutting strategies, this most recent iteration of the PSCi updates the materials for the existing proven safety countermeasures to reflect the latest research, applications, and considerations for implementation. New website features, including a filter tool and search function, will help practitioners identify applicable countermeasures that meet their needs.

FHWA believes that widespread implementation of proven safety countermeasures, where appropriate, will accelerate the achievement of local, State, and national safety goals. The updated *Proven Safety Countermeasures website* is the one-stop shop for resources and information to advance the safety countermeasures in your jurisdiction.

For more information, visit *https://safety.fhwa.dot.gov/provencountermeasures/*, or contact Phillip Bobitz at *phillip.bobitz@dot.gov*.

ANTHONY BOUTROS is a transportation specialist in FHWA's Office of Safety.

JEFFREY SHAW is the Intersection Safety Program Manager in FHWA's Office of Safety.

PHILLIP BOBITZ is a safety engineer in FHWA's Office of Safety.

FHWA's nine new proven safety countermeasures.

Source: FHWA.

Utility managers coordinating transportation project efforts.
©Banana Oil / Shutterstock.com.

Improve Construction Projects Through Utility Coordination

by **JULIE JOHNSTON** and **SABRINA SYLVESTER**

Utility coordination is critical to safely and efficiently completing any transportation project. If unexpected utility conflicts occur during highway construction projects, contractors can experience major hazards, which can then result in delays and increased project costs. In addition, insufficient utility information and poor management of utility conflicts can affect the success of these projects. Some common challenges include disruptions to construction sites, damage to installations, risk to the health and safety of the general public, and unnecessary utility relocation.

The Federal Highway Administration's (FHWA's) National Highway Institute (NHI) now offers two web-based trainings (WBTs) specifically to assist transportation managers who handle utility coordination, design, and relocation in construction projects. Participants will learn about utility agreement requirements, as well as how to identify and document existing utility facilities.

Achieving Success in Utility Coordination with NHI

NHI has developed two new courses in utility coordination for construction engineers, design project managers, highway designers, and utility coordinators and managers. The WBTs listed below will provide transportation professionals the knowledge and resources they need to more effectively coordinate utility functions.

Preparing and Communicating Effective Utility Relocation Requirements (FHWA-NHI-134117). The Preparing and Communicating Effective Utility Relocation Requirements course provides information about the purpose and value of utility agreements and their requirements. In this 3.5-hour WBT, participants will learn to differentiate between effective and ineffective supporting documents in utility agreements and statements, prepare and communicate these agreements, and evaluate the effectiveness of utility agreements and information in construction bid packages.

Source: FHWA.

Utility Investigations (FHWA-NHI-134208). The Utility Investigations course provides attendees with a robust overview of practices and procedures for performing utility investigations during project delivery. In this 3.5-hour WBT, participants will learn the purpose of applying a risk-based approach to utility investigations, how to compare various utility investigation methods, how project delivery phases and utility investigation activities relate to each other, and how to identify typical utility investigation deliverables.

How to Attend or Host a Course

NHI invites professionals interested in earning continuing education units or professional development hours to visit *http://bit.ly/NHIHome* and browse the complete digital course catalog, which encompasses more than 400 courses spanning 18 program areas. To sign up for alerts when a course session is scheduled, visit the individual course's description page and click the "Sign Up for Session Alerts" link.

Interested hosts can submit a Host Request Form or find more information about hosting NHI courses by visiting *http://bit.ly/NHIHome*.

NHI is an approved Accredited Provider by the International Association for Continuing Education and Training (IACET). As an IACET Accredited Provider, NHI offers continuing education units for its programs that qualify under the American National Standards Institute/IACET Standard.

JULIE JOHNSTON is the program manager for Utility, Railroad, and Value Engineering for FHWA.

SABRINA SYLVESTER is a contracted senior marketing specialist for FHWA's NHI.

CARMA℠ Products Pioneer Cooperative Driving Automation Research

Cooperative driving automation (CDA) research is the key to creating a safer and more efficient transportation system. The CARMA product suite provides the necessary software to enable this research.

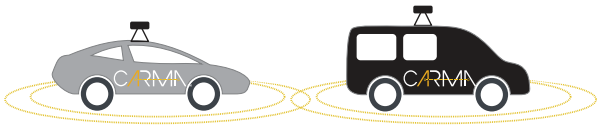
All four products (CARMA Cloud℠, CARMA Platform℠, CARMA Streets, and CARMA Messenger) work together with V2X (Vehicle-to-Everything) Hub, a separate system that enables networked, wireless communications between automated vehicles, infrastructure devices, and personal communications devices.

These tools are available online for collaboration and are currently being used in a set of research tracks examining the impact of CDA on traffic, reliability, and freight operations.

CLOUD

CARMA Cloud is a set of cloud-based, open-source software services enabling communication and cooperation between cloud services, vehicles, infrastructure, and road users.

PLATFORM



CARMA Platform is a vehicle-based platform that enables automated vehicles to interact and cooperate with road elements, such as other vehicles, infrastructure, and pedestrians.

STREETS

CARMA Streets is an infrastructure-based system that allows automated vehicles to share information with other vehicles and infrastructure to enable cooperation and improve transportation operations and safety.

MESSENGER

CARMA Messenger is a vehicle-based system for non-automated vehicles, and enables their communication with other road entities to allow participation in the CDA network.

Download CARMA products at **https://github.com/usdot-fhwa-stol**.
Learn more at **https://highways.dot.gov/research/operations/CARMA-products**.

Are you a longtime transportation professional conducting new research on a particular topic? Or an industry freshman looking to expand your knowledge base?

The Federal Highway Administration (FHWA) has the online research tool that can help.

Since 2006, "What's New" in FHWA publications has been the online resource for fact sheets, TechBriefs, reports, and more. Each year, FHWA produces these comprehensive, up-to-date, and data-driven publications that can support your research needs. These publications cover a wide range of topics, including:

- Roadway safety and enhancements.
- Pedestrian and bicycle safety.
- Transportation equity.
- Connected and automated vehicles.
- Nondestructive evaluations.
- Bridge innovations, reconstruction, and rehabilitation.
- Pavement technology and materials.
- Intersection improvements and design.
- Intelligent transportation systems.

To access the list of downloadable research documents, visit **www.fhwa.dot.gov/publications/lists/whatsnew/index.cfm**.

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